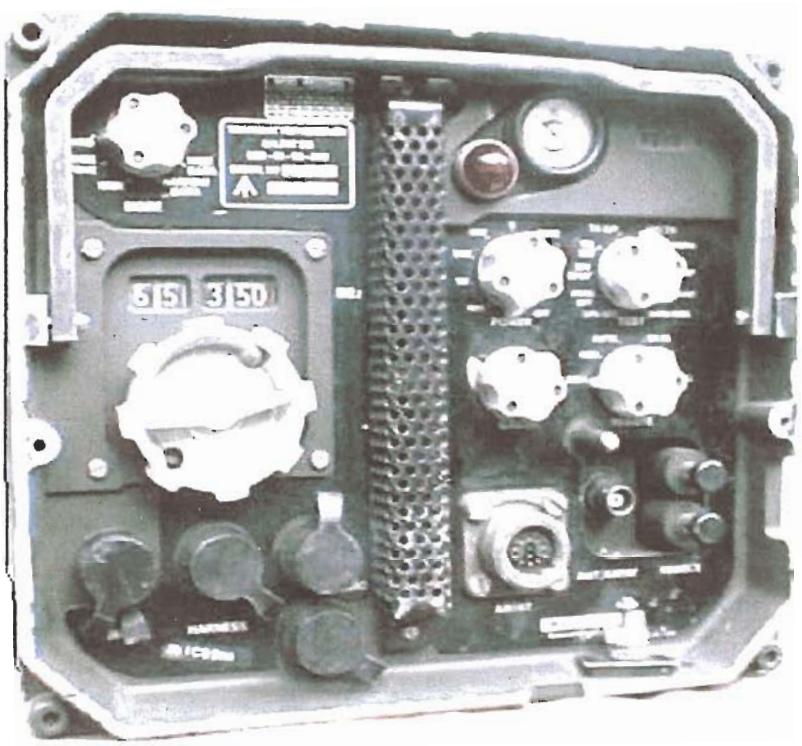
CLANSMAN

UK / V.R.C. 353

TECHNICAL DESCRIPTION



December 1978

RADIO SET RT-353

VHF VEHICLE SET

UK/VRC-353

Main Contractors: MARCONI SPACE AND DEFENCE SYSTEMS LIMITED (MSDS)

FOREWORD

In addition to manufacturing and supplying the UK VRC-353, Marconi Space and Defence Systems Limited undertakes the prime contractorship of the Clansman VHF Vehicle Radio System which includes the Control Harness, headsets, etc. As such it provides systems proposals and planning facilities and is able to supply all the items necessary to meet customers specific requirements in vehicies, both armoured and soft-skinned.

INTRODUCTION

The UK VRC-353 is a VHF FM transmitter receiver providing two-way simplex voice and data communication.
Although designed primarily for vehicular multi-set installation, in conjunction with the Clansman harness it is equally suitable for applications such as fixed or portable ground station and unattended repeaters. It may be used with a variety of specially-developed antenna systems. There are built-in facilities for remote control of transmit/receive, operator intercommunication and local or remote automatic re-transmission with or without the harness. The set, which is sealed, may be stored or transported un-packaged in conditions of high humidity or low air-pressure, and will operate in extremes of temperature fully exposed to rain, dust or solar radiation. Its performance is unaffected by wide voltage variations of battery, and it incorporates protection against high-level supply transients.
The UK VRC-353 is interoperable with the Clansman VHF manpack sets and with equipment now in service, such as the C-42 No. 2, the VRC-I2 and the SEM 25, and it meets NATO specification for a 30 km (20 mile) set.

DESIGN FEATURES

Ease of operation
A single channel-setting switch controls simultaneously the transmitter, the receiver and the antenna tuning unit, and re-tuning from any frequency to any other is completed within ten seconds. Automatic gain control holds the modulating level constant for microphone inputs corresponding to any speaking level from a whisper to a shout.

Frequency stability
The digital synthesiser with its high stability, temperature compensated master oscillator maintains the selected operating frequency within 5 parts per million at any ambient temperature down to -40 C.

Immunity to interference
The extremely high selectivity and the low spurious radiation allows sets separated in frequency by only 5% and with aerials 2 metres (6 ft) apart to be operated, at full power with negligible mutual interference.

Channel availability
The stability and selectivity of the set make it possible to use 25 KHz channel spacing without restriction of performance, but a 50 KHz mode is also provided so that the set is interoperable with equipment now in service and those projected for future NATO use.

Versatility
A switch, incorporated in the front panel, enables the equipment to be operated in either an analogue voice mode or in a digital data mode, with data rates up to 20 kilobits per second.

Microminiaturization
The use of microminiature components and techniques enables high performance to be achieved in about one-third of the volume of comparable sets now in service, and greatly increased reliability.

Ruggedness
The set is engineered to withstand rough handling and transport by land, sea or air unpackaged, and to operate in the shock and vibration conditions encountered in fighting vehicles.

Ease of Maintenance
Modular construction allows faults to be located to replaceable sub-units, the more expensive of which may be repaired at base workshops.

Comprehensive facilities
All circuitry required to provide the control and operational facilities for the various types of installation within the equipment, eliminating the need for extra units.

ENVIRONMENTAL SPECIFICATION

The equipment has been designed to meet the requirements of the British Defence Specification DEF.133 Class L3 (Ground Equipment, exposed and immersible, unpackaged). Its Ambient working temperature range is -40 C to +55 C and in addition it will withstand the heating effects of solar radiation. The storage temperature range is -40 C to +65 C. It is designed to meet the operational conditions in wheeled and tracked land vehicles, travelling on surfaced and unsurfaced roads and open country, and transported by land, sea and air. It will withstand operational shocks in armoured fighting vehicles due to the impact of non-penetrating shells on the vehicle armour, and delivery by normal parachute techniques. The equipment is capable of operation and storage under conditions of heavy driving rain, salt spray, high wind, driving dust, driving snow and humidity in excess of 95% at 30 C.
The equipment can be operated and stored at altitudes of 2,500 metres (8,200 ft) and can be transported in unpressurised aircraft at altitudes of 8,500 metres (25,000 ft). The equipment will stand immersion to a covering depth of 1.6 metres (5 ft) of water for at least two hours. It is immune to the corrosive effects of acid spray from secondary batteries and it is also unaffected by severe contamination by fuel oils, hydraulic oils and lubricating fluids.

BRIEF TECHNICAL SPECIFICATION

General

Frequency Range	30 - 75.975 MHz
Number of RF Channels	30 Km (20 miles).
Channel Spacing	1840 at 25 KHz spacing. 920 at 50 KHz spacing. 25 KHz with 5 KHz peak deviation. 50 KHz with 10 KHz peak deviation. Selected by switch on the front panel.
Frequency Setting	Manually by switch on front panel.
Frequency Stability	+/- 5 parts per million (380 Hz maximum) from all causes.
Radio System	VHF FM simplex voice or VHF FM data.
Ambient Temperature range	-40 C to +55 C.
Size	Height 21.7 cm (8.5 in), width 24.2 cm (9.5 in), depth 25.9 cm (14 in).
Weight	22 kg (about 50lb).
Power Supply	Will work with battery voltages between 21.5V and 34V, with superimposed ripple of 4 volts peak to peak and short duration spikes of +/- 600 volts. There is no DC connection between supply terminals and any other terminals and/or the case.
Power Consumption	Typical current consumption: 3A on receive, 10A on transmit at 24V DC.

Transmitter

Output Power	Full-power output of 50W into resistive load of 50R and 35W into a v.s.w.r. of 2.1. Output power can be reduced by a switch to 15W, 1W or 100mW. The transmitter will continue to function without damage into any load impedence.
Harmonic Suppression	Harmonic frequencies up to 500 MHz are at least 50 dB below the wanted output.
Spurious Suppression	The spurious output in any 25 KHz channel 5% or more off-tune is at least 120 dB down on maximum transmitter power except in channels which are harmonics of the transmitter frequency.

AF Input	Full deviation of the transmitter is produced by the signal level of 0.5 mV - 20 mV.
AF Response	300 Hz: -3 dB, 1000 Hz: 0dB, 3000 Hz: -3 dB

Receiver

Sensitivity	Less than 0.5 uV r.m.s. e.m.f. for 6 dB S/N at 1000 Hz modulation frequency and N full deviation.
Selectivity	Rejection of the receiver at the centre frequency of all channels, except that to which the receiver is tuned is greater than 100 dB.
Image Response	At least 100 dB down on main response.
IF Suppression	Better than 100 dB.
Interfering Signal Rejection	A sensitivity of 10 dB less than that defined above can be achieved in the presence of an unmodulated interfering signal +/- 5% off tune and of e.m.f. 20 volts r.m.s.
Receiver Protection	No damage will be caused by a signal on the antenna terminal of e.m.f. 100 volts r.m.s. and at any frequency within the tuning range.
AF Output	Local Headset: 100 mW maximum.
AF Response	300 Hz: -3 dB, 1000 Hz: 0 dB, 3000 Hz: -3dB.
Squelch	Fully automatic.

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CLANSMAN RADIO RT-353

INTRODUCTION

WARNINGS:

High Voltage

This equipment uses an internal supply of +600V d.c. and great care must be taken to avoid contact with this line.

Beryllium

This equipment uses components containing beryllium or beryllium-oxide. In certain circumstances they can constitute a health hazard. Before working- on the equipment consult Gen K050 - Beryllium Toxic Hazard in Electronic Equipments - which gives general information, handling and disposal instructions.

COOLING AIR

The cooling air flow through this equipment must not be obstructed at the back or front of the equipment.

ROLE AND PURPOSE OF EQUIPMENT

1. The VRC 353 is one of the CLANSMAN range of radio equipments, designed for use in vehicle installations or as a ground station.

2. The RT 353 is a VHF (FM) transmitter/receiver which covers the frequency range 30 to 75.975 MHz and is capable of transmitting and receiving speech, data, telegraph and facsimile signals, the latter being via an applique unit.

3. An identifying modulation of 150 Hz is superimposed on transmissions (except in the WIDE or DATA mode) to permit interworking with equipments of diverse origin and for use during automatic rebroadcasting working.

4. The RT 353 is capable of being used in three basic configurations:

   a. In a harness system (Data or Analogue).

   b. Remote operation, using a single pair field telephone cable up to 3 km long terminated in a remote handset, another radio or special applique unit. When connected to another suitable radio, an automatic rebroadcast link can be established. Telegraph signals are accepted via the remote terminals from an appropriate Telegraph Radio L/HL.

   c. Local operation via the AUDIO connectors on the front panel.

5. In harness or remote operation, the audio routing (send and receive) and transmit/receive switching are remotely controlled, but frequency and mode selection remain on the radio. This provides single frequency SIMPLEX communication.

6. The RT 353 is operated in conjunction with the Adaptor RF Antenna Tuning (ARFAT) and the Tuner Unit Automatic Antenna Matching/TN 402 - TUAAM/TN402.

MAIN PARAMETERS

7. Operational Parameters

Range: Up to 50 km with a recommended vehicle antenna.
When used in a static role greater distances may be obtained by the use of an elevated whip or inverted "V" antenna.

8. Physical Parameters

Height: 215 mm (8 1/2 in)
Width: 240 mm (9 1/2 in)
Depth: 355 mm (14 in)
Weight: 22 kg (50 lb)

9. Electrical Parameters

Frequency Range: 30 MHz to 75.975 MHz in three discrete bands:

Band 1: 30 MHz - 40.975 MHz
Band 2: 41 MHz - 55.975 MHz
Band 3: 56 MHz - 75.975 MHz

Frequency Stability: +/- 5 ppm

Intermediate Frequencies: 1. 9.6875 MHz
2. 312.5 kHz

No. of channels: 1840 at 25 kHz spacing
920 at 50 kHz spacing

Receiver sensitivity:
Analogue: 6 dB (s+n/n) for 0.5 uV rms emf input, modulated by 1 kHz at 5 kHz deviation (NARROW) or 10kHz (WIDE)
Data: Sensitivity such as to give error rates specified for corresponding input levels of unfiltered data at 16 Kb/s.

Signal Level (rms/emf)	Error Rate
1.413 uV	Less than 0.3%
1.0 uV	Less than 4%
0.71 uV	Less than 14%
0.5 uV	Less than 26%

Receiver selectivity: Rejection greater than 80 dB on all channels other than that selected.

AF Output:

Analogue: For input of 0.5 uV rms emf modulated by 1Khz at 5 kHz deviation (NARROW) or 10 kHz (WIDE)	2.7V rms (nominal into 75 ohms at AUDIO sockets with GAIN control fully clockwise. 1.7V rms (nominal) into 75 ohms at HARNESS socket, independent of GAIN control. 0.75V rms (nominal) into 300 ohms at REMOTE terminals, independent of GAIN control
Sidetone level: For input of 30 mV rms emf at 1 kHz to AUDIO socket pins A and B	2.75V rms (nominal) into 75 ohms at AUDIO sockets with GAIN control fully clockwise.
Data: For input of 0.5 uV rms emf modulated by 2 kHz at 4 kHz deviation (NARROW DATA) or by 2 kHz at 8 kHz deviation (WIDE DATA)	900 mV emf peak-to-peak (nominal) from a nominal 500 ohms at HARNESS connector pin D.
Squelch operation:	By 85 Hz internal modulation of local oscillator.
Transmitter power output:	100 mW to 50W (nominal) according to setting of POWER switch, into 50 ohms.

Modulation Sensitivity:

Analogue:	5 kHz (nominal) peak deviation (NARROW) 10 kHz (nominal) peak deviation (WIDE) for a 1 kHz at 1-40 mV rms emf signal to AUDIO connectors pins A and B with GAIN control to mid-position, or for a 1 kHz at 80 mV - 4V rms emf balanced input to REMOTE terminals or HARNESS connector pins A and B independent of GAIN control.
Data:	4 kHz (nominal) peak deviation (NARROW), 8 kH (nominal) peak deviation (WIDE), for a binary input of a regular 00001111 pattern at 16 kb/s (WIDE DATA) or 8 kb/s (NARRROW DATA) at a level of 3.2V emf peak to peak at HARNESS plug pin A (wrt pin B) from a source impedance of 600 ohms (nominal)
Tone:	1.45 kHz (nominal) peak deviation(NARROW) 2.9 kHz (nominal) peak deviation (WIDE)
Side tone:	True, by leakage across the antenna

10. Remote Control Parameters. The radio will transmit when a d.c. current of between 8 and 11 mA is drawn from the remote terminals. The radio will generate a call tone of 2 kHz (nominal) when a d.c. current of between 20 and 35 mA is drawn from the remote terminals. The remote user has false sidetone generated in the remote headgear.

11. Power Supply Parameters. The radio will perform to specification for d.c. inputs between 21V - 33V d.c. (24V d.c. nominal).

Current Consumption: 12A maximum at 28V on transmit
9A nominal at 28V on transmit
3A +/- 1A on receive.

12. Coding and Identification Data. Table 1 lists the assemblies/sub-assemblies which together form the equipment.

Assembly Number	Designation	Principal items and sub-assemblies
1	Chassis Wired Assembly	Heat Exchanger, Front Panel complete with switches/sockets/plugs, internal plugs/sockets and wiring harness. (1a) Front Panel Components (1b) Meter control (1c) Blower drive (1d) Audio pre-amplifier (1e) +28V supply filter (1f) TURF filter (1g) Gain control (1h) Crystal oscillator (1j) TUAAM Control Board
2	Printed Circuit Board Pack	(2a) Tuning Board (2b) Modulator Board (2c) Control Board (2d) Audio Board (2e) Motherboard
3	Receiver	(3a) Chassis and components (3b) Front-end protection (3c) Control IF (3d) Signal IF (3e) Signal mixer (3f) Buffer Amplifier (3g) Turret drive - 3g TS1 p.e.c./relay and connector (3h) Local oscillator (3j) Filter (3k) Varactor amplifier (3p) Turret lids r.f. (3r) Turret lids band-pass

Assembly Number	Designation	Principal items and sub-assemblies	
4	Transmitter	(4a)	Chassis and components
		(4a)	TS1 End Filter
		(4a)	TS3 Power amp component plate
		(4a)	TS4 High volts end plate
		(4b)	Varactor plate
		(4c1)	Control Board 1
		(4c2)	Control Board 2
		(4e)	End plate TS1
		(4e)	TS2 Harmonic Filters
		(4f)	Turret drive
		(4g)	Turret lids including
		(4h)	Oscillator
		(4j)	
		(4k)	Temperature sensor
5	IF Amplifier	(5a)	Main chassis and components
		(5b)	Relay assembly
		(5c)	Amplifier
6	Synthesiser	(6a)	Buffer amplifier
		(6b)	Fixed divider
		(6c)	Variable divider
		(6d)	Comparator
7	Power Supply	(7a)	Chassis and components
		(7b)	Control panel
		(7c)	Regulator drive
		(7d)	Tunnel diode
		(7e)	HV diode
		(7f)	Choke section
		(7g)	Output section
		(7n1)	Blower drive supply chassis
		(7n2)	Blower drive p.e.c.

Table 1 - RT 353 Assembles/Sub-Assemblies

14. Testing and Repair Facilities.

a. Unit Repairs. The RT 353 is a sealed equipment and consequently no attempt should be made at Unit level to carry out repairs other than the exchange of loose CES items, and the replacement of external components.
b. Field Repairs. Repairs at Field level will be the replacement of any of the 6 items designated CENTREMS (see Table 2) and the replacement of discrete components on the 3 major assemblies. In addition, repairs to the Front Panel and Chassis Wired Assembly will be by replacement of individual components or 'throwaway' PECs.
c. Base Repairs. Other than complete overhaul of the equipment. Base Workshops will be responsible for the repair of faulty CENTREMS backloaded from Field Workshops.

Designation
Amplifier Intermediate Frequency (Unit 5)
Panel Electronic Circuit (Tuning Board 2a)
Panel Electronic Circuit (Modulator Board 2b)
Panel Electronic Circuit (Control Board 2c)
Panel Electronic Circuit (Audio Board 2d)
Synthesiser, Electrical Frequency (Unit 6)

Table 2 - RT 353 Designated CENTREM Items

BRIEF DESCRIPTION

CONSTRUCTION

15. The equipment is housed in a rectangular cast aluminium alloy case and secured by five dowel bolts, one at each corner of the equipment front panel and one centrally located in the rear wall of the case. The rear wall sealing bolt includes a sealing washer.

16. Sealing is provided by torodial rubber sealing rings between front panel and case and at each blower outlet in the rear wall. Additional sealing is provided at the blower outlets by a rubber and metal seal located beneath the sealing rings.

17. Excessive internal temperatures are limited by the use of a heat exchanger. Air is drawn into the equipment via the front panel grille passed through a hollow metal chassis (heat exchanger) on which all the main assemblies are mounted, and exhausted to the rear by two blower motors.

18. A carrying handle, retained in the stowed position by a spring clip, an earth bonding terminal and a cable stripper are mounted on the front panel. A cartridge dessicator and seal test plug are located in the rear wall of the case.

19. Two retaining blocks, secured to the rear bottom corners of the case, provide the method of retaining the equipment on CLANSMAN mounting bars, the bars engaging with slots machined in the bottom of the case.

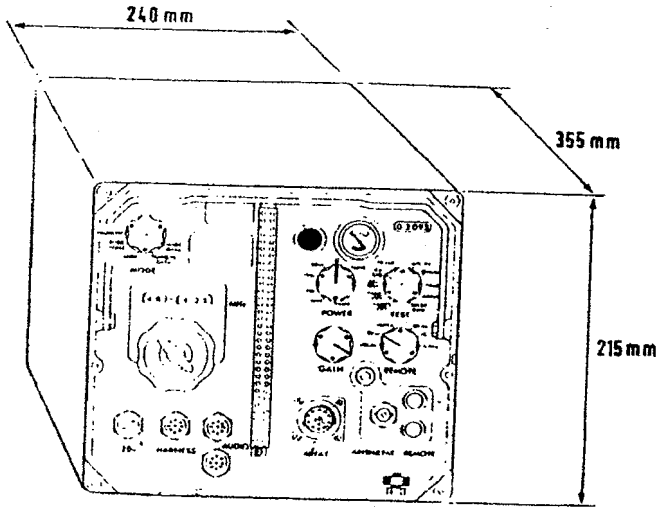


Fig 1. Dimensions

OUTLINE OF WORKING

20. The RT 353 VHF transmitter - receiver operates in three discrete bands within the operating frequency range by automatic band selection controlled by an electrically - controlled mechanical turret system, there being one turret for the receiver and one for the transmitter.

21. A band change is initiated by the front panel frequency switch which also controls a frequency synthesis loop system to maintain tuning to the selected frequency to within +/- 5 ppm, the loop ensures that the local oscillator is phase locked to a crystal reference frequency.

22. The Tuning Unit Automatic Antenna Matching TN402 (TUAAM/TN/402) is automatically tuned to the required frequency using frequency and phase detectors and servo amplifier driven motors. Control signals from the RT 353 are used to operate the Attenuator RF Antenna Tuning (AFAT).

CONTROLS AND FACILITIES (Fig 2)

23. The functions of the RT 353 are controlled by six front panel switches (1a)S1 - (1a)S6, control and information signals being passed to and from the equipment by eight front panel connectors, (1a)PL2, (1a)SK1 - (1a)SK6.

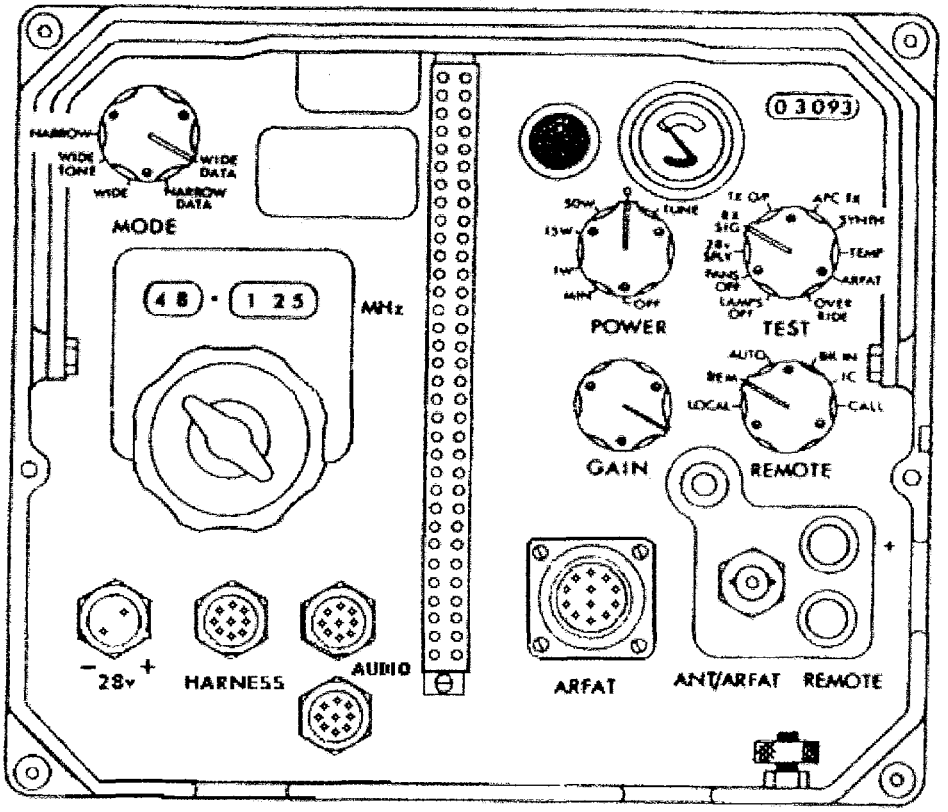


Fig 2. Controls and Connections

24. Frequency Selector Switch (1a)S1 The inner selector determines which decade will be varied by the outer knob. Thus the two left-hand windows select all MHz settings between 50 and 75 inclusive, and the two right-hand windows can be set to between .000 and .975 in steps of .025 MHz. A slipping clutch becomes operative after the maximum or minimum is reached on each of the indicator drums. The minimum of the 10 MHz drum is 'O'. Thus by counting the click positions from zero, the desired frequency can be obtained without visual observation.

25. MODE Switch (1a)S2 A five position switch providing the following facilities:

WIDE DATA	:	Data operation of 50 kHz channel spacing
NARROW DATA	:	Data operation of 25 kHz channel spacing
WIDE	:	Analogue operation at 50 kHz channel spacing with no 150 Hz tone modulation.
WIDE TONE	:	As for WIDE but with 150 Hz tone modulation
NARROW	:	Analogue operation at 25 kHz channel spacing with 150 Hz tone modulation,

26. POWER Switch (1a)S3 A seven position switch providing the following facilities:

OFF	:	complete equipment switched off.
MIN	:	r.f. power output level 100 mW nominal.
1 W	:	r.f. power output level 1W nominal.
15W	:	r.f. power output level 15W nominal.
50W	:	r.f. power output level 50W nominal.
0	:	Equipment will not transmit except during tuning sequence of TUAAM/TN402 when the power output is absorbed by a dummy load in the tuner.
TUNE	:	The 28V supply to the TUAAM/TN402 is interrupted. This causes the TUAAM/TN402 to start a tuning sequence when the switch is return from this position. Switch biased to the 0 position.

27. TEST Switch (1a)S4 A ten position switch providing the following facilities:

LPS OFF	:	All lamps off. Test Meter (1a)ME1 indicates received signal strength.
FANS OFF	:	Fans and lamps off, transmitter inhibited. Test Meter indicates received signal strength.
28V SUPPLY	:	Meter indicates supply voltage on marked scale, whenever the 28V supply is connected.
RX SIG	:	Test Meter indicates received signal strength on arbitrary scale.
TX 0/P	:	Test Meter indicates whether the transmitter output valve is drawing the current appropriate to its power setting. Correct operation is indicated by pointer in green area (approx 2/3 f.s.d)

AFC TX	:	Test Meter indicates whether the transmitter frequency control loop is operating correctly. Meter measures d.c. level from loop which will be OV(nominal) when phase locked. Pointer should be central +/- 3 divisions
SYNTH	:	Test Meter indicates whether synthesiser is locked. For correct operation meter reads right of centre. For incorrect operation meter reads left of centre.
TEMP	:	Test Meter indicates whether the radio is overheated. For normal operation meter reads right of centre. For overheat meter reads left of centre.
TURF	:	Test Meter indicates whether ARFAT temperature is within limits. For normal operation meter reads right of centre. For incorrect operation meter reads left of centre.
OVERRIDE	:	In this switch position the TEMP and ARFAT alarms are over-ridden, muting by the squelch circuit is overridden and the cooling fans are switched on. The switch is biased to the ARFAT position. Test Meter indicates whether Transmitter is locked, correct operation meter reads right of centre.

28. GAIN Switch (1a)S5 A ten position rotary switch which simultaneously controls the audio level to the AUDIO sockets and the audio level from the microphone pre-amp such that increasing the level of one decreases the level of the other.

29. REMOTE Switch (1a)S6 A six position switch giving the following facilities:

LOCAL	:	Control of the radio is by a CLANSMAN headset/handset connected to either of the AUDIO sockets.
REM	:	Control of the set, in addition to the local operator, is by either a CLANSMAN remote handset connected to the REMOTE terminals or a CLANSMAN harness installation connected via the HARNESS socket.
AUTO	:	Automatic rebroadcast available using a further radio connected via the REMOTE terminals or via an appropriate system connected to the HARNESS socket.
BK-IN	:	Supervisory facility for the local operator preparing for automatic rebroadcast working. Automatic rebroadcast is inhibited and operation of the local pressel causes both the local and the remote controlled sets to transmit. With the pressel released, the operator hears both the local and the remote received signals.
I.C.	:	Intercommunication between the local operator and the remote user without r.f. transmission.
CALL	:	Audible tone heard by local and remote users. 'Call' current is drawn from the remote lines. The switch is biassed to the IC position.

30. DC Input Plug (1a)PL1 A two-pin plug with '+' and '-' identification.

31. AUDIO Sockets (1a)SK1 (upper) and (1a)SK2 (Lower) Two 7-way sockets for local handsets and headsets.

Pin:		
	A	Mic +
	B	Mic -
	C	Supply (28V)
	D	phone
	E	earth (return for C,D,F and G)
	F	pressel
	G	phone

The supply at Pin C is through a 470 ohm resistor to prevent damage due to accidental short circuits. Pin D and G are connected together inside the equipment, pin B is a separate mic earth return to avoid unwanted audio feedback.

32. HARNESS Plug (1a) PL2 A 7-way plug for operation via CLANSMAN harness. Pins A and B are connected in parallel with the upper and lower REMOTE terminals respectively when the RT 353 is operated in the analogue mode.

Analogue pin:		
	A	Mic +
	B	Mic -
	C	earth
	D	phone +
	E	phone -
	F	not used
	G	earth

Data pin:		
	A	data input
	B	transmit/ receive command
	C	earth
	D	data output
	E	signal strength/squelch/tone output
	F	clear speech command
	G	earth

33. TURF Connector (1a)SK3 A 12-way double density pattern 104 connector for control of TUAAM/TN402.

Pin:		
	A)	
	B)	
	C)	not used
	D)	
	E)	
	H)	
	K)	
	L	ARFAT Temperature
	M	Tuner keyline
	O	Silent tune
	P	earth
	S	+28V

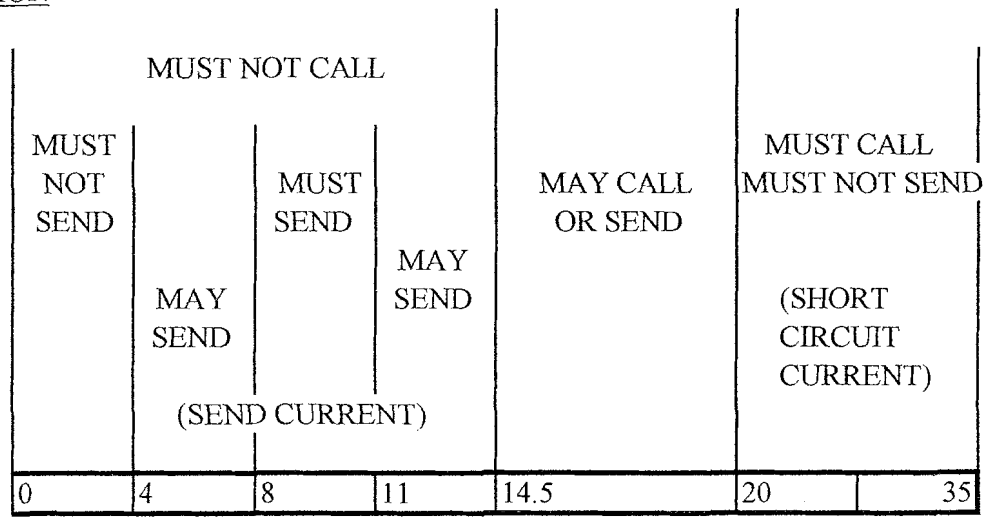
34. A current not exceeding 100 mA may be drawn from Pin S whilst the set is transmitting on full power, up to 4A may be drawn whilst the set is not transmitting, but if the set is made to transmit whilst such a current is being drawn the PSU will trip out. The supply can be interrupted by the POWER switch.

35. Pin L will be at logic 1 for ARFAT temperatures within limits, this will change to logic 0 (overheat) to produce an ALARM condition. Pin M is an input from the TUAAM/TN402. When connected to earth (Pin P) it causes the radio to transmit at a fixed r.f. power level (50W) for TUAAM tuning. Pin 0 is open circuit except when connected to 0V by the POWER switch to cause the TUAAM/TN402 to absorb all transmitted power in a dummy load during tuning.

36. ANT/TURF Connecter(1a)SK4. A BNC pattern 16 connector for RF input and output.

37. REMOTE Terminals (1a)SK5('+') and (1a)SK6. Spring terminals suitable for connecting to stripped wire, used for the remote handset or remote radio. The equipment contains 'SEND' and 'CALL' detectors which operate at pre-determined line current threshold levels. The behaviour of the current detector is shown below:

FUNCTION



Similarly, when set for AUTO operation, and not already responding to currents drawn from the terminals, the equipment draws send current from the line in response to the appropriate r.f. input as defined below:

MODE switch setting	Required response to r.f.
NARROW	150 Hz modulation detected.
WIDE TONE	150 Hz modulation detected.
WIDE	Squelch operated

38. Indicator Lamps The equipment has a red indicator lamp (1a) LPl which is illuminated when the set is transmitting. The meter and tuning scale are illuminated by internal white lamps. All illumination is inhibited in the LPS OFF, FANS OFF AND OVERRIDE positions of the TEST switch.

39. Test Meter (1a)ME1 A test meter is provided, marked 16 to 32V. The right-hand sector of the scale (24 to 32V) is coloured green and the left-hand sector coloured red. Divisions are in 2V steps.

The test meter monitors:

a. Supply voltage.
b. Received signal strength.
c. Transmitter power.
d. Transmitter frequency control loop.
e. Transmitter lock.
f. Synthesiser
g. Temperature.
h. ARFAT Temperature.

40. Alarm Indications Certain equipment fault conditions produce alarm indications in one of two ways:

a. Frequency dial illumination flashing on and off (at approx 1 Hz) and all audio outputs interrupted (at approx 1 Hz).

b. Non-illumination of TX lamp when transmit commanded in other than LPS OFF, FANS OFF and OVERRIDE positions of TEST switch (1a)S4.

41. Transmitter working is inhibited in the following conditions:

a. Failure of transmitter phase locked loop.
b. Failure of frequency synthesis giving incorrect frequency output.
c. ARFAT Overheat.
d. Equipment overheat.

Indication of (a.) is absence of transmit lamp indication with the TEST switch on other than LPS OFF, FANS OFF and OVERRIDE posistions and by meter reading in the OVERRIDE position. Indication of (b.) to (d.) is primarily by flashing lamps together with an audible indication in any earpiece or loudspeaker connected to the equipment. The TEST switch then allows the cause to be located by interpretation of meter readings.

42. In the event of a cooling failure a thermostat switches off the transmitter. If the temperature continues to rise, a second thermostat will switch the equipment off before overheating causes any damage. Certain alarm conditions may be overridden, ie the equipment can be operated in the ARFAT or equipment overheat alarm condition if urgently required. Setting TEST switch S4 to OVERRIDE cancels the alarm output from the control logic circuits and lifts the audio muting on Audio Board 2d. The blowers are switched on regardless of prevailing temperature conditions, the front panel meter indicates whether the transmitter is locked, and the front panel TX lamp is switched off.

43. The logic circuits within the equipment employ conventional positive logic techniques with intergrated circuit 'chips' providing elements such as Nand gates, inverters, bistables, monostables, etc. The symbols employed in this precis together with their associated truth tables are shown in Figure 3.

44. Unity Gain Amplifier This is a gated amplifier specially developed for the RT353 being used on both Audio and Modulator Boards. The amplifier exhibits the properties of a linear gate with both normal and negated inhibiting inputs as the controlling influences. A logic 1 input to the normal inhibiting gate will prevent an output signal representing 1 whatever the level of the other inputs. A logic 0 input to the negated inhibiting gate will have the same effect.

45. The 'through' signal paths are at an audio frequency at a level of +/-2 volts and not switched logic levels; the gain as the name implies is unity.

SIGNAL IDENTIFICATION AND LOGIC SYMBOLS

46. Identification of Signal Logic A signal is identified on the Logic Diagrams by a 'name', the name of the signal relating to the defined 1-state. The convention 'name' with a bar over the top refers to the logic negation of the same signal.

eg SYNC = the logic negation of SYNC

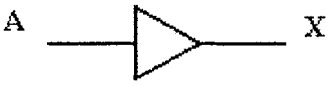
Logic Symbols employed in this Precis

Buffer

TRUTH TABLE

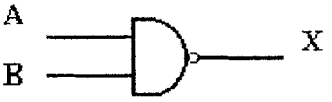
A	X
0	0
1	1

Inverter



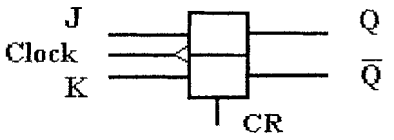
A	X
0	1
1	0

NAND Gate



A	B	X
1	1	0
0	1	1
1	0	1
0	0	1

JK Element with direct clear



INPUT			AFTERCLOCK PULSE	
J	K	CR	Q	$\overline{Q}$
1	0	1	1	0
0	0	1	+	+
0	1	1	0	1
1	1	1	*	*
-	-	0	0	1

* Depends on last previous Q and Q state (output states reverse)
\+ Output states remain as for before the clockpulse

Fig 3. Signal Identification and Logic Symbols.

47. The output function P.A. ON (Fig 4) is only present when TRANSMITTER LOCK AND SYNTHESISER LOCK AND (OVERRIDE OR ARFAT TEMP AND TEMP) are present as inputs.

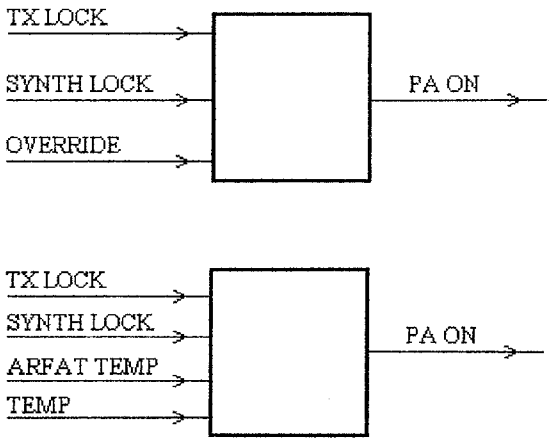


Fig 4. Output Function - PA On

TURRET BAND SELECTION

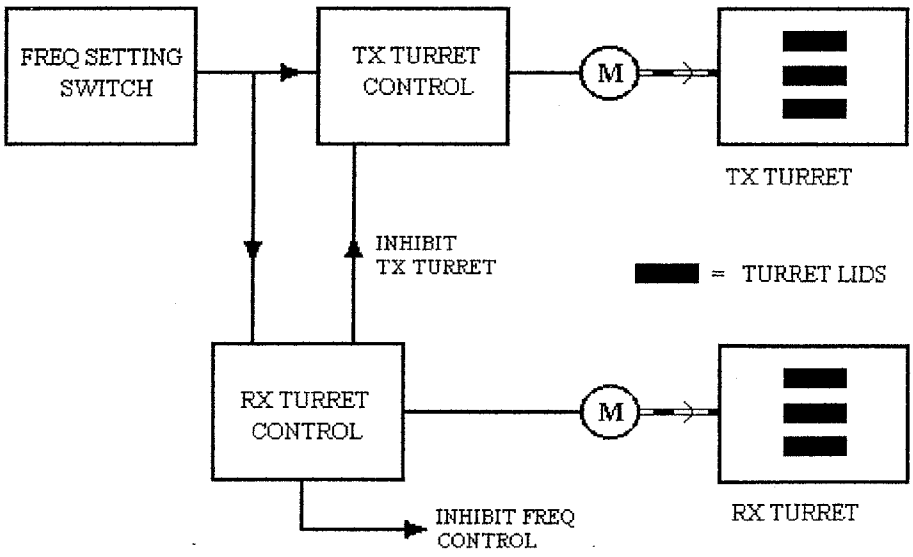


Fig 5. Turret Control Block Diagram

48. The frequency range of the RT353 is divided into three discrete bands:

Band 1 --- 30 - 40.975MHz
Band 2 --- 41 - 55.975MHz
Band 3 --- 56 - 75.975MHz

49. Each band has discrete RF tuned circuits and oscillator circuits, the components of which are mounted on the turret lids. The transmitter lid has one turret per band each containing the P.A. rf timed circuits and oscillator components (less main timing capacitor). The receiver turret has two lids per band, the turret lid RF, containing two rf tuned circuits associated with the first rf amplifier, and the 'turret lid bandpass', containing a further three rf timed circuits associated with the second rf amplifier and the local oscillator tuned circuit (less main tuning capacitor).

50. The receiver and transmitter turrets are each driven from band to band by individual dc electric motors under the control of associated circuits. The two control systems are interconnected to ensure that whilst the receiver turret is timing the transmitter is locked stationary. A control output also holds the frequency control system inhibited until the receiver turret has completed tuning.

51. Band change is automatic and is initiated as the frequency selection switch (FSS) is changed from a frequency lying within one band to a frequency within another band. The system is earth seeking.

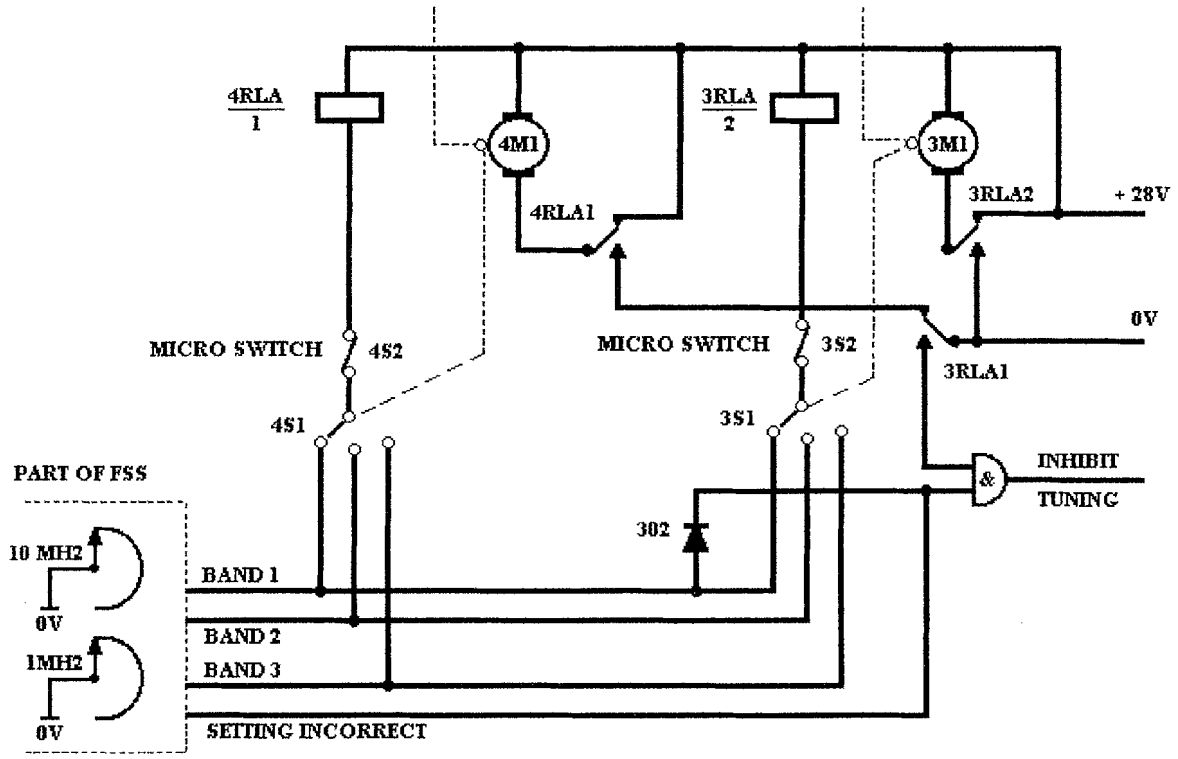


Fig 6. Simplified Turret Band Select

52. Fig 6 shows the system in the quiescent condition having selected Band 1. If the frequency selection switch is now changed to a frequency in Band 3 the following sequence occurs:

a. 0V is removed from Band 1 line from FSS and switched to Band 3.

b. The two control relays 3RLA/2 and 4RLA /2: de-energise.

c. Contact RLA-1 places 0V (logic 0) on one input of a 2 input NAND Gate 3TR1 (inhibit Tune).

d. Contact RLA-2 places 0V on one side of the Rx turret drive motor 3M1, the other side of which is permanently connected to +28.
Motor 3M1 thus rotates.

e. Contact 4RLA-1 moves over awaiting OV to be placed on it by 3RLA re-energizing after the Rx turret has tuned.

f. Motor 3M1 drives the Rx turret round. The turret is ganged to a six position rotary switch 3S1. Every alternate switch position is used, six positions being included for mechanical design purposes only. A single lobed cam on the turret opens and closes microswitch 3S2 in sympathy with 3S1 breaking and making. 3S2 is included to ensure a high degree of repeatability of turret positioning.

g. When the turret has rotated far enough such that 3S1 is in the Band 1 position and 3S2 is made, relay 3RLA re-energises. Contact 3RLA-1 removes the 0V input to the 2 input NAND gate thereby removing the Tuning Inhibit. Contact 3RLA-2 removes the 0V from motor 3M1 and replaces it with +28V. With +28V connected to both sides, 3M1 stops immediately and is not permitted to "run-on".

h. Contact 3RLA-1 places 0V on motor 4M1 (TX turret) via relay contact 4RLA-1 (de-energised).

j. 4M1 rotates, taking with it rotary switch 4S1 and microswitch 4S2, in the same manner as switches 3S1 and 3S2 were moved by the Rx turret. Upon reaching Band 3 with 4S1 in the Band 3 position and 4S2 made, relay 4RLA re-energises. Contact 4RLA-1 removes the 0V from 4M1 and replaces it with +-28V, thereby stopping it.

53. Incorrect Frequency Setting The construction of the FSS makes it possible to select frequencies outside the frequency range of the set. These are designated 'Prohibited Frequencies' and their selection results in 0V being applied to the Setting Incorrect line. This is fed as a logic 0 to the other input of the 2 input NAND gate 3TR1 placing an inhibit on the synthesiser tuning. Diode D2 is forward biassed placing 0V on the select Band 1 line.

54. Thus both turrets tune to Band1, but because of the tuning inhibit from 3TR1 the receiver synthesiser does not tune, resulting in the front panel alarm being activate.

FREQUENCY CONTROL

55. The RT 353 may be tuned to any one of 1840 channels spaced 25 kHz apart (narrow) or 920 channels spaced 50 kHz apart (wide). To obtain rapid channel selection and to maintain the selected frequency to a high degree of accuracy control loops based on a digital frequency synthesiser are employed.

56. A reference frequency at 4.84375 MHz from a temperature controlled crystal oscillator is fed to a fixed divider in the synthesiser. This divider provides two outputs one at 968.75 kHz, (div/5) and one at 781.25 Hz (div/6100), the latter is fed to a frequency and phase comparator within the synthesiser.

57. A portion of the local oscillator frequency (fo) is fed to a variable divider within the synthesiser whose division ratio is set according to the particular frequency set on the frequency setting switch, the resulting output at fo/N is fed as the second input to the frequency and phase comparator.

58. Any detected frequency error at the synthesiser comparator inputs results in a logic output to the motor control circuits. This output consists of a train of pulses at a p.r.f. corresponding to the size and sense of that error (low/high). The control circuits cause the motor to drive the receiver main tuning capacitor in the correct sense to remove the detected error by coarse tuning the local oscillator, the transmitter oscillator being simultaneously coarse tuned. This primary loop gives a fast pull-in facility to bring the system rapidly within the capture range of a secondary Delta-Sigma loop in the motor control circuits.

59. When the inputs to the comparator are within 1 cycle of one another, the frequency high/low drive to the motor circuits is removed and replaced by a local oscillator phase error signal routed to the Delta-Sigma loop circuits. In this loop system the local oscillator phase error signal is first used to inch the motor drive to within the capture range of the varactor diodes in the local oscillator and, having attained this condition, the varactor diodes then fine tune the local oscillator. The varactor diodes are held in the centre of their operating characteristic by the inching action of the secondary loop.

60. Fine tuning of the transmitter oscillator is accomplished on a separate sub-loop system where a portion of the local oscillator output is mixed with a portion of the transmitter oscillator output to produce a 'Transmitter IF' of 9.6875 MHz. This transmitter IF is fed to a discriminator centred on 9.6875 MHz with a bandwidth of approx 2 MHz whose output is applied via a summing amplifier to the varactor diodes in the transmitter VCO to give a fast 'pull in' facility to the oscillator. The transmitter IF is also fed as one input to a frequency and phase error detector, the second input to the detector being the 968.75 kHz output from the fixed divider in the synthesiser.

61. Any detected frequency error produces proportional d.c. correction voltage fed to varactor diodes in the transmitter oscillator tuned circuit to cause the frequency to change in the correct sense to remove the existing error. With frequency errors removed, phase relationships are compared and the varactor diode d.c. correction voltage is modified to remove any detected error.

62. Phase lock detector circuits monitor the phase error detector, and a Tx Lock (=1) signal is produced by Modulator Board 2b dependent upon four conditions. These are:

a. Presence of 9.6875 MHz transmitter IF.

b. Presence of 968.75 kHz reference frequency.

c. Presence of transmit 3 command.

d. No phase slip between a. and b.

63. Once tuning is completed the main loop system is continuously self-monitoring to phase-lock the local oscillator to the reference frequency. The transmitter fine tuning loop however is only operative when the transmit command is present (eg pressel operated).

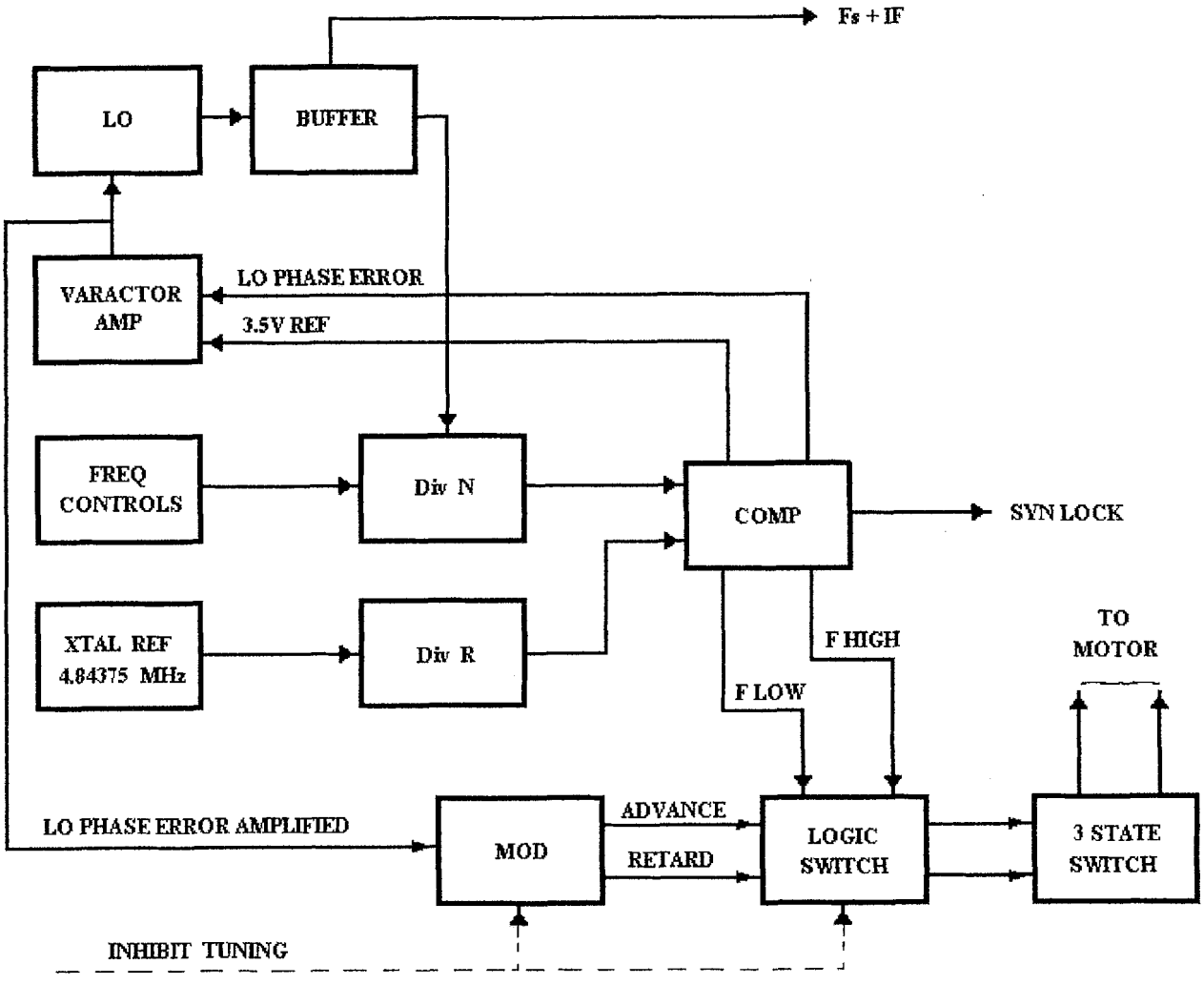


Fig 7. Complete Control Diagram RT353 Receiver

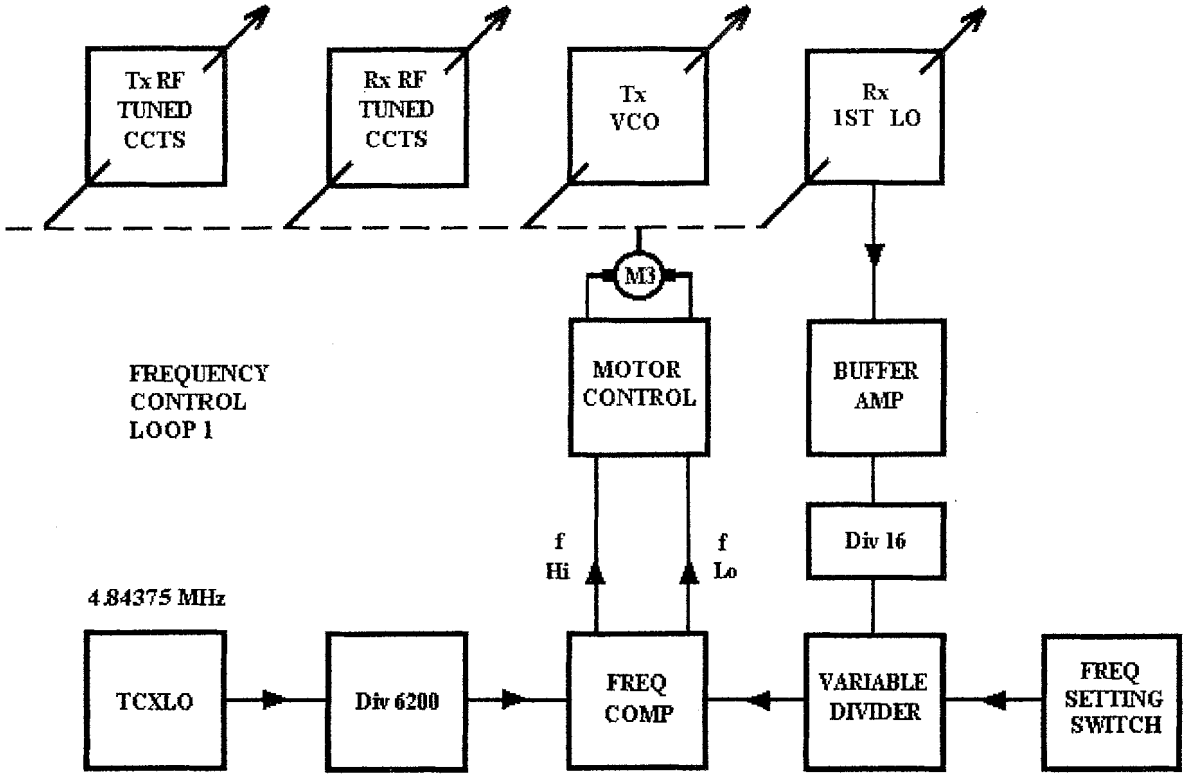


Fig 8. Coarse Tuning of Receiver Local Oscillator and all RF Tuned Circuits

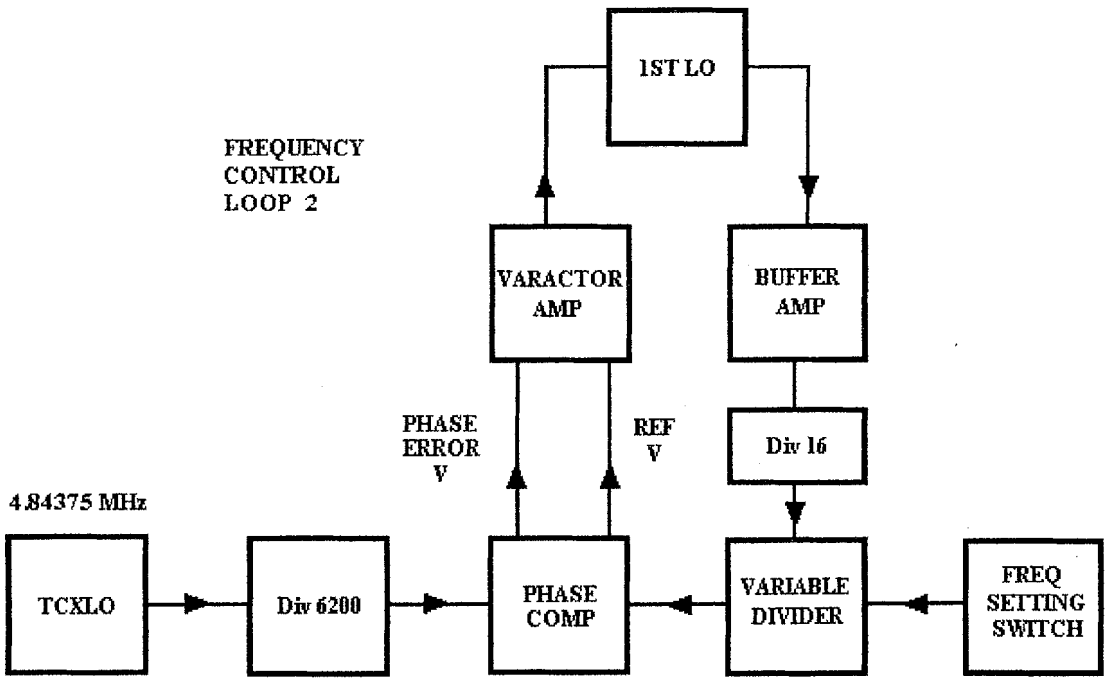


Fig 9. Fine Tuning of Receiver LO

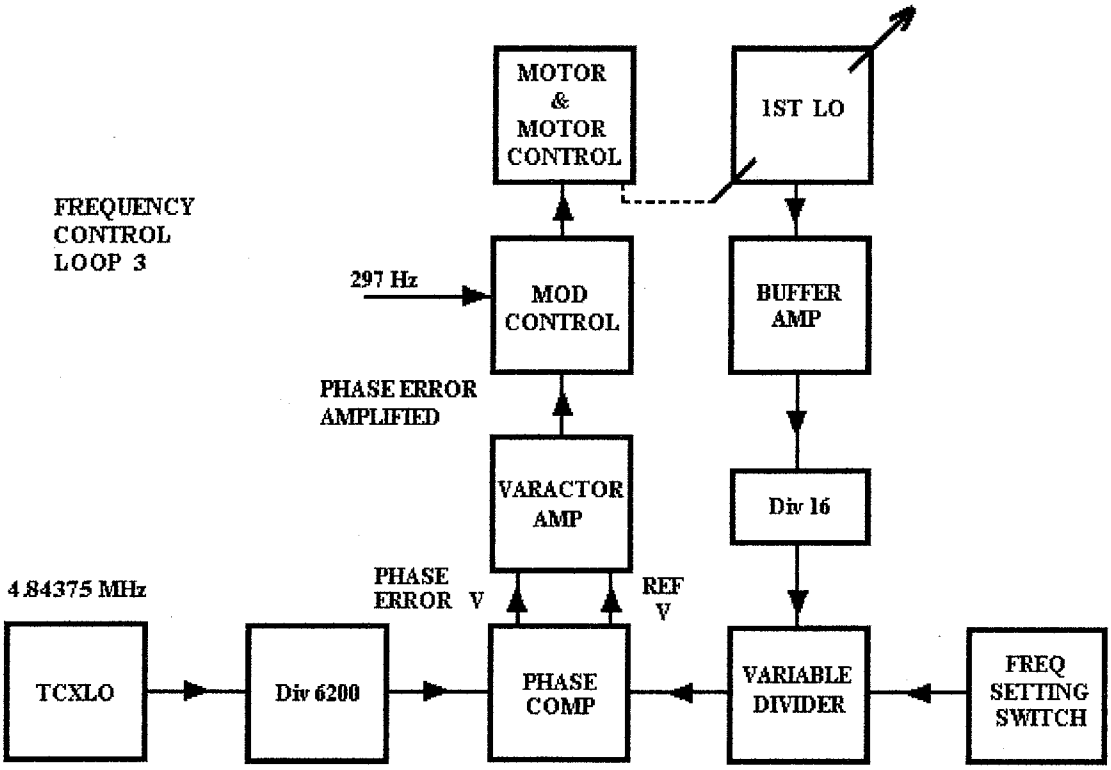


Fig 10. 'Inching' Action - Receiver LO

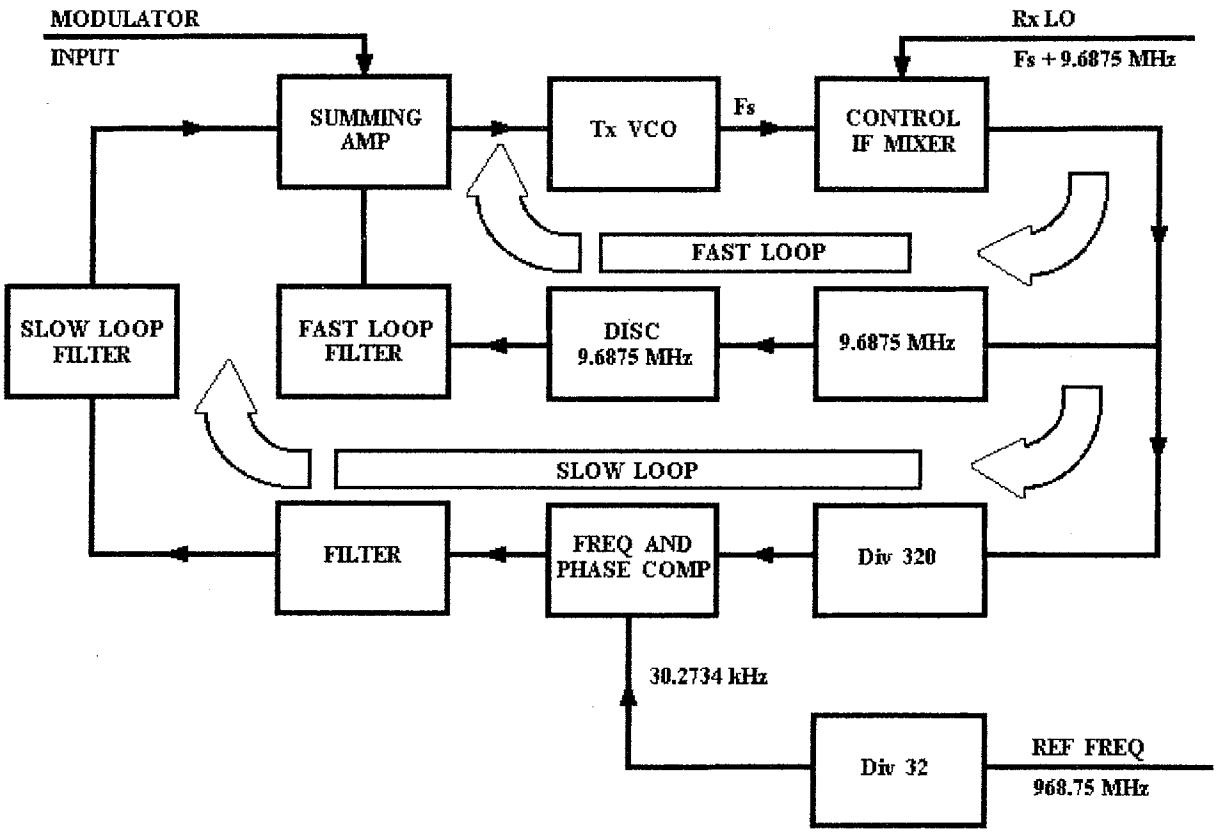


Fig 11. Tx AFC Block Diagram

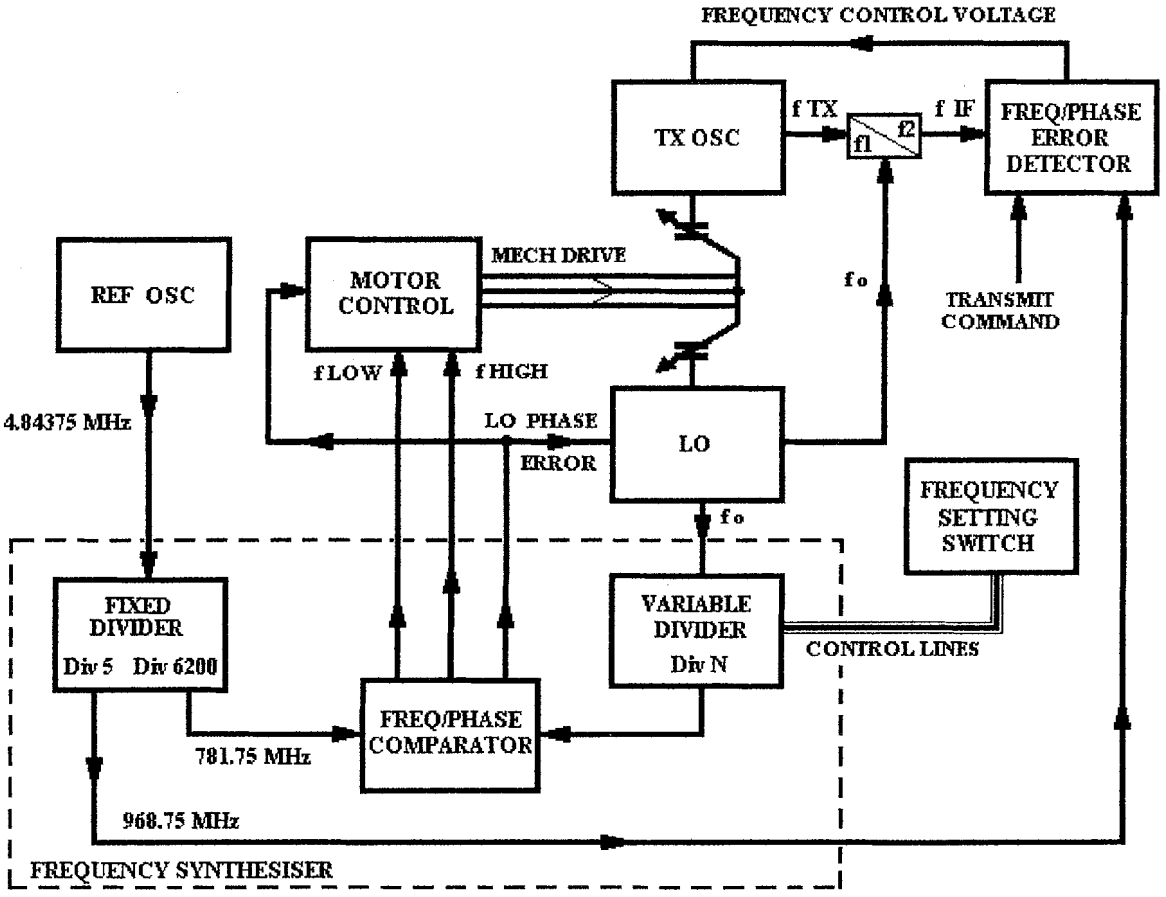


Fig 12. Frequency Control Block Diagram

RECEIVER

RF Amplifier

64. The received r.f. signal which also contains the 150 Hz Clansman recognition tone when NARROW or WIDE TONE modes are selected, is routed from the front panel ANT/TURF socket via the antenna change-over relay (de-energised) to the selected turret lid r.f. This turret lid contains a high selectivity double tuned r.f. tuned circuit. The output of the turret lid r.f. is fed to the grid of triode VI , which with transistor TR1 in cascode forms the first r.f. amplifier. This configuration is used because of its high gain, low noise characteristic, ie it introduces the gain of a pentode without its inherent noise.

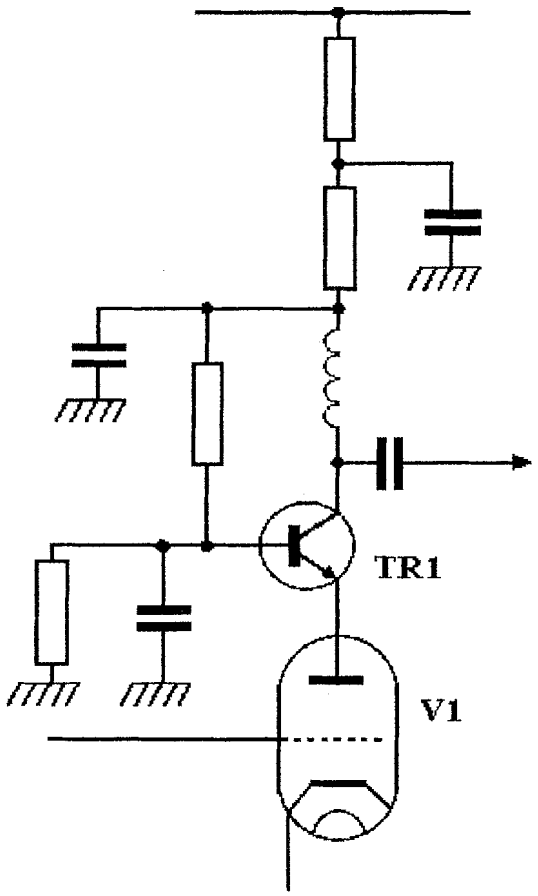


Fig 13. V1 with TR1 in cascode

65. The cathode of V1 is taken to the Front End Protection Unit, which provides a cathode current of LL 9mA, UL 11mA for normal signal operation. Under large signal conditions, the consequent increase in V2 cathode current is drawn from the bias control circuit up to a maximum of 5mA. Current drawn from this source results in the cathode voltage increasing in the range +7V to +38V, which reduces the gain of V1 proportionally. A bias voltage in the range -30V to +1V is also produced and applied to the anode of a PIN diode which is connected between the signal input line to V1 grid and the 0V line. Reception of an extremely high signal will cause the cathode voltage to exceed 37.9V, at which point the bias voltage to the PIN diode, having increasing from -30V has become positive, thereby forward biassing the diode, causing it to conduct and

shunt the received signal to OV. V1 and the subsequent stages are thus protected.

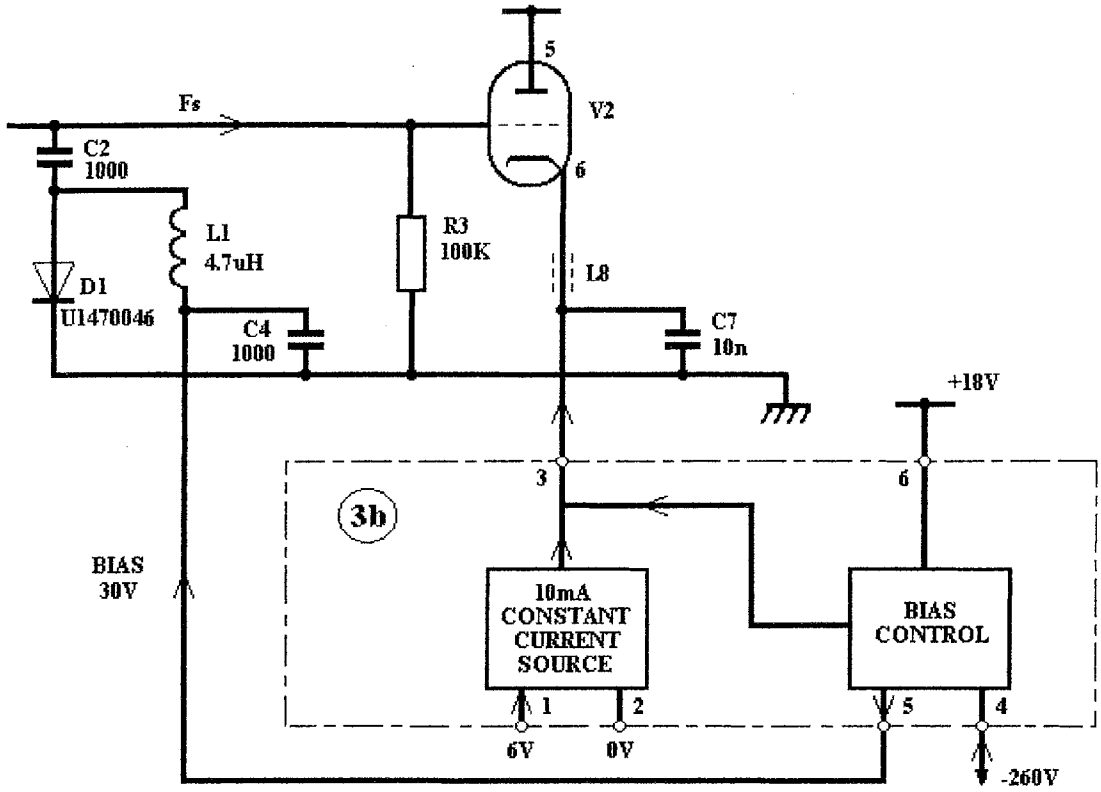


Fig 14. Front End Protection

66. The amplified output of V1/TR1 is fed to the selected turret lid bandpass which contains a high selectivity triple tuned r.f. tuned circuit and local oscillator tuned circuit. The total selectivity provided by the tuned circuits in the turret lids (r.f. + bandpass) is such that receipt of a signal whose frequency is more than +/-5% away from the frequency of the wanted signal is greater than 15 dB down on that signal. The output of the turret lid bandpass is fed to the grid of V2, a conventional triode r.f. amplifier. V2 output is fed as one input to the signal mixer.

67. Local Oscillator The local oscillator is a VHF Colpitts oscillator operating in the range 40 to 86 MHz, controlled by the frequency synthesis loop. The local oscillator output is fed to a buffer amplifier which matches the single input to three outputs. One output is used as the second input to the signal mixer, and the other two are used in the frequency synthesis loop. The local oscillator output is modulated by the 85 Hz tone generator on Control Board 2c for squelch operation. This tone is inhibited when the transmit (=1) is produced by control board 2c or when data working is selected (except when clear speech is commanded).

68. Signal Mixer The signal mixer is a balanced VHF mixer converting the two inputs (from the turret lid bandpass and the local oscillator) to a push pull output at the difference frequency of 9.6875 MHz. This frequency is fed to the Signal IF Output which is a balanced transformer tuned to a centre frequency of 9.6875 MHz.

IF Unit

69. The frequency modulated first IF at 9.6675 MHz is passed via relay contacts to one of two crystal filters, one for WIDE band (50 kHz channel spacing) and one for NARROW band (25 kHz channel spacing). The selectivity produced by these filters is such that frequencies outside the filter pass bands are greater than 80 dB down on the wanted signals.

70. Relay contacts select the appropriate filter output and pass it to an AGC controlled IF amplifier with a gain of greater than 100 dB. AGC is employed to prevent overloading the stage and prevent 'pulling' of the local oscillator frequency. The AGC voltage is also passed to the front panel test meter to give an arbitrary indication of the received signal strength. This meter indication also provides a useful aid to fault finding

71. The amplified IF output is fed to a balanced mixer stage where it is mixed with the output of a crystal controlled oscillator at 9.575 Mz to produce a second IF of 512.5 kHz. The second IF is then limited before being applied to a Round Travis type discriminator tuned to 312.5 kHz. The resulting demodulated output is passed via a buffer amplifier to the Audio Board 2d and the Control Board 2c.

72. For data working the IF output is routed to HARNESS Plug pin D via the MODE switch S2 for onward routing to the data equipment.

Audio/Tone Circuits

73. The demodulated output taken to control board 2c contains:

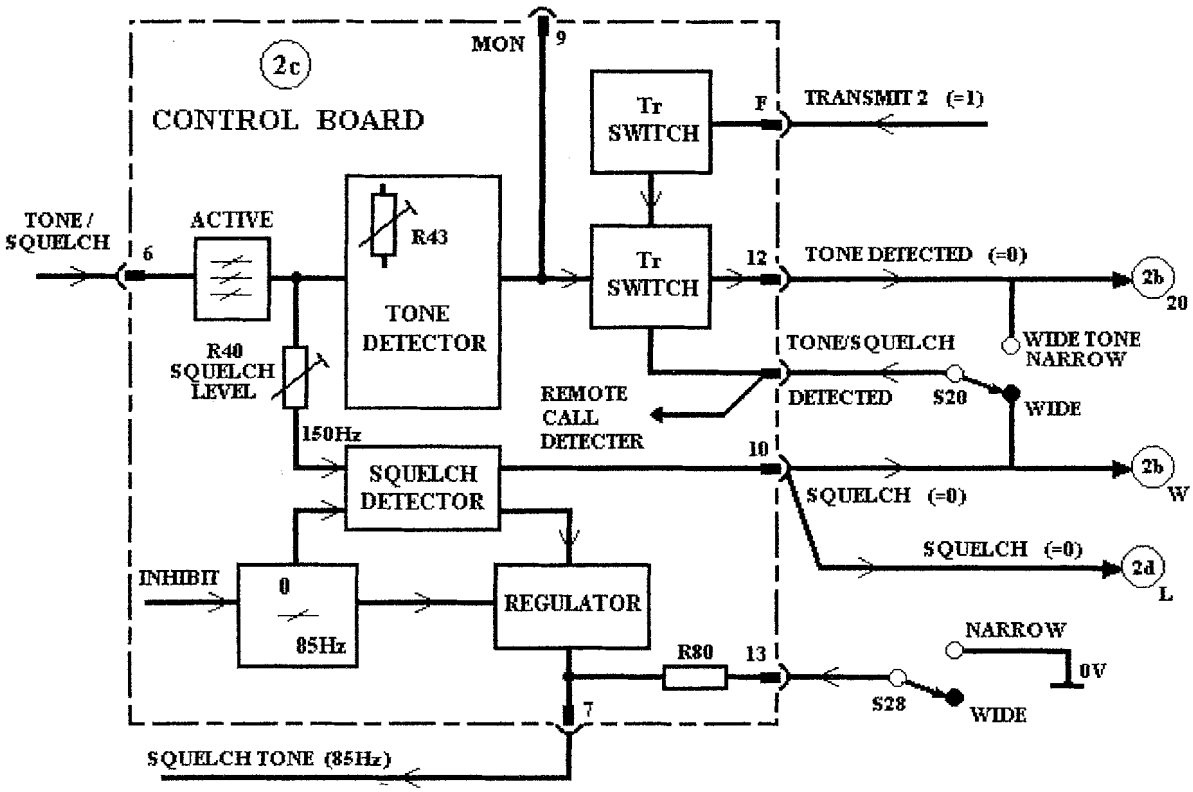


Fig 15. Squelch Tone Circuits

a. the 85 Hz squelch tone (except for data selections of MODE switch S2 when clear speech is not commanded).

b. the 150 Hz Clansman identification tone (except for WIDE and data selections of MODE switch S2 when clear speech is not commanded).

74. The input to Control Board 2c is passed through a high 'Q' active filter nominally tuned to 85 Hz but which will pass 150 Hz. The filter output is routed to both the squelch and tone detector circuits.

Squelch System (85 Hz)

75. The 85 Hz tone is generated by a three stage RC oscillator whose output is fed via a series regulator circuit to the first local oscillator. The 85 Hz oscillator is inhibited in the transmit condition and in data mode working.

76. The squelch tone on the demodulated signal is fed to the squelch detector which produces a squelch detected (=0) output. The squelch detected (=0) signal is fed:

a. to logic circuits on the audio board 2d to open the squelch gate.
b. to the modulator board 2b for data working
c. to the MODE switch S2 for auto working

77. The response of the first local oscillator for a given modulation level input is not linear with frequency. Therefore, if the output level of the 85 Hz tone generator were maintained at a constant level, the deviation produced at the local oscillator would vary from channel to channel throughout the frequency range. The output of the 85 Hz generator is therefore routed via a series regulator, the output level of which is controlled by the level of the 85 Hz on the demodulated signal, to maintain a constant deviation at the local oscillator of 1 kHz throughout the frequency range. Resistor R80 is included to reduce the output level of the 85 Hz tone generation when NARROW mode is selected.

Tone Detection (150 Hz)

78. The 150 Hz content of the high 'Q' filter output is fed to a full wave tone detector tuned to 150 Hz. The detector will respond to frequencies in the range 146 to 154 Hz. Detection of the 150 Hz tone switches on a transistor switch to give a tone detected (=0) output. In WIDE TONE and NARROW modes this logic 0 is fed back to the transistor switch to maintain it in the on condition. A transmit 3 (=1) signal switches on a second transistor switch which in turn switches on the transistor switch controlling the tone detected (=0) output, which is fed to the modulator board 2b together with the squelch detected (=0) output for data working.

79. The 85 Hz tone is always used to operate the squelch circuit, and the 150 Hz tone, when present, is always used for automatic rebroadcast working. When the set is in the WIDE mode there is no 150 Hz on the demodulated signal, therefore to permit automatic rebroadcast the 85 Hz squelch tone is utilised to simulate the tone detected (=0) output from the 150 Hz tone detector. The tone detected (=0) output is also routed to the remote current detectors for auto working.

Audio Routing to Phones

80. The demodulated output from the IF buffer amplifier is passed through, a 150 Hz band stop filter before dividing into two paths:

a. the received audio path.

b. the sidetone path.

The received audio enters the unity gain amplifier ML3b (see technical notes para 44) the signal path of which is controlled by the squelch detected (=0) output from the 85 Hz tone detector, the alarm flash generator, TEST Switch S4 and the transmit 1 line. With the alarm flash generator in the quiescent (non-alarm) condition a logic 1 is placed on the 3 input NAND gate. 'Gate Control 2' which together with the logic 0 from the squelch detector and logic 1 from the TEST switch S4 wafer CF (when not switched to OVERRIDE) places a logic 1 on the negated inhibiting input of unity gain amplifier ML3b. The normal inhibiting input of ML3b is connected to the transmit 1 line which when the set is in the receive condition is at logic 0. ML3b is thus opened allowing the received audio to pass through. After passing through a 300 Hz to 3 kHz audio filter (also shared by the transmitted audio path),the signal is fed to unity gain amplifier ML4a, whose normal inhibiting input is connected to the transmit 1 line (logic 0 in receive condition), and negated inhibiting input is permanently connected to logic 1, and is thus opened, allowing the signal to pass through. The signal is amplified by the audio output amplifier and passed to the audio output transformer 2T1, and to the remote transformer 2T2 whenever relay RLA is energised by the 'speak to remote' command from control board 2c. The output of transformer 2T1 is fed directly to the HARNESS plug pins D and E for all analogue settings of MODE switch S2, and to the AUDIO connector via the gain control. The output of remote transformer 2T2 is routed directly to the REMOTE terminals SK5 and SK6.

81. When in the transmit condition, due to the 85 Hz tone being inhibited, the squelch gate ML3b cannot open. If it were opened the sidetone would mix with the transmitted audio in the 300 Hz to 3kHz filter causing distortion. To allow the sidetone through to the receiver phones, unity gain amplifier ML4b is opened by the transmit 1 (=1) line thereby isolating the sidetone from the transmitted audio.

TRANSMITTER
MODULATION ROUTING

82. In the analogue mode the microphone input is pre-amplified on assembly (1d) before being applied to a gain control. This control is mechanically linked to the receiver audio output gain control such that increasing the microphone gain decreases the receiver audio gain and vice-versa, preventing unwanted feedback and providing a whisper facility. The gain control output is routed to a buffer amplifier on Audio Board 2d.

83. The harness/remote microphone inputs are not subject to gain control and are routed via remote transformer 2T2 and relay contacts on 2d before being applied to the buffer amplifier.

84. The buffer amplifier output is routed to a constant voltage amplifier (CVA) functioning as a peak noise limiter acting in an AMC circuit without detracting from the modulating characteristics of the audio signal.

85. The CVA output is routed via 2d ML3a (open in transmit condition) to an active audio filter which is shared with the received audio, the filter output being passed to Modulator Board 2b . The 150Hz identification tone is routed from Tuning Board (2a) to Modulator Board (2b). For WIDE selections of MODE switch 1aS2 the 150Hz tone is inhibited.

86. In Data mode working the data input is fed directly to the Modulator Board (2b) by-passing circuits so far mentioned. The 150Hz tone is inhibited for data working.

87. For Narrow selections of MODE switch (la)S2, the modulating inputs to (2b) (analogue/data/tone) are routed via a 1k ohm resistor to a summing amplifier to provide the required 5kHz deviation. For WIDE selections, a second 1k ohm resistor is switched in parallel to effectively double the current and hence produce 10kHz deviation. The dc oscillator control voltage from the frequency synthesis loop is added to the modulating signals in the summing amplifier to produce a composite output which is routed to the Transmitter (4).

TRANSMITTER MODULATION

88. The transmitter oscillator has a separate voltage controlled oscillator for each frequency band, located in the turret lids. Each oscillator is a common emitter astable multivibrator giving an output of approximately 50V peak to peak. The oscillators, pre-set by external capacitor C1, are tuned to the selected frequency by the frequency synthesiser loop, varactor diodes being used for fine frequency control. The 28V supply to the oscillators is routed via transistor switches on Control Board 2c, controlled by the transmit 3 (= 1) command. Modulation is achieved by routing the summing amplifier output via a varactor amplifier to varactor diodes which form part of the voltage controlled oscillators.

PA ON COMMAND

89. The PA On (= 1) command from the Control Board 2c is a safety control to prevent the transmitter being switched on under certain circumstances. It is produced subject to the following inputs being present at Control Board 2c.

a. Tx lock (= 1) - transmitter frequency synthesiser loop locked

b. ARFAT temp (= 1) - no overheat of ARFAT.

c. Temp (=1) - transmitter temp within limits

d. Synth lock (=1) - frequency synthesis loop coarse tuning complete

90. If one or more of the above inputs changes to logic 0 (fault) the PA On (=1) command is not produced, thus inhibiting the transmitter. Conditions b and c may be overridden by setting TEST switch S4 to OVERRIDE, should an emergency occur and the transmitter must be used.

91. The PA On condition can be stated most concisely by using the BOOLEAN EQUATION:

PA On = Synth lock. Tx lock (Temp.ARFAT Temp + O/R)
ie PA On = Synth lock AND Tx lock AND Temp AND ARFAT Temp

OR

PA On = Synth lock AND Tx lock AND O/R

92. The PA On (=1) is applied as one input to a two input NAND gate, the other input being from a 30 sec delay circuit. 30 sec after switching on the equipment, the delay circuit provides an output (=1). This is a safety device to allow sufficient warm up time for the PA. With both inputs present the NAND gate activates the lamp and relay drive circuits and enables the bias control circuits.

POWER AMPLIFIER

93. The Power Amplifier consists of a power tetrode output valve. The PA cathode current flows through a combination of resistors on Control Board (4d) selected by the POWER switch S5. The effective resistance for each switch setting is as follows:

a. Min - 820 ohms
b. 1W - 186 ohms
c. 15W - 44 ohms
d. 5OW - 19 ohms

94. A constant voltage loop acts to maintain the PA cathode potential at 3.1V wrt 0V by adjusting the grid bias within the range -20V to -260V as the cathode current is adjusted by POWER switch selection. The power delivered by the PA is directly proportional to its cathode current, thus the POWER switch controls the rf power output. The Tx o/p position of TEST switch S4 gives an indication of cathode potential. As the cathode potential is maintained at 3.1V, the front panel test meter will indicate centre scale on all four ranges for correct power outputs.
Should the antenna become open or short circuit, the constant voltage loop biasses the power amplifier hard back to protect it and its associated circuitry.

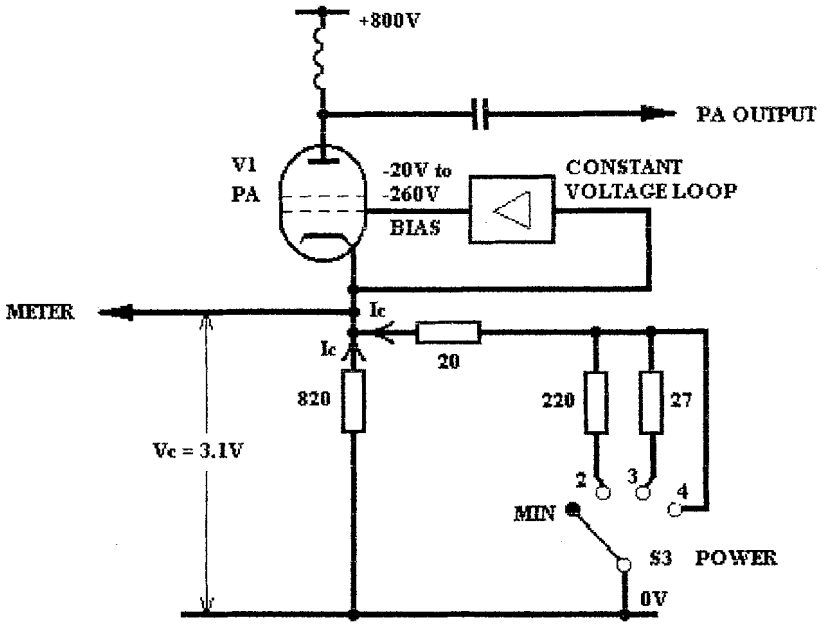


Fig 16. PA Bias

95. The power output is fed to a harmonic filter located on the end plate assembly (4e), there being one filter per band. Each filter passes frequencies in the selected band with an attenuation of less than 0.5dB, whilst for harmonics of these frequencies the attenuation is greater than 30dB.

PA OUTPUT

96. The output of the selected harmonic filter is routed via the antenna change over relay contacts to the ANT/TURF connector on the front panel.

97. True sidetone is achieved by leakage across the contacts of the antenna change over relay into the receiver circuits. The sidelong path on Audio Board 2d is via unity gain amplifier ML4b to the audio output amplifier, by-passing the squelch unity gain amplifier ML3b.

TRANSMIT COMMANDS

98. Presence of either pressel 1 (= 0) or pressel 2 (= 0) command from the front panel audio sockets will produce a transmit (= 1) command from Control Board 2c when REMOTE switch (S6) is set to LOCAL. A current of 8-11mA drawn from either the harness microphone lines or the remote terminals produces the same transmit (= 1) command for REM or AUTO selections. This transmit (= 1) command is also used to inhibit the 85Hz squelch tone.

99. The transmit (= 1) output from Control Board 2c is fed:

a. to Audio Board 2d:

(1) to enable the Tx af unity gain amplifier ML3a and the sidetone unity gain amplifier ML4b.
(2) to inhibit the squelch unity gain amplifier ML3b, and the Rx af unity gain amplifier ML4a.

b. to Tuner Control Board (1j) (designated transmit 2).

100. Provided the TUAAM/TN402 is not tuning, the transmit 2 command is routed via relay contacts on Control Board (1j) to:

a. Modulator Board 2b to enable the transmitter frequency synthesis fine tuning loop.
b. Control Board 2c for control of the tone detector circuits.
c. The Transmitter Unit (4) to enable the transmitter oscillator.

101. The transmit 2 command is inhibited in the FANS OFF position of TEST switch S4 to prevent transmission under radio silence conditions.

102. During SILENT TUNE of the TUAAM/TN402, 0V is fed to the Audio Board 2d (along the transmit 2 line) to inhibit the Tx at unity gain amplifier ML3a, thus ensuring that the high power rf output into the TUAAM/TN402 is not modulated under radio silence conditions.

103. For data selections of MODE switch S2 the transmit command originates from the data equipment and performs the same functions as already described for the transmit 2 command. The audio routine is held permanently in the receive condition as the data input by-passes the Audio Board.

REMOTE SWITCH CONTROL FUNCTIONS

104. For analogue selections of MODE switch S2, Control Board 2c produces control logic outputs according to the settings of REMOTE switch S6.

105. Local For LOCAL setting of the REMOTE switch it is required that full control of the equipment is with the local operator only. The 'speech to remote' relay 2dRLA is energised allowing a remote operator to monitor traffic. The remote transformer 2T2 output is connected to the HARNESS plug via the MODE switch S2 allowing any harness operator to monitor traffic. Depressing either the harness or remote pressels produces no change in the logic outputs from Control Board 2c, and control of the equipment remains solely with the local operator.

106. Remote For REM selection of the REMOTE switch it is required that both local and remote/harness operators shall have control of the equipment. Depressing either local pressel puts the equipment to transmit without de-energising relay 2dRLA, thereby maintaining the remote monitor facility. Depressing either the harness or remote pressels draws a current of 8-11mA via the remote transformer 2T2 through the current detector. This results in a send command from Control Board 2c logic circuits, putting the equipment to transmit. Relay 2dRLA is de-energised allowing the audio from the harness/ remote microphone to be fed to the modulator via the remote transformer 2T2, contact 2dRLA-1 (de-energised), the CVA, unity gain amplifier ML3a and the 300Hz to 3kHz filter. Control of the equipment is now with the harness/remote operator as well as the local operator.(The local operator, however, has priority)

107. Auto For AUTO selection of the REMOTE switch it is required that the equipment forms part of an automatic rebroadcast link. In this role it must fulfil two functions:

a. To receive a signal via the antenna and to pass the resulting audio to modulate another equipment connected to the harness plug/remote

terminals, and to put that equipment in the transmit condition so that the signal is rebroadcast.

b. To receive audio via the harness/remote lines and route that audio to modulate the transmitter, and to rebroadcast the information in answer to a send command received from the harness/remote lines .

Setting S6 to AUTO places the set on receive, energises relay 2dRLA, and selects the current detector on Control Board 2c. Reception of a signal containing the 150Hz identification tone in WIDE TONE or NARROW selections of MODE switch S2, or detection of the 85Hz squelch tone in WIDE selections introduces the 10mA load on Control Board 2c. This load is connected via remote transformer 2T2 and the remote terminals/harness plug to the current detector of the set connected to the remote/harness terminals. The 8-11mA drawn from that current detector puts the remote/harness equipment in the transmit condition.

108. Relay 2dRLA routes the received audio to the equipment connected to the remote terminals/harness plug via remote transformer 2T2. With the link working in the reverse direction the roles of the local set and the remote set are reversed. Each operator can monitor the traffic through the auto-rebro link.

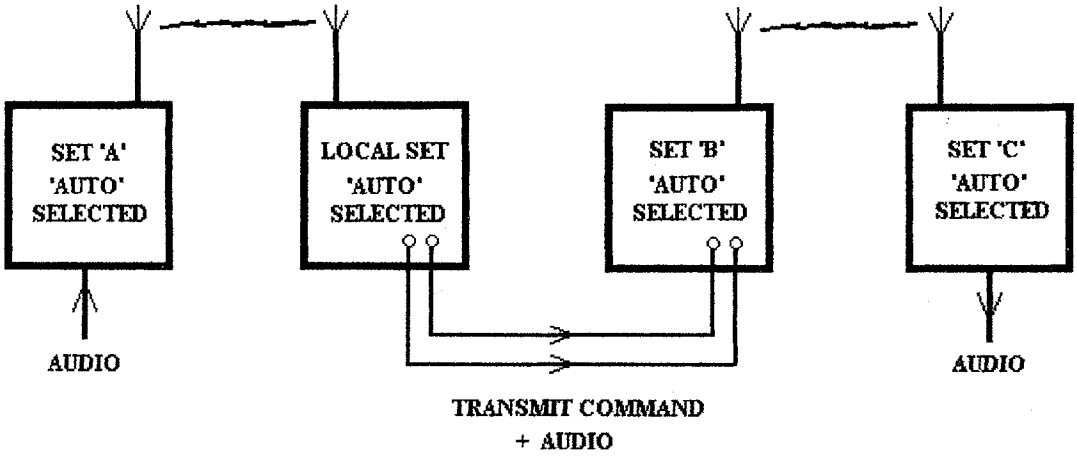


Fig 17. Auto Rebro Link

109. Break In For BK-IN selection of the REMOTE switch it is required that the local operator acts in a supervisory capacity during automatic rebroadcast working. To achieve this he must perform three functions:

a. Inhibit the rebroadcast link
b. Receive from both ends of the link
c. Transmit to both ends of the link.

110. Setting S6 to BK-IN places the set on receive, de-energises relay 2dRLA, introduces the current detector on Control Board 2c and places a BK-IN logic command (= 0) on to audio board 2d. Relay 2dRLA being de-energised prevents any audio being routed to the remote plug/harness terminals, and the tone/squelch detected (= 0) does not connect the 10mA load in Control Board 2c resulting in no current being drawn from the remote/harness current detectors. The auto-rebro link is thus inhibited in one direction. Upon receipt of a send command from the remote/harness 10mA load, Control Board 2c does not produce a logic command to put the local set to transmit, thus the auto-rebro link is inhibited in the reverse direction.

111. The local operator is able to monitor his own received signals by normal receiver action.To monitor signals from the remote set the BK-IN logic command (= 0) to the Audio Board 2d is used to open unity gain amplifier ML3a, the Tx af gate. ML3a is normally closed in the receive condition, but the signal from the harness plug/remote lines is now routed via ML3a, ML4a and the audio output amplifier to the local phones. Depressing either local pressel produces logic send command from Control Board 2c, placing the local set to transmit. The 10mA load on Control Board 2c is also switched in and relay 2dRLA is energised putting the remote set to transmit and routing the transmitted audio to it.

112. Intercommunication (IC) For IC selection of REMOTE switch S6 it is required that the local operator shall be able to communicate with the harness/ remote operator without rf transmission.

113. Setting S6 to IC places the set on receive, de-energises relay 2dRLA, connects the current detector on Control Board 2c and places an intercom logic command (= 0) on Audio Board 2d.

114. The intercom logic command (= 0) to Audio Board 2d opens unity gain amplifier ML3a in the same manner as did the BK-IN logic command. The local operator can now hear the remote operator via the remote transformer 2T2, 2dRLA (de-energised), ML3a, ML4a and the audio output amplifier. Any audio from a received rf signal at the antenna will also be heard by the local operator when switched to IC.

115. Depressing either local pressel energises relay 2dRLA without putting the set to transmit. Audio from the local operator is now fed via ML3a, ML4a, audio output amplifier, relay contact 2dRLA-1 (energised), and remote transformer 2T2 to the remote/harness phones.

116. Call For CALL selection of the REMOTE switch it is required that the local operator shall be able to gain the attention of the remote/harness operator by producing an audible tone in the remote/harness headset. Similarly the remote/harness operator must be able to call the local operator.

117. Setting S6 to CALL places the set on receive, energises relay 2dRLA, and connects the current detector on Control Board 2c. Wafer AF of switch S6 draws more than 15mA from the current detector circuit which produces a call (= 0) to the control logic circuits and to Tuning Board 2a, where it is inverted to enable a 2-input NAND gate. The 2kHz call tone is derived from the temperature controlled crystal oscillator after which it is divided down and fed as the other input to the 2-input NAND gate. After passing through the NAND gate the call tone is fed to the audio output amplifier from where it is routed to the harness/remote phones via relay contact 2dRL-1 (energised) and the remote transformer 2T2. In all positions of S6 except CALL, if the remote/harness operator depresses his CALL switch, he places a load of 10 ohms or less across the remote terminals/harness plug, thereby drawing a current of more than 15mA from the current detector on Control Board 2c. The call is then generated in the same manner as for local operation of switch S6.

TEMPERATURE SENSOR (4k)

118. The control input to the series limiter in the blower supply line is produced by a temperature sender located in the transmitter. A positive temperature coefficient (PTC) resistor (TH1) located in the transmitter heat transfer wall is used to control the bias of a transistor amplifier such that for temperatures of below 60 C the blowers are inhibited, and for temperatures above 70 C they are switched on. The control output is routed to the series limiter in all but FANS OFF and OVERRIDE positions of TEST switch S4. In the FANS OFF position the blowers are permanently inhibited, and in the OVERRIDE position switch S4 provides a 0V input to turn the motors on.

119. A second PTC resistor (TH2) is also located in the transmitter heat transfer wall. For temperatures above 95 C TH2 inhibits the transmitter by routing 0V to the alarm flash circuit. In this condition, with TEST switch S4 set to TEMP the front panel test meter (1aME1) will read 'hard left' in the red sector. The transmitter inhibit may be overridden in emergencies by setting S4 to OVERRIDE.

CONTROL OF TUAAM/TN402

120. Information passed by the set to the TUAAM/TN402 via the front panel TURF connector (1aSK3) is:

a. +28V d.c. at pin 3 (except for OFF and TUNE positions of POWER switch S3).
b. 0V at pin P.
c. Silent tune (0V) at pin 0 (when POWER switch S3 is set to 'O').

121. Information received by the set from the TUAAM/'TN402 via the front panel TURF connector (1aSK3) is:

a. Tuner key line (0V) at pin M (during TUAAM/TN402 tune sequence).
b. ARFAT temp (=1) at pin L.

122. Setting the POWER switch S3 to the spring loaded TUNE position breaks the 28V supply at pin S of the TURF connector and starts the tune sequence. After breaking this 28V supply to the tuner, it's re-connection by returning S3 to any position except OFF, produces a 0V on the tuner keyline (pin M) which is fed to the tuner control board (1j) energising relay 1jRL1. Relay contact RL1-2 places a permanent logic 1 (=transmit) on the transmit 3 line, and contact RL1-1 bypasses the POWER swith S3 and places 0V directly on to the power 4 line. Contact RL1-2 thus puts the set to transmit, and contact RL1-1 switches the PA to power 4 (50W nominal output).

123. In the 'O' posistion of POWER switch S3, 0V is placed on the silent tune line (pin 0) which switches in a dummy load in the TUAAM/TK402, thus ensuring that no r.f. power is irradiated from the antenna during the tune sequence when radio silence is required.

124. When the tuning sequence is completed the 0V is removed from the tuner keyline (pin M) de-energising relay 1jRL1 and putting the set back to receive.

125. Normal transmit will be inhibited as long as POWER switch S3 remains in the 'O' (silent tune) position.

126. Should the 50 ohms 10 dB attenuator in the ARFAT become too hot during the tuning sequence the logic 1 at TURF connector 1aSK3 pin L changes to logic O, inhibiting the transmitter. In this condition, with TEST switch set to TURF, the front panel test meter (1aME1) will read 'hard left' in the red sector. The transmitter inhibit may be overridden in emergencies by setting S4 to OVERRIDE.

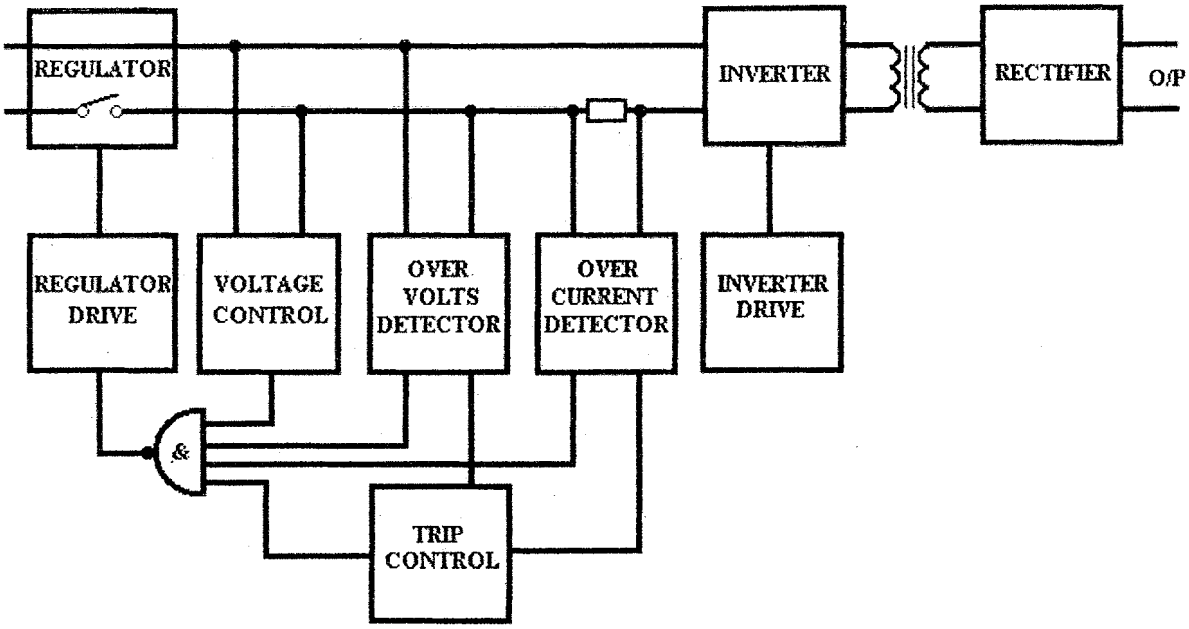


Fig 18. Power Supply Unit Block Diagram

127. The power supply unit is fundamentally a DC to DC converter controlled by a square wave switching regulator. Control loops operate on the regulator and converter to ensure adequate overload and over-voltage protection.

128. The voltage supply to the equipment, +24V nominaly is applied at (1a)PL1 from where it is passed via supply filter (1e) to Meter Control Board (1b). The negative line is also routed directly to (7g)X2 and the positive line to (1a)RLA1.

129. The Meter Control Board (1b) has a resistive network incorporating variable component (1b)R1 which enables the front panel test meter (1a)ME1 to be centred when the input voltage is at +24V d.c. (TEST switch S4 to 28V supply).

130. The positive line connection into (1b) is routed via (1b)D1 to Power Relay RLA. In the event of a reverse polarity supply connection into (1b), D1 prevents (1a)RLA from energising. The negative supply to (1a)RLA is routed via (1a)THT (closed for temperatures LT 85 C) and wafer AF of POWER Switch S3. (1a)RLA will energise for correct polarity supplies in the range 21-33V d.c. at all temperatures below 85 C when S3 is in any position except OFF. With (1a)RLA energised, contact RLA1 connects the positive polarity input line to (7g)X1. Both input lines are isolated from the chassis.

131. The wide range of input voltage levels over which the power supply unit is expected to perform to specification presents different impedances at X1 and X2. To compensate for this an impedance correction network comprising R1 and C5 is incorporated.

132. Voltage Control The negative polarity input at X2 is fed to a series regulator switch (7TR1) which switches on and off at a nominal 32 kHz, controlled by the regulator drive (7TR2), one input of a four input NAND gate (ML6a), a D-type bistable (ML2b) and a clock pulse generator used as the clock input to ML2b. (7g)D2 provides reverse spike protection for (7)TR1 when it is switching rapidly. The output of the series regulator is sampled and fed via a SET VOLTS variable resistor to a voltage comparator, the reference voltage input of which is derived from zener diodes. With the series regulator open, the sampled voltage to the comparator falls below that of the reference resulting in an output from the comparator (=1) being fed to a one input of NAND gate (ML6b), inverted and fed as the clear (=0) input to ML2b. The resulting logic 1 at ML2b (NOT Q) output is fed as one input to the four input NAND gate ML6, whose output (=0) is fed to the regulator drive to close the series regulator switch (7TR1). With 7TR1 closed, the sampled voltage output rises above that of the reference input, thereby removing the clear input to ML2b. On the next clock pulse input to ML2b the Q output changes to logic 0 and is fed to ML6a. The resulting logic 1 from ML6a ia fed to the regulator drive opening the series regulator, allowing the sampled voltage to fall and the cycle to repeat itself. A tendency for the sampled voltage to fall acts via the loop to increase the regulator ON time, and a tendency for the sampled voltage to rise increases the regulator OFF time. The regulator is self starting upon application of voltage at X1 and X2.

133. Over Volts If, due to a fault condition, the sampled voltage rises to 22.5V, an over-volt detector circuit produces a logic output to ML6a and the resulting logic 1 output from ML6a holds the series regulator off. The time for which the logic 0 is applied to ML6a is integrated in a trip time integrator, and should this be greater than 4 mS a pulse is applied to a thyristor (SCR) which places a logic 0 output to ML6a to hold the series regulator off. Once 'fired', the thyristor can only be reset by switching off the input supply (POWER switch to OFF).

134. Over Current The maximum available current drawn from the power supply unit is controlled by monitoring the output of a tunnel diode oscillator which is in series with the main current path. A tunnel diode is used as it displays a negative resistance over part of its operating characteristic. When the device is operated over this portion of the curve it can be used to enable an oscillator. The frequency of the oscillator is approximately 1 MHz, but it will only oscillate when the current instantaneously exceeds the trip level (16.5A approximately). This will normally occur at least once during each 32 uSec period due to switching transients. Hence the output in any one clock period of 32 uSec, consisting of a number of 1 uSec wide pulses, is fed into a counting circuit via an inverting gate ML3a. The counting circuit is set to ignore this spurious pulse. The counting circuit (ML4, ML5a) is cleared every 32 uSec by the clock pulse generator, and should ML3a provide more than 7 pulses in any one 32 uSec period the trip cycle is initiated.

135. When an overload current is drawn from the power supply supply unit:

a. The tunnel diode pulse generator feeds negative going pulses of approximately 1 MHz to ML3a, where they are inverted and fed to the div/8 counting circuit ML4, ML5a.

b. ML5a output is used as the clock input to a J-K bistable ML5b which clocks through both logic 1 and logic 0 permanently at its inputs.

c. The not Q output of ML5b changes to logic O, which is fed as one input to the four input NAND gate ML6a to switch off the series regulating switch 7TR1 for the remainder of the 32 uSec period.

d. The Q output of ML5b changes to logic 1 and is fed as one input to a two input NAND gate ML5b, thus enabling the gate.

e. A series of pulses from the div/4 counter ML4 is fed as the other input to ML3b. Under overload conditions, the prf of these pulses is high enough (approximately 250 kHz) for them to be considered as a permanent logic 1.

f. The resultant logic 0 output from ML3b triggers a recovery delay circuit the output of which changes to logic 0 and climbs back up to logic 1 after approximately10 uSec, thereby inhibiting the two input NAND gate ML3c for this period of time. With ML3c inhibited, no reset pulse from the clock pulse generator can reach the J-K bistable ML5a, via ML3c, ML3d. Thus, should a fault condition occur within 10 uSec before a reset pulse, this pulse will be ignored and the bistable will not reset until the next pulse, (32 uSec later).This circuit is incorporated to ensure that the protection circuit is not reset too rapidly after a fault condition occurs.

g. Upon receipt of the clear (=0) pulse, the Q output of ML5b returns to 0, inhibiting ML3b.

136. Should the fault condition be permanent, and not just a transient, ML3b output is permanently held at logic 0 and the output of the recovery delay circuit is never permitted to climb back up to logic 1, thereby permanently inhibiting ML3c. The logic 0 at the not Q output of ML5b is fed to the trip time integrator which then operates in the same manner as during the over volts fault condition. Once again, should the thyristor be 'fired', it can only be reset by switching off the input supply and switching it back on.

137. The stabilised 18V is fed to an inverter operating at 5.33 kHz, the inverter frequency being derived from the clock pulse generator and the div/6 circuit ML1. The inverter output is fed to a power transformer, rectified and smoothed to provide the requisite voltages for the radio. Additional voltage stabilisation is provided for the synthesiser supply.

CONTROL OF EQUIPMENT IN DATA MODE

138. For data selections of MODE switch S2, control of the transmit/receive function of the equipment is performed by the data equipment connected at HARNESS plug 1aPL2.

DATA RECEPTION

139. When receiving data:

a. the demodulated output from the IF Unit (5) is fed via the MODE switch S2 to the HARNESS plug pin D, by-passing the receiver audio circuits. Various inputs are combined on the Modulator Board 2b, producing an output to the HARNESS plug pin E to control the data equipment. These inputs are:

(1) Tone detected (= 0) from Control Board 2c
(2) Squelch detected (= 0) from Control Board 2c
(3) Signal strength from the mixer and AGC detector in the IF Unit (5).

b. It is required that the 85Hz squelch tone is inhibited. This is achieved by the MODE switch S2 feeding 0V to the modulator board 2b when set to either DATA selection thus enabling the control logic circuits. As long as the transmit clear speech (= 1) command is not received from the data equipment, Modulator Board 2b feeds a logic 0 to the Control Board 2c as the Inhibit Squelch command. If a "Transmit Clear Speech" command is received from the data equipment, the Inhibit Squelch command reverts to logic 1 and the squelch tone is restored.

DATA TRANSMISSION

140. When transmitting data, the 'Tx data' command at the input to the HARNESS plug 1aPL2 performs the same function as the transmit 2 command for analogue selections. As the data input by-passes the audio board the transmit 1 function is not required to control the audio routing and is therefore taken to 0V for both DATA selections of MODE switch S2.

141. The data input at HARNESS plug 1aPL2 is routed via MODE switch S2 to the Modulator Board 2b, where it passes through the data level potentiometer and the current doubler circuit to the summing amplifier for transmitter modulation. The data mode (= 0) input to Modulator Board 2b is used to inhibit unity gain amplifier ML3a thus preventing any audio from either front panel AUDIO socket modulating the transmitter.

142. When transmitting data it is required that the 150Hz tone is inhibited. This is achieved by the data mode (= 0) input to Modulator Board 2b being passed to the logic gating circuits. Provided the transmit clear speech (= 1) command is not received from the data equipment, the resulting logic 0 (tone off) output from Modulator Board 2b inhibits the 150Hz tone. The 150Hz tone is also inhibited in the WIDE selection of MODE switch S2 by a wide mode (= 0) input to the Modulator Board 2b.

143. Associated Literature

EMER Tels H610 - 619 Clansman Radio UK/VRC 353
EMER Tels L210 - 219 Clansman VHF Antenna Systems

144. Army Code Number

61393	User Handbook for Radio Station UK/VRC 353
61388	User Handbook for VHF Antennae for Clansman
61172	User Handbook for Clansman Radio Control Harness

User Handbook for Test Set Audio, Radio Audio Accessories

User Handbook for Adaptor, Telegraph, Radio

CLANSMAN RADIO CONTROLLED HARNESS SYSTEM

INTRODUCTION

The Clansman Radio Control Harness is a system of active and passive electronic units, connectors and ancillary audio gear designed to interconnect crew positions with the installed radios in vehicle installations.
The Radio Control Harness can be fitted to provide for one, two or three radio installation, depending on the operational role of the vehicle.

CLIMATIC DURABILITY CHARACTERISTICS

Clansman Radio Control Harness has been produced to meet all the requirements of Class L3 of DBF 133 and is thus classified as Ground Equipment (exposed and immersible unpacked).
It is capable of continuous operation between ambient temperatures of -40 C to +52 C (plus solar radiation to give a case temperature of +75 C) under conditions of heavy driving rain, salt spray, driving dust and sand.
It is also capable of operation in 95 - 100% humidity with temperatures not normally exceeding 30 C.
The equipment will withstand rough treatment, including operational shocks when installed in vehicles travelling over rough ground, and in armoured vehicles due to impact of non-penetrating shells on the vehicles' armour.
The equipment will withstand immersion in up to 5 ft of water for at least two hours and is immune to corrosion from acids and alkalies.
Operation is unaffected by severe comamination by fuel oils, hydraulic and lubricating fluids.
Storage can be for long periods of tropical conditions in a trade pack.
Normal storage should be held within the range of -40 C to +60 C.
Normal vehicle supply (ie nominal 28V) is used to power the Clansman Radio Control Harness, and it will withstand variations in supply of 21V to 33V with switching surges and pulses without malfunction. It is electromagnetically compatible with vehicular equipment.

LOGISTICS

The Clansman Radio Control Harness is a flexible system of eight control units and twelve ancillary items. Flexibility is ensured by mechanical and electrical interfaces between harness ring units, radios and audio gear. Faulty units are easily changed and diagnosed down to sub-assemblies level.
A minimum range of sub-assemblies needs to be carried as spares.
It is possible to operate the equipment efficiently after only a brief period of instruction and as such can used by relatively unskilled operators.
It is capable of efficient operation under difficult conditions, eg in the dark or in a vehicle moving across open country whilst subject to high ambient noise, (eg vehicle and gun noise, etc).

SUMMARY OF TERMS USED

145. IC: Normal voice intercommunication between crew posistions with 'press to talk' facilities.
LIVE IC: Voice intercommunication between crew posistions with 'hands free' operation.
COMMUNAL IC: Common voice intercommunication between vehicles via communal terminal and line.
REBROADCAST: (LRB or RRB) Signals received by one radio are re-transmitted by the other. This can occur through the harness using two installed radios (LRB) or one installed radio and a remote radio through a line (RRB).
OVERRIDE (O/R): The O/R allows any crew member's voice to be heard by all the crew, in their right ear, irrespective of their switch settings without interferring with their selected working channel.
WORKING SIGNAL: Signal of selected working radio or channel, heard in the left ear.
MONITOR (M): This allows reception of signals on a selected channel without the ability to transmit, heard in the right ear.
REMOTE: (REM) To perform the same function as a person able to "use" the harness, from a remote point. Operation of a radio or intercommunication via a telephone cable (D10) up to 3 km in length, or up to 5km using CT10 cable.

SYSTEMS

146. The basic harness configuration is the two radio installation which can provide set selection, IC, Live IC, Monitor and Override facilities for all crew posistions.
The harness facilities, as determined by the IB2, are also available to a Remote user.
Provision is made for Automatic or Manual rebroadcast between the two local installed radios or between either installed radio and a remote radio.
The system will also accept a Central Warning Indicator (CWI) tone.
A three-radio installation would normally be used in a Command Vehicle role where re-broadcast and remote facilities are not required. It provides the control of up to three radios, normal and live IC, override and monitor. Communal IC is provided so that two or more vehicle harnesses can be linked together for voice intercommunication whilst the vehicles are stationary.

UNITS FOR TWO RADIO SYSTEM

147. There is a combination of seven types of units which can be used in the two-radio system, the types and quantities in any particular installation being dependant on the opperational role of the vehicle.
Auto Manual - Local Remote rebroadcast facilities on two radios either in Local in Harness or with one remote and connected via twin cable (D10) up to 3 km distance through the remote terminals of the IB2.

148. Interconnectin Box 2 Radio (IB2)
The IB2 is used in a two-set installation and is a combined control, junction and power supply unit for harness items. It contains an IC amplifier and acts as the inlet and outlet to the main harness distribution for radios and remote users.
It enables the two installed radios, or one installed radio and a remote radio, to be connected for manual or auto rebroadcast, as appropriate; or a remote user to be connected into the harness to use an installed radio or talk to the crew using IC. These facilities are controlled by a local operator whose headset is plugged into the IB2.

From the vehicle supply 28V DC is fed into the box and out to the harness items.
The harness is protected by a 1A fuse in the IB2. The IB2 does not supply power to the radios, loudspeaker amplifier or emergency crew control boxes.
For PRC-351/352 and LARKSPUR radios, the MANUAL/AUTO switch may be left at AUTO for any condition of use from the harness.

149. Interconnecting Box 2 Radio, Crew and Remote (IB2CR)
As an alternative to the IB2 where rebroadcast is not required, the IB2CR may be used. Its main advantage over more conventional alternatives is cost reduction since only one box is required and it allows a virtually universal application.

150. Crew Box 2 Set (CB2)
The CB2 is the standard Crew Box. It gives the crew member access through the harness to either of the two radios, one as a working set and simultaneously to the other for monitoring purposes.
Volume controls are provided for both the working set and the monitor set.
NORMAL, LIVE IC and LIVE IC + MONITOR posistions are provided on the selector switch. With LIVE IC selected the microphone is live all the time without the use of a pressel, thus giving hands free operation on intercom.
Operation of the pressel under these conditions switches the selected working radio to transmit. With LIVE IC + MONITOR selected with 'A' radio being worked and 'B' radio being monitored, the hands free operation on IC is retained, the 'A' radio is heard in the left ear and operation of the pressel causes the 'A' radio to transmit. 'B' radio and IC are heard in the right ear at a reduced level. Switching to OVERRIDE enables the operator to be heard at all other crew posistions irrespective of their switch posistions.

151. Commander's Box Fixed (CBF) and Commander's Personal Unit (CPU)
The CBF comprises a fixed box installed in the vehicle and a CPU carried by the commander. These boxes are always used together and are connected by a 2m or a 10m lead.
The CBF and CPU together provide all the facilities of the CB2, but the most imperative controls, such as radio selection, press to talk and override are carried on the CPU which is held by a webbing strap around the commander's neck. A standard CLANSMAN headset is used. Webbing and headset cable are fitted with snatch release devices.
An independent pressel may be plugged into the CBF and it is in parallel with the press to talk button on the CPU. When not in use, the IND PRESSEL switch should be off, to prevent accidental operation. The CBF will also accept tone signals from a Central Warning Indicator.

152. Driver's Box Fixed (DB) and Driver's Box Set Selector (DBS)
In installations where intercommunication facilities only are required, the DB is used by itself. The DBS can only be used in conjunction with a DB; together they provide similar facilities as the CB2. They are used in turreted vehicles where the DB is located in the driver's compartment and the DBS in the turret. Interconnection between the two units needs only five wires through the Rotary Base Junction (RBJ) and the DBS is controlled by an operator in the turret.
The DBS is fitted with an indicator lamp which lights when the selector is switched to I or Ia.
The driver has full intercom facilities as well as use of either radio, but he cannot work one radio while monitoring the other. When a Tank Telephone is fitted, this can be connected into the harness via the Driver's Box.

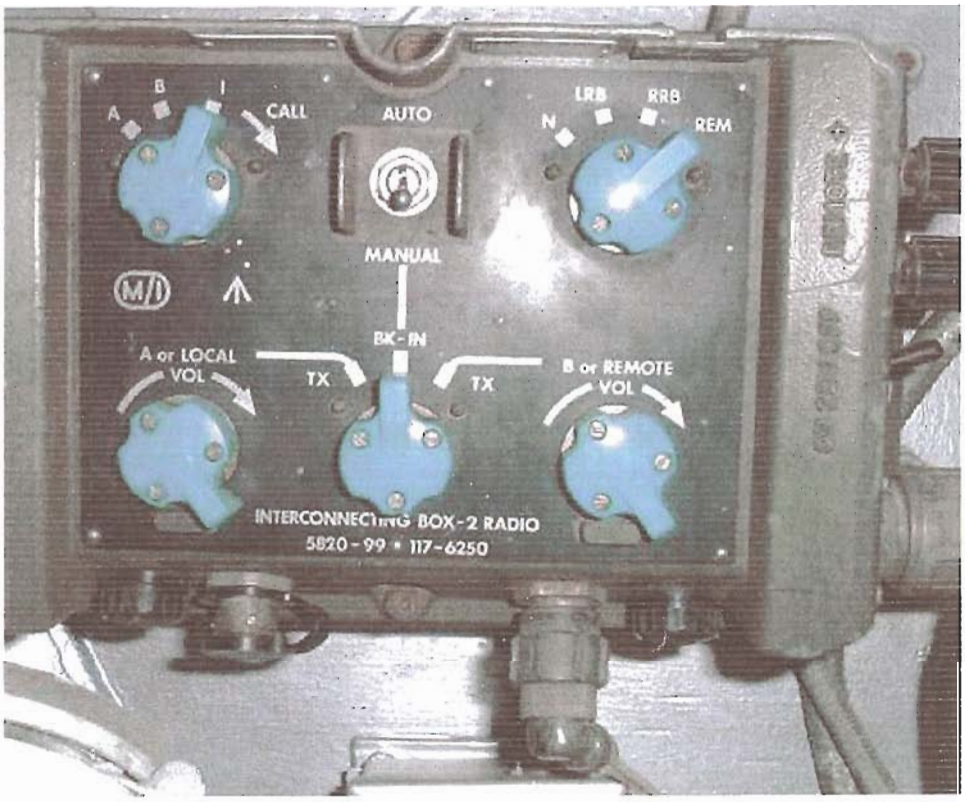


Fig 19. Interconnecting Box-2 Radio (IB2)

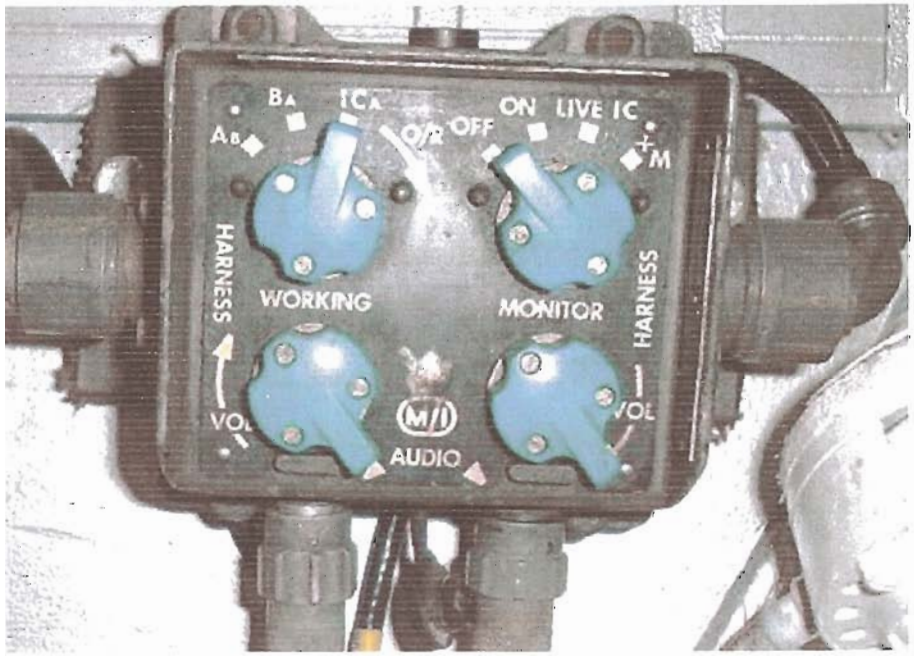


Fig 20. Crew Box 2 Set (CB2)

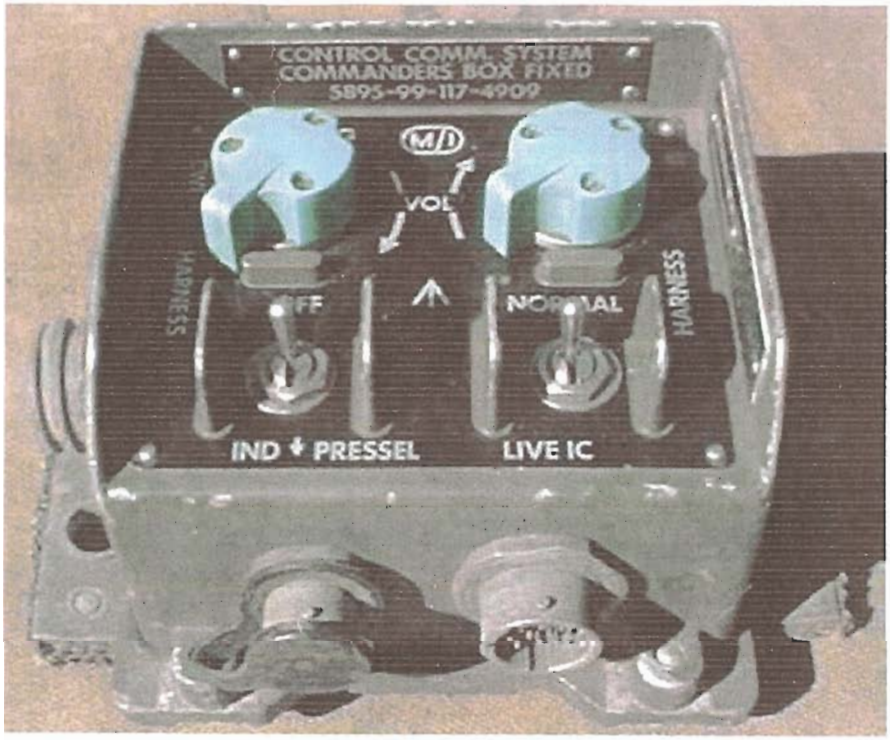


Fig 21. Commanders Box Fixed (CBF)

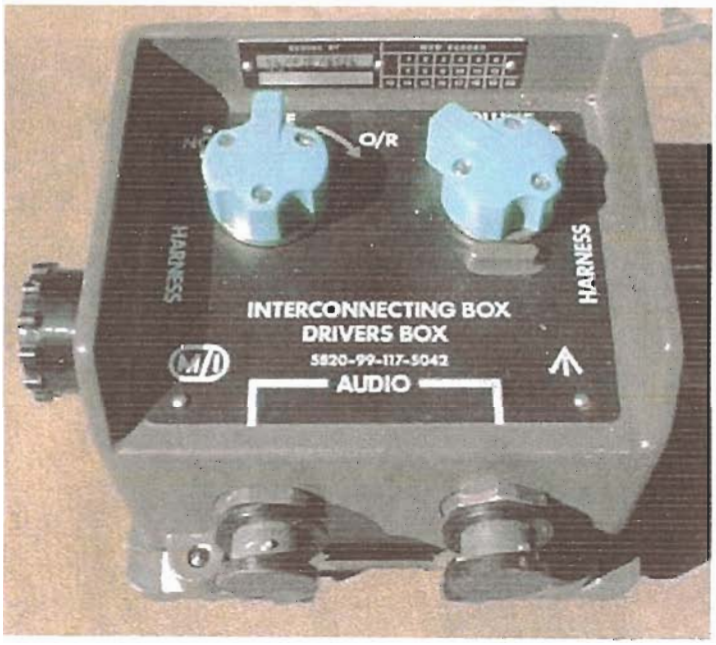


Fig 22. Drivers Box (DB)

UNITS FOR THREE RADIO SYSTEM

153. Two additional units are used in a three radio system, they are the Interconnecting Box 3 Radio (IB3) and a Crew Box 3 Set (CB3). CB3 provides for the working of any of the three installed radios while monitoring either of the others. IC and O/R are also available.
Any combination of CLANSMAN Harness Units, except the IB2, may be used in a three radio installation. IB3 together with CB2 provide for the control of two of the three radios by the CB2 operator as well as IC and O/R. The IB3 is also fitted with Communal IC terminals to allow intercom with the harness ring of another vehicle.

154. Interconnecting Box 3 Set (IB3)
The IB3 is a junction and power supply unit for harness items in installations of up to three radios, where rebroadcast facilities are not important. The IB3 connects the radios into the harness so that:

(a) 'A', 'B' or 'C' radio, IC or CALL may be selected and operated from a CB3 connected to the HARNESS and ACTIC sockets on the IB3.
(b) Normal 'A' or 'B' radio, IC or CALL may be selected and operated from any CB2 connected to the HARNESS socket on the IB3.
(c) 'A' or 'C' radio, IC or CALL ('A', 'C', together with IC - ACTIC) may be selected and operated from a CB2 connected to the ACTIC socket on the IB3.
The operator will read C or B on the control box selector switch.

155. Crew Box 3 Set (CB3)
The CB3 is used in the special case of a three set installation and is used in conjunction with the IB3. It enables the user to select and operate one of the three installed CLANSMAN radios, to select and monitor a second radio, and have intercommunication and call facilities.

ANCILLARY ITEMS

156. In addition to the standard range of boxes, there are ancillary units that can be supplied to extend the range of facilities.

157. Amplifier AF Loudspeaker (A AF L)
Amplifier AF Loudspeaker is a four watt audio amplifier which can be connected into the harness ring and used to select and amplify a radio or IC signal. It can drive up to four fixed (LSV) or free standing (LFS) loudspeakers. The A AF L can be used outside of a harness installation, completely seperate from the harness and be fed directly with signals from a radio or audio gear. A 28V DC power source is supplied to the A AF L either from a battery or a vehicle power supply.

158. Loudspeaker Free Standing (LFS)
The Loudspeaker Free Standing is a portable loudspeaker fitted with its own volume control, a short six-way connecting lead and a socket to which may be connected another loudspeaker or a headset/handset to give talk-back facilities. Short distance remote use (up to 10m) is available when the loudspeaker is connected via an Audio Extension Lead (AEL).
The loudspeaker may be connected to any audio socket in the harness for use under quiet conditions, or it may be connected to any Amplifier AF Loudspeaker by up to 50m of twin cable (D10) or by AEL.

159. Loudspeaker Vehicle Mounting (LSV)
Loudspeaker Vehicle Mounting is an installed loudspeaker which can be connected into any

of the audio sockets in the harness installation or radio for use under quiet conditions, or connected to any A AF L.

160. Audio Extention Lead (AEL)

The audio extension lead provides short range (up to 10m) remote audio facilities from any harness unit with an audio outlet. It has access for two sets of headgear or handsets.

161. Remote Combining Unit (RCU)

The remote combining unit (RCU) permits one of the two CLANSMAN radios to be selected and used on voice or morse as appropriate; and a second radio to be monitored; at a distance of up to 3 Kms over D10 cable, or 5 Kms over one pair in a CT 10 pr.
It contains a transistor amplifier to increase the signal power to the line and to provide a locally-generated side-tone. The amplifier obtains its DC supply along the line from the radio or harness.
When switched to CALL, a tone is generated within the connected radio, which is heard by the local operator, and by any crew member switched to that radio.
The RCU is used as follows:

(1) To a two-radio installation:
  (a) The line is connected to the IB2.
  (b) Morse and/or voice as appropriate are available on radio, and IC and CALL within the harness.
(2) To any CLANSMAN radio (except PRC-320 and PRC-350); no harness.
  (a) The line is connected directly to the terminals on the radio.
  (b) Morse and/or voice as appropriate are available on radio, and IC and CALL within the harness.
(3) To PRC-320; no harness.
  (a) The line is connected to the radio through the CRSL/R.
  (b) Morse and/or voice as appropriate are available on radio, and IC and CALL within the harness.

162. Remote Personal Unit (RPU)

The RPU permits the operation of CLANSMAN radios, CALL and IC with an operator at the radio, at a distance of up to 3 Kms over D10 cable or 5 Kms over one pair in a CT 10 pr. Cable is connected between the terminals on the unit and the REMOTE terminals on the radio, or the LINE terminals on the IB2 in an installation.
The unit is carried by a webbing around the neck of the user and the headset plugs into it. Both webbing and headset cable are fitted with snatch release devices.
The unit contains a transistor amplifier to increase the signal power to the line and to provide a locally generated side-tone. The amplifier obtains its DC supply along the cable from the radio or IB2. The unit is polarity conscious. A wrong connection will be indicated by the call tone being heard at both local and remote terminals.

163. Interconnecting Box Harness Adaptor (IBHA)

The IBHA adapts the CLANSMAN manpack radio PRC-320 or PRC-351/352 for connection into the harness system, and provides control and rebroadcast facilities through the harness, as if the manpack radio was a vehicle radio. The unit also contains an amplifier which raises the audio output level of the manpack radio to that of a vehicle radio harness output.
The radio is powered from its own battery, which may be float charged from a DC charging unit.

The DC charging unit can obtain its 28V supply through the IBHA.

PRC-320. The IBHA is used in conjunction with the CRSL/R of the PRC-320.
The CRSL/R will be switched to REM. Normal selection and operation of the radio is available from control boxes in the harness; manual, local or remote rebroadcast is possible through the IB2.

PRC-351/352. The normal selection and operation of the radio is available from control boxes in the harness. The radio will be switched to REM. Manual or auto, local or remote rebroadcast is possible through the IB2. The radio will be switched to REM for manual rebroadcast and to AUTO for auto rebroadcast as for any other VHF radio.

164. Set Combining Box (SCB)
The SCB is used when CLANSMAN radios are not in harness and IC is not needed.
It enables an operator to use two radios, monitoring the receiver output of the radio not being worked. A third radio may be held in readiness for selection, its cable being plugged into a dummy socket on the box.
Connection to the radios is made using cables from the standard CLANSMAN range, connected to the audio output of the radio. This cable length should not exceed 1 metre when connecting the PRC-350 or PRC-351/352. Any of the standard range of audio gear may be connected, appropriate to the mode of signalling intended.
Audio levels, however, are adjusted at the radio.

165. Radio Adaptor Box (RAB)
The Radio Adaptor Box (RAB) enables the LARKSPUR generation of radios to be used at their full potential when controlled from the CLANSMAN Radio Control Harness harness.

166. Interconnecting Box Radio Adaptor (IBRA)
The IBRA permits any installed CLANSMAN radio to be used by vehicle crew members using LARKSPUR harness, headgear and remote control gear.
IBRA converts a VRC into a C13/42/45 type radio, and a PRC into a B47/48 type radio.
In the latter case, it is necessary to use an IB in the installation if the PRC plus IBRA combination is to be used as the 'A' set, since the I/C amplifier in the IBRA is used to increase the PRC audio output, and therefore is not available for IC use.
The type of radio input, VRC or PRC, is selected by a preset switch.
Power supply is fed through the box to the radios.

167. Key Telegraph Manual (KTM)
The Key Telegraph Manual (KTM) can either be used free or clipped into a mounting tray in its vehicle role. It is connected into any audio socket in the harness or radio by a short jumper lead that is permanently plugged into one of its two sockets. A Clansman headset or handset can be plugged into the second socket to monitor the key operation. In this mode, normal audio facilities are available when the key is not being operated.

168. Remote Rebroadcast Box (RRB)
The Remote Rebroadcast Box (RRB) enables CLANSMAN HF radios to be used in the rebroadcast function. This box may be used with IB2CR or IB3 in harness installations, and SCB or RCU in non-harness installations.

169. An example of the application of this harness can be seen in the British version of the Anglo-German-Italian SP70 self-propelled gun. In common with standard armoured fighting vehicle practice the harness has a central feature of a harness ring with interconnecting boxes, including as the main unit the Radio Lines Box (RLB).

Two features are included to meet the special requirements of self-propelled artillery:

(i) Automatic communication of gun laying data, in digital form, from the battery command post over existing voice channels. This communication is effected by land line, or in exceptional circumstances via the installed radio.

(ii) Two-way cordless communication with ammunition numbers working outside the vehicle under non-silent conditions. This is achieved by use of rugged amplifier/loudspeaker units mounted on the turret bustle. Either loudspeaker can be used as a microphone by the operation of a press-to-talk button. The use of two speakers ensures that at least one is accessible at all turret positions.

A typical system includes seven types of installed box, of which the Interconnecting Box Harness Adaptor (IBHA) and the Drivers Box (DB) are taken from the existing Clansman range (the DB is utilised as a general crew box).

The personal communication gear, including the Commanders Personal Unit (CPU), is standard, except that the CPU switch has a slightly different function from standard Clansman practice.

The radio equipment may be based on either a PRC-351 VHF Manpack adapted to the vehicle role by use of the Interconnecting Box Harness Adaptor, or a Clansman vehicle radio, interfacing directly with the RLB. Signals received over the radio or lines, or both, can be superimposed on the harness intercommunication channel at the discretion of the commander.

170. Radio Lines Box (RLB)

The Radio Lines Box is operated by the commander in conjuction with his Commanders Personal Unit (CPU). The controls comprise the working and monitor volume controls for his headphones, the harness power supply on/off switch, the on/off switch for the loudspeaker function of the AIB, a live IC intercom switch for the commander's microphone, and a push button for passing a status signal over the land line. The internal circuits include the lines signal amplifier, the crew intercommunication amplifier, the voltage regulator for the harness power supply, and the relay contacts by which signals, including the radio signals, are selected and diverted in response to the CPU switch positions.

171. Amplifier Intercom Box (AIB)

Two identical Amplifier Intercom Boxes are mounted on the rear exterior of the turret bustle for intercommunication with ammunition numbers working outside the vehicle. When switched on at the RLB, both AIB's become loudspeakers, allowing the ammunition numbers to monitor the harness intercommunication channel or be addressed by the commander. The volume of each AIB can be adjusted independently by a control on the lower surface.

The operation of a push-button switch, located on the same surface of the AIB, connects the loudspeaker into the harness as a microphone. A microphone amplifier is incorporated in each AIB to raise the output of the loudspeaker to a level compatible with the output of the other crew boxes. This facility is independent of the loudspeaker control switch on the RLB. Under silent conditions a Clansman headset can be connected to the audio socket of either of the AIB's to provide the user with the same facilities as the crew members inside the vehicle.

172. Loudspeaker Tee Box (LST)

The Loudspeaker Tee Box (LST) has two functions:

(i) As a harness junction box with two spur outlets, one to each Amplifier Intercom Box (AIB).

(ii) As an interconnector between the two AIB's so that operation of the press-to-talk button on either box mutes both loudspeakers, thus eliminating acoustic feedback.

173. Interconnecting Box 12-way (IB12)

The Interconnecting Box 12-way (IB12) is a junction box connection into the harness ring to provide one spur outlet to the Emergency Crew Control equipment (ECC) and another, via the slip-rings to boxes installed in the hull.

There are no operator controls on the box, and it has a wide field of potential applications.

173. Telephone Adaptor Box. (TAB)

A tank telephone position , incorporating a handset, is mounted on the vehicle exterior. This is also the normal connection point for line connection to the battery command post. The Telephone Adaptor Box (TAB) is the first interior box to which the tank telephone connects. The lines connection are linked through the TAB, and terminate at the Radio Lines Box. The signals to and from the tank telephone handset are adjusted within the TAB to levels compatible with the harness. The TAB also incorporates an indicator lamp visible to the driver, who may respond to a call from the tank telephone handset by operating a switch on the TAB, thereby, connecting the handset to the harness ring.

AUDIO ANCILLARIES

174. Racal-Amplivox Communications Limited specializes in the field of electro-acoustics and has developed the Armoured Vehicle Crewman's Helmet and Staff User's Headset to meet the stringent requirements of the Clansman programme.

Both items incorporate the unique Amplivox "Acoustic Valve" in the earshells which can be opened or closed at will. In the 'open' position, the wearer can hear important airborne sounds such as commands, warnings, etc., whilst being protected from loud percussive noises, such as gunfire. In the 'closed' position, the earshell becomes a high quality ear-protector.

175. AFV Crewman's Helmet (Helmgard)

This helmet protects the AFV crewman against head injury due to the serious shocks that can occur in an AFV when travelling at high speed over rough terrain.

Different head sizes can be accommodated by means of detachable headband comfort pads and adjustment of the crown pad.

176. "A" Vehicle Staff User's Headset (Sonovalve II)

This maximum comfort headset has been designed for use by troops and other military personnel engaged in areas of continuous or intermittent noise where headsets have to be worn with seperately issued protective helmets.

This headgear is designed to be worn under the later style infantry helmet and will be used by staff officers in 'A' vehicles. It is fitted with noise-excluding earshells having adjustable valves and a boom microphone, similar to those mounted in the AFV helmet.

177. "B" Vehicle Staff User's Headset

This headgear is similar in general design to the 'A' vehicle staff user's headgear, but the earshells provide less noise exclusion and are not fitted with acoustic valves. Primarily intended for use with the Clansman range of Manpack and 'B' vehicle radio sets, the assembly is fitted with rocking armature receiver insets mounted in foam padded circum-aural earshells, a boom mounted noise-cancelling microphone and a 1 metre 6-way coiled cable terminated in a 7-way snatch connector, for connection to the Pressel Switch Box Assembly.

The left-hand earshell carries the microphone boom and a 3-pole socket which provides for the optional connection of the Clansman Respirator Microphone. The right-hand earshell (Satellite) is detachable from the headgear, leaving its earpad in position to stabilize the assembly. The action of attaching the Satellite to its earpad automatically completes the electrical circuit to the right-hand receiver.

The headgear is compatible with the latest type of Infantry Helmet and also with Respirator, Anti-Gas, No. S6. Cables and earpads may be changed without the use of tools.

178. Pressel Switch Box Assembly

This assembly is for use with the Clansman Infantry and 'B' Vehicle Headgear, AFV Creman's Helmet and the Staff User's Headset. It consists of a pressel box with snatch socket, clothing clip and a coiled cable, extending to 1.5 metres, fitted with a 7-way bayonet lock plug for connection to user equipment.

The fixed socket on the pressel box accepts the headgear while the main pressel bar actuates a double-pole microswitch, controlling the microphone and send/receive control lines. The pressel box may be set to either the 'live microphone' or the 'switched microphone' (Mic. Off-On) mode by adjusting the sliding stepped washer at the cord outlet end to the appropriate limit of its travel and tightening the retaining screw.

179. Respirator Microphone

The respirator microphone is provided to allow communications to be retained when wearing the AFV crewman's helmet or the staff user's headgear with the respirator S6. The primary function is to maintain full voice communication facilities when the use of a boom microphone is rendered ineffective due to the use of a gas respiratior.

It consists of a rocking armature receiver (used as a microphone) mounted in a rubber housing designed to clip over the exit of the respirator voice valve. The cord of the microphone terminates on a 4-way plug which fits into the respirator microphone socket mounted on the associated assemblies. The fit of the microphone on the respirator is reletively loose, and the cord is kept short, so that any snagging of the cord should displace the microphone without breaking the seal between the respirator and the face.

180. Single Transducer Assembly

The Single Transducer Assembly can be worn as a single-sided headset or used as a hand-held microphone. The design includes a press-to-talk switch, webbing harness and a coiled cable extending to 1 metre in length.

The single transducer assembly consists of a single rocking armature receiver, which is used alternately as a receiver, with the pressel switch released, and a microphone with the pressel switch operated.

181. General Purpose Handset

The General Purpose Handset may be used with any CLANSMAN radio either by direct connection or through a control harness box. It is fitted with a rocking armature receiver and a pressure gradient (PG) microphone. A pressel switch operates the radio transmit/receive or control harness IC switching.

The Remote Handset can be used to remotely operate the following radios, either by direct connection over 3 Kms of D10 cable or through the control harness via an IB2.

(i) PRC-320 via a CRSL/R, when not in harness.
(ii) PRC-351/352
(iii) VRC-353
(iv) UK/PRC-344

The remote handset is fitted with a rocking armature receiver, a PG microphone and a transistor amplifier to increase the signal power to the line and to provide a locally generated side-tone. A pressel switch operates the radio transmit/receive or control harness IC switching. A second pressel switch operates the call tone which is generated by the radio, and is heard by the local and remote operators or all crew members connected into a control harness. The handset is fitted with insulation piercing cable contacts and is polarity concious. If it is incorrectly connected, a call tone will be heard at both local and remote terminals.

183. Tank Telephone Handset

The Tank Telephone Handset is used in the tank telephone assembly mounted in an armoured box on the outside of the vehicle. The handset is attached by 3 metres of telephone cord which is wound on a spring loaded drum for automatic retraction after use. The handset is similar to the GP handset but contains a transistor amplifier to match into the vehicle harness circuits.

184. Associated Literature

User Handbook for CLANSMAN Radio Control Harness, Army Code No. 61172.
User Trials Report, School of Signals, Report No. 723 F/72.
Ease of Maintenance Assessment Report No. EME/8c/2896.
Technical Specifications, SRDE No. DS 1192B.

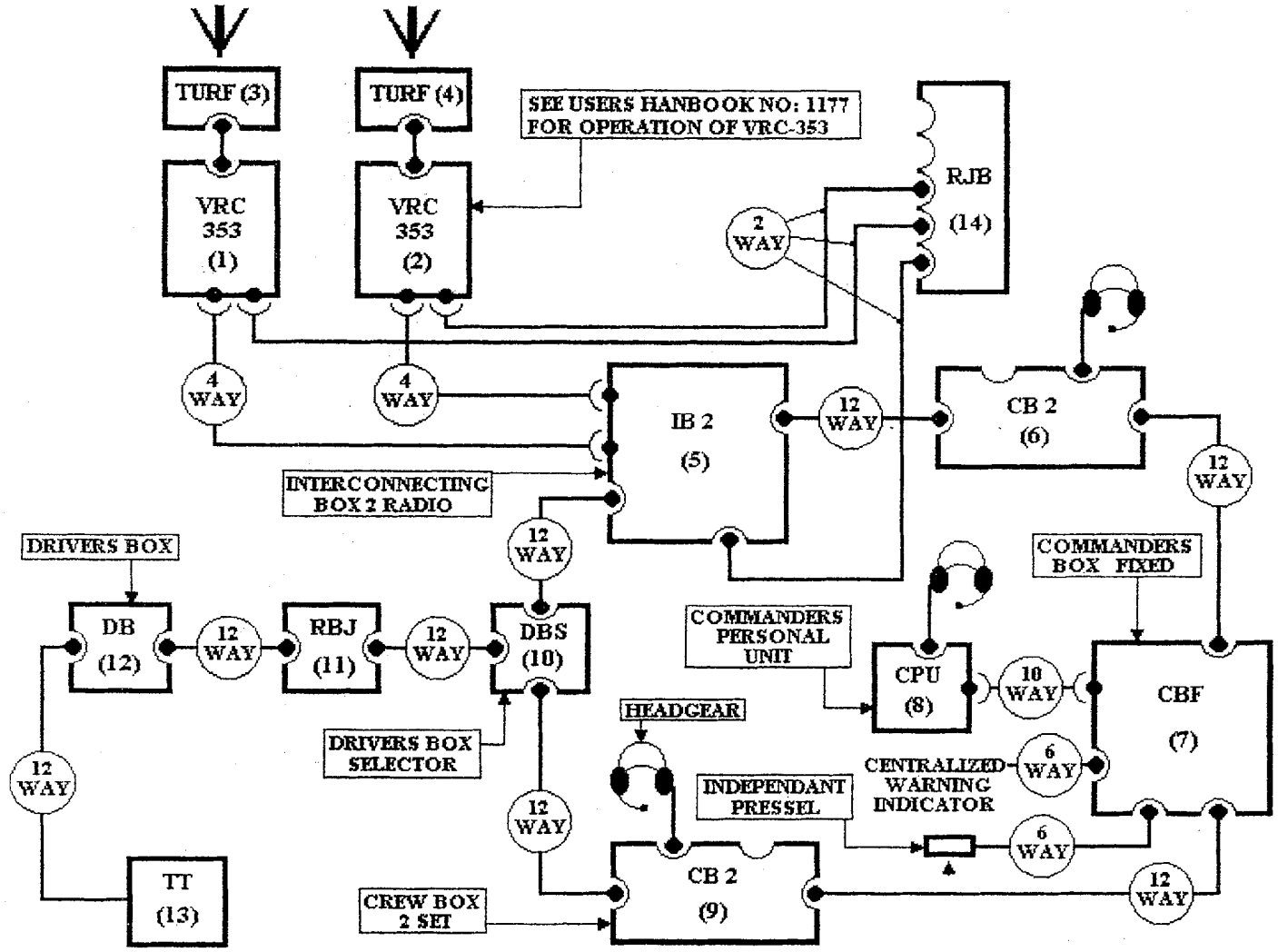


Fig 23. Two Clansman Radios and Clansman Control Harness in a Chieftain Installation

CREW BOX - 2 INSTRUCTION

Switch Positions		Facility
Working	Monitor	
A B	OFF	Work 'A' set; press to talk; signal in both ears.
A B	ON	Work 'A' set; press to talk; signal in left ear. Monitor 'B' set; signal in right ear.
B A	OFF	Work 'B' set; press to talk; signal in both ears.
B A	ON	Work 'B' set; press to talk; signal in left ear. Monitor 'A' set; signal in right ear.
I A	OFF	Intercom; press to talk; signal in both ears.
I A	ON	Intercom; press to talk; signal in left ear. Monitor 'A' set; signal in right ear.
O/R (Over-ride, spring loaded)	....	Voice call without use of pressel; heard by all crew members Revert to I A for subsequent communication. An O/R call from any other control box in the harness replaces the signal in the CB-2 operators right ear, irrespective of any switch settings. The loudness of the O/R call will depend on the MONITOR - VOL setting.
A B or B A	Live IC	Microphone live - talk on IC; monitor IC in right ear. Press to transmit on selected 'A' or 'B' set; signal in left ear.
A B or B A	+	Microphone live - talk on IC; monitor 'A' or 'B' set and IC in right ear. Press to transmit on selected 'A' or 'B' set; signal in left ear.

Switch Positions		Facility
Working	Monitor	
A, B or C	A, B and C OFF	Work selected 'A', 'B' or 'C' set; press to talk; signal in both ears.
A or B	C ON	Work selected 'A' or 'B' set. press to talk; signal in left ear. Monitor 'C' set; signal in right ear.
B or C	A ON	Work selected 'B' or 'C' set. press to talk; signal in left ear. Monitor 'A' set; signal in right ear.
A or C	B ON	Work selected 'A' or 'C' set. press to talk; signal in left ear. Monitor 'B' set; signal in right ear.
I	A, B and C OFF	Intercomm; press to talk; signal in both ears.
I	A, B or C ON	Intercomm; press to talk; signal in left ear. Monitor 'A', 'B' or 'C' set; signal in right ear.
O/R (Over-ride, spring loaded)	Any Combination of A, B and C ON/OFF	Call to all crew members without use of pressel. Microphone automaticlly made live. Revert to I for subsequent communication. An O/R call from any other control box in the harness replaces the signal in the CB-3 operators right ear, irrespective of any switch settings. The loudness of the O/R call will depend on the MONITOR - VOL setting.

REMOTE COMBINING UNIT INSTRUCTION

Switch Positions		Facility
Working	Monitor	
A	MORSE or VOICE	Work 'A' set; signal in both ears.
A B	MORSE or VOICE	Work 'A' set; signal in left ear. Monitor 'B' set; signal in right ear.
B A	MORSE or VOICE	Work 'B' set; signal in left ear. Monitor 'A' set; signal in right ear.
B	MORSE or VOICE	Work 'B' set; signal in both ears.
Any posistion	CALL (spring loaded)	CALL tone heard by local operator of selected working set, who will switch to IC to reply. Remote operator then switches to VOICE for subsequent communication.

SET COMBINING BOX INSTRUCTION

Switch Positions		Facility
Working	Monitor	
VRC or PCR	OFF	Work selected set; press to talk; signal in both ears.
VRC or PCR	ON	Work selected set; press to talk; signal in left ear. Monitor other set; signal in right ear.
A or B	LIVE IC	signal in both ears at reduced level. As 'A' or 'B' -- NORM above