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SYNCAL

TRA. 921
H.F. S.S.B. Manpack Transmitter-Receiver

Technical Manual

RACAL
THE ELECTRONICS GROUP

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TYPE TRA.921

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TRA. 921 H.F. S.S.B.

TRANSMITTER - RECEIVER

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PART 1 H.F. S.S.B. TRANSMITTER-RECEIVER

TYPE TRA. 921.

CONTENTS

ILLUSTRATIONS

Illustrations for the Synthesizer are in Part 3.
All other illustrations are at the end of Part 2.

TECHNICAL SPECIFICATION

GENERAL

Frequency Range	2 to 8 MHz
Channels	6000 Channels in 1 kHz steps derived from single high stability crystal selected by four in-line switches. Maximum synthesizer locking time is less than one second.
Operating Modes	U. S. B. Suppressed Carrier (VOICE U. S. B.) L. S. B. Suppressed Carrier (VOICE L. S. B.) A. M. (A3)(VOICE A. M.) C. W. (U. S. B. keyed tone). (KEY U. S. B.) C. W. (L. S. B. keyed tone). (KEY L. S. B.)
Frequency Stability	Over the temperature range of 0°C to 40°C the frequency change will be less than 30 Hz relative to the frequency at 25°C.
Temperature Range	Operating - 10°C to + 55°C. Storage - 40°C to + 70°C.
Power Supply	Internal Battery:- 18 volt 3.5 AH nickel-cadmium rechargeable battery, Type MA. 928. Vehicle Operation:- 12/24 volt D. C. Power Unit type MA. 926. Static Operation:- 100-125/200-250 volt 45 to 60 Hz Power Unit Type MA. 927.
Antennas	8 ft. (2.4 m) Whip, Long Wire or Dipole.
Antenna Tuning	Single-control tuning. Inbuilt ATU tunes above antennas for both transmit and receive.

Sealing	Transmitter-Receiver case sealed and fitted with desiccator. Battery container may be removed without breaking main seal.
Front Panel Controls and Facilities	(a) Four frequency Selection Switches (b) Function Switch Selecting: OFF VOICE AM KEY LSB VOICE LSB VOICE USB KEY USB TUNE (c) Antenna Tuning Control (d) Gain Control (e) High/Low Power Switch (f) Meter monitoring battery voltage (on a.m., c.w. and s.s.b. modes) and antenna current (on Tune). (g) Whip Antenna Socket (h) Two 50 ohm sockets for dipole antenna (i) 2-4 MHz. (ii) 4-8 MHz. (j) Ground terminal (k) Two ancillary sockets for handset, head-set or morse key or loudspeaker amp-lifier/power supply unit or battery charging unit.
Weight:	Basic TRA.921 unit 10 lb. (4.5 kg). Operational manpack with handset, whip antenna, nickel cadmium battery and haver-sack 22¼ lb. (10 kg) approx.
Dimensions	Width: 12.5/16 in. (13.2 cm.) Height: 4.3/8 in. (11.1 cm.) Depth: 15.1/2 in. (39.4 cm.)
Ancillaries	Full details of ancillaries will be found in 'Racal HF SSB Manpack Ancillaries' Brochure. A list of ancillaries is given in Appendix No. 1.

TRANSMITTER

Power Output	High Level	Low Level
VOICE (SSB)	20 watts p.e.p. nominal	5 watts p.e.p. nominal
KEY	15 watts nominal	3.5 watts nominal
VOICE (A.M.)	5 watts carrier	1.5 watts carrier

NOTE 1: The minimum output power for SSB and KEY operation in the 'High' position, under all conditions of channel frequency, sideband selection and operating temperature (-10°C to +55°C), is better than 1.5 dB below the nominal output.

NOTE 2: 'Key' output refers to normal keyed c.w. operation. The TRA.921 is not suitable for use as a 'beacon' under continuous key-down conditions in the 'High' power position.

Harmonic Emmissions	No harmonic will exceed -40 dB relative to full p.e.p. in 50 ohms load.
Spurious Emissions	Typically better than -40 dB relative to full p.e.p. in 50 ohms load.
Carrier Suppression	-40 dB relative to full p.e.p. output.
Unwanted Sideband Suppression	-40 dB relative to full p.e.p. output at 1 kHz.
Intermodulation Distortion	-25 dB relative to full p.e.p. output.
Power Consumption	1.5A for s.s.b. average speech.

RECEIVER

Sensitivity	1 microvolt (p.d.) r.f. input will give 2 mW a.f. output with a signal to noise ratio of not less than 15 dB.
Selectivity	SSB 6 dB bandwidth 2.2 kHz typical 40 dB bandwidth 5.0 kHz typical A.M. 6 dB bandwidth 7 kHz typical 55 dB bandwidth 25 kHz typical
Image Rejection	Better than 60 dB.
Spurious Responses	All spurious responses attenuated by at least 40 dB.
A.F. Power Output	4 mW nominal.

Distortion	5% maximum at 2 mW.
A. G. C.	The a. f. output will change less than 6 dB for an r. f. signal input variation of 80 dB.
Power Consumption	Approximately 170 mA.

NOTE: The above mentioned performance figures are measured with a power supply of not less than 18 volts.

CHAPTER 1

GENERAL DESCRIPTION

INTRODUCTION

1. The 'Syncal' Type TRA. 921 manpack provides transmission and reception facilities in the frequency range of 2 to 8 MHz. Six thousand channels are available, spaced at 1 kHz intervals throughout the frequency range. The transmitter provides a high power output of approximately 20 watts p. e. p. or a low power output of approximately 5 watts p. e. p: the selection of high or low power output is made at a switch fitted to the front panel.

2. The manpack provides single sideband (upper and lower) and double sideband (a. m.) telephony operation. In addition c. w. telegraphy facilities are provided by means of a keyed tone on the upper or the lower sideband.

3. The casing and front panel is moulded in high impact plastic, allowing the equipment to withstand severe handling. The manpack is fully waterproofed, allowing it to be totally immersed without damage. A dessicator is fitted to the front panel, and can be changed without dismantling the equipment. The element of the dessicator can be re-activated by means of a hot-air blower after removal from the set.

4. Sockets are fitted to the front panel to allow the connection of ancillary equipment, including antennas. A wide range of ancillary equipment is available, as listed in Appendix No. 1.

5. The power supply is normally provided by an 18V nickel-cadmium battery fitted in a case which is joined to the main case. The battery can be re-charged in situ, via a front panel socket, or can be changed without disturbing the waterproof sealing of the main case. For certain applications an external power supply can be used in place of the battery.

6. The total weight of the complete packset, including the haversack, battery, whip antenna and handset, is approximately 22¼ lb (10 kg).

COMPOSITION OF 'SYNCAL' MANPACK TYPE TRA. 921

7. A 'Syncal' Manpack Type TRA. 921 consists of two main units in addition to the battery. The two units are the Transceiver Unit Type MA. 924 and the Synthesizer Type MA. 920. Part 1 of this handbook gives

information on the complete manpack, Part 2 covers the Transceiver Unit and Part 3 the Synthesizer. Illustrations for the Synthesizer will be found in Part 3, other illustrations are at the end of Part 2.

Transceiver Unit MA. 924

8. This unit includes the control panel on which are mounted all the operating controls and external connector points. (see fig. 1 of Part 2). These latter points include the three antenna sockets, one for the whip antenna and two for the dipole or end-fed antennas. These two sockets are used to cover the frequency range in two steps of 2 - 4 and 4 - 8 MHz.

9. The two AUDIO sockets on the front panel are connected in parallel, permitting the connection of various combinations of handset, headset etc. Examples of these may be a loudspeaker amplifier and a handset, a handset (used by a second operator) and a headset (used by first operator for monitoring), or a headset and a morse key. The sockets are also used to connect the various combined loudspeaker amplifiers and power units or battery charging unit to the manpack.

10. The majority of the transmitter/receiver circuit is contained on a single fibreglass printed circuit board, giving easy access to all components. The printed circuit board is held in a chassis assembly mounted on hinges which are fitted at the rear of the control panel. Screening of the circuit against unwanted external pick-up is provided by the fitting of screening covers over the two faces of the chassis assembly.

Battery

11. The battery power pack is attached to the upper section of the unit by two retaining screws, which, when screwed firmly home, ensure a watertight seal between the two sections. The nickel cadmium re-chargeable battery has a capacity of 3.5 ampere-hours.

12. Metering of the battery voltage is carried out at the control panel meter, in conjunction with the mode selector switch. When set to any one of the Voice or Key positions, the switch connects the meter across the battery. A reading of less than half scale deflection under transmit conditions, with HIGH or LOW power selected, (dependent upon the power output to be used) indicates that the battery needs recharging.

13. The contact arrangement between the battery and the main unit is so designed that, provided the battery is inserted with the terminals outward, incorrect connection is impossible (see fig. 4 of Part 2).

Synthesizer MA. 920

14. The Synthesizer is housed in a light alloy casting that bolts to brackets at the rear of the front panel. The four frequency selection controls are fitted to the front panel of the manpack.

PRINCIPLES OF OPERATION

Transceiver Unit

15. Microphone inputs are made to the a. f. amplifier and then to the clipper, (see simplified block diagram fig. 5 of Part 2). The a. f. input modulates a 10. 7 MHz frequency and the resultant i. f. signal is amplified and fed to one of the three filters, u. s. b., a. m. or l. s. b., dependent upon mode selected. The filtered signal is then mixed with the channel oscillator frequency, fed through a low pass filter, and amplified in the driver and p. a. stages prior to being fed to the antenna via the a. t. u.

16. The power output of the transmitter can be HIGH or LOW, dependent upon the setting of the POWER switch.

17. Received r. f. signals are fed via the a. t. u., a protection circuit and a low pass filter, to the r. f. mixer, where the signals are mixed with the channel oscillator frequency to provide the i. f. of 10. 7 MHz. The i. f. is fed via the appropriate filter, dependent upon mode selected, then to the i. f. amplifier. The amplified signal is detected and the resultant a. f. is amplified prior to being fed to the output connector.

18. An a. g. c. circuit, operating upon the r. f. and i. f. stages, is provided and maintains a sensibly constant a. f. output level for wide variations of r. f. input level.

Synthesizer

19. The main oscillator, which covers the range 12. 7 to 18. 7 MHz, is approximately tuned by a corase bias selected by the front panel MHz control and applied to the oscillator via a summing amplifier. The fine tuning of the main oscillator is completed by a control loop which comprises a mixer and programmed divider feeding into frequency and phase comparators.

20. The setting of the front panel MHz switch selects the required coarse bias and also one of six crystal oscillators in the 12-17 MHz Generator. The output of the 12-17 MHz Generator is mixed with the output of the main oscillator and applied to a programmed divider whose division ratio is determined by the setting of the 'kHz' controls. The output of the divider is exactly 1 kHz when the output frequency is correct.

21. The phase and frequency comparators provide an error output when a difference exists between the 1 kHz signal from the reference frequency generator and the signal from the programmed divider. The error output causes the summing amplifier to adjust the frequency of the main oscillator until the output frequency is correct. The frequency comparator brings the synthesizer into correct tune after a frequency change; it is then held 'in lock' by the phase comparator.

22. The channel frequency and the 10.7 MHz frequency are of the same order of accuracy as the 5 MHz crystal which controls the outputs from the reference frequency generator.

CHAPTER 2

PREPARATION

1. Unpack the equipment from the transit case and remove the manpack from its haversack.

2. Carefully inspect the equipment for any transit damage.

3. Unscrew the two retaining screws in the base of the container and detach the battery power pack.

4. Check that the 7 amp. fuse is serviceable and that a spare fuse is fitted. Insert the battery with the battery terminals pointing outwards from the case. Refit the battery pack and screw the retaining screws firmly home, to ensure a waterproof seal between the pack and the main case.

NOTE: Do not overtighten since this may damage the seal.

5. Set the MODE SELECTOR switch on the control panel to a position other than OFF or TUNE and read the level indicated. A fully charged battery is indicated by a reading of three-quarters scale deflection.

6. Replace the manpack in the haversack and tighten the haversack frame retaining screws into the threaded inserts which are located behind two of the eyelet holes in the bottom of the haversack. The remaining eyelet holes provide for haversack drainage.

7. Check the Humidity Indicator. If it has changed to a pink colour, the desiccator insert should be removed and re-activated, or replaced with a new insert.

CHAPTER 3

OPERATION

CONTROLS AND CONNECTIONS

1. The controls and sockets fitted to the front panel of the manpack are listed below.

(a)	FREQUENCY SELECTION CONTROLS	The four control switches are used to select the required frequency.
(b)	MODE SELECTOR SWITCH	The seven position rotary switch is used to select the mode of operation of the equipment. The positions of the switch are OFF, VOICE A. M., KEY L. S. B., VOICE L. S. B. VOICE U. S. B., KEY U. S. B. and TUNE.
(c)	GAIN	This potentiometer controls the receiver a. f. gain.
(d)	TUNE	This control operates an a. t. u. which matches the transmitter and receiver to the antenna.
(e)	HIGH/LOW POWER SWITCH	This switch controls the output level of the transmitter.
(f)	METER	The meter indicates the battery voltage when the mode selector switch is at a VOICE or KEY position. The meter indicates antenna current when TUNE is selected.
(g)	AUDIO SOCKETS	These two sockets are connected in parallel, and allow ancillary equipment (such as a headset, morse key, external power supply or battery charging equipment etc.) to be connected to the manpack.

(h)	WHIP SOCKET	This socket allows a whip antenna to be connected to the manpack.
(j)	2-4 MHz and 4-8 MHz 50Ω SOCKETS	These sockets allow an antenna (other then a whip) to be connected to the manpack.
(k)	GROUND TERMINAL	This terminal allows a grounding spike to be connected to the manpack.

ANCILLARY EQUIPMENT OF OTHER MANUFACTURES

2. Care should be exercised when using ancillary equipment made by other manufacturers. As an example, certain morse keys which look identical with Racal products have different pin connections. These keys will not normally cause damage to the manpack, but will prevent telegraphy working taking place.

CONNECTION OF ANTENNA

3. Connect the required antenna. For man-portable working the whip antenna is used, while static operation permits the use of either a dipole or long wire antenna. Enhanced performance of the equipment will be obtained by the use of the latter antenna types.

Whip Antenna

4. (1) Assemble the sectional whip antenna and insert the antenna plug into the WHIP antenna socket on the control panel.

(2) Where a flexible connector is provided, plug the flexible connector into the WHIP antenna socket, and the antenna plug into the free end of the flexible connector.

NOTE: The whip antenna is easily assembled by laying the antenna along the ground in a straight line, with the antenna plug away from the user. Holding the thinest section of the antenna, draw the centre wire tight, until the sections become interlocked.

End-Fed Antenna

5. (1) Erect the antenna, using a mast or tree etc.

(2) Connect the antenna plug into the WHIP antenna socket.

(3) Drive the earthing spike into the ground and connect the ground lead to the ground terminal on the control panel.

Dipole Antenna

6. (1) Adjust the length of the antenna as required, by reference to the 0.5 MHz markings provided on the antenna.

(2) Erect the antenna horizontally with the line of the antenna running at right angles to the desired direction of transmission/reception.

(3) Connect the coaxial feeder plug into the relevant 50Ω coaxial socket on the control panel. The two sockets are clearly marked for the two frequency ranges covered.

(4) Drive the earthing spike into the ground and connect the ground lead to the ground terminal on the control panel.

BATTERY ECONOMY

7. The equipment should, whenever possible, be used with LOW POWER selected to give the maximum operating time between battery changing or charging. The TUNE condition should only be selected for the time necessary to carry out tuning, to avoid excessive battery drain.

VOICE AM/VOICE LSB AND USB OPERATION

8. (1) Connect the handset to either of the AUDIO sockets.

(2) Set the HIGH/LOW Power switch to the appropriate position.

(3) Set the frequency selection controls to their appropriate position.

(4) Set the Mode Selector switch to TUNE.

(5) Adjust the TUNE control for a maximum reading on the meter.

(6) Set the Mode Selector switch to the appropriate position i.e. VOICE AM/VOICE LSB or USB.

(7) Adjust the GAIN control to give the desired a.f. level.

(8) To transmit, press the handset switch.

TELEGRAPHY OPERATION

9. (1) Connect the headset into one AUDIO socket and the morse key into the other.

   (2) Set the HIGH/LOW Power switch to the appropriate position.

   (3) Set the frequency selection control switches to their appropriate positions.

   (4) Set the mode selector switch to TUNE.

   (5) Adjust the TUNE control for a maximum reading on the meter.

   (6) Set the mode selector switch to either KEY LSB or KEY USB.

   (7) Adjust the gain control to give the desired a.f. level.

   (8) To transmit, operate the morse key. The transmit condition is maintained for approximately half a second after the key is re-leased.

BATTERY POWER CHECK

10. (1) Select HIGH or LOW power, in accordance with output power required during transmission.

    (2) Set the mode selector switch to TUNE.

    (3) Adjust the TUNE control for a maximum reading on the meter.

    (4) Set the system switch to either KEY L.S.B. or KEY U.S.B. and operate the morse key, observing the meter, or select VOICE U.S.B. or VOICE L.S.B. and whistle loudly into the microphone. If the reading falls appreciably, then the battery is nearing a discharged condition. If the reading falls below half scale deflection the battery should be re-charged or changed.

PART 2

TRANSCEIVER UNIT TYPE MA.924

REF: 410
ISSUE B

PART 2 - TRANSCEIVER UNIT TYPE MA.924

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CONTENTS - PART 2 (Continued)

CONTENTS - PART 2 (Continued)

ILLUSTRATIONS

CHAPTER 1

GENERAL DESCRIPTION

INTRODUCTION

1. The Transceiver Unit Type MA.924 consists of the front panel with controls (except those controls which form part of the synthesizer or 49 channel crystal oscillator), the a.t.u. and all circuitry other than that associated with the synthesizer or 49 channel crystal oscillator. The majority of the circuit components are fitted to a printed circuit board which is housed in a light alloy box. The box is hinged to the rear of the front panel. A general view of the equipment is given in Fig. 4.

PRINCIPLES OF OPERATION (Fig. 2)

Transmission -Voice U.S.B. and L.S.B.

2. Microphone inputs are made, via an r.f. filtering stage, to an audio pre-amplifier VT39 and VT40. The output of the pre-amplifier is fed to a symmetrical compressor D26a and D26b which compresses the peaks of the a.f. signal if a pre-determined level is exceeded.

3. The signal from the compressor is fed via an amplifier VT37 to the balanced modulator stage T14, D24a and D24b. A 10.7 MHz signal is also injected into the balanced modulator via buffer amplifier VT36, providing a double sideband suppressed carrier i.f. signal centred on 10.7 MHz at the output.

4. A sidetone signal is also fed from the compressor stage to the receiver.

5. The i.f. signal is amplified by VT34 and VT33 and fed to the sideband filter via the diode switch D10. The gain of VT34 is controlled at high or low level by the VT35 gate.

6. Either the upper or lower sideband filter will be in use, dependant upon mode selected; the following description (up to para. 10) assumes that VOICE U.S.B. mode is selected.

7. A positive voltage is supplied to diodes D28, D30, D34 and D36 in u.s.b. mode, opening the upper sideband channel and allowing the signal to be fed via filter FL4. This filter has a pass band of 10.6995 to 10.6975 MHz and thus accepts the lower sideband of the i.f. signal.

NOTE: Frequency relationships are discussed in paras. 29 to 31.

8. The signal from the u.s.b. filter is fed via D28 and D30 the a.m. filter FL3 and diode D6 to the mixer T13, VT31, VT32, where it is mixed with the channel oscillator signal (12.7 - 18.7 MHz), supplied by the synthesizer or 49 channel crystal oscillator via filter FL2 and diode switch D3. The difference frequency (2 to 8 MHz plus u.s.b. modulation) is selected by the filter FL6.

9. The output of the filter is fed to the pre-driver amplifier VT30 and VT28, and from there to the push-pull driver stage VT26 and VT27. The bias of the driver stage is adjusted for HIGH or LOW power by the control gate VT29, which is, in turn, controlled by relay RLB.

10. The output of the driver is fed to the p.a. stage VT24 and VT25, where it is coupled, via T7, T8, and the relay contacts RLA-1, to the manually tuned a.t.u. L1, C1/C2 and C3. The matching of the a.t.u. in high or low power is controlled by RLB-1.

11. The transmitter operates in a similar manner in l.s.b. mode except that the sideband filter FL5 is brought into use (by D29, D31, D35 and D37) instead of filter FL4 (see para. 7).

Transmission - Key U.S.B. and L.S.B.

12. In keying modes a 1000 Hz tone from the VT41 tone oscillator stage is used as the modulating signal for the selected sideband. When the external key is closed the oscillator is brought into operation, and the 1000 Hz tone is injected into the audio circuit, after the compressor stage. The remainder of the transmitter circuits then operate as for u.s.b. or l.s.b. voice modes.

13. When the key is released the transmit relay RLA (and relay RLB if HIGH power is selected) are held in the 'operated' position for a short time. This ensures that the receiver is muted during normal keying breaks.

Transmission - Voice A.M.

14. In this mode the microphone input aduio pre-amplifier and audio compressor stages operate as described in para. 2. The input to VT37 is controlled by a level adjusting gate D25 and RV8, which reduces the a.f. level to a suitable value. The reduction in level is necessary for two reasons:

(1) As a carrier and both sidebands are transmitted in this mode, the a.f. level must be reduced to ensure that the output stages are not overdriven.

(2) As only the a.m. (7 kHz) filter is in circuit the filter losses will be lower than in s.s.b. modes.

15. The reduced a.f. level is fed to the modulator T14, D24a and D24b via the amplifier VT37. The modulator unbalancing circuit incorporating RV6 is brought into use in this mode.

16. During s.s.b. working the modulator produces sum and difference frequencies (para. 3) but the i.f. centre frequency (10.7 MHz) is suppressed as the modulator is balanced. In a.m. mode the modulator is unbalanced, allowing the stage to produce the sum and difference frequencies and the i.f. frequency, resulting in a true a.m. signal.

17. The a.m. signal is fed to the a.m. filter FL3 via the VT34 and VT33 stages, the D10 diode switch (para. 5) and the D32 and D33 switching stage. The signal from filter FL3 is then fed to the mixer, pre-driver, driver and p.a. stages as described in paras. 8 to 10.

Transmission - High and Low Power Output

18. Relay RLB is de-energized when low power is selected and energized when high power selected. Relay contacts RLB-1 adjust the coupling of the p.a. stage to the a.t.u. to suit the output power level; contacts RLB-2 adjust the gain of the i.f. amplifier and the bias of the driver stage.

Reception - U.S.B. and L.S.B. Modes

19. Voice and key modes are identical as far as the receiver circuits are concerned, as the keyed tones are demodulated and amplified in the same manner as a.f. signals.

20. The incoming r.f. signal is fed via the a.t.u. and the de-energized contacts of relay RLA-1, to the protection diodes D1a and D1b, which prevent damage to the receiver as the result of overloading. The signal is then fed, via a low pass filter FL1, to the mixer and i.f. amplifier stage T1, VT1, VT2 and T3, which mixes the signal with the channel oscillator signal (obtained from the synthesizer or 49 channel oscillator via filter FL2 and diode switch D2) producing an i.f. signal based on 10.7 MHz.

21. The i.f. signal is fed, via the diode switch D5 and the 7 kHz filter FL3, to the sideband filters. The filter FL4 is brought into circuit by diode switches D28, D30, D34 and D36 when U.S.B. VOICE or U.S.B. KEY is selected. If an l.s.b. mode is selected switches D29, D31, D35 and D37 will bring filter FL5 into circuit.

22. The signal from the selected filter is fed to the i.f. amplifier stages VT13, VT14 and VT15, and then to the product detector stage VT17. A 10.7 MHz input from the synthesizer or 49 channel crystal oscillator is also applied to this stage, and the difference frequency of the two signals is extracted. This difference signal is the required audio modulation carried by the sideband. The a.f. is amplified by the audio pre-amplifier stage VT19 and fed to the manual gain control RV2 via a level limiting stage D14a, D14b,

D15a, D15b, which is a symmetrical clipping circuit that prevents overloading of the audio power amplifier circuits which follow.

23. The output from the audio power amplifier stage is fed to the audio sockets on the front panel of the unit. The audio power amplifier is also connected to the sidetone circuit from the compressor stage (para. 3) and a sample of the a.f. signal fed to the transmitter (which may be voice or keyed tone) is heard in the receiver circuits during transmission.

Reception - Voice A.M. Mode

24. The circuit from the antenna to the mixer and amplifier is the same as that used for u.s.b. and l.s.b. working (para. 20). From the mixer and amplifier stage the i.f. signal is fed via diode switch D5 to filter FL3, which allows the carrier complete with both sidebands to be fed to the i.f. amplifier VT13, VT14 and VT15, via diode switches D32, D33 and D7.

25. During reception in VOICE A.M. mode the 10.7 MHz signal from the synthesizer or 49 channel crystal oscillator is muted and the product detector VT17 acts as a normal a.m. detector, separating the a.f. content from the i.f. The audio pre-amplifier VT19, limiter and audio power amplifier stages function as described in paras. 22 and 23.

Receiver - A.G.C. Circuit

26. A.g.c. voltages are derived from two sources, the VT17 detector stage and the VT19 a.f. amplifier stage. When a.m. working is selected and modulation is absent the VT19 stage is inoperative, and the detector stage controls the gain of the receiver. The a.g.c. voltage is derived from the carrier signal, which is continuous during a.m. reception.

27. In u.s.b., l.s.b. or a.m. mode with modulation present, the a.g.c. voltage is derived from the VT19 amplifier stage and takes precedence in controlling the gain of the receiver. The circuit embodies a time delay so that the a.g.c. potential is maintained during normal breaks in the received signal, thus preventing noise being heard between words or keyed tones.

28. The a.g.c. voltage is rectified and amplified in the VT16, VT18 stage to generate a voltage which is applied to the VT13 and VT14 i.f. amplifier stages and the mixer stage, thereby maintaining a constant a.f. output from the receiver over a wide range of input signal levels.

Frequency Relationships - Transmission

29. Frequency relationships are illustrated easiest by an actual example, i.e. a 500 Hz audio note transmitter at 4 MHz. This gives the following, for u.s.b. and l.s.b. channels.

30. U.S.B. Channel. A.F. in, 500 Hz, mixed at balanced modulator to give 10.7005 MHz (10.7 MHz + 500 Hz) and 10.6995 MHz (10.7 MHz - 500 Hz). The lower frequency 10.6995 MHz is selected by filter FL4, and is mixed with the channel frequency, which, when 4 MHz is selected, will be 10.7 + 4 HMz, i.e. 14.7 MHz. The mixer provides sum and difference frequencies of 25.3995 and 4.0005 MHz. The sum frequency is rejected by filter FL6, and the difference frequency, 4.0005 MHz, is transmitted.

31. L.S.B. Channel. In this case the higher frequency from the balanced modulator, 10.7005 MHz, is selected by filter FL5 and mixed with 14.7 MHz. The difference frequency, in this case 3.9995 MHz, is selected by filter FL6 and provides the transmitted frequency.

Frequency Relationships - Reception

32. Again a 500 Hz note at 4 MHz received frequency will be considered. The 4 MHz signal with modulation (i.e. 4.0005 MHz for u.s.b.) is received at the antenna, and converted in the mixer stage to an i.f. signal of 10.6995 MHz by mixing with a channel frequency of 14.7 MHz and selecting the difference frequency. This frequency is fed to the appropriate filter which, in the case of u.s.b., selects the signal of 10.6995 MHz.

33. The signal is mixed in the product detector with a 10.7 MHz frequency, and the difference frequency, 500 Hz, is the required a.f. output.

34. The l.s.b. channel is similar to the u.s.b. except that the filter selects a frequency above 10.7 MHz i.e. in the case of a 500 Hz audio tone, 10.7005 MHz.

Tuning

35. Tuning is carried out by selecting TUNE at the MODE switch, adjusting the selection controls of the synthesizer or 49 channel crystal oscillator so that the required frequency or channel is indicated on the dials, then adjusting the TUNE control to give maximum reading, after which the mode switch is set to OFF or to the required mode. During the short time that the synthesizer is tuning pulsed tones are supplied to the audio amplifier, and these tones are heard in the a.f. circuits, along with the 1 kHz tone (para. 37). When a 49 channel crystal oscillator is used only the 1 kHz tone is heard.

36. When the TUNE condition is selected the p.t.t. relay RLA, and the High Power relay RLB (if HIGH is selected) are energized, giving the Transmit condition. The microphone input and amplifier, and the audio compressor stage are disconnected in this condition.

37. The 1000 Hz Oscillator VT41 is permanently switched on when TUNE is selected, providing a tone which is fed, via the sidetone circuit, to the audio power amplifier. This tuning tone indicates that the TUNE position is selected.

The VT38 muting gate is set to the mute condition when TUNE is selected, preventing an audio or tone input being fed to the transmitter.

38. The 'unbalancing gate', set by RV6, is in operation during tuning, unbalancing the modulator as for a.m. working (paras. 15 and 16), thus providing a 10.7 MHz unmodulated signal. This signal is then fed to the a.m. filter, mixer pre-driver and p.a. stages as given in para. 17.

39. The a.t.u. is manually tuned by the front panel TUNE control. In the TUNE condition of the mode switch a sample of the r.f. current supplied to the antenna is detected and rectified by the T6, D18 stage, to form a positive d.c. signal whose amplitude is proportional to the antenna current. The d.c. signal is fed to the meter, which is used as a tuning indicator.

Power Supplies (Fig. 3)

40. Power is supplied by an 18V battery, or by an external power supply. A diode D17 is fitted to prevent damage due to a reversed polarity or incorrect supply connection. The diode passes sufficient reverse current to blow the fuse in the case of a wrong connection.

41. The battery voltage is fed via the mode switch to the various stages, relay and metering circuits when a mode is selected. A stabiliser circuit provides a 9V stabilised supply to certain stages. The metering circuit reads the battery voltage in all positions except TUNE (see para. 39) and OFF. The remainder of the power supplies are self evident.

CHAPTER 2

CIRCUIT DESCRIPTION

TRANSMITTER CIRCUITS (Fig.7)

Input Pre-Amplifier and Speech Compressor

1. Microphone inputs appear between pins A and D of SKT4 or 5 and are fed, via isolating resistors R154 to R157 and r.f. decoupling capacitors, to the input pre-amplifier VT39 and VT40. The amplifier stages are d.c. coupled and the gain is adjusted during manufacture or maintenance, by the pre-set potentiometer RV10 in the feed-back loop.

2. The speech compressor consists of two diodes D26a and D26b which symmetrically clip the peaks of audio signals when the 'knee' voltage of the diodes is exceeded.

Amplifier VT37, Level Control Gate and Muting Gate

3. Transistor VT37 forms an amplifier which accepts the a.f. signal from the speech compressor. Interposed between the speech compressor and the amplifier is a level control gate D25, RV8, and a muting gate. The level control is brought into operation during A.M. VOICE working, by a positive potential from switch SA1F which drives diode D25 into conduction, causing a part of the audio signal to be fed to earth via RV8. The reduced a.f. level is necessary to give the correct sideband to carrier level during this mode of working.

4. The muting gate VT38 is set to the conducting condition during the selection of TUNE, by a positive potential from switch SA1. In the TUNE condition the audio input to the modulator is not required, and is therefore fed directly to earth via VT38.

Modulator, Unbalancing Gate and Buffer Amplifier VT36

5. The modulator T14, D24a and D24b acts as a balanced modulator for s.s.b. working and an unbalanced modulator during A.M. VOICE and TUNE conditions. When the modulator is balanced the 10.7 MHz centre frequency is suppressed and the output consists of two sidebands centred about 10.7 MHz. When the stage is unbalanced the output consists of a 10.7 MHz signal with sidebands, i.e. a true a.m. signal.

6. Consider the case when there is no a.f. input and the modulator is in its balanced condition. The 10.7 MHz signal from the synthesizer or 49 channel oscillator is applied via the buffer amplifier VT36, to the primary of T14. The induced signal in the secondary of T14 will cause a current flow in the loop D24a, D24b, R125, R126 and RV7, producing a d.c. voltage across RV7. The capacitors C113 and C114 balance out the capacitance of the two diodes.

7. The modulator is set up during manufacture or maintenance so that the output at the wiper of RV7 is zero when no a.f. input is present. The modulator is then in its balanced condition. The injection of an a.f. signal (at the centre tap of T14 secondary) causes an output to be provided which consists of the two sidebands of the 10.7 MHz sub carrier signal, with the centre (10.7 MHz) frequency suppressed.

8. During a.m. working the 10.7 MHz signal and its sidebands are required. The unbalancing gate is brought into use by a positive potential fed to potentiometer RV6, which supplies a part of the potential to the two diodes of the modulator via the centre tap of T14. This unbalances the modulator providing a 10.7 MHz signal at its output when no a.f. input is present. When an i.f. input is applied a true a.m. signal results.

9. During tuning the 10.7 MHz signal only is required and this produces a signal at the required carrier frequency which is used to tune the equipment. A positive potential applied to RV6 unbalances the modulator as described in the previous paragraph. The a.f. input is muted (para. 4), therefore the output is a 10.7 MHz signal which is mixed, as described later, to form a continuous carrier.

I.F. Amplifiers VT34 and VT33

10. The output of the modulator is amplified by VT34, which is tuned to the i.f. by L14, C103 and C104. The gain of the stage can be controlled at a high or low level as described in para. 19. The output of VT34 is fed to a further i.f. amplifier VT33, whose gain is preset by potentiometer RV4, and then to the filtering and switching stages.

Filtering and Switching Stages

11. During transmission the switching diode D10 is set to the conducting condition (see para. 43), allowing the signal from VT33 to be fed to the appropriate filter via transformer T4. If an u.s.b. mode is selected, diode switches D36, D34, D30 and D28 are set to the conducting condition, allowing the signal to be fed through filter FL4 to filter FL3. If a l.s.b. mode is selected, switches D37, D35, D31 and D29 are set to conduct providing a path to filter FL3 via filter FL5. The appropriate filter FL4 or FL5 is therefore selected, filter FL3 having little effect upon the signal as its passband is larger than that of either of the other two filters.

12. When A.M. VOICE is selected switches D33 and D32 are set to conduct allowing the i.f. signals to be fed directly to filter FL3. The output of filter FL3 is fed, via diode switch D6, to the mixer T13, VT31, VT32.

Mixer T13, VT31, VT32 and Filter FL6

13. The T13, VT31, VT32 mixer accepts the i.f. signal and the appropriate channel oscillator frequency via diode switch D3, which is set to the conducting condition during transmission (see para. 43). The output of the mixer is filtered providing a modulated signal at channel output frequency.

14. The modulated i.f. signal is fed to the primary of T13. The centre tap of the secondary is fed with the channel oscillator signal and sum and difference signals are generated by the mixer VT31 and VT32. The potentiometer RV3 is preset to give the correct balance condition i.e. to prevent the channel oscillator frequency appearing at the output. The output of the amplifier is fed, via transformer T12, to the low pass filter FL6, which removes the sum frequency and passes the required difference frequency to the pre-driver stage.

Pre-Driver and Driver Stages

15. The pre-driver stage consists of VT30 and VT28, a d.c. coupled wideband stage embodying feedback via R89. The output of VT28 is coupled, via T11, to the wideband driver stage VT26 and VT27. The transformer T11 is damped by resistors R86 and R83 to give the required bandwidths. The diodes D23a and D23b provide the bias supply to the two transistors. The bias voltage is adjusted for HIGH or LOW power output by the bias control gate VT29, as given in para. 18. The driver stage is a push-pull amplifier stage, and is coupled to the p.a. stage via transformers T9 and T10, which are damped by R76, R77, R78 and R79.

P.A. Stage

16. The p.a. stage is a wideband push-pull amplifier, formed by transistors VT24 and VT25. Base bias for the transistors is provided by the network consisting of R68 to R71 and diode D22. The bias is taken from the 9V stabilized supply; the remainder of the p.a. stage is supplied from the 18V unstabilized supply. Feedback is supplied via R61, R62, C78 and R63, R64, C79; in addition frequency compensation is provided by R65, C80 and R66, C81. Transformers T7 and T8 couple the output of the p.a. to the a.t.u.; stabilizing networks R57, R58, C75 and R59, R60, C76 are fitted in the output circuit.

A.T.U.

17. The output of the p.a. is fed via relay contacts RLB-1 (see para. 21) and RLA-1 (in transmit condition) to the a.t.u. L1. This is a manually tuned inductor which is matched, in conjunction with C1 and C2, or C3, for use with a dipole or end-fed antenna, or is directly matched with a whip antenna. The r.f. signal to the a.t.u. is fed via the antenna current detector T6, which is described in para. 40.

High and Low Power Selection

18. Switch SB controls the selection of HIGH or LOW transmitted power, via relay RLB which gives high power when it is energized. Relay contacts RLB-2 control the Bias Adjusting Gate VT29 and the Gain Control Gate VT35, by applying a positive voltage to the two stages when high power is required.

19. Gain Control Gate VT35. The i.f. amplifier VT34 (see para. 10) embodies the Gain Control Gate VT35 in its emitter circuit, to allow the gain of the amplifier to be increased when high power is selected. This is achieved by applying a positive potential to the base of VT35, and driving it into conduction. The conducting transistor places C107 in parallel with R116; the capacitor has a very low impedance at i.f. therefore the resistor R116 is effectively short circuited to a.c. signals, and the current swing, and consequently the gain, of VT34 is increased.

20. Bias Adjusting Gate VT29. The base bias for the driver amplifier VT26, VT27 is derived from the voltage drop across D23a and D23b. In the LOW power condition the bias is fed from the 9V supply via resistor R84. When relay contacts RLB-2 are closed a positive potential is fed to the base of VT29, which drives this transistor into saturation. This brings resistor R90 into circuit, in parallel with R84, increasing the current supply to the driver stage and increasing the bias voltage to VT26 and VT27 to handle the increased drive level.

21. Matching of A.T.U. Relay contacts RLB-1 connect the secondary of T7 in series with the secondary of T8 for high power operation, thus ensuring optimum matching of the a.t.u. to the power amplifier.

RECEIVER CIRCUITS (Fig. 7)

A.T.U., Protection Circuit and Filter FL1

22. The antenna input is fed, via the a.t.u., to a protection circuit consisting of diodes D1a and D1b. If signals are received whose amplitude is above the 'knee' voltage of the diodes, the signals are clipped, preventing damage due to overloading of the receiver circuits. The filter FL1 ensures that signals above 8 MHz (e.g. the channel oscillator of i.f. signals) cannot be fed to the antenna system.

Diode Switches D3, D5 and Mixer VT1, VT2

23. The input from the filter FL1 is fed, via T1, to a mixer stage VT1, VT2, D4a, D4b. This stage is also supplied with the channel frequency via filter FL2 and diode switch D2, which is conducting during reception (see para. 43). The mixer works in a similar manner to the mixer VT31, VT32 (para. 13) providing sum and difference frequencies. The balance of the mixer is set by RV1. The difference signal, which is the i.f. signal carrying modulation, is selected by T3 and fed via conducting diode switch D5, to the filtering and switching stages. An a.g.c. potential is applied to the stage,

as described in para. 30.

Filtering and Switching Stages

24. These stages and associated switches operate in the same manner as during transmission (see para. 11) except that the signal flow is in the opposite direction.

Diode Switch D7 and I.F. Amplifiers VT13 and VT14

25. The i.f. signal from the filter stages is fed to the i.f. amplifiers via diode switch D7, which is conducting during reception. VT13 and VT14 are two tuned stages which amplify the i.f. signal and feed it to a third stage VT15. An a.g.c. voltage is applied to the i.f. amplifiers, as described in para. 30.

I.F. Amplifier VT15 and Detector VT17

26. The load for the amplifier VT15 is formed by transformer T5, which couples the stage to the detector, VT17. During s.s.b. working a 10.7 MHz signal is applied to the secondary of T5 via C39, so the base of VT17 is fed with two signals, a suppressed carried 10.7 MHz s.s.b. signal and an unmodulated 10.7 MHz signal. Mixing takes place in VT17, due to the arrangement of bias, and the resultant difference signal is fed, via C46, to the audio stages. This difference is the required a.f. intelligence. The i.f. and 10.7 MHz signals are suppressed by L11 and associated filtering components.

27. During a.m. reception the unmodulated 10.7 MHz signal is muted at source via switch wafer SA1B, therefore only the modulated 10.7 MHz a.m. signal is applied to VT17 which acts as a normal detector and extracts the a.f. intelligence.

Audio Pre-Amplifier and Level Limiter

28. Transistor VT19 is an audio amplifier, the output of which is limited by diodes D14a, D14b, D15a and D15b. The diodes conduct if a predetermined audio level is exceeded, feeding part of the a.f. signal to earth and preventing large transients in the a.f. output.

Manual Gain Control and Audio Power Amplifier

29. The a.f. gain level to the audio power amplifier is controlled by RV2, the manual GAIN control fitted to the front panel. Transistor VT20 is a driver for the symmetrical, transformerless, output stage VT21, VT22, which provides the required a.f. level from the receiver.

A.G.C.

30. The a.g.c. amplifier consists of transistors VT16 and VT18 and is fed with input signals from the VT17 and VT19 stages. Considering the input from the VT17 stage first, this is rectified by D11 to form a positive voltage which is applied to the base of VT18. The magnitude of the positive voltage is dependent upon input signal level to VT17.

31. The positive voltage at VT18 base produces a reduction in voltage at the output of VT16 which reduces the positive bias applied to the controlled stages (VT1 and VT2, VT13, VT14) and reduces the gain of the stages. Thus an increase in the detector output reduces the i.f. gain so that the receiver output is maintained at a sensibly constant level.

32. During s.s.b. reception, or a.m. reception when modulation is present, the input to the a.g.c. amplifier is taken from the a.f. stage VT19. A time delay circuit is included to prevent noise being heard between words or keyed tones. During a.m. reception when modulation is not present the input is taken from VT17, and is due to the carrier signal.

33. The audio signal is fed via R43 and C49 to the voltage doubler D12 and D13, where it is rectified to form a positive voltage at the base of VT18, which operates as given in para. 31. C45 is charged during a.g.c. operation and, since the charge can only leak away slowly, via VT18 and associated circuit, the a.g.c. voltage is maintained for a short while after the audio input ceases.

34. The two inputs to the a.g.c. amplifier are both in operation during reception, and the applied a.g.c. voltage is due to the largest of the two inputs under the particular operating conditions.

MODE P.T.~~T. AND~~ KEYING CIRCUITS (Figs. 7 and [illegible]) 3

35. The appropriate diode switches for the u.s.b., l.s.b. and a.m. filters are set to the conducting condition by a positive voltage from the mode switch, thus selecting the appropriate filter to suit the required mode. When a VOICE mode is selected a power supply is fed to the input pre-amplifier of the transmitter, ~~allowing [illegible]~~ inputs to be made. In KEY modes the pre-amplifier is switched off and a power supply is fed to the tone oscillator VT41.

Tone Oscillator VT41

36. The tone oscillator is a Colpitts circuit whose frequency is determined by the pre-set inductor L15, C129 and C130. The amplitude of signal from the oscillator is pre-set by potentiometer RV9. The diode D27 limits the positive voltage applied to the emitter of VT41 during key-up conditions.

P.T.T. Circuits

37. The P.T.T. (Press to Transmit) circuit is brought into operation by connecting pins C and D of an audio socket together, via an external switch. This action causes relay RLA to be energized if LOW power is selected or both relays RLA and RLB to be selected if HIGH power is in use. Relay contacts RLA-1 change-over the a.t.u. circuit from the receiver to the transmitter circuits; contacts RLA-2 change-over power supplies. The operation of the HIGH-LOW power relay RLB is given in para. 18.

Keying Circuits

38. When a keying mode is selected power is supplied to the 1 kHz tone oscillator via switch SA2B, and relays RLA and RLB are connected to the external key circuit at pins E and D of the audio sockets. When the key is depressed the tone oscillator circuit is completed, providing a 1000 Hz tone to the transmit circuits, and the relay(s) circuit(s) is (are) completed giving the conditions described in the previous paragraph. In this case the time delay circuits, C83, R75 for relay RLA and C82, R80 for relay RLB, are also brought into circuit. When the key is released the capacitors must discharge via the resistors before the relay(s) can de -energize, thus maintaining the transmit condition during normal keying spaces.

TUNING CIRCUITS

39. When TUNE is selected, relay RLA and relay RLB (if HIGH power is in use) are energized giving the transmit condition. The modulator 'unbalancing gate' is brought into circuit as described in para. 8, and carrier signal, at the selected frequency, is fed to the a.t.u. via T6 and an Antenna Current Detector D18 and D19. The 'A.M.' condition of the filter and switching stages is selected by switch SA1F, in the same manner as given in para. 12.

Antenna Current Detector

40. The r.f. current to the a.t.u. is coupled by the current transformer T6 to its load resistor R55. The voltage across R55 is rectified by diode D18 which, in conjunction with a load resistor R56 and the meter circuit, forms a d.c. circuit whose current flow is proportional to r.f. current. Diode D19 protects the meter; C77 is a smoothing capacitor.

Metering Circuit

41. The d.c. current developed by the detector is fed to the meter via switch wafer SA3F (figs. 3 and 7) to give an indication of antenna current during tuning.

Tuning Tone

42. The I kHz oscillator is in operation during tuning to provide a tone in the receiver a.f. circuits. This tone is not fed to the transmitter circuits as it is muted by VT38 when TUNE is selected (see para. 4). When a synthesizer is used pulsed 'out of lock' tones are also fed to the receiver a.f. circuits during the short time that the synthesizer is tuning. The pulsed tones are not provided when a 49 channel crystal oscillator is in use.

DIODE SWITCHES (Fig. 7)

43. The diode switches control the flow of r.f. and i.f. signals, by presenting a low impedance (conducting condition) or a high impedance (non-conducting condition) to the signals in accordance with d.c. control voltages. The diode switches D2 and D3 will be described as typical examples.

44. During reception a positive voltage is applied to D2, via R5. This causes a d.c. current flow through D2 to earth via T2 secondary. Because the diode is conducting it offers a low impedance to the channel oscillator signal from FL2 and this is fed via T2 and the diode to the receiver circuits. When the positive voltage is removed the diode does not conduct presenting a high impedance to the channel oscillator thus preventing the signal reaching the receiver.

45. The diode D3 works in a similar manner to D2, controlling the supply of the channel oscillator signal to the transmitter.

46. The diodes do not rectify or alter the r.f. signal (apart from a small attenuation) as the applied d.c. level is greater than the peak to peak swing of the r.f., and the diodes are conducting during the whole of the r.f. cycle.

POWER SUPPLIES

47. Power supplies are taken from an 18V battery within the unit, or from an external source connected to pins B and D of an audio socket (see fig. 7). The supply is stabilized at 9 volts by D16 and VT23.

Stabilizer VT23

48. The Zener diode D16 provides, in conjunction with R50, a constant reference voltage at the base of the series current regulator VT23, which acts as an emitter follower. This transistor, in conjunction with R53, ensures that a stabilized 9V supply is maintained. Capacitor C65 prevents surges affecting the reference voltage.

Stabilizer VT23

49. The Zener diode D16 provides, in conjunction with R50, a constant reference voltage at the base of the series current regulator VT23, which acts as an emitter follower. This transistor, in conjunction with R53, ensures that a stabilized 9V supply is maintained. Capacitor C65 prevents surges affecting the reference voltage.

CHAPTER 3

MAINTENANCE

INTRODUCTION

1. This chapter covers maintenance procedures and tests on the complete Manpack and on the Transceiver Unit MA.924. Maintenance information on the Synthesizer MA.920 or the 49 channel Crystal Oscillator MA.923 is given in Part 3 Chapter 3 of this handbook. Each procedure can be carried out in isolation from the remainder of the procedures, unless otherwise indicated.

TEST EQUIPMENT

2. The following test equipment is required to carry out the procedures given in this chapter.

(1) Test Set (including power supply). The Racal Type CA.470B is suitable.

(2) Multimeter, Electronic, R.F., having d.c. ranges and r.f. ranges which can be used up to 25 MHz. The Marconi Type TF2604 is suitable.

(3) Multimeter, Electronic, A.F., having a range of up to 10 mV at 20 Hz to 100 kHz. The advance Type 77C is suitable.

(4) Audio Power Output Meter, having a range of 10 Hz to 100 kHz at an input impedance to 300Ω and ranges of 1 mW to 10 mW. The Marconi Type TF893 is suitable.

(5) R.F. Signal Generator having a range of 1 to 20 MHz at 50Ω output impedance, which can be modulated up to 30% at 1000 Hz. The Marconi Type TF.144H is suitable.

(6) A.F. Two Tone Signal Generator, having outputs of 20 to 3000 Hz at 600Ω impedance, with an output level of 1 mV to 1V. The Dymar Type 745 is suitable.

(7) Digital Frequency Counter having a range of up to 20 MHz at 50 mV r.m.s. input. The Racal type 9022 is suitable.

(8) Oscilloscope having a frequency range of d.c. to 20 MHz and a sensitivity of 50 mV/cm. The Advance OS2000 is suitable.

(9) A.F. Signal Generator having a frequency range berween 20 Hz and 20 kHz at 600Ω impedance. The advance J2 is suitable.

(10) R.F. Wattmeter covering the range of 2 to 8 MHz at 50Ω input impedance and capable of dissipating 25W. The Marconi Type TF.2503 is suitable.

NOTE: The wattmeter is not required when the CA.470B Test Set is used.

(11) Multimeter, General Purpose. The Avometer Model 8 is suitab

(12) Power Supply capable of continuously providing 3A at 18V d.c.

NOTE: The power supply is not required when a CA.470B test set is used.

Use of Test Set CA.470B

3. The Test Set CA.470B simplifies maintenance operations. It consists of the following circuits.

(1) A power supply with overload protection, allowing a manpack to be driven from 100 to 125V or 200 to 250V 45 to 60 Hz mains, without risk of damage due to internal short circuits etc.

(2) A 50Ω dummy load incorporating a wattmeter, allowing easy measurements of output power.

(3) Connecting points for a.f. inputs and outputs and a frequency counter or oscilloscope.

(4) Transmit/Receive and Key switching.

4. The power supply circuit within the test set will 'trip out' if excess current is drawn, removing the power supply. The POWER switch must be set to the OFF AND RESET position, then returned to the ON position to re-establish the power supply.

5. The following paragraphs are written on the assumption that a test set is available. If a test set is not available it will be necessary to use a six pole plug connected to an audio socket SKT4 or SKT5, to provide power supplies, audio inputs and outputs, keying signals and p.t.t. signals. A metered dummy load will be required to measure output powers.

CHANNEL FREQUENCY SELECTION

5A. As previously stated, the SYNCAL utilises a synthesizer with controls which are marked in frequency, and the COMCAL utilises a 49 channel crystal oscillator, with controls marked in channel numbers. It is important to note that the channel frequency of the oscillator is not the crystal frequency, but is 10.7 MHz below crystal frequency.

INITIAL PROCEDURE

6. (1) Set the mode switch to the OFF position.

(2) Remove the manpack from its haversack and remove the battery.

(3) Remove the transmitter - receiver from its case.

(4) Remove the outer cover from the transceiver unit.

(5) Set the POWER switch on the test set to OFF and the TRANS/REC switch to REC. Connect the six pole plug of the test set to the audio socket on the front panel of the transmitter-receiver.

(6) Check all controls (including TUNE control) for smooth action. Check plugs and sockets for correct mating.

(7) Switch on power at the CA.470B Test Set, and select VOICE A.M., KEY L.S.B., VOICE L.S.B., VOICE U.S.B. and KEY U.S.B. in turn on the manpack mode switch and check that the meter indicates approximately 0.8 scale deflection. Select OFF at the mode switch.

VOLTAGE STABILIZER CHECK

7. (1) Connect a multimeter, set to the 25V d.c. range, across the 10.7 MHz mute connection (pin 2 on the synthesizer, or 49 channel crystal oscillator) and earth.

(2) Select VOICE A.M. and check that a reading between 8.5V and 10.5V is given.

(3) Select OFF at the mode switch and remove the multimeter.

RECEIVER

A.F. Power Output Check

8. (1) Connect an audio power meter, set to the 10 mW range at an input impedance of 300Ω to terminals A.F. and EARTH of the Test Set.

(2) Connect the 600Ω output of the A.F. Signal Generator and an AF valve voltmeter to the point TP6 and earth.

(3) Connect an oscilloscope across the aduio power meter.

(4) Select any mode (other than TUNE), set the GAIN control to maximum and the audio generator to provide a 1 kHz signal at minimum output. Increase the audio generator level until clipping can be seen to start, denoted on the oscilloscope by a flattening of the peaks of the signal.

(5) Check that the audio power meter indicates between 10 to 20 mW.

(6) Set the mode switch to OFF and remove test equipment.

A.F. Amplifier Sensitivity and Bandwidth Check

9. (1) Carry out operations (1) and (2) of the preceding paragraph.

(2) Select any mode (other than TUNE), and adjust the audio generator to 1 kHz, at an output level sufficient to provide an indication on the power meter of 4 mW, with the GAIN control set to maximum. The input from the audio generator should be betweem 6 amd 10 mV.

(3) Reduce the frequency of the signal without disturbing its output level setting, until the power output has dropped to 1 mW. The audio generator frequency should be between 90 and 150 Hz.

(4) Increase the audio generator frequency without disturbing its output level until the power output has again dropped to 1 mW. The frequency should be between 5 and 10 kHz.

(5) Set the mode switch to OFF and disconnect test equipment from TP6.

I.F. Amplifier Alignment

10. (1) Connect an audio power meter to the A.F. and EARTH terminals of the test set. Set the meter to the 10 mW range at 300Ω input.

(2) Connect an r.f. signal generator to test point TP4 and earth.

(3) Select A.M. VOICE and adjust the signal generator to provide an output of 20μV e.m.f. at 10.7 MHz, modulated by a tone of 1 kHz to a depth of 30%.

(4) Adjust the cores of L10 and L9, in that order, to give maximum indication on the audio power meter.

(5) Repeat operation (4) until optimum conditions are obtained, then set the mode switch to OFF.

(6) Lock the cores of L10 and L9 using a compound such as Silicone Coil Retaining Compound Part No. 915906.

Channel Oscillator and 10.7 MHz Input Level Checks

11. (1) Connect an electronic voltmeter, set to the 300 mV r.f. range, to test point TP1 and earth.

(2) Set the synthesizer controls to 4·000 MHz, or the channel oscillator controls to nearest frequency, select VOICE L.S.B. and check that the electronic voltmeter indicates 150mV minimum when a synthesizer is used, or 175mV minimum when a channel oscillator is used.

(3) Connect the electronic voltmeter to test point TP5 and check that an indication of 100 mV minimum is given. Set the mode switch to OFF and remove test equipment.

Mixer Balancing

12. (1) Set the synthesizer controls to 2.000 MHz or the channel oscillator controls to nearest frequency. Connect a signal generator to the 2-4 MHz antenna socket, and tune the generator to provide an output at the selected frequency, at an output level of 2 μV e.m.f. Connect an audio power meter to the A.F. and EARTH terminals of the test set, and adjust the power meter to the 10 mW range at 300Ω input.

(2) Select VOICE U.S.B. and with the GAIN control at maximum adjust the TUNE control and signal generator frequency to give maximum output on the audio power meter.

(3) Switch the signal generator carrier off, adjust RV1 for minimum reading on the power meter.

(4) Restore the signal generator carrier and adjust RV13 to give 2 mW on the power meter.

(5) Set the mode switch to OFF and remove test equipment.

Sensitivity Check

13. (1) Connect an a.f. power meter, set to the 10 mW range at an input impedance of 300Ω to terminals A.F. and EARTH of the test set.

(2) Connect an r.f. signal generator to the 2 - 4 MHz 50Ω antenna socket on the manpack.

(3) Set the synthesizer controls to 2.000 MHz, or the channel oscillator controls to nearest frequency.

(4) Adjust the output of the signal generator to channel frequency plus 1 kHz, unmodulated, at a level of 2μV e.m.f.

(5) Select VOICE U.S.B., set the gain control to maximum, and adjust the TUNE control for maximum output.

(6) Check that the a.f. power meter indicates an output of at least 2 mW.

(7) Retune the signal generator output frequency. Select VOICE L.S.B. and check that a minimum a.f. power meter reading of 2 mW is obtained.

(8) Repeat operations (4) to (7) with the synthesizer controls set to 8 MHz, or the channel oscillator controls set to nearest frequency.

(9) Set the mode switch to OFF. Remove test equipment unless further checks are to be carried out.

Signal to Noise Ratio Check

14. (1) Carry out operations (1) to (5) of the preceding paragraph. Note the a.f. power output.

(2) Mute the signal generator output and check that the power meter indicates at least 15 dB below the previous level.

(3) Repeat the previous operations with the mode switch set to VOICE L.S.B.

(4) Repeat operation (3) with the synthesizer controls set to 8 MHz, or the channel oscillator controls set to nearest frequency, and VOICE U.S.B. selected.

(5) Repeat operation (4) with the VOICE L.S.B. selected.

(6) Set the mode switch to OFF. Remove test equipment unless further checks are to be carried out.

Overall Frequency Response

15. (1) Carry out operations (1) to (5) of para. 13. Connect a digital frequency counter across the a.f. power meter. Adjust the GAIN control to give a power output of 2 mW.

(2) Increase the generator output to 4 μV e.m.f. Gradually increase the frequency of the signal generator until the power output returns to 2 mW.

(3) Check that the frequency indicated on the counter is between 2.5 and 2.5 kHz.

(4) Reset the signal generator to the original frequency, then slowly decrease frequency until the power output drops to 2 mW.

(5) Check that the frequency indicated on the counter is between 100 Hz and 500 Hz.

(6) Repeat the above procedures with VOICE L.S.B. selected.

(7) Set the mode switch to OFF. Remove test equipment unless further checks are to be carried out.

A.G.C. Response Check

16. (1) Carry out operations (1) to (5) of para. 13. Adjust the GAIN control to give 1 mW output.

(2) Increase the signal generator output by 10dB (i.e. to 6 μV e.m.f.) and check that the power output increases to 4 mW maximum.

(3) Increase the signal generator output by a further 90 dB (i.e. to 200 mV e.m.f.) and check that the power output increases to 6 mW maximum.

(4) Set the mode switch to OFF. Remove test equipment unless further checks are to be carried out.

Spurious Response

17. (1) Connect an a.f. power meter, set to the 10 mW range at an input impedance of 300Ω to terminals A.F. and EARTH of the test set.

(2) Connect an r.f. signal generator to the 4-8 MHz 50Ω antenna socket of the manpack.

(3) Set the synthesizer controls to 5.352 MHz or the channel oscillator controls to the nearest frequency.

(4) Adjust the output of the generator to the channel frequency and its output to 2 μV emf.

(5) Select VOICE L.S.B. and adjust the tune controls for maximum output.

(6) Set the gain control to give 2 mW output.

(7) Set the synthesizer controls to 7.999 MHz or the channel oscillator controls to the nearest frequency.

(8) Check that the increase in output level of the signal generator is at least 40 dB above 2 μV to obtain a reading of 2 mW as before, retuning the generator slightly to obtain maximum output.

(9) Adjust the output of the generator to the channel frequency and its output to 2 μV emf.

(10) Adjust the TUNE control for maximum output and set the GAIN control to give 2 mW output.

(11) Re-tune the signal generator to the image frequency of 29.401 MHz and increase the output level until the a.f. power meter again indicates 2 mW.

(12) Ensure that the signal generator output level necessary to achieve 2 mW output is at least 60 dB above 2 μV, i.e. an output level of 2 mV.

(13) Reduce the generator frequency to the i.f. of 10.701 MHz and adjust its output level to obtain an output level of 2 mW.

(14) Ensure that the signal generator output level necessary to achieve 2 mW output is at least 40dB above 2 μV i.e. an output level of 200 μV.

(15) Set the mode switch to OFF and disconnect all test equipment except the CA.470 test set.

TRANSMITTER

Setting of A.F. Amplifier and Speech Clipper Check

18. (1) Connect a link between test point TP8 and earth.

(2) Connect the 600Ω output of the two tone audio generator to MOD and EARTH terminals of the test set. Adjust the generator to provide an 1000 Hz tone at an output level of 6 mV e.m.f.

(3) Connect an electronic voltmeter and an oscilloscope to test point TP9 and earth.

(4) Select HIGH power and VOICE L.S.B. at the mode switch and TRANSMIT at the test set.

(5) Adjust RV10 until an a.f. output of 100 mV is indicated on the electronic voltmeter.

(6) Increase the audio generator output by 10dB (i.e. to 20 mV) and check that the waveform shown on the oscilloscope is compressed.

(7) Set the mode switch to OFF and remove test equipment unless the check given in the next paragraph is to be carried out.

A.F. ~~A.M.~~ Amplifier Response Check

19. (1) With the equipment in the condition given at the end of the previous check, decrease the audio generator output to 6 mV.

(2) Increase the frequency of the audio generator until the indicated output on the electronic voltmeter drops to 50 mV. Check that the frequency of the aduio generator is between 10 and 30 kHz.

(3) Reset the audio generator to 1000 Hz, then decrease frequency until the indicated output again drops to 50 mV. Check that the frequency of the audio generator is between 75 and 150 Hz.

(4) Set the mode switch to OFF and disconnect test equipment except test set and audio oscillator.

Tone Oscillator Check

20. (1) Connect an electronic voltmeter and digital frequency meter to test point TP9 and earth. Set RV9 fully clockwise, set the mode switch to KEY L.S.B. and depress the KEY push button on the test set.

(2) Adjust L15 to give a reading of 1000 Hz on the frequency meter.

(3) Disconnect frequency meter and connect an oscilloscope in its place. Depress the KEY push button and adjust the oscilloscope to display the 1000 Hz note.

(4) Select TUNE and check that the oscilloscope display is muted.

(5) Set the mode switch to OFF, remove oscilloscope and electronic voltmeter from TP9.

NOTE: RV9 must be set to give the required level as in para. 28 (output power setting) after carrying out the above procedure.

Channel Oscillator Output Level Check

21. (1) Connect an electronic voltmeter, set to the 300 mV r.f. range, between test point TP2 and earth.

(2) Select VOICE L.S.B. and TRANSMIT, and check that the electronic voltmeter indicates a level greater than 200 mV, with the synthesizer controls set, in turn, to 2.000, 4.000, and 7.999 MHz, or the channel oscillator controls set to each usable channel in turn.

(3) Set the mode switch to OFF and remove electronic voltmeter.

Balanced Modulator Setting and I.F. Amplifier Alignment

22. (1) Set the synthesizer controls to 4.000 MHz, or the channel oscillator to the nearest frequency. Select the ~~10 W~~ 50W position of the meter on the test set, and connect the test set r.f. connector to the 2-4 MHz 50Ω output socket of the manpack. Connect an oscilloscope to the COUNTER socket of the test set.

(2) Select VOICE L.S.B., TRANSMIT and HIGH power, and adjust the TUNE control for maximum output, modulating the signal as given in para. 18(2).

~~NOTE: Ensure that the meter of the test set is now overloaded, use the 50 W setting if necessary.~~

(3) Adjust RV4 to give an output of approximately 10 W.

(4) Adjust L14 to give maximum output and seal the core using a suitable compound such as Rocol Silicone Coil Retaining Compound MS.2241.

(5) Disconnect the a.f. input and adjust the sensitivity of the oscilloscope to maximum.

(6) Adjust RV7 and C113 to give minimum indication on the oscilloscope.

NOTE: RV4 must be set to give the required I.F. gain as in para. 24 after carrying out the above procedure.

Sideband Filter Output Matching

23. (1) Carry out operations (1) and (2) of the preceeding paragraph.

(2) Note the output level on the power meter.

(3) Select VOICE U.S.B. mode and again note the output level on the meter. If the readings differ adjust RV11 and RV12 as necessary to give identical readings with one of the potentiometer settings remaining fully clockwise.

(4) Switch the mode switch to OFF.

Channel Mixer Balancing and I.F. Amplifier Gain Setting

24. (1) Connect the 600Ω output of an audio generator to the MOD and EARTH terminals of the test set. Set the output to 1100 Hz, at 6 mV.

(2) Select VOICE L.S.B., TRANSMIT and HIGH power, and set the synthesizer controls to 4.00 MHz or the channel oscillator to the nearest frequency. Adjust TUNE control for maximum output.

(3) Adjust RV3 to give maximum power output.

(4) Adjust RV4 to give a power output of 17 W.

(5) Set the mode switch to OFF.

Two-Tone Output Level Tests

25. (1) Connect an oscilloscope to the COUNTER socket on the test set. Connect an electronic voltmeter, set to the 100V range, to the rear of the 2-4 MHz 50Ω output socket.

(2) Set the synthesizer controls to 4 MHz or the channel oscillator to the nearest frequency.

(3) Connect the 600Ω output of a two-tone audio generator to the MOD and EARTH terminals of the test set. Set the output to 1100 Hz and 1800 Hz, each at a level of 5 mV.

(4) Select VOICE L.S.B., TRANSMIT and HIGH power, and check that the two tone test pattern is slightly compressed, due to the action of the speech compressor.

(5) If necessary, slightly adjust the TUNE control for maximum reading on the electronic voltmeter. The reading should not be less than 32V. Set the mode switch to OFF and remove test gear.

Setting of Carrier Re-Insertion Level (A.M. Voice and Tune)

26. (1) Connect an audio generator to the MOD and EARTH terminals of the test set. Connect an oscilloscope to the COUNTER socket of the test set.

(2) Set the synthesizer controls to 4.000 MHz, or the channel oscillator to the nearest frequency, select VOICE A.M., HIGH power and TRANSMIT. Adjust TUNE control for maximum output.

(3) Adjust RV6 to provide a power output of 7 W, with no audio input.

(4) Select LOW power and check that a power output of 1 to 2 W is given.

(5) Tune the audio generator to provide an 1000 Hz input at 50 mV. Select HIGH power and adjust RV8 until the signal, as displayed on the oscilloscope, is 100% modulated.

(6) Select TUNE and check that a power output of 7 W is obtained.

(7) Set the mode switch to OFF, and remove test equipment.

Measurement of Carrier Suppression

27. (1) Remove the audio generator input to the test set, and open circuit the MOD and EARTH terminals.

(2) Connect an oscilloscope to the rear of the 2-4 MHz 50Ω output socket.

(3) Set the synthesizer to 4.000 MHz, or the channel oscillator to the nearest frequency, select TUNE and HIGH power. Adjust the TUNE control for maximum output.

(4) Select VOICE L.S.B. and check that the peak-to-peak voltage indicated on the oscilloscope is not greater than 800 mV.

(5) Select VOICE U.S.B. and repeat operation (4).

(6) Set the mode switch to OFF and remove oscilloscope.

Setting of Output Power-Keying Modes

28. (1) Set the meter switch to the 50 W position. Set the synthesizer controls to 4.000 MHz, or the channel oscillator to the nearest frequency, select KEY L.S.B. mode, and adjust the TUNE control for maximum output with KEY push button depressed.

(2) Adjust RV9, again with KEY push button depressed, to give an output power of 23 W.

(3) Select KEY L.S.B., depress key, and check that the power output is within 22-24W.

(4) Set the synthesizer controls to 2.000 MHz, or the channel oscillator to the nearest frequency, select KEY L.S.B. mode, tune the equipment and check that, with key depressed, an output between 12 and 23 W is obtained.

(5) Repeat operation (4) with the synthesizer controls set to 4.000 MHz, or the channel oscillator set to the nearest frequency, and the output connection connected to the 4-8 MHz socket.

(6) Repeat operation (5) with the synthesizer controls set to 7.999 MHz, or the channel oscillator set to the nearest frequency.

(7) Set the mode switch to OFF, unless the check given in the next paragraph is to be carried out.

Sidetone Check

29. This check should be carried out after the procedure in the preceding paragraph has been carried out.

(1) With the equipment in the condition given at the end of the preceding paragraph connect an electronic voltmeter, set to the 1V range, to the A.F. and EARTH terminals of the test set.

(2) Select KEY U.S.B., press the KEY push button, and check that an audio output of between 150 and 300 mV is indicated.

(3) Select KEY L.S.B. and repeat operation (2).

(4) Select TUNE and check that an audio output of between 150 and 300 mV is indicated.

(5) Set the mode switch to OFF and remove all test equipment.