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PART. 1

PART 1

LEADING PARTICULARS AND GENERAL INFORMATION

LEADING PARTICULARS

TGRI(AT)23183/1 comprises the main equipments listed below plus their carrying cases:-

Transceiver KWM-2A fitted with a Noise blanker 136B-2 and an a.c. power supply PM-2;

Station control 312B-4;

Microphone SM-2;

◀ Portable antenna TD-1 or Adjustable dipole antenna 637T-2. ▶

An additional unit, the r.f. linear amplifier 30L-1, is also available for transforming the transceiver KWM-2A output from low power to medium power. This unit is not part of TGRI(AT)23183/1, but is fully described in this publication.

The above units comprise a manually operated, portable transmitter-receiver system for operation on single-sideband (upper or lower) or c.w. transmission and reception. The system frequency range is 3·4 MHz to 30 MHz divided into two groups of fourteen crystal-controlled bands.

The equipment is transported in two carrying cases CC-2 and one carrying case CC-3, and operates from a 50 - 60 Hz single-phase mains supply.

▶◀

PERFORMANCE DATA

TRANSCEIVER KWM-2A (110D/39169)

Frequency range	3·4 MHz to 5 MHz and 6·5 MHz to 30 MHz
Frequency bands	A maximum of twenty-eight, each 200 kHz wide
Frequency calibration accuracy ...	±1 kHz
Frequency stability	Not greater than 100 Hz variation after initial warm-up
Modes of operation	Single-sideband (upper or lower) or c.w.
Type of service	Single-sideband: continuous, c.w.: 50 per cent duty cycle. (Continuous key-down conditions not to exceed 15 sec duration).
Type of c.w. keying	Break-in
Ambient temperature range	32 °F to 122 °F (0 °C to 50 °C)
Ambient humidity range	0 to 90 per cent
Operational altitude	Sea level to 10,000 ft
Supply voltages	The associated a.c. power supply PM-2 provides all necessary h.t. and valve heater supplies

Power consumption (approximate)	235 W (receive); 475 W (transmit)
Transmitter characteristics:	
R.F. power output	100 W p.e.p. into 50 ohms
R.F. output impedance	50 ohms unbalanced with a v.s.w.r. of not greater than 2 : 1
Distortion	At least 30 db below p.e.p. output (third-order distortion)
Carrier suppression	50 db below p.e.p. output
Unwanted sideband suppression ...	50 db below p.e.p. output
Oscillator breakthrough or undesired mixer products	50 db below p.e.p. output
Second harmonic radiation	40 db below p.e.p. output
Microphone or phone patch input impedance	High impedance, unbalanced
Audio frequency response	300 Hz to 2·4 kHz at -6 db
Receiver characteristics:	
Sensitivity	0·5 μV for 10 db signal-to-noise ratio
Selectivity	2·1 kHz bandwidth at -6 db, 4·2 kHz bandwidth at -60 db (either sideband)
Input impedance	50 ohms, unbalanced
Image rejection	50 db minimum
Audio output power	1 W maximum
Output impedances	Loudspeaker: 4 ohms. Headphones: 600 ohms. Phone patch: 500 ohms.

NOISE BLANKER 136B-2 (110D/39172)

Frequency	40 MHz
Bandwidth	1·5 MHz ± 0·5 MHz
I.F. bandwidth	1·5 MHz to 4 MHz
Sensitivity	Input signal of 100 μV (peak) causes at least 35 db reduction of gain in the receiver signal path
Cross modulation	6 db maximum deterioration in cross modulation and/or blocking characteristics of the associated transceiver
Spurious response	Internal noise introduced by 136B-2 is less than 1 μV equivalent signal

Input impedance	40 MHz amplifier: 50 ohms ± 50% unbalanced; i.f. amplifier: high impedance.
Output impedance	High impedance
Power supply	The associated transceiver
Ambient temperature range	32 °F to 122 °F (0 °C to 50 °C)
Ambient humidity range	0 to 90 per cent
Operational altitude	Sea level to 10,000 ft

A.C. POWER SUPPLY PM-2 (110K/39171)

Supply voltage	115 V to 230 V, 50 - 60 Hz, single-phase
Output voltages	+800 V, d.c.; +275 V, d.c.; -50 V to -90 V, d.c. (adjustable bias supply); and 6·3 V, a.c.
Ambient temperature range	32 °F to 122 °F (0 °C to 50 °C)
Ambient humidity range	0 to 90 per cent
Operational altitude	Sea level to 10,000 ft

R.F. LINEAR AMPLIFIER 30L-1 (110D/39170)

Frequency range	3·4 MHz to 30 MHz
Modes of operation	Single-sideband or c.w.
Type of service	Single-sideband: continuous; c.w.: 50 per cent duty cycle (Continuous key-down conditions not to exceed 15 sec duration when used with KWM-2A).
Ambient temperature range	32 °F to 122 °F (0 °C to 50 °C)
Ambient humidity range	0 to 90 per cent
Operational altitude	Sea level to 10,000 ft
Supply voltage	115 V or 230 V, 50 - 60 Hz, single-phase
Power consumption (approximate) ...	1·55 kW maximum
Input impedance	52 ohms unbalanced
Drive power input	70 W
Output impedance	52 ohms unbalanced with a v.s.w.r. of not greater than 2 : 1
R.F. power output	500 W p.e.p. (s.s.b.) or 500 W (c.w.) into 52 ohms
Harmonic radiation	All harmonics at least 40 db below p.e.p. output

STATION CONTROL 312B-4 (110L/39168)

Telephone line impedance	600 ohms, balanced
Phone patch impedance	Receiver output to phone patch: 500 ohms; phone patch input to transmitter: high impedance.
Loudspeaker impedance	4 ohms
Ambient temperature range ...	32 °F to 122 °F (0 °C to 50 °C)
Ambient humidity range	0 to 90 per cent
Operational altitude	Sea level to 10,000 ft

MICROPHONE SM-2 (110AH/39085)

Type	Pressure operated dynamic
Impedance	100 kohms
Frequency response	250 Hz to 2·5 kHz at -3 db
Output level	-50 db below 1V/dyne/cm
Polarization pattern	Omni-directional

PORTABLE ANTENNA TD-1 (110B/39086)

Type	Adjustable half-wave dipole
Frequency range	3·5 MHz to 30 MHz
Impedance	50 ohms
Feed system	Unbalanced coaxial cable
Maximum r.f. power input	1000 W p.e.p.; or 1000 W, 100 per cent amplitude modulated.

◀ ADJUSTABLE DIPOLE ANTENNA 637T-2 (110B/5820-99-140-4229)

Type	Adjustable half-wave dipole
Frequency range	3·4 MHz to 30 MHz
Impedance	50 ohms
Feed system	Unbalanced coaxial cable
Maximum r.f. power input	1000 W, p.e.p.; or 1000 W, 100 per cent amplitude modulated. ▶

DIMENSIONS AND WEIGHTS

◀ Carrying cases CC-2 and CC-3	Height (in)	Width (in)	Depth (in)	Weight (lb)
CC-2 empty	21·5	21	9·5	9·5
CC-3 empty	21·5	21	9·5	10 ▶

DIMENSIONS AND WEIGHTS (cont.)

Carrying cases CC-2 and CC-3 (cont.)	Height (in)	Width (in)	Depth (in)	Weight (lb)
CC-2 loaded with KWM-2A and PM-2	21·5	21	9·5	42·5
CC-2 loaded with 30L-1	21·5	21	9·5	47·5
CC-3 loaded with 312B-4 and TD-1	21·5	21	9·5	22
Transceiver KWM-2A				
Including 136B-2	7·75	14·75	14	19·5
Noise Blanker 136B-2	4·75	6·38	1·88	1·25
A.C. power supply PM-2				
When detached from KWM-2A	7·75	14·75	11	13·5
When attached to KWM-2A	7·75	14·75	4	13·5
R.F. linear amplifier 30L-1	7·75	14·75	13·75	38
Station control 312B-4	7·5	10·75	11·75	8·5

Microphone SM-2

Length (without cable) 8·75 in; diameter 1·13 in;

Weight (without cable and stand) 14 oz.

Portable antenna TD-1

Height 5·5 in; depth 2 in; length (retracted) 10 in; length (fully extended) 132·5 ft; weight 3·5 lb.

Adjustable dipole antenna 637T-2

Height 5 in; length (retracted) 9 in; length (fully extended) 150 ft; width 4 in; weight 4·1 lb.

Chapter 1

INTRODUCTION AND BRIEF DESCRIPTION
(Completely revised)

CONTENTS

ILLUSTRATIONS

Modification state:

There are no official Service modifications applicable to this chapter.

Introduction

1. TGRI(AT) 23183/1 is a portable, h.f., 100 W, single-sideband (s.s.b.) or c.w. communications installation and consists of the equipments listed in the Leading Particulars together with a complete set of interconnecting cables. The r.f. linear amplifier 30L-1 (and its Carrying case Type CC-2) is not part of this installation, but is an additional unit for increasing the transmitted power output to 500 W and is described in full in this publication. The carrying cases are designed for transporting the complete equipment (fig. 1, 2 and 3) which can be operated from a 115 V or 230 V, 50 - 60 Hz, single-phase mains supply.

2. The transceiver KWM-2A frequency range of 3·4 MHz to 30 MHz is covered in two groups of fourteen bands, each band being 200 kHz wide. Twelve crystals are supplied as standard with the transceiver covering the frequency

bands listed below. A further sixteen crystals can be fitted as required to cover the remaining sections of the range 3·4 MHz to 30 MHz.

(1) 80 metre band: 3·4 MHz to 3·6 MHz; 3·6 MHz to 3·8 MHz; 3·8 MHz to 4 MHz.

(2) 40 metre band: 7 MHz to 7·2 MHz; 7·2 MHz to 7·4 MHz.

(3) 20 metre band: 14 MHz to 14·2 MHz; 14·2 MHz to 14·4 MHz; 14·8 MHz to 15 MHz.

(4) 15 metre band: 21 MHz to 21·2 MHz; 21·2 MHz to 21·4 MHz; 21·4 MHz to 21·6 MHz.

(5) 10 metre band: 28·5 MHz to 28·7 MHz

Note...

1. The transceiver KWM-2A should not be operated between 5 MHz and 6·5 MHz as this is the range of the variable i.f. second harmonic which could cause the transmission of spurious signals.

2. The two unused sockets on this board are for 10-metre band crystals only.

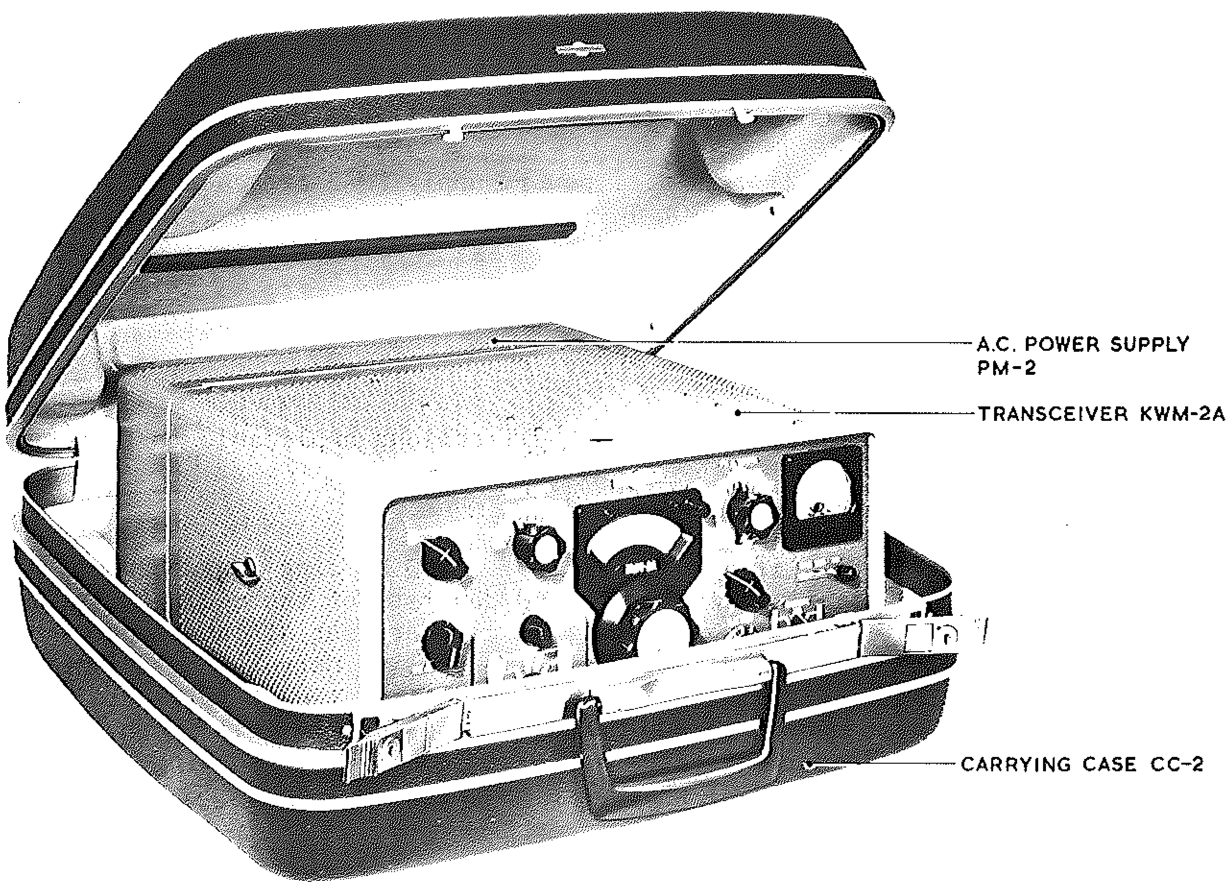

Fig. 1 Carrying case CC-2 with transceiver KWM-2A and a.c. power supply PM-2

3. Briefly, the equipment consists of a transceiver KWM-2A and its associated a.c. power supply PM-2 (fig. 4) providing an r.f. output of approximately 70 W, p.e.p. This is applied to the r.f. linear amplifier 30L-1 (fig. 5) providing a maximum output of approximately 500 W, p.e.p. which, in turn, is fed to the antenna TD-1 (fig. 7) or 637T-2 (fig. 8) via a directional coupler in the station control 312B-4 (fig. 6). The KWM-2A can, if desired, be operated without the r.f. linear amplifier as a low power (100 W, p.e.p.) transceiver.

4. A voice-operated transmission facility (vox) is incorporated so that when the equipment is operational in its normal quiescent state, it is in the receive function. It switches to the transmit function only when the a.f. input from the microphone or phone patch circuits exceeds a predetermined

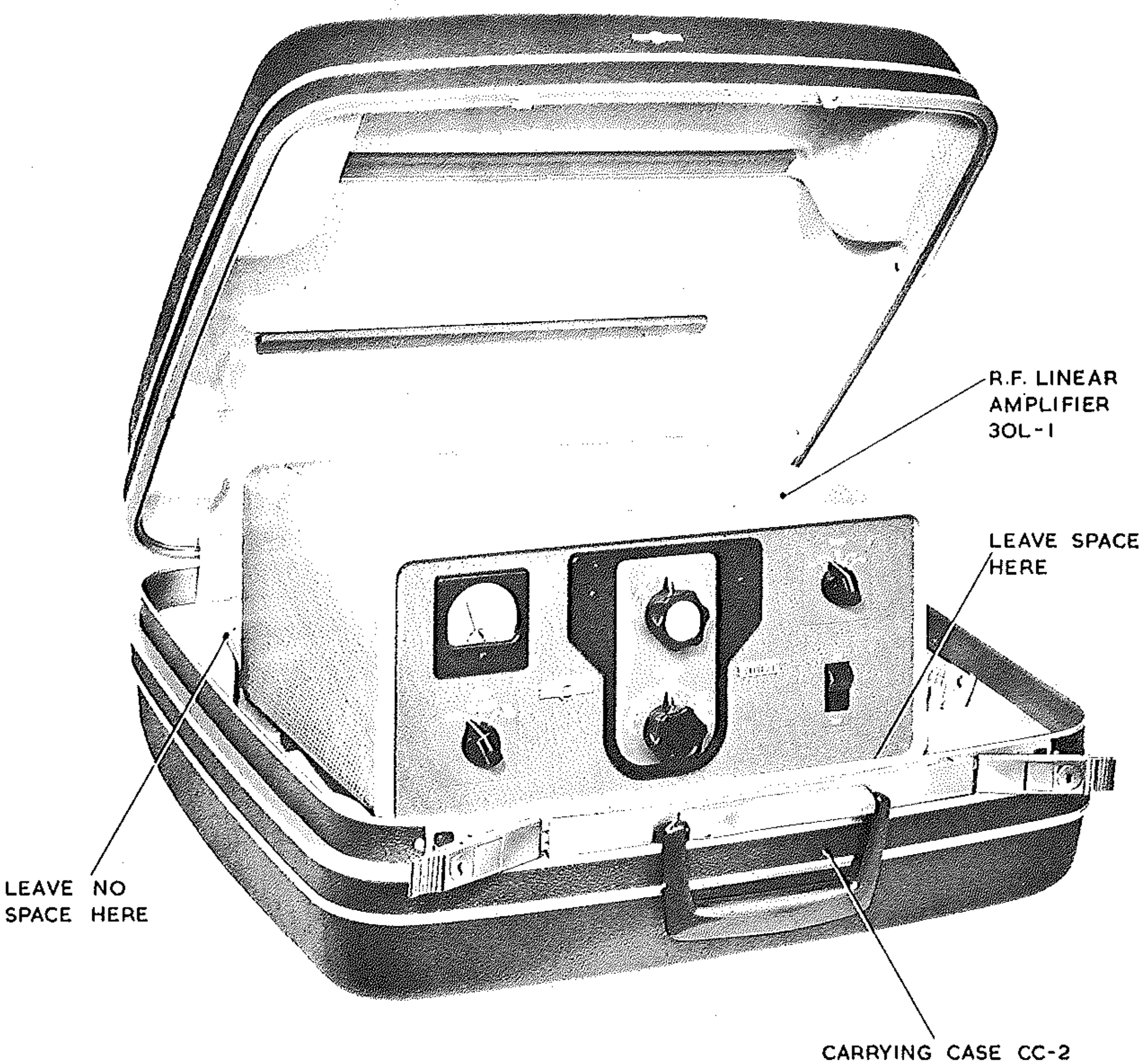

Fig. 2 Carrying case CC-2 with r.f. linear amplifier 30L-1

level. The vox circuit, however, can be by-passed if necessary by the use of a microphone with a "press-to-transmit" (p.t.t.) switch. The equipment can then be maintained in the transmit function by holding the switch closed. The phone patch circuit provides a means of connecting the a.f. input and output stages of the transceiver KWM-2A to a balanced 600-ohm telephone line.

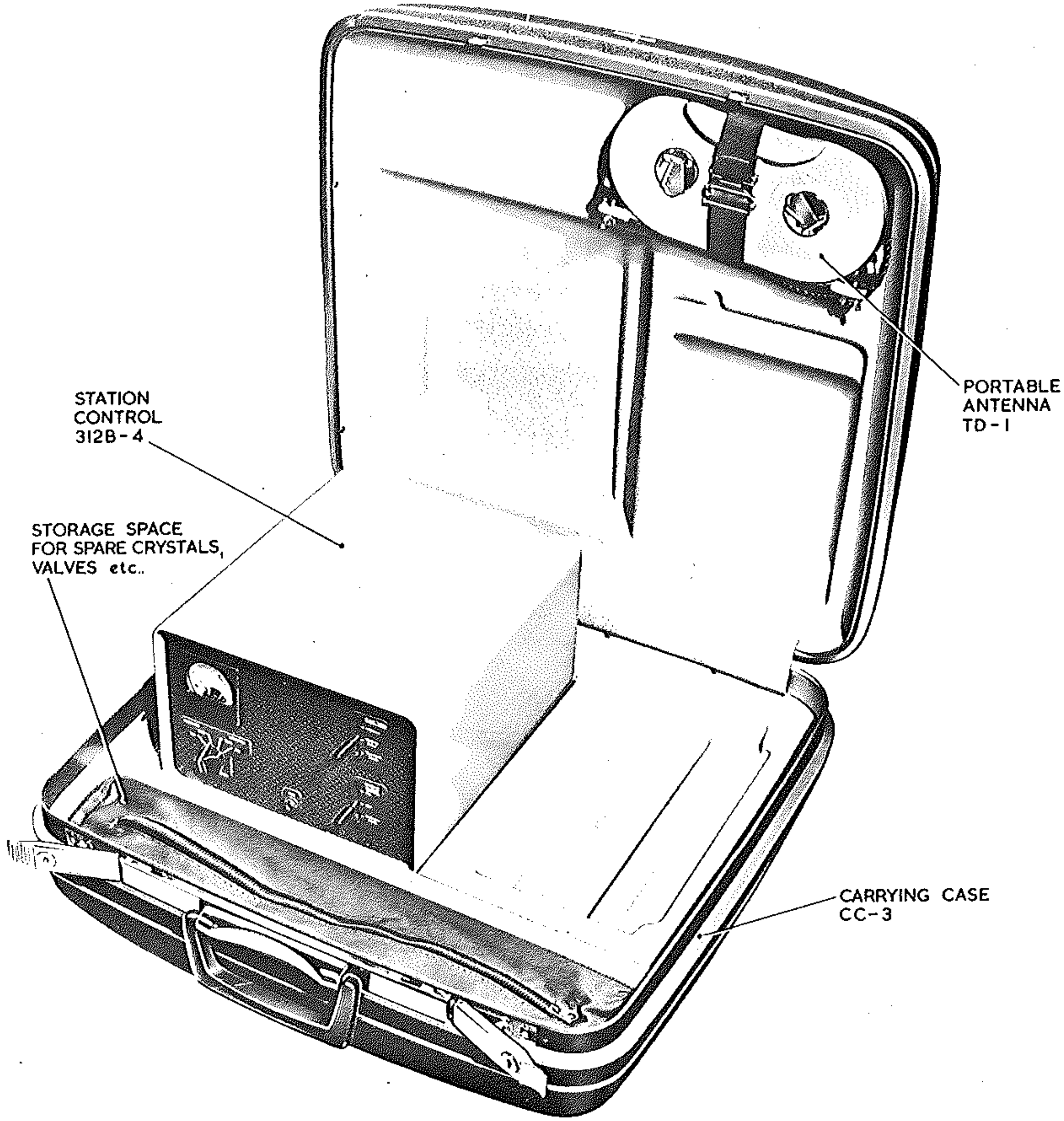

Fig. 3 Carrying case CC-3 with station control 312B-4 and portable antenna TD-1.

GENERAL DESCRIPTION

TRANSCEIVER KWM-2A

5. This unit is a conventional, s.s.b. transmitter-receiver consisting of a double-conversion receiver and a double-conversion transmitter. The transmitter s.s.b. generator consists of a balanced modulator to suppress the carrier frequency followed by a mechanical filter to select the required sideband. The transmitter and receiver channels use common oscillators, a common mechanical filter and a common r.f. amplifier. The low frequency i.f. in each case is 455 kHz and the high frequency i.f. is 2·955 MHz to 3·155 MHz. This is a bandpass i.f. to accommodate the full 200 kHz of each of the frequency bands detailed in para. 2. In the s.s.b. mode, either sideband can be selected for transmission and reception.

6. The a.f. input to the transceiver is usually via the microphone SM-2 — the vox facility maintaining the unit in the receive function until the audio signal level exceeds a preset threshold level. An ANTI-VOX feedback circuit in the receiver channel is incorporated to prevent the loudspeaker output picked up by the microphone circuits from triggering the vox circuit. The microphone SM-2 is not fitted with a p.t.t. switch, but a facility is available for incorporating an external switch for this purpose.

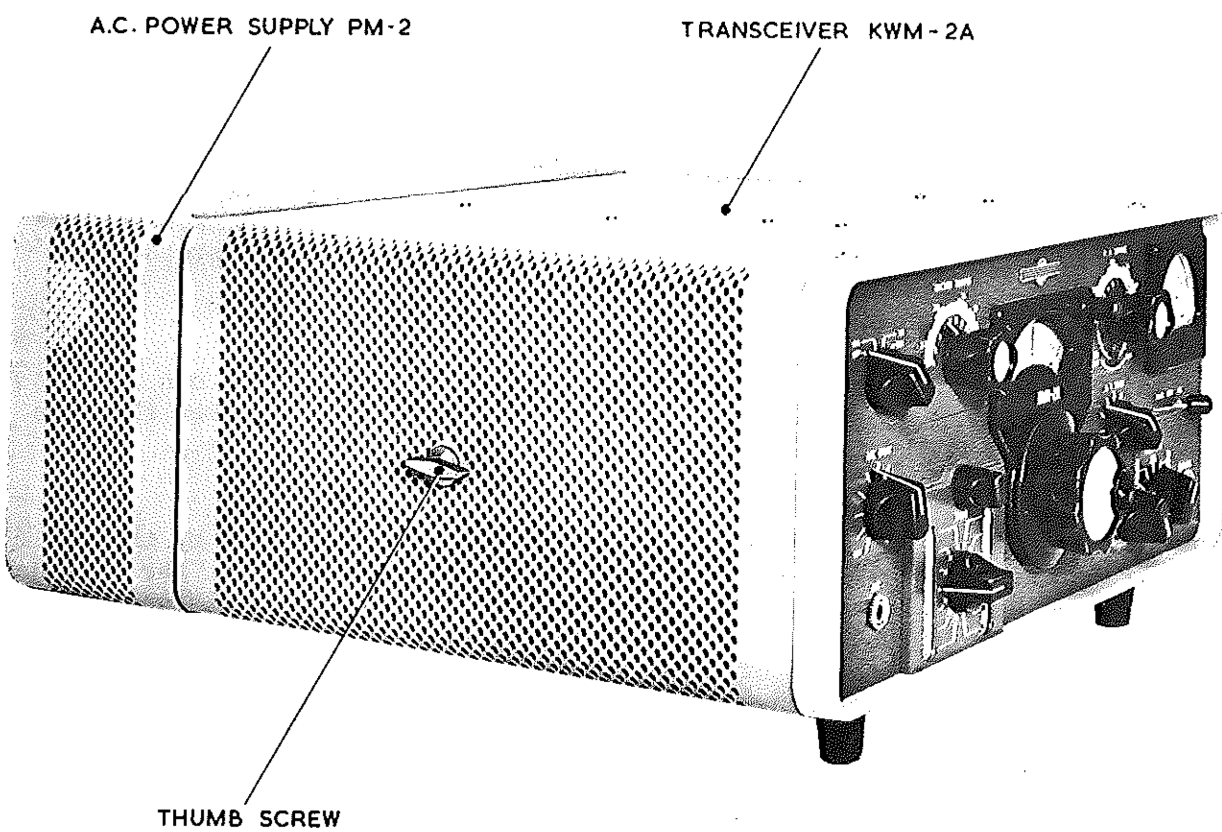

Fig. 4 Transceiver KWM-2A with a.c. power supply PM-2 attached

7. A 600-ohm balanced telephone line can be connected to the transceiver via a phone patch matching circuit on the associated station control 312B-4.

8. Built into the transceiver is a special sub-assembly unit, the noise blanker 136B-2. This converts noise to bias signals for gating the receiver circuit of the transceiver, thereby minimizing receiver output noise. The noise blanker is tuned to approximately 40 MHz; the principle of operation being that spurious noise signals (mainly caused by motor transport electrical ignition systems) in the 40 MHz region of the h.f. spectrum occur simultaneously in the 3 MHz to 30 MHz region. A 40 MHz coaxial-fed whip antenna is required for the noise blanker in addition to the antenna TD-1 or 637T-2 used by the transceiver.

9. As an alternative to the single-sideband mode of operation, the transceiver can be operated in the c.w. mode. For this purpose, and also for initial tuning and setting-up, a 1500 Hz tone oscillator is provided. Break-in keying is employed in the c.w. mode and the transmitter frequency is 1500 Hz higher than the KWM-2A dial reading.

A.C. POWER SUPPLY PM-2

10. This unit can be considered as an integral part of the transceiver KWM-2A, its purpose being to convert 115 V or 230 V, a.c. power to suitable voltages for operating the transceiver. The power supply unit clamps to the rear of the transceiver by means of two thumb screws, one either side of the transceiver (fig. 4), and the complete assembly fits into a carrying case CC-2 for portability (fig. 1).

11. A small, low-impedance loudspeaker is included in the power supply unit that may, if required, be connected to the 4-ohm audio output from the transceiver KWM-2A. In this particular equipment configuration, however, it is usual to use the loudspeaker in the station control 312B-4 instead.

R.F. LINEAR AMPLIFIER 30L-1

12. This unit (fig. 5) is a tuned power amplifier generating its own d.c. power supplies from 115 V or 230 V, a.c. mains. It is tunable over the same frequency range as the transceiver KWM-2A and provides 500 W, p.e.p. r.f. output for a drive input from the transceiver of 70 W, p.e.p.

13. The r.f. linear amplifier includes an antenna relay actuated by the vox circuit in the transceiver KWM-2A. Thus, in the receive function the antenna is connected direct to the KWM-2A receiver channel, while in the transmit function the r.f. output from the KWM-2A transmitter channel is applied to the r.f. linear amplifier input. The output from the r.f. linear amplifier is then routed to the antenna. Also, while the antenna relay is de-energized (receive function) the four amplifier valves in the 30L-1 are maintained in a cut-off state by a negative bias voltage applied to their grids.

STATION CONTROL 312B-4

14. This unit (fig.6) contains a directional coupler and associated wattmeter; a low impedance loudspeaker; a phone patch circuit and the associated switches

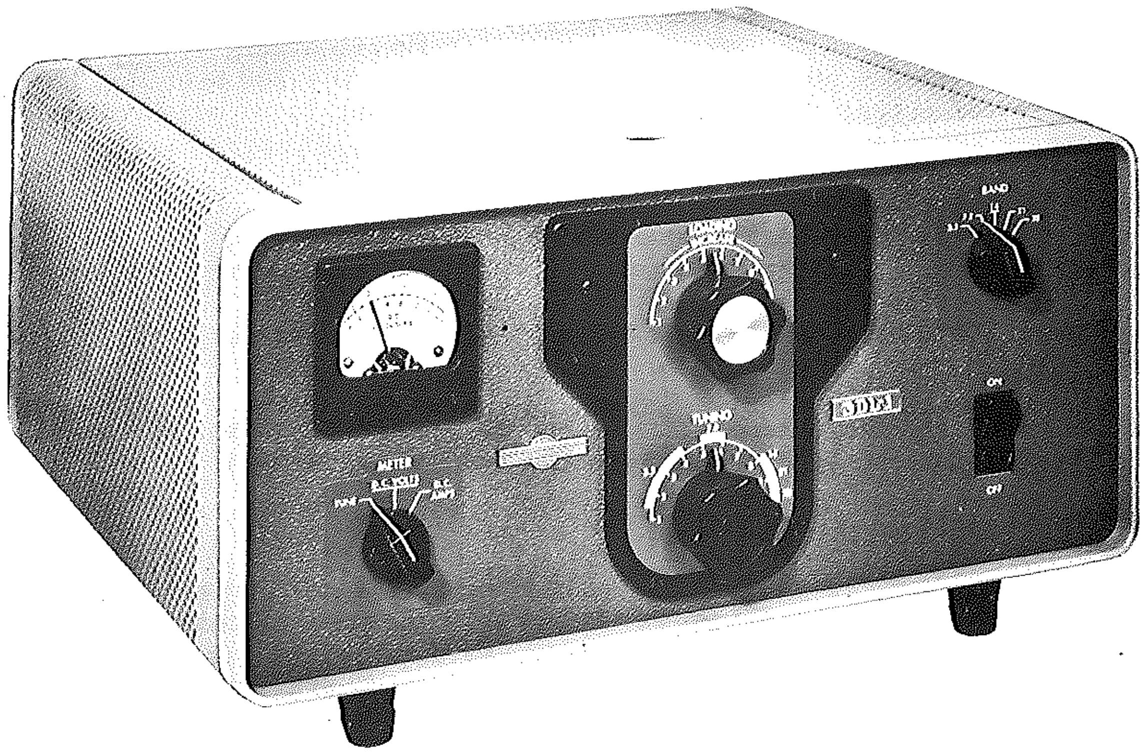

Fig. 5 R.F. linear amplifier 30L-1

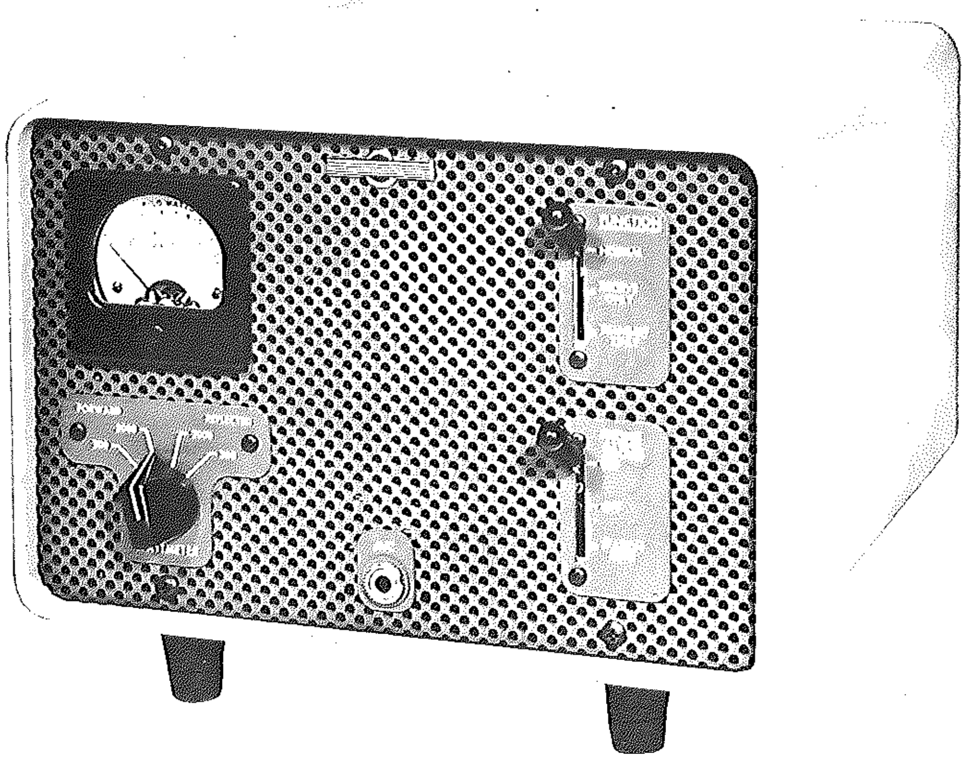

Fig. 6 Station control 312B-4

for connecting the phone patch circuit to the transceiver KWM-2A and for maintaining the KWM-2A in the receive or transmit function only if required. The wattmeter indicates power levels within the ranges 0 - 200 W or 0 - 2000 W, forward or reflected. This enables r.f. power output to be measured and v.s.w.r. to be calculated.

15. The phone patch circuit allows a third party at a remote location to use the transceiver equipment via a 600-ohm balanced telephone line. In the event of the telephone signal being too weak to operate the transceiver KWM-2A vox circuit, the function switch on the station control 312B-4 can be used to switch the transceiver manually back and forth from "receive only" to "transmit only".

16. If required, the microphone SM-2 can be plugged into a socket on the station control instead of directly into the transceiver KWM-2A.

PORTABLE ANTENNA TD-1

17. This unit (fig. 7) is a 50-ohm impedance portable dipole antenna for use at any frequency in the 3·5 MHz to 30 MHz range. The antenna consists of a moulded plastic housing and two equal-length, adjustable, stainless steel tape elements. The elements extend and rewind on steel drums and are locked by wing nut clamps. The connection to the antenna is made via a coaxial fitting and a 50 ft length of coaxial cable supplied with the antenna. The tape elements are calibrated for accurate adjustment.

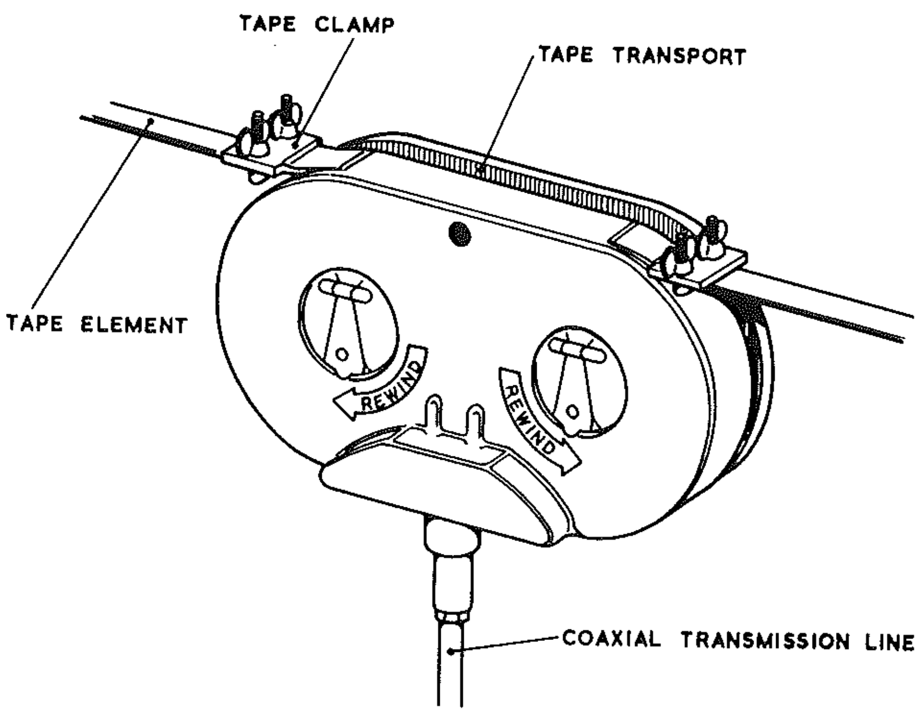

Fig. 7 Portable antenna TD-1

ADJUSTABLE DIPOLE ANTENNA 637T-2

18. This unit (fig. 8) is an alternative to the portable antenna TD-1 and is a 50-ohm impedance portable dipole antenna for use at any frequency in the 3·4 MHz to 30 MHz range. The antenna consists of a moulded plastic housing and two equal-length, adjustable, phosphor-bronze wire elements. The elements extend and rewind on two reels and are locked (and electrically connected) at the required frequency by two thumb nuts mounted on the housing. The phosphor-bronze wire elements are accurately calibrated to indicator points on both sides of the housing and, when the indicator frequency is selected by the pointers, the wire elements cannot be deployed beyond the correct length per frequency.

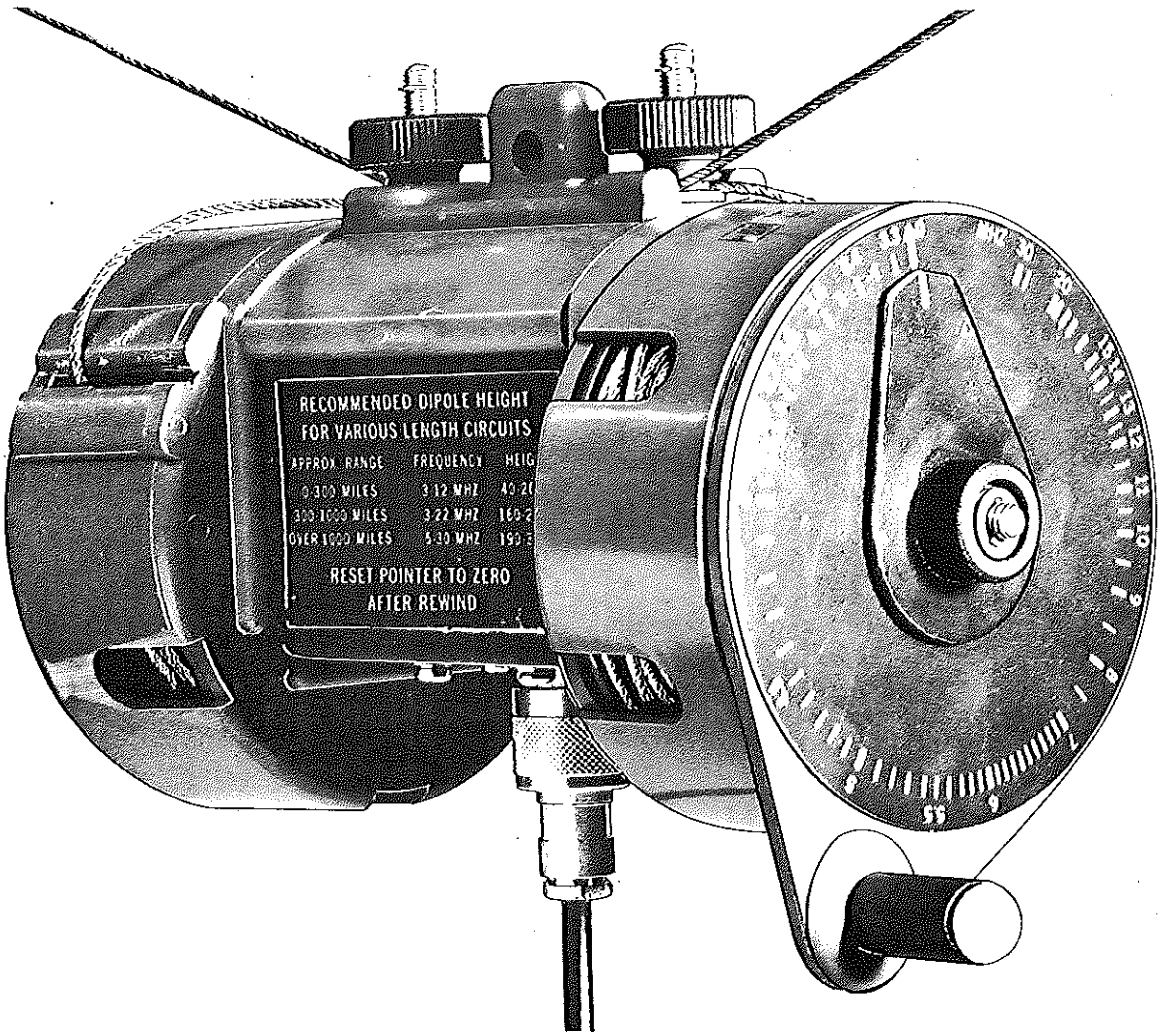

Fig. 8 Adjustable dipole antenna 637T-2

Chapter 2

PRINCIPLES OF OPERATION

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LIST OF ILLUSTRATIONS

Introduction

1. The transceiver KWM—2A and its associated peripheral equipment together comprise a single-sideband transmitting and receiving station. The use of a single-sideband (s.s.b.) system has certain advantages over a conventional amplitude-modulation system and these are discussed in detail in this chapter.

2. Long range communication on the h.f. band is often restricted to morse telegraphy since the range and reliability obtainable with small portable, or airborne, amplitude-modulated carrier R/T equipment is not always adequate for satisfactory service. This inadequacy is due principally to the restriction of power in small transmitters, adjacent channel interference and the use of a double-sideband system that is subject to the ill effects of multipath propagation.

Amplitude-modulated signals

3. When a carrier frequency is amplitude-modulated with an audio frequency tone signal, two sideband frequencies are produced, one on either side of the original carrier. These two sideband frequencies are the means of conveying intelligence in a radio transmitter. The above type of signal is referred to as an amplitude-modulated double- sideband transmission, and is shown in diagram form in fig. 1. The frequencies are for example only and the modulation level in this case is 100%.

4. The frequency, amplitude and phase of the carrier component of an amplitude-modulated wave are unaffected by the presence or absence of modulation. The carrier therefore contains none of the intelligence represented by the modulation and so need not be transmitted. Also, each sideband considered separately contains all the information present in the modulated wave. It is therefore possible to convey all the information represented by a modulating signal by transmitting only one sideband, while suppressing both the carrier and the other sideband. Such a system requires a frequency band only half as wide as that occupied by a modulated wave consisting of two sidebands and the carrier.

5. If we now remove the carrier and also one of the sideband signals (e.g. the lower), the result is a single-sideband signal of amplitude $\frac{E}{2}$. Thus it can be seen that a single-sideband signal can be considered as the transposition of an audio frequency, or band of frequencies, into a suitable part of the r.f. spectrum (fig. 2).

Double and single sidebands

6. The improvement in transmission due to single-sideband working may be explained by first considering the application of double-sideband and secondly single-sideband to the final stage of a transmitter in which the output is limited by the maximum permissible peak anode voltage.

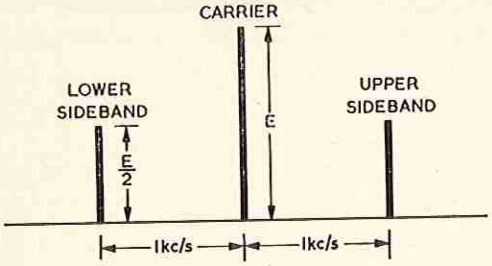

Fig. 1. A.M. transmission showing sideband components

7. Consider the case of double-sideband (d.s.b.) working with 100% modulation.

Let E = peak carrier voltage
f = carrier frequency
f_m = modulating signal frequency

The peak voltage when modulated is then 2E and the amplitude of the sidebands in the receiver will be proportional to $\frac{E}{2}$ since the equation for a 100% modulated wave can be written.

$$e = E\sin 2\pi ft + \frac{E}{2}\cos 2\pi(f-f_m)t - \frac{E}{2}\cos 2\pi(f+f_m)t$$

If there is no distortion in the transmission path the sidebands will add in phase with the result that the receiver ouptut is proportional to $\frac{E}{2}+\frac{E}{2}=E$.

8. In single sideband (s.s.b.) working, with the same limit of peak voltage applying, the amplitude of the received sideband is proportional to 2E. The relationship between the respective d.s.b. and s.s.b. outputs is therefore $2E \div E = 2$, or 6dB. Therefore, due to transmitter conditions, s.s.b. working effects a 6dB improvement in the signal-to-noise ratio.

9. At the receiver the band with d.s.b. working must be approximately twice that with s.s.b. working, hence the output of noise energy with d.s.b. will be twice that with s.s.b. This gives a further improvement of 3dB in the signal-to-noise ratio, i.e. a total inprovememt of 9dB.

10. In a given circuit the advantage may be employed to improve the signal-to-noise ratio, or to give approximately the same signal-to-noise ratio over the same working period with considerable saving of power and valve costs at the transmitter. A further saving of power is effected since no power is emitted using the single sideband (if complete carrier suppression is employed) between periods of speech emission. Further advantages at the receiver include reduction of the effect of certain types of fading since the constancy of the re-supplied carrier gives improved signal-to-noise ratio during deep fading.

Power rating

11. As stated in para. 7, for 100% modulation of a carrier of amplitude E each sideband amplitude must be $\frac{E}{2}$. Hence the ratio of power in the carrier to the power in each sideband is 4:1, or the ratio of carrier power to total power in the two sidebands is 2:1. Thus it will be seen that when the modulation depth is 100% and the carrier and one sideband are suppressed a considerable saving in mains power results, for an equal d.s.b. or s.s.b. output.

12. Also, as stated in para. 9, the signal-to-noise improvement due to single-sideband operation is 9dB for single and double-sideband transmitters of the same peak power. This corresponds to a power ratio of eight times, so that the peak power output of an s.s.b. transmitter to give the same signal-to-noise ratio as a d.s.b. transmitter of 100 kW peak power is 100/8—12·5kW.

13. It is necessary when referring to s.s.b. power to refer to the peak sideband power or peak envelope power since we have no carrier reference in this type of transmission and a signal will appear at the output only whilst modulation signals are applied. Thus peak sideband or peak envelope power is a useful reference in the same way that the carrier power is a useful reference for power in the case of d.s.b. transmission.

Note on definitions

Peak sideband power (p.s.p.) is that part of the peak power supplied by the sidebands. Peak envelope power (p.e.p.) is the average power in one r.f. cycle at the highest crest of the modulation envelope under specified conditions of operation.

Demodulation

14. In a conventional a.m. receiver the incoming signal is finally applied to a diode detector and the a.f. signals appear as a component of the output. However, if an s.s.b. signal is applied to the diode detector, the output is simply a d.c. level which corresponds to the amplitude of the input signal.

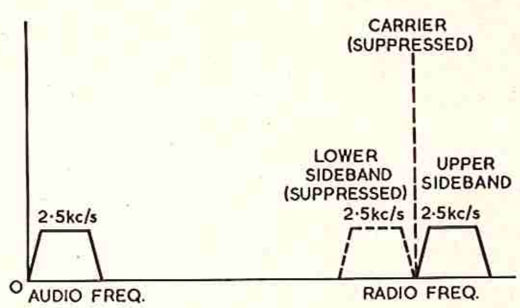

Fig. 2. Generation of the sideband signals

15. The essential difference between the two signals referred to in para. 14, is of course, that the d.s.b. a.m. signal has a carrier whose amplitude apparently varies at the a.f. rate. To extract the information from a single-sideband signal, it is first of all necessary to re-insert the carrier. How this may be accomplished is described later in this chapter.

Advantages and disadvantages of s.s.b. operation

16. The advantages of s.s.b. as compared with d.s.b. operation are as follows:—

(1) The bandwidth of an s.s.b. transmission is only one half that of the corresponding d.s.b. transmission; s.s.b. operation thus results in a considerable saving in the frequency spectrum required for any given service.

(2) The signal-to-noise ratio is increased by some 9dB relative to that of the corresponding d.s.b. system, the peak power output of the transmitter being the same in the two cases. Of the 9dB improvement in the signal-to-noise ratio, 6dB is due to the increase in sideband power output of the s.s.b. transmitter, and a further 3dB is obtained because the noise power output of an s.s.b. receiver is half that of a d.s.b. receiver of equal gain, since the i.f. bandwidth of the s.s.b. receiver is one half that of the d.s.b. receiver.

(3) A useful saving in the mains power consumption is effected with s.s.b. operation, since with no audio input the transmitter produces only a small r.f. output. Thus it consumes very little h.t. power in the high power amplifier stages, whereas with d.s.b. operation under the same conditions the carrier would be transmitted at approximately one quarter the normal peak output power; that is at half the current corresponding to the peaks of modulation where the modulation depth is 100%.

(4) The non-linear distortion present with d.s.b. operation under conditions of multipath propagation and selective fading is eliminated with s.s.b. working. To illustrate this, consider the simple case of a 1000 c/s tone modulation on a carrier. With a d.s.b. system the loss of the carrier at the receiver during a selective fade allows the two sideband components to beat together at the detector and so produce a 2000 c/s tone, i.e. severe second-order distortion occurs. In the s.s.b. system only one of the sideband components is present at the receiver input and is demodulated by beating with a high level carrier in a linear demodulator so that no distortion occurs. Similar considerations apply when the modulation compresses not a single tone but several audio frequency components such as speech, music or multi-channel voice frequency telegraphy. The freedom of s.s.b. systems from non-linear distortion due to selective fading is of great value when the radio link is used for speech that has passed through privacy equipment or for multi-channel voice frequency telegraphy. The effect of non-linear distortion on speech with privacy is to give rise to a serious loss of quality and intelligibility due to the non-harmonic nature of the distortion of components in the reproduced speech. The effect of non-linear distortion of multi-channel voice frequency telegraphy is to give rise to intermodulation between the signals in the various channels and thus to teleprinter errors. Similarly, the absence of non-linear distortion enables an s.s.b. system to provide several telephony channels and single transmitter and receiver without crosstalk between channels due to selective fading.

(5) An important operational advantage of the s.s.b. technique is the flexibility it permits in the use of the transmitting and receiving equipment and the high degree of standardisation that it allows. Thus, using standard s.s.b. transmitters and receivers, it is possible by the addition of audio equipment only, to transmit many different types of signal. This advantage arises directly from the fact that an s.s.b. system is simply a device for translating a band of audio frequency signals to any desired part of the high frequency range for transmissions over a radio link, and back to audio frequency again.

17. The disadvantages of s.s.b. multi-channel operation arise from the increased complexity of the equipment and the higher standard of performance required, as compared with that for d.s.b. operation. The main factors concerned are as follows:—

(1) High performance filters, usually of the quartz-crystal or mechanical type, are required in the transmitter for the production of the s.s.b. signal, and in the receiver to separate the sidebands and the carrier.

(2) All the amplifier and modulator stages of the transmitter and receiver must be operated linearly if inter-channel crosstalk is to be avoided. This requirement is difficult to combine with high efficiency. A compromise between efficiency and linearity may be necessary in stages such as the power amplifier of the transmitters.

(3) In the receiver a high level carrier must be provided for demodulation purposes, the frequency of which must be within a few c/s of the correct relationship with the sideband frequencies if good quality is to be obtained. This requirement necessitates the use of oscillators with very good frequency stability, both in transmitter and receiver.

18. The advantages of s.s.b. working have been found to outweigh by far the disadvantages for the operation of long distance point-to-point short-wave radio links.

Frequency errors

19. Assuming that a carrier component is supplied at the receiver demodulator from a local oscillator, and the carrier is completely eliminated at the transmitter; then the maximum permissible injected carrier error before speech becomes distorted is approximately 50 c/s. The error is either added to or subtracted from the a.f. signal. As the error is made up of all errors of all the oscillators in the transmitter and receiver, all must be very stable and the oscillators of the highest frequency normally contribute the greater part of the error.

20. Doppler effect caused by one transmitter-receiver equipment moving relative to the other transmitter-receiver (e.g. in the case of airborne equipment) can introduce a small frequency error which in conjunction with the other errors produced by the transmitter and receiver oscillators can produce a significant overall error. The Doppler frequency shift error is worse as the relative velocity increases and the frequency in use becomes higher.

Single sideband-generation

21. The method employed in the transceiver KWM—2A to suppress the carrier component of the amplitude-modulated wave is to mix the audio signal from the speech amplifier with the carrier signal in a balanced modulator. The output from the balanced modulator contains both side-bands but no carrier (fig. 3).

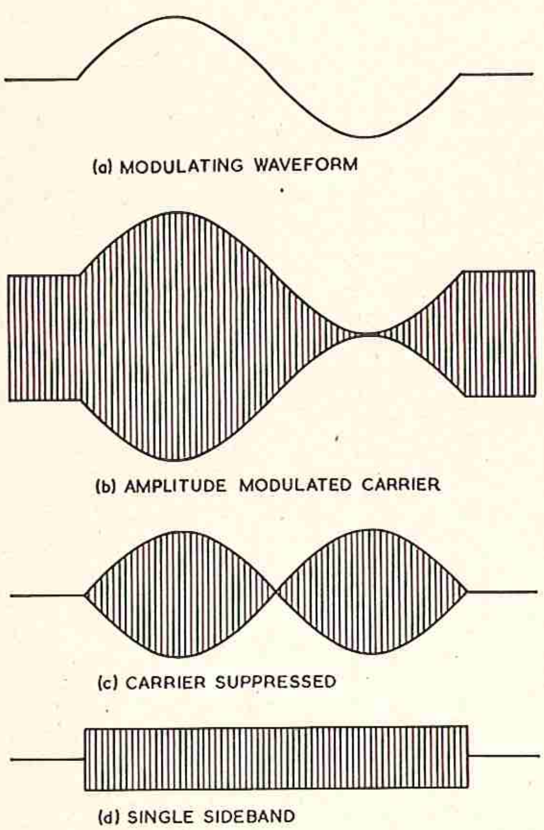

Fig. 3. Single sideband waveforms

22. The required sideband is then obtained by passing the output of the carrier suppression circuit through a filter that is sufficiently selective to transmit one sideband while suppressing the other. Such a filter needs to have a sharp cut-off pass band of 2 to 3 kc/s about a centre frequency equal to the low frequency i.f. of the transmitter (i.e. 455 kc/s in the case of the transreceiver KWM—2A). This is equivalent to a Q in the order of 10 000, thus necessitating the use of a crystal filter or a mechanical filter.

23. Either sideband can be selected simply by switching the carrier generator (usually a crystal-controlled oscillator) to produce a frequency approximately 1500 c/s above or below the centre frequency of the filter.

S.S.B. TRANSMITTING SYSTEM

24. Consider now the operation of a typical s.s.b. transmitter (e.g. the KWM—2A), operating for example, in the 20 Mc/s band, that is required to transmit audio signals of 300 to 2400 c/s. The basic units are shown in their functional relationship in fig. 4. The audio amplifier is of conventional design; audio filtering is not required as the highly selective filtering in the s.s.b. generator attenuates all unnecessary frequencies below 300 c/s and above 1400 c/s.

25. The a.f. output from the audio amplifier is applied to a balanced modulator together with a 456·35 kc/s carrier from a crystal-controlled oscillator. The output from the balanced modulator therefore consists of the two sidebands 456·65 to 458·75 kc/s and 456·05 to 453·95 kc/s (considering only the 300 to 2400 c/s audio signals), but no 456·35 kc/s component. This is then applied to a highly selective mechanical filter having a 2·1 kc/s pass band centered about 455 kc/s, i.e. a pass band of 453·95 to 456·05 kc/s. The filter output therefore consists only of the lower i.f. sideband, an increase in the frequency of the audio signal appearing as a decrease in the frequency of the filter output signal.

26. The 455 kc/s i.f. is now mixed with the 2·5 Mc/s output of a second oscillator (not necessarily crystal-controlled for reasons that will be explained later) and the sum frequency of 2·955 Mc/s is selected. It will be noted that an increase in the frequency of the audio input signal is still represented as a decrease in the high frequency i.f.

27. The 2·955 Mc/s i.f. signal is now applied to another mixer stage, the other input to which is the 22·955 Mc/s output from a crystal-controlled master oscillator. In this mixer, however, the difference frequency of 20 Mc/s is selected so that now an increase in the frequency of the audio signal that previously caused a decrease in the frequency of the i.f. signals, now causes an increase in the 20 Mc/s, i.e. the upper sideband has been selected. The total variation in the frequency of the second mixer output is 2·1 kc/s, this being equal to the bandwidth of the mechanical filter and corresponds to an a.f. band of 300 to 2400 c/s.

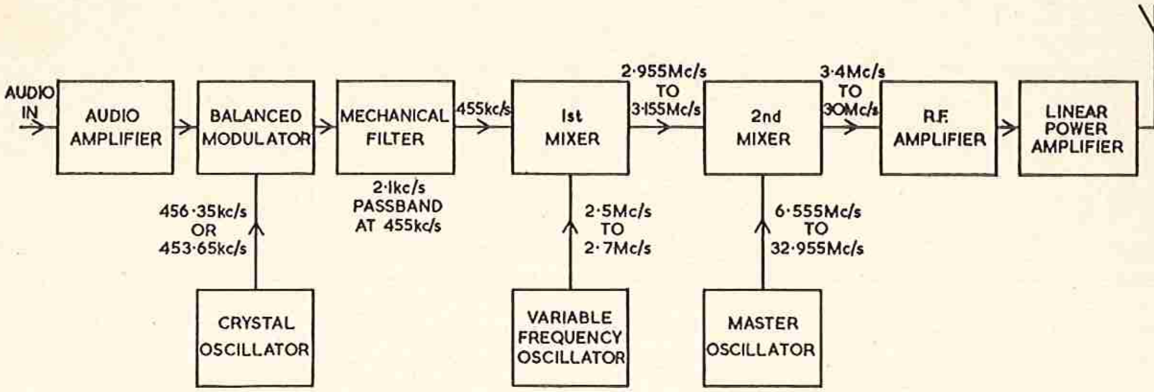

Fig. 4. Functional units of a typical s.s.b. transmitting system

28. It will be seen from the foregoing description that if the frequency of the first oscillator was 453·65 kc/s the balanced modulator output would be effectively 453·95 to 456·05 kc/s and 453·35 to 451·25 kc/s and the mechanical filter would select the upper i.f. sideband. Due to the selection of the difference in the second mixer this would in turn appear as a lower sideband output from the mixer. Therefore, simply by switching the crystals on the first oscillator it is possible to select either sideband for transmission.

29. Consider now the effect of making the second oscillator (para. 26) a variable frequency oscillator, manually variable over the range 2·5 to 2·7 Mc/s. The high frequency i.f. will, therefore, be variable between 2·955 and 3·155 Mc/s (assuming that the high frequency i.f. stage is designed to have a 200 kc/s bandwidth centered on 3·055 Mc/s) resulting in an output frequency band of 20·0 to 19·8 Mc/s. This is the manner in which the 200 kc/s bands are obtained in the transceiver KWM—2A.

30. The 20 Mc/s signal is applied via r.f. amplification and drive stages to a linear power amplifier to produce the high power r.f. signal. A linear power amplifier is required for s.s.b. transmission as it is essential that the anode output r.f. signal should be an exact replica of the grid input signal. Any non-linear operation of the power amplifier will result in intermodulation (mixing) between the frequencies of the input signal. This will produce not only undesirable distortion within the desired channel, but will also produce intermodulation output on adjacent channels.

S.S.B. RECEIVING SYSTEM

31. Consider now the operation of a typical s.s.b. receiver (e.g. the KWM—2A once again) receiving upper sideband signals in the 20 Mc/s channel from the transmitter described in para. 24 to 30. The basic units are shown in their functional relationship in fig. 5.

32. The output from the conventional r.f. amplifier is applied to the first mixer, the second input to which is the 22·955 Mc/s output from a crystal-controlled local oscillator. This mixer selects the difference frequency of 2·955 Mc/s so that what was previously an upper sideband signal appears as a high frequency i.f. lower sideband signal.

33. The 2·955 Mc/s is then mixed with the output from a 2·5 Mc/s oscillator and the difference frequency is selected by a 455 kc/s mechanical filter. The use of a narrow pass-band, sharp out-off filter at this stage is necessary in order to obtain the required receiver selectively. It will be noted that a frequency decrease in the 2·955 Mc/s i.f. still appears as a decrease in the 455 kc/s i.f., i.e. the 20 Mc/s upper sideband signal now appears as a 455 kc/s lower sideband signal.

34. The pass band of the mechanical filter is 453·95 to 456·05 kc/s (2·1 kc/s centered on 455 kc/s) and the output from the filter is amplified and applied to a third mixer or a.f. detector stage the other input to which is the 456·35 kc/s carrier output from a crystal-controlled oscillator. This mixer selects the difference frequency so that a frequency variation in the i.f. of from 456·05 to 453·95 kc/s (the lower sideband) produces an audio output of 300 to 2400 c/s.

35. The receiver can be made to receive lower sideband signals simply by switching the final oscillator frequency from 456·35 to 453·65 kc/s. Also, by making the second oscillator variable over the range 2·5 to 2·7 Mc/s and assuming a suitable high frequency i.f. bandwidth, it can receive signals in the 20·0 to 19·8 Mc/s band. As in the case of the transmitter described previously, this is the manner in which the 200 kc/s bands are obtained in the transceiver KWM—2A.

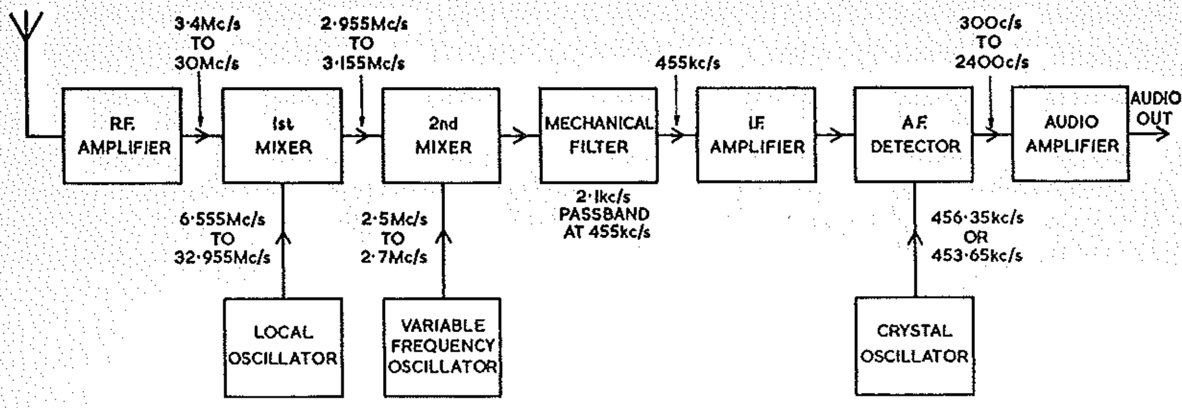

Fig. 5. Functional units of a typical s.s.b. receiving system

36. Many of the s.s.b. receiver units are identical to those in the s.s.b. transmitter as will be seen by comparing fig. 4 and fig. 5. The oscillators, r.f. amplifier and mechanical filter are identical and this similarity of function permits the construction of a transceiver with much of the circuitry used in both functions, by simply including switching circuits that reverse the direction of the signals.

TRANSMITTER AUTOMATIC LOAD

37. The human voice produces a complex waveform that can be represented by numerous frequency components of various amplitudes and various instantaneous phase relationships. No human voice is exactly identical to another voice but statistical averages of the frequencies and amplitudes involved can be determined. The average power level of speech is relatively low when compared to the peak power level. Overall transmission efficiently depends upon the average power transmitted, while the transmitter power is limited to the peak power capability of the equipment. Therefore, for voice transmission the transmitter must include speech processing circuits that increase the average power in the voice signal without increasing the peak power. This can be done in three different ways:—

(1) By clipping the power peaks.

(2) By emphasizing the low power, high frequency components of the speech signal.

(3) By using a.g.c. circuits to maintain the signal level near the maximum capability of the transmitter.

38. The power/frequency distribution for the human voice, after filtering below 200 c/s and above 3000 c/s, is shown in the curve fig. 6. This clearly shows that the high-power components of speech are concentrated in the low frequencies. Fortunately it is the low-frequency components of speech which contribute little to intelligibility since these frequencies are concentrated in the vowel sounds. The low frequencies may, therefore, be attenuated without undue loss in speech intelligibility.

39. The low-power, high-frequency components present in a voice signal can be pre-emphasized to increase the average power of the signal. As it is the high-frequency components which are predominant in the consonant sounds, some emphasis of high frequencies will improve intelligibility. However, to emphasize the high frequencies sufficiently to raise the average power level significantly would require compatible de-emphasis at the receiver to prevent loss of fidelity. This is, therefore, not a practical solution.

40. Clipping power peaks results in flattening the waveform at the clipping level, and with severe clipping the voice signal becomes a series of square-waves. As an s.s.b. square wave envelope requires infinite bandwidth, clipping must be done with discretion. In the s.s.b. transmitter, automatic load control (a.l.c.) is used to control the average power level input in preference to clipping, to avoid overdriving the power amplifier. Clipping is used only to remove the occasional power peaks.

41. An a.l.c. negative feedback signal, produced by the linear amplifier when the valves in this stage are driven into grid current, is applied as a bias signal to the transmitter r.f. amplifier and first i.f. amplifier. This system allows a high average level of modulation and optimum power output from the linear amplifier within the rated limits of distortion.

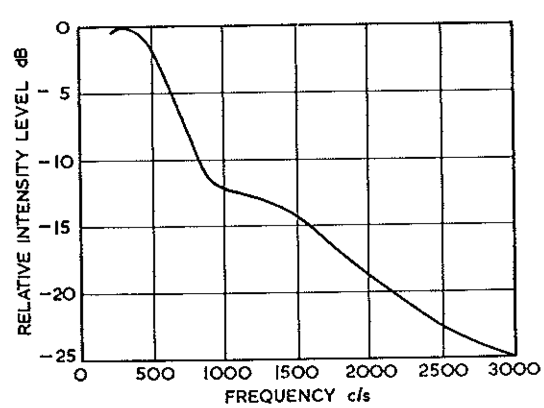

Fig. 6. Power distribution in speech frequencies

MECHANICAL FILTERS

42. It will be seen from the foregoing description that one of the principal requirements for efficient s.s.b. operation is a very selective bandpass filter. In the transmitter channel, the signal bandwidth must be limited sharply in order to pass the desired sideband and reject the other sideband. Similarly, in the receiver channel a high order of adjacent channel reiection is required if channels are to be closely spaced to conserve spectrum space. The filter used, therefore, must have very steep skirt characteristics and a flat bandpass characteristic. These requirements are satisfied by the use of a mechanical filter. This has excellent rejection characteristics and a Q in the order of 10 000.

43. The mechanical filter (fig. 7) is a mechanical resonance device which receives electrical energy, converts it into mechanical vibration, and then converts the mechanical energy back into electrical energy at the output. The filter consists of an input transducer which converts the electrical input into mechanical oscillations, metal discs which are mechanically resonant, coupling rods which couple the discs and an output transducer which converts the mechanical oscillations back into electrical energy. The electrical analogy of the filter is shown at (b) of fig. 7. In the analogy the series resonant circuits L1C1 represent the metal discs, the capacitors C2 represent the coupling rods, and the input and output resistances R represent the matching mechanical loads.

44. The transducer, which converts electrical energy into mechanical energy and vice versa, is a magnetostrictive device and is based on the principle that certain materials elongate or shorten when in the presence of a magnetic field. Therefore, if an electrical signal is sent through a coil which contains the magnetostrictive material as the core, the electrical oscillation will be converted into mechanical oscillation. The mechanical oscillation can then be used to drive the mechanical elements of the filter.

45. From the electrical equivalent circuit (fig. 7) it can be seen that the centre frequency of the filter is determined by the metal discs which represent the series resonant circuit L1C1. Since each disc represents a series resonant circuit, it follows that increasing the number of discs will increase the skirt selectively of the filter. Skirt selectivity is specified as shape factor which is the ratio of the bandpass 60dB below peak to the bandpass 6dB below peak. The coupling between the discs is represented by C2 in the equivalent circuit and by varying the mechanical coupling, i.e. making the coupling rods larger or smaller, the bandwidth of the filter is varied. Since the bandwidth varies approximately as the total area of the coupling wires, the bandwidth can be increased by using either larger or more coupling wires. The mechanical filter used in the transceiver KWM—2A has a centre frequency of 455 kc/s and a bandwidth of 2·1 kc/s at the —6dB points and 4·2 kc/s at —60dB, i.e. a shape factor of 2.

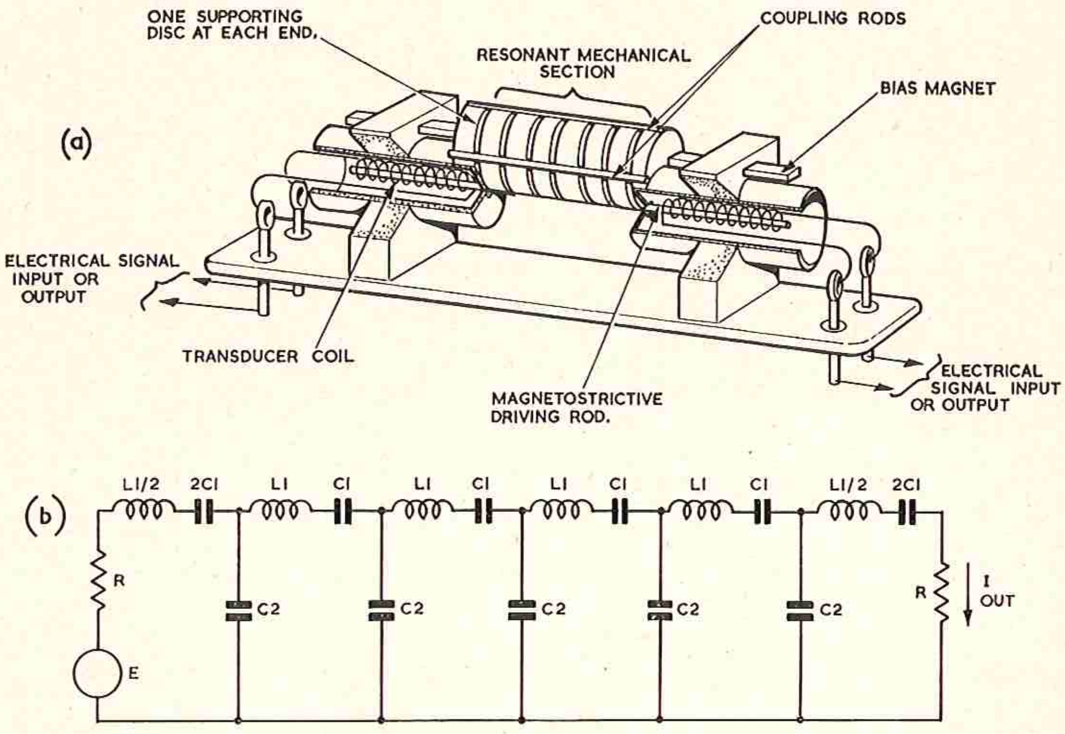

Fig. 7. Mechanical filter and equivalent circuit

46. Although an ideal filter would have a flat 'nose' or passband, practical limitations prevent the ideal from being obtained. The term 'ripple amplitude' or 'peak-to-valley ratio' is used to specify the nose characteristics of the filter. The peak-to-valley ratio is the ratio of maximum to minimum output level across the useful frequency range of the filter. A peak-to-valley ratio of 3dB is normal and this can be improved to 1dB by accurate adjustment of the filter elements.

47. Spurious responses occur in mechanical filters due to mechanical resonances other that the desired resonance. By proper design, spurious resonances can be kept far enough from the passband for them to be attenuated by other tuned circuits in the system.

48. Since the input and output transducers of the mechanical filter are inductive, parallel external capacitors are used to resonate the input and output impedance at the filter frequency. With these capacitors connected, the input and output impedances are mainly resistive and range between 1000 to 50 000 ohms.

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Chapter 3

INSTALLATION
(Completely revised)

CONTENTS

ILLUSTRATIONS

Modification state:

There are no official Service modifications applicable to this chapter.

Introduction

1. This chapter gives instructions for the packing of the portable KWM-2A equipment into the associated carrying cases and for interconnecting the individual units for operational use.

CARRYING CASES CC-2 AND CC-3

2. Three carrying cases are provided for transporting the individual units, two type CC-2 and one type CC-3. The two types of carrying case are of similar size and differ only in the moulded plastic, shock-resistant lining. Lockable catches are fitted on each carrying case.

3. One carrying case CC-2 accommodates the transceiver KWM-2A with its associated a.c. power supply PM-2 attached, while the second CC-2 accommodates the r.f. linear amplifier 30L-1. The carrying case CC-3 accommodates the station control 312B-4, the portable antenna TD-1 (strapped in a compartment inside the lid) and spare crystals, valves etc. To ensure that in the normal carrying position the weight of each unit is taken on its back, the units

must be placed in the carrying cases with their front panels towards the case handle. Also, the r.f. linear amplifier 30L-1 should be placed as far back as possible towards the hinged side of the case. Adequate spare space is provided in the carrying cases for packing various ancillary items, such as connecting leads, microphone, headset, morse key, etc., on either side of the large units.

CAUTION...

Do not pack heavy articles between the unit front panels and the handle-side of the case, or damage to controls or meter dials may result. When moving or storing, ensure that the latches are secure and store with the handle up.

EQUIPMENT INSTALLATION

SITING CONSIDERATIONS

4. When planning the station location, consideration must be given to the following points:

(1) Availability of a 115 V or 230 V, 50 - 60 Hz, single-phase power supply capable of supplying a peak load of 2 kW.

(2) The desirability of installing the horizontally-polarized dipole antenna Type TD-1 or Type 637T-2 clear of surrounding objects and as high as possible off the ground. A 50 ft length of coaxial transmission line is supplied with each of these antennae.

5. If desired, the individual units can be operated from their carrying cases with the lids open, although for ease of adjusting the controls it is preferable to remove the equipment completely from the cases.

CAUTION...

Do not attempt to operate the transceiver KWM-2A or the r.f. linear amplifier 30L-1 in their cases with the lid closed or overheating will occur.

A.C. POWER SUPPLY

6. Before attempting to interconnect the units or to make any connections to the available a.c. mains supply, ascertain whether the mains voltage is nominally 115 V or 230 V. The equipment, as supplied, is usually set for operation on 230 V, a.c. and, if the available supply is found to be 115 V, the transformer primary taps on the power supply PM-2 and the r.f. linear amplifier 30L-1 must be changed in the following manner:

(1) Slacken the thumb screw on either side of the transceiver KWM-2A and pull the a.c. power supply PM-2 away from the rear of the KWM-2A (fig. 1). Remove the PM-2 from its case (two securing screws through the back of the unit) in order to gain access to the LINE VOLT SELECTOR toggle switch on the chassis. Set this switch to the appropriate position and reassemble the PM-2 in its case. At this stage, however, do not attach the unit to the rear of the KWM-2A.

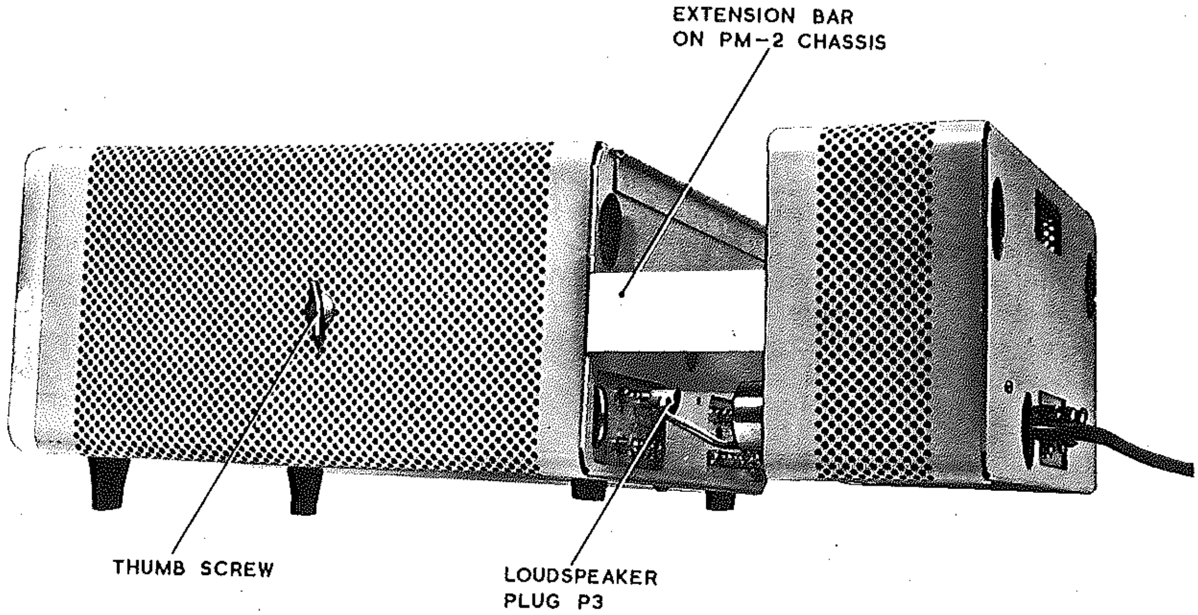

Fig. 1 Removal of a.c. power supply PM-2 from transceiver KWM-2A

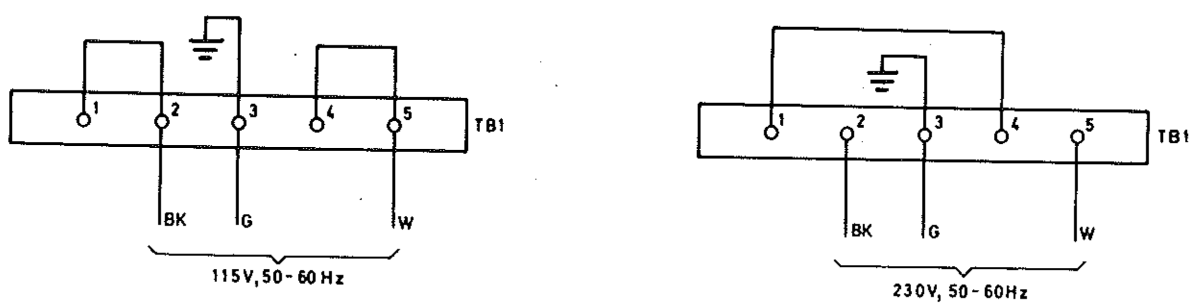

Fig. 2 Connections to r.f. linear amplifier 30L-1 for 115 V or 230 V operation

(2) On the r.f. linear amplifier 30L-1, lift the case lid and remove the two screws located at the top front edge of the case. Remove the four feet and the screw located midway between the rear feet. Push the unit forward from the rear until the front panel projects sufficiently to grasp it on the edges and slide the unit out of the case. This is necessary to gain access to the tagstrip TB1 to which the incoming mains lead is connected. TB1 is located on the underside of the chassis adjacent to the two fuses. To change from 230 V to 115 V operation, remove the jumper lead between pins 1 and 4 of TB1 and insert jumper leads instead between pins 4 and 5 and between pins 1 and 2 (fig. 2). Reassemble the unit in its case.

Note...

It is not necessary to make any fuse changes on the a.c. power supply PM-2 or the r.f. linear amplifier 30L-1; in the PM-2 the switch automatically selects a fuse of a higher rating, and in the 30L-1 the changes to TB1 wiring cause two fuses that were previously series connected to be parallel connected.

7. It is preferable that the available a.c. mains should be a 3-wire supply so that the green wire on the PM-2 and 30L-1 mains leads can be earthed. In the event of only a 2-wire supply (line and neutral) being available, the green wires on the two mains leads must be connected together and attached to a good earth line.

8. Assuming that it is capable of supplying the peak load requirement of approximately 2 kW, the PM-2 and 30L-1 mains leads can be connected to the same mains outlet socket via a suitable plug adapter.

INTERCONNECTION OF UNITS

9. There are several possible station configurations for the equipment, as supplied, and these can be divided basically into medium power output (500 W p.e.p.) and low power output (100 W p.e.p.) systems. The r.f. linear amplifier 30L-1 converts the transceiver KWM-2A output from low power to medium power, while the station control 312B-4 provides additional refinements, such as a phone patch circuit and an r.f. power output monitoring facility.

10. The three most likely station configurations are illustrated in the unit interconnection diagrams shown in fig. 4. Fig. 4(a) shows the interconnections for a medium power station using all the equipment available; fig. 4(b) shows a simple medium power station with no station control 312B-4; and fig. 4(c) shows a simple low power station using only the transceiver KWM-2A and a.c. power supply PM-2.

11. In order to make connections to the sockets at the rear of the transceiver KWM-2A it is first necessary to temporarily remove the a.c. power supply PM-2. This is the reason for not replacing the PM-2 after changing or checking its line voltage setting (para. 6(1)). Slacken the thumb screw on either side of the transceiver KWM-2A and pull the a.c. power supply sufficiently clear to make the necessary connections (fig. 1). The leads from the transceiver KWM-2A are brought down through the channel between the KWM-2A and the PM-2 and out beneath the PM-2. After making the connections press the PM-2 firmly home onto the rear of the KWM-2A and tighten the two securing screws. The power connections between these two units are made when they are clamped together.

12. The extension speaker plug on the a.c. power supply PM-2 should be connected to the 4-ohm socket on the transceiver KWM-2A only when the station control 312B-4 is not being used and a loudspeaker audio output is required. At all other times the plug and lead should be tucked away carefully between the two units to avoid fouling. Headphones (600 ohms impedance) can be plugged into the appropriate socket on the KWM-2A front panel, but it should be noted that this has the effect of disconnecting the 4-ohm audio output. The high impedance microphone SM-2 is usually connected to the appropriate

socket on the station control 312B-4 front panel, but in the absence of this unit (fig. 4(b) and (c)) the socket on the KWM-2A front panel is used.

13. If necessary, the directional coupler in the station control 312B-4 can be removed completely from this unit and installed elsewhere. If this is done, the terminals 1 to 4 and the earth terminal 5 on the directional coupler must be connected via extension leads to the corresponding five terminals on the rear of the 312B-4 chassis. On the directional coupler the coaxial connector, J1, at the same end as the five terminals, must always be connected to the antenna, the connector J2 to the transmitter.

14. Ground (earth) terminals (GND) are provided at the rear of the a.c. power supply PM-2 and the r.f. linear amplifier 30L-1. These should be connected together and attached to a good earth line.

ANTENNA SYSTEMS

PORTABLE ANTENNA TD-1

15. The antenna TD-1 should be erected as high as possible off the ground. A 50 ft length of 50-ohm coaxial transmission line is provided with the antenna for interconnection with the station control. Height is particularly critical at the centre of the dipole and, if possible, the antenna TD-1 tape housing should be attached to the highest possible point. The elements may then be attached to any other available structure, but care should be taken to have the elements as near the same height above ground as possible. If flexible structures, such as trees, are used for supporting the ends of the elements, adequate slack must be left in the elements to allow for flexing. Details of the tape element length settings are given in Pt. 1, Chap. 4.

16. When removing the antenna TD-1 from its installed position, the tape elements must be wiped clean of dirt and sand etc., before being rewound.

CAUTION...

Do not attempt to rewind the tape in the wrong direction as the tape connections may be damaged. Wind only in the direction indicated by the REWIND arrows on the tape housing.

ADJUSTABLE DIPOLE ANTENNA 637T-2

17. This antenna is an alternative to the Type TD-1 and is erected in a similar manner. Deployment of the phosphor-bronze wire stored in the cylindrical housing is carried out as follows: Ensure that all wire is wound onto the reels and then set both wire length indicator pointers to '0' by loosening the indicator clamp knobs, positioning the indicators to '0', and retightening the clamp knobs. Pull both wires out of the housing until the indicators read the required frequency. Secure the wires at the desired length with the wire lock knobs mounted on the antenna housing. Details of wire length settings are given in Pt. 1, Chap. 4.

18. The end of each wire is attached through a swivel to a length of nylon rope. This forms an insulator as well as the staking attachment.

NOISE BLANKER

19. For best performance from the noise blanker 136B-2 in the transceiver KWM-2A, the NB ANT socket on the KWM-2A should be connected to a 50-ohm, 40 MHz whip antenna. However, by accepting a reduction in the noise blanker performance, the broadcast antenna (either the horizontal dipole or a suitable whip antenna) can be used by connecting it in the manner shown in fig. 3. If this system is used, the r.f. choke L and the capacitor C shown in fig. 3 must be connected as close as possible to the aerial.

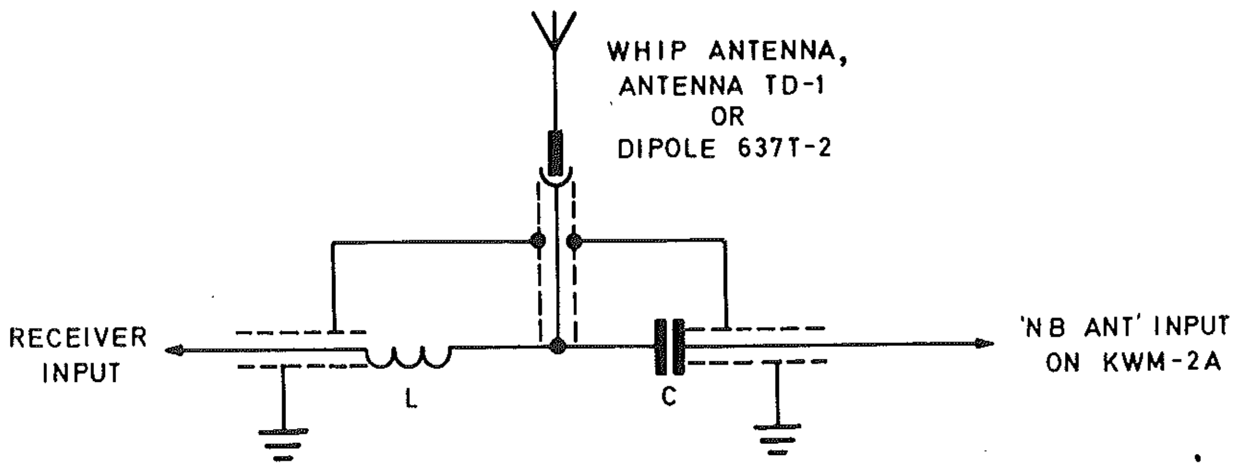

Fig. 3 Use of the broadcast antenna for the noise blanker 136B-2