

This book is the property of H.M. Government

B.R.1771(39)

C.R.E.T.E.

HANDBOOK FOR

N.S.N. 6625-99-972-6000

SIGNAL GENERATOR (2-250 MC/S)

CT378A

ANY SUGGESTIONS FOR AMENDMENTS OR ADDITIONS TO THIS BOOK  
SHOULD BE SUBMITTED TO THE CAPTAIN SUPERINTENDENT, ADMIRALTY  
SURFACE WEAPONS DEPARTMENT, THROUGH THE USUAL CHANNELS

WEAPONS DEPARTMENT, ADMIRALTY  
1961 (W.50481/61)



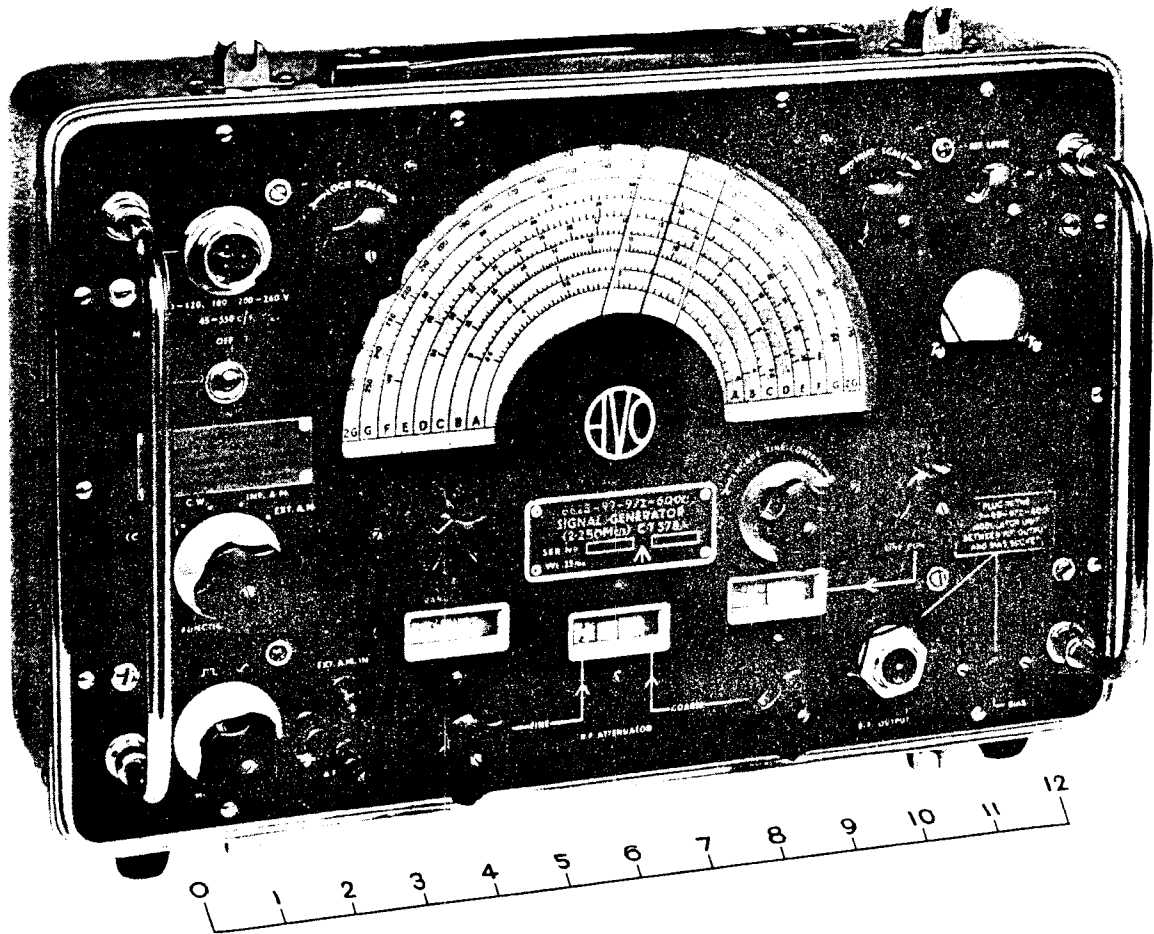


FIG 1.1.1. FRONT PANEL OF SIGNAL GENERATOR



H A N D B O O K F O R

N . S . N . 6 6 2 5 - 9 9 - 9 7 2 - 6 0 0 0

S I G N A L G E N E R A T O R ( 2 - 2 5 0 M C / S ) C T 3 7 8 A

L I S T O F C O N T E N T S

SUMMARY OF DATA

PART 1

CHAPTER 1 TECHNICAL DESCRIPTION

PART 2

CHAPTER 1 OPERATING INSTRUCTIONS

CHAPTER 2 MAINTENANCE

CHAPTER 3 LIST OF PREFERRED COMPONENTS FOR REPLACEMENT PURPOSES

APPENDIX A 5905-99-972-8353 ATTENUATOR FIXED  
5905-99-972-8352 ATTENUATOR FIXED  
5905-99-972-6357 ATTENUATOR FIXED

APPENDIX B 6625-99-972 6001 MODULATOR UNIT - SIGNAL GENERATOR



CHAPTER 1

TECHNICAL DESCRIPTION

LIST OF CONTENTS

	Paragraph
Introduction.....	1
Panel Controls and Frequency Coverage.....	2
The RANGE Mc/s switch.....	3
The TUNING CONTROL.....	4
The ENGAGE FINE CONTROL and FINE CONTROL.....	6
The SHIFT SCALE and LOCK SCALE controls.....	7
The FUNCTION and SINE-SQUARE Switches.....	10
The R. F. ATTENUATOR Controls.....	11
The SET LEVEL Control.....	14
<b>CIRCUIT DESCRIPTION</b>	
The R. F. Oscillator circuit.....	15
The Tone Generator.....	18
The Modulation System.....	23
Internal Preset Controls.....	35
The SET LEVEL Meter and Attenuator System.....	36
The Power Supply.....	38

LIST OF ILLUSTRATIONS

	Figure
Front Panel of Signal Generator.....	1.1.1
R.F. circuit Feeding Variable Load.....	1.1.2
R.F. circuit Feeding Constant Load.....	1.1.3
Simple modulation System.....	1.1.4
Graph showing change of crystal resistance with current.....	1.1.5
R.F. superimposed on A.F. waveform.....	1.1.6
Amplitude Modulated R.F.....	1.1.7
The Modulation Circuit.....	1.1.8

## SUMMARY OF DATA

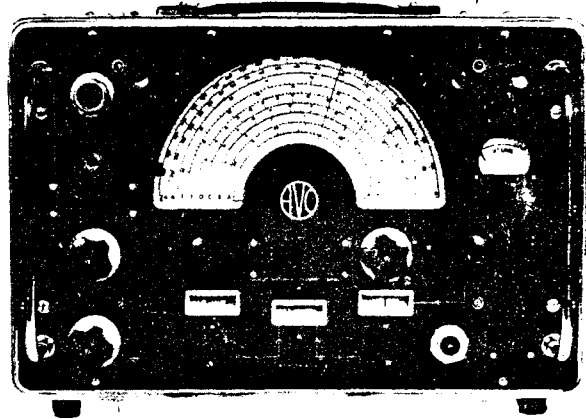
## PURPOSE

Simple testing of radar and communications receivers.

## BRIEF DESCRIPTION

NOTE: CT378A differs from -943-1825 CT378 in that its frequency is extended to 250 Mc/s and an additional power supply is included for use with pulse modulator.

This signal generator provides signals between 25 mV and 1  $\mu$ V into a 75 ohms load at any radio frequency between 2 and 250 Mc/s. An external attenuator unit is used when working into 50 ohm loads; signals between 12.5 mV and 1  $\mu$ V are then available. The seven frequency ranges are so chosen that common radar i.f. amplifiers etc. can be checked for centre frequency and bandwidth without range changing. An internal 1 kc/s tone generator and optional squaring stage provide a nominal 30 per cent amplitude modulation, with either sine or square waveform at any radio frequency within the range. External sine wave and pulse modulation are also possible. The modulation circuits are of novel design to reduce frequency modulation to negligible proportions for normal measurements. The second harmonic of range G is calibrated for use between 170 and 500 Mc/s.



## PERFORMANCE

<u>Ranges</u>	Range A 2-4.5 Mc/s
	Range B 4-9 Mc/s
	Range C 7.5-16 Mc/s
	Range D 11.24 Mc/s
	Range E 22-50 Mc/s
	Range F 45-100 Mc/s
	Range G 85-250 Mc/s

GENERAL VIEW OF CT378A

Harmonic Range 2G 170-500 Mc/s.

Scale calibration accuracy  $\pm 1$  per cent  $\pm 2$  per cent at scale extremes.

Output Output into 75 ohms, 1  $\mu$ V to 25 mV continuously variable; into 50 ohms, 1  $\mu$ V to 12.5 mV using fixed attenuator.

Accuracy  $\pm 2$  dB  $\pm 1$   $\mu$ V up to 150 Mc/s

$\pm 3$  dB  $\pm 2$   $\mu$ V 150-250 Mc/s

Harmonic range - the level is approximately 10 per cent of that indicated.



## CHAPTER 1

### TECHNICAL DESCRIPTION

#### Introduction.

1. The Signal Generator CT378A is a general purpose Signal Generator which has been designed to produce a 30% a.m. signal having an f.m. content not greater than 5 kc/s. The tuning mechanism has been built to enable the instrument to be used in conjunction with radio receivers having a 10 kc/s passband, and both the attenuator and stray field have been required to meet an exacting specification. This instrument incorporates a new form of attenuator using a printed circuit technique, to give negligible reaction with change of frequency. In conjunction with a plug-in modulator unit, pulse modulation is also available.

#### Panel Controls and Frequency Coverage

2. Eleven controls are provided, together with a MAINS 'ON-OFF' switch. Their respective functions are as follows:-

#### The RANGE Mc/s switch

3. This is a seven-position switch marked:-

A	-	4.5	-	2
B	-	9	-	4
C	-	16	-	7.5
D	-	24	-	11
E	-	50	-	22
F	-	100	-	40
G	-	250	-	85

The position of this control indicates the band in Mc/s over which the instrument is set to operate, the upper and lower limit of each band also being displayed on the main scale plate adjacent to each section of the calibrated scale.

In addition, when the switch is set to G - 250 - 85, the harmonic range 2G covering 500-170 Mc/s may also be used. In general, it should, however, only be used as a harmonic range for frequencies above 250 Mc/s i.e.  $2 \times 125$  Mc/s.

#### The TUNING CONTROL

4. This control operates the main capacitor, which is directly coupled to the cursor, which sweeps the calibrated frequency dial. There is, therefore, no possibility of errors being introduced due to backlash between capacitor and cursor.

5. The complete frequency range of the instrument is 2 - 500 Mc/s covered in eight bands as follows:-

- |  |  |
|--|--|
| A - 4.5 Mc/s - 2 Mc/s .....            | Calibrated sub-divisions at mid-scale are marked at intervals of 50 kc/s.  |
| B - 9 Mc/s - 4 Mc/s .....              | Calibrated sub-divisions at mid-scale are marked at intervals of 100 kc/s. |
| C - 16 Mc/s - 7.5 Mc/s .....           | Calibrated sub-divisions at mid-scale are marked at intervals of 100 kc/s. |
| D - 24 Mc/s - 11 Mc/s .....            | Calibrated sub-divisions at mid-scale are marked at intervals of 200 kc/s. |
| E - 50 Mc/s - 22 Mc/s .....            | Calibrated sub-divisions at mid-scale are marked at intervals of 0.5 Mc/s. |
| F - 100 Mc/s - 40 Mc/s .....           | Calibrated sub-divisions at mid-scale are marked at intervals of 1 Mc/s.   |
| G - 250 Mc/s - 85 Mc/s .....           | Calibrated sub-divisions at mid-scale are marked at intervals of 1 Mc/s.   |
| Harmonic range 2G - 500 - 170 Mc/s ... | Calibrated sub-divisions at mid-scale are marked at intervals of 2 Mc/s.   |

#### The ENGAGE FINE CONTROL and FINE CONTROL

6. The TUNING CONTROL is fitted with a knurled ring labelled ENGAGE FINE CONTROL which when tightened down in a clockwise direction enables movement of the FINE CONTROL to be transmitted by a vernier drive to the main capacitor via the TUNING CONTROL. The FINE CONTROL operates an interpolation dial, which can be observed through a window adjacent to the TUNING CONTROL. If the knurled clamping ring on the TUNING CONTROL is turned in a counter-clockwise direction, the FINE control and dial are disengaged. The frequency range can then be scanned at high speed by means of the TUNING CONTROL.

#### The SHIFT SCALE and LOCK SCALE Controls

7. Despite the extremely wide frequency coverage of the instrument, the accuracy of the calibrated frequency scale is, at mid-scale, within  $\pm 1\%$ . This degree of accuracy is not however sufficient to enable the scale to be set to within a small fraction of a megacycle at 200 Mc/s, or within 10 kc/s at 5 Mc/s. The instrument has therefore been fitted with a device which enables the scale to be moved with respect to the cursor, enabling the calibration at any point to be precisely set, by beating the output of the signal generator against a signal of a known frequency. This precise scale setting can then be locked and subsequent frequency settings made in the region around the set point to a very high degree of accuracy.

8. The scale can be freed by turning the LOCK SCALE knob in a counter-clockwise direction and then moved with respect to the Cursor by turning the SHIFT SCALE control to give the frequency setting required. The scale is then locked by turning the LOCK SCALE knob in a clockwise direction.

9. When it is desired to return the instrument to its original calibration setting, the scale can be freed by means of the LOCK SCALE knob, and the scale moved by means of the SHIFT SCALE control until the reset mark on the scale plate is located in the centre of the small viewing aperture provided. The scale is then locked by turning the LOCK SCALE knob in a clockwise direction.

#### The FUNCTION and MOD SWITCHES

10. The FUNCTION SWITCH is a four-position switch marked:-

- |                     |      |   |
|---------------------|------|---|
| (1) A.F. (C.W. off) | .... | The r.f. oscillator is quiescent and the internal tone oscillator (1000 c/s) is used to produce 4-5V r.m.s. from the source impedance of about 10,000 ohms across the 'A.F. OUT' and '↓' terminals.   |
| (2) C.W.            | .... | Unmodulated r.f. carrier.   |
| (3) INT. A.M.       | .... | R.F. carrier modulated at a nominal depth of 30% by the internal 1000 c/s tone generator.   |
| (4) EXT. A.M.       | .... | R.F. carrier can be amplitude modulated to a depth not exceeding 50%, by applying a modulation voltage to the terminals 'EXT. A.M. IN' and '↓'. The input impedance is about 1 M ohm in parallel with 20 pF. A nominal modulation depth of 30% is given by a sine wave of about 6V r.m.s. at any frequency between 100 c/s and 10 kc/s. |

NOTE: In positions 3 and 4 the modulation signal is available between the 'A.F. OUT' and '↓' terminals and can thus be conveniently used to lock an oscillograph time base, but the circuit must not be heavily loaded. When so used, the load employed should not drop below 50 k. ohms, for otherwise the modulation depth of the r.f. signal may be altered and/or spurious f.m. introduced on to the carrier.

The MOD switch either selects the sine wave oscillator for driving the modulator or else introduces a simple squaring circuit between the oscillator and modulator.

#### The R.F. ATTENUATOR controls

11. The attenuator is divided into sections, COARSE and FINE, the setting of each control being visible through a centre window, the dials working in juxtaposition.

12. The COARSE dial is marked 'FORCE, X1mV, X0.1 mV, X 10 μV, and X 1μV. The FINE dial is marked 'FORCE, 25, 20, 15, 10, 7.5, 5, 4, 3, 2, 1. A minor calibration point is put in at 3.16 equivalent to 10dB on the "1" point.

13. To obtain FORCE output from the signal generator, the force calibration points on both dials, must be placed adjacent to one another. When the COARSE dial is set to its remaining positions, then any setting of the FINE dial between 25 and 1 when multiplied by the COARSE dial setting, gives the output from the r.f. cable (when terminated by 75 ohms) after adjustment of the SET LEVEL control. When a 50 ohm source impedance is required a 5905-99-972-6357 attenuator, fixed, containing a 75 ohm load and a 12.5 ohm series resistor should be used. See operating instructions.

#### The SET LEVEL control

14. When using the signal generator on the ranges 'C.W.' 'INT. A.M.' or 'EXT. A.M.', the output level required should be set on the R.F. ATTENUATOR controls and the SET LEVEL control turned until the set level meter needle is set at the datum mark on the scale plate. The output from the r.f. cable, when terminated with a load of 75 ohms, will then be as indicated on the R. F. ATTENUATOR control. When used with 5905-99-972-6357 ATTENUATOR, FIXED, for 50 ohm loads, the indicated voltage should be divided by a factor of two.

### CIRCUIT DESCRIPTION

#### The R.F. Oscillator Circuit

15. This is a modified Colpitt's circuit employing a high-slope triode valve V3, delivering approximately 200 mV at the junction of R19, R15 and MR1 into a novel form of constant impedance modulator and attenuator system.

16. The amplitude of the r.f. signal delivered into the modulation system, can be adjusted by the panel control RV3 which limits the anode voltage fed to V3. The amplitude of the r.f. signal is adjusted to 400 mV by placing a high impedance valve voltmeter across R36 and L16a, when the range control is set to A - 4.5 - 2 Mc/s. The resistor R36, plays no part in the function of the r.f. circuit, but is inserted to enable the SET COMPENSATION Control to be adjusted. When RV3 has been correctly adjusted, the valve voltmeter circuit, C21, MR3, R31, C26, R33, C27, and R32, is so adjusted that the indicator needle of M1 reads on the graduation on the scale, by selecting the value of R.32.

17. Resistor R37 is inserted when SAa is set to its A.F. 'C.W. OFF' position. When SAa is so set, the r.f. oscillator ceases to operate and the dummy load R37 maintains a constant load on the power pack. This loading prevents a surge of r.f. when switching from A.F. (C.W. OFF) to C.W.

#### The Tone Generator

18. This is a simple Hartley oscillator employing V1B and remains in operation except when SA is set to 'EXT. A.M.' This stage is supplied with anode voltage direct from L6 which is fed to the centre-tapped choke L1. The a.f. output is fed via C3 to SAB and the function of this switch should be noted in relation to SAa to which it is of course directly ganged. The functions of the switch are given below:-

19. A.F. (C.W. Off) - The a.f. signal is fed to the grid of V1A which acts as a cathode follower delivering an a.f. output of about 4 to 5 volts r.m.s. via C14 to the a.f. output terminals. Note that the r.f. oscillator is quiescent, and there is therefore no output via the attenuator.

20. C.W. - No a.f. signal is applied to V1A, the grid of which is shorted. An unmodulated r.f. signal can be obtained from the r.f. cable.

21. INT. A.M. - an a.f. signal is fed into the grid of V1A from whence two outputs are taken into the modulation system (to be described) which produces an r.f. signal, amplitude modulated at 1000 c/s to a depth of 30%. If the MOD switch is put at square, valve V5 is introduced into circuit giving a substantially square-wave output which is fed on to the modulator.

22. EXT. A.M. - The a.f. input terminal is connected to the grid of V1A and thus an outside a.f. source can be used to modulate the r.f. signal via the anode and cathode stages of V1A which feeds into the modulation network. The internal tone generator is muted by SAd to avoid spurious a.f. pickup from this source. A voltage of about 6V r.m.s. produces a nominal 30% modulation. Modulation up to about 60% is available without appreciable distortion. The internal square-wave generator is inoperative.

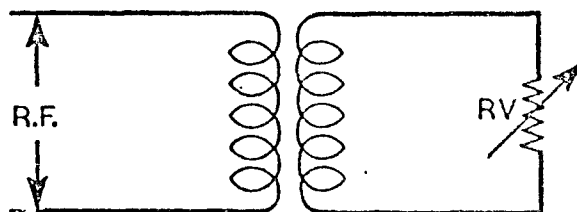
### The Modulation System

23. This is a novel and ingenious form of modulation network, designed to reduce to a minimum the variation of load imposed on the r.f. circuit. (Patent Applied for).

24. Consider a simple r.f. generator coupled to a variable load, which is imposed on the r.f. circuit in the form of an amplitude modulated signal. Alterations in the load will be reflected back to the generator, which sees the load as a variable impedance, which does, of course, mean that the frequency of the signal produced by the r.f. circuit may tend to change. This phenomenon is of little consequence when designing simple signal generators for aligning ordinary broadcast receivers, but it cannot be tolerated in an instrument such as this, for an amplitude modulated r.f. signal may be produced having a frequency modulation content greater than the band-width of the 10 kc/s i.f. channels into which the instrument is designed to inject a signal.

25. The problem has therefore been to design a circuit to give amplitude modulation signals with a minimum of frequency modulation content. This has been done by employing the following method, bearing in mind that the essential task is to impose a constant load on the r.f. circuit. Suppose that an r.f. circuit (Fig. 1.1.2) is loaded by the potentiometer RV, then variations of RV will impose a variety of loads on the coupling circuit, thus pulling the generator.

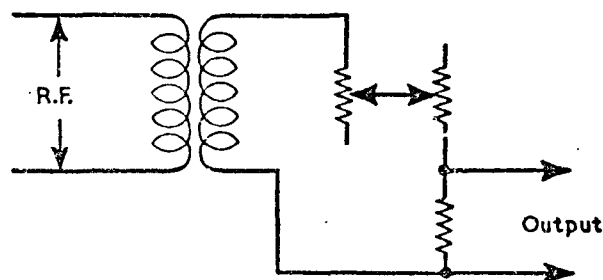
R.F. Circuit Feeding Variable Load



(Fig. 1.1.2)

26. Suppose however that the circuit is rearranged as in Fig. 1.1.3, using two identical potentiometers ganged in such a manner that movement of the control increases the value of one by the same amount as it decreases the value of the other - then the value of the load will be constant. This is the principle adopted in this instrument, but instead of using an impracticable arrangement of potentiometers to keep the load (in practice an amplitude modulated output) constant, germanium crystals have been employed.

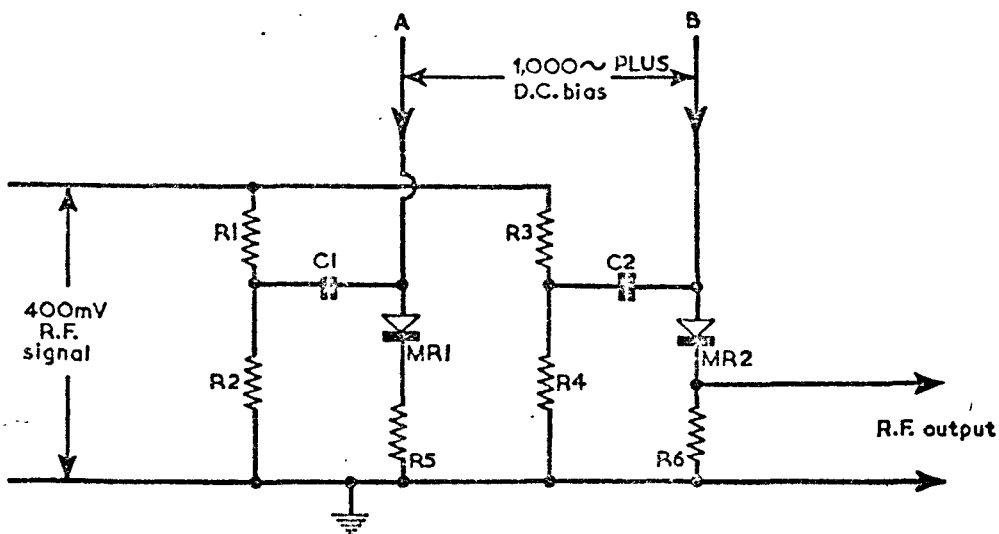
R.F. Circuit Feeding Constant Load



(Fig. 1.1.3)

27. Consider the simplified modulation circuit Fig. 1.1.4. The approximately 200 mV r.f. signal is fed to the two potential dividers R1, R2, R3, and R4. With no a.c. input at points A & B, but with fixed d.c. bias applied to the crystals MR1 and MR2, these potential dividers, together with their associated circuitry, present a constant load to the r.f. generator.

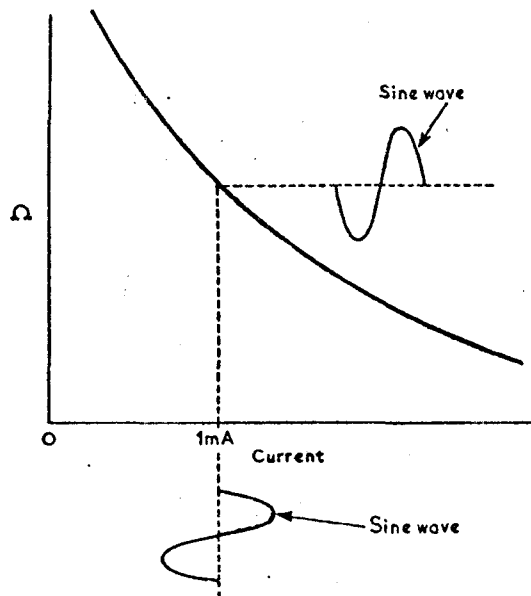
Simple Modulation System



(Fig. 1.1.4)

28. Consider now the current-resistance characteristic of one of the germanium rectifiers MR1 or MR2 (Fig. 1.1.5) and, for the purpose of explanation, assume that the two functions have a linear relationship (the graph is a straight line), the resistance of the rectifier varying with the current passing. If the current rises, the resistance falls and conversely, if the current falls, the resistance rises. If therefore a nominal working point is selected at about 1 mA, the resistance of the device will be constant, but if then a sinusoidal waveform is applied on top of the d.c. bias, then the resistance of the device will vary in sympathy with the applied waveform. Thus the variable resistance device shown in Fig. 1.1.2 has been produced electronically.

Graph showing change of crystal resistance with current

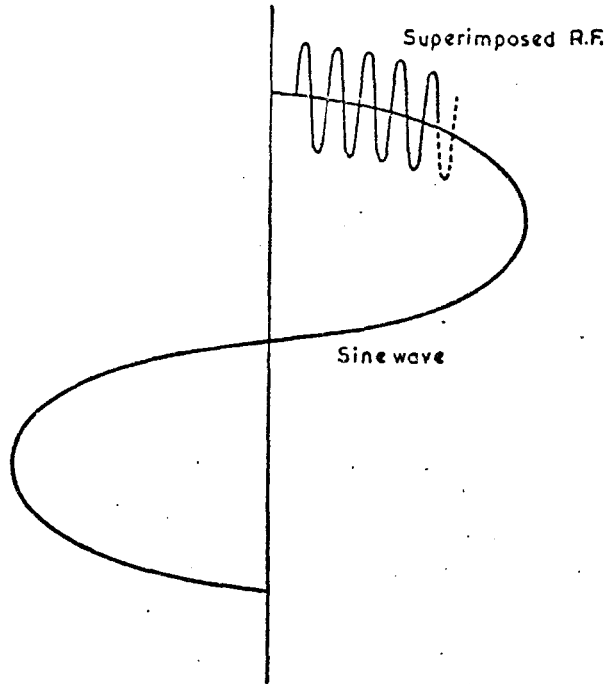


(Fig. 1.1.5)

29. Consider once again the modulation circuit shown in Fig. 1.1.4. With a constant d.c. bias, the load on the r.f. generator is constant, but if now a 1000 c/s waveform is applied at points A & B, these points being fed in anti-phase, it can at once be seen that one crystal tends to conduct more heavily, whilst the other cuts off to the same degree. Thus the device still maintains a constant load on the r.f. generator.

30. It must now be realised that in the practicable circuit, the 1000 c/s bias carries a relatively smaller r.f. waveform (Fig. 1.1.6) and the magnitude of this signal will vary as the resistance of the crystals varies.

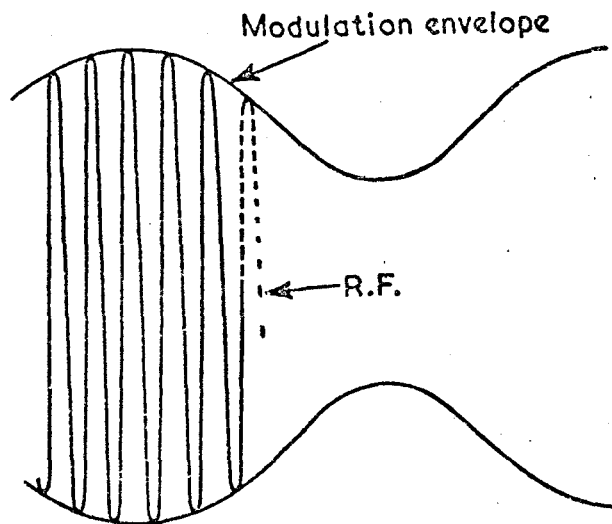
R.F. Superimposed on A.F. Waveform



(Fig. 1.1.6)

31. If a suitable oscilloscope is connected across R6 it should be possible to see the r.f. waveform varying in amplitude (Fig. 1.1.7). In other words, the r.f. waveform is amplitude modulated.

Amplitude Modulated R.F.

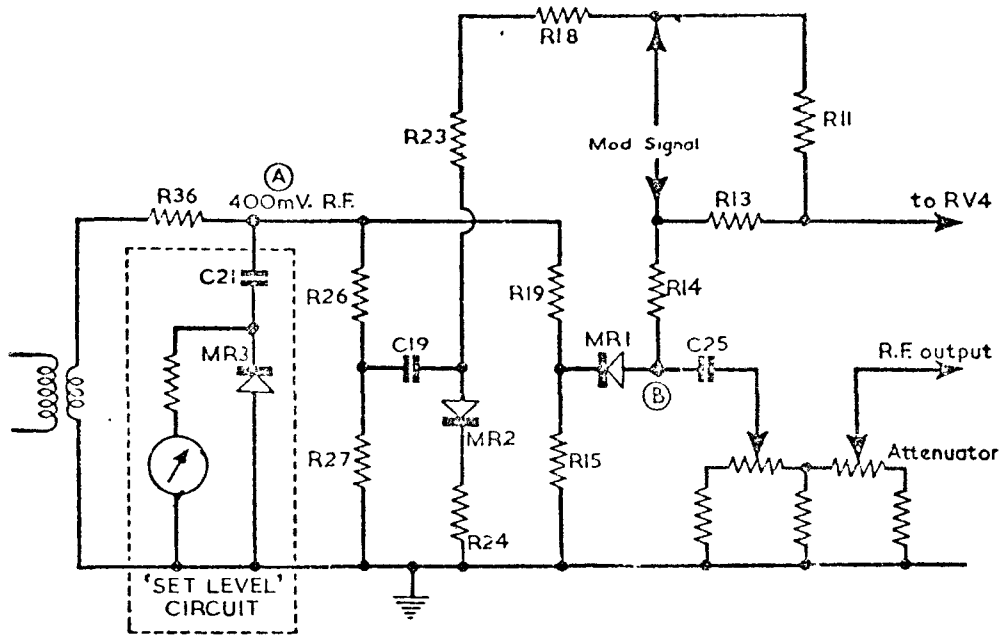


(Fig. 1.1.7)

32. Correct selection of circuit values, d.c. bias for the crystals, magnitude of the 1000 c/s modulation signal and a constant impedance attenuator in place of R6 (in Fig. 1.1.4) is all that is now required to meet the specification.



## The Modulation Circuit



(Fig. 1.1.8)

33. The operation of the whole modulation circuit can be better understood from the more detailed but still simplified circuit (Fig. 1.1.8), which can best be explained by the manner in which it is set up to operate correctly.

34. The r.f. signal is fed to the two potential dividers, R26, R27 and R19, R15, both of which feed into crystal loaded circuits. Each crystal is d.c. biased via R23, R18, R11 and R13, R14, the magnitude of the biasing current being controlled by RV4. Valve V1B supplies the a.f. modulation signal which is fed in anti-phase to the circuit via capacitors C8 and C9. The magnitude of these signals is controlled by RV1 and RV2.

### Internal Preset Controls

35. Full setting-up procedure is given later, but can be explained briefly by saying that RV4 is adjusted until a c.w. signal of 25 mV is obtained from the attenuator; it will be noted that the attenuator and R24 present substantially the same loading to the crystal circuits. An oscillograph is then placed between points B (Fig. 1.1.8) and earth, and RV2 adjusted until 50% depth modulation is obtained. The oscillograph is then transferred across points A (Fig. 1.1.8) and earth and RV1 adjusted until a minimum depth of modulation is observed, thus insuring that / whilst the r.f. waveform is being correctly modulated, the load on the r.f. generator remains constant.

## The Set Level Meter and Attenuator System

36. The SET LEVEL meter simplified circuit is shown in Fig. 1.1.8. As already explained, the circuit is set in such a manner that when 400 mV r.f. appear between points A and earth, the built-in meter reads on the graduation mark. This ensures that a constant magnitude of signal is fed into the attenuator circuit, quite irrespective of frequency. When the meter has been adjusted by means of the panel control RV3, the output from the r.f. cable, when terminated by 75 ohms, will be as shown on the ATTENUATOR dial settings.

37. The attenuator (Patent Nos. 675, 392 and 699, 684) itself is of interest, for it employs virtually non-inductive resistors housed within a silver-plated, copper-bronze casting which assists in reducing radiation to a very low level.

## The Power Supply

(Fig 2.2.11)

38. This is a conventional full-wave rectifier system fed by transformer T1. The primary of the transformer is connected to the supply by r.f. filters which prevent unwanted signals getting either into or out of the generator by the mains lead. A conventional pi-filter network feeds smoothed h.t. to several circuits and, in addition, a neon stabiliser regulates the supply to the r.f. oscillator and the d.c. bias to the modulator circuits. A negative bias line is provided by MR5, C34, R48 and R49 to be fed to 6625-99-972-6001 MODULATOR UNIT SIGNAL GENERATOR. R49 is adjusted in calibration (A.I.C.) to give a 10 mA bias current. This is automatically connected when the MODULATOR UNIT is plugged into CT378A. The bias is picked up from an internal contact accessible via the hole to the right of the R.F. OUTPUT plug. The external pulse is fed into the MODULATOR UNIT via the B.N.C. socket on the side.

PART 2

CHAPTER 1

OPERATING INSTRUCTIONS

LIST OF CONTENTS

	Paragraph
Conditions of operation.....	1
The Power Supply, Tap changing and fuse.....	2
Setting Frequency 2-250 Mc/s (Accuracy 1% except at extremi- ties of bands)... ..	4
Using the Harmonic Frequency range (2G).....	5
Setting the main scale for more accurate frequency measurements	6
Setting the R.F. Output to a known level (with the exception of range 2G).....	7
Selection of modulation and Tone Generator output.....	16
The use and supply of Leads and Adaptors.....	17
Use of 6625-99-972-6001 Modulator Unit, SIGNAL GENERATOR.....	20

ILLUSTRATION

	Figure
ATTENUATOR CONVERSION CHARTS.....	2.1.1.



P A R T 2

C H A P T E R 1

O P E R A T I N G I N S T R U C T I O N S

Conditions of Operation

1. The instrument is designed to operate over an ambient temperature range of  $-25^{\circ}\text{C}$ . to  $+55^{\circ}\text{C}$ . It is splash proof when the lid is closed, but not immersion proof.

The Power Supply, Tap Changing and Fuse

2. The instrument will operate on the following power supplies:-

110-120 volts)	
175-185 volts)	
200-220 volts)	45-550 c/s.
220-240 volts)	
240-260 volts)	

3. The tap changing panel and line fuse can be located by removing the a.c. plug from the mains supply, turning the instrument face downwards taking care to rest it on the guard rails and not on the glass of the scale, and removing the rectangular cover plate on the bottom of the case by unscrewing the two screws. Tap selection is made by removing the 1 amp. fuse and replacing it in the clips corresponding to the magnitude of the a.c. supply voltage. Replace the cover plate, and connect to the a.c. supply. Switch on, and allow five minutes for the instrument to warm up.

Setting Frequency 2-250 Mc/s (Accuracy 1% except at extremities of bands)

4. (For 250-500 Mc/s see para. 5)

- (a) Locate on the main scale a red tab near the 240 Mc/s mark on the G scale. The black dot on the scale plate should lie in the centre of the hole in the red tab. If it does not, then turn the LOCK SCALE control counter-clockwise until it releases the main scale. Carefully rotate the main scale using the SHIFT SCALE control until the black dot is central in the hole in the red tab. Turn the LOCK SCALE control clockwise until the scale is firmly locked. Do not use great force when making this adjustment.
- (b) Set the desired frequency range on the RANGE MC/S switch; and note the corresponding range letter.
- (c) Locate the tuning control. Turn the aluminium ENGAGE FINE CONTROL holding the TUNING CONTROL (black knob) counter-clockwise, to unlock the FINE CONTROL. Tune to the desired frequency using correct range letter calibration, e.g. there are two settings for 22 Mc/s; the correct one must be determined by reading 22 Mc/s on the scale lettered to correspond with the lettering on the RANGE MC/S control.

- (d) When using narrow-band receivers, it may be convenient to use the FINE CONTROL. Set to near the desired frequency as detailed above, and then holding the TUNING CONTROL (black knob) to prevent rotation, turn the knurled aluminium knob clockwise, until it tightens on the shaft. It should now be found that the FINE CONTROL drives the main frequency pointer through the subsidiary friction drive. Rough, band-width measurements may be made by using the calibration of the vernier scale located in the window below the TUNING CONTROL. This vernier control is only locked to the TUNING CONTROL when the FINE CONTROL is in use.

NOTE. Always unlock the ENGAGE FINE CONTROL before turning the TUNING CONTROL.

#### Using the Harmonic Frequency Range (2G)

5. When the frequency required lies between 250 and 500 Mc/s turn the RANGE Mc/s switch to G-250-85, then set the required frequency by means of the FINE CONTROL on scale 2G, covering 170-500 Mc/s. The second harmonic of the oscillator operating between 85 and 250 Mc/s is used to produce the desired frequency. The output voltage will be very approximately about 10% of that indicated by the r.f. attenuator setting when a 75 ohm load is employed, or 5% using 50 ohm loads and adaptors. The modulation percentage varies over the 2.G. Range and should not be used for accurate signal noise tests.

#### Setting the main scale for more accurate frequency measurements

6. If, for example, a receiver is known to be tuned to a given frequency, e.g. a known transmitter frequency, the CT378A should then be tuned to the known frequency, zero beat being obtained by using a loose coupling against the known transmitter signal. Unlock the LOCK SCALE control, and carefully set the scale to line up with the pointer at the known frequency, using the SHIFT SCALE control. A frequency shift of not more than 2% maximum should be necessary. Lock the scale by means of the LOCK SCALE control, taking care to ensure that it does not move during this operation. The calibration of the frequency scale can then be used as being more accurate than the nominal 1%, for a range of about 10% either side of the calibration frequency.

#### Setting the R.F. Output to a known level (with the exception of range 2G)

##### 7. NOTES:

- (a) The instrument operates as a generator of twice the voltage shown by the R.F. ATTENUATOR in series with an internal impedance of 75 ohms, but see below for 50 ohms adaption.
- (b) Thus if the load into which the instrument works is 75 ohms, the output voltage will be that shown by the R.F. ATTENUATOR.
- (c) If the instrument is to be used on a high impedance load - e.g. a valve grid - then the cable must be terminated to avoid standing waves. A convenient method is to connect either 5905-99-972-8352 ATTENUATOR, FIXED or 5905-99-972-6357 ATTENUATOR, FIXED to the end of the output cable. The -8352 ATTENUATOR is a 75 ohm load to earth (i.e. across the coaxial line), with a resistor of 37.5 ohms in series to the output screenector plug. The -6357 is similarly 75 ohms to earth with a 12.5 ohm series resistor ending in a B.N.C. socket. If the load is a high impedance the effect of the 37.5 or 12.5 ohm series resistors can be neglected.

- (d) For signals below 1 mV a better impedance match is obtained by fitting 5965-99-972-8353 ATTENUATOR, FIXED at the end of the 5995-99-972-8349 cable. This is a 20 dB, 75 ohm input and output, attenuator and the output voltage obtained is one tenth of that obtained when it is out of circuit. The 5905-99-972-8352, or -6357 ATTENUATOR, FIXED (see para. (c) above) should be added as necessary and the additional loss be allowed - dependent on the load conditions, i.e. 'High' 75 or 50 ohms.
- (e) When the instrument is used with 50 ohm loads the 5995-99-972-8349 cable must be terminated by 5905-99-972-6357 ATTENUATOR, FIXED (see (c) above). The B.N.C. connector is to be fed to the external 50 ohm load via a 50 ohm coaxial cable. The CT378A then operates as a generator of E.M.F. equal to that shown by the ATTENUATORS COARSE and FINE settings in series with 50 ohms. The voltage across the external 50 ohm load is thus ONE HALF that shown by the ATTENUATORS of CT378A.

#### CAUTION

To preserve the R.F. ATTENUATOR of CT378A, and/or the ATTENUATORS FIXED from being damaged, do not connect the R.F. OUTPUT leads directly to a point in a circuit where a potential to earth exists, e.g. the anode of a valve.

8. Ensure that the FUNCTION switch is set to C.W., INT. A.M. or EXT. A.M. as required and that the MOD. switch is to the correct position. Connect 5995-99-972-8349 cable to the R.F. OUTPUT plug and connect terminations as required (see note and CAUTION above). The r.f. level is shown by two dials in a window and can be adjusted between the limits of 25 mV maximum, to below 1  $\mu$ V. into a 75 ohm load. Where the desired output is below 1 millivolt it is preferable to attenuate externally using 5905-99-972-8353 ATTENUATOR, FIXED, since a better match and lower leakage is obtained.

9. The COARSE dial must be set to one of five positions:- FORCE, x1mV, x.1mV, x10 $\mu$ V, or x 1  $\mu$ V (i.e. the mark on the scale must be lined up with the graticule). R.F. output is obtained at intermediate positions of this control and is of unknown level. This control is not a switch, it is a continuously variable control which must be set to the definite points indicated by the dial.

10. The FINE dial can either be set to FORCE, or any position from 25 to below 1, and is continuously variable.

11. Having set the two ATTENUATOR dials to the magnitude of signal required, turn the SET LEVEL control until the SET LEVEL meter reads at the graduation mark on the scale. The actual voltage produced is twice that indicated on the ATTENUATOR dials, but provided that the r.f. lead is terminated by a 75 ohm load, the actual voltage supplied to the load will be as indicated on the calibration dials. The actual r.f. voltage fed to the receiver is a product of the two dials, e.g. with the FINE dial set at 25, and the COARSE dial set at x 1  $\mu$ V, the output will be 25  $\mu$ V; with FINE dial set at 17 (estimated), and the COARSE dial set at 1 mV, the output will be 17 mV. When using 5905-99-972-6357 ATTENUATOR, FIXED divide the voltage indicated by a factor of two.

12. If it is desired to set up or read off a signal in decibels with a reference level of one microvolt across 75 ohms (-or 50 ohms see below), either set up or read off the ATTENUATOR FINE and COARSE dials as in Fig. 2.1.1. which gives a graphical conversion for the 1-25 scale of the FINE control and a tabulated scale for the COARSE, together with notes on the loss of various ATTENUATORS, FIXED, etc. It must be noted that when using a 75 ohm system the decibel reference point:-  $0 \text{ dB} \equiv 1 \mu\text{V}$  across 75 ohms is applicable but when 5905-99-972-6357 ATTENUATOR, FIXED is in circuit the reference level must be changed to  $0 \text{ dB} \equiv 1 \mu\text{V}$  across 50 ohms. To allow for the loss that 5905-99-972-6357 ATTENUATOR, FIXED produces calculate the dB level from the settings of the FINE and COARSE dials and subtract 6 dB.

13. As explained in para. 9 the COARSE control is a continuously variable control but if, for example, when checking RX bandwidth it is required to change a voltage in a ratio of 2:1, when watching the change in level of a receiver output meter, it is convenient to set the FINE dial to say 20, and adjust the output to give a known reading on the output meter by moving the COARSE control and ignoring for this purpose, the calibration points. A reduction in level by 2:1 can now be achieved by setting the FINE dial to 10. This method saves setting, to say, 23 (estimated) and 11.5 (estimated) and will lead to fewer errors in readings.

14. When both FINE and COARSE controls are set at FORCE, the ATTENUATOR is out of circuit and about 200 mV from a source impedance of 200-300 ohms is available. No attempt should be made to use this output except as a source of uncalibrated voltage. The output signal can be modulated, but the depth of modulation is a function of the load impedance. This effect is readily apparent when the method of modulation is understood. Do not use any external attenuators, as results will be meaningless.

15. The attenuator system is inoperative with one dial set at FORCE and the second at some figure. Thus the FINE control cannot be used to adjust the level when the COARSE control is at FORCE. The result will be meaningless. Only an unknown breakthrough voltage is normally detectable.

#### Selection of modulation and tone generator output

16. (a) A.F. (C.W. OFF) - The r.f. oscillator is quiescent and the internal tone generator is used to give about 4-5 volts from a source impedance of about 10k. ohms across the A.F. OUT and earth terminals, for simple audio testing.
- (b) C.W. - carrier is unmodulated.
- (c) INT. A.M. - The r.f. carrier is amplitude modulated at a nominal depth of 30% by the internal 1000 c/s tone generator. Sine or Square wave modulation is obtained dependent on the setting of the MOD. switch.
- (d) EXT. A.M. - r.f. carrier can be amplitude modulated to a depth not exceeding 50% by the application of a modulation voltage between earth and 'EXT. A.M. IN' Terminals. The input impedance is about 1M ohm in parallel with 20 pF. Nominal depth of 30%.



amplitude modulation is given by a sine wave of about 6V r.m.s. at any frequency between 100 c/s and 10 kc/s. The MOD. switch is inoperative.

#### NOTE

In positions 3 and 4 the modulation signal is available at the 'A.F. OUT' terminal. It can conveniently be used to lock an oscilloscope time base, but it must not be heavily loaded. The load should be resistive of not less than 50k. ohms since otherwise the modulation depth may be altered and/or spurious f.m. introduced on to the carrier.

#### The use and supply of leads and adaptors

17. Dependent on storekeeping procedure the CT378A may be issued as:-  
CT378A SET comprising:-

1. 6625-99-972-6000 CT378A - i.e. instrument only.
2. 5995-99-940-0491 mains lead.
3. 5995-99-972-8349 5 ft. r.f. lead. (75 ohm).  
The following items are available:-
4. 5965-99-972-8353 ATTENUATOR FIXED  
(20 dB d.c.-500 Mc/s. 75 ohms input and output).
5. 5905-99-972-8352 ATTENUATOR FIXED  
(75-75 ohm 'L' Pad d.c.-500 Mc/s.).
6. 5905-99-972-6357 ATTENUATOR FIXED  
(75 ohm in - 50 ohm out 'L' Pad d.c.-500 Mc/s.).
7. 6625-99-972-6001 MODULATOR UNIT, SIGNAL GENERATOR

Further details of items 4, 5, 6 and 7 are given in the Appendices to this book.

18. Other leads may be introduced as necessary but it must be noted that at higher frequencies, matching of cables is important. To obtain consistent results using different test rigs of nominally the same type, the matched condition introduces the lowest spread of errors.

19. A useful discussion of matching of signal generators will be found in BR.1771(16) (A.P.2563CF) Vol. 1 Part 1 Chapter 2 para. 19 onwards also Appendix - Notes on Output Terminations. The CT378A is specified in the same manner as CT218 regarding output voltage and impedance when used with 75 ohm loads. Care is required however when the 5905-99-972-6357 ATTENUATOR, FIXED is used to connect the CT378A to a 50 ohm source impedance.

#### Use of 6625-99-972-6001 MODULATOR UNIT, SIGNAL GENERATOR

WARNING. Do not plug Modulation Unit into CT378A with mains switched ON, or connect to the BIAS socket without first earthing the housing of the Modulator.

20. Plug into R.F. OUTPUT socket of CT378A taking care to mate up the projecting pin into the hole in the front panel of CT378A near the R.F. OUTPUT. A rubber grommet provides resilient mounting and insulation.



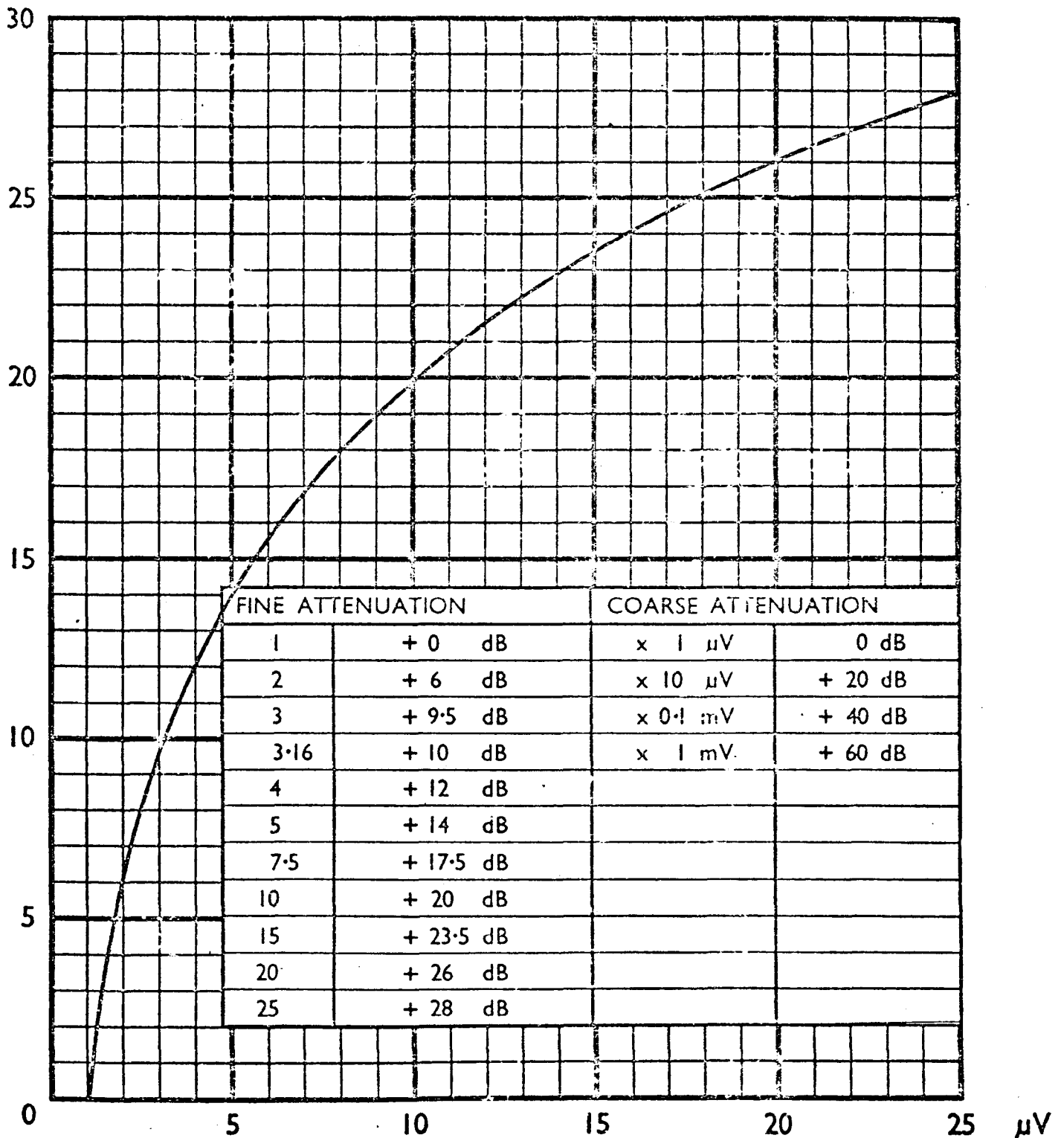


Fig. 2.1.1. ATTENUATOR CONVERSION CHARTS

0 dB = 1 μV across 75 ohm load

When using 5905-99-972-8353 loss is 20 dB

When using 5905-99-972-8352 loss is 6 dB

When using 6625-99-972-8001 loss is 7 dB

When using 5905-99-972-6357 loss is 6 dB\*

\*NOTE. Ref. level is 0 dB = 1 μV across 50 ohm load using this pad.  
However allowance must be made for the 6 dB loss in this pad.

This table and graph also appear in the lid of CT378A



P A R T 2

C H A P T E R 2

M A I N T E N A N C E

L I S T O F C O N T E N T S

	Paragraph
General.....	1
Rapid performance checks.....	2
Apparatus required.....	3
Preparation for test.....	4
To Test C.W. output.....	5
To Test A.M. output.....	6
Fault symptoms and diagnosis.....	7
To Remove the Instrument from its case.....	9
Repair data and typical voltages.....	10
To renew the attenuator card.....	11
Method of renewing card.....	12
Adjustments of Attenuator, etc. ....	13

L I S T O F I L L U S T R A T I O N S

	Figure
Plan view of instrument with front panel removed.....	2.2.1
Plan view of instrument showing partial removal of one control spindle and positioning of dial and disc.....	2.2.2
The Attenuator Assembly.....	2.2.3
Removal of controls from attenuator.....	2.2.4
Separation of attenuator castings.....	2.2.5
Removal of attenuator card.....	2.2.6
Attenuator assembly.....	2.2.7
Component layout on upper side of main panel.....	2.2.8
Component layout on lower side of main panel.....	2.2.9
Layout of R.F. compartment.....	2.2.10
Signal Generator (2-250 Mc/s) CT378A J.S. Cat. No. 6625-99-972-6000 Circuit Diagram.....	2.2.11



## P A R T 2

### C H A P T E R 2

#### M A I N T E N A N C E

NOTE:- Component layouts (Figs. 2.2.8-2.2.10) are provided to facilitate the identification of components.

#### General

1. The instrument should not require any routine adjustment. Do not open the instrument or adjust the preset controls until the need to do so has been clearly established. The following data is given for emergency use, but the instrument should be returned to the appropriate repair centre as soon as possible for recalibration, should it be necessary.

#### Rapid Performance Checks

2. The following paragraphs 3 to 6 provide a quick method of determining if the instrument is working normally. These tests can be performed without removing the instrument from its case.

#### Apparatus required

3. (a) CT378A under test, with mains lead.
- (b) Avometer Model 7 or 7X (Type 9979).
- (c) Valve Voltmeter CT54 or CT38 (optional, required for few tests only).

#### Preparation for Test

4. (1) Set the MAINS switch to OFF. Set the FUNCTION SWITCH to C.W. Set the RANGE Mc/s switch to A 4.5-2. Set the R.F. ATTENUATOR COARSE control to X 1 mV and the FINE control to 25. Turn the ENGAGE FINE CONTROL knurled ring fully counter-clockwise. Turn the SET LEVEL control fully counter-clockwise. Set MOD switch to sine.
- (2) Connect the 5995-99-940-0491 CONNECTOR to the MAINS plug of the instrument.
- (3) Test the continuity of the earth lead of the instrument, using Avometer on 10,000 ohm range. This should be done by connecting one lead of the Avometer to the chassis of the instrument, and the other lead of Avometer to the earth-pin of the 3-pin plug of MAINS CONNECTOR. This continuity resistance should be less than 0.5 ohms. If the continuity resistance exceeds 0.5 ohms, the defective earth lead must be repaired before proceeding further with the RAPID PERFORMANCE-CHECKS.

- (4) Test the resistance of the R.F. ATTENUATOR using the Avometer on 10,000 ohm range. This should be done by connecting one lead of the Avometer to the centre-pin of the R.F. OUTPUT plug and the other lead of the Avometer to the chassis of the instrument. This resistance should be between 50 and 100 ohms. Repeat this measurement as the FINE control is varied from 25 to 1 and as the COARSE control is varied from X 1 mV to XI $\mu$ V.
- (5) Measure the voltage of the a.c. mains supply. Set the tap-selecting fuse-link to suit the voltage of the mains as detailed in the operating instructions.
- (6) Connect mains CONNECTOR to the mains supply point.
- (7) Set the MAINS switch to ON. Check that the scale indicator lamp is alight. Wait five minutes for the instrument to warm up.

#### To Test C.W. Output

5. (1) Set the TUNING control to 3 Mc/s. Check that, by rotating the SET LEVEL control clockwise, the pointer can be aligned with the calibration mark on the SET LEVEL meter.
- (2) Check that, by rotating the SET LEVEL control clockwise, the pointer can be aligned with the calibration mark on the SET LEVEL meter, when the RANGE Mc/s switch and the TUNING control are set to:-

<u>RANGE Mc/s</u>	<u>TUNING CONTROL</u>
A 4.5 - 2	4.5 Mc/s and 2 Mc/s
B 9 - 4	9 Mc/s, 6 Mc/s and 4 Mc/s
C 16 - 7.5	16 Mc/s, 11 Mc/s and 7.5 Mc/s
D 24 - 11	24 Mc/s, 16 Mc/s and 11 Mc/s
F 50 - 22	50 Mc/s, 35 Mc/s and 22 Mc/s
F 100 - 40	100 Mc/s, 65 Mc/s and 40 Mc/s
G 250 - 85	250 Mc/s, 130 Mc/s and 85 Mc/s

- (3) Set the RANGE Mc/s switch to A 4.5-2 and the TUNING CONTROL to 3 Mc/s. Set the R.F. ATTENUATOR COARSE and FINE controls to FORCE. Adjust the SET LEVEL control to align the pointer with the calibration mark on the SET LEVEL meter. (If the SET LEVEL control cannot be so adjusted, turn the SET LEVEL control fully clockwise). Measure the r.f. output voltage of the instrument, using Valve Voltmeter. This should be done by connecting the probe low terminal of the probe unit to the chassis of the instrument, and the probe live terminal to the centre-pin of the R.F. OUTPUT plug. The voltage should be about 0.2V a.c. Proceed to step (4) before disconnecting valve voltmeter.



- (4) Set the R.F. ATTENUATOR COARSE control to X1 mV and the FINE control to 25. Set the FUNCTION SWITCH to A.F. (C.W. OFF) and check that the SET LEVEL pointer indicates zero. The valve voltmeter reading in (3) above should also fall to zero.

To Test A.M. Output

6. (1) Set the FUNCTION SWITCH to INT. A.M. Adjust the SET LEVEL control to align the pointer with the calibration mark on the SET LEVEL meter. Check that the internal a.f. oscillator of the instrument is operating using the Valve Voltmeter. This should be done by connecting the probe low terminal of the probe unit to the chassis of the instrument, and the probe live terminal to the A.F. OUT terminal of the instrument. The a.f. output voltage should be about 4-5V a.c.
- (2) Set the FUNCTION SWITCH to A.F. (C.W. OFF). Check that the internal a.f. oscillator is operating as in paragraph 6(1).

Fault Symptoms and Diagnosis

7.

FAULT SYMPTOM

POSSIBLE CAUSE AND REMEDY

- (1) During paragraph 4(4) the resistance of the R.F. ATTENUATOR is less than 50 ohms or exceeds 100 ohms.

The R.F. ATTENUATOR card is defective. This is a major defect which requires the instrument to be withdrawn from its case (see Paragraphs 9 and 11). Local repairs may not be possible with some service organisations.

- (2) On completion of paragraph 4(7). The scale indicator lamp is not alight.

(a) No mains supply voltage. Set the MAINS switch to OFF.

Remove rectangular cover plate on the rear of the instrument by releasing the two cover-screws. Remove the mains fuse (1 amp.) Set the MAINS switch to ON. Measure the supply voltage by connecting Avometer (400V a.c. range) between the terminals from which the fuse has been withdrawn. If no voltage is present, measure the supply voltage at the mains supply point. If the voltage is present at the supply point, but not at the transformer, disconnect mains CONNECTOR from the mains supply point and check the mains CONNECTOR and MAINS switch continuity.

If voltage is present between the fuse terminals proceed to (b).

(b) Mains fuse or scale lamp is defective.

FAULT SYMPTOM

POSSIBLE CAUSE AND REMEDY

Set the MAINS switch to OFF, check the mains fuse for continuity using Avometer. If fuse is sound the scale lamp, or its circuit, is defective. If the fuse is defective, this can be due to age or overload. Replace defective fuse by one that is sound and attempt paragraph 4(7) again. If the fault persists, it is due to overload. This is a major defect in which the many parts of the circuit require separate investigation. This requires the instrument to be withdrawn from its case (see paragraphs 9 and 10).

(3) Throughout paragraph 5(1) and (2) the SET LEVEL meter indicates zero.

(a) Attempt paragraph 5(3). If this is unsatisfactory either the r.f. oscillator circuit (V3) or the power supply circuit (V4 and V2) is defective. This is a major defect in which the many parts of these circuits require separate investigation. This requires the instrument to be withdrawn from its case (see paragraphs 9 and 10). If paragraph 5(3) is satisfactory proceed to (b).

(b) The SET LEVEL meter circuit is defective. This is a major defect in which the components of this circuit require separate investigation. This requires the instrument to be withdrawn from its case (see paragraphs 9 and 10).

(4) No r.f. output voltage obtained during paragraph 5(3) though the SET LEVEL control can be set as in paragraph 5(1) and (2).

Defective modulation circuit. This is a major defect in which the components of this circuit require separate investigation. This requires the instrument to be withdrawn from its case (see paragraphs 9 and 10).

(5) No a.f. output voltage obtained during paragraph 6(1) and (2).

Defective a.f. oscillator circuit (V1A and B). This is a major defect in which the components of this circuit require separate investigation. This requires the instrument to be withdrawn from its case (see paragraphs 9 and 10).

8. As a result of the RAPID PERFORMANCE-CHECKS it should be possible, by inference and the study of the table of FAULTS SYMPTOMS, to localise most defects to a small part of the circuit of the instrument. To determine the actual defective component and to carry out repair, it is usually necessary to remove the instrument from its case.

To remove the instrument from its case

9. (1) Disconnect mains CONNECTOR from the mains supply point and from MAINS plug. Slacken off, but do not remove, the eight in number 6 B.A. screws backed by red coloured washers from the periphery of the case. Turn the instrument upon its face, taking care that it rests upon the guard rails fitted to the front panel. Remove the four hexagonal-screw feet. Lift the case clear of the instrument.
- (2) If access is required to the r.f. oscillator and modulation circuits, turn the TUNING CONTROL so that the frequency-indication pointer is in its extreme clockwise position. Unscrew the r.f. screening can.

NOTE:-- To replace the instrument in its case, place the case, with its open side uppermost, on the bench. Insert the instrument making sure that the top of the main frequency dial is adjacent to the suitcase handle on the case; take care that all the retaining plates (attached to the periphery of the case) pass inside the rim, which is riveted to the front panel. Keeping the instrument firmly home in its case, turn it over on to its front face, and insert and tighten the four hexagonal-screw feet at the rear of the instrument. Set the instrument, front panel uppermost, on the bench and carefully tighten the eight in number 6 B.A. screws.

Repair Data and Typical Voltages

10. (1) Inspect the instrument carefully for visual signs of failure, e.g. broken or charred components and connections. Repair any obvious defects. Ensure that the MAINS switch is OFF. Connect mains CONNECTOR to the MAINS plug and to the mains supply point. Set the MAINS switch to ON. Check that the scale indicator lamp, and the filaments of V1 and V4 are alight (also V3 if the r.f. screening can has been removed). Check that V2 glows. Allow five minutes for the instrument to warm up. Measure the voltage between C7 and earth and between C6 and earth, using the Avometer on 400V d.c. range. The voltage on C6 should be approximately 270V d.c. and the voltage on C7 should vary between approximately 60V d.c. and 150V d.c. as the SET LEVEL control is varied. If these voltages are correct, proceed with further tests on the suspected part of the circuit.
- (2) The following table of typical voltages has been obtained with the instrument operating normally. RANGE Mc's switch to A 4.5-2, TUNING control to 3 Mc/s, FUNCTION SWITCH to INT. A.M., SET LEVEL control adjusted so that the meter pointer coincides with its calibration mark and the R.F. ATTENUATOR COARSE CONTROL set to X 1mV and the FINE control set to 25.

TABLE OF TYPICAL VOLTAGES

\*Where two starred voltages are given, first one is the square wave mod. condition.

Test Point	Avometer Model 7X (Type 9979)	Valve Voltmeter CT54	Valve Voltmeter CT38
1. Power supply Unit V4 CV493			Range Ext. Mult. 10 $\mu$ A d.c.
Across C18	290V d.c. (400V d.c.)	280V d.c. (480V d.c.)	280 d.c.
Across C17	275V d.c. (400V d.c.)	270V d.c. (480V d.c.)	265 d.c.
Across C6	270V d.c. (400V d.c.)	265V d.c. (480V d.c.)	255 d.c.
2. Stabiliser Unit V2 CV1832			
Between earth and the junction of R21 and R12	150V d.c. (400V d.c.)	150V d.c. (240V d.c.)	150 d.c. (250 d.c.)
Between earth and the centre contact of RV4	90V d.c. (400V d.c.)	90V d.c. (240V d.c.)	95-145 d.c. (250 d.c.)
Across C7 (Voltage varies with SET LEVEL)	60-150V d.c. (400V d.c.)	60-150V d.c. (240V d.c.)	60-140 d.c. (250 d.c.)
3. A.F. Oscillator Unit V1B CV491			
Between earth and the junction of C1 and V1B anode a.c. volts across L1	270V d.c. (400V d.c.)	265V d.c. (480V d.c.) *140/60V a.c. (240V a.c.)	250 d.c. (250 d.c.) 150*/65 a.c. (250 a.c.)
Between earth and the junction of C3 and R3	-	*72/37V a.c. (48V a.c.)	75*/37 a.c. (100 .ac.)
Between earth and the junction of R3 and R4	-	*17/5V a.c. (24V a.c.)	15.5*/7.5 (25 a.c.)
4. A.F. Amplifier Unit V1A CV491			
Between earth and the junction of R7 and V1A anode	255V d.c. (400V d.c.)	250V d.c. (480V d.c.)	242 d.c. (250 d.c.)

TABLE OF TYPICAL VOLTAGES

\*Where two starred voltages are given, first one is the square wave mod. condition.

Test Point	Avometer Model 7X (Type 9979)	Valve Voltmeter CT54	Valve Voltmeter CT38
4. (Cont.)			
Between earth and the junction of R8 and C14	-	4 to 5 a.c. (24V a.c.)	4 to 5 a.c. (10 a.c.)
a.c. volts across R7	-	4 to 5 a.c. (24V a.c.)	4 to 5 a.c. (10 a.c.)
5. R.F. Oscillator Unit V3 CV468			
Between earth and V3 anode (Varies with SET LEVEL)	-	75V d.c. (240V d.c.)	75 d.c. (100 d.c.)
Between earth and SBb contact (Varies with SET LEVEL)	-	0.4V a.c. (2.4V a.c.) See Note 3	0.4 a.c. (1 a.c.)
6. Square Wave generator V5			
At anode/R44 junction 15K $\Omega$ - nearest valve	*135/40 d.c. 400V d.c. range	*80/0V a.c. (240V a.c. range)	*68/0 a.c. (100 a.c.)
At junction of R45/R46 mounted on board with V5	- -	*6.5/0V a.c. (24V a.c. range)	*6.4/0 a.c. (10 a.c.)

NOTE:-

- (1) With the exception of V3 and V5 suspected valves can be tested on 6625-99-943-2419 Valve Tester CT160.
- (2) The two valves V3 and V5 are flying lead types, with the SOFT wires cut short and inserted in a very small base. If V3 or V5 is suspected it should be tested by replacement. A new CV468 can be tested on Valve Tester CT160 (because its leads are of sufficient length). The leads should then be cut to the desired length, and may be straightened by use of the spare valve base mounted on the chassis support. Then the replacement CV468 can be fitted into its base.

- (3) When the SET LEVEL control is adjusted so that the meter pointer coincides with its calibration mark the r.f. voltage applied to the modulator unit should be 0.4V a.c. measured across L16a and R36 to earth, with the 4.5 - 2 Mc/s coil (Range A) in circuit..

#### TO RENEW ATTENUATOR CARD

11. This information is given for emergency use in the field, when a straight replacement for a damaged card will produce a usable, but probably less accurate output level. This however is better than a completely unserviceable instrument. When an attenuator is damaged and replaced in the field the instrument should be returned as soon as possible to either a repair depot or calibration centre (- or the factory for civilian users) together with a label or notice clearly stating that the card has been changed and requesting a calibration.

Some notes are given in para. 12 for information on the calibration procedure which can only be carried out in a properly equipped laboratory or factory.

#### METHOD OF RENEWING CARD

12. Place the instrument out of its case in its normal operating position on the bench with the controls towards you.

- (1) Mark and unsolder three wires from the output terminals below the control panel, also the modulator bias lead.
- (2) Unscrew the retaining rings from the MAINS input plug and MAINS switch so that they will drop through the panel.
- (3) Remove knobs and carrier from control spindles by removing the screw in the top of each knob, and then extracting the retaining pin from each knob carrier. Unscrew the knurled ring from the ENGAGE FINE CONTROL. Note the washers.
- (4) Remove carrying handles.
- (5) Remove the retaining nut from the MOD. switch so that it can drop through the panel.
- (6) Remove eight fixing screws from the control panel.
- (7) Remove movement fixing nuts from SET LEVEL INDICATOR.
- (8) Lift off control panel. (See Figure 2.2.1).
- (9) Remove bolt in pillar 'A' and loosen the other 'B' holding the drive to the right hand uniformly calibrated dial, and swing assembly away from dial. Remove bulb holder 'C'. (See Figure 2.2.2).

- (10) Set the Cursor to the low frequency-P.H.S. end of scale and turn instrument over. Carefully unscrew circular screening can from r.f. compartment.
- (11) Remove plug covering feed from compartment to the attenuator. Unsolder connections, and remove internal screwed insert. (This plug is shown in Figure 2.2.9 adjacent to L12A and L12B labelled 'MR1 Under').
- (12) Turn instrument back to its original position, and unsolder wire entering attenuator from the tag-board on the left hand side of the attenuator.
- (13) Remove the seven screws holding the attenuator to the main chassis. The heads of the screws are on the Mains transformer side of the plate. Two of the screws hold down the back cover of R.F. output plug.
- (14) Remove the hexagonal pillar that holds screw A (Fig. 2.2.1). Place the right hand uniformly divided dial into the position shown in Figure 2.2.2. Turn the spindle until the hole in the circular plate beneath the calibrated dial lines up with the plug-nut in the attenuator casting. Loosen this plug-nut.
- (15) Withdraw the complete attenuator, which will now appear as shown in Figure 2.2.3 and Figure 2.2.7.
- (16) Loosen two Allen screws beneath dials on the attenuator.
- (17) Unscrew and remove control nut spindles. Lift off the dials.
- (18) Withdraw split pins under dials, and remove washers, and contact assemblies. See Figure 2.2.4.
- (19) Remove four 6 BA screws from beneath attenuator assembly.
- (20) Unsolder wire to output socket.
- (21) Lift off bottom casting (see Figure 2.2.5).
- (22) Remove screw from centre of the attenuator card, and remove card.
- (23) Remove brass ferrules, and fittings, two wires (one in series with a resistor), and a capacitor from attenuator card. (See Figure 2.2.6).
- (24) Replace faulty card with a new replacement and re-assemble.
- (25) When replacing the dials they should be locked on to the spindles after setting in the following positions:-  
 The FINE contact should be about 1/64" clear of the metal segment (Item 37 on Fig. 2.2.7) when at the 25 position and the COARSE contact should be in the middle of this smaller metal segment when the dial is at the xlrV position, i.e. as shown on Fig. 2.2.3.

(26) When replacing the complete attenuator into the chassis it has been found convenient to remove the original short wire and to solder nine inches of about 22 s.w.g. tinned copper wire on to the attenuator input. Pull the free end carefully through the housing labelled:- "MRL under" in Fig. 2.2.9 as the attenuator is slipped into place.

The connection inside the housing should be made and the surplus wire cut off - taking care that the joint is clean and central in the housing. The joint must be well inside the tube so that the inner is not shorted when the screw cap is replaced.

(27) NOTE. In some attenuators an additional resistor will be found inside the pillar connecting the attenuator card to the R.F. OUTPUT. This will only be a few ohms, and is included to bring a low impedance card up to the nominal 75 ohm impedance. When fitting the new card this resistor should always be replaced by a short wire unless calibration at one of the centres is in progress.

#### Adjustments of attenuator, etc.

13. It is not intended that this paragraph is used to recalibrate a CT378A but is given to indicate the general procedure only.

Tune to 2 Mc/s. Adjust to obtain 400 mV to  $\pm 3\%$  unmodulated r.f. across the junction of L16a and R36 to chassis. Select R32 to make SET LEVEL meter read at mark. Remove valve voltmeter and replace screening. Using a standard 75 ohm attenuator (similar to Marconi Type TF1073), a well screened receiver and a second detector current meter set up the combination at 15 Mc/s to read 25 mV obtained from a standard signal generator (i.e. a first class laboratory instrument - not a test oscillator). Connect CT378A into the combination and adjust to 15 Mc/s c.w. Set the attenuators on the CT378A to 25 mV and turn RV4 - mod. bias - to give exactly 25 mV. Either replace the dial or scratch out the X 1 mV, X 0.1 mV, X 10  $\mu$ V and X 1  $\mu$ V markings on the COARSE attenuator. Remark new settings by comparison - in slide-back - against the standard 75 ohm attenuator at signal levels of 25, 2.5 mV and 250 and 25  $\mu$ V. Check the attenuator system at 15, 50 and 200 Mc/s using calibrated receivers, etc. Finally readjust nominal 400 mV, R32, RV4, etc. to bring whole system into tolerance. As the attenuator has been changed, check the modulation system.

Next adjust RV2 to give nominal 50% a.m. - set to about 35-40% a.m. outside of case; replace case, check and readjust as necessary for 30% in case. Eddy current losses in L1 caused by the proximity of the case cause the mod. depth to fall when case is replaced. R4 is also provided to give control on the sine wave amplitude reaching V1A and is set to give 4-5 volts unloaded across A.F. OUT terminal to chassis. RV1 is adjusted to give minimum f.m. at 200 Mc/s. Alternatively minimum a.m. across R56, L16a to earth - when the 2 Mc/s waveform is examined by a j.r.o.

Having adjusted for correct sine wave modulation switch to square wave and select R47 to give 30% a.m. square wave modulation.

The final results of the above procedure can only be obtained by careful and constant attention to detail - together with accurately calibrated equipment and a full knowledge of the procedure. This information is only available to the makers and to certain servicing organisations for H.M. forces.



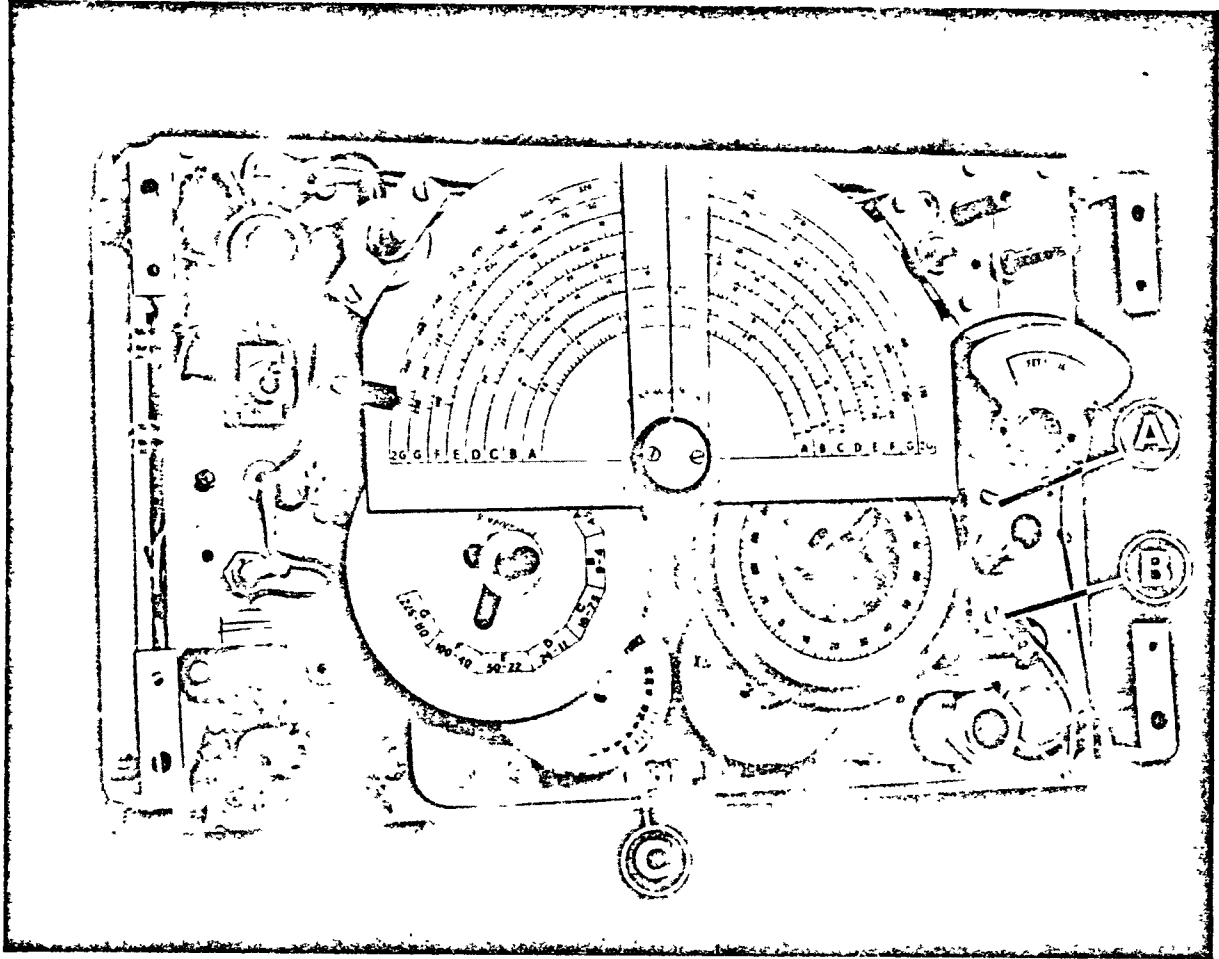


Fig. 2.2.1

Plan view of instrument with front panel removed.



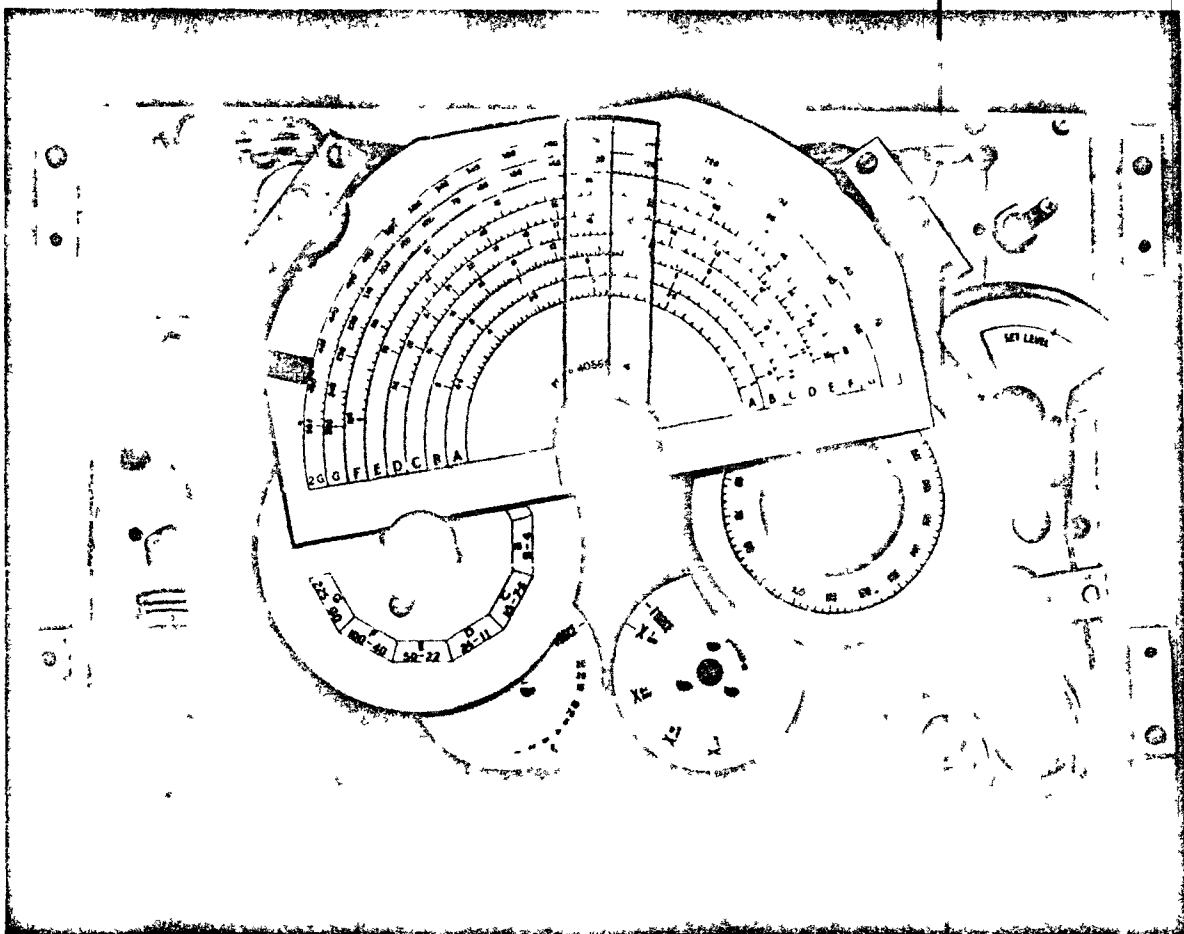


Fig. 2.2.2

Plan view of instrument showing partial removal of one control spindle and positioning of dial and disc.



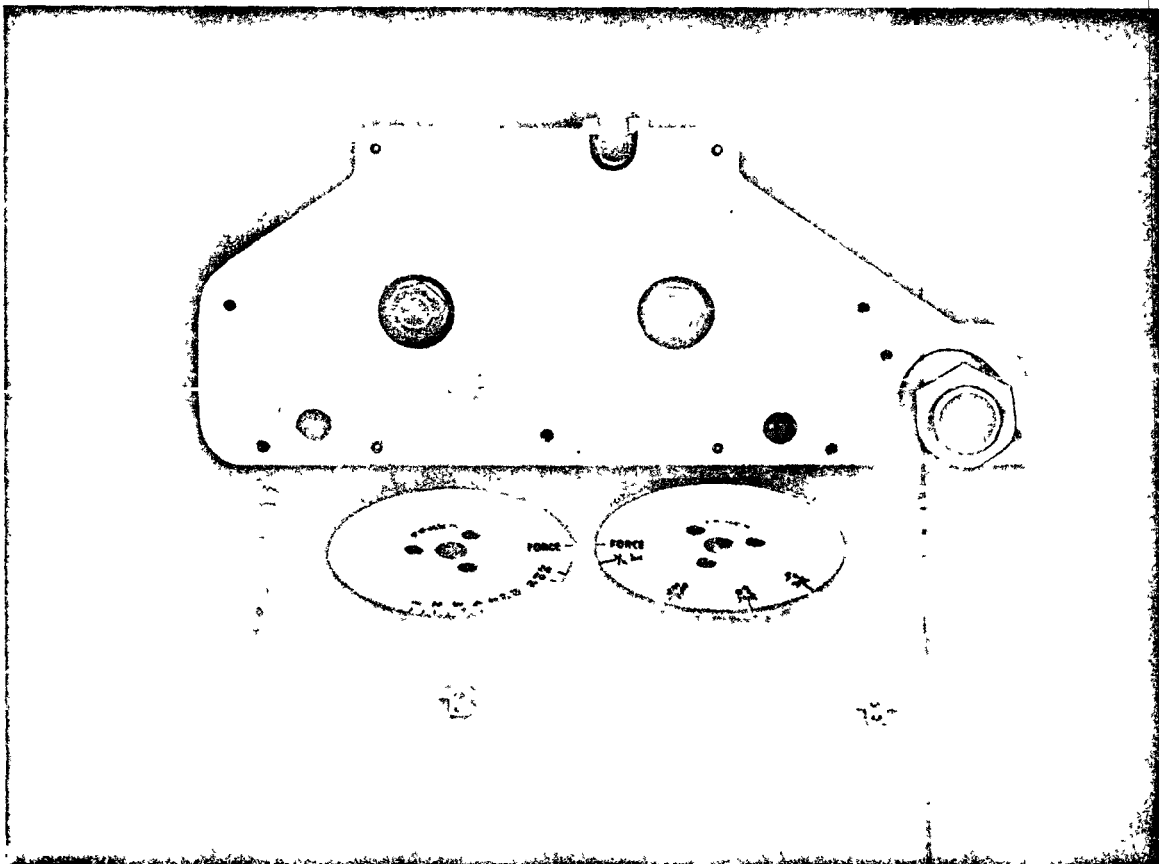


Fig. 2.2.4

Removal of controls from attenuator.



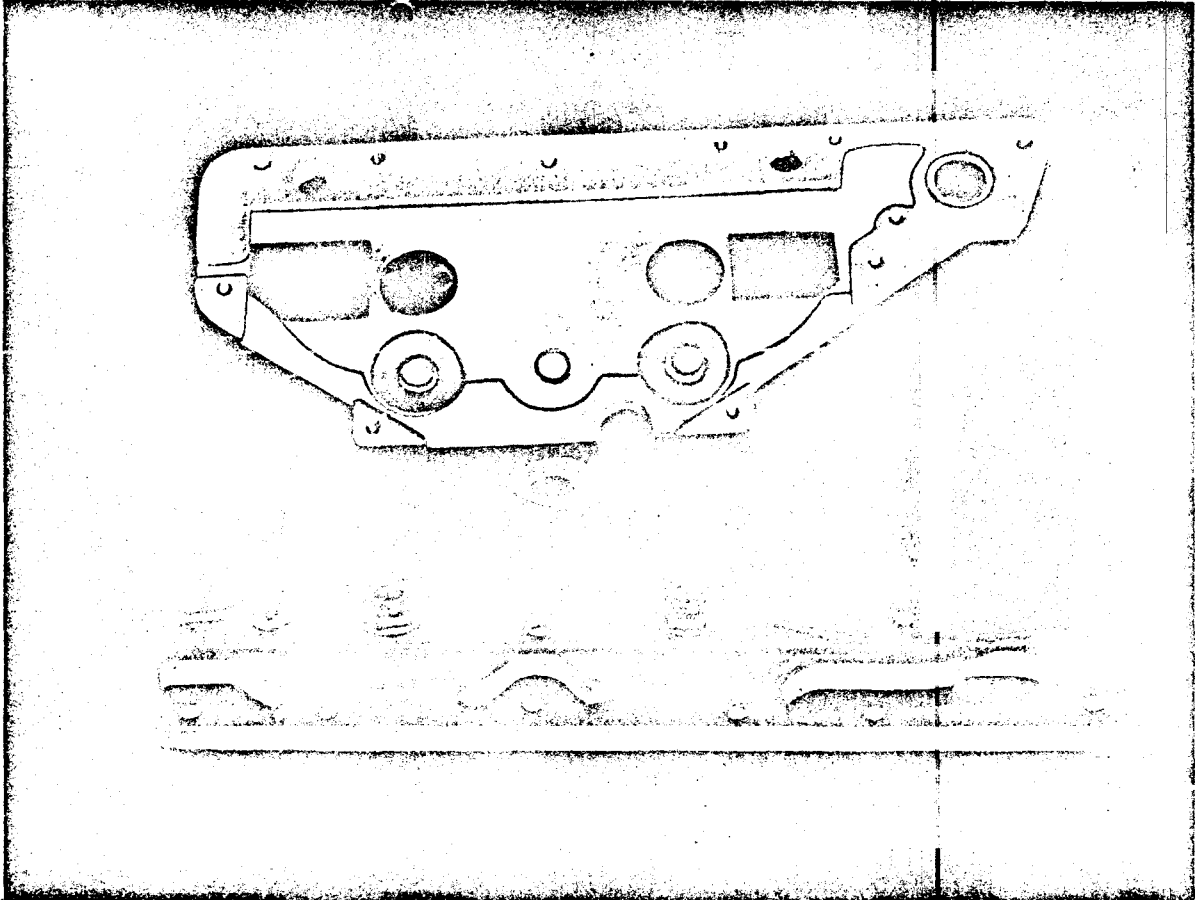


Fig. 2.2.5  
Separation of attenuator castings.





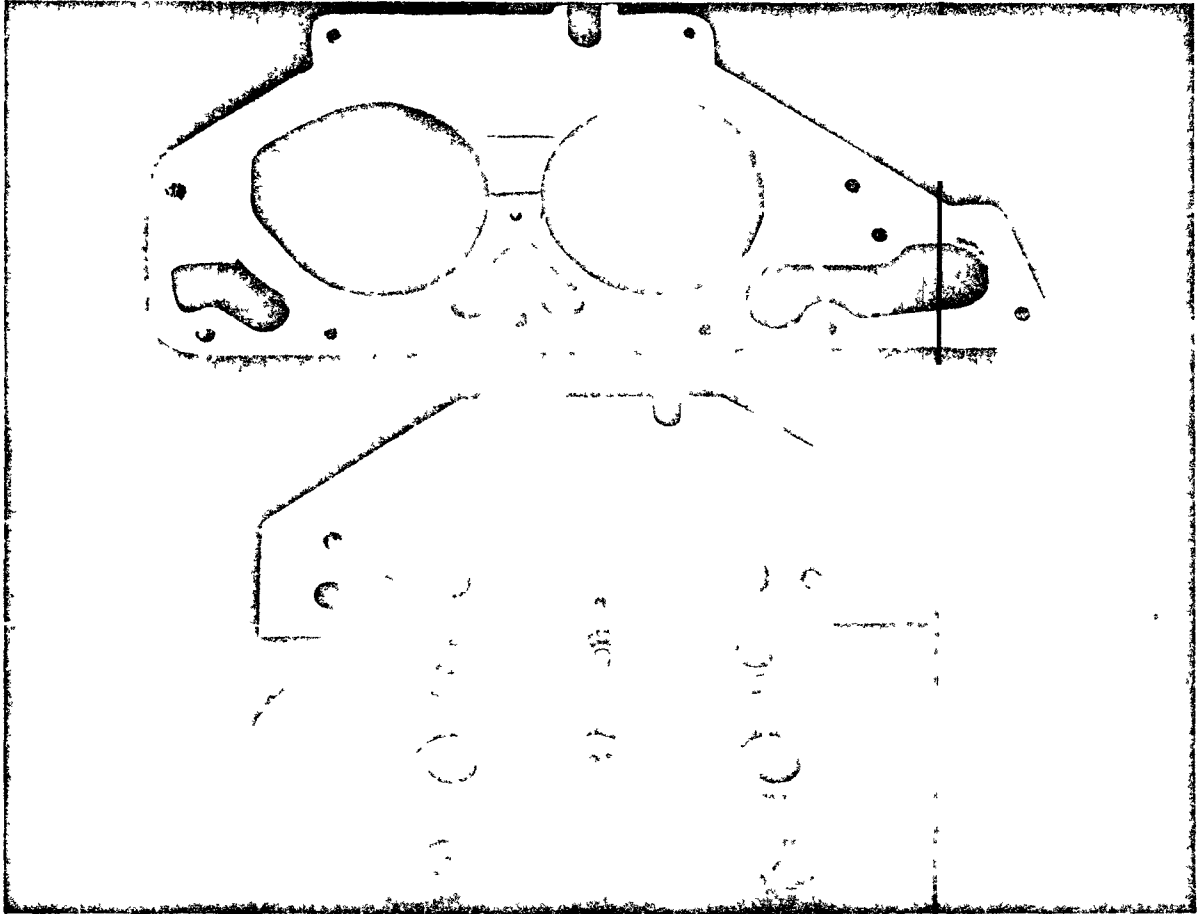
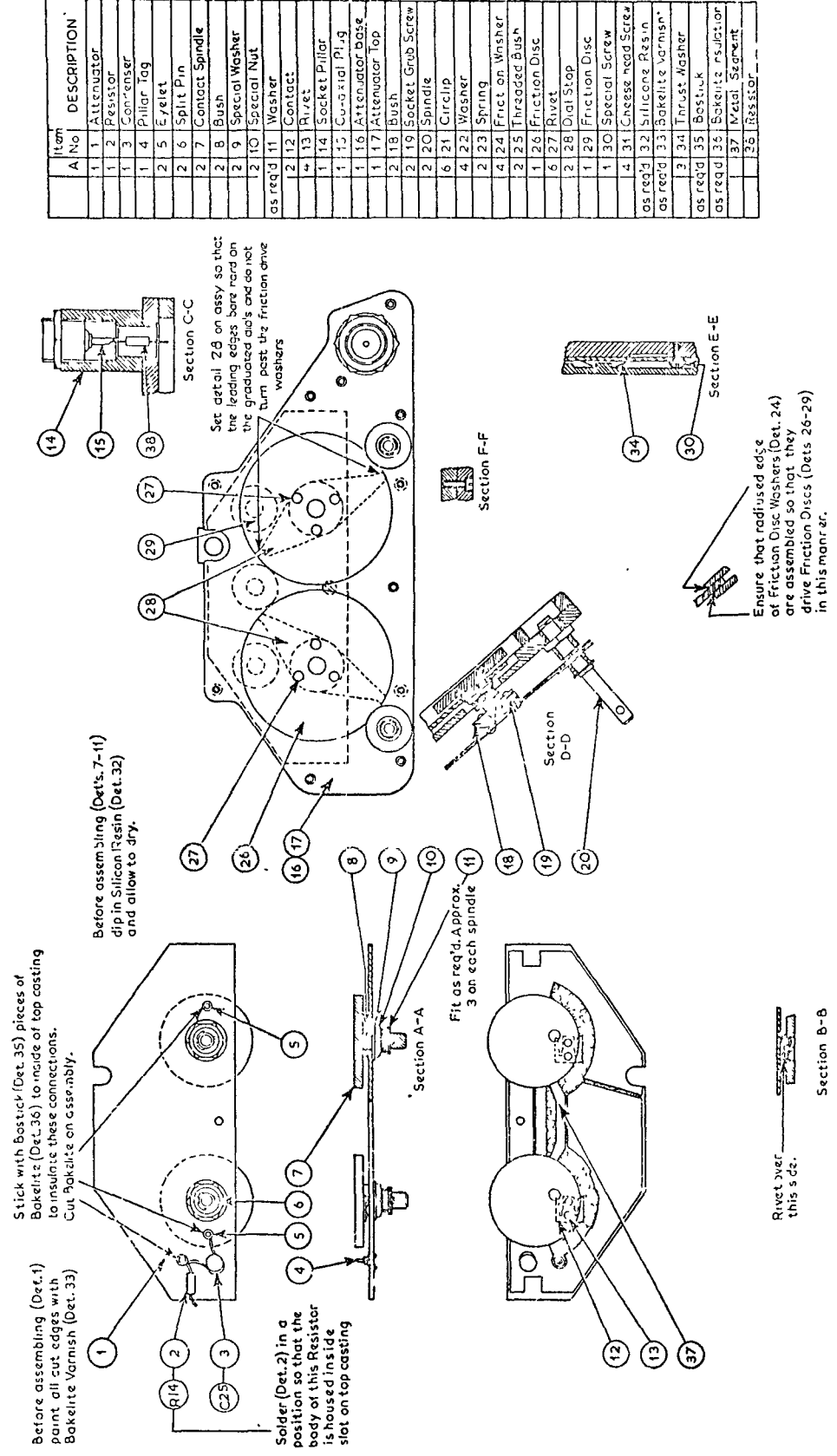


Fig. 2.2.6  
Removal of attenuator card.





Item	DESCRIPTION
A No.	
1	Attenuator
2	Resistor
3	Con-senser
4	Pillar Tag
5	Eyellet
6	Split Pin
7	Contact Spindle
8	Bush
9	Special Washer
10	Special Nut
as req'd	11 Washer
12	Contact
13	Rivet
14	Socket Pillar
15	Co-axial Plug
16	Attenuator Base
17	Attenuator Top
18	Bush
19	Socket Grab Screw
20	Spindle
21	Circlip
22	Washer
23	Spring
24	Friction Washer
25	Threaded Bush
26	Friction Disc
27	Rivet
28	Dial Stop
29	Friction Disc
30	Special Screw
31	Cheese head Screw
as req'd	32 Silicone Resin
as req'd	33 Bakelite Varnish*
34	Thrust Washer
as req'd	35 Bostick
as req'd	36 Bakelite insulation
37	Metal Segment
38	Resistor

Fig. 2-2.7 Attenuator Assembly



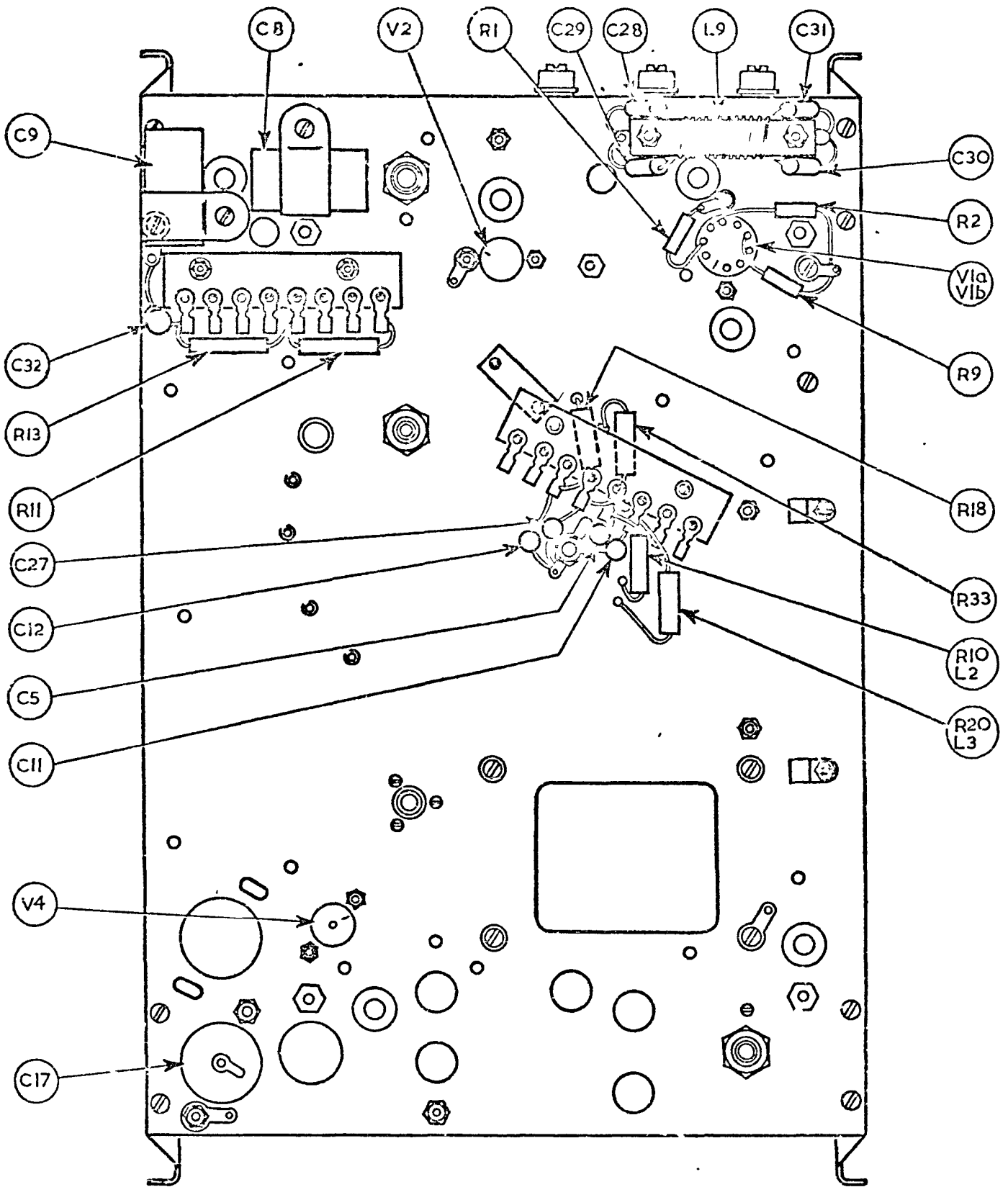


Fig. 2.2.8

Component layout on upper side of main panel

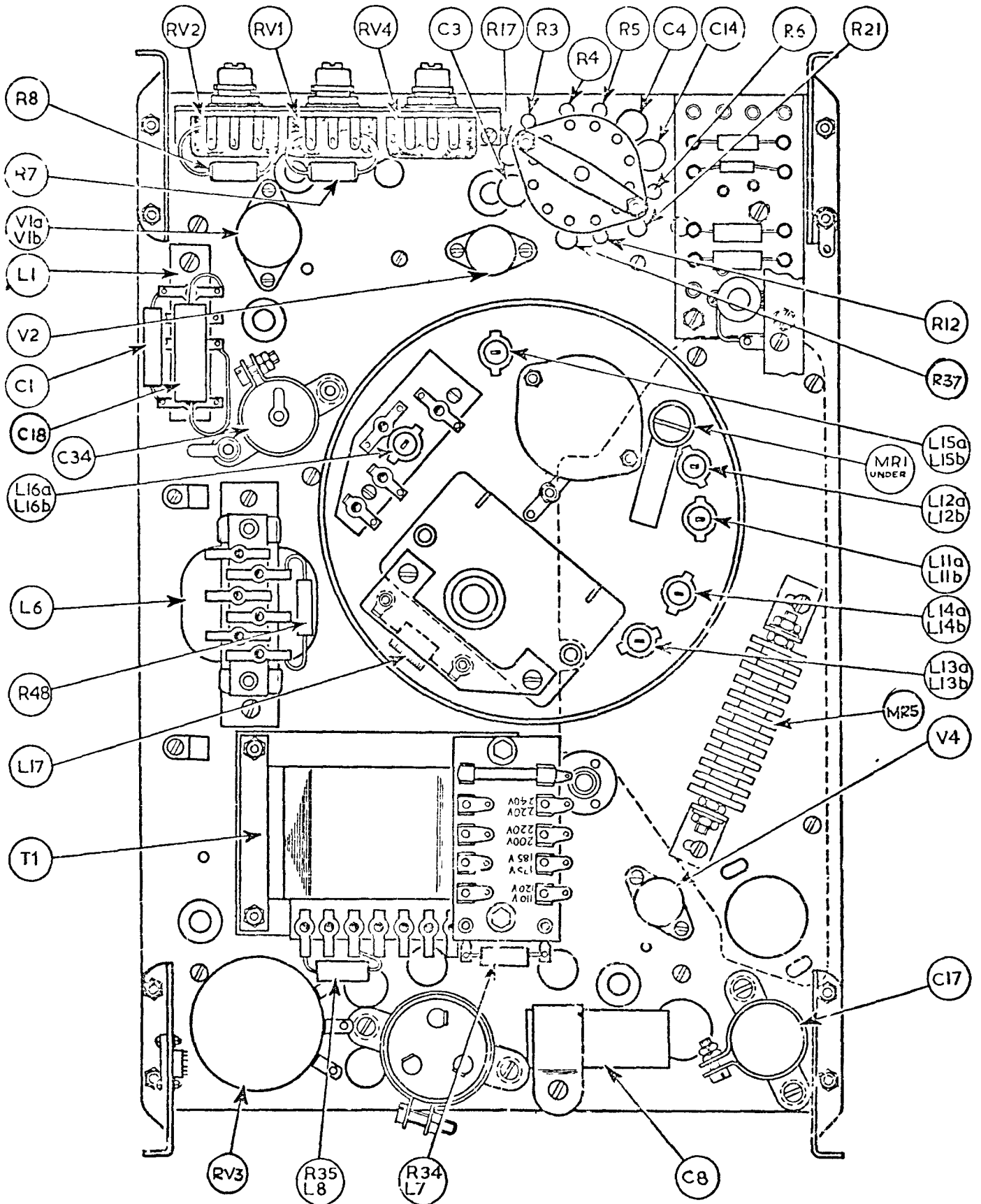


Fig. 2.2.9

Component layout on lower side of main panel.

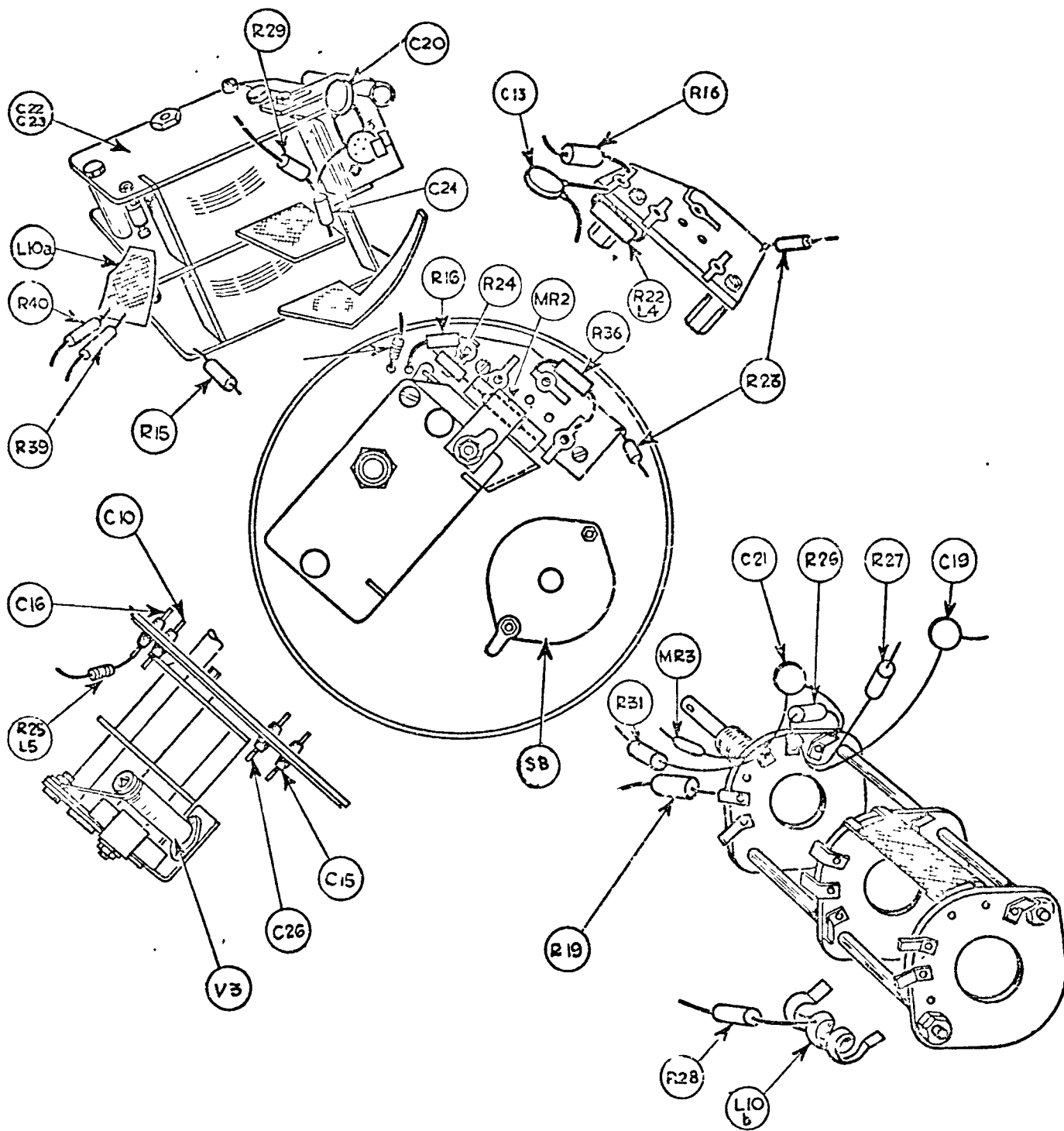
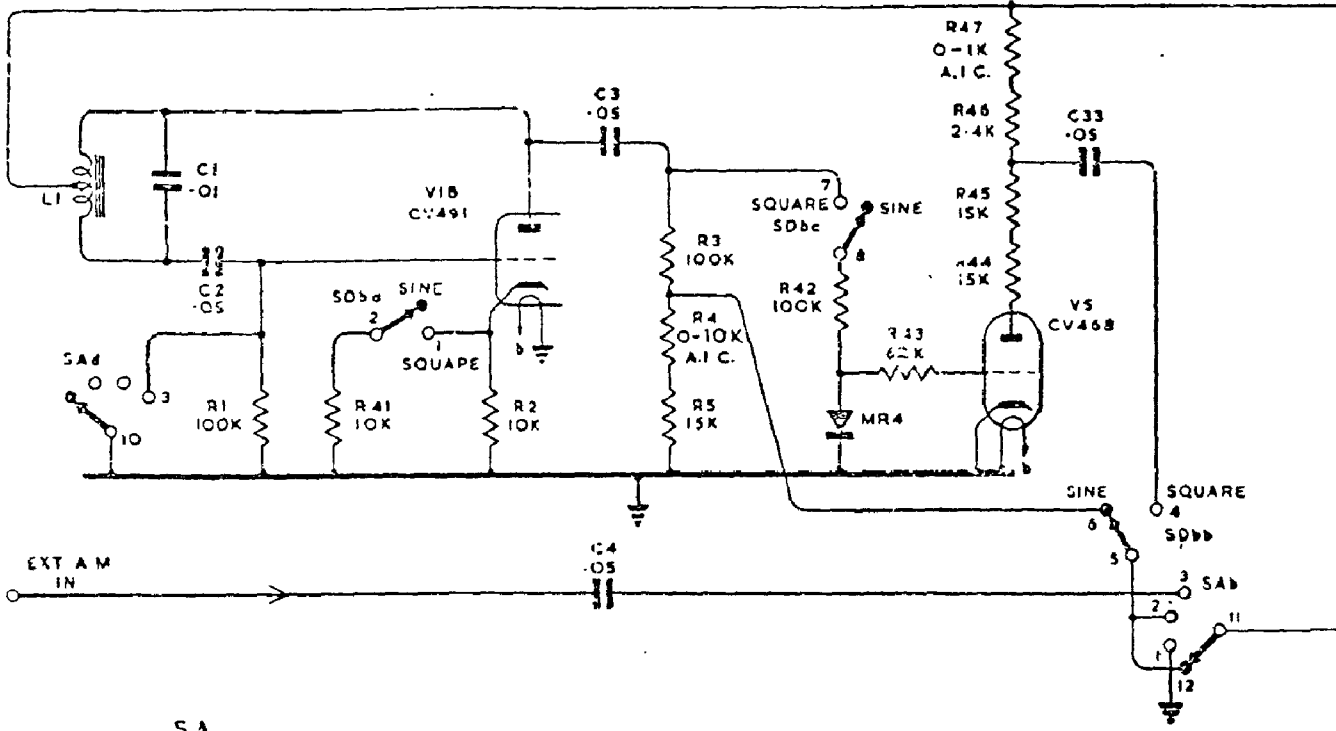


Fig. 2.2.10  
 Layout of R.F. Compartment

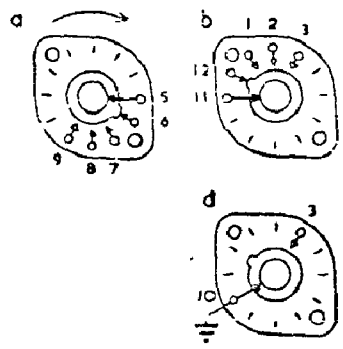




P	1	41	2	4	5	42	43	44-47
C	1	7		4				31
MISC	L1 SA4		SDba	ViB		SDbc MR4	V5	SDbb SAa

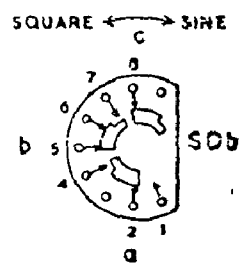


SA  
FUNCTION SWITCH

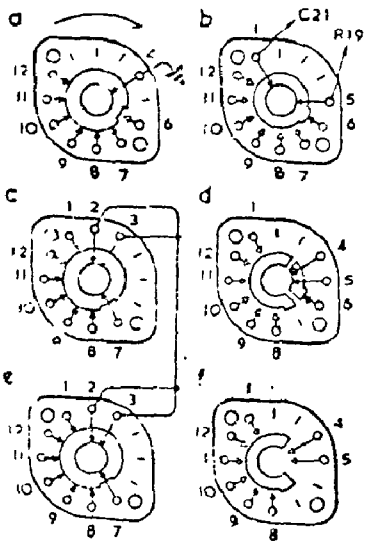


a	b	d	FUNCTION
6	12	-	AF (CW OFF)
7	1	-	CW
8	2	-	INT AM
9	3	3	EXT AM

SD  
MODULATION SWITCH

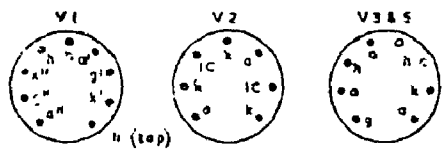


SB  
RANGE Mc/s



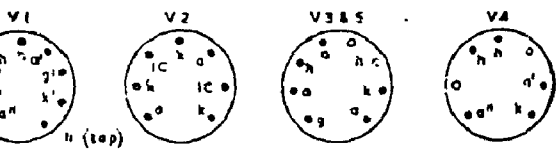
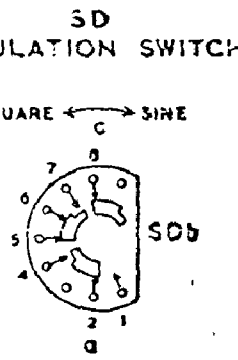
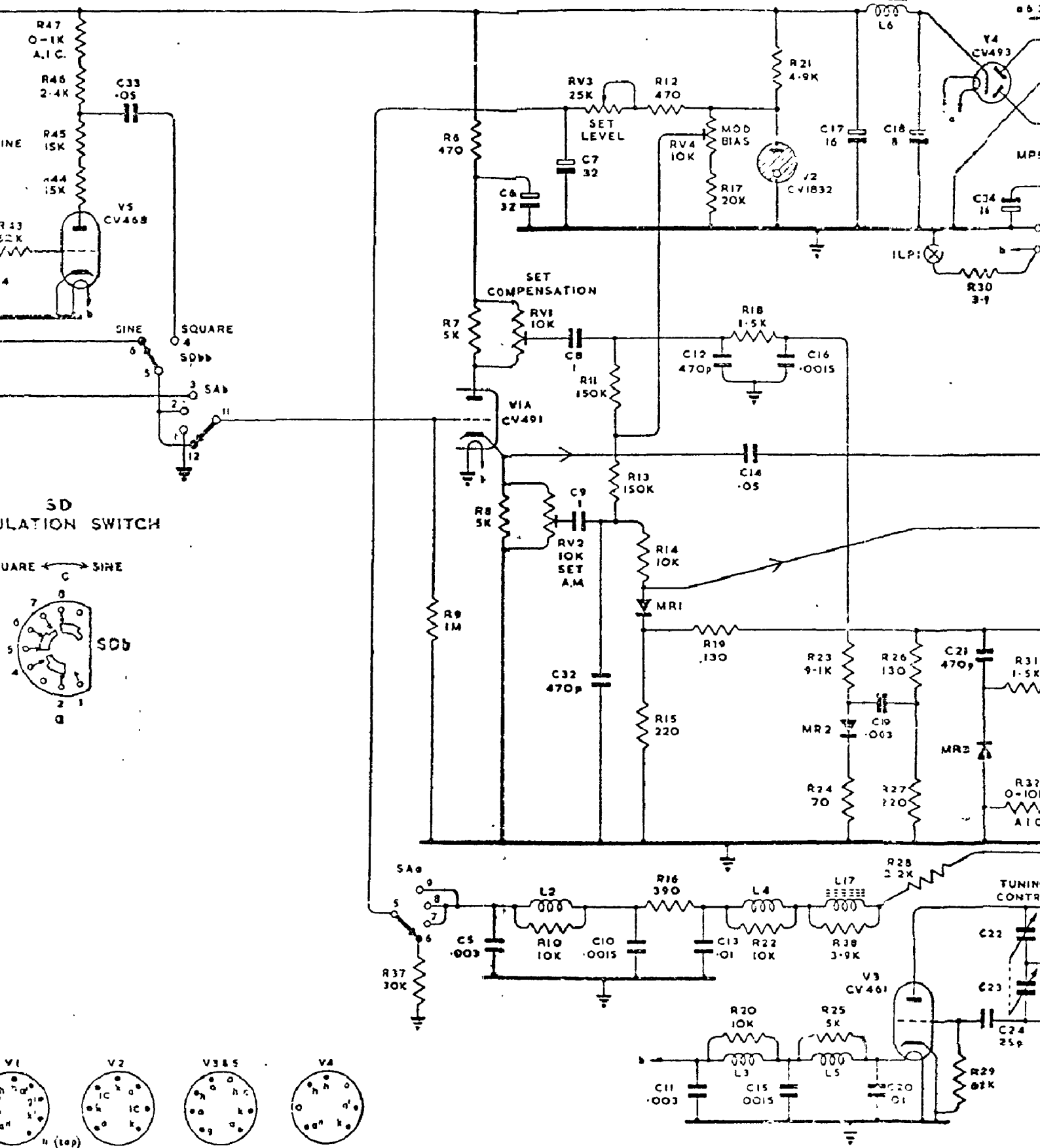
TERMINAL			SCALE	RANGE Mc/s	COIL CT REF
b	d	f			
6	6		2G + G	170-500 85-250	L10
7	8	8	F	40-100	L11
8	9	9	E	25-50	L12
9	10	10	D	11-24	L13
10	11	11	C	7.5-16	L14
11	12	12	B	4-8.5	L15
12	1	1	A	2-4.5	L15

NOTE:-  
FOR ANY POSITION OF SB COILS  
NOT IN USE, EXCEPT LI0B, ARE  
SHORTED BY FRONT WAFER  
SECTIONS a.c & e.





43	44-47		6	7	8		11	12	13	14	17	18	2	23	24		27	28	30				
			17	9			10		10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
V5	SDbb	SAa	SAa	VIA	RV1	RV2	RV3	MR1	RV4	V2	MR2	L6	ILP1	RV3									
					L2				L3	L4	L5	L17	V2										









PART 2

CHAPTER 3

LIST OF PREFERRED COMPONENTS FOR  
REPLACEMENT PURPOSES

LIST OF CONTENTS

	<u>Paragraph</u>
Some important notes of components and their effect on the calibration of this instrument.....	1-3





P A R T 2

C H A P T E R 3

L I S T O F P R E F E R R E D C O M P O N E N T S F O R  
R E P L A C E M E N T P U R P O S E S

Before ordering replacement components consult the relevant servicing spares lists and substitution guides.

SOME IMPORTANT NOTES ON COMPONENTS

AND THEIR EFFECT ON THE CALIBRATION OF THIS INSTRUMENT

1. For test equipment to do its job properly it must remain within accuracies quoted over its period of life. To this end periodic calibration is performed at various centres equipped for this purpose.

For this reason it is obvious that users not so equipped should not attempt to recalibrate a test instrument unless the relevant handbook gives the necessary setting up instructions.

2. It should be realised that any repair of a test instrument can result in the calibration of the instrument being affected and for this reason it is essential that great care should be taken when making any repair.

Further, it is of vital importance to ensure that the faulty component is replaced by another as near as possible to the original, not only in electrical characteristics but also in its physical size, shape and location.

3.

In addition to the remarks in 2 above, some components are certain to affect calibration and even if an identical component can be used, the calibration of the instrument must still be suspect.

As a guide to maintenance personnel these components are marked thus:

\*e.g. \*R<sub>1</sub> ..... in the component lists.

If it is found necessary to replace a component so marked \* in the component list, this should be noted and arrangements made for the instrument to be calibrated at the earliest opportunity.

RESISTORS, fixed

Circuit Ref.	Name or Notes	Nato Stock No.	Value ohms	Rating Watts	Tol. ±%
R1		5905-99-022-3037	100k	$\frac{1}{4}$	10
R2		5905-99-022-2132	10k	$\frac{1}{2}$	10
R3*		5905-99-022-3057	100k	$\frac{1}{4}$	10
R4*		A.I.C. Grade 2	0-10k	$\frac{1}{4}/\frac{1}{2}$	10
R5*		5905-99-022-2153	15k	$\frac{1}{2}$	10
R6		5905-99-022-1193	470k	$\frac{1}{4}$	10
R7	See Note 1	5905-99-022-2094	5.1k	$\frac{1}{4}$	10
R8	See Note 1	5905-99-022-2094	5.1k	$\frac{1}{4}$	10
R9		5905-99-022-3063	1M	$\frac{1}{4}$	10
R10	Filter see L2	5905-99-022-2132	10k	$\frac{1}{2}$	10
R11		5905-99-021-6486	150k	$\frac{1}{2}$	1
R12		5905-99-022-1193	470	$\frac{1}{4}$	10
R13		5905-99-021-6486	150k	$\frac{1}{4}$	1
R14	Select to 5%	5905-99-022-2130	10k	$\frac{1}{4}$	See Col. 2
R15		5905-99-022-1151	220	$\frac{1}{4}$	10
R16		5905-99-022-1184	390	$\frac{1}{4}$	10
R17		5905-99-021-6284	20k	1	2
R18		5905-99-022-2025	1.5k	$\frac{1}{4}$	10
R19		5905-99-022-1124	130	$\frac{1}{4}$	5
R20	Filter see L3	5905-99-022-2132	10k	$\frac{1}{2}$	10
R21		5905-99-011-7895	5.1k	4.5	5
R22	Filter see L4	5905-99-022-2132	10k	$\frac{1}{2}$	10
R23		5905-99-022-2124	9.1k	$\frac{1}{4}$	5
R24		5905-99-943-8315	70	$\frac{1}{4}$	1
R25	Filter see L5	5905-99-022-2088	4.7k	$\frac{1}{4}$	10
R26		5905-99-022-1124	130	$\frac{1}{4}$	5
R27		5905-99-022-1151	220	$\frac{1}{4}$	10
R28		5905-99-022-2048	2.2k	$\frac{1}{4}$	10
R29*		5905-99-022-3010	62k	$\frac{1}{4}$	5
R30	See Note 2	5905-99-022-1002	10	$\frac{1}{4}$	10
R31		5905-99-022-2025	1.5k	$\frac{1}{4}$	10
R32*	Meter Calibr'n.	A.I.C. Grade 1	0-10k	$\frac{1}{4}$	2
R33	See Note 3	5905-99-021-5801	4.7k	$\frac{1}{2}$	2
R34	Filter see L7	5905-99-022-1186	390	$\frac{1}{2}$	10
R35	Filter see L8	5905-99-022-1186	390	$\frac{1}{2}$	10
R36	See Note 4	5905-99-022-1094	75	$\frac{1}{4}$	5
R37	See Note 5	5905-99-022-2195	33k	$\frac{1}{4}$	10
R38	See L17	-	3.9k	$\frac{1}{4}$	5
R39*	See Note 6	5905-99-022-1151	220	$\frac{1}{4}$	10
R40*	See Note 6	5905-99-022-1151	220	$\frac{1}{4}$	10

RESISTORS, fixed (Continued)

Circuit Ref.	Name or Notes	Nato Stock No.	Value ohms	Rating Watts	Tol. ±%
R41		5905-99-022-2130	10k	$\frac{1}{4}$	10
R42		5905-99-022-3037	100k	$\frac{1}{4}$	10
R43		5905-99-022-3016	62k	$\frac{1}{4}$	10
R44		5905-99-022-2153	15k	$\frac{1}{2}$	10
R45		5905-99-022-2153	15k	$\frac{1}{2}$	10
R46	See Note 7	5905-99-022-2046	2.2k	$\frac{1}{4}$	10
R47*	See Note 7	A.I.C. Grade 2	0-1.2k	$\frac{1}{4}$	10
R48		5905-99-011-8243	24k	4.5	5
R49*		A.I.C. Grade 2	approx. 4.9k	$\frac{1}{2}$	10
AT1*	Attenuator Card resistor				
-	Attenuator Contacts. Plate, Marking, black for dial scale See Note 8	5977-99-972-8400 9905-99-943-2459			

RESISTORS, variable

Circuit Ref.	Name or Notes	Nato Stock No.	Value ohms	Rating Watts	Tol. ±%
RV1	Preset Mod. Compensation	5905-99-911-6450	10k	1	10
RV2	Preset A.M.	5905-99-911-6450	10k	1	10
RV3	Set Level	5905-99-972-8377	25k	2.5	5
RV4	Preset Mod. bias	5905-99-911-6450	10k	1	10

Note 1. Original may be 5k - Reset Mod. and Mod. Comp. in full calibration.

Note 2. Original may be 3.9 ohms - use 2 x 10 ohm in parallel.

Note 3. Original may be 5k - Reselect R32 in full calibration.

Note 4. May be replaced without readjustment of Modulation.

Note 5. Original may be 30k - no readjustments.

Note 6. Position of resistors is much more important than actual value. Some slight alteration of position may be necessary to maintain level output over band. Full calibration adjustment.

note 7. Original may be 2.4k - Reselect R47 in full calibration.

Note 8. Spare COARSE dial for use during full calibration.

VALVES

Circuit Ref.	Name	Nato Stock No.
V1	CV491/CV4003	5960-99-000-4003
V2	CV1832/CV4020	5960-99-000-4020
V3	CV468/CV4507	5960-99-000-4507
V4	CV493/CV4005	5960-99-000-4005
V5	CV468/CV4507	5960-99-000-4507

CAPACITORS

Circuit Ref.	Name or Notes	Nato Stock No.	Value	Rating Volts	Tol. ±%	
C1		5910-99-011-5552	0.01 μF	350V	20	
C2		5910-99-011-5554	0.05 uF	350V	20	
C3		5910-99-011-5554	0.05 uF	350V	20	
C4		5910-99-011-5554	0.05 uF	350V	20	
C5		5910-99-911-7943	3000 pF	300V	+80 -20	
C6		5910-99-014-5601	32 Dual 32	350V	+50 -20	
C7				350V	+50 -20	
C8		5910-99-011-5570	1	250V	20	
C9		5910-99-011-5570	1	250V	20	
C10	Soldered in	5910-99-911-6459	1500 pF	350V	+80 -20	
C11		5910-99-911-7943	3000 pF	300V	+80 -20	
C12		5910-99-911-6460	470 pF	300V	-80 -20	
C13		5910-99-911-4622	0.01	375V	+80 -20	
C14		5910-99-011-5554	0.05	350V	20	
C15	Soldered in	5910-99-911-6459	1500 pF	350V	+80 -20	
C16	Soldered in	5910-99-911-6459	1500 pF	350V	+80 -20	
C17		5910-99-014-5507	16	450V	+50 -20	
C18		5910-99-014-5504	8	450V	+50 -20	
C19		5910-99-911-7943	3000 pF	300V	+80 -20	
C20		5910-99-911-4622	0.01	375V	+80 -20	
C21		5910-99-911-6460	470 pF	300V	+80 -20	
C22	Main Tuning	Non-Patt.	-	-	-	
C23						
C24*			5910-99-911-4661	25 pF	750V	0.5 pF
C25		5910-99-911-7943	3000 pF	300V	+80 -20	
C26		5910-99-911-6459	1500 pF	350V	+80 -20	
C27		5910-99-911-7943	3000 pF	300V	20	
C28		5910-99-011-5807	300 pF	600V	20	
C29		5910-99-011-5807	300 pF	600V	20	

CAPACITORS (Continued)

Circuit Ref.	Name or Notes	Nato Stock No.	Value ohms	Rating Watts	Tol. ±%
C30		5910-99-011-5807	300 pF	600V	20
C31		5910-99-011-5807	300 pF	600V	20
C32		5910-99-911-6460	470 pF	300V	+80 -20
C33		5910-99-011-5554	0.05	350V	+20
C34		5910-99-014-5507	16	450V	+50 -20

MISCELLANEOUS

Circuit Ref.	Names or Notes	Nato Stock No	Value	Rating Watts	Tol. ±%
SA	Mod. Selector	Non. Patt.		3A - 250V	M.E.S.
SB	Range Selector	Non. Patt.			
SC	Mains ON/OFF	5930-99-051-0304			
SD	SINE SQUARE	Non. Patt.			
MR1	CV2290	5960-99-000-2290			
MR2	CV2290	5960-99-000-2290		6.5V 0.3A	M.E.S.
MR3	CV425	5960-99-000-0425			
MR4	CV425	5960-99-000-0425			
MR5	Rectifier, Metal (Selenium)	6131-99-075-1511			
ILPI	Lamp	6240-99-995-1225			
FS1	Fuse	5920-99-059-0109		26.5 uA f.s.d.	
M1	Meter - special scale	6625-99-943-1298			
T1	Mains Transformer	5950-99-972-8411			
L1	Oscillator Coil	5950-99-972-8401			
L2	Wound on R10	54 Turns 34 s.w.g. enamel copper			
L3	Wound on R20	54 Turns 34 s.w.g. enamel copper			
L4	Wound on R22	54 Turns 34 s.w.g. enamel copper			
L5	Wound on R25	11 Turns 27 s.w.g. enamel copper			
L6	Inductor	5950-99-972-8426			
L7	Wound on R34	30 Turns 28 s.w.g. enamel copper			
L8	Wound on R35	30 Turns 28 s.w.g. enamel copper			
L9	Bifilar 2X 8 turns stranded 2 amp P.V.C. wire (not critical)				
L10a & b	G & 2G Not replaceable - L10a is inductance of R39 & R40 in parallel.				
L11a & b	F Range	$\frac{1}{2}$ turn 27 s.w.g. plus 2 $\frac{1}{2}$ turns 27 s.w.g. enam. copper			
L12a & b	E Range	1 turn 27 s.w.g. plus 6 turns 27 s.w.g. enam. copper			

MISCELLANEOUS (Continued)

Circuit Ref.	Name or Notes	Nato Stock No.	Value	Rating	Tol.
L13a & b	D Range	2 turn 27 s.w.g. plus 12 turns 27 s.w.g. enam. copper			
L14a & b	C Range	2 turn 28 s.w.g. plus 19 turns 28 s.w.g. enam. copper			
L15a & b	B Range	3½ turn 28 s.w.g. plus 47 turns 34 s.w.g. enam. copper			
L16a & b	A Range	5 turn 34 s.w.g. plus 100 turns 40 s.w.g. enam. copper			
L17	filter on R38	78T 42 s.w.g. whole item is 5950-99-972-8178			
PLA	Mains Input	5935-99-056-0565			
V1 Base		5935-99-056-0137			
V2 Base		5935-99-056-1156			
V3 Base		5935-99-056-1156			
V4 Base		Non. Patt.			
V5 Base		Non. Patt.			
Terminals	A.F.E., etc.	5940-99-911-4721			