

OUTPUT TEST SET

TF 1065A series

OPERATING AND MAINTENANCE HANDBOOK

©

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MARCONI INSTRUMENTS LTD.

ST. ALBANS HERTFORDSHIRE

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APPENDIX 1 - Decibel Conversion Table

1 GENERAL INFORMATION

1.1 INTRODUCTION

The TF 1065A is a combined a.f. power meter, r.f. power meter, a.m. and f.m. modulation monitor, and d.c. volt/ammeter.

It is designed primarily as a companion instrument to the TF 1064 or TF 995 series of V.H.F. Signal Generators. Together,

Test Set and Generator provide comprehensive facilities for testing f.m. and a.m. mobile transmitter/receiver equipments; by itself, the Test Set is a self-contained unit, chiefly concerned with the transmitter or receiver output.

The TF 1065A/1 is an alternative version of the Test Set with an r.f. input impedance of 75Ω instead of 50Ω .



Fig. 1.1 Test Set, Type TF 1065A/1

1.2 DATA SUMMARY

A. F. POWER METER

Power Range:	0 to 3 W in five ranges: 300 μ W, 3 mW, 30 mW, 300 mW, and 3 W full-scale. The meter scale has an auxiliary calibration in decibels.
Frequency Range:	250 c/s to 5 kc/s.
Measurement Accuracy at 1 kc/s:	Within $\pm 15\%$ of reading above 1/3 full-scale.
Input Impedance:	3, 8, 15, 600 and 5,000 Ω .

R. F. POWER METER

Power Range:	0 to 25 W in one range. Inverse square law calibration.
Frequency Range:	50 c/s to 200 Mc/s, and 450 Mc/s to 500 Mc/s.
Measurement Accuracy:	Within $\pm 15\%$ of full-scale from 50 c/s to 500 Mc/s. $\pm 3.75 \text{ watt}$
Input Impedance:	TF 1065A : 50 Ω . TF 1065A/1 : 75 Ω .
V. S. W. R.:	Better than 1.2 up to 250 Mc/s and better than 1.4 from 250 to 500 Mc/s.

A. M. MONITOR

Range:	0 to 80% modulation depth.
Accuracy:	$\pm 10\%$ of full-scale, i.e. $\pm 8\%$ modulation.
Modulation Frequency Range:	250 c/s to 5 kc/s.
Carrier Frequency Range:	1 to 500 Mc/s.
Input Requirement:	Approximately 1 W carrier power.

F. M. MONITOR

Range:	0 to 15 kc/s deviation.
Accuracy:	Better than 15% for 15 kc/s deviation at 1 kc/s sinewave modulation frequency.
Modulation Frequency Range:	250 c/s to 5 kc/s.
Carrier Frequency Range:	10 to 500 Mc/s.

F. M. MONITOR (continued)

Input Requirements: With 1 W transmitter power applied to the r.f. power inlet, approximately 100 mV c.w. is required at the signal generator inlet.

D.C. VOLT/AMMETER

Current Ranges: 50 μ A, 10 mA, 100 mA, and 1 A d.c. full-scale.

Voltage Ranges: 10, 100, and 1,000 V d.c. full-scale at 20 k Ω /volt.

Accuracy (at 20°C): $\pm 5\%$ of full-scale.

GENERAL

Power Supply: 6.75 V, 3400 mA battery: Mallory Type SKB 639.

Dimensions & Weight:	Height	Width	Depth	Weight
	9 in	12 in	8 $\frac{1}{2}$ in	13 $\frac{1}{2}$ lb
	(23 cm)	(31 cm)	(21.5 cm)	(6 kg)

1.3 ACCESSORIES AVAILABLE

PROBE UNIT, Type TM 5302. Used in conjunction with the 50 μ A range of a TF 1065A or TF 1065A/1, this Probe enables either instrument to be used as a signal tracer at frequencies from 50 kc/s to 500 Mc/s. Within these frequency limits the overall sensitivity varies between 1 V and 100 mV for full-scale deflection. The dimensions of the Probe, which contains a silicon diode rectifier, have been kept to a minimum to facilitate use in a confined space. Connection to the point under test is made by means of the tip of the Probe and an earthing clip; the rectified output is fed via a 4 ft cable to the voltmeter/ammeter terminals on the Test Set.

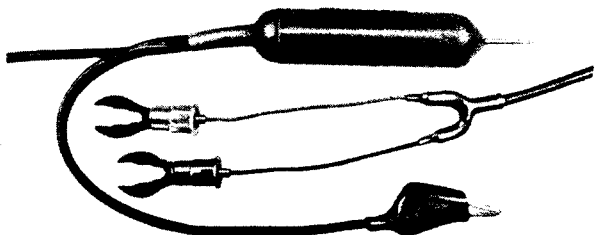


Fig. 1.2 Probe Unit, Type TM 5302

7 dB ATTENUATOR, Type TM 5280. When using the TF 1065A to test transmitters requiring a 50 Ω r.f. load, this accessory extends the power measurement range to 125 watts over the band 150 to 185 Mc/s. The unit is fitted with a Type N 50 Ω coaxial connector to allow insertion between the transmitter unit under test and the r.f. power inlet on the TF 1065A.

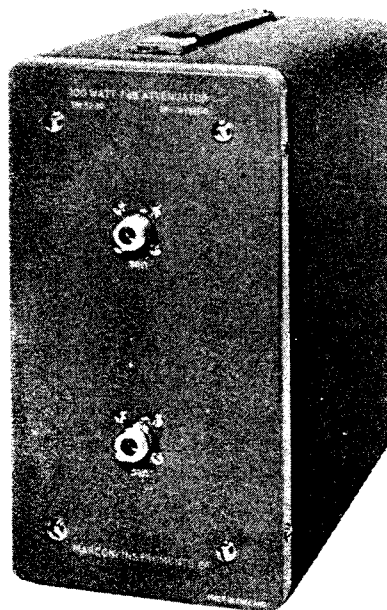


Fig. 1.3 7 dB Attenuator, Type TM 5280

2 OPERATION

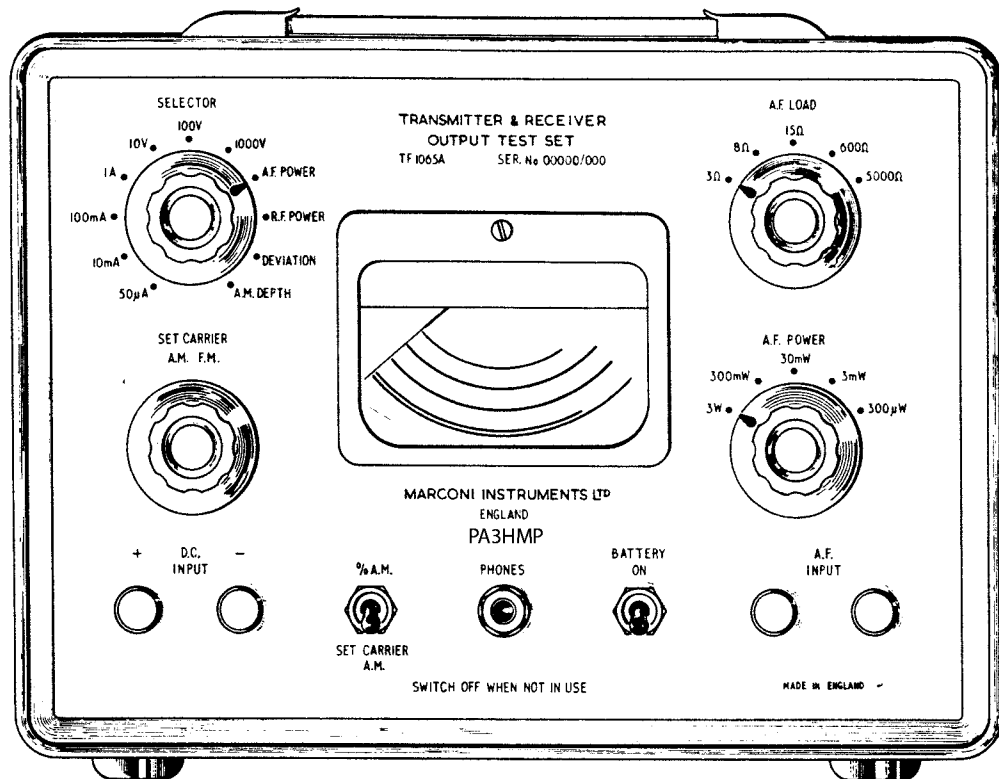
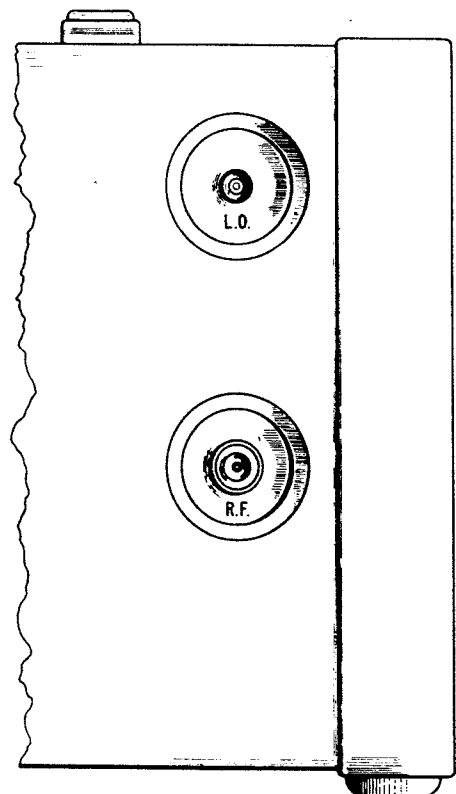


Fig. 2.1 Front Panel and R. F. Input Details



2.1 SWITCHING ON

- (1) Put the supply switch to ON. In the OFF position the switch short circuits the meter to avoid damage during transit.
- (2) Check the mechanical zero setting of the meter.

2.2 A.F. POWER MEASUREMENT

- (1) Turn the SELECTOR switch to A.F. POWER.
- (2) Turn the A.F. LOAD switch to the required impedance.
- (3) Turn the A.F. POWER switch to 3 W.
- (4) Connect the apparatus under test to the A.F. POWER terminals. The left terminal is connected to instrument chassis on the 5,000 Ω impedance range.
- (5) Rotate the A.F. POWER switch for a suitable meter deflection.
- (6) Note the final range setting and read the a.f. power on the appropriate scale of the meter.

Red spots, at intervals of 2 dB over a range of 10 dB, are marked on the meter scale for a.f. power. Since the A.F. POWER switch alters the sensitivity in 10-dB steps, comparative measurements may be made over a range of 50 dB.

2.3 R.F. POWER MEASUREMENT

- (1) Turn the SELECTOR switch to R.F. POWER.
- (2) Connect the coaxial cable from the transmitter under test to the R.F. socket on the right side of the instrument.

Note: The TF 1065A has an input impedance of 50 Ω ; TF 1065A/1, 75 Ω .

- (3) Read the r.f. power on the meter.

2.3.1 Using the 7 dB Attenuator, Type TM 5280

This optional accessory extends the r.f. power range of the TF 1065A only (not the TF 1065A/1) to 125 W between 150 and 185 Mc/s. The Attenuator has a nominal loss of 7 dB; the actual loss varies with frequency and is taken into account in the graph of multiplying factors.

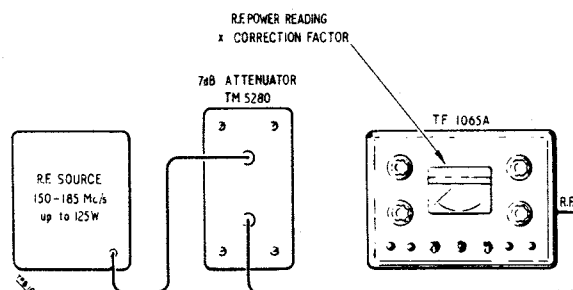


Fig. 2.2 Connecting the 7 dB Attenuator

To measure r.f. power using the Attenuator :-

- (1) Turn the SELECTOR switch to R.F. POWER.
- (2) Connect the Attenuator between the transmitter under test and the R.F. socket.
- (3) Switch on the transmitter and note the power indicated on the meter.
- (4) Multiply this reading by the factor given in the graph below.

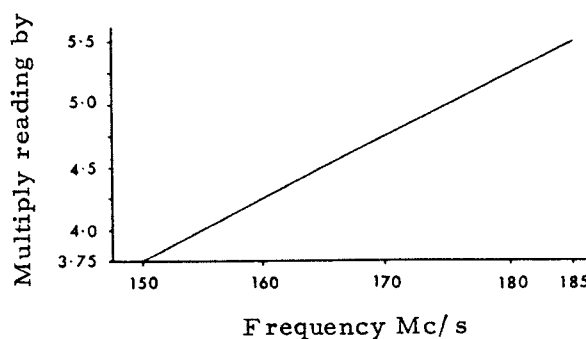


Fig. 2.3 Attenuator Multiplying Factors

2.4 F.M. DEVIATION MEASUREMENT

For deviation measurements a signal generator is required, with a frequency covering that of the signal under test. Suitable Marconi Instruments types include the TF 1064 series and TF 995 series.

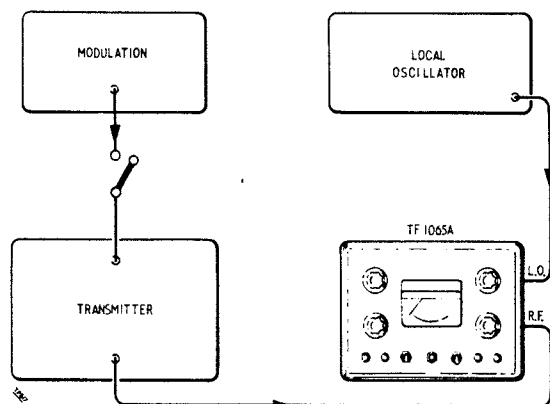


Fig. 2.4 Deviation Measurement Set-up

The use of generators employing a simple oscillator with no buffer or multiplier stages is not recommended. With such generators difficulty may be experienced, particularly at the higher frequencies due to pulling of the oscillator by the transmitter signal.

To measure deviation :

- (1) Connect the r.f. signal at about 1 W, unmodulated, to the R.F. socket.
- (2) Connect the signal generator output to the L.O. socket and adjust for 100 mV output at about the same frequency as the r.f. signal.
- (3) Turn the SET CARRIER control mid-way.
- (4) Turn the SELECTOR switch to DEVIATION.
- (5) Tune the signal generator to either of the two frequencies that give peak meter deflection, and adjust the output to bring

the peak near full scale. Re-check the tuning.

- (6) Adjust the SET CARRIER control to bring the meter pointer to the SET CARRIER mark.
- (7) Modulate the r.f. signal and read the peak deviation on the meter.

2.5 A.M. DEPTH MEASUREMENT

- (1) Connect the modulated r.f. signal at about 1 W to the r.f. socket.
- (2) Turn the SELECTOR switch to A.M. DEPTH.
- (3) Set the toggle switch to SET CARRIER A.M.
- (4) Adjust the SET CARRIER control and, if necessary, the signal input level to bring the meter pointer to the SET CARRIER mark.
- (5) Set the toggle switch to % A.M. and read off the modulation depth on the meter.

The modulation envelope can be monitored on headphones plugged into the PHONES jack.

2.6 D.C. VOLT/AMMETER MEASUREMENTS

- (1) Turn the SELECTOR switch to 1,000 V for voltage measurement, or 1 A for current measurement.
- (2) Connect the source under test to the + and - D.C. INPUT terminals. Either side of the source may be earthed.
- (3) Rotate the SELECTOR switch for a convenient meter deflection.
- (4) Note the final range setting and read the voltage or current from the bottom scale of the meter.

2.6.1 Using the Probe Unit, Type TM 5302

This optional accessory can be used for such purposes as signal tracing or location of parasitic oscillations.

Connect it to the D.C. INPUT terminals (red to +, black to -), and turn the SELECTOR switch to 50 μ A.

Do not apply the probe to signals greater than 1 V a.c. or 300 V d.c.

3 TECHNICAL DESCRIPTION

3.1 CIRCUIT SUMMARY

A.F. power is measured using a matching transformer and resistive load. The matching transformer windings are tapped to provide five impedance and five power ranges. Output from a switch-selected tap on the secondary is taken to a detector which in turn supplies a d.c. signal to the meter.

R.F. power is applied to a $50\ \Omega$ ($75\ \Omega$ for TF 1065A/1) slab line load. A tap on the load feeds a crystal detector to provide a measurement range of 25 W full scale.

Amplitude and frequency modulation measurements require a signal level of about 1 W at the R.F. socket, part of which is taken from a tap on the r.f. load and applied to the measuring circuits.

A.M. signals are taken to a crystal detector which provides a d.c. output proportional to the carrier level and an a.c. component proportional to the modulation depth. The d.c. level is used to establish a SET

CARRIER datum. The a.c. component, after amplification, is applied to a peak responding detector, the resulting d.c. level giving a percentage modulation reading on the meter.

For deviation measurements a signal generator is connected to the L.O. socket and tuned to the signal frequency plus or minus the Test Set i.f. of 130 kc/s. The R.F. and L.O. signals are mixed and fed to a 130 kc/s discriminator, the i.f. output from which is amplified and then detected to drive the meter.

Initially the R.F. signal is applied unmodulated and the local oscillator is tuned for the greatest meter deflection; the input level and SET CARRIER control being adjusted to bring the meter reading to SET CARRIER. The signal is then modulated causing the meter reading to fall as the i.f. signal is detuned on the modulation peaks.

For D.C. Volt/Ammeter measurements, the meter is connected to the D.C. INPUT terminals via series or parallel resistors.

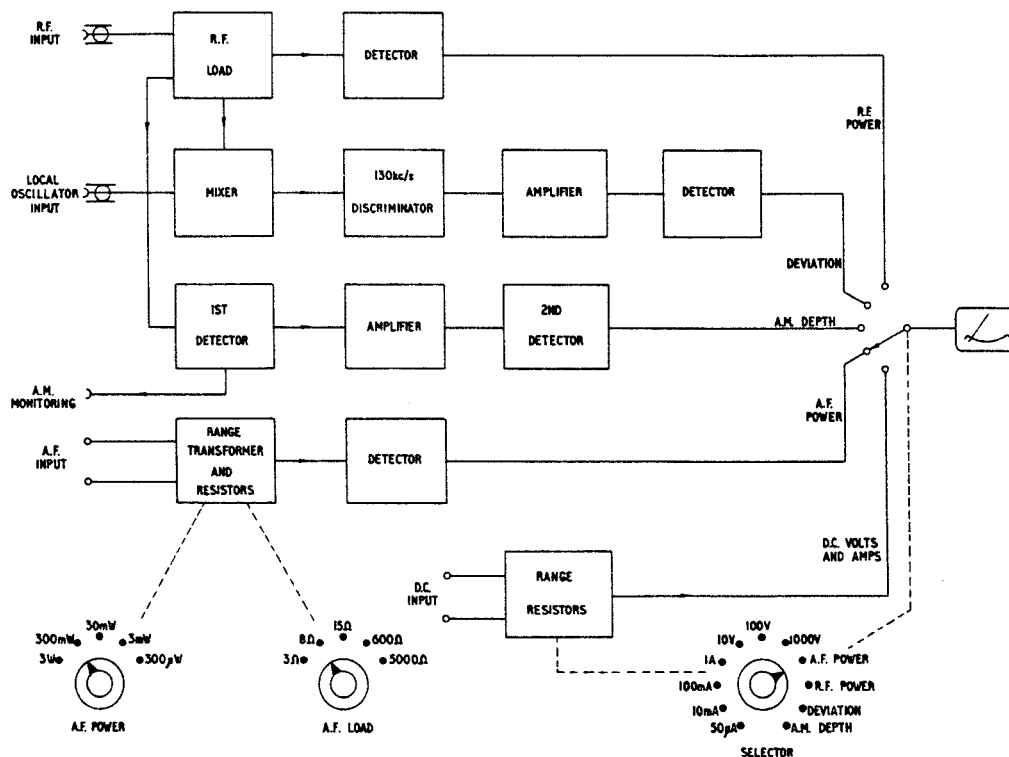


Fig. 3.1 Block Diagram

3.2 A.F. AND R.F. POWER METERS

The load element of the a.f. power meter section is a $5,000\ \Omega$ resistor formed by R35, with padding resistor RV6. This is switched directly to the input terminals on the $5,000\ \Omega$ ranges and via a tapped matching transformer on the lower-impedances ranges. The meter, which is fed from the transformer secondary via a rectifier, is an average-responding voltmeter calibrated directly in power and also in decibels.

The r.f. power meter section employs a heavy-duty high-stability resistor, R1, as the dissipative element; this resistor is mounted to form the central conductor of a slab line. The input power is fed via the R.F. socket to the live end of the resistor by an outward-tapering section which preserves a constant impedance between the socket and the relatively large-diameter resistor. From live to earthy end of the resistor, the broad metal plates which form the outer conductor have an inward taper so that continuous matching is maintained along the whole length of the resistor.

The indicating meter is fed, via silicon diode, MR1, from a tap on the load resistor, and measures mean power of sinusoidal inputs.

3.3 MODULATION MONITOR—A.M.

The depth of modulation can be measured on a.m. signals applied to the r.f. power input socket. A fraction of the signal is taken from a tapping on the r.f. load resistor, detected by MR3, amplified by VT3 and applied via second detector MR5 to the meter, which has a scale calibrated from 0 to 80%. The output of the first detector is also fed to a telephone jack for aural monitor-

ing of the modulation envelope. For the 'set carrier' adjustment VT3 and MR5 are bypassed by switch SD, and the carrier level meter reading is standardized by potentiometer RV1A.

3.4 MODULATION MONITOR—F.M.

The deviation indicator uses the superheterodyne principle. A portion of the frequency-modulated signal is obtained from a tapping point on the r.f. load resistor. This signal is applied together with an externally-derived signal, to a silicon-diode mixer, MR2. The i.f. output from this mixer is applied to a 130 kc/s tuned circuit (L1 - C9) via a low-pass filter consisting of C6, R6, and C7. The voltage developed across the tuned circuit is amplified by VT1 and VT2, and rectified by MR6 and MR7. With f.m. applied, the instantaneous i.f. deviates from the resonant frequency of the tuned circuit during part of the modulation cycle; thus the mean voltage across the tuned circuit is less than if there were no modulation present. Output from MR6 and MR7 therefore varies inversely with deviation.

3.5 D.C. VOLT/AMMETER

This section comprises the $50\ \mu\text{A}$ panel meter with series and shunt range resistors. When switched to one of the three voltage ranges, a resistor, R17, R18, or R19, is switched in series with the meter. For current measurement, except on the $50\ \mu\text{A}$ range where the meter is used at full sensitivity, shunt resistors R23, R24 or R25 are switched across the meter, and the ranges standardized by means of series potentiometers RV7, RV8 and RV9.

4 MAINTENANCE

4.1 GENERAL

The information given below will enable you to carry out most of the performance checks, adjustments and repairs that may require doing on the instrument.

Servicing is simplified by the hinged chassis design which gives easy access to all the component parts.

For routine inspection of the instrument follow the instructions given in Sections 4.5 to 4.11, which describe techniques for both checking and standardizing the performance. Do not make an internal adjustment until you are sure that a particular performance characteristic is inferior to that outlined in Data Summary (Section 1.2).

The need to replace the power supply - a long life mercury battery - will not arise until the instrument has seen a considerable amount of service.

For fault location, having first gained an understanding of the circuit functions, examine the suspected section. Look first for obvious signs of failure or damaged components. Despite thorough manufacturing precautions or as a result of arduous operating conditions, dry joints or faulty connections may be the trouble; check for these by noting changes in performance caused by gently tapping or applying light pressure to the joints with an insulated prod.

When an appreciation of the fault has been made adopt a systematic tracing method depending upon the symptoms presented. After clearing a fault check that the instrument performance is satisfactory in all respects.

In case of difficulties which cannot be cleared using this instruction book, or for

general advice on servicing the instrument, please write or telephone our Service Department or nearest Area office. Always mention the type number and serial number of your instrument. (For addresses, see rear cover.)

If the instrument is being returned for repair please indicate clearly the nature of the fault or the work you require to be done.

4.2 ACCESS AND COMPONENT LAYOUT

The instrument case should be removed as follows :-

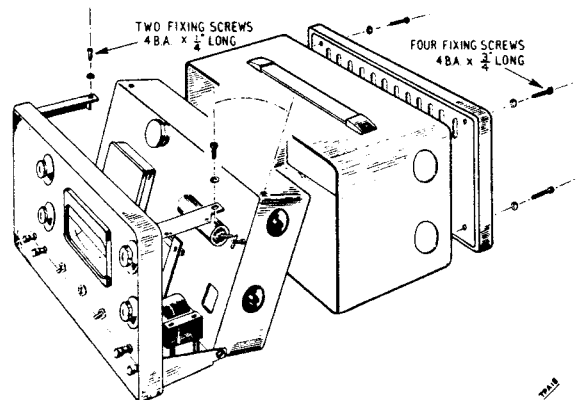
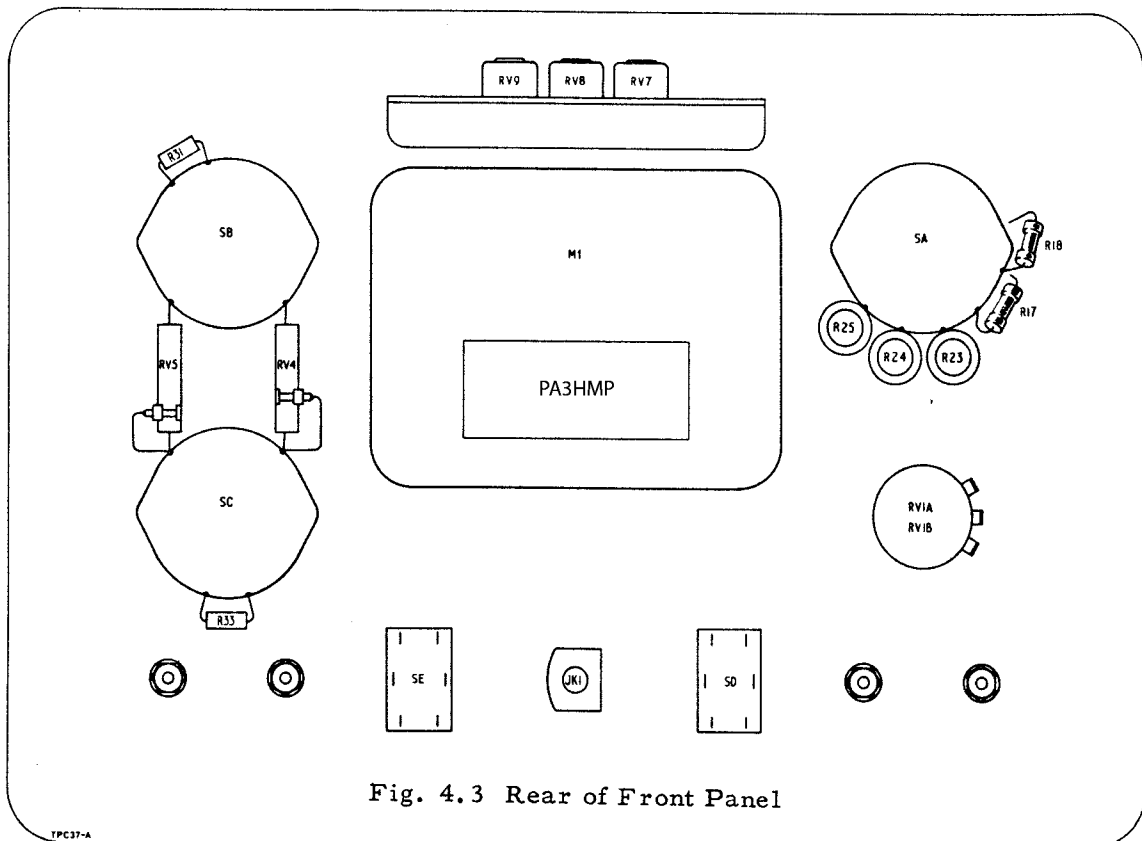
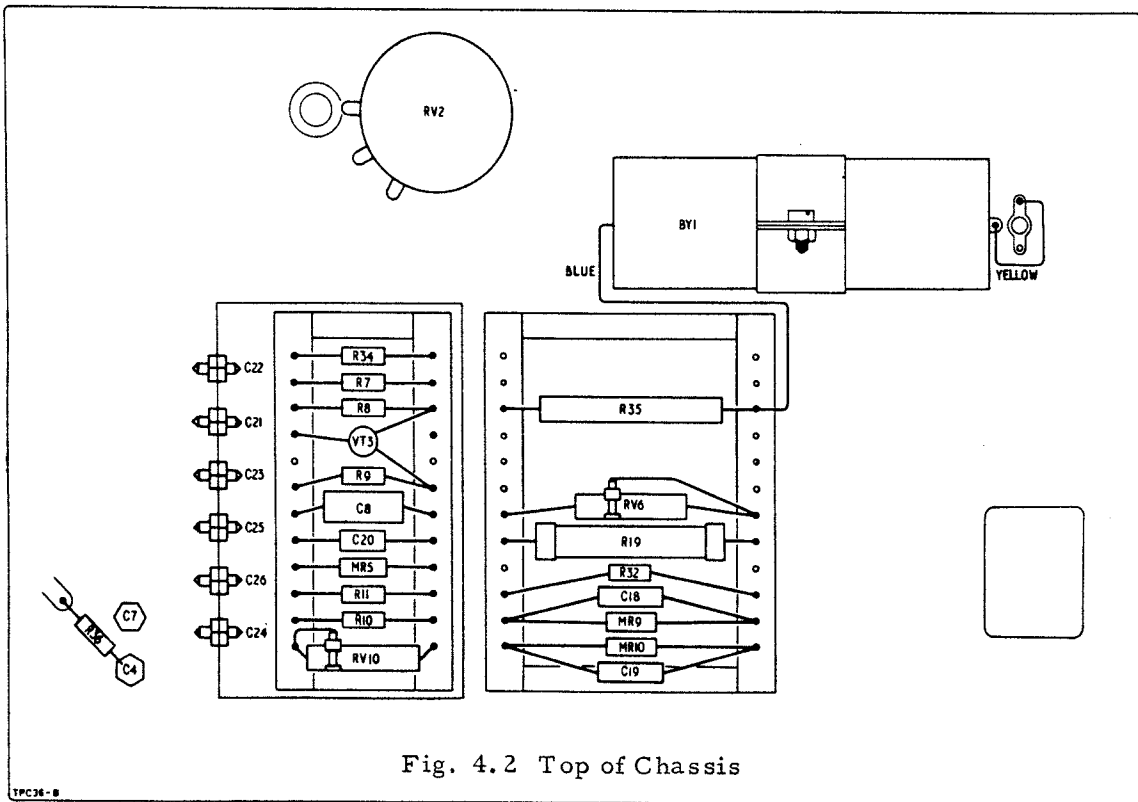


Fig. 4.1 Removal of Case

- (1) Place the instrument case face downwards and remove the four 4 BA fixing screws.
- (2) Lift the rear panel and sheet metal cover clear of the instrument.
- (3) Remove the two 4 BA screws from the retaining brackets. The hinged chassis can now be opened away from the front panel.



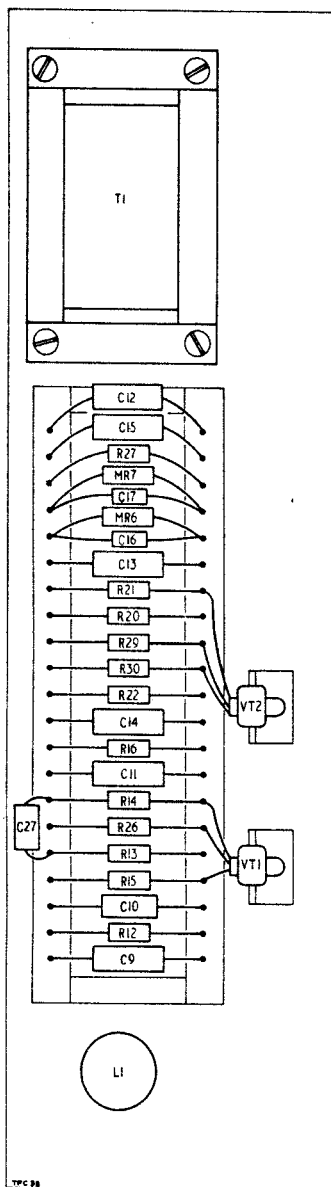


Fig. 4.4
Main Tag Strip

4.3 REPLACEMENT OF BATTERY

The power supply for the instrument consists of a single Mallory type SKB 639 mercury battery. The life of this 3400 mAh unit is extremely long. However, to avoid the inconvenience of battery failure, check the voltage every six months.

The two positive battery leads are marked 6.75 and 5.4 V; these figures represent the open-circuit voltage with a new battery. The on-load voltage of the 6.75 V lead should be between 6.6 and 6.7 V. The 5.4 V tap is not used.

To change the battery proceed as follows :-

- (1) Remove the rear panel and instrument cover (see 4.1). The battery is clamped on to the hinged chassis.
- (2) Unsolder the blue positive lead marked 6.75 V.
- (3) Unsolder the negative connection at the base of the battery.
- (4) Slacken the clamping screw and remove the spent unit.
- (5) Fit the replacement battery and tighten the clamp sufficiently to prevent movement; take care to avoid overtightening
- (6) Cut off the 5.4 V yellow lead and solder the positive and the negative leads to their appropriate tags (see 4.2).

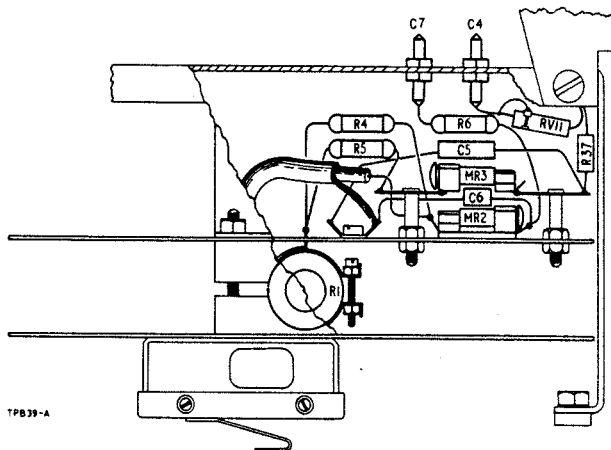


Fig. 4.5 F.M. and A.M. Monitor Detectors

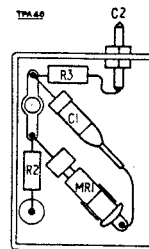


Fig. 4.6 R.F. Power Meter Detector

4.4 PRESET OR SELECTED COMPONENTS

Many of the operating parameters are brought within close limits by means of preset controls. These controls will not normally require adjustment except following the replacement of a component. When the replaced part is not designated as specially selected or preset, consider carefully the possible effect upon the performance of the circuit involved.

If the performance has been set previously by means of a preset or specially selected component, it may be necessary to reset or reselect the control element.

When adjustment is necessary refer to the section number in the third column of the table.

Circuit Ref.	Adjusts or Controls	See Section No.
--------------	---------------------	-----------------

D.C. VOLT/AMMETER		4.6
-------------------	--	-----

RV9	10 mA range	
-----	-------------	--

RV8	100 mA range	
-----	--------------	--

RV7	1 A range	
-----	-----------	--

R17	10 V range.	
-----	-------------	--

R18	100 V range.	
-----	--------------	--

R19	1,000 V range.	
-----	----------------	--

A.F. POWER METER		4.7
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RV6	Input impedance - overall accuracy.	
-----	--	--

RV4	Measurement accuracy - overall.	
-----	------------------------------------	--

R31	Measurement accuracy - 5 k Ω load.	
-----	--	--

R33	Input Impedance - mW range.	
-----	--------------------------------	--

RV5	Input Impedance - 300 μ W range.	
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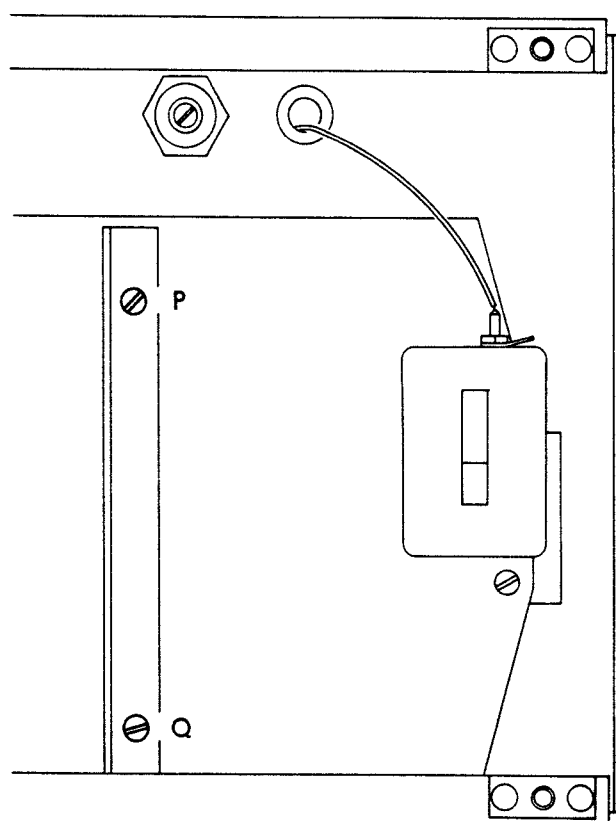


Fig. 4.7 V.S.W.R. Adjusting Screws

Circuit Ref.	Adjusts or Controls	See Section No.
--------------	---------------------	-----------------

R.F. POWER METER		4.8
------------------	--	-----

Screws 'P' V.S.W.R.
and 'Q'

R2	R.F. response	
----	---------------	--

RV2	Measurement accuracy (adjusted at l.f.)	
-----	---	--

C1	Measurement accuracy (adjusted at h.f.)	
----	---	--

F.M. MONITOR		4.9
--------------	--	-----

R12	Measurement accuracy.	
-----	--------------------------	--

A.M. MONITOR		4.10
--------------	--	------

RV10	A.M. level	
------	------------	--

RV11	'SET CARRIER' level.	
------	-------------------------	--

4.5 PERFORMANCE CHECKS—GENERAL

The procedures described in this section, which is intended to be read with reference to the circuit diagram at the back of this handbook, cover the verification of all the main points of performance and indicate a recalibration procedure which should only be followed if the performance is outside limits.

TEST LIMITS

These are given in Data Summary.

TEST EQUIPMENT

- (a) Variable d.c. source to supply up to 1 A and up to 500 V.
- (b) Ammeter, standardized to measure 10 mA, 100 mA and 1 A.
- (c) Valve Voltmeter with an accuracy of $\pm 2\%$ of full-scale or better, e.g. Marconi Type TF 1041 (series).
- (d) Oscillator capable of delivering 2 W at 1 kc/s; 600 Ω impedance, e.g. Marconi Type TF 894A.
- (e) Sensitive Valve Voltmeter, e.g. Marconi Type TF 1100 or TF 2600.
- (f) Resistance Box or close tolerance 3 Ω , 8 Ω , 15 Ω , 600 Ω , 5000 Ω resistors, 2 W.
- (g) A.F. matching transformer, at least 4 W rating.
- (h) Standing wave measuring equipment (50 Ω for TF 1065A, 75 Ω for TF 1065A/1), 100 to 500 Mc/s.
- (i) A.C. source, variable up to 25 W at the supply frequency, e.g. variable transformer.
- (j) Dynamometer wattmeter for accurate measurements in the range 2 W to 20 W at 50 c/s.
- (k) R.F. Power Meter for accurate measurements at 450 Mc/s, e.g. Standardized Marconi Type TF 1152A/1, (TF 1152A for TF 1065A/1).
- (l) Source of r.f. power capable of delivering at least 4 W at frequencies up to 450 Mc/s.
- (m) Signal Generator with accurately calibrated output attenuator, covering 120 kc/s to 140 kc/s, e.g. Marconi Type TF 885A/1.
- (n) Signal Generator to deliver 1 V at frequencies up to 470 Mc/s, and capable of being amplitude modulated up to at least 80% with sinewave modulating frequencies between 250 c/s and 5 kc/s. The drift after warm up to be not greater than 0.02% in a 10 minute period, e.g. Marconi Type TF 801C or TF 801D.
- (o) Test circuit for deviation indicator, see Fig. 4.11.
- (p) Frequency modulated signal generator to provide outputs from 10 to 470 Mc/s with a frequency stability of the order of (n) above. Deviations of 5, 10 and 15 kc/s required, e.g. Marconi Type TF 1066 (series).
- (q) F.M. deviation meter for the accurate measurement of deviations of 5, 10 and 15 kc/s at about 11 Mc/s, e.g. Marconi Types TF 791 (series) or TF 934 (series).
- (r) Oscilloscope to measure amplitude modulation depth at frequencies up to 10 Mc/s e.g.: Marconi Types TF 1331, TF 2200 series or TF 2201.
- (s) Crystal controlled transmitter to supply 1 W at v.h.f.; output impedance 50 Ω for TF 1065A, 75 Ω for TF 1065A/1.
- (t) A.F. transformer, 1:1 ratio.
- (u) Modulated r.f. source with an output (c.w.) of 0.5 W into 50 Ω at a frequency between 2 and 10 Mc/s. The requirement could be met with a signal generator feeding a linear amplifier.

4.6 D.C. VOLT/AMMETER TESTS

Test equipment required:- (see section 4.5) a, b, c.

CURRENT RANGES

Apart from the 50 μ A range when the basic meter movement is used alone, each range employs a shunt resistor. The current ranges are checked by applying known currents to the instrument and then noting the panel meter indications.

The test sequence is as follows :-

- (1) Switch to the 10 mA range and check that the indication is correct. If not, adjust RV9.
- (2) Switch to the 100 mA range and check that the indication is correct. If not, adjust RV8.
- (3) Switch to the 1 A range and check that the indication is correct. If not, adjust RV7.
- (4) When checking the 50 μ A range, multiply the meter scale reading by five. No adjustment is provided for this range.

VOLTAGE RANGES

The three voltage ranges 10, 100 and 1000 V use series resistors R17, R18, and R19 respectively in series with the meter.

The method of selecting these resistors is as follows :-

- (1) Connect a variable d.c. voltage source to the D.C. terminals of the Test Set. Connect an accurate voltmeter in parallel with these terminals.
- (2) Switch the Test Set to the 1000 V range and set the d.c. source to give an output of 500 V, as indicated on the monitoring voltmeter.

- (3) Check the reading accuracy of the TF 1065 meter. If necessary, select a new value for R19.
- (4) Repeat steps (1) to (3) with a 100 V source and the Test Set switched to the 100 V range. Select a value of R18 to give the correct meter reading.
- (5) Repeat steps (1) to (3) with a 10 V source and the Test Set switched to the 10 V range. If necessary, reselect R17.

4.7 A.F. POWER METER TESTS

Test equipment required:- (see section 4.5) d, e, f, g, t.

Measurements can be made at either 3 Ω , 8 Ω , 15 Ω , 600 Ω , or 5000 Ω impedance, over five ranges from 300 μ W to 3 W full scale. These ranges can be standardized by the procedure described below.

INPUT IMPEDANCE MEASUREMENT

- (1) Switch A.F. LOAD to 600 Ω , A.F. POWER to 3 W.
- (2) Connect the output from the power source, at 1 kc/s and 600 Ω , via the A.F. transformer and a 600 Ω resistor to the A.F. input terminals (see Fig. 4.8).
- (3) Connect the earthy valve voltmeter lead between the resistor and the A.F. INPUT terminal.
- (4) Set the 1 kc/s level to provide a convenient voltmeter deflection when connected across the resistor.
- (5) The voltage across the A.F. terminals should be within 5% of the voltage across the resistor. If necessary adjust RV6 to achieve this.

- (6) Select each of the other A.F. load positions adjusting the series resistor to each nominal value in turn. For the lower impedance ranges switch the oscillator output impedance to match. If your oscillator has a fixed output impedance use a matching transformer. In every case the A.F. terminal voltage should match the voltage across the resistor within 5%.
- (7) If necessary reset RV6 for the greatest overall accuracy.

- (4) Check the measurement accuracy on the other A.F. LOAD positions, 3 Ω , 8 Ω , 15 Ω , and 5000 Ω : R31 provides adjustment for the 5 k Ω load.

Load	For 2 W	For 1 W	For 0.5 W
5000 Ω	100 V	70.71 V	50 V
600 Ω	34.64 V	24.49 V	
15 Ω	5.477 V	3.873 V	
8 Ω	4 V	2.828 V	
3 Ω	2.449 V	1.732 V	

POWER MEASUREMENT

- (1) Switch A.F. LOAD to 600 Ω and A.F. POWER to 3 W.
- (2) Feed a signal at 1 kc/s to the A.F. INPUT terminals, monitor the voltage across the terminals and set the input level to 34.64 V (2 W in 600 Ω) or 24.49 V (1 W) if 2 W is not available.
- (3) The Test Set panel meter should indicate 2 W (or 1 W), if necessary adjust RV4 to obtain this reading.
- (5) Make a full scale check on the other A.F. POWER ranges (at 600 Ω) 300 μ W, 3 mW, 30 mW and 300 mW.
- (6) Check the meter scale shape on the 300 mW range at 600 Ω .
- (7) Repeat the input impedance check on the 3 mW and 300 μ W ranges at 600 Ω . Select R33 or reset RV5 if necessary.
- (8) Repeat the full scale power measurement check on the 300 μ W range at 600 Ω .
- (9) Finally check power measurement and input impedance on all 25 ranges, or on as many as required.

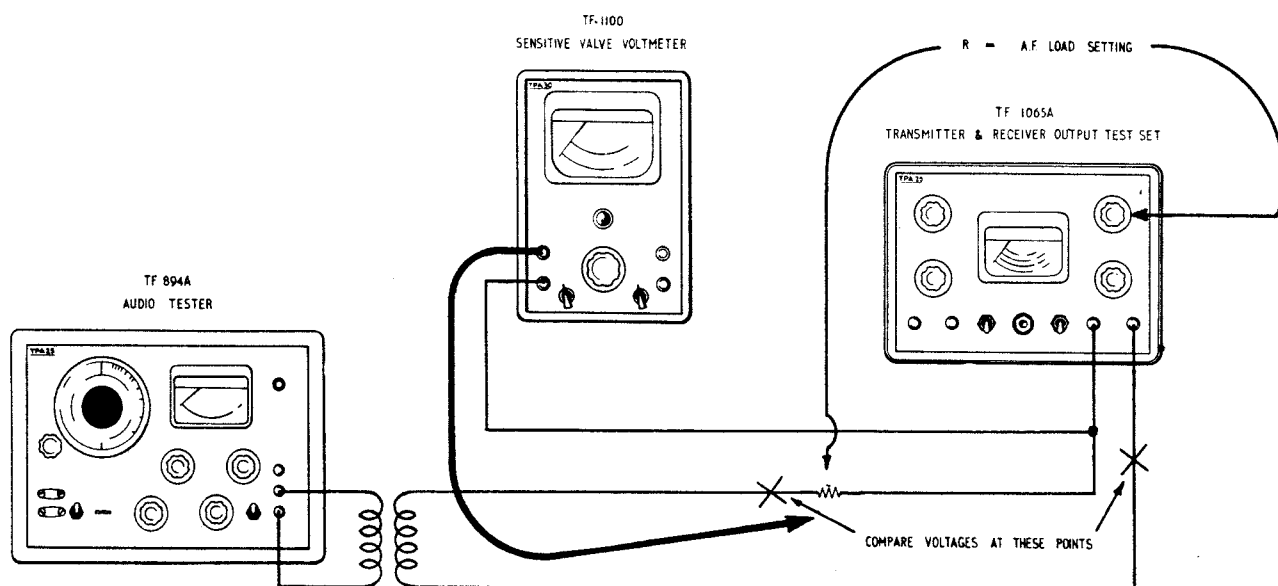


Fig. 4.8 Measuring A.F. Input Impedance

4.8 R.F. POWER METER TESTS

Test equipment required:- (see section 4.5) h, i, j, k, l.

Unless you have the necessary test equipment, it is recommended that the component parts of the power meter should not be dismantled - or their positions altered.

STANDING WAVE RATIO

In the type of R.F. Power Meter used on the TF 1065A series, v.s.w.r. is a function of the general configuration and spacing of the slab line side plates. This spacing can be varied by the screws marked P and Q in figure 4.7.

The method of adjusting these screws is given below.

- (1) Connect the v.s.w.r. measuring device to the R.F. socket and set it to operate at or near 500 Mc/s. Remember that the input impedance is:- TF 1065A 50 Ω , TF 1065A/1 75 Ω .

- (2) Determine the v.s.w.r. If too high adjust screws P and Q.

The spacing between the slab plates can be increased or decreased as necessary in order to obtain minimum v.s.w.r. but the screw settings should always be kept equal.

- (3) Make measurements at a selection of frequencies down to 100 Mc/s.

CALIBRATION ACCURACY

The power reading accuracy is best checked in two stages, firstly at low frequency (e.g. the local a.c. supply frequency) and then compared with that of a standardized R.F. Power Meter near the upper limit of the frequency range.

To standardize the meter scale, carry out the following procedure:-

Low Frequency Adjustments

- (1) Select R.F. POWER and connect the 50 c/s (supply frequency) source, via the dynamometer wattmeter, to the R.F. input socket.
- (2) Apply a known power of 25 W and, if necessary, adjust RV2 to obtain a corresponding reading on the panel meter.
- (3) Note the scale error at the following power levels: 2 W, 6 W, 10 W, 14 W, 18 W, and 22 W.
- (4) If the scale shape error is greatly in excess of 3% of f.s.d. at any point, readjust RV2 and repeat step (3) until the positive and negative errors are equalized.

R.F. Adjustments

Trimmer capacitor C1 is provided to damp out a rise in meter indication which may occur above about 400 Mc/s; the correct method of adjusting this component is given below.

- (1) Connect a 450 Mc/s r.f. source to a standardized r.f. power meter; the source, and power meter, should have an output impedance of 50 Ω when testing a TF 1065A and 75 Ω when testing a TF 1065A/1.
- (2) Set the level of the power source to give an exact indication of, say, 5 W.
- (3) Substitute the Test Set, switched to R.F. POWER, for the power meter, taking due precaution to prevent damage to the r.f. source when the load is momentarily disconnected.
- (4) Adjust C1 to obtain an identical power indication on the TF 1065A with the LID OF THE SCREENING BOX IN POSITION.
- (5) Check the accuracy of indication at other frequencies. If necessary, R2 may be reselected for optimum frequency response.

4.9 F.M. MONITOR TESTS

Test equipment required :- (see section 4.5) e, m, n, o, p, q.

I. F. SENSITIVITY

Make the following test to check that the i.f. sensitivity of the deviation indicator is satisfactory and that the i.f. circuit resonates at the correct frequency.

- (1) Select DEVIATION, and turn the SET CARRIER control to mid-travel.
- (2) Disconnect R6 and apply about 10 mV from a standard signal generator to the tap on L1. Tune the signal generator for maximum deflection on the TF 1065A panel meter.
- (3) The resonant frequency, at which maximum meter deflection is obtained, will normally be between 120 and 140 kc/s.
- (4) Reduce the input signal to 4 mV or less and turn the SET CARRIER control to maximum. The input required for the meter to indicate SET CARRIER should not be greater than about 4 mV.
- (5) With the SET CARRIER control at minimum, an input signal of between 16 and 21 mV will normally be required to give SET CARRIER meter indication.
- (6) Connect a sensitive valve voltmeter across L1, maintain the SET CARRIER

meter indication and measure the i.f. voltage developed when the SET CARRIER control is at both minimum and maximum settings. This should be about 300 mV and 200 mV respectively.

MEASUREMENT ACCURACY

The reduced i.f. voltage appearing across L1/C9 for a given deviation is a function of the shape of the response curve. In most cases, the Q of the tuned circuit is such that the voltage falls away too rapidly and, if left uncorrected, exaggerated deviation indications result.

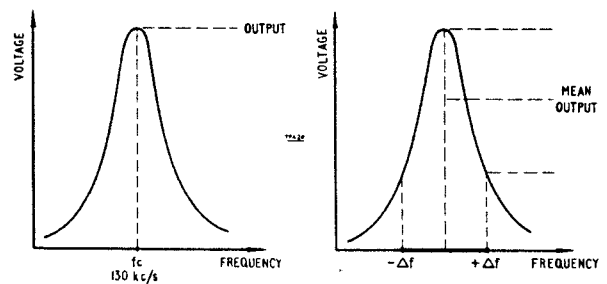


Fig. 4.9 F.M. Monitor Tuned Circuit Response

Correction is applied, where necessary, by means of a shunt resistor (R12) connected across the tuned circuit. The correct value for this resistor is determined in the following manner :-

- (1) Select DEVIATION, turn the SET CARRIER control to mid-travel and disconnect R6.

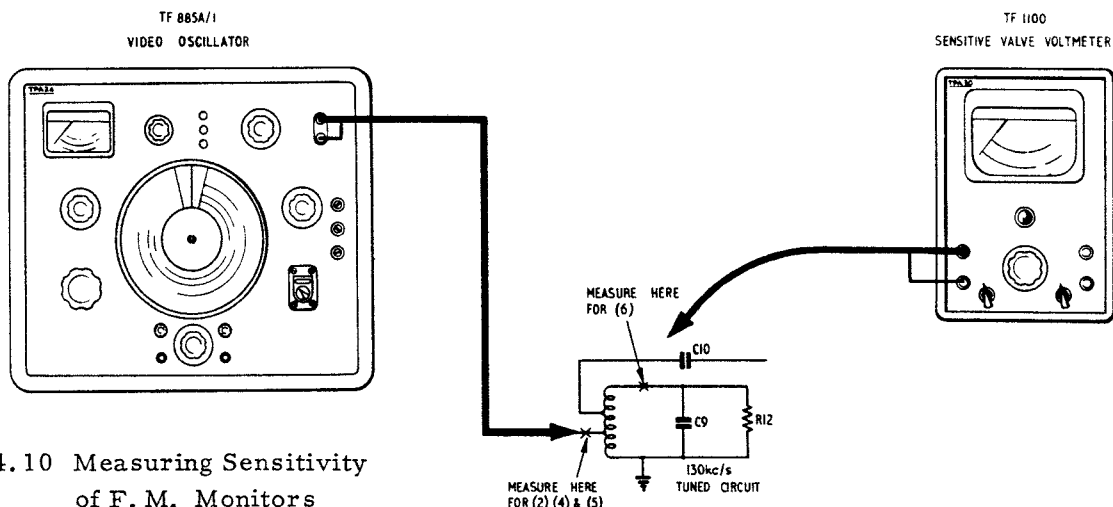


Fig. 4.10 Measuring Sensitivity of F.M. Monitors

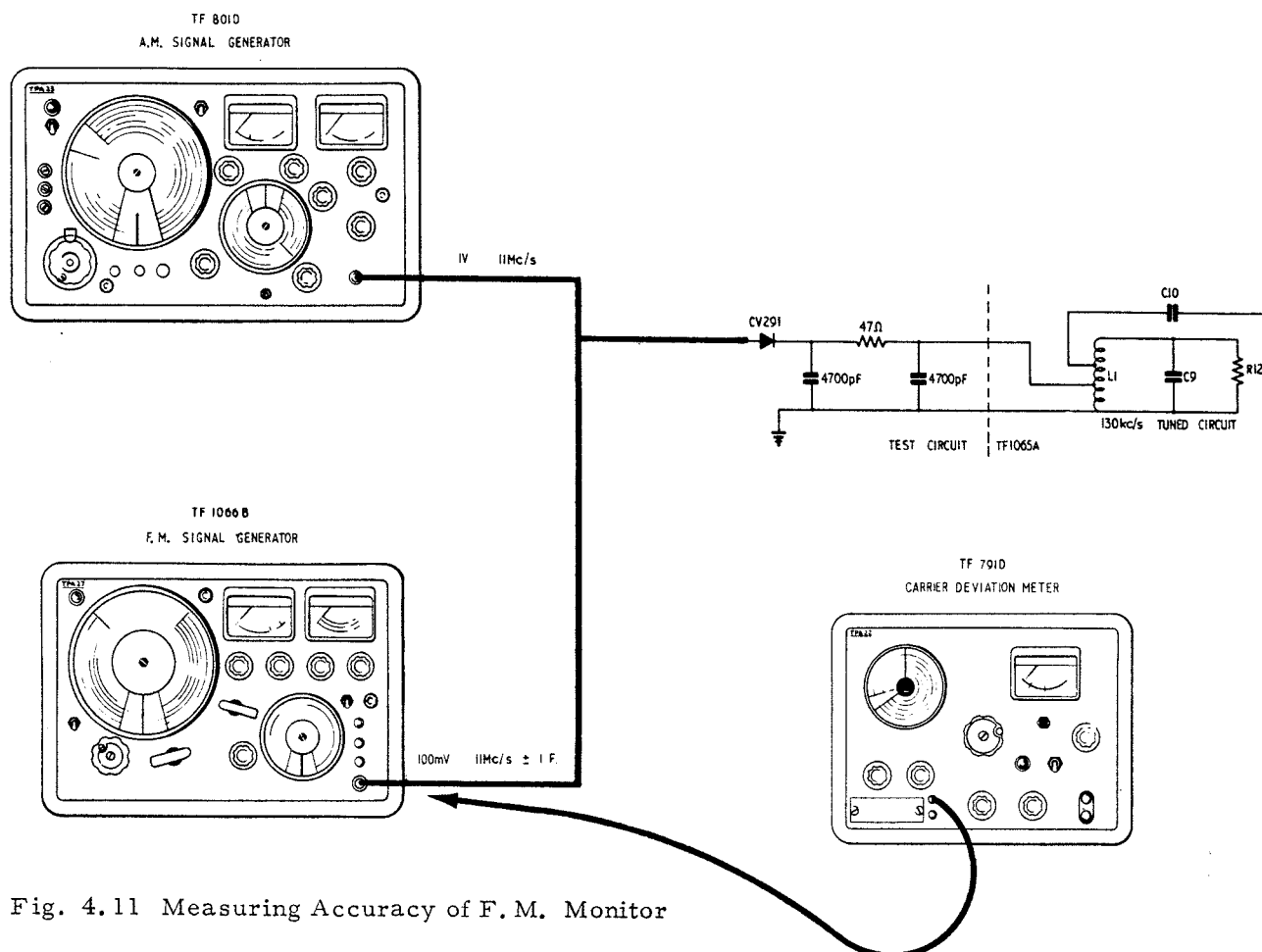


Fig. 4.11 Measuring Accuracy of F.M. Monitor

- (2) Connect the tap on L1 to the test circuit shown.
 - (3) Set the unmodulated r.f. source, item (n), to supply 1 V at 11 Mc/s.
 - (4) Adjust the f.m. signal generator output to about 100 mV - unmodulated - and tune to obtain a peak on the TF 1065A panel meter, which should occur at a frequency of about 130 kc/s above or below 11 Mc/s.
 - (5) Adjust the 11 Mc/s input level to give a meter deflection of SET CARRIER.
 - (6) Apply known deviations of 5, 10, and 15 kc/s (using the deviation meter to check the accuracy) and note the indications given on the TF 1065A.
 - (7) If the Test Set indication is outside limits at 15 kc/s deviation using 1 kc/s sinewave modulation, reselect R12, and repeat (6).
- #### 4.10 A.M. MONITOR TESTS
- Test equipment required:- (see section 4.5) c, r, u.
- #### MEASUREMENT ACCURACY
- (1) Position the TF 1065A controls as follows:-

SELECTOR switch to A.M. DEPTH
SET CARRIER A.M. /% A.M. switch to
SET CARRIER A.M.
SET CARRIER control to mid-travel

- (2) Connect the TF 1065A R.F. input socket to the r.f. source set to deliver c.w. at a frequency between 2 and 10 Mc/s. Measure the r.f. level with the valve voltmeter, making connection with the T connector.
- (3) Adjust the output level from the r.f. source until the voltmeter indicates 5V. Adjust RV11 until the TF 1065A meter indicates SET CARRIER.
- (4) Modulate the r.f. source at 1 kc/s. Turn the SET CARRIER/% A.M. switch to % A.M. Adjust the modulation depth of the r.f. source to 80% or any high value that can be achieved with low distortion and measure the depth using the oscilloscope. Percentage modulation measured this way is given by
- $$M (\%) = \frac{D_{\max} - D_{\min}}{D_{\max} + D_{\min}} \times 100$$
- where D max is the peak-to-peak and D min the trough-to-trough amplitude of the oscilloscope display.
- (5) Adjust RV10 until the TF 1065A meter indicates the modulation depth measured by the oscilloscope.
- (6) Return the SET CARRIER/% A.M. switch to SET CARRIER and check that the meter still reads at the SET CARRIER mark.
- (7) Switch back to % A.M. and check the % MOD scale linearity at about 20%, 40% and 60% modulation depth.
- (8) Repeat the tests at 5 kc/s modulation frequency and check that the indication is within the limits indicated in Sect. 1.2 Data Summary.
- (9) Connect a pair of earphones to the PHONES socket and check that the modulating tone is audible.

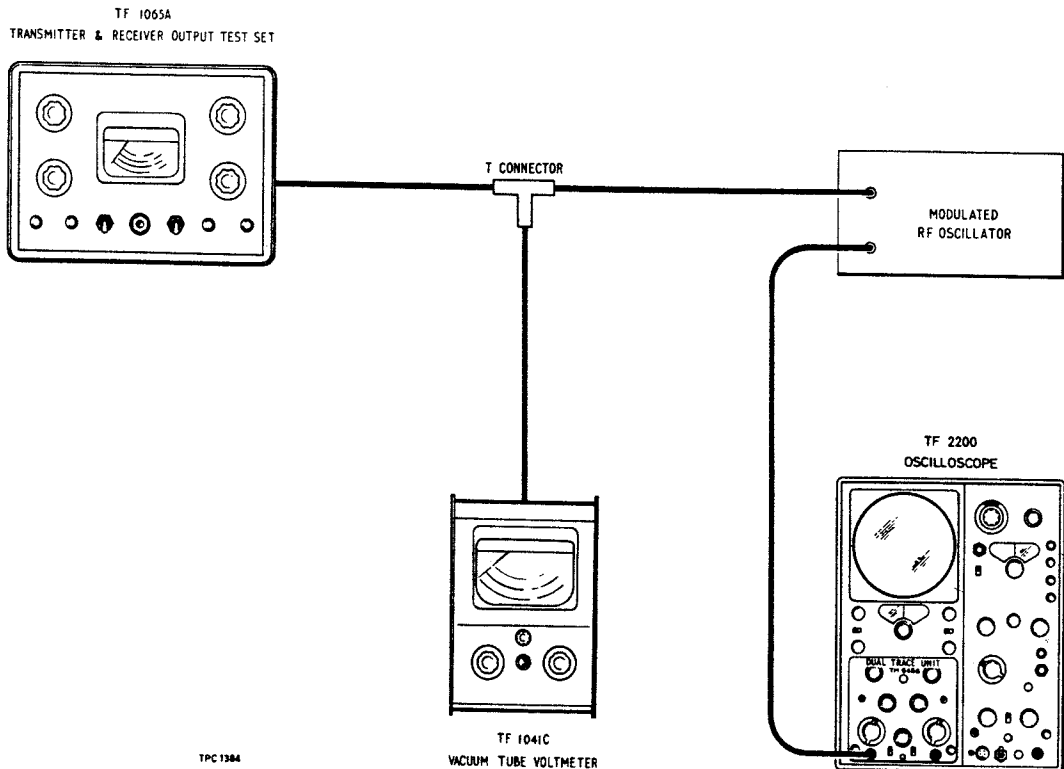


Fig. 4.12 Measuring Accuracy of A.M. Monitor

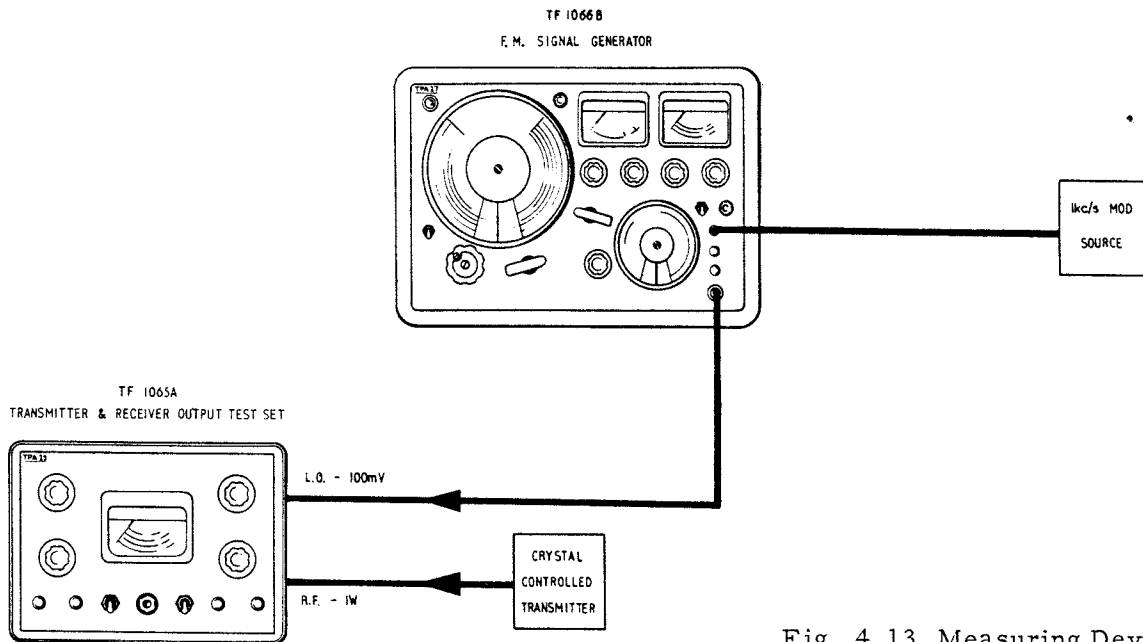


Fig. 4.13 Measuring Deviation

4.11 TESTS USING A TRANSMITTER

Test equipment required :- (see section 4.5) p, q, r, s, k.

With the TF 1065A completely assembled carry out the following tests :-

DEVIATION MEASUREMENT

- (1) Switch to DEVIATION and turn the SET CARRIER control to mid-travel.
- (2) Using a suitable transmitter, apply a v.h.f. signal of 1 W to the R.F. input socket of the TF 1065A.
- (3) Connect the output from a signal generator to the L.O. socket and tune to the transmitter frequency $\pm$ the i.f. of the Test Set.
- (4) With the SET CARRIER control turned fully clockwise, adjust the output level of the signal generator so that the Test Set panel meter indicates SET CARRIER. An output of between 45 and 60 mV will normally be required.
- (5) Repeat step (4) with the SET CARRIER control turned fully counter-clockwise.

A voltage of between 75 and 100 mV is usually required for SET CARRIER conditions.

- (6) Frequency modulate the signal generator output at 1 kc/s, to known deviations of 5, 10 and 15 kc/s and check that the Test Set indication is substantially correct.

A.M. DEPTH MEASUREMENT

- (1) Connect an amplitude modulated r.f. signal of about 1 W to the R.F. socket.
- (2) Turn the SELECTOR switch to A.M. DEPTH.
- (3) Set the toggle switch to SET CARRIER A.M.
- (4) Adjust the SET CARRIER control and, if necessary, the signal input level to bring the meter pointer to the SET CARRIER mark. Check that the power needed to 'SET CARRIER' is not greater than 1 W throughout the frequency range.
- (5) Check the measurement accuracy at 80% modulation (or less if 80% is not available) at several frequencies over the whole range.

NOTES

1. COMPONENT VALUES

Resistors : No suffix = ohms. k = kilohms. M = megohms.

Capacitors : No suffix = microfarads. p = picofarads.

*Value selected during test; nominal value shown.

2. VOLTAGES

These are d. c. and relative to chassis except where otherwise indicated.

Voltmeter : 20 k Ω /V model on highest convenient range.

3. SYMBOLS

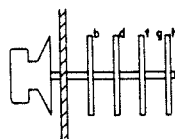
⊗ preset component

⤵ arrow indicates clockwise rotation of knob

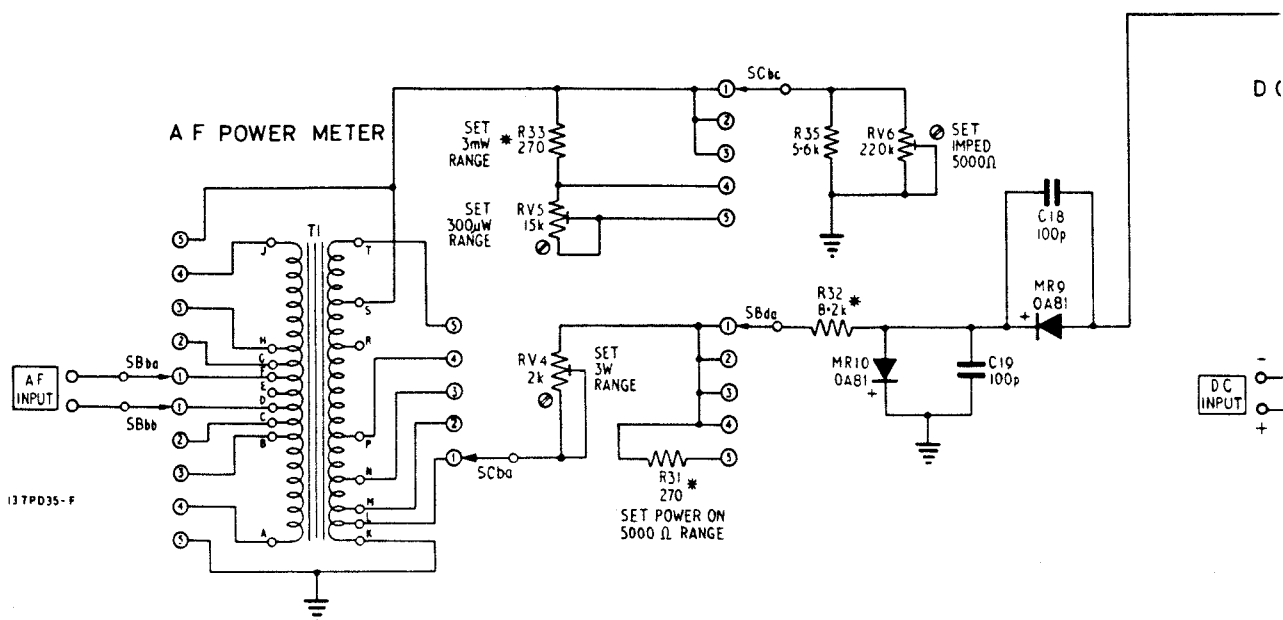
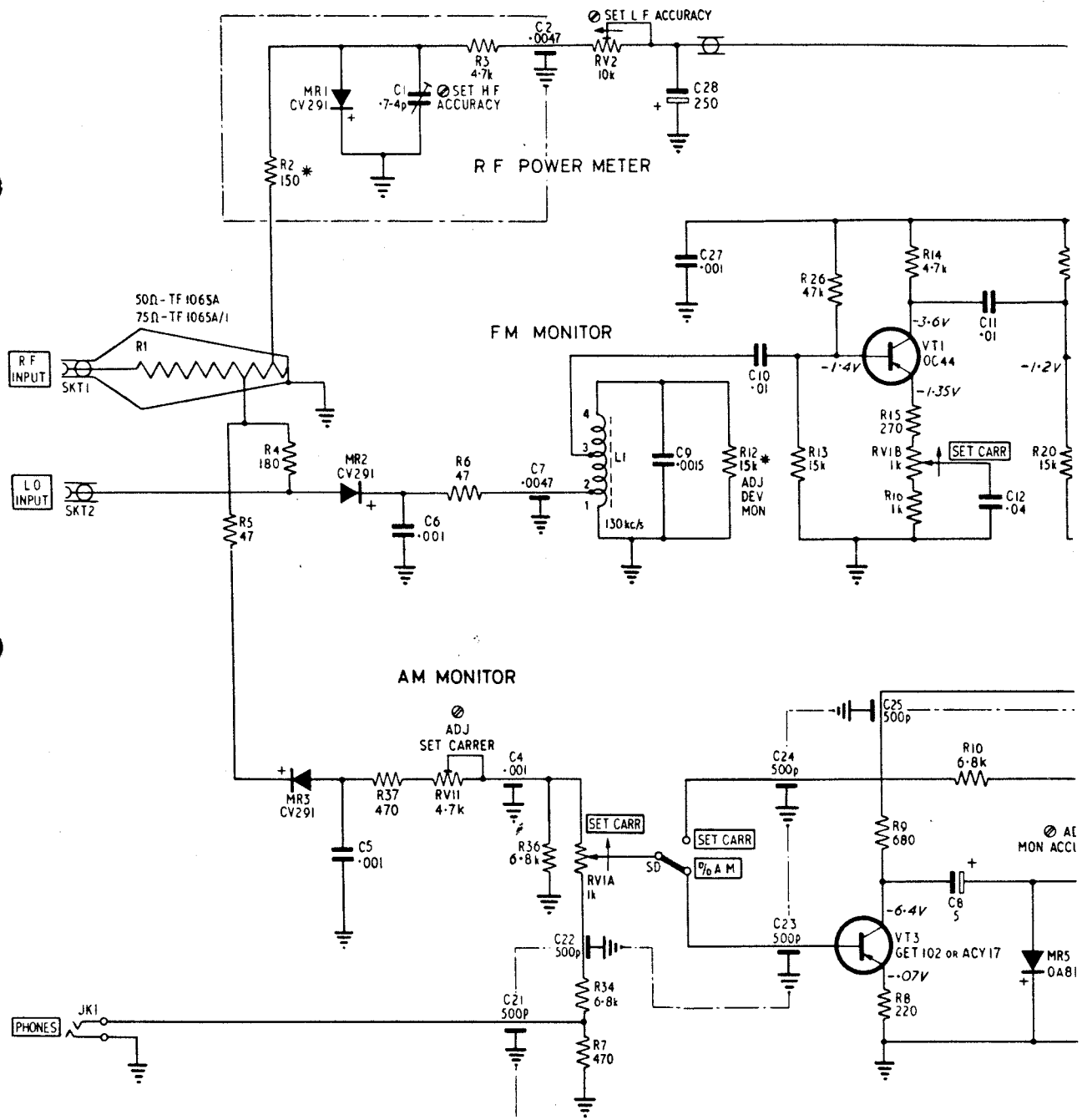
EXT panel marking

4. SWITCHES

Rotary switches are drawn schematically. Numbers indicate control knob setting.



Sequence of sections.



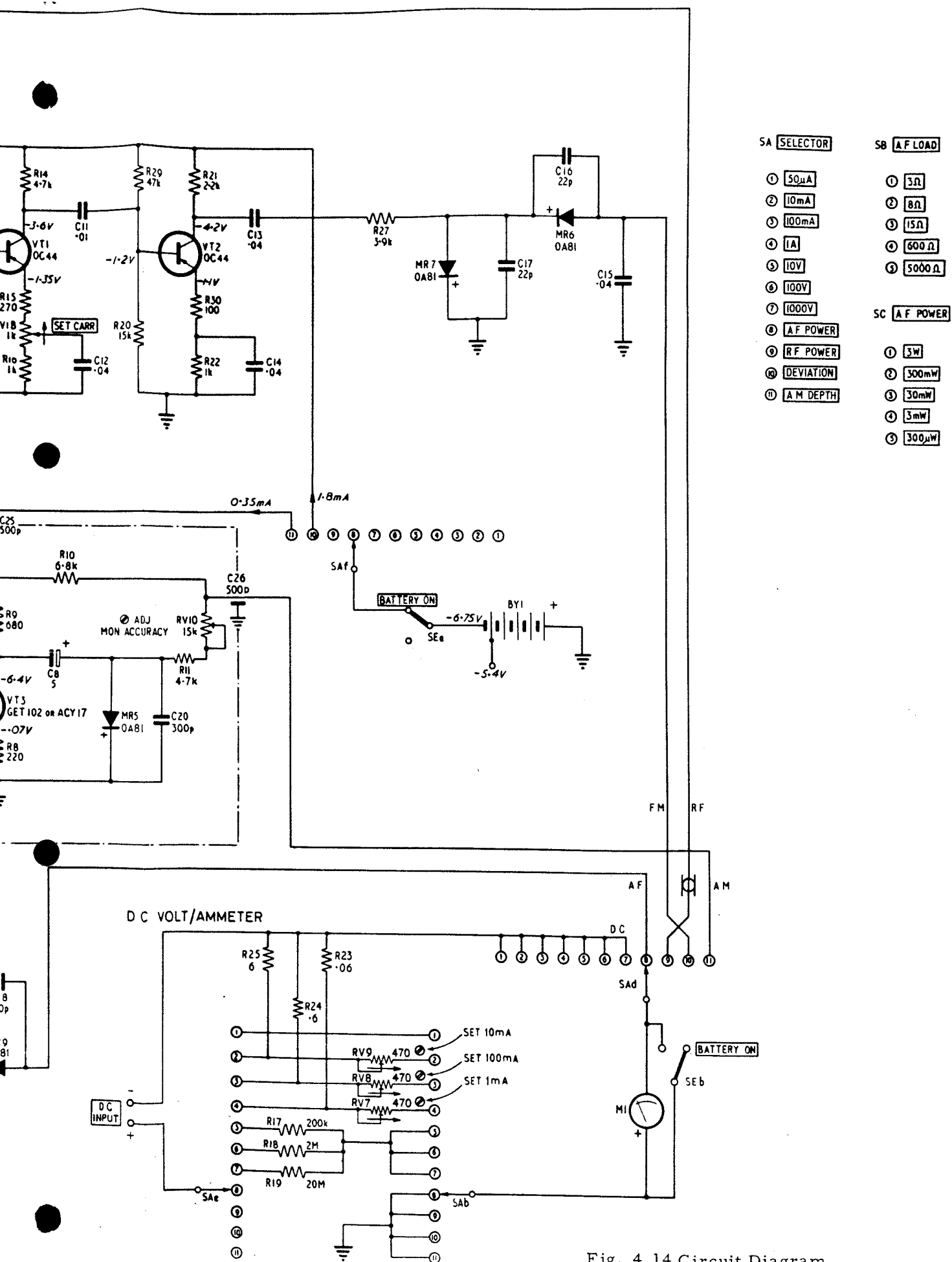


Fig. 4.14 Circuit Diagram

5 SPARES ORDERING SCHEDULE

When ordering replacement parts, always quote the TYPE NUMBER and SERIAL NUMBER of the instruments concerned.

To specify the individual parts required, state for each part the QUANTITY required and the appropriate SOS ITEM NUMBER.

For example, to order replacements for the 1 k Ω resistor, R16, and the 0.1 μ F capacitor C10, quote as follows :

Spares required for TF 1065A, Serial Number 000000

1 off, SOS Item 58
1 off, SOS Item 11

If the part required is not listed please state its location, function and description.

SOS No.	Circuit Ref.	Description	Works Ref.
1	BY1	Battery, Type SKB639, 6.75 V	55-TM 6664

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating Volts d.c.	Works Ref.
CAPACITORS						
2	C1	Trimmer	0.7-4 pF	-	500 V pk	37-TM 6664
3	C2	Lead-through	.0047 μ F	+ Inf. -0	350	39-TM 6664
4	C3	Not used				
5	C4	Lead-through	1000 pF	+ Inf. -0	350	40-TM 6664
6	C5	Metallised paper	.001 μ F	$\pm$ 20%	600	38-TM 6664
7	C6	Metallised paper	.001 μ F	$\pm$ 20%	600	38-TM 6664

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating Volts d.c.	Works Ref.
CAPACITORS (continued)						
8	C7	Lead-through	.0047 μ F	+ Inf. -0	350	39-TM 6664
9	C8	Electrolytic	5 μ F	+100% -20%	50	22-TM 6668
10	C9	Mica	1500 pF	$\pm$ 5%	350	18-TM 6669
11	C10	Metallised paper	.01 μ F	$\pm$ 20%	400	17-TM 6669
12	C11	Metallised paper	.01 μ F	$\pm$ 20%	400	17-TM 6669
13	C12	Metallised paper	.04 μ F	$\pm$ 20%	250	16-TM 6669
14	C13	Metallised paper	.04 μ F	$\pm$ 20%	250	16-TM 6669
15	C14	Metallised paper	.04 μ F	$\pm$ 20%	250	16-TM 6669
16	C15	Metallised paper	.04 μ F	$\pm$ 20%	250	16-TM 6669
17	C16	Ceramic	22 pF	$\pm$ 5%	750	19-TM 6669
18	C17	Ceramic	22 pF	$\pm$ 5%	750	19-TM 6669
19	C18	Ceramic	100 pF	$\pm$ 2%	750	4-TM 6667
20	C19	Ceramic	100 pF	$\pm$ 2%	750	4-TM 6667
21	C20	Metallised paper	300 pF	$\pm$ 20%	600	21-TM 6668
22	C21	Lead-through	500 pF	+ Inf. -25%	350	25-TM 6668
23	C22	Lead-through	500 pF	+ Inf. -25%	350	25-TM 6668
24	C23	Lead-through	500 pF	+ Inf. -25%	350	25-TM 6668
25	C24	Lead-through	500 pF	+ Inf. -25%	350	25-TM 6668
26	C25	Lead-through	500 pF	+ Inf. -25%	350	25-TM 6668
27	C26	Lead-through	500 pF	+ Inf. -25%	350	25-TM 6668
28	C27	Metallised paper	.001 μ F	$\pm$ 20%	600	15-TM 6669
28/1	C28	Electrolytic	250 μ F	+50% -20%	6	35-TM 6664

SOS No.	Circuit Ref.	Description	Works Ref.
29	JK1	PHONES jack	44-TF 1065A
30	L1	Inductor, 950 μ H	TC 33884/19
31	M1	Meter, 50 μ A, 1 k Ω	TM 3970/112

SEMI-CONDUCTOR DIODES

32	MR1	Silicon, type CV291 (6-2000 <i>Verbrengen door 1N415D</i>)	41-TM 6664
33	MR2	Silicon, type CV291	41-TM 6664
34	MR3	Silicon, type CV 291	41-TM 6664
35	MR4	Not used	
36	MR5	Germanium, type OA81	29-TM 6668
37	MR6	Germanium, type OA81	5-TM 6669
38	MR7	Germanium, type OA81	5-TM 6669
39	MR8	Not used	
40	MR9	Germanium, type OA81	5-TM 6667
41	MR10	Germanium, type OA81	5-TM 6667

OA81 $\rightarrow$ OA91 $\rightarrow$ AA133

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating Watts	Works Ref.
42	R1	Carbon special complete with bonded input cone and tapping band. (For TF 1065A.)	50 Ω	$\pm 5\%$	30	TM 9556/1
43	R1	Carbon special complete with bonded input cone and tapping band. (For TF 1065A/1.)	75 Ω	$\pm 5\%$	30	TM 9556/3

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating Watts	Works Ref.
FIXED RESISTORS (continued)						
44	R2	Metal oxide	150 Ω	(nominal value)	3/8	31-TM 6664
45	R3	Composition	4.7 k Ω	$\pm 10\%$	1/4	32-TM 6664
46	R4	Deposited carbon	180 Ω	$\pm 5\%$	1/4	29-TM 6664
47	R5	Deposited carbon	47 Ω	$\pm 5\%$	1/4	28-TM 6664
48	R6	Deposited carbon	47 Ω	$\pm 5\%$	1/4	28-TM 6664
49	R7	Composition	470 Ω	$\pm 10\%$	1/4	10-TM 6668
50	R8	Metal oxide	220 Ω	$\pm 5\%$	1/4	14-TM 6668
51	R9	Metal oxide	680 Ω	$\pm 7\%$	3/8	13-TM 6668
52a	R10	Metal oxide	6.8 k Ω	$\pm 7\%$	3/8	24552-106
53a	R11	Metal oxide	4.7 k Ω	$\pm 7\%$	3/8	24552-100
54	R12	Composition	15 k Ω	(nominal value)	1/4	24342-114
55	R13	Composition	15 k Ω	$\pm 10\%$	1/4	9-TM 6669
56	R14	Composition	4.7 k Ω	$\pm 10\%$	1/4	7-TM 6669
57	R15	Composition	270 Ω	$\pm 10\%$	1/4	11-TM 6669
58	R16	Composition	1 k Ω	$\pm 10\%$	1/4	10-TM 6669
59	R17	Deposited carbon	200 k Ω	$\pm 2\%$	1/4	30-TF 1065A
60	R18	Deposited carbon	2 M Ω	$\pm 2\%$	1/4	31-TF 1065A
61	R19	Deposited carbon	20 M Ω	$\pm 2\%$	2	8-TM 6667
62	R20	Composition	15 k Ω	$\pm 10\%$	1/4	9-TM 6669
63	R21	Composition	2.2 k Ω	$\pm 10\%$	1/4	8-TM 6669
64	R22	Composition	1 k Ω	$\pm 10\%$	1/4	10-TM 6669
65	R23	Wire-wound	0.06 Ω	$\pm 10\%$	-	29-TF 1065A
66	R24	Wire-wound	0.6 Ω	$\pm 3\%$	-	33-TF 1065A
67	R25	Wire-wound	6 Ω	$\pm 3\%$	-	34-TF 1065A

SOS No.	Circuit Ref.	Type	Value	Tolerance	Rating Watts	Works Ref.
FIXED RESISTORS (continued)						
68	R26	Composition	47 k Ω	$\pm 10\%$	1/4	14-TM 6669
69	R27	Composition	3.9 k Ω	$\pm 10\%$	1/4	6-TM 6669
70	R28	Not used				
71	R29	Composition	47 k Ω	$\pm 10\%$	1/4	14-TM 6669
72	R30	Composition	100 Ω	$\pm 10\%$	1/4	12-TM 6669
73	R31	Composition	270 Ω	(nominal value)	1/4	35-TF 1065A
74	R32	Composition	8.2 k Ω	(nominal value)	1/4	6-TM 6667
75	R33	Composition	270 Ω	(nominal value)	1/4	35-TF 1065A
76	R34	Composition	6.8 k Ω	$\pm 10\%$	1/4	15-TM 6668
77	R35	Wire-wound	5.6 k Ω	$\pm 5\%$	14	13-TM 6667
78	R36	Composition	6.8 k Ω	$\pm 10\%$	1/2	34-TM 6664
78b	R37	Metal oxide	470 Ω	$\pm 7\%$	3/8	24552-069

VARIABLE RESISTORS

79	RV1A	Wire-wound	1 k Ω		2	38-TF 1065A
	RV1B	Wire-wound	1 k Ω			
80	RV2	Wire-wound	10 k Ω		1	TB 17392/9
82	RV4	Wire-wound	2 k Ω		1/2	36-TF 1065A
83	RV5	Carbon	15 k Ω		1/4	37-TF 1065A
84	RV6	Carbon	220 k Ω		1/4	9-TM 6667
84/1	RV7	Carbon	470 Ω		1/4	39-TF 1065A
84/2	RV8	Carbon	470 Ω		1/4	39-TF 1065A
84/3	RV9	Carbon	470 Ω		1/4	39-TF 1065A
84/4	RV10	Carbon	15 k Ω	$\pm 20\%$	1/4	25678-309
84/5	RV11	Carbon	4.7 k Ω	$\pm 20\%$	1/4	25678-303

SOS No.	Circuit Ref.	Description	Works Ref.
85	SA	Wafer switch, SELECTOR	TC 31600/74
86	SB	Wafer switch, A. F. LOAD	TC 31600/73
87	SC	Wafer switch, A. F. POWER	TC 31600/72
88	SD	Switch, SET CARRIER/% A. M.	46-TF 1065A
89	SE	Switch, BATTERY ON	46-TF 1065A
90	SKT1	Type N socket, R. F. , 50 Ω , for TF 1065A	42-TM 6664
91		Type N socket, R. F. , 75 Ω , for TF 1065A/1	65-TM 6664/1
92	-	Mating plug for SOS No. 90 above :- Type N free plug, 50 Ω	53-TF 1065A
93	-	Mating plug for SOS No. 91 above :- Type N free plug, 75 Ω	60-TF 1065A/1
94	SKT2	Type BNC socket, L. O. , 50 Ω	43-TM 6664
95	-	Mating plug for SOS No. 94 above :- Type BNC free plug, 50 Ω	54-TF 1065A
96	T1	Mains Input Transformer	TM 5135/8
97	VT1	Transistor, germanium, p-n-p, type OC44	55-TF 1065A
98	VT2	Transistor, germanium, p-n-p, type OC44	55-TF 1065A
99	VT3	Transistor, germanium, p-n-p, type GET102 or ACY 17	31-TM 6668

SOS No.	Description	Works Ref.
MISCELLANEOUS		
100	Knob for SELECTOR control	TB 17848/3
101	Knob for A. F. LOAD control	TB 17848/3
102	Knob for A. F. POWER control	TB 17848/3
103	Knob for SET CARRIER control	TB 17848/3
104	Terminal for D. C. INPUT or A. F. INPUT	TB 24330/5
105	Carrying handle	41-TF 1065A
106	Front or rear panel surround	TB 24786/1
107	Case wrapper	TD 25931
108	Rubber strip to fit between case and surround	42-TF 1065A
109	Case foot	TA 11420
110	Plastic cover	51-TF 1065A
111	Shouldered screw for hinging chassis	TB 35666
112	Lid for R. F. Power Detector box	TB 26348
113	Contact for lid of box for SOS No. 112 above	TE 25927/10
114	Lid for Tag Strip Assembly box	TB 36750
115	Variable Resistor Nut for RV2	TB 24000/1

DECIBEL CONVERSION TABLE

<i>Ratio Down</i>			<i>Ratio Up</i>	
VOLTAGE	POWER	DECIBELS	VOLTAGE	POWER
1.0	1.0	0	1.0	1.0
·9886	·9772	·1	1.012	1.023
·9772	·9550	·2	1.023	1.047
·9661	·9333	·3	1.035	1.072
·9550	·9120	·4	1.047	1.096
·9441	·8913	·5	1.059	1.122
·9333	·8710	·6	1.072	1.148
·9226	·8511	·7	1.084	1.175
·9120	·8318	·8	1.096	1.202
·9016	·8128	·9	1.109	1.230
·8913	·7943	1.0	1.122	1.259
·8710	·7586	1.2	1.148	1.318
·8511	·7244	1.4	1.175	1.380
·8318	·6918	1.6	1.202	1.445
·8128	·6607	1.8	1.230	1.514
·7943	·6310	2.0	1.259	1.585
·7762	·6026	2.2	1.288	1.660
·7586	·5754	2.4	1.318	1.738
·7413	·5495	2.6	1.349	1.820
·7244	·5248	2.8	1.380	1.905
·7079	·5012	3.0	1.413	1.995
·6683	·4467	3.5	1.496	2.239
·6310	·3981	4.0	1.585	2.512
·5957	·3548	4.5	1.679	2.818
·5623	·3162	5.0	1.778	3.162
·5309	·2818	5.5	1.884	3.548
·5012	·2512	6	1.995	3.981
·4467	·1995	7	2.239	5.012
·3981	·1585	8	2.512	6.310
·3548	·1259	9	2.818	7.943
·3162	·1000	10	3.162	10.000
·2818	·07943	11	3.548	12.59
·2512	·06310	12	3.981	15.85
·2239	·05012	13	4.467	19.95
·1995	·03981	14	5.012	25.12
·1778	·03162	15	5.623	31.62

DECIBEL CONVERSION TABLE (continued)

Ratio Down			Ratio Up		
VOLTAGE	POWER	DECIBELS	VOLTAGE	POWER	
·1585	·02512	16	6·310	39·81	
·1413	·01995	17	7·079	50·12	
·1259	·01585	18	7·943	63·10	
·1122	·01259	19	8·913	79·43	
·1000	·01000	20	10·000	100·00	
·07943	$6·310 \times 10^{-3}$	22	12·59	158·5	
·06310	$3·981 \times 10^{-3}$	24	15·85	251·2	
·05012	$2·512 \times 10^{-3}$	26	19·95	398·1	
·03981	$1·585 \times 10^{-3}$	28	25·12	631·0	
·03162	$1·000 \times 10^{-3}$	30	31·62	1,000	
·02512	$6·310 \times 10^{-4}$	32	39·81	$1·585 \times 10^3$	
·01995	$3·981 \times 10^{-4}$	34	50·12	$2·512 \times 10^3$	
·01585	$2·512 \times 10^{-4}$	36	63·10	$3·981 \times 10^3$	
·01259	$1·585 \times 10^{-4}$	38	79·43	$6·310 \times 10^3$	
·01000	$1·000 \times 10^{-4}$	40	100·00	$1·000 \times 10^4$	
$7·943 \times 10^{-3}$	$6·310 \times 10^{-5}$	42	125·9	$1·585 \times 10^4$	
$6·310 \times 10^{-3}$	$3·981 \times 10^{-5}$	44	158·5	$2·512 \times 10^4$	
$5·012 \times 10^{-3}$	$2·512 \times 10^{-5}$	46	199·5	$3·981 \times 10^4$	
$3·981 \times 10^{-3}$	$1·585 \times 10^{-5}$	48	251·2	$6·310 \times 10^4$	
$3·162 \times 10^{-3}$	$1·000 \times 10^{-5}$	50	316·2	$1·000 \times 10^5$	
$2·512 \times 10^{-3}$	$6·310 \times 10^{-6}$	52	398·1	$1·585 \times 10^5$	
$1·995 \times 10^{-3}$	$3·981 \times 10^{-6}$	54	501·2	$2·512 \times 10^5$	
$1·585 \times 10^{-3}$	$2·512 \times 10^{-6}$	56	631·0	$3·981 \times 10^5$	
$1·259 \times 10^{-3}$	$1·585 \times 10^{-6}$	58	794·3	$6·310 \times 10^5$	
$1·000 \times 10^{-3}$	$1·000 \times 10^{-6}$	60	1,000	$1·000 \times 10^6$	
$5·623 \times 10^{-4}$	$3·162 \times 10^{-7}$	65	$1·778 \times 10^3$	$3·162 \times 10^6$	
$3·162 \times 10^{-4}$	$1·000 \times 10^{-7}$	70	$3·162 \times 10^3$	$1·000 \times 10^7$	
$1·778 \times 10^{-4}$	$3·162 \times 10^{-8}$	75	$5·623 \times 10^3$	$3·162 \times 10^7$	
$1·000 \times 10^{-4}$	$1·000 \times 10^{-8}$	80	$1·000 \times 10^4$	$1·000 \times 10^8$	
$5·623 \times 10^{-5}$	$3·162 \times 10^{-9}$	85	$1·778 \times 10^4$	$3·162 \times 10^8$	
$3·162 \times 10^{-5}$	$1·000 \times 10^{-9}$	90	$3·162 \times 10^4$	$1·000 \times 10^9$	
$1·000 \times 10^{-5}$	$1·000 \times 10^{-10}$	100	$1·000 \times 10^5$	$1·000 \times 10^{10}$	
$3·162 \times 10^{-6}$	$1·000 \times 10^{-11}$	110	$3·162 \times 10^5$	$1·000 \times 10^{11}$	
$1·000 \times 10^{-6}$	$1·000 \times 10^{-12}$	120	$1·000 \times 10^6$	$1·000 \times 10^{12}$	
$3·162 \times 10^{-7}$	$1·000 \times 10^{-13}$	130	$3·162 \times 10^6$	$1·000 \times 10^{13}$	
$1·000 \times 10^{-7}$	$1·000 \times 10^{-14}$	140	$1·000 \times 10^7$	$1·000 \times 10^{14}$	