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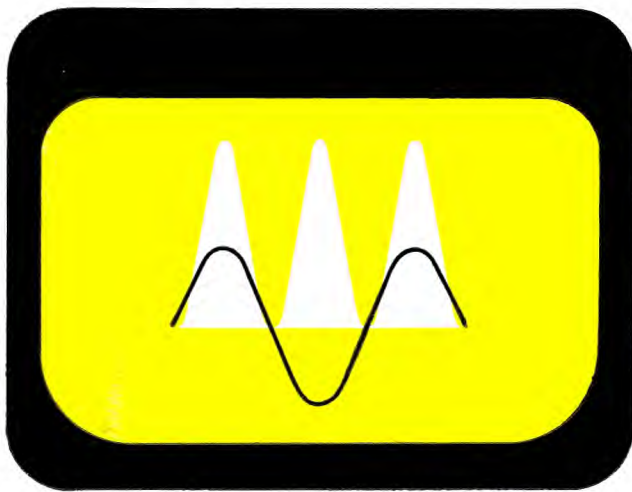
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Colin Hinson

In the village of Blunham, Bedfordshire, UK.



TF 893A

A.F. POWER METER

Operating and Maintenance Handbook

**MARCONI INSTRUMENTS LIMITED
ST. ALBANS HERTFORDSHIRE ENGLAND**

OPERATING AND MAINTENANCE HANDBOOK
No. OM 893A



A. F. Power Meter

TF 893A

MARCONI INSTRUMENTS LTD ST. ALBANS HERTFORDSHIRE ENGLAND

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A.F. POWER METER

Frontispiece

FUNCTIONAL DIAGRAM

Fig. 1.1

CONTROLS AND OPERATING FACILITIES

Fig. 2.1

TEST CIRCUIT—IMPEDANCE

Fig. 3.1

TEST CIRCUIT—POWER

Fig. 3.2

SCHEDULE OF PARTS SUPPLIED*The complete equipment comprises the following items:—*

1. One A.F. Power Meter Type TF 893A.
2. One Operating and Maintenance Handbook No. OM 893A.

DATA SUMMARY

Power Range

20 μ W to 10 watts in five ranges. Full-scale deflections: 1, 10 and 100 mW, 1 and 10 watts.

Impedance Range

2.5 to 20,000 ohms thus:

$\left. \begin{matrix} 2.5 & 3 & 4 & 5 & 6 & 8 \\ 6.25 & 7.5 & 10 & 12.5 & 15 & 20 \end{matrix} \right\}$ with multipliers of $\times 1$, $\times 10$, $\times 100$ and $\times 1000$.

Impedances of one-quarter the above—extending the range down to 0.625 ohm—can be obtained by using the input centre tap, but with reduced accuracy.

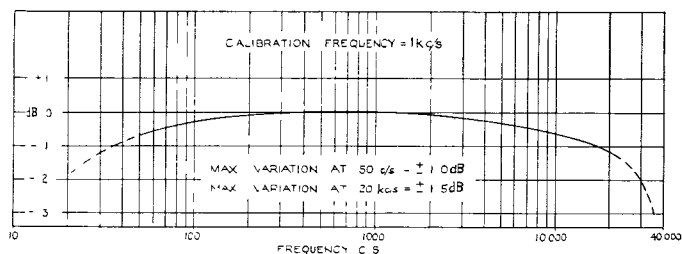
The impedance of the Power Meter falls when it is connected into a circuit carrying d.c.; at 50 c/s, a drop of approximately 5% is produced by 60 mA d.c. at the 100-ohm setting or 4 mA d.c. at the 20-k Ω setting.

Accuracy (at 1 kc/s and 20°C)

POWER: $2\frac{1}{2}\%$ of f.s.d. up to half-scale deflection; 5% of the reading from half-scale to full-scale deflection.

IMPEDANCE: 5%.

Frequency Characteristic



A typical frequency characteristic with all controls at approximately mid-setting. Other control settings will modify the characteristic to within the limits stated.

Dimensions and Weight

Height	Width	Depth	Weight
11 in (28 cm)	7 $\frac{1}{2}$ in (19 cm)	6 $\frac{3}{4}$ in (17 cm)	9 lb (4.1 kg)

I DESCRIPTION

1.1 GENERAL

The Marconi A.F. Power Meter Type TF 893A measures audio-frequency power levels up to 10 watts in five ranges. It can be used for both balanced and unbalanced measurements at any one of 48 input impedances, its meter being direct-reading in both watts and decibels relative to 1 mW.

Power is measured by a temperature-compensated multi-range rectifier voltmeter, the required input impedance being obtained by the use of a tapped transformer and a switched resistance-changing pad.

The instrument is mounted in a portable case and has no conventional chassis, all components being mounted on the sloping front panel which hinges upwards to facilitate servicing. The input terminals are located in the case-top recess; the lid of this recess hinges back to form a support that allows the instrument to be used, if so required, in a sloping position.

1.2 DESIGN DETAILS

The Meter measures the power delivered by an audio-frequency source into a load provided by the instrument itself. The wide power, impedance, and

frequency ranges of the instrument are due primarily to two important features of design. These are (a) the use of switched resistive matching pads for selection of the significant figures of the input impedance value—a patented feature—and (b) decade multiplication of the input impedance value by means of a transformer having a tapped primary winding. This transformer has an English Electric wound-strip C core of anisotropic magnetic alloy.

There are three panel-mounted controls—POWER RANGE, IMPEDANCE SELECTOR, and IMPEDANCE RANGE MULTIPLIER. The power ranges are 0 to 1 mW, 10 mW, 100 mW, 1 watt, and 10 watts; the first calibration is at 20 μ W. A scale of decibels relative to 1 mW is also provided.

The overall impedance range of 2.5 to 20,000 ohms is covered in forty-eight steps arranged in two groups identified by the use of engraving in contrasting colours. The primary winding of the input (impedance-matching) transformer, which is of low d.c. resistance and is isolated from the case, is provided with a centre tap for push-pull working; this centre tap also allows impedances down to 0.625 ohm to be obtained, but with some falling off in performance.

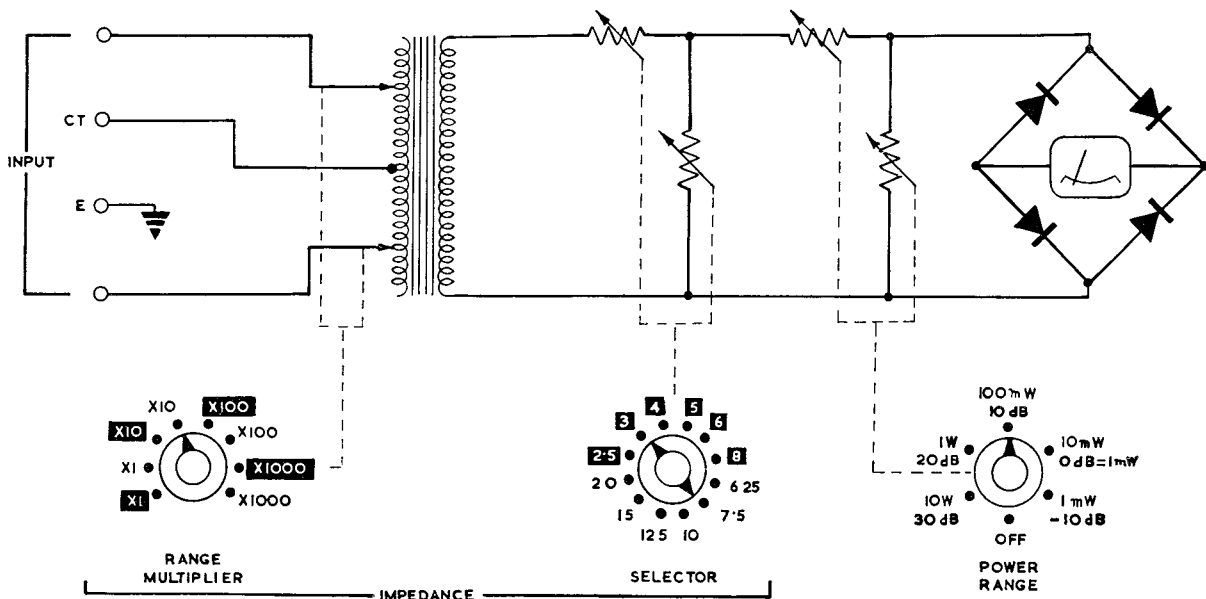


Fig. 1.1 Functional Diagram of TF 893A

2 OPERATION

2.1 CONTROLS

Power Range Control. The black mW figures associated with the POWER RANGE control refer to the full-scale deflection of the bottom meter scale at each setting except 1 mW. A separate scale is provided for the latter.

The alternative figures, in red, indicate the decibels above 1 mW when the meter is reading 0 on its red scale. For any other meter reading the decibel indication on the meter should be added to the decibels indicated by the switch.

At the 1 mW switch setting, the red -10 dB marking indicates decibels below 1 mW when the meter is reading 0 on its red scale. For any other meter reading at this switch setting, the decibel indication should be subtracted from 10 dB, the result obtained also being in terms of decibels below 1 mW.

Impedance Controls. Each of the six positions of the IMPEDANCE SELECTOR has two engraved values—a yellow figure above and a black figure below the control. The IMPEDANCE RANGE MULTIPLIER has alternate positions marked in black and yellow, every multiplication value being repeated in each colour.

This system is adopted in order to avoid awkward multiplying factors; the impedance at any setting is given by multiplying together the IMPEDANCE RANGE MULTIPLIER setting and the similarly-coloured figure at the setting of the IMPEDANCE SELECTOR control. For example, to set the Power Meter to 600 ohms, the IMPEDANCE SELECTOR should be set to 6/15 and the IMPEDANCE RANGE MULTIPLIER to $\times 100$ -yellow. For an input impedance of 1,500 ohms, the IMPEDANCE SELECTOR should have the same setting—i.e. 6/15—but the IMPEDANCE RANGE MULTIPLIER should be set to $\times 100$ -black.

2.2 MEASUREMENT PROCEDURE

Note: Before making connection to the instrument, set the POWER RANGE switch to OFF in order to avoid possible damage to the meter.

Unbalanced Measurements

For normal unbalanced output measurements:—

- (1) Connect the audio source under test to the INPUT terminals; these are located underneath the hinged lid on top of the instrument.
- (2) Set the IMPEDANCE controls to give the required load impedance.
- (3) Adjust the POWER RANGE switch to give a convenient meter deflection and read the power indicated directly on the meter.

Balanced Measurements

To carry out measurements on balanced outputs, connect the centre tap of the output to the CT terminal on the A.F. Power Meter. The measurement may then be carried out as for unbalanced outputs.

Measurement at Low Impedance

To obtain impedances of one-quarter the value indicated at any setting of the IMPEDANCE controls, the power source should be connected between the CT terminal and either of the INPUT terminals. Loss of accuracy inevitably arises from this procedure as the input transformer is being operated in an out-of-balance condition. Some degree of improvement may be obtained by making two measurements—applying the power between the CT terminal and each of the INPUT terminals in turn—and taking the average.

Measurement of Source Impedance

To measure the internal impedance of a tone source, connect as for a normal power measurement and adjust the two IMPEDANCE controls for maximum indication. The impedance of the source is then approximately the same as that indicated by the settings of the IMPEDANCE controls.

2.3 VARIATION OF IMPEDANCE WITH D.C. CURRENT

The TF 893A is designed to measure a simple a.f. power and not a complex power which includes a d.c. component as well as the a.f. component under investigation. The effect of any d.c. component is to polarize the core of the transformer and reduce the effective input impedance of the Power Meter.

It is therefore recommended that the Power Meter should not be used where it is desired to simulate

a high-impedance, unbalanced load if the d.c. component exceeds 5 to 10 mA. Such a case occurs when it is desired to use the A.F. Power Meter in place of the output transformer of a single-ended

output stage. The Power Meter can, however, be used for such a measurement on a push-pull stage; in this case, the only d.c. current that need be considered is the out-of-balance current.

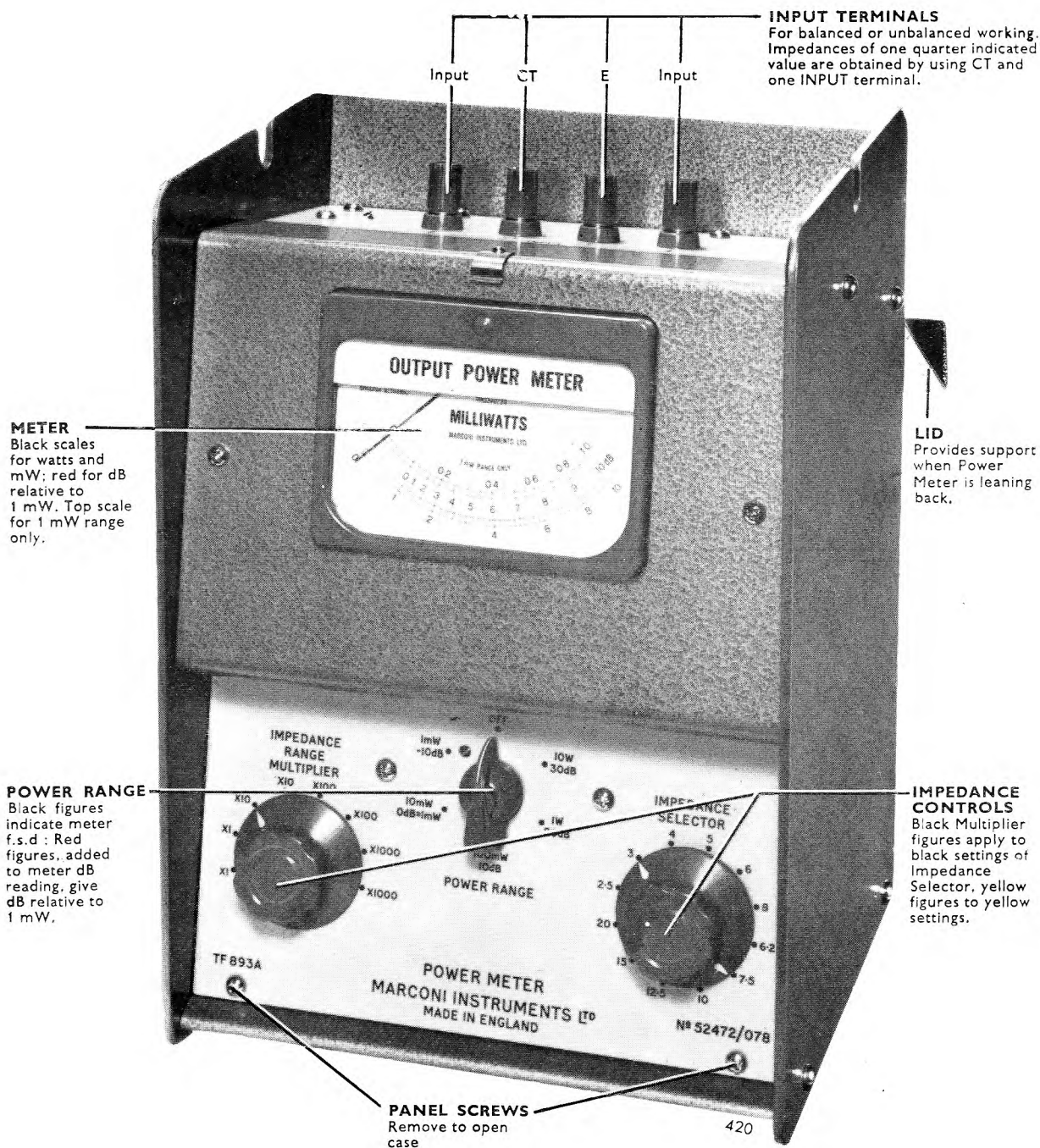


Fig. 2.1 Controls and Operating Facilities

3 MAINTENANCE

3.1 GENERAL

Before commencing the adjustment or replacement of component parts of the instrument, it is recommended that the user should study the design details given in Section 1, DESCRIPTION, and illustrated in the Functional Diagram.

The complete Circuit Diagram shows all the electrical components contained in the instrument. The description of these components—their type, value, rating, etc.—is given in the Spares Ordering Schedule; this Schedule also lists certain selected mechanical components.

The physical location of the electrical components is shown in the Component Layout Illustrations.

3.2 ACCESS TO COMPONENTS

To gain access to the interior of the instrument, simply remove the two 4-BA screws at the bottom corner of the front panel, and swing the panel upwards. To avoid possible damage to the paintwork, first slacken all the screws in both side-panels.

The input transformer is attached to the panel by means of four nuts and bolts. Two of these bolts are covered by the meter surround which may be removed by withdrawing the round-head screw on either side of the meter face.

Caution: *The meter is held in position only by this surround; great care should therefore be taken to ensure that the meter does not fall out when the surround is released.*

To remove the meter, first unsolder the leads to the meter tags and then detach the metal surround, as described above.

The majority of the components are fitted to tag panels mounted on the transformer. Exceptions are the power-determining resistors (R27 to R36) mounted on small annotated side panels; resistor R37 and capacitor C1, wired direct to the meter terminals; and the actual indicating circuit components which are contained inside the panel meter.

All connections have been made in heavy-gauge wire with insulated sleeving of distinguishing colours to facilitate tracing of the circuit.

3.3 SPECIALLY SELECTED COMPONENTS

During factory calibration, certain of the performance characteristics of the Power Meter are

brought within close limits by means of specially selected components.

Following replacement or aging of components in certain parts of the circuit, it is essential, if the performance is not to be impaired, to repeat the calibration procedure by which the selected components were chosen.

The section dealing with the procedure appropriate to each selected component is indicated in TABLE 1. The procedure referred to should also be carried out in the event of replacement of any of these components.

TABLE 1

Component	Section Describing Selection
C1	3.4.7
R1	3.4.4
R2	3.4.4
R3	3.4.4
R4	3.4.4
R5	3.4.4
R6	3.4.4
R7	3.4.4
R8	3.4.4
R9	3.4.4
R26	3.4.5
R37	3.4.8

3.4 SCHEDULE OF TESTS

3.4.1 Introduction

The following sections give a range of tests by which the main points of performance of the instrument can be checked; they are based on abstracts from the internal Factory Test Schedule.

The tests can be divided into two main categories, (a) those for measuring the input impedance of the Power Meter, and (b) those for measuring the overall power-reading accuracy.

(a) During the factory calibration of the instrument, the impedance is measured by means of an a.c. bridge as shown in Fig. 3.1. As the total reactance referred to the primary of the transformer is negligible compared with the total referred

resistance, for all settings of the IMPEDANCE controls, the impedance becomes:

$$Z = R_A \frac{R_C}{R_B}$$

C_B is simply used as a phase balance to correct for the small amount of reactive component that will

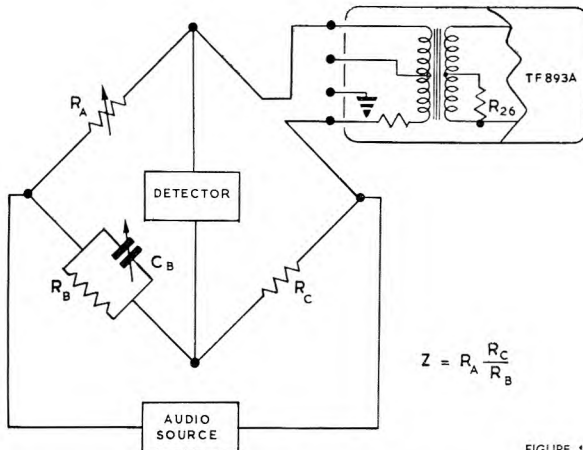


FIGURE 1

Fig. 3.1 Test Circuit—Impedance

obviously be present. Thus it can be seen that, if $R_C = R_B$, then R_A is the value of the input impedance. These conditions are assumed throughout, although in practice it will probably be found convenient to alter the ratio $R_C : R_B$ to obtain greater sensitivity at the extremes of the range.

(b) The circuit for obtaining the power reading accuracy is shown in Fig. 3.2. The value of R_E is made equal to the nominal impedance indicated by any particular setting of the IMPEDANCE controls. If the voltage (V) applied to the resultant network

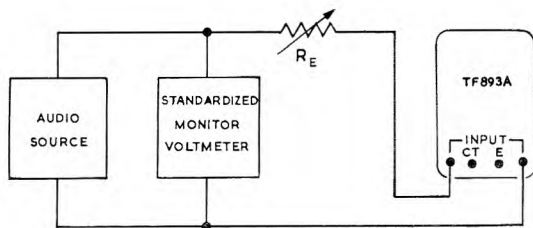


FIGURE 2

Fig. 3.2 Test Circuit—Power

is known, the power dissipated in the load presented by the Power Meter alone is given by:

$$P = \frac{V^2}{4R_E}$$

3.4.2 Apparatus Required

- Insulation Tester, 500 volt.
- Wheatstone Bridge.
- Variable Resistor, 30 kΩ.
- Detector, for bridge circuit.
- Decade Capacitor, 0 to 0.2 μF (C_B).
- Two Standardized Resistance Boxes (R_B and R_C).
- Standardized Decade Resistance Box (R_A , and also R_E).
- Audio Oscillator, 40-volt. output minimum; Marconi Types TF 195 (Series) or TF 894 (Series).
- Standardized Monitor Voltmeter, 0 to 40 volts; Marconi Types TF 899 (Series), TF 1041 (Series), etc.

For circuit references see Figs. 3.1 and 3.2

3.4.3 Insulation (Apparatus required: Item a)

Connect the insulation tester between either of the INPUT terminals and the E terminal and measure the insulation resistance. About 50 MΩ or greater can be expected.

3.4.4 Transformer D.C. Resistance

(Apparatus required: Item b)

Connect the test terminals of the Wheatstone Bridge to the INPUT terminals of the Power Meter. The total d.c. resistance of the portion of the primary winding in use and the associated padding resistor for any particular setting of the IMPEDANCE RANGE MULTIPLIER is given in TABLE 2.

If the measured resistance is in error, reselect the associated pad resistors to bring the resistance within the limits quoted.

Secondary

Before measuring the secondary resistance, disconnect one end of R26, set the IMPEDANCE SELECTOR to 8/20, and the POWER RANGE switch to OFF.

Measure the resistance between the junction of R9/R10 and tag 20 of the transformer; select a pad resistor (R_9) so that the total resistance of the secondary winding and R_9 is 790 ohms $\pm 5\%$ at 20°C ambient temperature. Finally, reconnect R26.

TABLE 2

IMPEDANCE RANGE MULTIPLIER setting	Total Resistance of Wdg. + Pad Resistor ($\pm 5\%$)	Pad Resistor Circuit Ref.
$\times 1$ (Yellow)	0.48 ohm	R8*
$\times 1$ (Black)	1.2 ohms	R7
$\times 10$ (Yellow)	4.8 ohms	R6
$\times 10$ (Black)	12.0 ohms	R5
$\times 100$ (Yellow)	48.0 ohms	R4
$\times 100$ (Black)	120.0 ohms	R3
$\times 1000$ (Yellow)	480 ohms	R2
$\times 1000$ (Black)	1200 ohms	R1

*Resistor R8 is not normally required.

3.4.5. Iron-Loss Balance Resistor

(Apparatus required: Items c to h)

- (1) Connect the A.F. Power Meter to the test circuit shown in Fig. 3.1—see also Section 3.4.1 (a).
- (2) Remove resistor R26 and in its place connect the 30-k Ω variable resistor—let this resistor be R_D .
- (3) Set the IMPEDANCE controls to 1,000 Ω and the POWER RANGE switch to 10 W.
- (4) With the bridge components set so that $(R_A R_C)/R_B = 1,000\Omega$, adjust C_B and R_D for balance at 1 kc/s. Measure the value of R_D required to produce balance and, if necessary, select R26 to equal this value.

3.4.6 Input Impedance Accuracy

(Apparatus required: Items d to h)

- (1) Connect the A.F. Power Meter to the test circuit shown in Fig. 3.1—see also Section 3.4.1 (a).
- (2) With the POWER RANGE switch set to 10 W, measure the input impedance at 1 kc/s with Power Meter settings (in ohms) of:

6.25	100	500	2,500
8	250	600	8,000
20	300	800	10,000
40	400	1,000	20,000

In all cases, the actual impedance should be within $\pm 5\%$ of the nominal value.

The above test does not include all possible combinations of the two IMPEDANCE controls, but it is

sufficient to ensure that all steps are functioning correctly and that the actual impedance at every setting is within limits.

3.4.7 Frequency Characteristic

(Apparatus required: Items g, h, and i)

- (1) Connect the A.F. Power Meter to the test circuit shown in Fig. 3.2—see also Section 3.4.1 (b).
 - (2) Set the IMPEDANCE controls and R_E to 1,000 Ω . Apply a voltage sufficient to produce a power reading of, say, 400 mW (in this case the voltage required is 40 V r.m.s.).
 - (3) Vary the frequency over the range 50 c/s to 20 kc/s and check the response; typical figures, with respect to 1 kc/s, are within -0.5 dB from 50 c/s to 10 kc/s and within -1 dB from 10 to 20 kc/s. (See graph under DATA SUMMARY, p. 4.)
- If the high-frequency characteristic is in error, it may be corrected by choosing a new value for C1.

3.4.8 Meter Scale Shape

(Apparatus required: Items g, h, and i)

Before checking the scale shape, it is advisable to adjust for optimum accuracy at 400 mW in the following manner:—

- (1) Connect the A.F. Power Meter to the circuit shown in Fig. 3.2—see also Section 3.4.1 (b).
- (2) Set the IMPEDANCE controls and R_E to 1,000 ohms.

(3) With the frequency at 1,000 c/s, apply 40 V r.m.s. to the R_E/TF 893A network and check that the meter indication is $400 \text{ mW} \pm 5 \text{ mW}$. The accuracy of indication may be adjusted by shunting meter terminals 1 and 2 (or 2 and 3) with a suitable resistor (R37).

(4) With the POWER RANGE switch set to the 100-mW range, vary the applied voltage in accordance with TABLE 3 and check that the Power Meter indication is within the limits quoted.

TABLE 3

<i>Applied Voltage (r.m.s.)</i>	<i>A.F. Power Meter Reading (mW)</i>
6.32	9.5 to 10.5
8.94	17.5 to 22.5
12.6	38 to 42
15.5	57 to 63
17.9	76 to 84
20	95 to 105

TABLE 4

<i>IMPEDANCE Setting</i>	<i>Applied Voltage</i>	<i>A.F. Power Meter Reading</i>
2.5 Ω	2 V	380 to 420 mW
6.25 Ω	2 V	135 to 185 mW
30 Ω	2 V	30.5 to 35.5 mW
100 Ω	20 V	0.95 to 1.05 W
500 Ω	20 V	175 to 225 mW
1500 Ω	20 V	63.3 to 69.9 mW
8000 Ω	16 V	7.6 to 8.4 mW
20000 Ω	8 V	0.76 to 0.84 mW

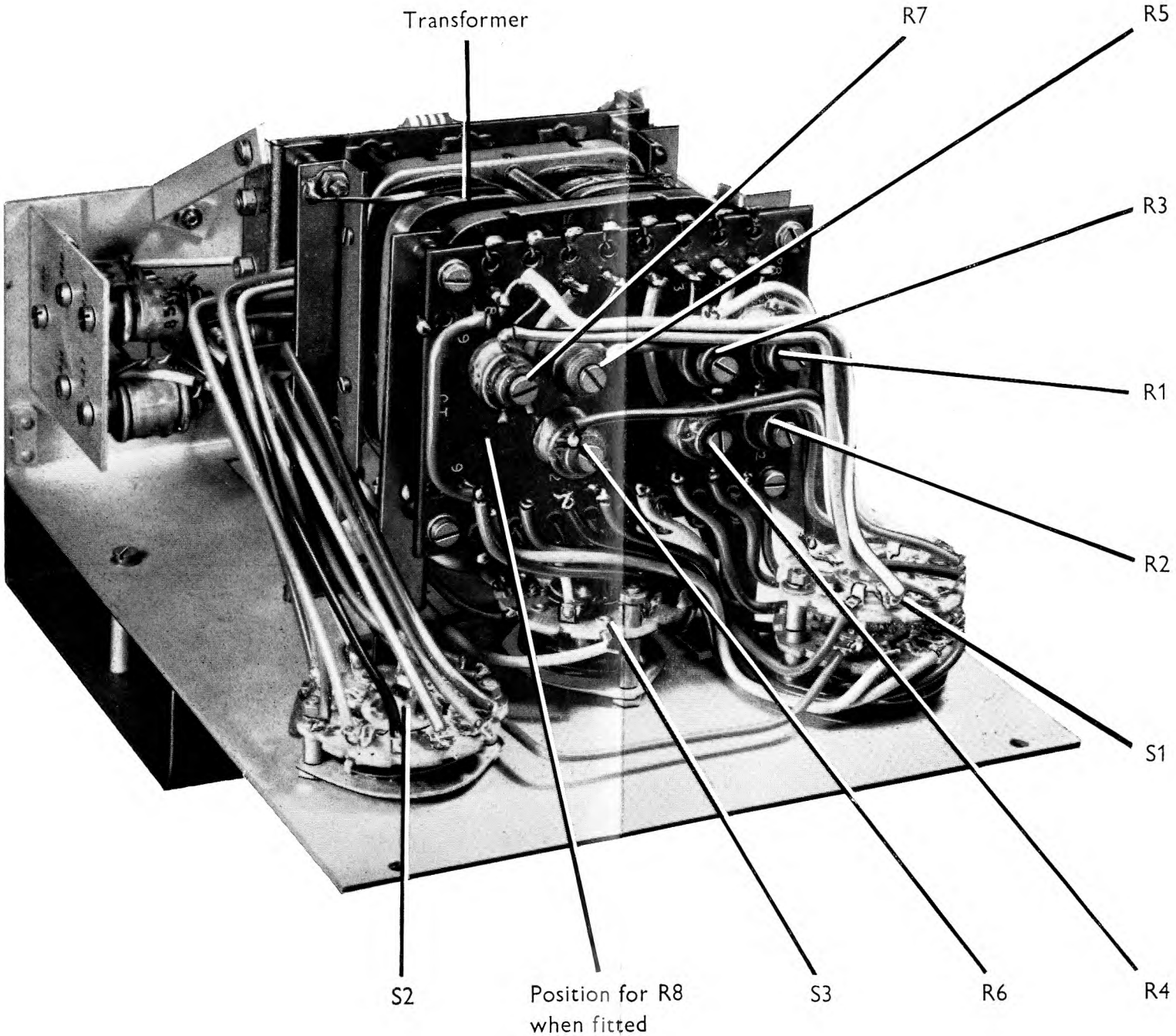
3.4.9 Overall Measurement Accuracy

(Apparatus required: Items g, h, and i)

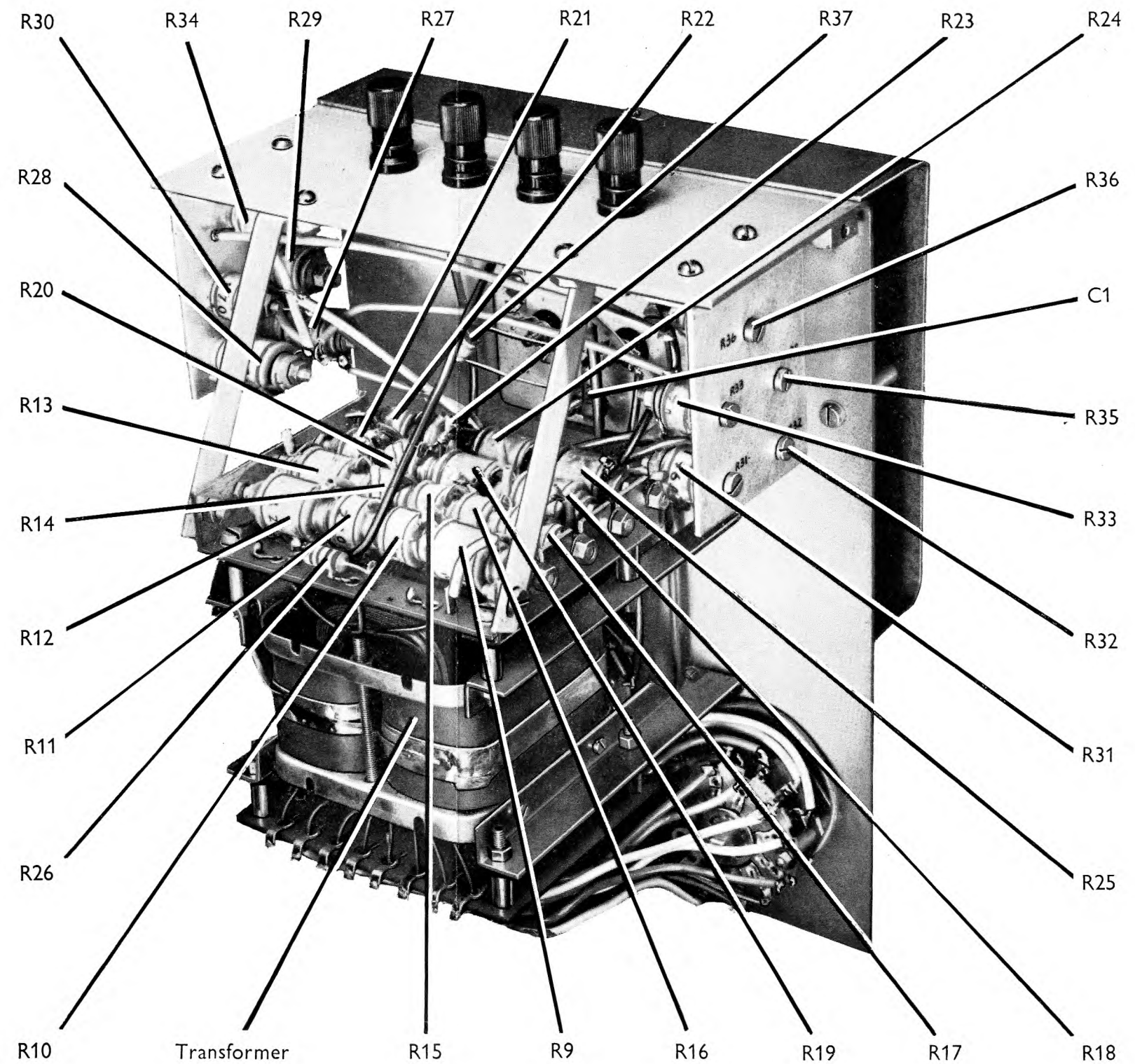
(1) Connect the A.F. Power Meter to the test circuit shown in Fig. 3.2—see also Section 3.4.1 (b).

(2) For various settings of the IMPEDANCE controls, check the accuracy of the power readings produced by applying 1-kc/s voltages as indicated in TABLE 4. The stated limits are only valid, strictly, at an ambient temperature of 20°C. At other temperatures some slight discrepancies may be found.

Section 4 COMPONENT LAYOUT ILLUSTRATIONS



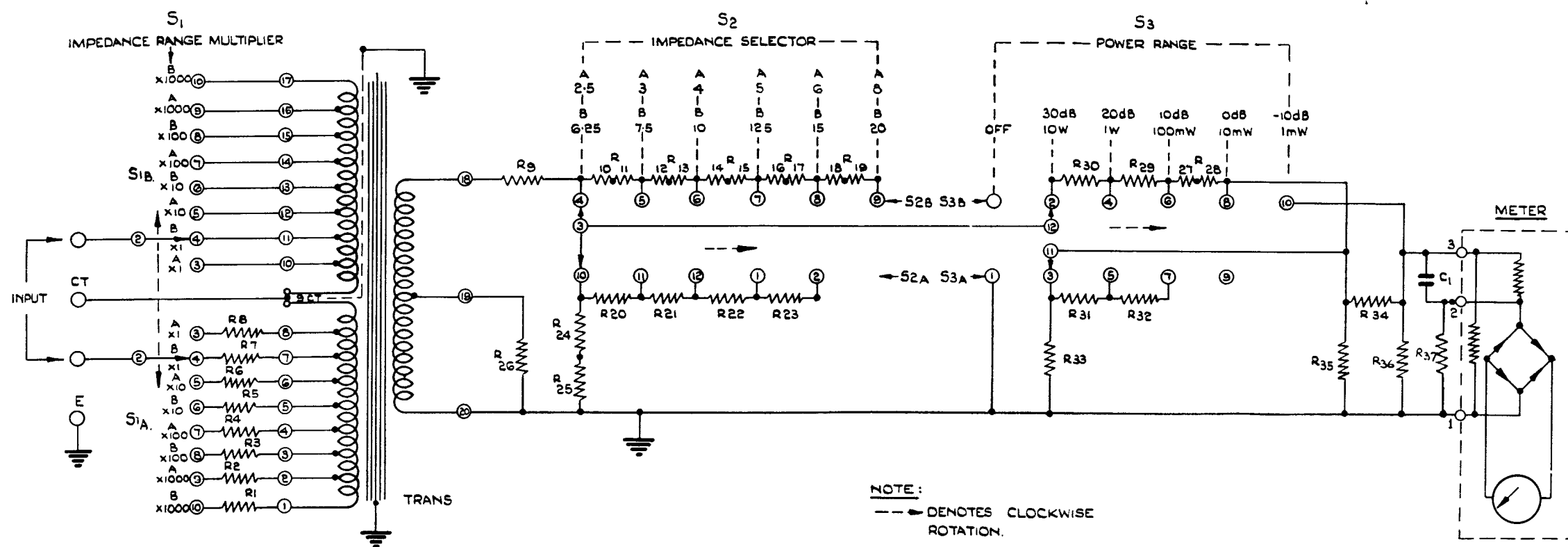
INT. IOR
FROM ELOW



INTERIOR
FROM ABOVE

<i>SOS Item No.</i>	<i>Circuit Ref.</i>	<i>Description</i>	<i>Works Ref.</i>
32	R32	Wirewound, $878\Omega \pm 0.1\%$.	58-TF893A
33	R33	Wirewound, $81.7\Omega \pm 0.1\%$.	59-TF893A
34	R34	Wirewound, $7120\Omega \pm 0.1\%$.	60-TF893A
35	R35	Wirewound, $3290\Omega \pm 0.1\%$.	61-TF893A
36	R36	Wirewound, $6200\Omega \pm 0.1\%$.	62-TF893A
37	R37	Composition; value determined during calibration (Section 3.4.8); $\frac{1}{2}W$.	53-TF893A
CAPACITOR			
38	C1	Paper, nominally 0.002 μF , 200 V d.c. (see Section 3.4.7).	66-TF893A
TRANSFORMER			
39	T1	Impedance-Matching Transformer; includes Items 1 to 8.	TM4218/1
METER			
40	M1	Meter Assembly; 50 μA f.s.d.; includes meter rectifier and temperature-compensating resistors.	TM3970/23
SWITCHES			
41	S1	IMPEDANCE RANGE MULTIPLIER; 2 pole, 8 way.	TC4428/310
42	S2	IMPEDANCE SELECTOR; 1 pole, 6 way.	TC4428/311
43	S3	POWER RANGE; 1 pole, 6 way.	TC4428/494
MECHANICAL COMPONENTS			
44		Knob, skirted, for Item 41.	TB17848 3
45		Knob, skirted, for Item 42.	TB17848/5
46		Knob, pointer, for Item 43.	TB25460/2
47		Terminal, for INPUT connection (two required).	34-TF893A
48		Terminal, for CT connection.	34-TF893A
49		Terminal, for EARTH connection.	35-TF893A
50		Meter Panel; Aluminium alloy.	TC27949/1
51		Front Panel; Aluminium alloy.	TE28521
52		Case Back; Aluminium alloy.	TE27943
53		Case Lid; Aluminium alloy.	TC27947
54		Lid Clip; Beryllium Copper.	TB27960
55		Side Panel (left or right), Aluminium alloy.	TC27948
MISCELLANEOUS			
56		Set of two Hexagonal Wrenches for socket set-screws; 2 and 4 BA; in linen bag.	TC21793/3
57		Operating and Maintenance Handbook	OM 893A

Section 6 CIRCUIT DIAGRAM



CIRCUIT DIAGRAM

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

<i>Ratio Down</i>			<i>Ratio Up</i>	
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	·006310	22	12·59	158·5
·06310	·003981	24	15·85	251·2
·05012	·002512	26	19·95	398·1
·03981	·001585	28	25·12	631·0
·03162	·001000	30	31·62	1,000
·02512	·0006310	32	39·81	1,585
·01995	·0003981	34	50·12	2,512
·01585	·0002512	36	63·10	3,981
·01259	·0001585	38	79·43	6,310
·01000	·0001000	40	100·00	10,000
·007943	·00006310	42	125·9	15,850
·006310	·00003981	44	158·5	25,120
·005012	·00002512	46	199·5	39,810
·003981	·00001585	48	251·2	63,100
·003162	·00001000	50	316·2	100,000
·002512	$6·310 \times 10^{-6}$	52	398·1	158,500
·001995	$3·981 \times 10^{-6}$	54	501·2	251,200
·001585	$2·512 \times 10^{-6}$	56	631·0	398,100
·001259	$1·585 \times 10^{-6}$	58	794·3	631,000
·001000	10^{-6}	60	1,000	10^6
·0005623	$3·162 \times 10^{-7}$	65	1,778	$3·162 \times 10^6$
·0003162	10^{-7}	70	3,162	10^7
·0001778	$3·162 \times 10^{-8}$	75	5,623	$3·162 \times 10^7$
·0001000	10^{-8}	80	10,000	10^8
·00005623	$3·162 \times 10^{-9}$	85	17,780	$3·162 \times 10^8$
·00003162	10^{-9}	90	31,620	10^9
·00001000	10^{-10}	100	100,000	10^{10}
$3·162 \times 10^{-6}$	10^{-11}	110	316,200	10^{11}
10^{-6}	10^{-12}	120	10^6	10^{12}
$3·162 \times 10^{-7}$	10^{-13}	130	$3·162 \times 10^6$	10^{13}
10^{-7}	10^{-14}	140	10^7	10^{14}

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