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POWER SUPPLIES
(ADVANCE TYPE PM44-56)

BY COMMAND OF THE DEFENCE COUNCIL

(Ministry of Defence)

High Reliability Power Supplies PM44–56

Instruction Manual

ADVANCE
INDUSTRIAL
ELECTRONICS

Raynham Road Bishops Stortford Herts

Telephone 0279–55155

Telex 81510

Division of ADVANCE ELECTRONICS LIMITED

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This new range of Modular Power supplies, PM44-56, marks a radical departure from accepted attitudes in commercial power supply design.

The range provides pre-set output voltages in the range 0-50V in current ratings of 1, 3, 5, 10A and 20A with very extensive facilities and a high degree of reliability.

Facilities available include the selection of various output characteristics, such as constant current operation, by means of internal links, external programming and optional built in SCR overvoltage protection.

Particular emphasis has been placed on a high specification, rugged mechanical construction and long-life components. As a result of this attention it is possible to quote estimated MTBF figures for each individual unit.

- 10,000:1 Stability
- Re-entrant protection with constant current optional
- Programmeable on Voltage and Current
- MTBF estimated not less than 25,000 hours

Low Voltage Units for Integrated Circuits.
The range of Modular Power Supplies PM16-20 consists of units having a fully variable output of 0 to 7V with a chòice of current ratings from 1 to 20A. They have been specifically designed to meet the requirements of Integrated Circuit Technology with particular reference to very high reliability, and incorporate a new protection circuit to safeguard both the power supply and the load. This range offers the Integrated Circuit user a power supply to satisfy most applications.

INPUT VOLTAGE
100, 105, 110, 115, 120, 125, 200, 220, 230, 240, 250V $\pm$10% 48–450Hz

LINE REGULATION
Less than $\pm$(0.001% + 30μV) for $\pm$10% AC line variation at any specified tap.

LOAD REGULATION
Less than (0.02% +1mV) for a no load to full load swing

RIPPLE
Less than 400μV pk-pk,(typically 250μ pk-pk)

TEMPERATURE CO-EFFICIENT
Less than (0.015% + 200μV) per ^{o}C

OUTPUT IMPEDANCE
Less than 0.25Ω at 100kHz. Typically less than 0.1Ω at 100kHz.

RECOVERY TIME
For a full load step change the output voltage will recover in approximately 20μ seconds to within 10mV of regulation Band.

OVERLOAD PROTECTION
Re-entrant overload protection which is variable from 15% to 105% at full load current by a potentiometer on the front panel. At switch-on the protection may be set to operate at constant current for a period of 200m seconds after which it reverts to re-entrant operation. This facility is optional and may be selected by an internal link but is not available below 4 volts output.

OVERVOLTAGE PROTECTION
Optional
Overvoltage protection is by means of a high speed SCR crowbar with fuse. The trip voltage may be varied by potentiometer or programming resistors. This facility is an optional extra which can be built into the unit if required.

TEMPERATURE RANGE
-10^{o} to +60^{o}C

INSULATION
Floating output must not exceed ±250V DC from ground. Input tested 500V DC live to ground, and live to output greater than 10M ohms.

CONSTANT CURRENT OPERATION
Optional
All units can be operated in the constant current mode at reduced ratings. Further details can be found on Graph 2 Section 3 and Tables 5 to 7.

PROGRAMMING
External programming of both voltage and current by means of external resistors, is possible and is restricted to operation within the re-entrant characteristic, or within the constant current restrictions if operating in this mode. Further details of this form of operation can be found in Section 3.

PROGRAMMING RESISTANCES

VOLTAGE MODE 100Ω/volt ±$\frac{1}{4}$%
CURRENT MODE 100Ω/100% of output current ±3% for re-entrant current mode
1050Ω/100% of output current ±3% for constant current mode

OUTPUT VOLTAGES AND CURRENTS

Output Voltage	Output Current				
	1A	3A	5A	10A	20A
0-15V	PM44	PM47	PM50	PM53	PM56
0-30V	PM45	PM48	PM51	PM54	-
30-50V	PM46	PM49	PM52	PM55	-

Output Voltages factory pre-set in 1V increments and variable by ±0.5V min by a potentiometer on the front panel.

FACTORY FITTED OPTIONS
Extra
SUFFIX 'X' Alternative PC board assembly to give (0.005% +50μV)/°C temperature Co-efficient fitted instead

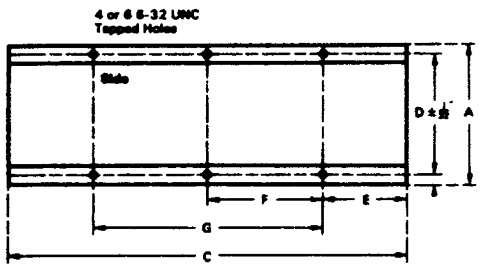
of standard (.015% + 200μV)/^{o}C temperature co-efficient.

SUFFIX 'Y' The Power Unit will be set to operate in constant current mode at the ratings in Tables 5, 6 and 7 instead of standard re-entrant mode.

SUFFIX 'Z' An SCR overvoltage protection circuit will be fitted within the Power Unit normally set to 10% or 1 volt (whichever is greater) above the nominal output voltage.

3.1 INSTALLATION

Dimension Diagram A



Dimension Diagram B

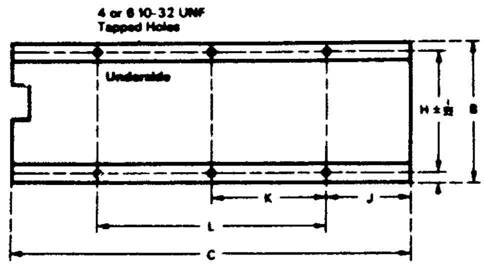


Fig. 2 Dimension Diagrams

Table 1 Fixing Centre Data, Dimensions, Weights and Dissipations

Overall Dimensions and Weights								
Type	Height A		Width B		Length C		Weight	
	in	cm	in	cm	in	cm	lb	kg
PM44	$5\frac{1}{8}$	13.0	$3\frac{9}{32}$	8.3	$5\frac{1}{8}$	13.0	4	1.8
PM45	$5\frac{1}{8}$	13.0	$4\frac{41}{64}$	11.8	$5\frac{1}{8}$	13.0	6	2.7
PM46	$5\frac{1}{8}$	13.0	$3\frac{9}{32}$	8.3	$9\frac{1}{4}$	23.5	8	3.6
PM47	$5\frac{1}{8}$	13.0	$3\frac{9}{32}$	8.3	$9\frac{1}{4}$	23.5	8	3.6
PM48	$5\frac{1}{8}$	13.0	$4\frac{41}{64}$	11.8	$9\frac{1}{4}$	23.5	11	5.0
PM49	$5\frac{1}{8}$	13.0	$7\frac{3}{8}$	18.7	$9\frac{1}{4}$	23.5	15	6.8
PM50	$5\frac{1}{8}$	13.0	$4\frac{5}{8}$	11.8	$9\frac{1}{4}$	23.5	11	5.0
PM51	$5\frac{1}{8}$	13.0	$7\frac{3}{8}$	18.7	$9\frac{1}{4}$	23.5	17	7.7
PM52	$5\frac{1}{8}$	13.0	$4\frac{5}{8}$	11.8	$15\frac{1}{16}$	38.2	21	9.5
PM53	$5\frac{1}{8}$	13.0	$7\frac{3}{8}$	18.7	$9\frac{1}{4}$	23.5	17	7.7
PM54	$5\frac{1}{8}$	13.0	$7\frac{3}{8}$	18.7	$15\frac{1}{16}$	38.2	35	15.9
PM55	$5\frac{1}{8}$	13.0	$9\frac{1}{8}$	23.2	$15\frac{1}{16}$	38.2	44	20.0
PM56	$5\frac{1}{8}$	13.0	$9\frac{1}{8}$	23.2	$15\frac{1}{16}$	38.2	44	20.0

Table 1 Fixing Centre Data, Dimensions, Weights & Dissipations (Cont)

Fixing Centres

Type	D in	D cm	E in	E cm	F in	F cm	G in	G cm
PM44	$4\frac{3}{4}$	12.07	1	2.54	-	-	$3\frac{1}{8}$	7.94
PM45	$4\frac{3}{4}$	12.07	1	2.54	-	-	$3\frac{1}{8}$	7.94
PM46	$4\frac{3}{4}$	12.07	1	2.54	-	-	$7\frac{1}{4}$	18.42
PM47	$4\frac{3}{4}$	12.07	1	2.54	-	-	$7\frac{1}{4}$	18.42
PM48	$4\frac{3}{4}$	12.07	1	2.54	-	-	$7\frac{1}{4}$	18.42
PM49	$4\frac{3}{4}$	12.07	1	2.54	-	-	$7\frac{1}{4}$	18.42
PM50	$4\frac{3}{4}$	12.07	1	2.54	-	-	$7\frac{1}{4}$	18.42
PM51	$4\frac{3}{4}$	12.07	1	2.54	-	-	$7\frac{1}{4}$	18.42
PM52	$4\frac{3}{4}$	12.07	$2\frac{1}{16}$	5.24	$5\frac{15}{32}$	13.89	$10\frac{15}{16}$	27.78
PM53	$4\frac{3}{4}$	12.07	1	2.54	-	-	$7\frac{1}{4}$	18.42
PM54	$4\frac{3}{4}$	12.07	$2\frac{1}{16}$	5.24	$5\frac{15}{32}$	13.89	$10\frac{15}{16}$	27.78
PM55	$4\frac{3}{4}$	12.07	$2\frac{1}{16}$	5.24	$5\frac{15}{32}$	13.89	$10\frac{15}{16}$	27.78
PM56	$4\frac{3}{4}$	12.07	$2\frac{1}{16}$	5.24	$5\frac{15}{32}$	13.89	$10\frac{15}{16}$	27.78

Type	H in	H cm	J in	J cm	K in	K cm	L in	L cm
PM44	$2\frac{29}{32}$	7.39	$1\frac{1}{2}$	3.81	-	-	$2\frac{1}{8}$	5.40
PM45	$4\frac{17}{64}$	10.85	$1\frac{1}{2}$	3.81	-	-	$2\frac{1}{8}$	5.40
PM46	$2\frac{29}{32}$	7.39	2	5.08	-	-	$5\frac{1}{4}$	13.3
PM47	$2\frac{29}{32}$	7.39	2	5.08	-	-	$5\frac{1}{4}$	13.3
PM48	$4\frac{17}{64}$	10.85	2	5.08	-	-	$5\frac{1}{4}$	13.3
PM49	7	17.78	2	5.08	-	-	$5\frac{1}{4}$	13.3
PM50	$4\frac{17}{64}$	10.85	2	5.08	-	-	$5\frac{1}{4}$	13.3
PM51	7	17.78	2	5.08	-	-	$5\frac{1}{4}$	13.3
PM52	$4\frac{17}{64}$	10.85	3	7.62	$5\frac{1}{16}$	12.86	$9\frac{1}{16}$	23.02
PM53	7	17.78	2	5.08	-	-	$5\frac{1}{4}$	13.3
PM54	7	17.78	3	7.62	$5\frac{1}{16}$	12.86	$9\frac{1}{16}$	23.02
PM55	$8\frac{3}{4}$	22.23	3	7.62	$5\frac{1}{16}$	12.86	$9\frac{1}{16}$	23.02
PM56	$8\frac{3}{4}$	22.23	3	7.62	$5\frac{1}{16}$	12.86	$9\frac{1}{16}$	23.02

Power Dissipations at Maximum Input Voltage

Unit	Max Full Load	Max Overload	Unit	Max Full Load	Max Overload
PM44	12W	13W	PM50	50W	60W
PM45	15W	20W	PM51	65W	105W
PM46	20W	33W	PM52	90W	155W
PM47	30W	35W	PM53	95W	130W
PM48	45W	60W	PM54	130W	200W
PM49	60W	95W	PM55	180W	310W
			PM56	190W	260W

3.2 AC SUPPLY

Verify that the connections to the primary of supply transformer T1 corresponds to the voltage of the local supply, and that the supply fuse FS1 is correct for the unit in use (see Table 4)

The primary connections of T1 should be paralleled when the local supply is 100 to 125V. Fig. 3 shows the connections for a 110V supply, and Table 2 gives the connections for supplies between 100 and 125V.

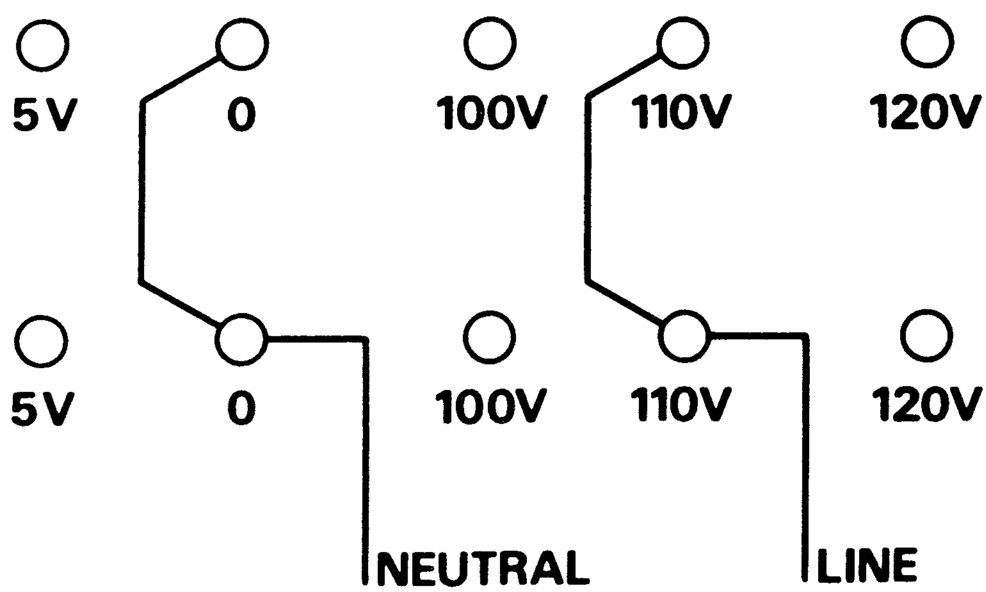


Fig. 3 Transformer Primary Connections for 110V

Table 2 Transformer Primary Connections 100-125V

Supply	Neutral	Line	Neutral Link Between	Line Link Between
100V	0	100	0-0	100-100
105V	5	100	5-5	100-100
110V	0	110	0-0	110-110
115V	5	110	5-5	110-110
120V	0	120	0-0	120-120
125V	5	120	5-5	120-120

When a 200 to 250V supply is available, the primary connections of T1 should be made in series. Fig. 4 shows the series connections to be made for a 240V supply, and Table 3 gives the connections for supplies between 200 and 250V.

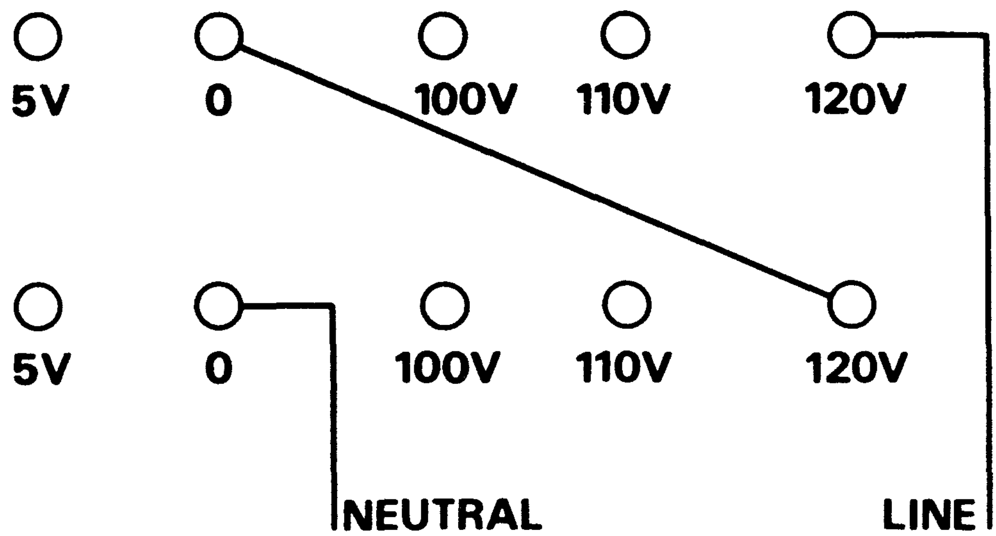


Fig. 4 Transformer Primary Connections for 240V

Table 3 Transformer Primary Connections 200-250V

Supply	Neutral to Inner Tag	Line to Outer Tag	Diagonal Link Between
200	0	100	0-100
210	5	100	5-100
220	0	110	0-110
230	5	110	5-110
240	0	120	0-120
250	5	120	5-120

Table 4 Fuse Rating (fuses up to 10A must be HRC type)

Power Supply	FS1 200-250V		FS1 100-125V		FS2 DC Fuse	
	Rating	Size	Rating	Size	Rating	Size
PM44	1A	00	2.5A	00	2.5A	00
PM45	2.5A	00	4A	00	2.5A	00
PM46	2.5A	00	4A	00	2.5A	00
PM47	2.5A	00	4A	00	4A	00
PM48	3A	0	7A	0	5A	0
PM49	5A	0	10A	0	7A	0
PM50	3A	0	7A	0	7A	0
PM51	5A	0	10A	0	7A	0
PM52	7A	0	15A	0	7A	0
PM53	5A	0	10A	0	12A	0
PM54	7A	0	15A	0	12A	0
PM55	10A	0	20A	0	12A	0
PM56	10A	0	20A	0	25A	*

*Fast Blow E E GS150/25

3.2.1. PRELIMINARY CHECKS

Before the line supply is connected to the unit, ensure that the correct fuses are fitted as specified in Table 4. Check that the following terminal links on terminal block TB2 (mounted on the front panel) and TB3 (mounted on the left-hand side of the unit) are in position.

(1) 1 and 2 on TB2 (DC LINK)
(2) 3 (+s) to 4 on TB2) DC output
(3) 6 (-s) to 5 on TB2)
(4) 1 and 2 on TB3 (External programming of current)
(5) 4 and 5 on TB3 (External programming of voltage)

NOTE If these links are not made the unit will not operate satisfactorily.

When the preliminary checks have been completed, connect the line supply to the following terminals on TB1.

Line	to 1
Neutral	to 2
Ground	to 3

3.3 RESETTING THE OUTPUT VOLTAGE

(a) SETTING THE OUTPUT VOLTAGE

The unit is adjusted in the factory to provide the voltage indicated on the serial number panel, with a further ± 0.5V control available on the SET O/P VOLTS control positioned on the front panel. The following conditions should be observed.

(1) The SET OUTPUT CURRENT control on the front panel should be fully clockwise.
(2) The level of output voltage does not exceed the trip level of the overvoltage protection circuit (when fitted).

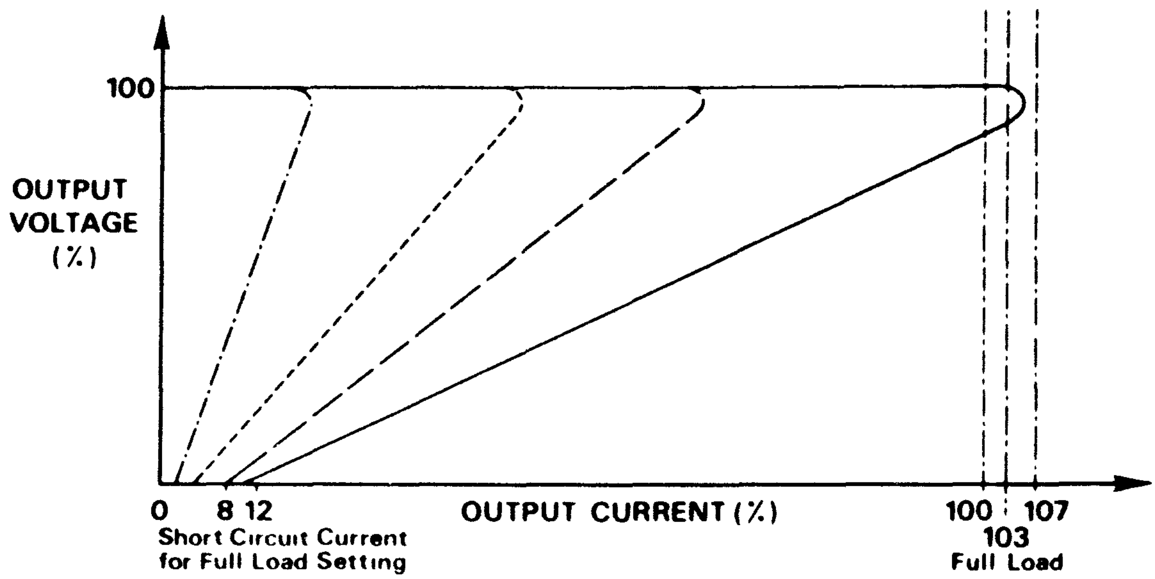
(b) TO CHANGE THE OUTPUT VOLTAGE

(1) Connect a voltmeter across terminals 3(+s) and 5 (-s) on TB2.
(2) Adjust the transformer taps on the secondary of T1 and R110, R111, R117, R118 and (R50 and R57 if fitted), as shown on tables 8, 9 and 10.
(3) Switch on the AC Supply.
(4) Adjust the SET OUTPUT VOLTS control to obtain the exact output level required.

(c) EXTERNAL PROGRAMMING OF OUTPUT VOLTAGE (see Section 3.7)

3.4 RESETTING THE OVERLOAD PROTECTION

(a) The current re-entrant limit level is determined by the SET OUTPUT CURRENT control on the front panel. The control can be set to any value of current within the range 15% to 105% of the maximum rated current of the unit, provided that the correct value of R110 and R111 has been fitted.



Graph 1 Output Voltage Plotted Against Output Current

To set the output current rotate the SET OUTPUT CURRENT control fully clockwise. Switch on the AC supply.

Connect an ammeter and adjustable load between terminals 4 (+) and 5 (-) on TB2, and carefully adjust the load until the ammeter indicates the unit is delivering the required current.

Adjust the SET OUTPUT CURRENT control counter clockwise until the output voltage starts to fall, and then rotate the control a small amount clockwise.

Decrease the load resistance slowly and verify the maximum load current available.

NOTE As the output current setting is reduced so the maximum short circuit current is reduced proportionately, as shown on Graph 1.

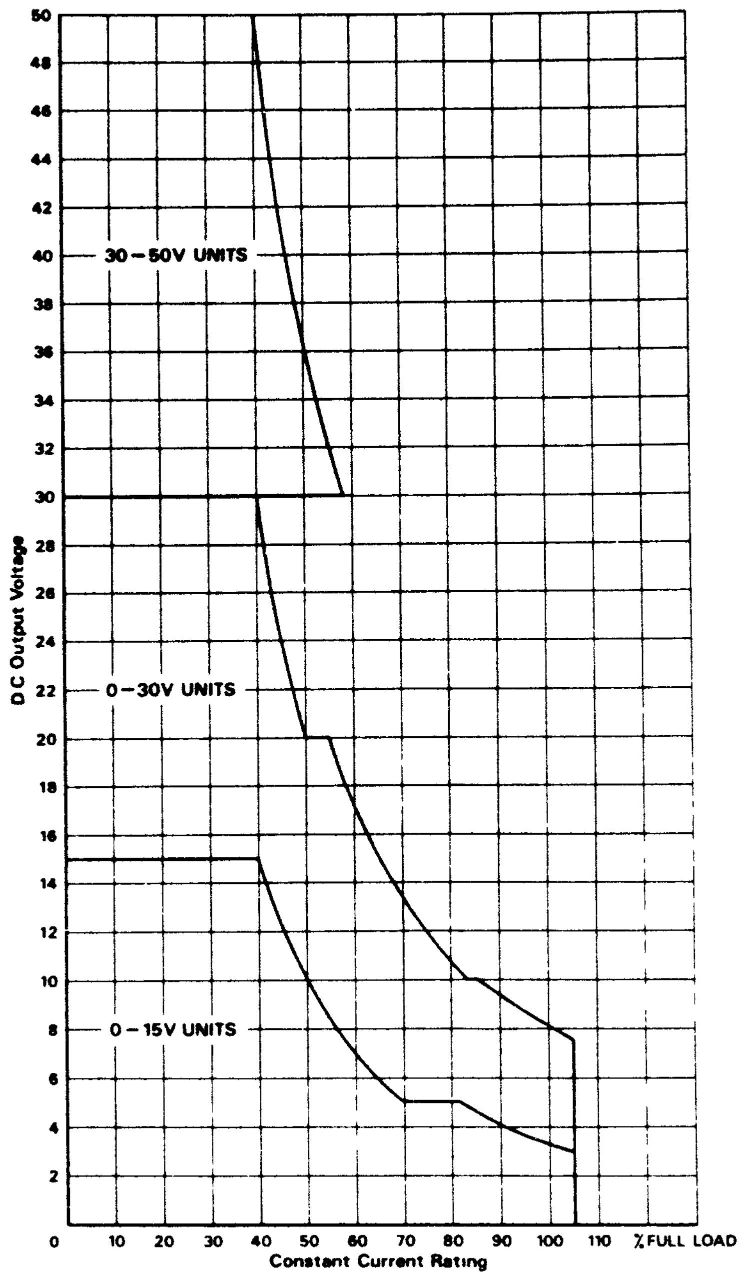
(b). TO OPERATE THE POWER SUPPLY IN CONSTANT CURRENT MODE

Remove the link between terminals 20 and 21, and 18 and 19 on the

AUX PC Board, and fit an external programming resistor between terminals 2 and 3 on TB3 having first removed the link between terminals 1 and 2. The maximum nominal currents allowable are shown on Tables 5, 6 and 7.

NOTE At no time must the current exceed the limit shown on Graph 2.

For currents other than those shown on Tables 5, 6 and 7 calculate programming resistor values as per specification, Section 2.



Graph 2 shows limits to output current in constant I mode

(c) CONSTANT CURRENT SWITCH ON

To remove the 200mS constant current switch on facility, remove the link between the terminals 20 and 21 on the AUX PC Board.

Table 5 Maximum Current in Constant Current Mode

With Output Volts set to	Nominal Output Current (Max)				
	PM44	PM47	PM50	PM53	PM56
1	1.0A	3.0A	5.0A	10A	20A
2	1.0	3.0	5.0	10	20
3	1.0	3.0	5.0	10	20
4	.83	2.9	4.1	8.3	16.6
5	.74	2.2	3.7	7.4	14.8
6	.62	1.9	3.1	6.2	12.4
7	.57	1.7	2.8	5.7	11.4
8	.54	1.6	2.7	5.4	10.8
9	.50	1.5	2.5	5.0	10.0
10	.48	1.4	2.4	4.8	9.6
11	.45	1.4	2.2	4.5	9.0
12	.42	1.3	2.1	4.2	8.4
13	.40	1.2	2.0	4.0	8.0
14	.39	1.2	1.9	3.9	7.8
15	.37	1.1	1.8	3.7	7.4

Table 6

With Output Volts set to	Nominal Output Current (Max)			
	PM45	PM48	PM51	PM54
1	1.0A	3.0A	5A	10A
2	1.0	3.0	5	10
3	1.0	3.0	5	10
4	1.0	3.0	5	10
5	1.0	3.0	5	10
6	1.0	3.0	5	10
7	1.0	3.0	5	10
8	.90	2.7	4.5	9
9	.82	2.5	4.1	8.2
10	.77	2.3	3.8	7.7
11	.72	2.2	3.6	7.2
12	.68	2.0	3.4	6.8
13	.65	1.9	3.2	6.5
14	.61	1.8	3.0	6.1
15	.58	1.7	2.9	5.8
16	.57	1.7	2.8	5.7
17	.55	1.6	2.7	5.5
18	.52	1.6	2.6	5.2
19	.51	1.5	2.5	5.1
20	.50	1.5	2.5	5.0
21	.47	1.4	2.3	4.7
22	.44	1.3	2.2	4.4
23	.43	1.3	2.1	4.3
24	.42	1.3	2.1	4.2
25	.40	1.2	2.0	4.0
26	.39	1.2	1.9	3.9
27	.38	1.1	1.9	3.8
28	.37	1.1	1.8	3.7
29	.36	1.1	1.8	3.6
30	.35	1.0	1.7	3.5

Table 7

With Output Volts set to	Nominal Output Current (Max)			
	PM46	PM49	PM52	PM55
30	.52A	.16A	2.6A	5.2A
31	.51	1.5	2.5	5.1
32	.50	1.5	2.5	5.0
33	.49	1.5	2.4	4.9
34	.48	1.4	2.4	4.8
35	.47	1.4	2.4	4.7
36	.46	1.4	2.3	4.6
37	.45	1.3	2.3	4.5
38	.44	1.3	2.2	4.4
39	.43	1.3	2.2	4.3
40	.42	1.3	2.1	4.2
41	.41	1.2	2.1	4.1
42	.40	1.2	2.0	4.0
43	.39	1.2	2.0	3.9
44	.38	1.1	1.9	3.8
45	.38	1.1	1.9	3.8
46	.37	1.1	1.9	3.7
47	.37	1.1	1.9	3.7
48	.36	1.1	1.8	3.6
49	.36	1.1	1.8	3.6
50	.35	1.0	1.8	3.5

3.5 RESETTING THE OVERVOLTAGE PROTECTION (IF FITTED)

(1) Having checked that the overload protection is working, connect a voltmeter from terminal 4 (+) to terminal 5 (-) on TB2.
(2) Set the overvoltage control (RV50) mounted on the Overvoltage Board to the maximum setting - fully clockwise.
(3) Set the output voltage by rotating the SET OUTPUT VOLTS control RV101 or by using the external voltage programming facility to the required overvoltage level. (See external voltage programming, Section 3. 7).
(4) Slowly turn RV50 counter-clockwise until the overvoltage circuit operates. Operation is evident by a reduction to approximately 1V on the voltmeter.
(5) Reduce the output voltage by varying the programming resistor to give approximately normal voltage.
(6) Switch off the AC supply, and the switch on again, to reset the circuit.
(7) Increase the output voltage by slowly increasing the programming resistor. This will check the operation of the circuit at the level indicated on the voltmeter.
(8) Remove the External programming resistor.
(9) Check the output voltage setting.

3.6 UNIT CONNECTIONS

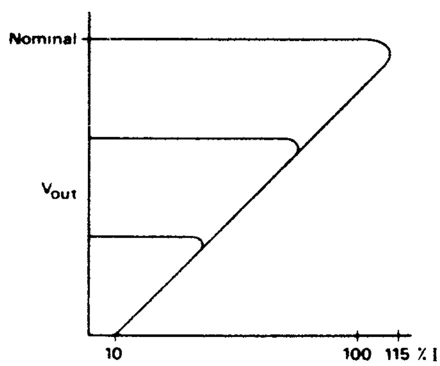
Tables 8, 9 and 10 show the connections that should be made between the various secondary windings of T1 and the values of R110, R111, R117, R118 and (R50 and R57 if fitted), that should be inserted to obtain the required output voltage. These resistors are located on the AUX. PC Board and R50 and R57 on the O/V PC board.

NOTE When the overvoltage circuit is fitted it is necessary to change the link on the O/V PC board when operating units above 7V i.e.

0 - 7V LINK terminals 1 and 9
8 - 50V LINK terminals 1 and 8

3.7 PROGRAMMING CURRENT AND VOLTAGE
Output Characteristics and Programming.
To enable users of these power supplies to have a wide range of operating conditions care has been taken in the design to accommodate facilities for modifying the basic operating characteristic. It will be appreciated that an alteration to the normal characteristic of the power unit must impose certain limits to its operating area.

3.7.1 EXTERNAL PROGRAMMING
Voltage, current and overvoltage protection levels can be controlled externally. To utilise the facility it is necessary to remove terminal links (which disconnect the internal controls from circuit) and connect external resistors by means of remote lines if necessary. By using resistors whose values correspond to the voltage or current required, voltage control, current control and overvoltage control can be effected remotely.



Graph 3

NOTE If remote lines are used, their resistance is to be included in the value of the programming resistor and they should be shielded from stray electromagnetic fields to minimise 'noise' pick-up.

3.7.1 (a) VOLTAGE CONTROL
For external control of voltage, RV101 is disconnected from circuit and replaced by an external potentiometer or fixed resistor. The level of the output voltage is related to the value of the external resistance by the 100Ω/V scale factor for all units.

NOTE When the voltage is reduced from the set MAX the MAX current setting is also reduced if re-entrant current mode protection is in use. See Graph 3.

To connect the unit for external programming of voltage the procedure is as follows:-

(1) Switch off AC supply.
(2) Disconnect the link across terminals 4 and 5 of TB3
(3) Connect the external programme resistor to terminal 4 of TB3 and terminal 6 of TB2. (-ve SENSE).
(4) Switch on the AC supply.

3.7.1 (b) CURRENT CONTROL
For external control of current, RV100 is disconnected from circuit and replaced by an external potentiometer or fixed resistor. The level of current is related to the value of the external resistance by the Ω/A scale factor which is given in Section 2 for each of the power supplies. To connect the unit for external programming of current, the procedure is as follows:-

(1) Switch off the AC supply.
(2) Disconnect the link across terminals 1 and 2 of TB3.
(3) Connect the external programme resistor to terminals 3 and 2 of TB3.
(4) Switch on the AC supply.

3.7.1 (c) OVERVOLTAGE CONTROL
For external control of the overvoltage protection circuit, RV50 is disconnected from circuit and replaced by an external potentiometer or resistors. A resistance range from 0 to 3.3KΩ corresponds approximately to an overvoltage protection range of

1.5V to 120% of FULL OUTPUT VOLTAGE FOR 0 -15V UNITS
3V to 120% of FULL OUTPUT VOLTAGE FOR 0 -30V UNITS
5V to 120% of FULL OUTPUT VOLTAGE FOR 30-50V UNITS

To connect the unit for external programming of overvoltage protection, the procedure is as follows:-

(1) Switch off the AC supply.
(2) Disconnect the link across terminals 4 and 5 on the overvoltage printed circuit board.
(3) Connect an external programme potentiometer of 3.3K resistance to terminals 4 (slider), 6 and 7 of the printed circuit board connector Alternatively connect fixed resistors between terminals 7 and 4 and between terminals 6 and 4.
(4) Switch on the AC supply.
(5) Adjust for overvoltage setting.

3.8 PARALLEL AND SERIES OPERATION

3.8.1. Up to a maximum of 5 modular power units can be operated in parallel, (or 3, 20A units) and should be connected as shown in Fig. 5. For best voltage regulation, the terminal labelled 'P' on the circuit, (terminal 6 of TB3) on each unit should be returned to a common point, and four-terminal sensing used as described in Section 3.10 - but this is not essential.

NOTE When units are connected in parallel the built-in thyristor of the optional overvoltage circuit in each unit must be made inoperative. because it is not possible to ensure that each thyristor will have an equal share of total current under fault condition unless connected as shown in Fig. 6. This is done by removing the gate connection of the thyristor either at the thyristor itself, or at the overvoltage PC board (terminal 3).

If overvoltage protection is required, an external thyristor of suitable rating for the total parallel current of all units should be used. Its gate terminal should be connected to pin 3 on the over-voltage board of one unit after disconnecting the existing gate connection to MR102. A gate firing current of approximately 50mA is available from pin 3. The cathode should be connected to the common negative line and the anode to the common positive line. Set overvoltage as in section 3.5 All other units should have gate connections to pin 3 removed as outlined above.

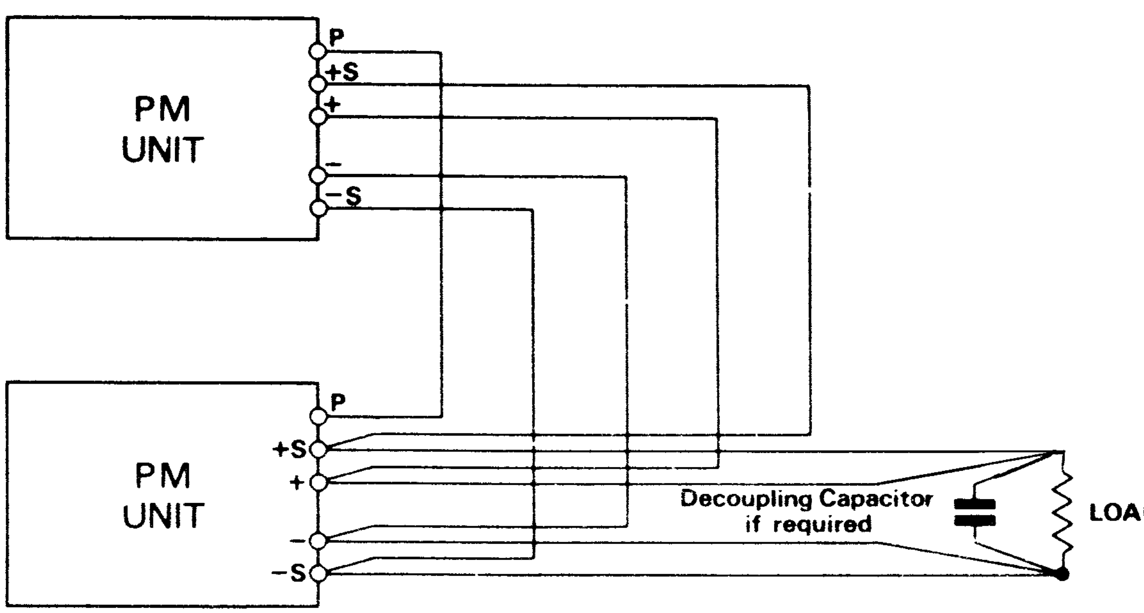


Fig. 5 Parallel Operations

3.8.2. PARALLEL OPERATION WITH BUILT IN THYRISTORS MR102. Units should be connected as shown in Fig. 6 under the conditions as follows:

(a) If necessary each unit is to be set up separately to the required operating conditions as detailed in paragraphs 3.4 and 3.5.
(b) A diode of the same current and voltage rating as the power module, must be connected in series with each output (positive end of the diode to negative terminal of power module.)
(c) Link the 'P' terminals 6 on TB3.
(d) Link the sensing terminal as shown in Fig. 6.

NOTE Because the forward voltage drop of the diode uses all the allowable external lead voltage drop no extra lead length can be allowed for four terminal sensing.

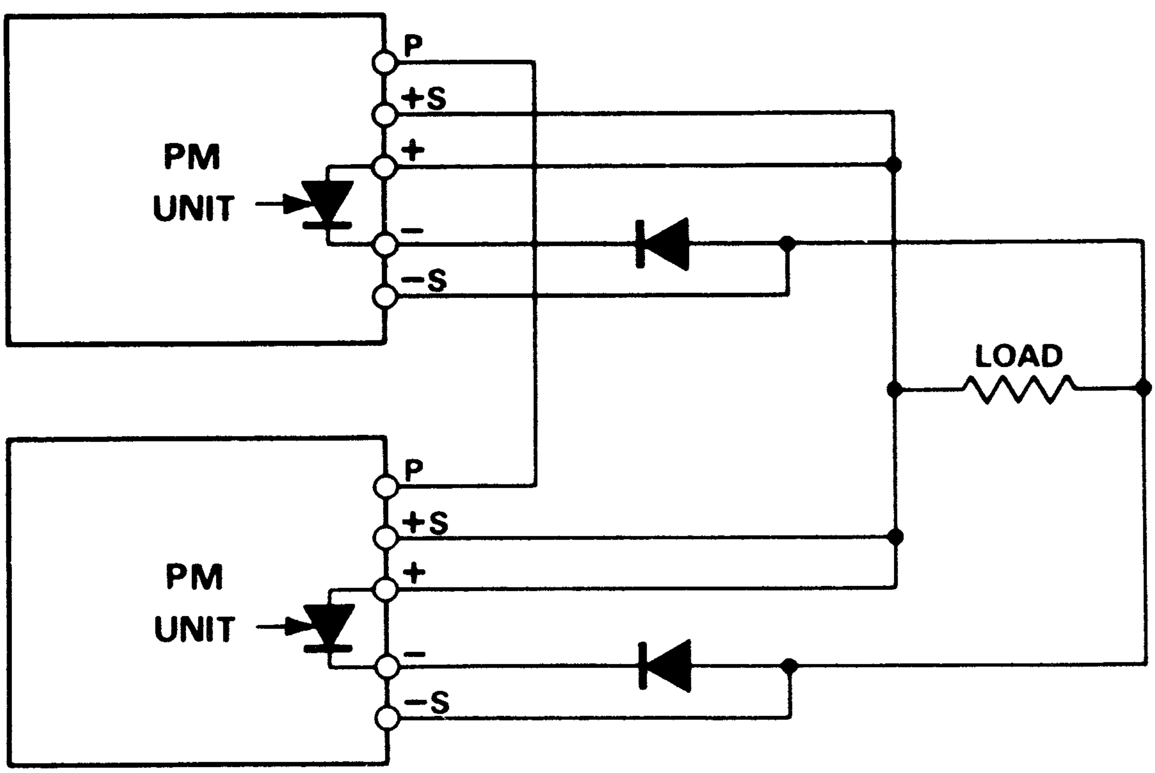


Fig. 6 Parallel Units with Overvoltage Circuits Fitted.

NOTE R106 must be removed from between terminals -ve and -ve sense.

3.8. 3 It is also possible to operate modular power units in series under certain conditions as follows:-

(a) If necessary each unit is to be set up separately to the required operating conditions as detailed in paragraphs 3.4 and 3. 5
(b) A diode, of the same current and voltage rating as the power module, must be connected across EACH power module output (positive end of diode to positive terminal of power module).
(c) The number of modules connected in series is limited to give a maximum of 250V DC.

3.9 OPERATION WITH OTHER POWER SUPPLY UNITS
When power modules are used in conjunction with other power supplies of opposite polarity, provision must be made as in 3. 8. 3(b) to protect the power module against reverse voltage conditions. The rating of the diode used must be sufficient to carry the fault current generated.

3. 10 FOUR-TERMINAL SENSING
Where long external output leads are used, four-terminal sensing is provided to enable the load voltage regulation of the power supply to be maintained at the load connections. The two links between the +ve output and the +ve sense, and the -ve output and the -ve sense terminals should be removed and connections made as shown in Fig. 7. These output connections should be run together and a decoupling capacitor, similar to C102 in the power supply, connected at the load terminals if the high frequency output impedance is to be maintained. Parallel connection should be made as shown in Fig. 8.

The maximum permissible voltage drop in the external leads when using four-terminal sensing is 0. 5V total in both leads i.e. 0. 25V in each lead +ve and -ve or 0. 5V in one supply lead with a ground return of negligible resistance. The total permissible length of lead for 0. 5V drop is listed in Table 11 for various wire sizes and current ratings. Note that this is the total permissible loop length 'go and return' and that the power supply can only be situated at half this distance from the load for a two wire +ve and -ve lead system.

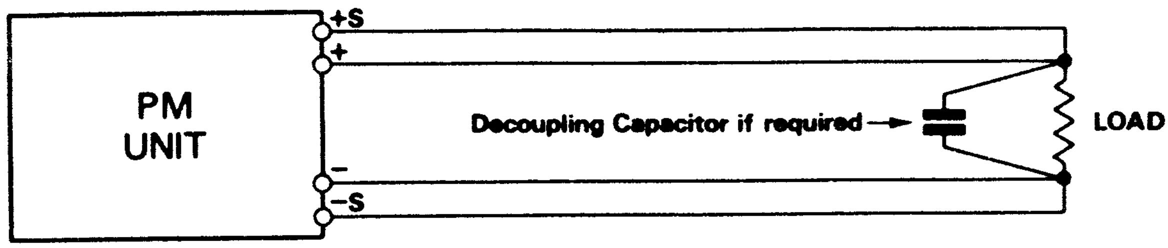


Fig. 7 Four-terminal Sensing

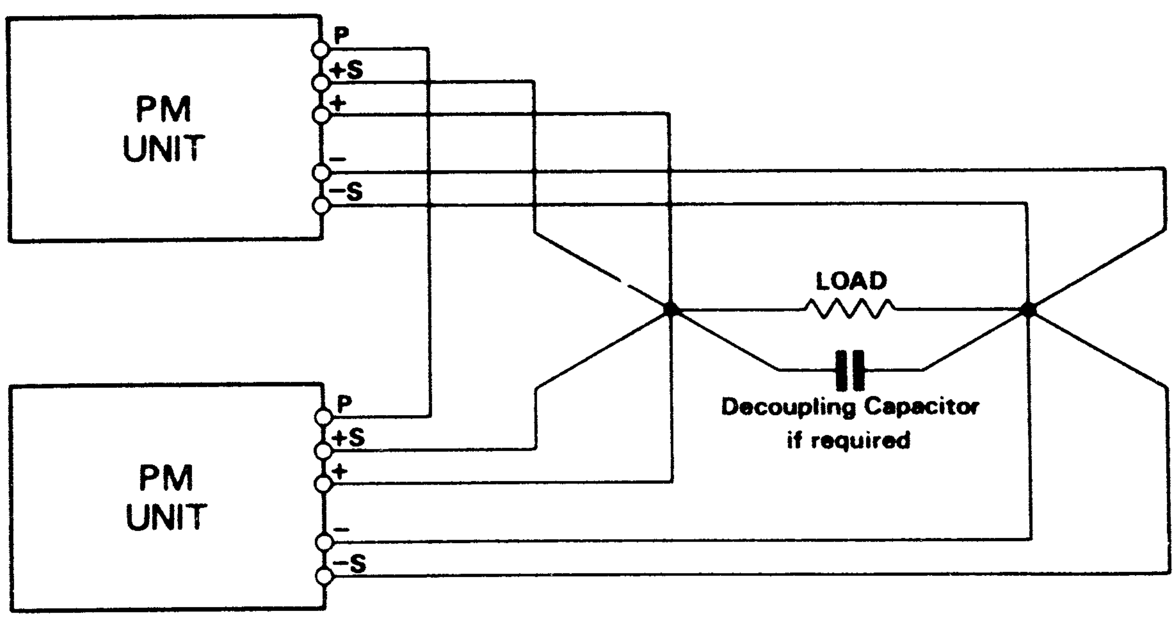
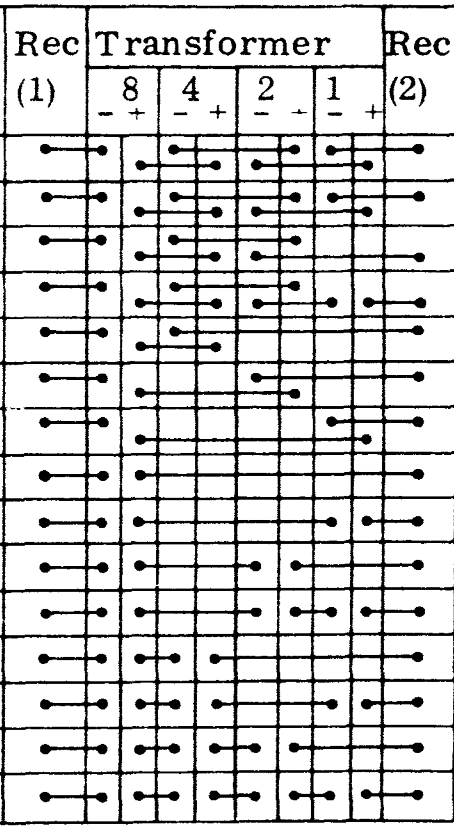


Fig. 8 Four-terminal Sensing (Parallel)

Table 8 Voltage Adjustments PM44, 47, 50, 53, 56.

CONNECTIONS: Volts out, Rec (1), Transformer (8, 4, 2, 1; − +), Rec (2)



Volts out	R110	R111	R117	R118	R50	R57
1	22Ω	22Ω	LINK	Not used for up to 15V	470Ω	91Ω
2	150Ω	12Ω	100Ω		470Ω	91Ω
3	270Ω	22Ω	220Ω		470Ω	91Ω
4	390Ω	33Ω	300Ω		470Ω	91Ω
5	560Ω	LINK	390Ω		470Ω	91Ω
6	680Ω	LINK	470Ω		470Ω	91Ω
7	820Ω	LINK	560Ω		470Ω	91Ω
8	910Ω	LINK	680Ω		120Ω	51Ω
9	910Ω	180Ω	820Ω		120Ω	51Ω
10	1. 2K	LINK	910Ω		120Ω	51Ω
11	1. 2K	150Ω	1K		470Ω	51Ω
12	1. 2K	270Ω	1. 1K		470Ω	51Ω
13	1. 5K	100Ω	1. 2K		470Ω	51Ω
14	1. 5K	220Ω	1. 3K		470Ω	150Ω
15	1. 8K	47Ω	1. 4K		470Ω	150Ω

NOTE

Resistors Types	Electrosil TR5 ±2%
R110 R111	CGS CR1. 5 up to 5V ±5%
R117	6V to 15V ±2%
R50	Electrosil TR5 ±5%
R57	Electrosil TR5 ±5%

Table 9 Voltage Adjustments PM45, 48, 51, 54.

CONNECTIONS							RESISTOR VALUES					
Volts out	Rec (1)	Transformer 17 − +	9 − +	3 − +	1 − +	Rec (2)	R110	R111	R117	R118	R50	R57
1							22Ω	22Ω	LINK	Not used up to 15V	470Ω	91Ω
2							150Ω	12Ω	100Ω		470Ω	91Ω
3							270Ω	22Ω	220Ω		470Ω	91Ω
4							390Ω	33Ω	300Ω		470Ω	91Ω
5							560Ω	LINK	390Ω		470Ω	91Ω
6							680Ω	LINK	470Ω		470Ω	91Ω
7							820Ω	LINK	560Ω		470Ω	91Ω
8							910Ω	LINK	680Ω		120Ω	51Ω
9							910Ω	180Ω	820Ω		120Ω	51Ω
10							1. 2K	LINK	910Ω		120Ω	51Ω
11							1. 2K	150Ω	1K		470Ω	51Ω
12							1. 2K	270Ω	1. 1K		470Ω	51Ω
13							1. 5K	100Ω	1. 2K		470Ω	51Ω
14							1. 5K	220Ω	1. 3K		470Ω	150Ω
15							1. 8K	47Ω	1. 4K		470Ω	150Ω
16							1. 8K	180Ω	1. 5K	47K	470Ω	150Ω
17							1. 8K	330Ω	1. 8K	12K	470Ω	150Ω
18							1. 8K	470Ω	1. 8K	22K	470Ω	150Ω
19							2. 2K	180Ω	1. 8K	68K	470Ω	220Ω
20							2. 2K	330Ω	2. 0K	27K	470Ω	220Ω
21							2. 2K	430Ω	2. 0K	82K	1. 5K	220Ω
22							2. 2K	560Ω	2. 2K	33K	1. 5K	220Ω
23							2. 7K	220Ω	2. 2K	100K	1. 5K	220Ω
24							2. 7K	330Ω	2. 4K	33K	1. 5K	220Ω
25							3. 0K	180Ω	2. 4K	100K	1. 5K	330Ω
26							3. 3K	LINK	2. 7K	27K	1. 5K	330Ω
27							3. 3K	120Ω	2. 7K	47K	1. 5K	330Ω
28							3. 3K	270Ω	2. 7K	120K	1. 5K	330Ω
29							3. 3K	390Ω	3K	33K	1. 5K	330Ω
30							3. 3K	510Ω	3K	56K	1. 5K	330Ω

NOTE

Resistor Types
R110 R111 Electrosil TR5±2%

R117	CGS CR1.5 up to 5V ±5%
	6V to 30V ±2%
R118	Electrosil TR5 ±5%
R50	Electrosil TR5 ±5%
R57	Up to 18V Electrosil TR5 ±5%
	19-30V Welwyn W21 ±5%

Table 10 Voltage Adjustments PM46, 49, 52, 55.

CONNECTIONS							RESISTOR VALUES					
Volts out	Rec (1)	Transformer 40 − +	6 − +	3 − +	1 − +	Rec (2)	R110	R111	R117	R118	R50	R57
30							3.3K	510	3K	56K	1.5K	330
31							3.6K	330	3K	160K	2.7K	390
32							3.6K	470	3.3K	39K	2.7K	390
33							3.6K	620	3.3K	68K	2.7K	470
34							3.9K	470	3.3K	220K	2.7K	470
35							3.9K	560	3.6K	47K	2.7K	470
36							2.4K	1.2K	3.6K	82K	2.7K	470
37							2.7K	2.0K	3.6K	220K	2.7K	470
33							2.7K	2.2K	3.9K	56K	2.7K	560
39							3.0K	2.0K	3.9K	91K	3.3K	560
40							3.3K	1.8K	3.9K	330K	3.3K	560
41							3.3K	2.0K	4.3K	47K	3.3K	560
42							3.6K	1.8K	4.3K	68K	3.3K	560
43							3.3K	2.2K	4.3K	120K	3.3K	560
44							3.6K	2.0K	4.3K	330K	3.9K	560
45							3.6K	2.2K	4.35K	Not used	3.9K	680
46							3.9K	2.0K	4.45K		3.9K	680
47							4.3K	1.8K	4.55K		3.9K	680
48							4.7K	1.5K	4.65K		4.3K	680
49							4.3K	2.0K	4.75K		4.3K	680
50							4.3K	2.2K	4.85K		4.3K	680

NOTE Resistors Types

R110 R111	Electrosil TR5 ±2%
R117	CGS CR1.5 30 and 31V ±2%
	32V to 50V ±1%
R118	Electrosil TR5 ±5%
R50	Electrosil TR5 ±5%
R57	30-32V Welwyn W21 ±5%
	33-50V RVW4-J ±5%

Table 11 Permissible lead length for four-terminal sensings.

Wire	Lead Length (feet and metres)									
Size	PM44, 45 46		PM47, 48 49		PM50, 51 52		PM53, 54 55		PM56	
	ft	m	ft	m	ft	m	ft	m	ft	m
7/0076	19	6								
14/0076	38	12	13	4						
23/0076	60	18	20	6	12	3.5				
40/0076			68	21	21	6.5	10	3		
70/0076					37	11	18	5.5	9	2.7
110/0076					58	18	29	9	14	4.5
162/0076							43	13	21	6.5

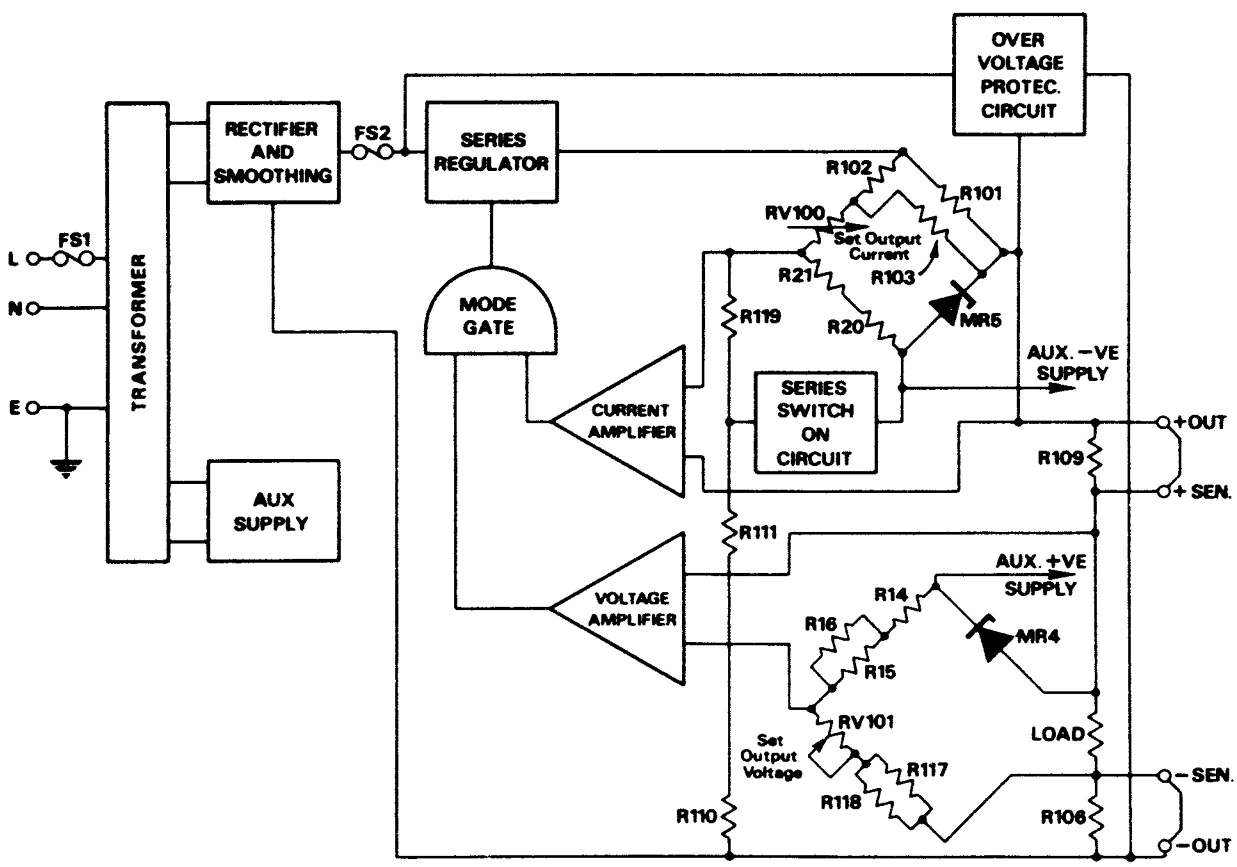


Fig. 9 Functional Diagram of Power Unit

4.1 GENERAL

A simplified functional diagram of the circuitry of the power unit is shown in Fig. 9. The voltage and current modes of operation are controlled by two independent bridge circuits. Any variation of load current or output voltage produces an out-of-balance condition of the associated bridge. The output of the bridge is applied to a comparator amplifier whose output is fed into a mode gate. The output of the mode gate controls the output resistance of a series regulator which (assuming the initial variation was within the present operating limits of the unit) restores the original mode conditions.

The circuit cannot operate in both modes simultaneously, and only the control signal from the bridge corresponding to the mode of operation passes through the gate. Crossover from one mode to another is automatic, and the point of crossover is determined by the settings of the two controls SET OUTPUT VOLTS (RV101) and SET OUTPUT CURRENT (RV100).

An auxiliary stabilised power supply is also incorporated. This supplies the bridge circuits and the comparator amplifiers; to simplify the functional diagram, the output connections of the auxiliary supply are not shown. Overvoltage protection is afforded by a sensing circuit connected across the stabilised output terminals The level at which the circuit operates is controlled by the setting of a potentiometer.

4.2 SUPPLY RECTIFICATION AND SMOOTHING

The AC input voltage within the range 100V-125V and 200V-250V, 48Hz to 450Hz is applied, via the terminals of TB1, to the primary of T1. Interconnection of the primary terminals for different voltage supplies is given in Section 3. 2.

The transformer has five secondary windings. The output voltage derived from one winding is used for the auxiliary supply. This AC voltage is full-wave rectified by MR1 and MR2 and smoothed by R1, C1 and C2. The output voltage of the other windings connected as per Section 3. 6 is applied to the bridge rectifier MR100 and then smoothed by C101. The resultant 'raw' DC is protected by fuse FS2 and then applied to the series regulator.

4.3 SERIES REGULATOR

The series regulator contains transistor VT100 and transistor VT101 (which may consist of several transistors in parallel) arranged in a Darlington-pair configuration. An increasing positive signal applied to the base of VT100 decreases the output resistance of the circuit; conversely, a decreasing signal increases the output resistance. Each transistor in VT101 has a separate resistor in the emitter circuit to provide current sharing between transistors. The voltage developed by the flow of load current through the resistor R101 is connected across a common potential divider network of resistor R102 and R103 to provide a voltage signal proportional to the output current which is standardised at 0.85V for 100% output current.

4.4 BRIDGE REFERENCE SOURCES

Two zener diodes, MR4 and MR5, are used as reference sources in the voltage and current bridges, respectively.

These diodes are connected in series with the resistor network of R10, R11 and R12 across the auxiliary voltage supply line, and MR4 is also used as the reference for the stabilising circuitry of the auxiliary voltage supply. The flow of current through the two diodes is determined by accurate adjustment of the value of the resistor network. This level of current is maintained by the stabilised auxiliary voltage.

4.5 STABILISATION OF THE AUXILIARY SUPPLY

Stabilisation is effected by the sensing network R5, R6 and R9 and the associated circuitry of the transistors VT1 to VT4. A proportion of any change in the auxiliary voltage is fed to the base of VT3 which is in a long-tail pair configuration with VT4. Assume that the voltage across the sensing network tends to rise. An increase in the voltage drop across R6 occurs. This increases the base voltage of VT3 which is compared with the fixed base voltage of VT4 establised by MR4. The resultant positive increase of the collector potential of VT4 decreases the conduction of VT2: the emitter voltage of VT2 is fixed by Zener diode MR3. As a result, the decreased conduction of VT2 reduces the base drive of the series regulator transistor VT1. Thus, the resistance of VT1 increases and counteracts the initial tendency of the output voltage to rise. Resistor R4 ensures initial conduction of VT1.

4.6 VOLTAGE CONTROL BRIDGE
The circuitry which senses any tendency of the output voltage to change is shown in a bridge configuration in Fig. 9 and the Circuit Diagram Fig. 12. Any unbalance of the bridge is detected by the long-tail pair VT5 and VT6 which operate as the voltage comparator amplifier. The two diodes, MR6 and MR7, connected from the base of VT5 to the base of VT6 protect the two transistors against heavy dishcarge current from C102 if the capacitor is in a charged condition when the sense lines are connected.

As shown in Fig. 9 the resistor network R14, R15, and R16 and RV101, R117 and R118 form two arms of the voltage control bridge. When the bridge is balanced, the voltage condition is as follows:-

$$V_{MR4} = V_{(R14+R15/R16)}$$

$$V_{(RV101+R117/R118)} = V_{OUT}$$

For V_{OUT} to equal (RV101 + R117/R118) at all settings of RV101, R117 and R118, the output voltage must be a direct function of the resistance of RV101, R117 and R118.

4.7 VOLTAGE CONTROL
With the bridge balanced, the circuit will remain in equilibrium until the output voltage tends to change. Any change in output voltage across the load is fed back, via the positive sense line to the base of VT6 where it is compared with the base voltage of VT5. The resultant change of level of the collector voltage of VT5 is applied to MR8 which with MR9 forms the mode gate. A change in signal to MR8 results in a change of output resistance of the series regulator in such a direction as to counteract the original change in voltage.

4.8 CURRENT CONTROL BRIDGE
The circuitry forms a bridge configurati on as shown in Fig. 10 and the Circuit Diagram Fig. 12.

The output current in passing through the R101's in parallel provides a voltage signal proportional to the output current which is divided down to a standard level by resistors R102 and

R103 in parallel with R104. This signal is compared with the voltage generated across RV101 by the current i_1 (which is the sum of currents i_2 and i_3) by the long-tail pair VT7 and VT8 operating as a comparator amplifier.

When the power unit is operating in the current mode the voltage amplifier is inoperative and the current bridge is in a balanced condition. The voltage conditions are then as follows:-

$$I_{OUT} \times R101 \left[\frac{R103/R104}{R102 + R103/R104}\right] = i_1 \times RV100$$

i.e. $I_{OUT} = K \times i_1 \times RV100$

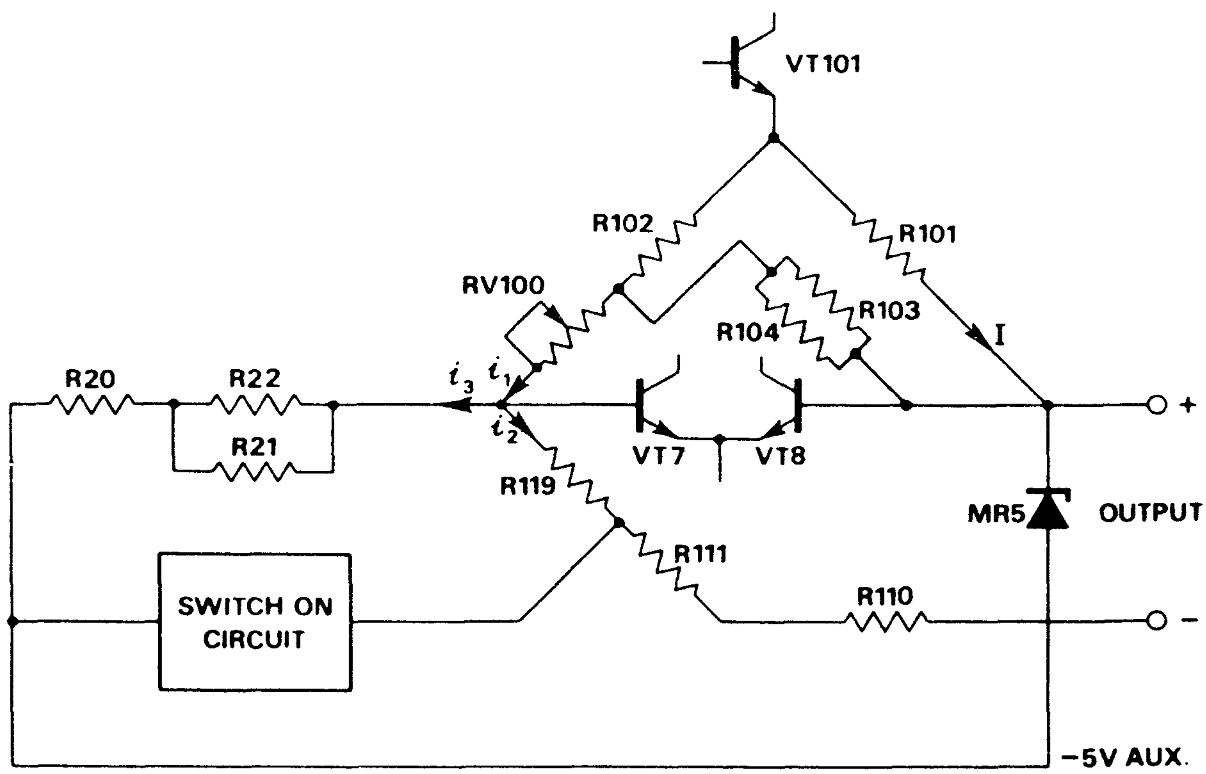


Fig. 10 Current Control Circuit

4.8.1 RE-ENTRANT CURRENT MODE

i_3 is supplied from the -ve auxiliary supply (MR5) via R20, R21 and R22 and therefore is essentially constant under all output voltage conditions. i_2 is supplied from the -ve output line via R119, R111 and R110 and is therefore proportional to output voltage.

As the load resistance changes from a high value R_{cv} through the critical value R_c (where the power unit changes from voltage controlled to current controlled operation) to a low value R_{cr} the output current falls at the same time as the output voltage falls as shown in Fig. 11.

At the limit, i.e. short circuit load

$$V_{OUT} = 0$$

hence $i_2 = 0$

and therefore

$$i_1 = i_3$$

and therefore for balance

$$I_{OUT} = K \times i_3 \times RV100$$

i_3 therefore sets the maximum short circuit current from the unit.

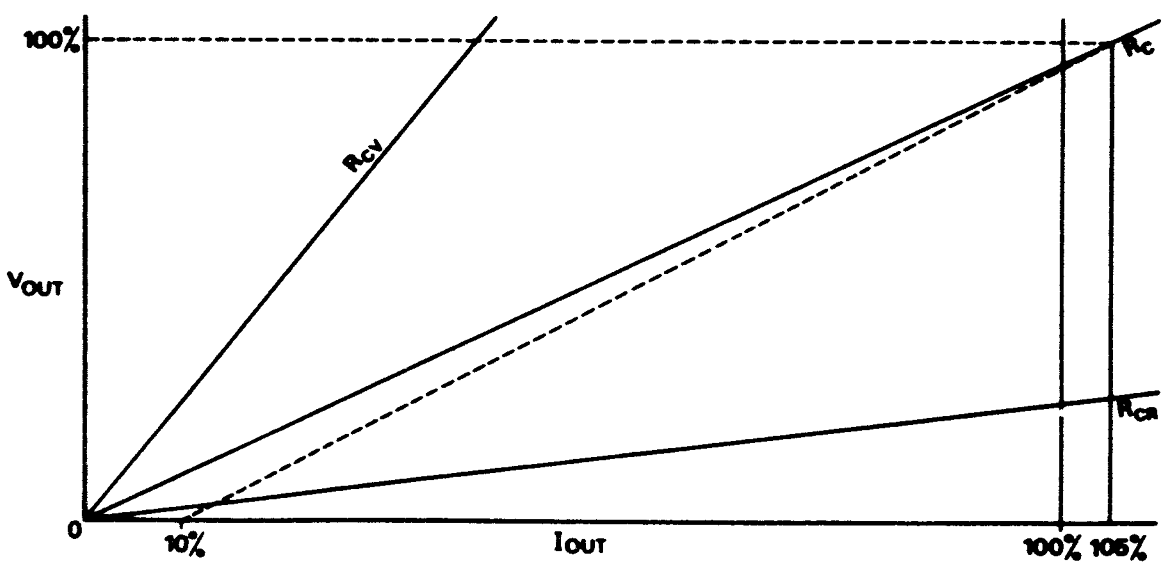


Fig. 11 Output Voltage plotted against Output Current in Re-Entrant Mode

4.8.2 CONSTANT CURRENT MODE
In the constant current mode i_2 is disconnected and the output current is therefore proportional to i_3 only and is therefore essentially not affected by the output voltage.

4.8.3 SERIES SWITCH-ON CIRCUIT
Due to the re-entrant circuit protection it is not possible to connect two or more power supplies in series with a common load current. It has therefore been necessary to modify the characteristic at switch on so that for approximately 200mS the supply will go into a constant current mode, this being the time the supplies take to stabilise their voltages.

At switch on the output voltage is zero, and hence without the switch-on circuit

$$i_1 = i_3$$

and therefore $$1_{OUT} = K \times i_3 \times RV100$$
$$= 10\% \text{ of output current}$$

To overcome this problem the current i_2 is provided via the switch-on circuit for the first 200mSec.

Now as C103 is charging at switch on VT102 is biased on, hence R119 is connected via VT102 to MR101 which in conjunction with MR5 forms a -2V supply. Hence R119 has the same i_2 flowing as if the output voltage was stabilised at full output, and hence the current will be held constant at $I_{max.}$ for APP. 200mS the charging time of C103, R114.

VT102 is biased off when C103 has charged and has no further part in the circuit.

4.9 CURRENT CONTROL
With the bridge balanced, the circuit will remain in equilibrium until the output current tends to change. Any change of load current changes the voltage drop across resistors R103, R104 with respect to the base of VT8. A proportion of this voltage change is applied, via RV100 to the base of VT7. The resultant change in the level of the collector voltage of VT8 is then applied. MR9 which with MR8 forms the mode gate. A change in signal to MR9 results in a change of output resistance of the series regulator in such a

direction as to counteract the original change in current

4.10 MODE OF OPERATION
The mode of operation of the power supply is determined by the load conditions and the setting of the voltage and current controls. Automatic crossover from one mode to the other is depicted in Fig. 11 and occurs at the value of load resistor designated R_C. The value (in ohms) of the load resistor R_C is obtained by dividing the voltage (volts) set by RV101, R117 and R118 and the current (amps) set by RV100. When the power supply is connected to any load R_{cv} whose resistance is more than R_C the mode of operation is constant voltage. When the resistance of the load decreases to any value R_{cr} below R_C the mode of operation is re-entrant or constant current.

During either mode of operation, both comparator amplifiers produce output voltages which are applied to two diodes in the mode gate. Diode MR8 is controlled by the output of the voltage comparator (collector of VT5), and diode MR9 is controlled by the output of the current comparator (collector of VT8). The diode which conducts is the one receiving the higher output voltage. The output from the conducting diode is amplified by VT9 and then applied, via the emitter-follower VT10, to the series regulator. Except for a brief transitional period at crossover, both diodes do not conduct simultaneously; thus, it is always the higher output of the two comparators which controls the resistance of the series regulator.
NOTE that VT9 introduces polarity inversion, and a high positive output from the mode gate produces high resistance of the series regulator.

The crossover action is best understood by considering the operation of the control circuits as the resistance of the load is decreased from a high value of R_{cv} to a low value below R_C. At first, with a very low load current flowing, the collector voltage of VT8 is very low because the voltage developed across R103, R104 is low, and the resultant low base voltage of VT7 allows VT8 to conduct heavily. At the same time, the collector voltage of VT6 is high because with low load current the stabilised output voltage tends to rise, but is held at its predetermined level by heavy conduction of VT6 which results in a high positive potential at the collector of VT5. Thus, of the two signals applied to the mode gate, the signal from VT5 will take control and effect the high value of output resistance required of the series regulator.

As the resistance of the load is decreased, VT7 senses the increased voltage drop across R103, R104 and increases conduction. This decreases the conduction of VT8 and its collector potential rises. Simultaneously, the collector voltage of VT5 decreases in order to reduce the output resistance of the series regulator so that the higher load current may flow.

This action of the collector voltage of VT8 rising and that of VT5 falling as the resistance of the load decreases continues until at the crossover point the signal from VT8 takes control and a rapid transition from voltage mode to current mode occurs. The output supply voltage of the unit then falls to the level required to sustain the preset current level. This rapid transition from voltage mode to current mode provides overcurrent protection.

4.11 OVERVOLTAGE PROTECTION
The overvoltage protection circuit uses a long-tail pair comparator circuit containing transistors VT50 and VT51. The input to the base of VT51 is derived from R55 which with R54 forms a potential divider across the stabilised output supply. VT51 base voltage is compared with the base voltage of VT50 derived from the potentiometer RV50 connected across a Zener diode reference source MR50. The level at which overvoltage protection is required is effected by the setting of RV50; because this level is obviously above the stabilised output voltage, the normal quiescent condition of the long-tail pair is such that VT50 is conducting much more than VT51. In practice, the overvoltage limit is set approximately 10% above the level of the stabilised voltage. If the stabilised output voltage rises above the level set by RV101, transistor VT51 conducts and drives VT52 into heavy conduction. The base voltage of VT52 is fixed by the Zener diode MR51; consequently, VT52 provides a constant current via R57 to the gate electrode of SCR MR102 which fires and produces a short circuit across the terminals of the stabilised output supply.

4.12 EXTERNAL PROGRAMMING
As explained during the description of the voltage and current control bridges, the balance conditions of the bridges are such that the following conditions exist.

(1) The voltage across the resistance of RV101 (SET OUTPUT VOLTS) is equal to the output voltage. A change of resistance of RV101 produces a directly proportional change of output voltage.
(2) The voltage across the resistance of RV100 (SET OUTPUT CURRENT) is equal to the voltage across resistors R103, R104 which, in turn, is directly proportional to output current. A change of resistance of RV100 produces a directly proportional change of output current.

Thus, resistance-output voltage and resistance-output current relationships exist, and these are expressed as Ω/V and Ω/A scale factors, respectively. By disconnecting the variable resistors from circuit and in their place connecting - by remote lines if necessary - fixed or variable resistors, the output voltage or current level can be set by altering the value of resistance. The advantage of this circuit facility is that without any monitoring or metering aid, the voltage and current level can be set simply by the value of resistance in circuit. The method of connecting the unit for external programming of output voltage, output current and overvoltage protection is detailed in Section 3.

5.1 ACCESS TO COMPONENTS

All components, except those mounted on the printed circuit boards, are accessible after removing the front panel (held by fixing screws) and detaching the heat sink assemblies from the side bars. Access to the components on the printed circuit board during operating conditions may be obtained by removing the board and connecting it to the socket in the unit via an extension board (Advance Part No. 19014).

NOTE The printed circuit boards must not be removed from the modules without first switching off the AC supply.

5.2 REPLACEMENT SERVICING OF PRINTED CIRCUIT BOARDS

The control boards used in any of the units in the PM44-56 range are interchangeable. The Overvoltage Boards, if fitted in the units,are also interchangeable.

The extension board is available as a servicing aid. This board can be used as an extended connector for any printed circuit board in the entire range PM44-56 of modular Stabilised Power Supplies.

All boards are available as spare parts, and the following Advance Part No. should be quoted when ordering.

(1) Control Board	Advance Part No. 26521
(2) Extension Board	Advance Part No. 19014

5.3 FAULT FINDING

Determine the state of the output voltage ON LOAD and proceed as outlined in Table 12.

Table 12. Fault Finding Chart

Output Voltage	Fault	Action
No Output	Input Fuse blown MR100 open circuit FS1 blown AND OR FS2	Change fuse. Change MR100 Change fuse. Check circuit for cause. VT1 may be short circuit.
	DC LINK OPEN CCT	Refit

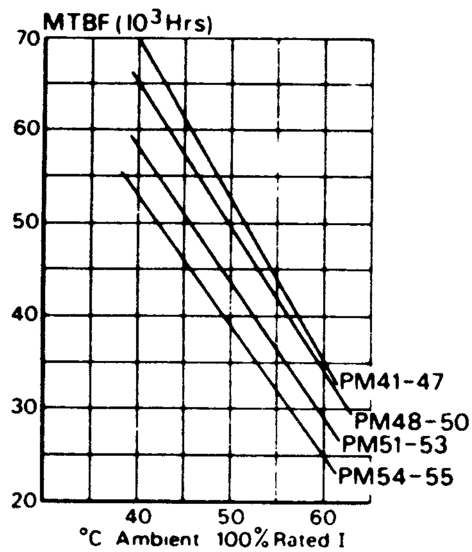
Table 12 Fault Finding Chart (Cont)

Output Voltage	Fault	Action
	VT101 open circuit	Change VT101.
	RV100 fully anti clock	Re. Adj.
	Printed circuit board out of socket or faulty	Replace with new assembly.
Low Output	MR100 partially open circuit	Change MR100
	MR102 has fired (if fitted)	Check external circuit for overvoltage.
	RV100 Set Low	Readjust
	Re-entrant Links o/c	Replace
	Printed circuit board faulty	Replace with new assembly.
High unstabilised output)	VT100 short circuit	Change VT100
)	VT101 short circuit	Change VT101
High Ripple)	Printed circuit board faulty	Replace with new assembly. Check to see why MR102 has not fired. If fitted.
Excessive Output Current	Programming link TB3 (2 & 3) o/c	Replace
	Programming link Resistor o/c	Replace
	Re-entrant links in for constant current operation	

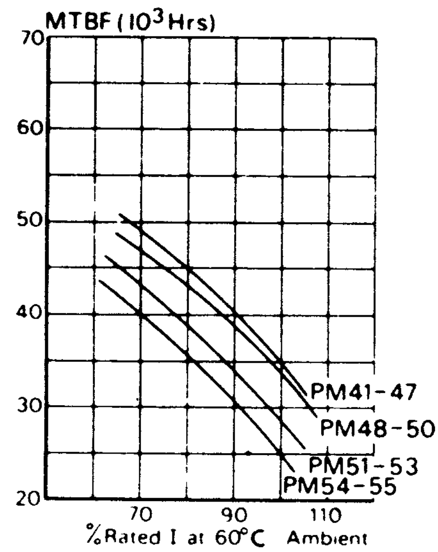
5.4 MEAN TIME BETWEEN FAILURES

The figures quoted below are estimated from data currently available from international sources. These estimates are based on continuous operation at maximum temperature, output voltage and current, and will improve appreciably if units are operated in less arduous conditions. An indication of the possible improvement can be obtained from the accompanying graphs.

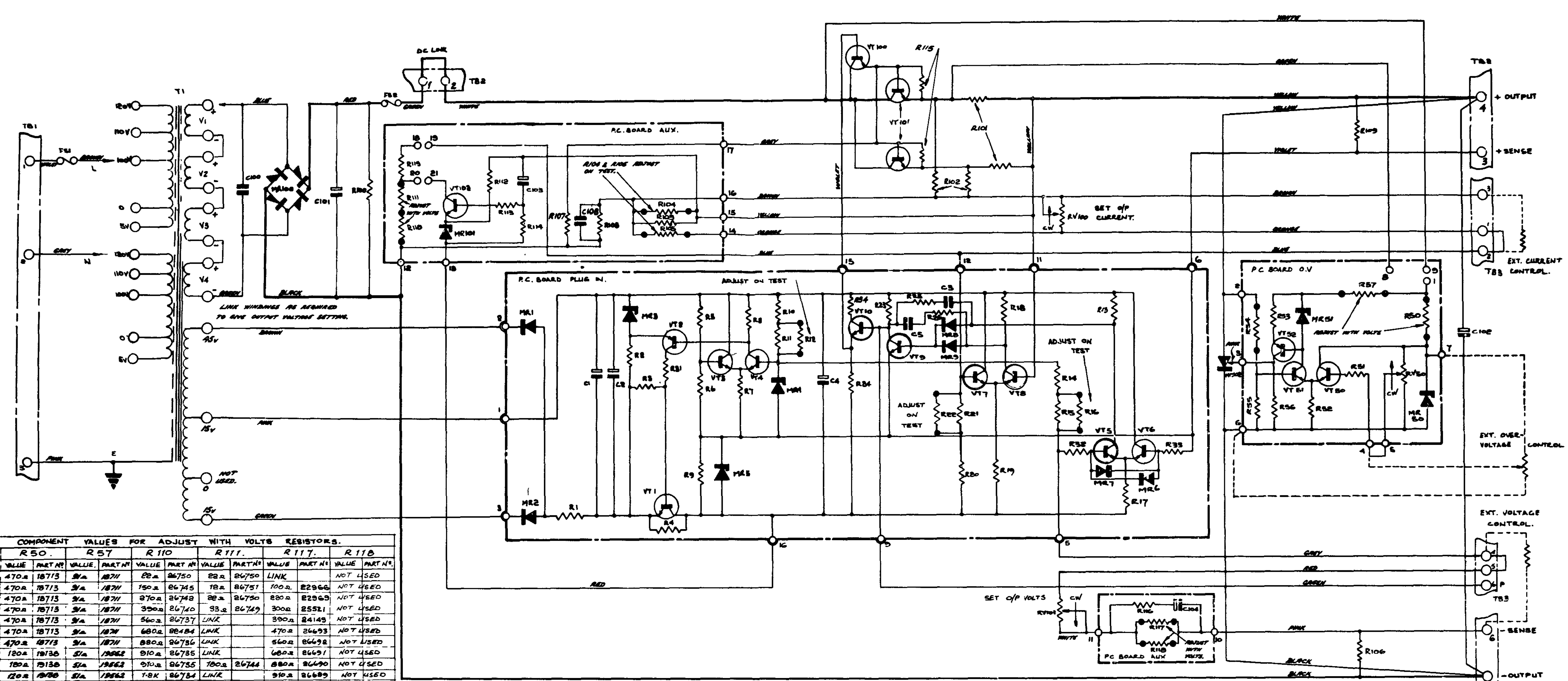
Unit	PM44-47	PM48-50	PM51-53	PM54-56
Estimated MTBF hrs	35,000	34,000	29,000	25,000



Graph 4



Graph 5



COMPONENT VALUES FOR ADJUST WITH VOLTS RESISTORS.

	R50.		R57		R 110		R 111.		R 117.		R 118	
VOLTS.	VALUE	PART Nº	VALUE.	PART Nº	VALUE	PART Nº	VALUE	PART Nº	VALUE	PART Nº	VALUE	PART Nº
1	470Ω	18713	91Ω	18711	22Ω	26750	22Ω	26750	LINK		NOT USED	
2	470Ω	18713	91Ω	18711	150Ω	26745	12Ω	26751	100Ω	22966	NOT USED	
3	470Ω	18713	91Ω	18711	270Ω	26742	22Ω	26750	220Ω	22969	NOT USED	
4	470Ω	18713	91Ω	18711	390Ω	26740	33Ω	26749	300Ω	25521	NOT USED	
5	470Ω	18713	91Ω	18711	560Ω	26737	LINK		390Ω	24149	NOT USED	
6	470Ω	18713	91Ω	18711	680Ω	22484	LINK		470Ω	26693	NOT USED	
7	470Ω	18713	91Ω	18711	820Ω	26736	LINK		560Ω	26692	NOT USED	
8	120Ω	19138	51Ω	19562	910Ω	26735	LINK		680Ω	26691	NOT USED	
9	120Ω	19138	51Ω	19562	910Ω	26735	180Ω	26744	820Ω	26690	NOT USED	
10	120Ω	19138	51Ω	19562	1·2K	26734	LINK		910Ω	26689	NOT USED	
11	470Ω	18713	51Ω	19562	1·2K	26734	150Ω	26745	1·0K	26688	NOT USED	
12	470Ω	18713	51Ω	19562	1·2K	26734	270Ω	26742	1·1K	26687	NOT USED	
13	470Ω	18713	51Ω	19562	1·5K	26733	100Ω	26747	1·2K	26686	NOT USED	
14	470Ω	18713	150Ω	19139	1·5K	26733	220Ω	26743	1·3K	26685	NOT USED	
15	470Ω	18713	150Ω	19139	1·8K	26732	47Ω	26748	1·4K	26684	NOT USED.	
16	470Ω	18713	150Ω	19139	1·8K	26732	180Ω	26744	1·5K	26683	47K	19148
17	470Ω	18713	150Ω	19139	1·8K	26732	330Ω	26741	1·6K	26682	12K	19145
18	470Ω	18713	150Ω	19139	1·8K	26732	470Ω	26739	1·8K	26682	22K	18776
19	470Ω	18713	220Ω	26765	2·2K	26730	180Ω	26744	1·8K	26682	68K	19160
20	470Ω	18713	220Ω	26765	2·2K	26730	330Ω	26741	2·0K	26681	27K	18718
21	1·5K	18709	220Ω	26765	2·2K	26730	430Ω	26752	2·0K	26681	82K	19151
22	1·5K	18709	220Ω	26765	2·2K	26730	560Ω	26737	2·2K	26680	33K	18705
23	1·5K	18709	220Ω	26765	2·7K	26728	220Ω	26743	2·2K	26680	100K	19152
24	1·5K	18709	220Ω	26765	2·7K	26728	330Ω	26741	2·4K	26679	33K	18705
25	1·5K	18709	330Ω	3870	3·0K	26727	180Ω	26744	2·4K	26679	100K	19152
26	1·5K	18709	330Ω	3870	3·3K	26726	LINK		2·7K	26678	27K	18718
27	1·5K	18709	330Ω	3870	3·3K	26726	120Ω	26746	2·7K	26678	47K	19148
28	1·5K	18709	330Ω	3870	3·3K	26726	270Ω	26742	2·7K	26678	120K	19153
29	1·5K	18709	330Ω	3870	3·3K	26726	390Ω	26740	3·0K	26677	33K	18705
30	1·5K	18709	330Ω	3870	3·3K	26726	510Ω	26738	3·0K	26677	56K	19149
31	2·7K	18771	390Ω	19800	3·6K	26725	330Ω	26741	3·0K	26677	160K	19595
32	2·7K	18771	390Ω	19800	3·6K	26725	470Ω	26739	3·3K	26181	39K	19147
33	2·7K	18771	470Ω	231	3·6K	26725	620Ω	22485	3·3K	26181	68K	19160
34	2·7K	18771	470Ω	231	3·9K	26724	470Ω	26739	3·3K	26181	220K	19156
35	2·7K	18771	470Ω	231	3·9K	26724	560Ω	26737	3·6K	26184	47K	19148
36	2·7K	18771	470Ω	231	2·4K	26729	1·2K	26734	3·6K	26184	82K	19151
37	2·7K	18771	470Ω	231	2·7K	26728	2·0K	26731	3·6K	26184	220K	19156
38	2·7K	18771	560Ω	19218	2·7K	26728	2·2K	26730	3·9K	26187	56K	19149
39	3·3K	18773	560Ω	19218	3·0K	26727	2·0K	26731	3·9K	26187	91K	19592
40	3·3K	18773	560Ω	19218	3·3K	26726	1·8K	26732	3·9K	26187	330K	19599
41	3·3K	18773	560Ω	19218	3·3K	26726	2·0K	26731	4·3K	26198	47K	19148
42	3·3K	18773	560Ω	19218	3·6K	26725	1·8K	26732	4·3K	26198	68K	19160
43	3·3K	18773	560Ω	19218	3·3K	26726	2·2K	26730	4·3K	26198	180K	19153
44	3·9K	18701	560Ω	19218	3·6K	26725	2·0K	26731	4·3K	26198	330K	19599
45	3·9K	18701	680Ω	19559	3·6K	26725	2·2K	26730	4·35K	26672	NOT USED	
46	3·9K	18701	680Ω	19559	3·9K	26724	2·0K	26731	4·45K	26671	NOT USED	
47	3·9K	18701	680Ω	19559	4·3K	26723	1·8K	26732	4·55K	26670	NOT USED	
48	4·3K	19580	680Ω	19559	4·7K	26722	1·5K	26733	4·65K	26669	NOT USED.	
49	4·3K	19580	680Ω	19559	4·3K	26723	2·0K	26731	4·75K	26668	NOT USED.	
50	4·3K	19580	680Ω	19559	4·3K	26723	2·2K	26730	4·85K	26667	NOT USED.	

ADJUST WITH UNIT.
COMPONENT VALUES FOR RESISTORS.
ALL ELECTROSIL TR5 ± 5%

	R 54		R 103		R 107	
UNITS.	VALUE	PART Nº	VALUE	PART Nº	VALUE	PART Nº
PM44	3·3K	18773	100Ω	18702	1·5K	18709
PM45	8·2K	19144	100Ω	18702	3·3K	18773
PM46	15K	18708	100Ω	18702	5·6K	18717
PM47	3·3K	18773	110Ω	19565	1·5K	18709
PM48	8·2K	19144	91Ω	18711	3·3K	18773
PM49	15K	18708	91Ω	18711	5·6K	18717
PM50	3·3K	18773	150Ω	19139	1·5K	18709
PM51	8·2K	19144	62Ω	19563	3·3K	18773
PM52	15K	18708	100Ω	18702	5·6K	18717
PM53	3·3K	18773	130Ω	18710	1·5K	18709
PM54	8·2K	19144	130Ω	18710	3·3K	18773
PM55	15K	18708	100Ω	18702	5·6K	18717
PM56	3·3K	18773	91Ω	18711	1·5K	18707

RESISTOR TYPES FOR ADJUST WITH VOLTS.

REF	DESCRIPTION.
R50	ELECTROSIL TR5 ±5%
R57	1–18V ELECTROSIL TR5 ±5%
R57	19–24V WELWYN W21 ±5%
R57	25–50V RWVA-J ±5%
R110	ELECTROSIL TR5 ±2%
R111	ELECTROSIL TR5 ±2%
R117	0-5V CGS CR1·5 ±5%
R117	6-31V CGS CR1·5 ±2%
R117	32-50V CGS CR1·5 ±1%
R118	ELECTROSIL TR5 ±5%

NOTE :- LINK PINS ON AUX. & O/V. P.C. BOARDS.

18-19 FOR RE-ENTRANT CUTOUT
20-21 FOR 200 mS CONSTANT CURRENT SWITCH ON.
1-9 FOR OVER VOLTAGE CIRCUITS 1-7V.
1-8 FOR OVER VOLTAGE CIRCUITS 8-50V.

COMPONENTS FOR PLUG IN P.C. BOARD ASSY Nº 26521

REF	DESCRIPTION	PART Nº
	RESISTORS	
R1	82Ω ELECTROSIL TR5 5%	19137
R2	5·6K ELECTROSIL TR5 5%	18717
R3	1K ELECTROSIL TR5 5%	19238
R4	680Ω ELECTROSIL TR5 5%	19143
R5	2K ELECTROSIL TR5 5%	18712
R6	11K ELECTROSIL TR5 5%	19575
R7	5·6K ELECTROSIL TR5 5%	18717
R8	12K ELECTROSIL TR5 5%	19145
R9	470Ω ELECTROSIL TR5 5%	18713
R10	200Ω ELECTROSIL TR5 1% / WELWYN METAL FILM 4013/D/200Ω ±1%	20046 / 50328
R11	510Ω ELECTROSIL TR5 5%	19571
R12	AOT ELECTROSIL TR5 5%	
R13	33K ELECTROSIL TR5 5%	18705
R14	560Ω C.G.S. TYPE CR1·5 5%	23232
R15	100Ω C.G.S. TYPE CR1·5 5%	22966
R16	A.O.T ELECTROSIL TR5 5%	
R17	4·7K ELECTROSIL TR5 5%	18706
R18	33K ELECTROSIL TR5 5%	18705
R19	4·7K ELECTROSIL TR5 5%	18706
R20	5·6K ELECTROSIL TR5 5%	18717
R21	1·2K ELECTROSIL TR5 5%	18700
R22	AOT ELECTROSIL TR5 5%	
R23	10K ELECTROSIL TR5 5%	18703
R24	6·8K ELECTROSIL TR5 5%	18714
R25	39Ω ELECTROSIL TR5 5%	19133
R26	LINK.	
R27	NOT USED.	
R28	NOT USED.	
R29	NOT USED	
R30	NOT USED	
R31	680Ω ELECTROSIL TR5 5%	19143
R32	47Ω ELECTROSIL TR5 5%	19134
R33	47Ω ELECTROSIL TR5 5%	19134
R34	220Ω ELECTROSIL TR5 5%	18697
	CAPACITORS	
C1	25µF 40V C428 AR/G25 MULLARD	20082
C2	25µF 40V C428 AR/G25 MULLARD	20082
C3	3300pF 10% 400V C296 AC/A MULLARD	774

REF	DESCRIPTION	PART Nº
	CAPACITORS (CONTD)	
C4	12·5µF 25V C428 AR/F12 5 MULLARD	22784
C5	0·01µF 20% 400V C296 AC/A MULLARD	781
	SEMICONDUCTORS	
MR1	DIODE AEI MS4H	20422
MR2	DIODE AEI MS4H	20422
MR3	ZENER DIODE STC ZF5 6	4109
MR4	DIODE INT. RECT IN821	25831
MR5	ZENER DIODE STC ZF5·1	20218
MR6	DIODE AEI MS1H	18806
MR7	DIODE AEI MS1H	18806
MR8	DIODE AEI MS1H	18806
MR9	DIODE AEI MS1H	18806
VT1	TRANSISTOR RCA 2N 3053	4039
VT2	TRANSISTOR MULLARD BCY70	23354
VT3	TRANSISTOR MULLARD BSX 20	23307
VT4	TRANSISTOR MULLARD BSX 20	23307
VT5	TRANSISTOR MULLARD BSX 20	23307
VT6	TRANSISTOR MULLARD BSX 20	23307
VT7	TRANSISTOR MULLARD BSX 20	23307
VT8	TRANSISTOR MULLARD BSX 20	23307
VT9	TRANSISTOR MULLARD BSX 20	23307
VT10	TRANSISTOR MULLARD BSX 20	23307
COMPONENTS FOR AUXILIARY P.C. BOARD		
	RESISTORS	
R103	SEE SEPERATE TABLE.	
R104	AOT ELECTROSIL TR5 5%	
R105	AOT ELECTROSIL TR5 5%	
R107	SEE SEPERATE TABLE.	
R108	NOT USED.	
R110	SEE ADJUST WITH VOLTS TABLE	
R111	SEE ADJUST WITH VOLTS TABLE	
R112	2·2K ELECTROSIL TR5 5%	18699
R113	5·6K ELECTROSIL TR5 5%	18717
R114	27K ELECTROSIL TR5 5%	18718

REF	DESCRIPTION	PART Nº
	RESISTORS (CONTD)	
R116	100Ω ELECTROSIL TR5 5%	18702
R117	SEE ADJUST WITH VOLTS TABLES	
R118	SEE ADJUST WITH VOLTS TABLE	
R119	100Ω ELECTROSIL TR5 5%	18702
	CAPACITORS	
C103	40µF 6·4V C428 AR/C40 MULLARD	26082
C104	5µF 64V C428 AR/H5 MULLARD	26294
C108	1000pF ±10% CERAMIC	22387
	SEMICONDUCTORS	
MR101	ZENER DIODE STC ZF3 3	4034
VT102	TRANSISTOR MULLARD BC108	26110
COMPONENTS FOR OVER VOLTAGE P.C. BOARD		
	RESISTORS	
R50	SEE ADJUST WITH VOLTS TABLE	
R51	1K ELECTROSIL TR5 5%	19338
R52	1·5K ELECTROSIL TR5 5%	18709
R53	33Ω ELECTROSIL TR5 5%	19132
R54	SEE SEPERATE TABLE.	
R55	1·5K ELECTROSIL TR5 5%	18709
R56	1K ELECTROSIL TR5 5%	19338
R57	SEE ADJUST WITH VOLTS TABLE.	
	POTENTOMETER	
RV50	3·3K 10% PLESSEY MPD	4425
	SEMICONDUCTORS	
MR50	ZENER DIODE STC ZF5 6	4109
MR51	ZENER DIODE HUGHES HS7027	21002
VT50	TRANSISTOR TEXAS 2S745 A	20831
VT51	TRANSISTOR TEXAS 2S745 A	20831
VT52	TRANSISTOR (SEE NOTE BELOW)	
	NOTE :- VT52 TRANSISTOR	
0-30V.	ALL UNITS USE BFX 88	22337
30-50V.	UNITS ONLY USE BFX 29	50181

REF	PM 44 DESCRIPTION	QTY	PART No
T1	TRANSFORMER	1	MT527
	CAPACITORS		
C100	MULLARD C296 AA/A (0 1μF 10% 160V)	1	804
C101	SPRAGUE 36D182G040AA2A (1800μF 40V)	1	22710
C102	MULLARD C431 BM/G500 (500μF 40V)	1	3102
	RESISTORS		
R100	ELECTROSIL TR5 (27K 5%)	1	18771
R101	CGS VPF 10 (1 5% 10W)	1	23066
R102	ELECTROSIL TR5 (10 5%)	2	19339
R106	ELECTROSIL TR5 (100 5%)	1	18702
R109	ELECTROSIL TR5 (100 5%)	1	18702
R115	ELECTROSIL TR5 (100 5%)	1	18702
	TRANSISTORS		
VT100	R.C.A 40250	1	4224
VT101	RCA 2N3055	1	3813
	MISCELLANEOUS		
MR100	RECTIFIER W005 PIRELLI 50V	1	19724
RV100	CONTROL POT COLVERN 1106/9S 120 10%	1	26272
RV101	CONTROL POT COLVERN 1106/9S 220 10%	1	26273
FS1	FUSE B/LEE L562 (240V 1A)	1	1254
FS2	FUSE B/LEE L562 (2 5A)	1	21189
MR101	THYRISTOR BTY 79/100R	1	18693

REF	PM 45 DESCRIPTION	QTY	PART No
T1	TRANSFORMER	1	MT624
	CAPACITORS		
C100	MULLARD C296 AA/A (0 1μF 10% 160V)	1	804
C101	SPRAGUE 36D851F075AA2A (850μF 75V)	1	22716
C102	MULLARD C431 BR/G500 (500μF 40V)	1	3102
	RESISTORS		
R100	ELECTROSIL TR5 (4 7K 5%)	1	18706
R101	CGS VPF 10 (1 5%)	1	23066
R102	ELECTROSIL TR5 (10 5%)	2	19339
R106	ELECTROSIL TR5 (100 5%)	1	18702
R109	ELECTROSIL TR5 (100 5%)	1	18702
R115	ELECTROSIL TR5 (100 5%)	1	18702
	TRANSISTORS		
VT100	RCA 40250	1	4224
VT101	RCA 2N3055	1	3813
	MISCELLANEOUS		
MR100	RECTIFIER W02 PIRELLI 200V	1	19725
RV100	CONTROL POT COLVERN 1106/9S 120 10%	1	26272
RV101	CONTROL POT COLVERN 1106/9S 330 10%	1	26758
FS1	FUSE B/LEE L562 (240V 2 5A)	1	21189
FS2	FUSE B/LEE L562 (2 5A)	1	21189
MR101	THYRISTOR BTY79/100R	1	18693

REF	PM 46 DESCRIPTION	QTY	PART No
T1	TRANSFORMER	1	MT529
	CAPACITORS		
C100	MULLARD C296 AA/A (0 1μF 10% 160V)	1	804
C101	SPRAGUE 36D901F100AB2A (900μF 100V)	1	22719
C102	MULLARD C431 BR/H500 (500μF 64V)	1	18780
	RESISTORS		
R100	CGS VPF-4 (6 8K 5%)	1	2053
R101	CGS VPF-10 (1 5%)	1	23066
R102	ELECTROSIL TR5 (10 5%)	2	19339
R106	ELECTROSIL TR5 (100 5%)	1	18702
R109	ELECTROSIL TR5 (100 5%)	1	18702
R115	ELECTROSIL TR5 (100 5%)	1	18702
	TRANSISTORS		
VT100	SDT 9202	1	24385
VT101	SDT 9202	1	24385
	MISCELLANEOUS		
MR100	RECTIFIER W02 PIRELLI 200V	1	19725
RV100	CONTROL POT COLVERN 1106/9S 120 10%	1	26272
RV101	CONTROL POT COLVERN 1106/9S 330 10%	1	26758
FS1	FUSE B/LEE L562 (240V 2 5A)	1	21189
FS2	FUSE B/LEE L562 (2 5A)	1	21189
MR101	THYRISTOR BTY 79/100R	1	18693

REF	PM 47 DESCRIPTION	QTY	PART No
T1	TRANSFORMER	1	MT584
	CAPACITORS		
C100	MULLARD C296 AA/A (0 1μF 10% 160V)	1	804
C101	SPRAGUE 36D42G040AD2A (6400μF 40V)	1*	22708
C102	MULLARD C431 BR/F1250 (1250μF 25V)	1	19215
	OR HUGHES 6000μF 40V FOR C101	1*	*22709*
	RESISTORS		
R100	CGS VPF-4 (820 5%)	1	19642
R101	CGS VPF-10 (0 33 5%)	1	24969
R102	ELECTROSIL TR5 (10 5%)	2	19339
R106	ELECTROSIL TR5 (100 5%)	1	18702
R109	ELECTROSIL TR5 (100 5%)	1	18702
R115	ELECTROSIL TR5 (100 5%)	1	18702
	TRANSISTORS		
VT100	RCA 2N3055	1	3813
VT101	RCA 2N3055	1	3813
	MISCELLANEOUS		
MR100	RECTIFIER TEXAS 1B40K20 200V	1	17763
RV100	CONTROL POT COLVERN 1106/9S 120 10%	1	26272
RV101	CONTROL POT COLVERN 1106/9S 220 10%	1	26273
FS1	FUSE B/LEE L562 (240V 2 5A)	1	21189
FS2	FUSE B/LEE L562 (4A)	1	5120
MR101	THYRISTOR BTY87/100R	1	23074

REF	PM 48 DESCRIPTION	QTY	PART No
T1	TRANSFORMER	1	MT624
	CAPACITORS		
C100	MULLARD C296 AA/A (0 1μF 10% 160V)	1	804
C101	SPRAGUE 36D392F075BB2A (3900μF 75V)	1	22714
C102	MULLARD C431 BR/G800 (800μF 40V)	1	2799
	RESISTORS		
R100	CGS VPF-10 (1 5K 5%)	1	4806
R101	CGS VPF-10 (0 68 5%)	2	23067
R102	ELECTROSIL TR5 (10 5%)	2	19339
R106	ELECTROSIL TR5 (100 5%)	1	18702
R109	ELECTROSIL TR5 (100 5%)	1	18702
R115	ELECTROSIL TR5 (100 5%)	2	18702
	TRANSISTORS		
VT100	RCA 40250	1	4224
VT101	RCA 2N3055	2	3813
	MISCELLANEOUS		
MR100	RECTIFIER TEXAS 1B40K20 200V	1	17763
RV100	CONTROL POT COLVERN 1106/9S 120 10%	1	26272
RV101	CONTROL POT COLVERN 1106/9S 330 10%	1	26758
FS1	FUSE B/LEE L693 (240V 3A)	1	12699
FS2	FUSE B/LEE L693 (5A)	1	638
MR101	THYRISTOR BTY87/100R	1	23074

REF	PM 49 DESCRIPTION	QTY	PART No
T1	TRANSFORMER	1	MT532
	CAPACITORS		
C100	MULLARD C296 AA/A (0 1μF 10% 160V)	1	804
C101	SPRAGUE 36D302F100BC2A (3000μF 100V)	1	22718
C102	MULLARD C431 BR/H800 (800μF 64V)	1	18147
	RESISTORS		
R100	CGS VPF-10 2·2K	1	17745
R101	CGS VPF-10 0 68	2	23067
R102	ELECTROSIL TR5 (10 5%)	2	19339
R106	ELECTROSIL TR5 (100 5%)	1	18702
R109	ELECTROSIL TR5 (100 5%)	1	18702
R115	ELECTROSIL TR5 (100 5%)	2	18702
	TRANSISTORS		
VT100	SDT 9202	1	24385
VT101	SDT 9202	2	24385
	MISCELLANEOUS		
MR100	RECTIFIER TEXAS 1B40K20 200V	1	17763
RV100	CONTROL POT COLVERN 1106/9S 120 10%	1	26272
RV101	CONTROL POT COLVERN 1106/9S 330 10%	1	26758
FS1	FUSE B/LEE L693 (240V 5A)	1	638
FS2	FUSE B/LEE L693 (7A)	1	13040
MR101	THYRISTOR BTY87/100R	1	23074

REF	PM 50 DESCRIPTION	QTY	PART No
T1	TRANSFORMER	1	MT583
	CAPACITORS		
C100	MULLARD C296 AA/A (0 1μF 10% 160V)	1	804
C101	SPRAGUE 36D123G040BC2A (12000μF 40V)	1	22501
C102	MULLARD C431 BR/F2000 (2000μF 25V)	1	4847
	RESISTORS		
R100	CGS VPF-10 (270 5%)	1	19641
R101	CGS VPF-10 (0 39 5%)	2	25142
R102	ELECTROSIL TR5 (10 5%)	2	19339
R106	ELECTROSIL TR5 (100 5%)	1	18702
R109	ELECTROSIL TR5 (100 5%)	1	18702
R115	ELECTROSIL TR5 (100 5%)	2	18702
	TRANSISTORS		
VT100	RCA 40250	1	4224
VT101	R.C.A. 2N3055	2	3813
	MISCELLANEOUS		
MR100	RECTIFIER SEMTECH SCBA2 200V	1	22721
RV100	CONTROL POT COLVERN 1106/9S 120 10%	1	26272
RV101	CONTROL POT COLVERN 1106/9S 220 10%	1	26273
FS1	FUSE B/LEE L693 (240V 3A)	1	12699
FS2	FUSE B/LEE L693 (7A)	1	13040
MR101	THYRISTOR BTY87/100R	1	23074

REF	PM 51 DESCRIPTION	QTY	PART No
T1	TRANSFORMER	1	MT626
	CAPACITORS		
C100	MULLARD C296 AA/A (0 1μF 10% 160V)	1	804
C101	SPRAGUE 36D692F075BD2A (6900μF 75V)	1*	22712
C102	MULLARD C431 BR/G2500 (2500μF 40V)	1	4848
	OR HUGHES 6200μF 75V FOR C101	1*	*22713*
	RESISTORS		
R100	CGS VPF-10 (470 5%)	1	4805
R101	CGS VPF-10 (0·82 5%)	4	25143
R102	ELECTROSIL TR5 (22 5%)	4	18707
R106	ELECTROSIL TR5 (100 5%)	1	18702
R109	ELECTROSIL TR5 (100 5%)	1	18702
R115	ELECTROSIL TR5 (100 5%)	4	18702
	TRANSISTORS		
VT100	RCA 2N3055	1	3813
VT101	RCA 2N3055	4	3813
	MISCELLANEOUS		
MR100	RECTIFIER SEMTECH SCBA2 (200V)	1	22721
RV100	CONTROL POT COLVERN 1106/9S (120 10%)	1	26272
RV101	CONTROL POT COLVERN 1106/9S (330 10%)	1	26758
FS1	FUSE B/LEE L693 (240V 5A)	1	638
FS2	FUSE B/LEE L693 (7A)	1	13040
MR101	THYRISTOR BTY87/100R	1	23074

REF	PM 52 DESCRIPTION	QTY	PART No
T1	TRANSFORMER	1	MT535
	CAPACITORS		
C100	MULLARD C296 AA/A (0 1μF 10% 160V)	1	804
C101	SPRAGUE 36D532F100CC2A (5300μF 100V)	1	22717
C102	MULLARD C431 BR/H2500 (2500μF 64V)	1	4849
	RESISTORS		
R100	CGS VPF-10 (1 5K 5%)	1	4806
R101	CGS VPF-10 (1 5%)	5	23066
R102	ELECTROSIL TR5 (27 5%)	5	19131
R106	ELECTROSIL TR5 (100 5%)	1	18702
R109	ELECTROSIL TR5 (100 5%)	1	18702
R115	ELECTROSIL TR5 (100 5%)	5	18702
	TRANSISTORS		
VT100	SDT 9202	1	24385
VT101	SDT 9202	5	24385
	MISCELLANEOUS		
MR100	RECTIFIER SEMTECH SCBA2 (200V)	1	22721
RV100	CONTROL POT COLVERN 1106/9S (120 10%)	1	26272
RV101	CONTROL POT COLVERN 1106/9S (330 10%)	1	26758
FS1	FUSE B/LEE L693 (240V 7A)	1	13040
FS2	FUSE B/LEE L693 (7A)	1	13040
MR101	THYRISTOR BTY87/100R	1	23074

REF	PM 53 DESCRIPTION	QTY	PART No
T1	TRANSFORMER	1	MT582
	CAPACITORS		
C100	MULLARD C296 AA/A (0 1μF 10% 160V)	1	804
C101	SPRAGUE 36D123G040BC2A (12000μF 40V)	2	22501
C102	MULLARD C431 BR/F4000 (4000μF 25V)	1	4850
	RESISTORS		
R100	CGS VPF-10 (270 5%)	1	19641
R101	CGS VPF-10 (0 39 5%)	4	25142
R102	ELECTROSIL TR5 (22 5%)	4	18707
R106	ELECTROSIL TR5 (100 5%)	1	18702
R109	ELECTROSIL TR5 (100 5%)	1	18702
R115	ELECTROSIL TR5 (100 5%)	4	18702
	TRANSISTORS		
VT100	RCA 2N3055	1	3813
VT101	RCA 2N3055	4	3813
	MISCELLANEOUS		
MR100	RECTIFIER SEMTECH SCBA2 (200V)	1	22721
RV100	CONTROL POT COLVERN 1106/9S (120 10%)	1	26272
RV101	CONTROL POT COLVERN 1106/9S (220 10%)	1	26273
FS1	FUSE B/LEE L693 (240V 5A)	1	638
FS2	FUSE B/LEE L1055 (12A)	1	20834
MR101	THYRISTOR 2N 3896	1	25473

REF	PM 54 DESCRIPTION	QTY	PART No
T1	TRANSFORMER	1	MT627
	CAPACITORS		
C100	MULLARD C296 AA/A (μF 10% 160V)	1	807
C101	SPRAGUE 36D692F075BD2A (6900μF 75V)	1*	22712
C102	MULLARD C431 BR/G4000 (4000μF 40V)	1	4851
	OR HUGHES 6200μF 75V FOR C101	1*	*22713*
	RESISTORS		
R100	CGS VPF-14 (470 5%)	1	19363
R101	CGS VPF-O (0 68 5%)	7	23067
R102	ELECTROSIL TR5 (33 5%)	7	19132
R106	ELECTROSIL TR5 (100 5%)	1	18702
R109	ELECTROSIL TR5 (100 5%)	1	18702
R115	ELECTROSIL TR5 (100 5%)	7	18702
	TRANSISTORS		
VT100	RCA 2N3055	1	3813
VT101	RCA 2N3055	7	3813
	MISCELLANEOUS		
MR100	RECTIFIER LUCAS DIODES DD6123 200V	2	27214
	RECTIFIER LUCAS DIODES DD6123A 200V	2	27215
RV100	CONTROL POT COLVERN 1106/9S (120 10%)	1	26272
RV101	CONTROL POT COLVERN 1106/9S (330 10%)	1	26758
FS1	FUSE B/LEE L693 (240V 7A)	1	13040
FS2	FUSE B/LEE L1055 (12A)	1	20834
MR101	THYRISTOR 2N3896	1	25473

REF	PM 55 DESCRIPTION	QTY	PART No
T1	TRANSFORMER	1	MT538
	CAPACITORS		
C100	MULLARD C296 AA/A (μF 10% 160V)	1	807
C101	SPRAGUE 36D532F100CC2A (5300μF 100V)	2	22717
C102	MULLARD C431 BR/H2500 (2500μF 64V)	2	4849
	RESISTORS		
R100	CGS VPF-14 (1K)	2	18755
R101	CGS VPF-10 (1)	10	23066
R102	ELECTROSIL TR5 (51 5%)	10	19562
R106	ELECTROSIL TR5 (100 5%)	1	18702
R109	ELECTROSIL TR5 (100 5%)	1	18702
R115	ELECTROSIL TR5 (100 5%)	10	18702
	TRANSISTORS		
VT100	RCA SDT 9202	1	24385
VT101	RCA SDT 9202	10	24385
	MISCELLANEOUS		
MR100	RECTIFIER LUCAS DIODES DD6123 200V	2	27214
	RECTIFIER LUCAS DIODES DD6123A 200V	2	27215
RV100	CONTROL POT COLVERN 1106/9S (120 10%)	1	26272
RV101	CONTROL POT COLVERN 1106/9S (330 10%)	1	26758
FS1	FUSE B/LEE L693 (240V 10A)	1	4227
FS2	FUSE B/LEE L1055 (12A)	1	20834
MR101	THYRISTOR 2N 3896	1	25473

REF	PM 56 DESCRIPTION	QTY	PART No
T1	TRANSFORMER	1	MT618
	CAPACITORS		
C100	MULLARD C296 AA/A (μF 10% 160V)	2	807
C101	SPRAGUE 36D123G040BC2A (12000μF 40V)	4	22501
C102	SPRAGUE 36D822G025AC2A (8200μF 25V)	1	25251
	RESISTORS		
R100	CGS VPF-14 (270 5%)	2	18767
R101	CGS VPF 10 (0 47 5%)	9	23069
R102	ELECTROSIL TR5 (47 5%)	9	19134
R106	ELECTROSIL TR5 (100 5%)	1	18702
R109	ELECTROSIL TR5 (100 5%)	1	18702
R115	ELECTROSIL TR5 (100 5%)	9	18702
	TRANSISTORS		
VT100	RCA 2N3055	1	3813
VT101	RCA 2N3055	9	3813
	MISCELLANEOUS		
MR100	RECTIFIER LUCAS DIODES DD6123 200V	2	27214
	RECTIFIER LUCAS DIODES DD6123A 200V	2	27215
RV100	CONTROL POT COLVERN 1106/9S (120 10%)	1	26272
RV101	CONTROL POT COLVERN 1106/9S (220 10%)	1	26273
FS1	FUSE B/LEE L693 (240 10A)	1	4227
FS2	FUSE AEI GS150/25 (25A)	1	19021
MR101	THYRISTOR AEI CR-26-051 B1	1	27298

This instrument is guaranteed for a period of one year from its delivery to the purchaser, covering the replacement of defective parts other than tubes, semiconductors and fuses. Tubes and semiconductors are subject to the manufacturers' guarantee.

We maintain comprehensive after sales facilities and the instrument can, if necessary, be returned to our factory for servicing. The Type and Serial Number of the instrument should always be quoted, together with full details of any fault and the service required. The Service Department can also provide maintenance and repair information by telephone or letter.

Equipment returned to us for servicing must be adequately packed, preferably in the special box supplied, and shipped with the transportation charges prepaid. We can accept no responsibility for instruments arriving damaged. Should the cause of failure during the guarantee period be due to misuse or abuse of the instrument, or if the guarantee has expired, the repair will be put in hand without delay and charged unless other instructions are received.

OUR SALES, SERVICE AND ENGINEERING DEPARTMENTS ARE READY TO ASSIST YOU AT ALL TIMES.

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