FARNELL INSTRUMENTS LIMITED.

INSTRUCTION MANUAL

"S" SERIES
STABILISED POWER SUPPLY UNITS
ISSUE 3

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CONTENTS

SECTION I

INTRODUCTION

The "S" series of units consists of a range of mains driven D.C. stabilised output voltage power supplies in sub-unit form. The output voltage and current ratings of the various unit types are given in the table in section IV, Page 6 The circuit diagram contained in the manual applies to the unit type supplied.

Output voltage is preset on test to a user specified voltage within the operating range of the particular unit type. Fine adjustment of ±1 volt about the preset voltage is available by means of a trimmer potentiometer on the unit front panel.

Overcurrent protection is provided by re-entrant current limiting, which resets when the overload is removed.

Overvoltage protection, consisting of S.C.R. "Crowbar" circuitry, is fitted to units on request.

The units are cooled by natural convection and provision should be made for free air flow into the bottom and out of the top of the unit particularly in the area of the main heat sinks. If the unit is to be mounted on a flat plate ventilation holes should be punched in the plate or the unit raised off the plate by at least 9.5 mm.

Mains input is normally set to 240 50-400 Hz. Inputs of 210 220, 230V and 105, 110, 115 and 120V can be accommodated by simple tap change on the transformer tag board. Mains and D.C. line fuses are fitted as additional protection.

SECTION II

OPERATION

1. Mains input is connected to the mains input terminals on the front panel (marked "L" "N" and "E".)

2. TWO TERMINAL OPERATION.

   For applications where remote sensing of load voltage is not required, the "FEEDBACK +" and "OUTPUT +" terminals should be linked, the "FEEDBACK -", "P" and "OUTPUT -" terminals should also be linked. Output connection should then be made to the "OUTPUT "+" and "-" terminals. Units are supplied from the Factory connected for this mode of operation, the connections being by means of tinned brass links.

3. FOUR TERMINAL OPERATION.

   For applications requiring compensation of the voltage drop in the leads between the unit and the load, the connections are as follows:

   (a) Remove the links between the "OUTPUT +" and "FEEDBACK +" terminals and between the "OUTPUT -" and "FEEDBACK -" terminals. The link between the "FEEDBACK -" and "P" terminals should be left connected.

   (b) Connect the load current carrying leads between the "OUTPUT +" and "-" terminals and the load.

   (c) Connect additional leads from the positive end of the load to the "FEEDBACK +" terminal, and from the negative end of the load to the "FEEDBACK -" terminal.
   Please refer to Section VI Page 9 for additional information on the use and limitations of this mode of operation.

4. RESISTIVE PROGRAMMING.

   The output voltage may be resistively programmed by introducing external resistance between the "FEEDBACK -" and the "P" terminals, after first removing the link normally connected between them.
   Please refer to Section VI Page 9 for notes on the use of this mode of operation.

5. OUTPUT VOLTAGE ADJUSTMENT.

   Each unit output voltage is preset to a user specified voltage.
   Fine adjustment of this voltage is available by means of the "OUTPUT ADJUST" control on the front panel.

   NOTE:- Although more adjustment is available, not greater than $\pm$ 1 volt deviation from preset voltage should be used, and for correct operation, the Unit maximum specified output voltage should not be exceeded.

6. CURRENT LIMIT ADJUSTMENT.

Should the current limit point need adjustment, the "CURRENT LIMIT" control is available on the front panel. Current limit is normally set 10% in excess of the unit maximum specified output current.

7. OVERVOLTAGE TRIP POINT ADJUSTMENT.

On units fitted with overvoltage protection, should the overvoltage trip point need adjustment a trimmer potentiometer is available on the upper edge of the main control circuit board. The trip point is normally set 20% in excess of the unit preset output voltage.

If the output voltage of this type of unit is adjusted as in 5 then it may be necessary to readjust the overvoltage trip point.
The method of adjustment is detailed in Section V Page.7

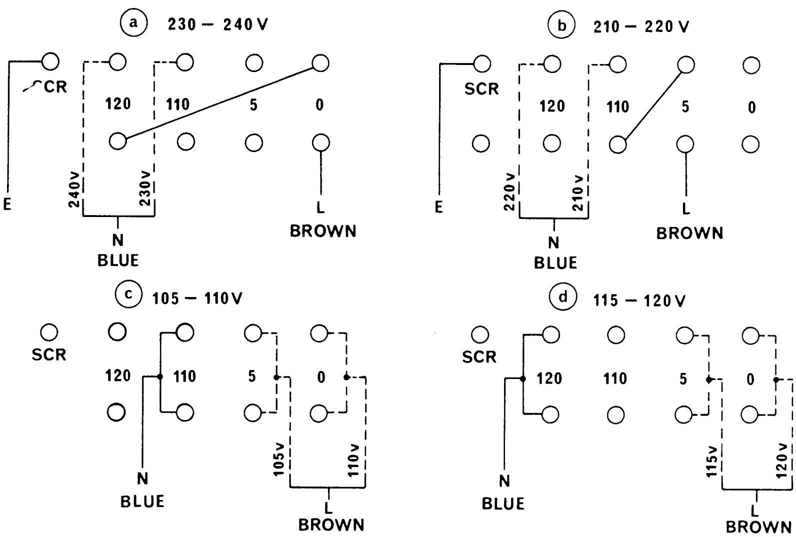
8. TRANSFORMER TAP SELECTION.

Units are normally set for 240V mains input. For other input voltages refer to Figure 1.

9. FUSES.

Fuses are fitted as additional protection on these units. They are located on the unit front panel, and their values are marked.
On heavy current units, the output fuse link is fitted within the body of the unit and reference should be made to the circuit diagram for the type and rating.

FIGURE 1 S' Series Primary Connections.



SECTION III

CIRCUIT DESCRIPTION.

The circuit employs series regulator transistors driven by emitter followers from a two stage differential amplifier which compares the voltage of a zener diode reference with a proportion of the output voltage derived from a resistive potential divider. The reference and amplifier sections are mounted on a plug-in printed circuit board which is common to all units in the range. The circuit diagram is in two parts, the current carrying components external to the board and the board itself.

The mains supply is connected to transformer MT1 via the input terminals and fuse F1. The main secondary windings supply a bridge rectifier, reservoir capacitor system, which provides the main unregulated D.C. supply. The positive line is connected via the series regulator transistors to the positive output terminal. The negative line is connected via fuse F2 to the negative output terminal.

The supply for the amplifier and reference section is derived from the auxiliary 36V-0-36V secondary transformer winding. Rectifiers D1 and D2 and capacitors C1 and C2 provide a D.C. supply rail. Z1 and Z2 provide a - 10V - 0 - +15V amplifier supply. VT4, R11, Z4, R14, and R15 comprise a constant current source feeding the main reference zener diode Z3 and potential divider chain R12, R13, and T2.

The base of VT6 and the negative of Z3 are connected to the zero of the - 10V - 0 - +15V supply, which in turn are connected via Pin 11 to the positive feedback terminal. Z3 gives a positive voltage with respect to the positive output terminal. R12 is connected between the positive of Z3 and VT5 base (R16 is merely for protection and takes no action in the control loop). Signal applied between VT5 and VT6 bases is amplified at VT5 collector and fed via D5 to VT9 base. It is further amplified at VT9 collector and fed to the first output emitter follower VT7, the signal is then fed via Pin 13 to the emitter follower (s) of the output series regulator stage and hence to the output terminal. This gives rise to a change in output voltage which is fed back to VT5 via potential divider R12, R13, and T2 in such a sense as to appose the original signal between VT5 and VT6 bases. The action of the loop is therefore to maintain zero voltage between VT5 and VT6 bases. Output voltage is defined by:-

$$Vo = \frac{V\ ref}{R12} (R13 + T2)$$

Where V ref is the voltage of Z3.

OVERCURRENT PROTECTION.

When output current is low VT12 is conducting and VT11 is cut off. As output current increases, the voltage across the emitter sharing resistors of the output series regulators increases and this voltage, fed to VT12 base, via T4 and R34 eventually causes VT12 to begin to cut off. VT11 then begins to conduct. The voltage across R30 begins to increase until D6 begins to conduct and applies more drive to VT9 base. The drive available to VT7 and hence to the output series regulator stage is therefore reduced. At this point further increase in load causes no further increase in current and the output voltage begins to fall. VT5 then cuts off by the action of potential divider R12, R13 and T2 reverse biasing D5. Also as output voltage falls the base of VT12 is driven more positive by the action of potential divider R35, R34 and T4. This causes VT12 to conduct less and VT11 to conduct more. VT9 is therefore driven further into conduction which reduces the output drive to the series regulator stages. In the absence of R33 the process would be regenerative, i.e. as soon as the limit point was reached, the output would fall immediately to zero. R33 increases the slope of the output V/I characteristic to produce the curve shown in Figure 2 Page 12 . With increasing overload the action of the circuitry is to reduce both output voltage and current until at short circuit the output current is approximately 10% of the maximum output current. This ensures that the unit will reset into normal loads, once the overload is removed.

OVERVOLTAGE PROTECTION.

For units fitted with overvoltage protection, the output voltage is sampled by potential divider chain R9, T1 and R10. As soon as output voltage approaches the overvoltage trip level, VT3 begins to cut off causing VT2 to conduct by regeneration from VT3 collector via R5 to VT2 base. This drives VT1 into conduction, which supplies gate drive to SCR1 which conducts. SCR1 is connected directly across the unit output and when conducting effectively shorts the output.

SECTION 1V

SPECIFICATION.

MAINS INPUT.

Standard:- 240 volt 50/60 Hz.

By internal link changes: 210, 220, 230,) 105, 110, 115, 120V) 50/60 Hz

Maximum mains variation tolerated:- ± 10% of nominal input voltage.

OUTPUT VOLTAGE AND CURRENT RANGES.

Output Current	Single Output Volts, Pre-Set Between							
	0-7V	Size	7-15V	Size	15-30V	Size	30-50V	Size
1A	-		-		30/1	A	50/1	B
2A	-		15/2	A	30/2	B	-	
3A	7/3	A	15/3	B	30/3	C	50/3	D
5A	7/5	B	15/5	C	30/5	D	50/5	F
10A	7/10	D	15/10	E	30/10	F	50/10	H
15A	-		15/15	F	-		-	
20A	7/20	G	15/20	H	30/20	J	-	
30A	7/30	H	15/30	J	-		-	
50A	7/50	J	-		-		-	
	Twin Output, Volts Pre-Set Between							
	0 - 15			Size	15 - 30			Size
0.5A	-				30/05T			P
1A	15/1T			P	30/1T			Q
2A	15/2T			Q	-			
3A	-				30/3T			F
5A	15/5T			F				

Options:- Crowbar Protection, Add C to Type No.
Low Temp Coefficient, Add T to Type No.

STABILITY.

(a) LINE:-
Output change for 10% mains change, short term - 1: 10,000 or 1mV whichever is greater.

(b) LOAD:-

Output change for zero to full load change short term -1; 10,000 or 1mV whichever is greater.

RIPPLE.

Ripple and noise. Less than 500 V p-p measured at 80 KHz bandwidth.

OVERLOAD PROTECTION.

Current limiting with reduction of output current on increasing overload set to 110% max output current. Short circuit current approximately 10% max output current.

AMBIENT TEMPERATURE.

Ambient temperature range for full load operation 0-60°C.
Storage temperature range -40°C to + 85°C.

SECTION V

INTERNAL ADJUSTMENT

The procedure for setting the unit to a given output voltage is as follows:-

1. Resistor R13 in the feedback voltage divider sets the unit output voltage, its value is given by:-

$$R13 = \frac{2.2}{V\ ref.} \times (Vo - 2)\ K\ ohm$$

   Where V ref is the voltage of reference zener diode Z3 (nominal 5.1V) and Vo is the required output voltage. For voltages below 2V R13 should be a wire link.

2. Resistor R35 sets the point at which current limit occurs its value being given by:-

$$R35 = Vo \times 0.5\ K\ ohm.$$

3. Resistor R34 restricts the maximum possible output current to 110% I max, and is selected on test to give a current limit point of 110% I max with T4, the CURRENT LIMIT adjusting trimmer potentiometer set at maximum (fully clockwise).

4. Transformer tap selection is made according to Tables 1, 2 or 3 Page 15.

5. Trimmer potentiometer T3, located on the main control circuit board, adjusts the zero balance of transistors VT11 and VT12. It is adjusted to give a unit short circuit load current of 10% of I max.

6. For units fitted with overvoltage protection, resistor R9 is given by:-

$$R9 = \frac{2.2}{V\ ref.} \times \left[(Vo + 20\%) - 2\right] K\ ohm$$

   Final adjustment of the overvoltage trip point is made by trimmer potentiometer T1, located on the upper edge of the control circuit board.

   The procedure for setting the overvoltage trip point is as follows:-

   (a) Adjust trimmer potentiometer T1 to its fully clockwise position.

   (b) Remove the unit output fuse.

   (c) Apply a voltage to the unit output terminals from an external variable voltage D.C. source, capable of 500mA output and current limit protected, taking care to observe marked polarities.

   (d) Switch on the unit and adjust the variable supply to the required trip voltage level (normally 20% in excess of unit output voltage).

(e) Adjust trimmer T1 until the voltage at the unit output terminals reduces to a low value. At this point the SCR crowbar has operated, short circuiting the unit output terminals.

(f) To recheck the trip point, switch off both supplies, reduce the voltage of the variable supply to the unit nominal output voltage, switch on both supplies then slowly increase the variable supply output voltage until the unit output voltage falls, the voltage at which the unit output falls is the trip level of the overvoltage circuit.

SECTION VI

TYPICAL PERFORMANCE AND APPLICATIONS

1. REMOTE SENSING.

Units are provided with sensing terminals to correct for resistive voltage drop in the load connecting leads. It is not possible to correct for more than 0.5V drop in each lead.

Addition of lead from the output terminals and feedback terminals increases the inductance in the feedback path, which may give rise to instability at high frequencies unless the following precautions are taken:

Positive output and positive feedback leads should be twisted together. Negative output and negative feedback leads should be twisted together. Since inductance is introduced between the output terminals and the load, the transient performance of the supply, at the load, is adversely affected. This may be restored by the addition of a capacitor, of the same value as the output capacitor within the unit, at the load terminals. It may also be necessary to decouple the output and feedback terminal pairs at the unit terminal block with low voltage electrolytic capacitors, to decouple the lead inductance at the supply. For the Output + and F/B + pair the capacitor positive is connected to Output +, and for the Output - and F/B - pair the capacitor positive is connected to F/B-.

NOTE: Care must be taken not to draw load current from the FEEDBACK terminals.

2. EXTERNAL PROGRAMMING.

Resistive programming of the supply is possible by introducing external resistance between the "FEEDBACK -" terminal and the "P" terminal. R13 should be replaced by a link and the "OUTPUT ADJUST" control adjusted to minimum (fully anticlockwise). The programming resistance Rprog, for a given output voltage Vo is given by:-

$$Rprog = \frac{Vo}{Vref} \quad 2.2. \text{ K ohm}$$

where Vref is the voltage of Z3 (5.1V nominal)

When the unit output voltage is programmed downwards from a given maximum, the current limit circuitry reduces the maximum current point of the supply. This is necessary to limit the amount of dissipation on the series regulator elements to a safe value. The permissable area of operation for a supply programmed from a voltage maximum of V, and maximum output current of 1, is given in Figure 2.

3. PARALLEL OPERATION

Units which are set to approximately the same output voltage may be connected directly in parallel. On increasing load the unit having the highest output voltage will carry the load until it current limits, thereafter the unit having the next highest voltage will supply the extra current until it limits and so on. A typical output characteristic for a parallel combination of three units is shown in Figure 3. The characteristic shows a series of descending steps in output voltage at the current limit points of individual units, the amplitude of the step depends on how closely the output voltages have been set and it may not be possible to adjust this to better than 50mV.

It is recommended that not more than three units are paralleled in this way.

4. SERIES OPERATION

Units may be connected in series, but diodes of current rating equal to the unit maximum output current, must be connected across the output terminals, cathode to positive. If all the load is connected directly across the series system, some difficulty may be experienced in attaining full output voltage when the mains is applied. On overload, difficulty may also be experienced on resetting the system when the overload is removed. Where possible a separate load switch should be incorporated to interrupt the load current on mains switch on and under overload conditions.

5. LAMP LOAD.

Where units are used to supply a lamp load the standard current limiting circuitry causes the unit to lock out if the load V/I characteristic intersects the unit V/I characteristic. The standard unit will accommodate a lamp load of approximately 60% of the maximum output current rating. If resistor R33 is changed to 33K then lamp loads of up to 100% of the maximum output current can be accommodated. This however means that the unit is not fully protected in its overload region. It will still accommodate short circuit overloads, but overloads between full load and short circuit could cause overheating of the series regulator element.

6. TYPICAL PERFORMANCE.

Stability.

Output voltage changes are due mainly to the following causes:-

(a) Load change
(b) Mains supply change
(c) Component temperature change.

(a) Load Change.

(i) Steady Load - For a change in steady load from zero to full load, typical output change is from 200uV at 1V output to 1mV at 30V output.

(ii) Transient Response - Typical response to a pulsed load is shown in Figure 4.

(iii) Output Impedance - For alternating load superimposed on a steady load, the output impedance of the supply increases with frequency due to fall off in gain of the control amplifier until it is determined only by the output capacitor. A typical output impedance/frequency curve is shown in Figure 5.

(b) Mains Supply Change.

Short term mains variation of up to $\pm$ 10% give corresponding variation of 0.01% on the output.

Surges on the mains in the form of short rise time pulses may be fed onto the output terminals by stray capacity. When monitoring the output waveform, both oscilloscope leads should be connected to the same output terminal before making a measurement to check that pulses, which may not appear across the unit terminals, are not present.

Where mains borne pulses exist it may be necessary to fit some form of mains input filter to the mains lead.

(c) Component Temperature Change.

Output variation is caused by component change due to temperature change. The temperature change can be:

(i) as a result of ambient temperature change or

(ii) as a result of internal temperature change, caused by change in load on mains input to the unit.

(i) Ambient Change - the typical temperature coefficient of the output voltage, at constant load and constant mains input is 0.02% per degree centigrade.

(ii) Internal Change - A typical plot of output variation against time for changes in mains input and load is shown in Figure 6.

7. MAXIMUM AMBIENT TEMPERATURE.

All units will supply full load to 60°C ambient. Above 60°C, the load current capacity derates linearly to zero at 80°C.

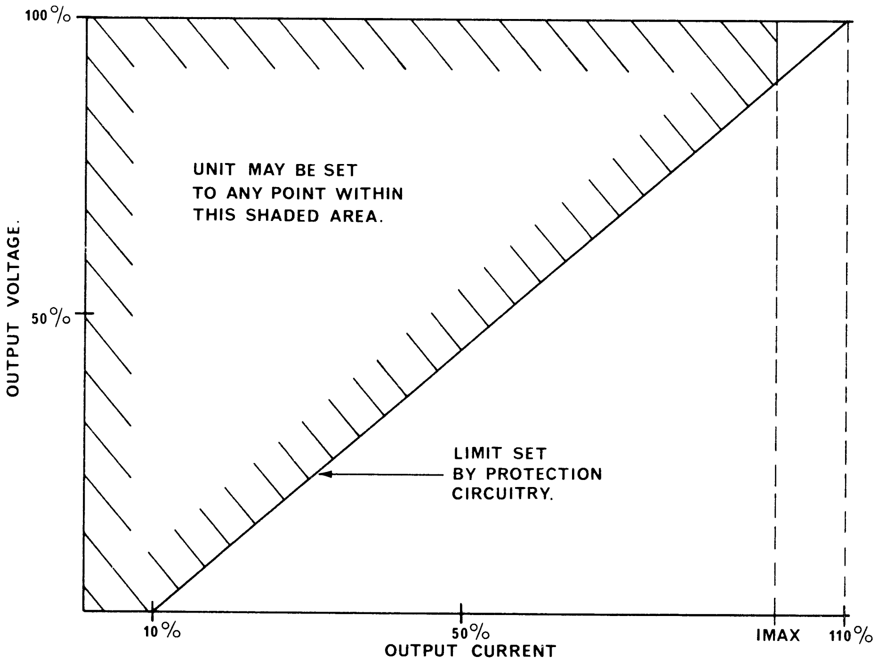


Fig. 2. PERMISSIBLE AREA OF OPERATION IN PROGRAMMED MODE.

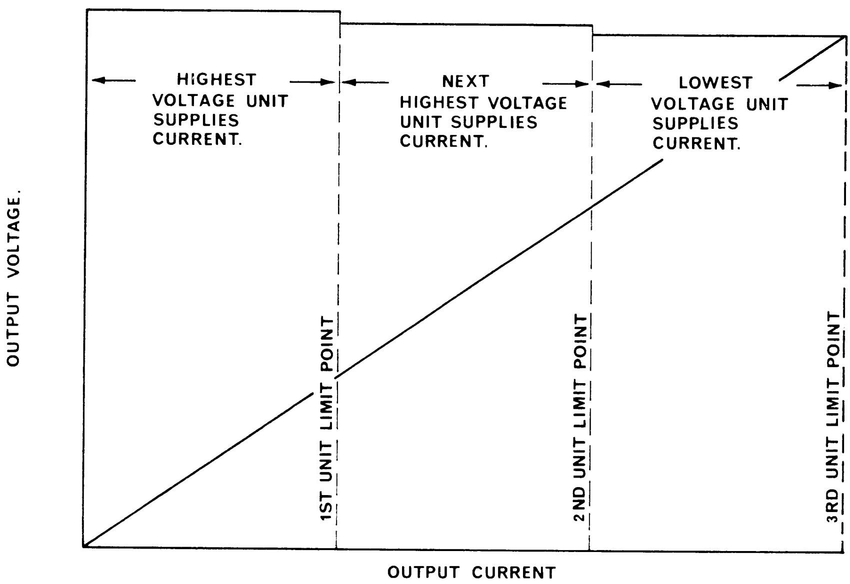


Fig. 3. PARALLEL OPERATION.

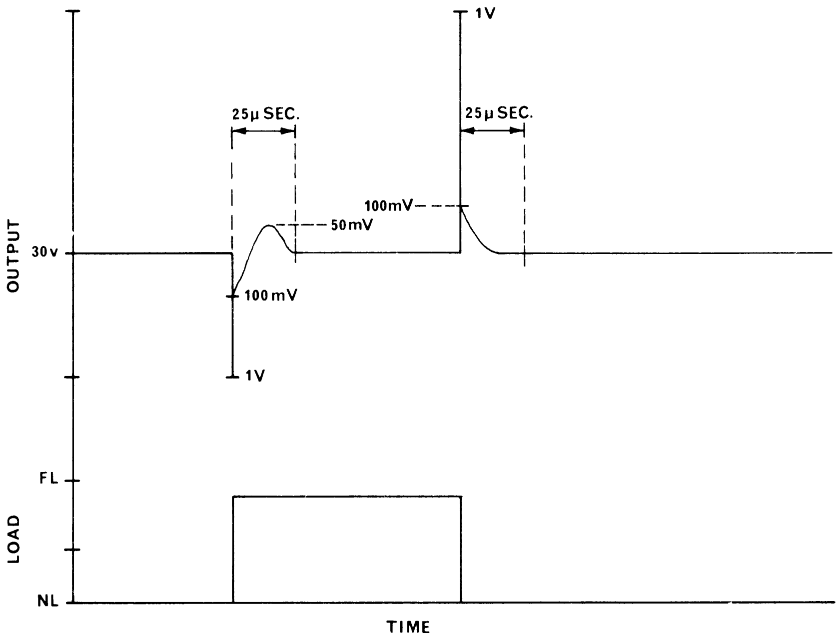


Fig.4. PULSE RESPONSE

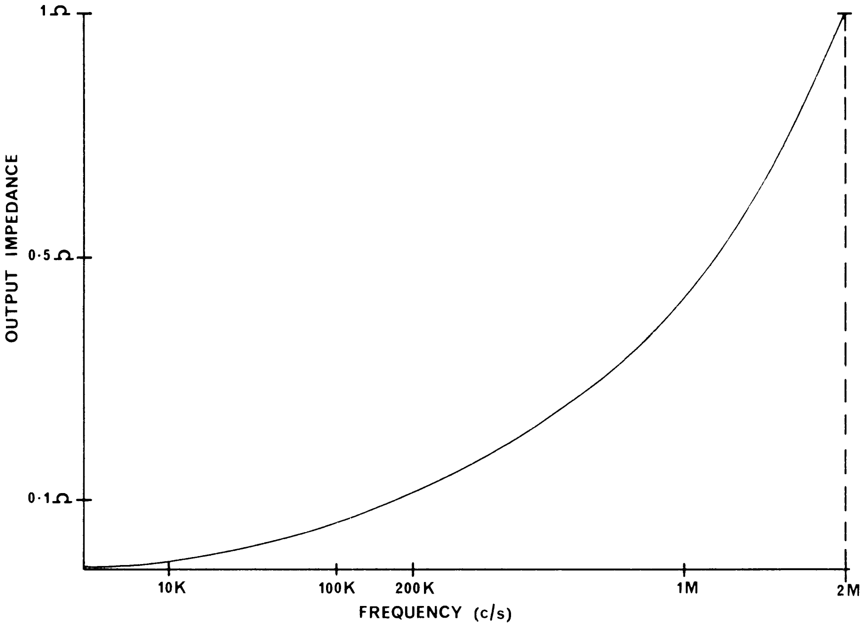


Fig.5. OUTPUT IMPEDANCE.

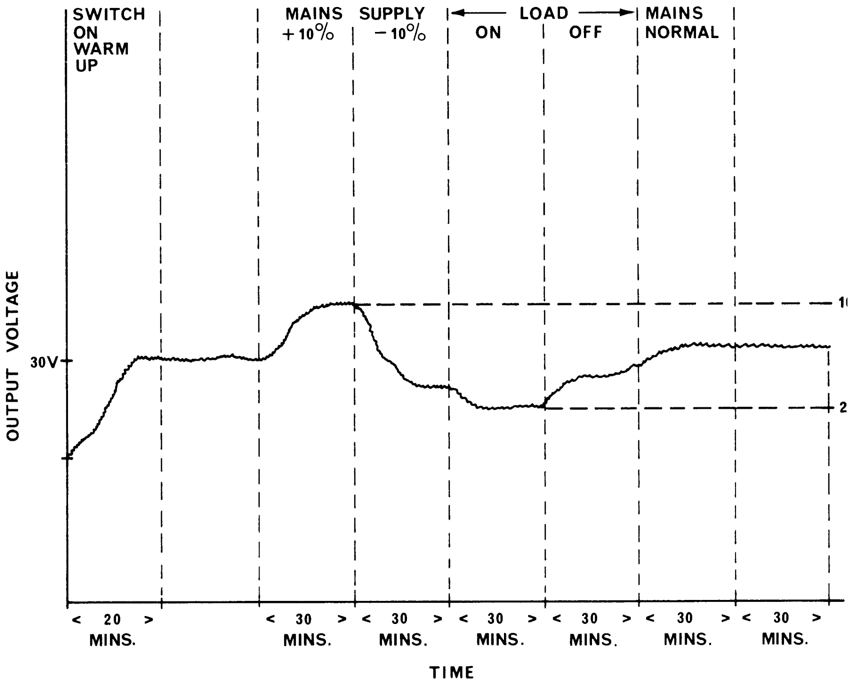


Fig.6. TYPICAL OUTPUT VOLTAGE VARIATION AGAINST TIME.

TABLE 1			
	OUTPUT VOLTS	CONNECT TO	LINK TOGETHER
15-30 Volt Units.	29 - 30	1 and 8	2 and 3
	28 - 29	1 and 8	2 and 4
	27 - 28	1 and 8	2 and 5
	25 - 27	1 and 8	2 and 6
	24 - 25	1 and 7	2 and 3
	23 - 24	1 and 7	2 and 4
	22 - 23	1 and 7	2 and 5
	20 - 22	1 and 7	2 and 6
	19 - 20	1 and 6	2 and 3
	18 - 19	1 and 5	2 and 3
	17 - 18	1 and 4	2 and 3
	15 - 17	1 and 2	

TABLE 2			
7-15 Volt Units.	14 - 15	1 and 8	2 and 3
	13 - 14	1 and 8	2 and 4
	11 - 13	1 and 8	2 and 5
	10 - 11	1 and 8	2 and 6
	9 - 10	1 and 7	2 and 3
	8 - 9	1 and 7	2 and 4
	6 - 8	1 and 7	2 and 5

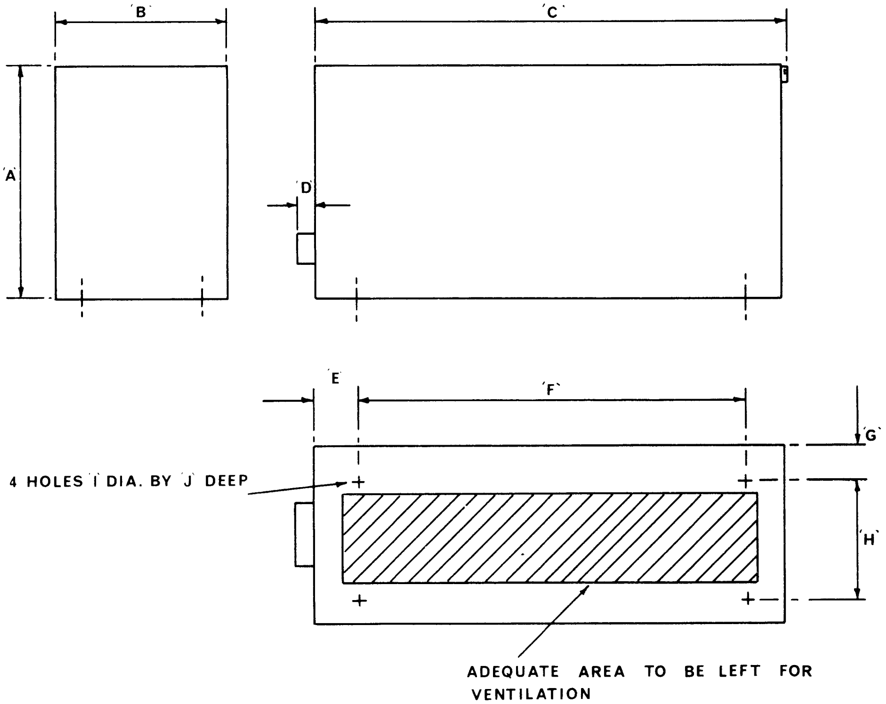
TABLE 3		
0-7 Volt Units.	6 - 7	1 and 7
	5 - 6	2 and 7
	4 - 5	3 and 7
	3 - 4	1 and 6
	2 - 3	1 and 6
	1 - 2	2 and 6
	0 - 1	2 and 6

SECTION VII

OVERALL SIZES AND FIXING DIMENSIONS

PACKAGE SIZE	A	B	C	D	E	F	G	H	I	J	WEIGHT	
											Kg	lbs
A	113	96	172	16	19.5	130	5	86	3M	8	2.3	5
B & C	125	110	248	16	27.5	190	5	100	3M	8	4.88	10.75
D	160	152	287	18	27.5	230	6.25	139.5	4M	8	8.05	19.75
E	160	152	318	18	27.5	260	6.25	139.5	4M	8	10.43	23
F	160	152	368	18	27.5	310	6.25	139.5	4M	8	13.15	29
G	160	152	426	18	27.5	370	6.25	139.5	4M	8	14.63	32.25
H	160	300	358	18	27.5	300	6.25	287.5	4M	8	20.3	44.75
J	215	348	412	18	27.5	340	6.25	335.5	4M	8	31.78	69.75
P	113	140	205	16	27.5	150	5	130	3M	8	3.71	7.4
Q	125	152	301	16	27.5	240	6.25	139.5	4M	8	7.12	14,2

The weights indicated in the above table are only approximate.



ERRATA AND ADDENDA

ALTERNATIVE COMPONENTS TO THOSE LISTED ON CIRCUIT DIAGRAM MAY BE USED IN THE EVENT OF SUPPLY DIFFICULTIES. MAJOR CHANGES TO THE DESIGN OR MANUAL ARE LISTED BELOW:-

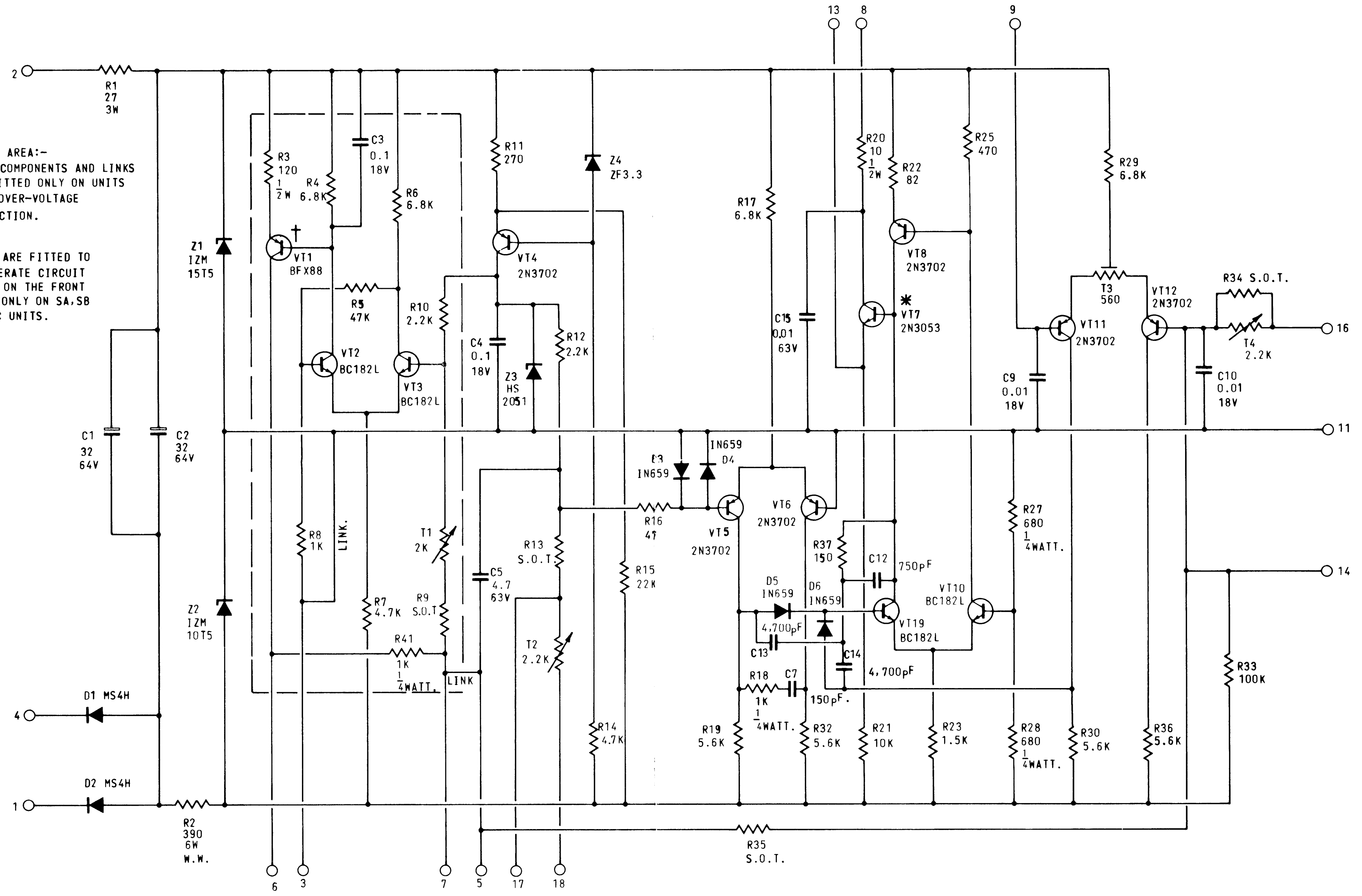
DRAWING No. 2 - 4602

USED ON

R	1 2 3 8 4 5 7 41 6 10 9 11 12, 13, 14, 15, 16 19, 17, 18, 32 37 20 21, 22 23, 25 27, 28, 30 29 36 34 33
C	1 2 3 4, 5 13 15, 7, 14, 12 9 10
VT	1 2 3 4 5 6 7 8 9 10 11 12
MISC	D1, 2 Z1, 2 T1 Z3 T2 Z4 D3, 4 D5, 6 T3 T4

SHADED AREA:-
THESE COMPONENTS AND LINKS ARE FITTED ONLY ON UNITS WITH OVER-VOLTAGE PROTECTION.

T2, T4 ARE FITTED TO A SEPERATE CIRCUIT BOARD ON THE FRONT PANEL ONLY ON SA, SB AND SC UNITS.



NOTE: CAPACITOR VALUES ARE MICROFARADS.
RESISTOR VALUES ARE IN OHMS UNLESS OTHERWISE STATED.

RESISTOR VALUES 1/2 WATT, 5% OR LESS UNLESS OTHERWISE STATED.
ABOVE 25V O P UNITS USE ZTX504
ABOVE 30V O P UNITS USE 2N1893

ISSUE	DATE	MOD. No.
4	3:2:71	853
3	3:12:70	823
2	15:7:70	777
1	19:3:70	

TRACED

CHECKED

DRAWN M.H.

FARNELL INSTRUMENTS LTD. WETHERBY, YORKS.

TITLE: CIRCUIT DIAGRAM S SERIES CIRCUIT BOARD.

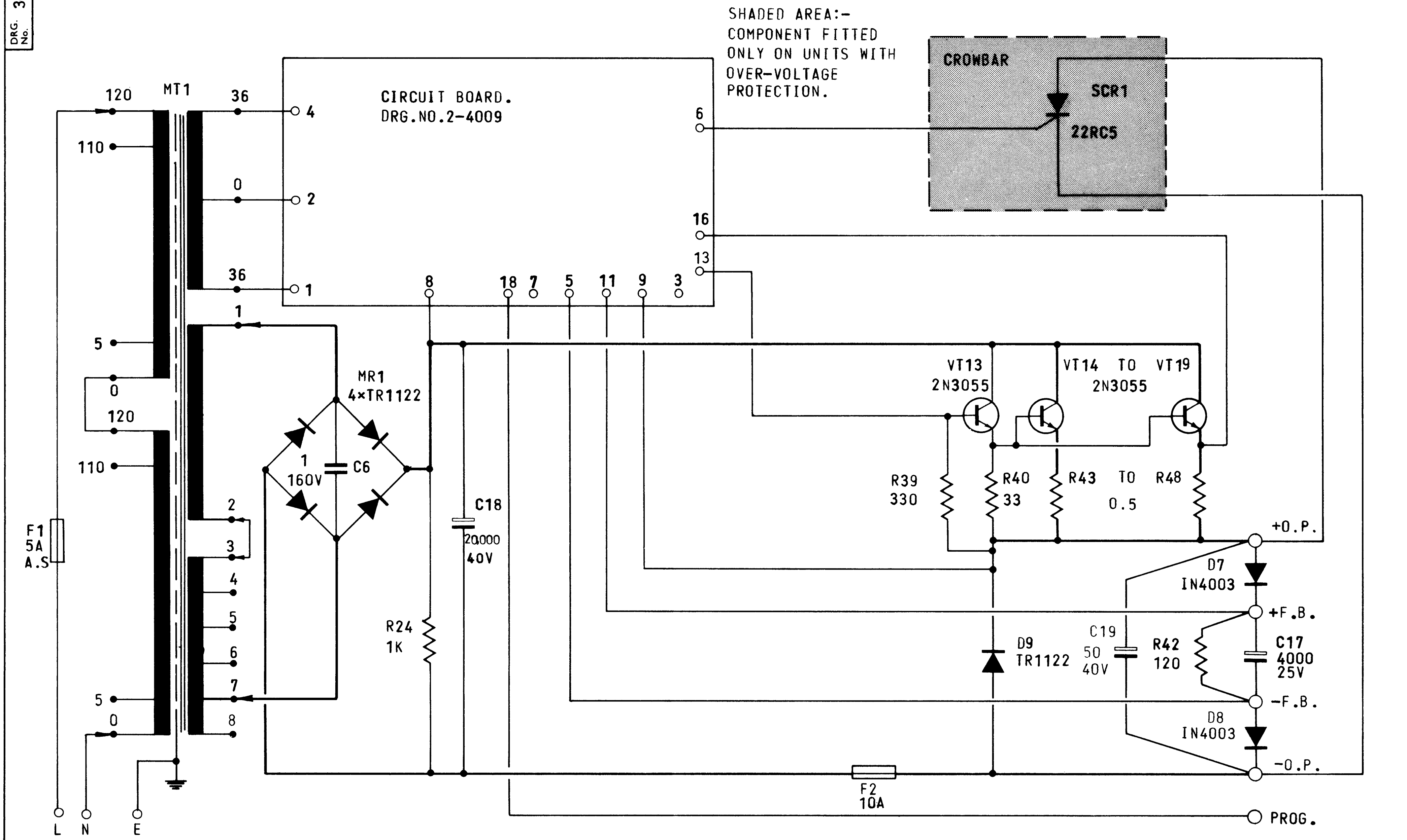
DRAWING No. 2 - 4602

SHEET 1 OF 1 SHEETS

USED ON

DRG. No. 3-4711

R	24 39 40, 43, 46,42	R
C	6 18 19 17	C
VT	13,14,15,16,17	VT
MISC	F1 MT1 MR1 F2 D9 SCR1 D7,8	MISC



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CHECKED	B. Jones			
DRAWN	M.H.	1	2:4:70	

NOTE :—
CAPACITOR VALUES GIVEN IN μF.
RESISTOR VALUES IN Ω
(2) REFERS TO CCT. BD. PIN CONNECTION Nos.

FARNELL INSTRUMENTS LTD. WETHERBY, YORKS.

CIRCUIT DIAGRAM 10E.

DRAWING No. 3-4711

E.A.F. L/1705/68