FARNELL INSTRUMENTS LIMITED

INSTRUCTION MANUAL
FOR
STABILISED VOLTAGE SUPPLY
TYPE TSV.70 MK. II.

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SECTION 1.

INTRODUCTION.

The supply type TSV.70 Mk. II provides a source of stabilised D.C. voltage variable over two ranges, 0 to 70 volts at output currents up to 5 amps or 0 to 35 volts at output currents up to 10 amps, range selection being achieved by a switch on the instrument front panel.

The output voltage is set by coarse and fine controls on the unit front panel, and is continuously variable over each range.

An output on/off switch is incorporated, allowing the load to be disconnected from the supply without switching off the mains input to the unit.

Overload protection is provided in the form of a constant current limit. The current limit level is adjustable by means of a front panel control.

Output voltage and current are monitored independently by front panel meters. The meter ranges are selected automatically by the output range switch.

The instrument operates from 50/60 Hz supplies of 105 to 120 volts on 210 to 240 volts rms. The required transformer input tapping is selected on the transformer tag board.

SECTION 11

OPERATING INSTRUCTIONS

MAINS INPUT.

The transformer tapping should be set to correspond to the mains input voltage from which the unit is to be operated. (Units are normally supplied for 240 volt operation). The transformer connections for other input voltages are shown in figure 1.P13. In order to change the transformer tapping the bottom cover of the unit must be removed. This is achieved by removing the four fixing screws in the rear panel, and removing it. The bottom cover may now be withdrawn from the rear of the unit.

Mains input is applied to the unit by the three cored input lead at the rear. The cable connections are BROWN-LIVE, BLUE-NEUTRAL, GREEN/YELLOW-EARTH.

FRONT PANEL.

INPUT ON/OFF SWITCH.

This connects the mains input to the unit, indication of mains is given by the neon lamp above this switch.

VOLTAGE ADJUST. COARSE AND FINE CONTROLS.

These provide continuous adjustment of output voltage from zero to maximum output. The maximum is determined by the setting of the "RANGE" switch. The coverage of the fine control is approximately 350mV on the 35V range and 700mV on the 70V range.

RANGE SWITCH.

This selects the output range of the unit the left hand setting being 0-35V 10A, and the right hand setting being 0-70V 5A.

METERS.

These monitor output voltage (left hand) and output current (right hand). The meter full scale ranges correspond to the setting of the range switch. 35 volts and 10 amp ranges are marked in black and correspond to the 35 volt 10 amp setting of the range switch. 70 volts and 5 amps are marked in red and correspond to the 70 volt 5 amp setting.

CURRENT LIMIT CONTROL.

This sets the point of maximum output current and may be adjusted from zero to 5.5 Amps or 11 Amps depending on the setting of the "RANGE" switch. If this control is set to give a current on the 10 amp range, the same setting would give rise to half the current on the 5 amp range. The current limit point may be set by short circuiting the output terminals and adjusting the current limit control to give the required limit current as indicated on the output current meter.

OUTPUT AND SENSE TERMINALS.

Units are normally supplied with the "+ SENSE" and the "+ OUTPUT" terminals linked, and the "- SENSE" and the "- OUTPUT terminals linked. The load should be connected to the "OUTPUT" "+" and "-" terminals. The supply is connected to the load when the "OUTPUT" switch is in its "ON" position.

For applications requiring correction of voltage drop along the leads connecting the supply to the load, the links between the "SENSE" and "OUTPUT" terminals should be removed and the current carrying leads to the load connected to the "OUTPUT" terminals. Another pair of leads should then be connected between the load and the "SENSE" terminal, ensuring that the positive end of the load is connected to the "+" "SENSE" terminal and the negative end of the load is connected to the "-" SENSE terminal. Care should be taken to ensure that no load current is drawn from the "SENSE" terminals. For notes on the limitations and use of this mode of operation refer to SECTION 6 page. 10.

OUTPUT SWITCH.

This disconnects the negative of the supply from the load when the switch is in the "OFF" position, and enables the required output voltage to be set before the load is connected. The load may also be disconnected from the supply without having to switch off the mains input.

COOLING.

The series regulator elements of the supply are fan cooled. The air intake for the fan is on the rear right hand side of the unit and the air outlet is on the rear left hand side. Care must be taken not to obstruct the air inlet or outlet. If such an obstruction is present or the cooling fan fails, a thermal trip within the unit will operate and shut the supply down when the load conditions are such as to give rise to a dangerous temperature on the series regulator. The trip will reset the output when the series regulator temperature is approximately 30^{o}C below the trip temperature, and if the cause of excess temperature is still present it will trip once again when the trip temperature is reached. This cycle will be repeated as long as mains input is applied to the unit and the cause of excess temperature is not removed.

The transformer and rectifiers within the unit are cooled by natural convection and no more than two units should be stacked one above the other without provision being made to force cool the stacked system in a vertical direction.

SECTION 111

CIRCUIT DESCRIPTION

The supply consists of a mains transformer feeding two bridge rectifier, reservoir capacitor and series regulator systems.

On the 35 volts 10 amps range the outputs of the two systems are paralled by switch S1. The series regulator bank driver inputs are paralled by S1A and driven from the main control circuit board No. 1. On the 70 volts 5 amps range the outputs of the two systems are connected in series. The upper system is driven from the main control circuit board No. 1, and the lower system is driven from circuit board No. 2.

35 Volts 10 Amps RANGE.

Mains Transformer MT1 feeds MR1 from a 37V R.M.S. secondary winding. MR2 is fed from a second 37V R.M.S. secondary. The negatives of reservoir capacitors C21 and 22 are connected to the negative output terminal via fuse F2, switch D1D, current monitoring resistor R67, and switch S3. The positive is connected via series regulators VT17-23 to the positive output terminal. The negatives of reservoir capacitors C25 and 26 are connected via fuse F3, current monitoring resistor R67 and switch S3 to the negative output terminal. The positive is connected via series regulator transistors VT24 - 30 and switch SIC to the positive output terminal. The input bases of VT17 and VT24 are paralled by SIA.

The control circuit of circuit board No. 1 consists of Diodes D1 and D2, and R1 which are fed from a 36-0-36V winding on MT1 and feed reservoir capacitors C1 and C2. This provides an unstabilised D.C. supply for zener diodes Z1 and Z2 which are fed via R2. Z1 and Z2 provide a +15 - 0 - -10 Volt supply for the reference and control amplifier circuitry.

VT4, R11, Z4, R14 and R15 comprise a constant current source which feeds Z3, R8 and T2, pins 3 and 18 being linked externally. Z3 is the main reference zener diode and provides a +5.1V source with respect to Pin 11 which is connected to the + SENSE front panel terminal.

P1 and P2 are the coarse and fine voltage controls on the front panel and are connected between the "-SENSE" terminal and Pin 17 on control circuit board No.1. Pin 17 is connected via R16 to VT5 base. A potential divider comprising P1, P2, T2 and R8 forms the output voltage sensing. The control amplifier VT5, 6, 8, 9, 10 drives emitter follower VT7. This drives the series regulator banks VT17-23 and VT24-30. The connection being from Pin 13 on the circuit board No. 1 via the thermal trip TT1 to Pin 9 on circuit board 2 then via R111 on circuit board No. 2 to Pin 10 and from there to the base of VT17 and via S1A to the base of VT24. The control loop acts in such a sense as to oppose any signal change on VT5 base, and hence maintains zero voltage between VT5 and VT6 bases. The output voltage Vo is therefore defined as:-

$$Vo = \frac{Vz3(R8 + T2)}{R8.T2}.(P1 + P2)$$

Overload protection is provided by VT11 and 12. P3 with T4 in parallel is connected to R49 and to VT12 base. R33 is connected to the 10 volt auxiliary rail. When the output current is low, the voltage across R49 is low. VT11 is biased off and VT12 is biased on. As output current increases the voltage across R49 increases, and the voltage at VT12 base becomes more positive. This continues until the base of VT12 is sufficiently positive to cause VT11 to begin to conduct. At this point, the voltage across R30 begins to increase until D6 becomes forward biased, and feeds current to VT9 base. This drives VT9 further into conduction, and limits the drive available to emitter follower VT7 and hence to the series regulator transistors. This action causes a fall in output voltage, and VT5 to be driven off. D5 then ceases to conduct and control is now taken over by VT11 and VT12. On further increase of load, the output voltage falls, and output current remains constant. The output characteristic of the supply is therefore constant voltage for loads less than the limit set by P3, the front panel current limit potentiometer and constant current for loads in excess of the limit.

70 volts 5 amps Range.

With switch S1 in the 70 volts 5 amps position, the positives of capacitors C21 and 22 are connected via regulators VT17-23 to the positive output terminal. The negatives of C21 and 22 are connected via fuse F2, and switch SID to the output of regulators VT24 - 30. The positives of C25 and 26 are connected via regulators VT24 - 30 to the negatives of C21 and 22 as above. The negatives of C25 and 26 are connected via fuse F3, resistor R67, and switch S3 to the negative output terminal. The input to regulators VT17-23 is as before, and the input to regulators VT24 to 30 is from Pin 12, circuit board No.2, via S1A. Thus the two regulator systems are connected in series and circuit board No.1 controls the upper regulators VT17-23, and circuit board No.2 controls the lower regulators VT24-30.

The function of circuit board No.1 is the same as on the 35 volt 10 amp range, and this is the master voltage and current limit control of the supply. The control circuitry of circuit board No.2 is merely to hold the voltage at regulators VT24 - 30 output at half the terminal output voltage. D103 and 104, and C101 are a full wave rectifier reservoir capacitor system fed from a 36-0-36 volt transformer winding and supplying D.C. voltage to Z101 and Z102 via R101. This provides a +10 - 0 - -5 volt supply for control amplifier consisting of VT101, 102, 103, and emitter follower VT104. VT104 drives series regulators VT24-30. The base of VT101 is connected to the output of this regulator and VT102 base is connected to the centre of the potential divider R113 and

R112 which is connected between the "+ SENSE" and "-SENSE" terminals. The voltage at the base of VT102 is therefore at half the output terminal voltage. The action of the loop is to maintain zero voltage between the bases of VT101 and 102, and hence the output of regulator VT24 - 30 is controlled at half the terminal output voltage.

The terminal output voltage is controlled by circuit board No. 1, and since switch S1B is closed on this range, the output voltage is now specified by:-

$$Vo = \frac{VZ3 \qquad (P1 + P2)}{\frac{(R8 // T2)\ (R9 + T1)}{(R8 // T2) + R9 + T1}}$$

$$\text{where} \quad R8//T2 = \frac{R8\ T2}{R8 + T2}$$

The voltage Vct at the output of regulators VT24 - 30 is controlled by circuit board No.2 and is specified by:

$$Vct = \frac{R113}{R112 + R113} \quad Vo$$

since R113 and R112 are equal

$$Vct = \tfrac{1}{2}\ Vo$$

<u>General</u>:

T103 and T104 are setting potentiometers to adjust the ammeter full scale deflection. T101 and 102 are setting potentiometers to adjust the voltmeter full scale deflection.

Thermal trip TT1 is a bi-metallic switch which is located on the heat sink assembly. Its purpose is to detect excessive temperatures on the series regulator elements, which could be caused by obstruction of air flow in the fan cooling system or by fan failure.

SECTION IV

SPECIFICATION

MAINS INPUT.

210, 220, 230, 240 Volts. 50/60 Hz.
105, 110, 115, 120 Volts. 50/60 Hz.

Maximum mains variation tolerated ± 10% of Nominal.

OUTPUT CAPABILITY.

0-70 Volts at 0-5A.
or 0-35 Volts at 0-10A according to the selected range.

Output voltage is continuously variable over either range.

METERING.

Two range voltmeter 35V F.s.d. and 70V F.s.d

Two range ammeter 5A F.s.d. and 10A F.s.d. The meter ranges are controlled by the output range switch to correspond to the output range in use.

LINE REGULATION.

OUTPUT CHANGE FOR 10% MAINS CHANGE.

SHORT TERM LESS THAN 0.01% OR 1mV whichever is greater.

LONG TERM (8 HOUR) LESS THAN 0.05% OR 5mV whichever is greater.

LOAD REGULATION.

OUTPUT CHANGE FOR ZERO TO FULL LOAD CHANGE.

SHORT TERM 0.01% OR 1mV whichever is greater.

LONG TERM 0.05% OR 5mV whichever is greater.

RIPPLE AND NOISE.

LESS THAN 1mV p-p Measured at 80KHz bandwidth.

OPERATING TEMPERATURE RANGE.

0-40°C.

OVERLOAD PROTECTION.

CONSTANT CURRENT LIMIT VARIABLE FROM 0 TO FULL LOAD CURRENT.

DIMENSIONS.	430mm WIDE,	410mm DEEP,	177.8mm HIGH.
	16.93" "	16.14" "	7" "
WEIGHT.	26.2 KGS.	57.75lbs.	

SECTION V.

SETTING UP PROCEDURE.

ACCESS.

Access to the circuitry may be gained by first removing the rear panel, and then withdrawing all the covers, bottom two sides and top, which are located in slots in the four extruded bar chassis members.

Setting the Voltage Ranges and Current Limit.

1) Set the "RANGE" switch to 35V, 10A. Set the COARSE and FINE front panel controls to fully clockwise.

2) Apply mains input to the unit and adjust T2 on circuit board No. 1 to give 35.5 volts output.

3) With the CURRENT LIMIT control set fully anti clockwise, and a short circuit applied to the output terminals, adjust T3 circuit board No. 1 to give zero output current. Remove the short circuit.

4) Connect a load to the output terminals and adjust it to give 11 Amps output current, with the "CURRENT LIMIT" control fully clockwise. Adjust T4 circuit board No. 1 until the output voltage of the unit just begins to fall at 11 Amps. Disconnect the load.

5) Set the range switch to 70V, 5A. Set the COARSE and FINE voltage control fully clockwise.

6) Adjust T1 circuit board No. 1 to give 71 volts output.

Circuit board No. 1 is located on the right hand side of the unit viewed from the front, and is the circuit board nearest to the front panel.

Setting the meter full scale deflections.

1) With the RANGE switch on the 70V 5A position adjust the output voltage of the unit by means of the COARSE and FINE front panel controls to give 70 volts output, as indicated on an accurate external meter. Set T101 until the front panel voltmeter reads 70 volts (full scale)

2) With the RANGE switch on the 35V 10A position adjust the output voltage of the unit to give 35 volts as indicated on an accurate external meter. Set T102 until the front panel voltmeter reads 35 volts. (full scale).

3) With the RANGE switch on the 35V 10A position apply an accurate external ammeter across the output terminals. Adjust the CURRENT LIMIT control to give a reading of 10 amps on this external meter. Set T104 until the front panel ammeter reads 10 amps (full scale).

4) With the RANGE switch on the 70V 5A position and an accurate external ammeter connected across the output terminals, adjust the CURRENT LIMIT control to give a reading of 5 amps on this meter. Set T103 until the front panel ammeter reads 5 amps (full scale).

SECTION V1

TYPICAL PERFORMANCE AND APPLICATIONS.

1) SERIES OPERATION

Units may be connected in series to provide higher output voltages. It is recommended that a protective diode is fitted across the output terminal of each unit, cathode to positive terminal to prevent the supplies becoming reverse biased under overload conditions. The diode should have a current rating equal to the maximum output capability of the unit. It is recommended that not more than three units be series connected.

2) PARALLEL OPERATION

Units may be connected in parallel to increase the current capability. In order to parallel them the units should be adjusted for equal output voltage and their output terminals then connected in parallel. In such a system, as output load current is increased from zero, the unit having the highest voltage setting will conduct until it reaches its current limit point. The unit with the next highest voltage will then conduct until it reaches its current limit point and so on. The V/I characteristic of a system of three units connected in parallel is shown in figure 2.P14.This shows a series of descending steps in voltage as the load current increases. The magnitude of the step depends on how closely the voltages can be set together. The resolution of the fine potentiometer is approximately 10mV hence the steps in voltage could not be lower than 10mV. No more than three units should be operated in parallel.

3) EXTERNAL SENSING OPERATION

Units are supplied with links between the SENSE and OUTPUT terminals. If it is required to correct for the voltage drop along the leads carrying current to the load, it is possible to use a four terminal connection. It is not possible to correct for more than ½ volt drop in each lead.

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

The leads from the + OUTPUT and + SENSE terminals should be twisted together. The leads from the "- OUTPUT" and "- SENSE" terminals 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 adding a capacitor of approximately 2000uF at 100 volts directly across the load.

It may also be necessary to decouple the output and sensing terminal pairs with low voltage electrolytic capacitors. For the + OUTPUT and + SENSE terminal pair the capacitor positive should be connected to the + OUTPUT terminal and for the - OUTPUT and - SENSE terminal pair, the capacitor positive should be connected to the - SENSE terminal.

NOTE: CARE MUST BE TAKEN NOT TO DRAW LOAD CURRENT FROM THE SENSE TERMINALS.

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.

(1) Steady load - for a change in steady load from zero to full load, the specification on page holds.

(11) Transient response - Typical response to a pulsed load is shown in figure 3. P.14.

(111) 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 eventually it is determined by the output capacitor and lead inductance. A typical output impedance/ frequency curve is shown in figure 4. P.15.

(b) Mains Supply Change.

Surges on the mains in the form of short rise time pulses may be fed on to the output terminals by stray capacitances. When monitoring the output waveform, both oscilloscope leads should be connected to the same output terminal before making a measurement to ensure that pulses which may not appear across the output 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 value change due to temperature change. The temperature change can be:

(1) As a result of ambient temperature change or

(11) As a result of internal temperature change caused by change in load or mains input to the unit.

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

(11) Internal change - a typical plot of output variation against time for changes in mains input and load is shown in figure 5. P.15.

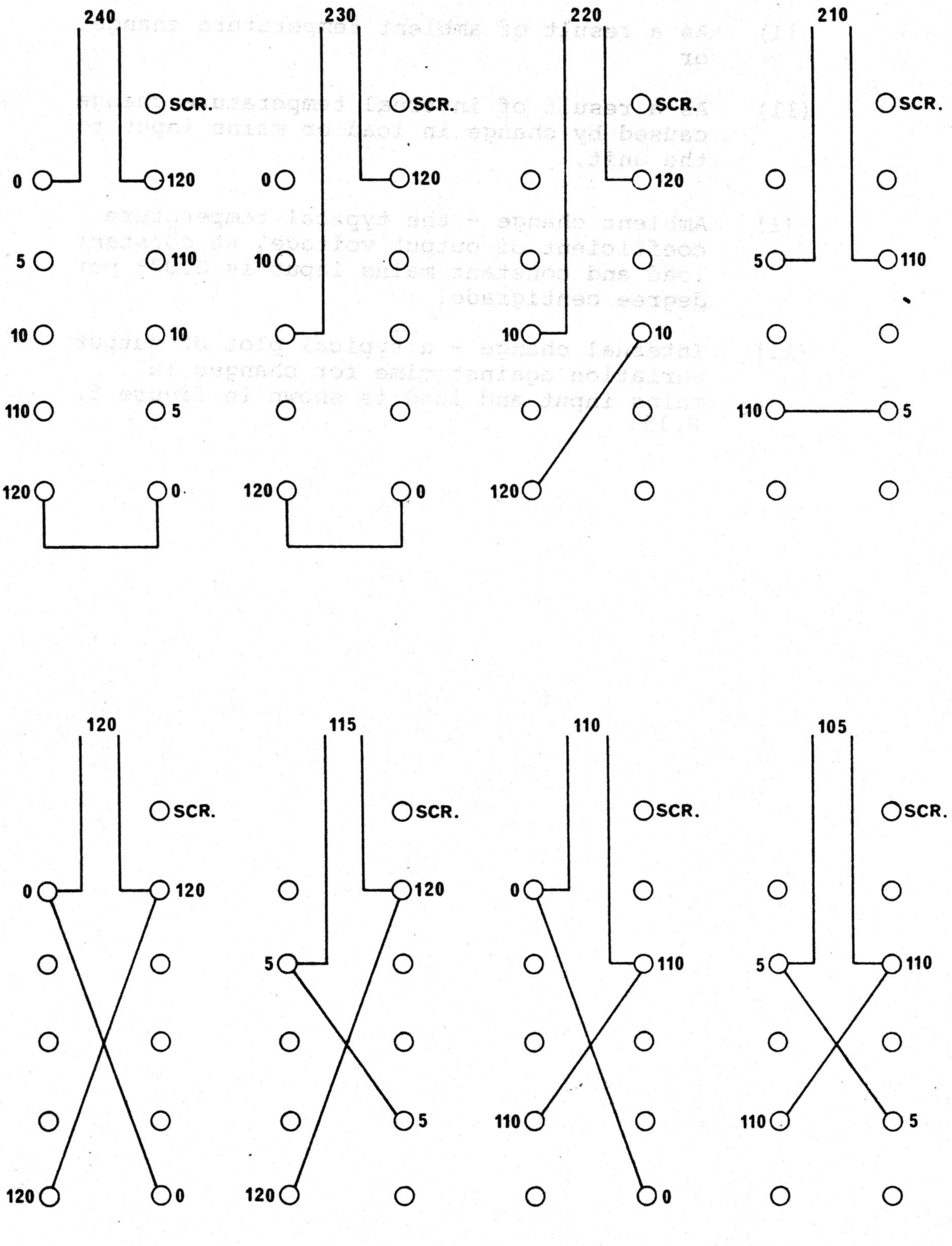


FIGURE 1 — TRANSFORMER PRIMARY CONNECTIONS.

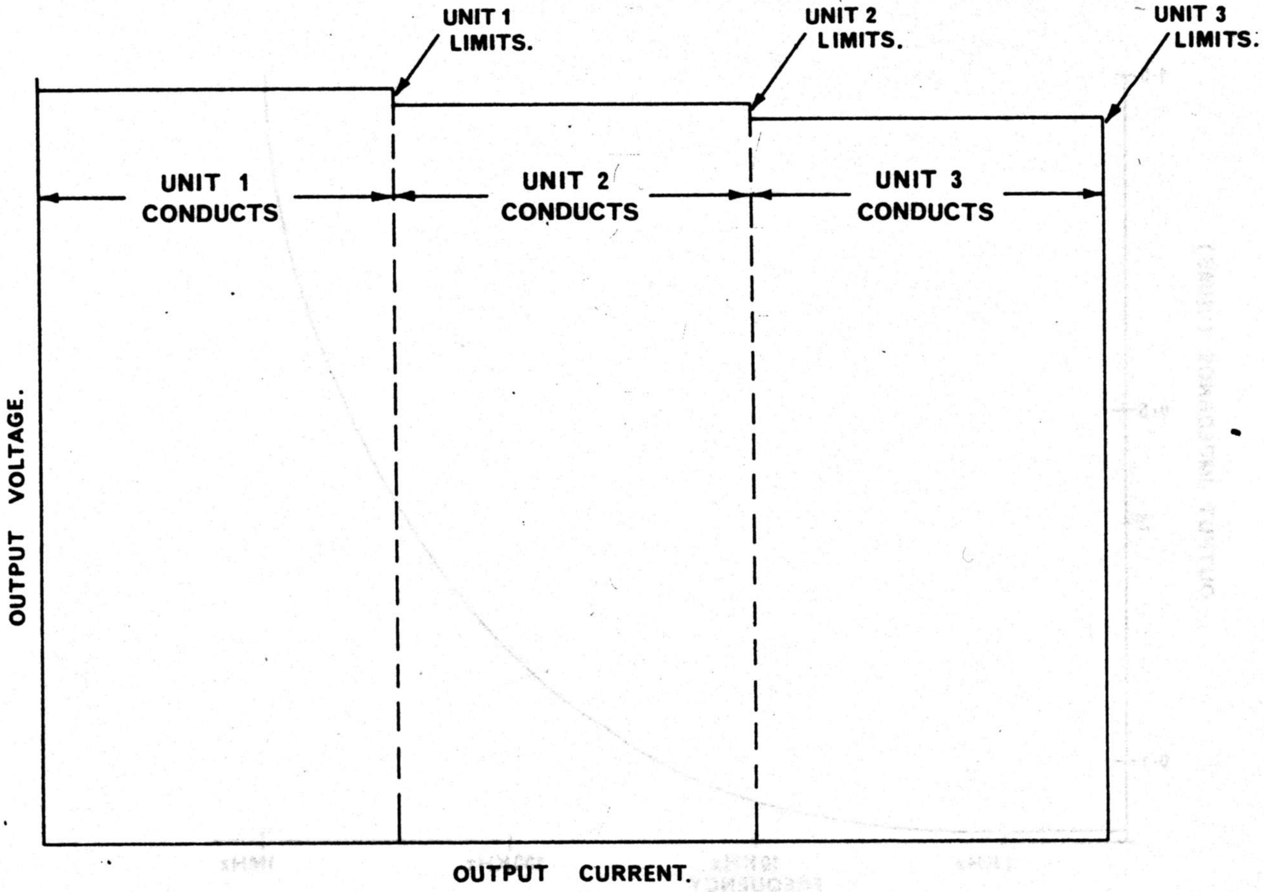


FIGURE 2 — PARALLEL OPERATION.

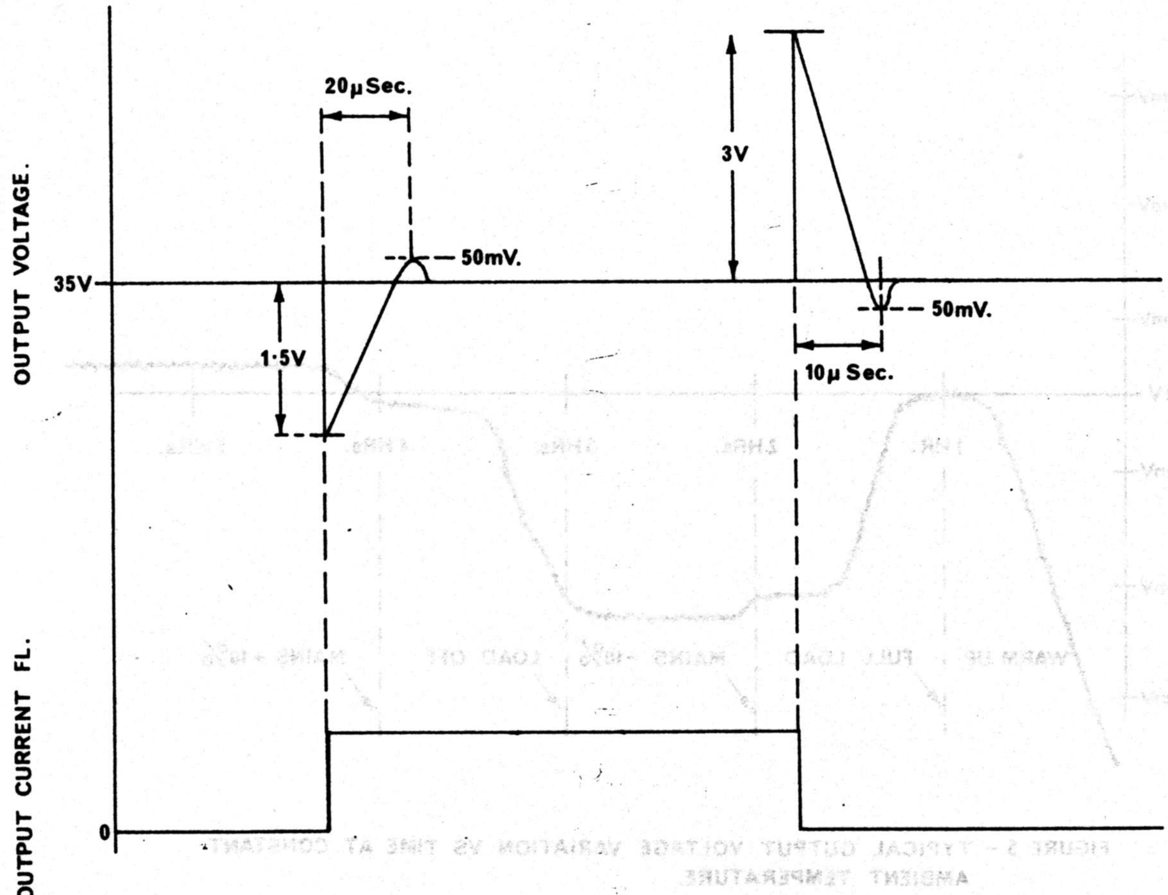


FIGURE 3 — TYPICAL TRANSIENT RESPONSE.

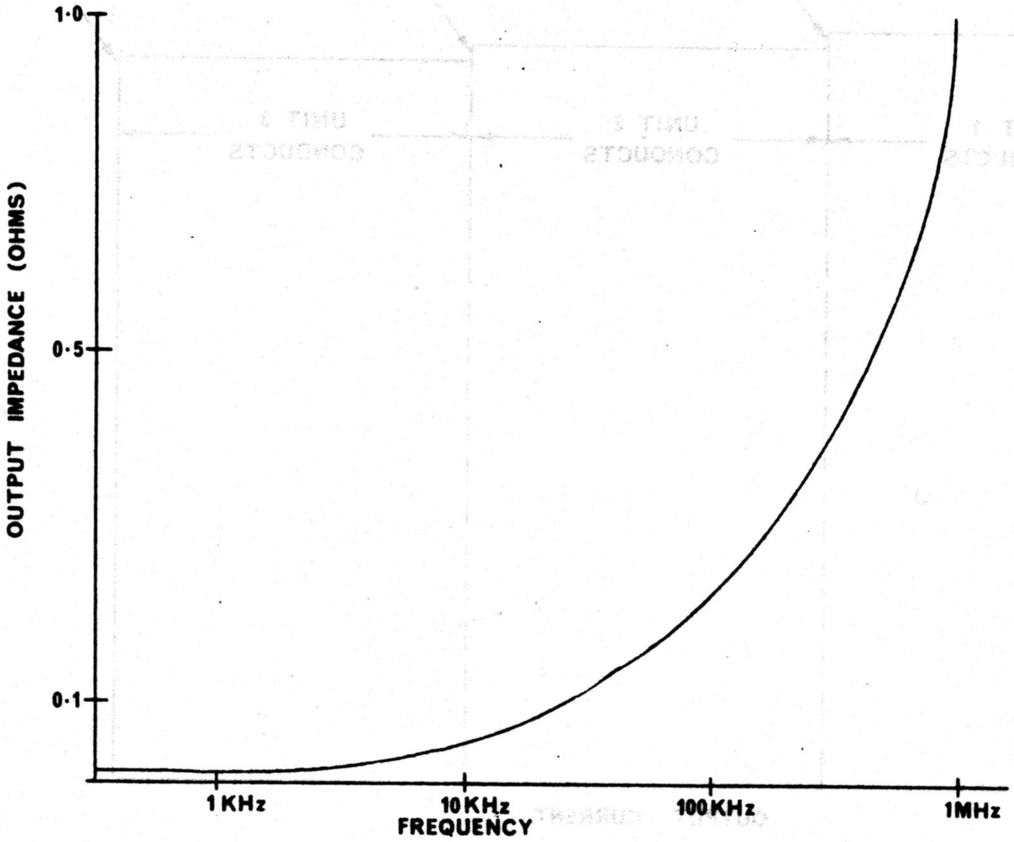


FIGURE 4 – TYPICAL OUTPUT IMPEDANCE VS FREQUENCY.

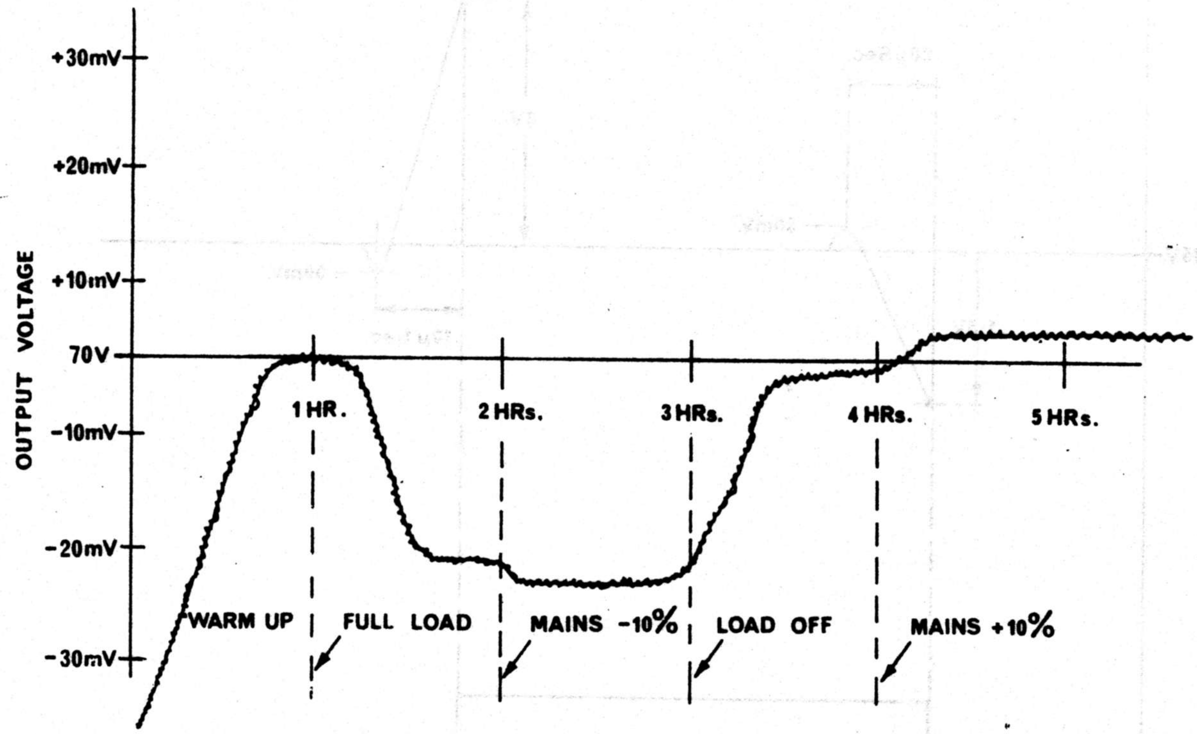
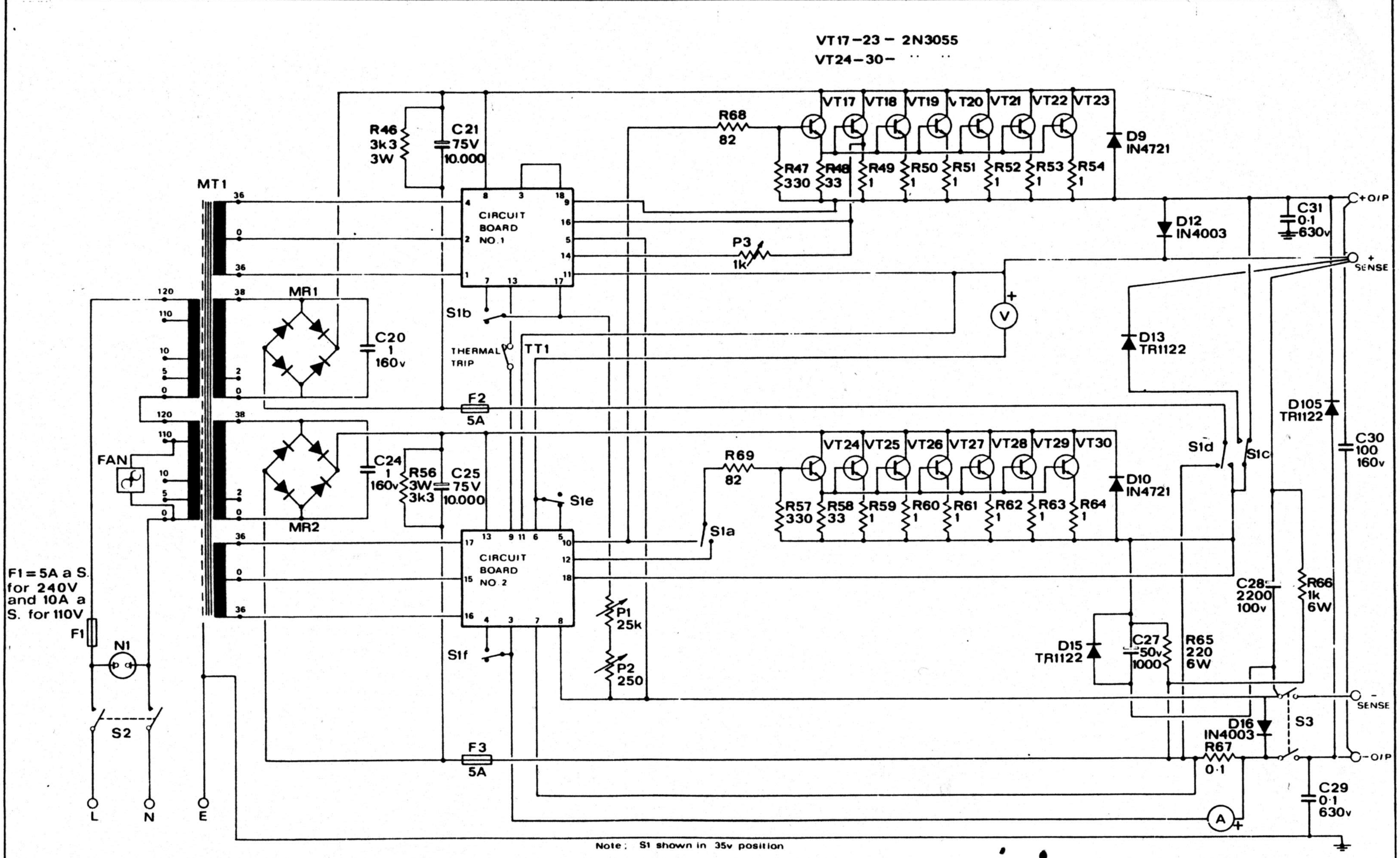


FIGURE 5 – TYPICAL OUTPUT VOLTAGE VARIATION VS TIME AT CONSTANT AMBIENT TEMPERATURE.

DRAWING No. 2-5508		
USED ON	R	46 56 · 68 47 57 · 48 56 · 49 59 · 60 60 51 61 · 52 62 · 53 63 54 64 · 65 · 67 · 66
	C	20 24 21 25 · 27 · 28 · 29 31 30
	VT	17 24 18 25 19 26 20 27 21 28 22 29 23 30
	MISC	F1 N1 S2 · MT1 · MR1, MR2 · F2 F3 S1b S1f S1e TT1 P1 P2 · S1a · P3 · D13 D15 D9 D10 D12 S1d · S1c · D16 S3 D105



TRACED			
CHECKED			
DRAWN K-L	ISS 9	DATE 17.12.75	MOD No 3642

NOTE:
All resistor values given in ohms unless otherwise stated
capacitor uF

TOLERANCES	PROTECTIVE FINISH
MATERIAL	
SCALE	DIMENSIONS IN M.M.

FARNELL INSTRUMENTS LTD. WETHERBY, YORKS.

TITLE: CIRCUIT DIAGRAM

TSV Mk. II

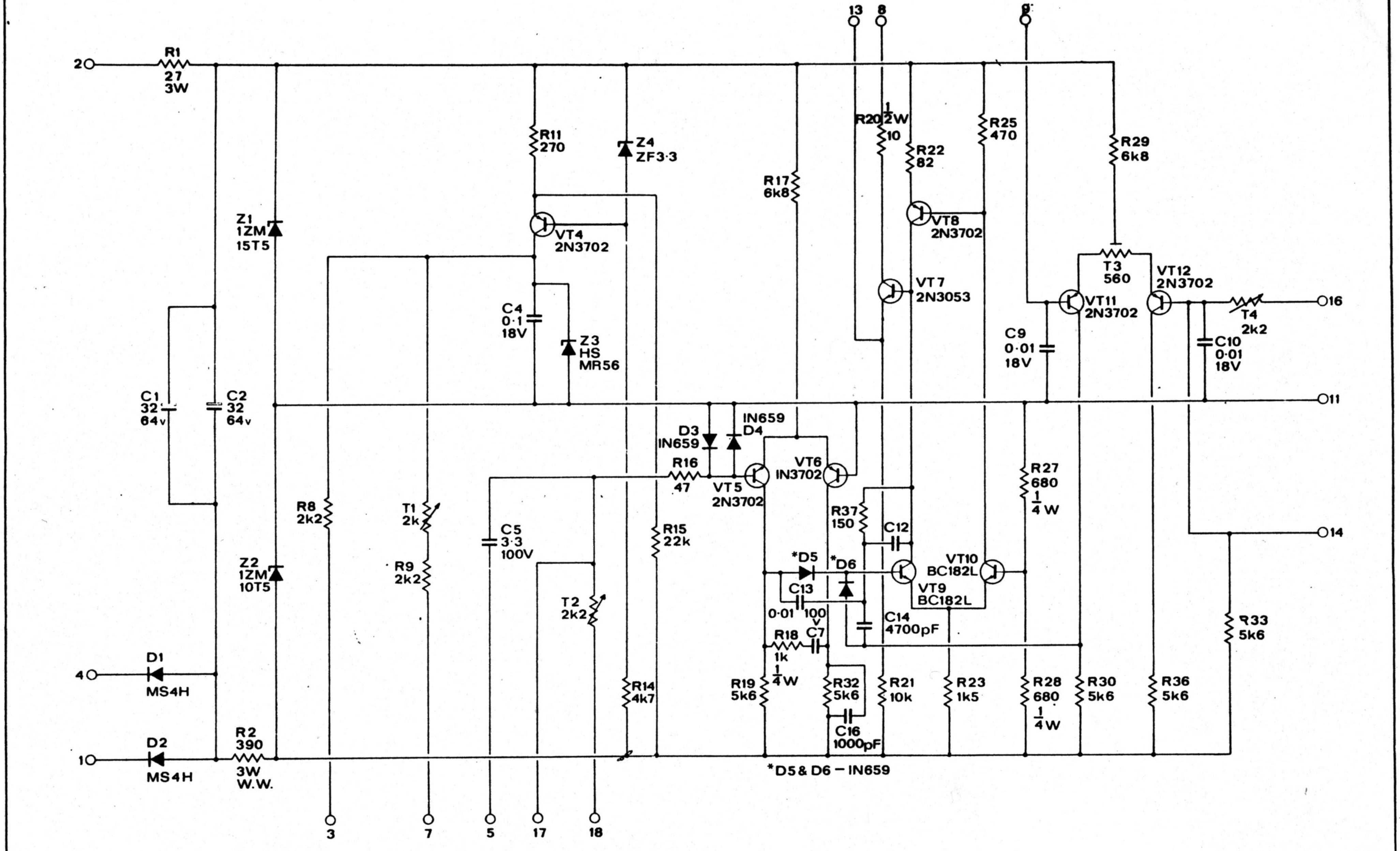
DRAWING No 2-5508

SHEET 1 OF 1 SHEETS

DRAWING No. 2 – 5509

USED ON

R	1 2 8 9 11 14 15 16 19,18,17 32 37,20,21 22 23 2 27,28 30 29 36 33
C	1 2 5 4 13 7 16 14 12 9 10
VT	4 5 6 7 9 8 10 11 12
MISC	D1-2 Z1-2 T1 Z3 T2 Z4 D3 D4 D5 D6 T3 T4



NOTE:–
All resistor values given in ohms unless otherwise stated
" capacitor " " " μF " " "
All resistor values 1/2W 5% or less " " "

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re-DRAWN	ISS	DATE	MOD No.
K-L	7	18·8·75	3528

TOLERANCES

MATERIAL

SCALE

PROTECTIVE FINISH

DIMENSIONS IN M.M.

FARNELL INSTRUMENTS LTD. WETHERBY, YORKS.

TITLE: CIRCUIT DIAGRAM
CCT. BOARD NO.1 TSV70 MK. II

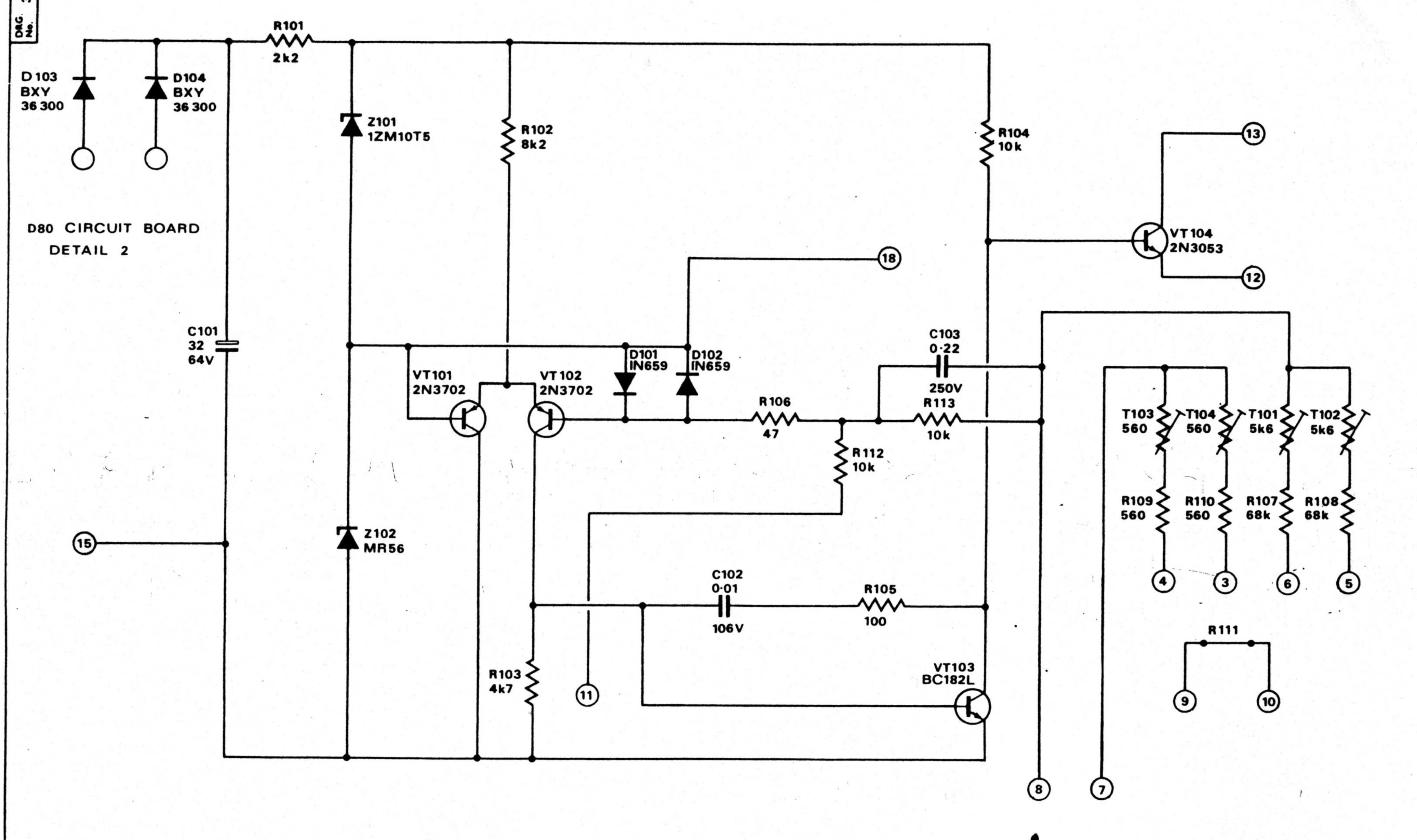
DRAWING No. 2–5509

SHEET 1 OF 1 SHEETS

USED ON

DRG. No. 3 - 5510

R	101		102 103		106		112	105	113	104		109	110	107	108		R
C		101				102			103								C
VT			101	102					103			104					VT
MISC	D103 - 104	Z101-2			D101 102							T103	T104	T101	T102		MISC



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		4	6 · 1 77						

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

CIRCUIT BOARD Nº 2

DRAWING No.

3 – 5510