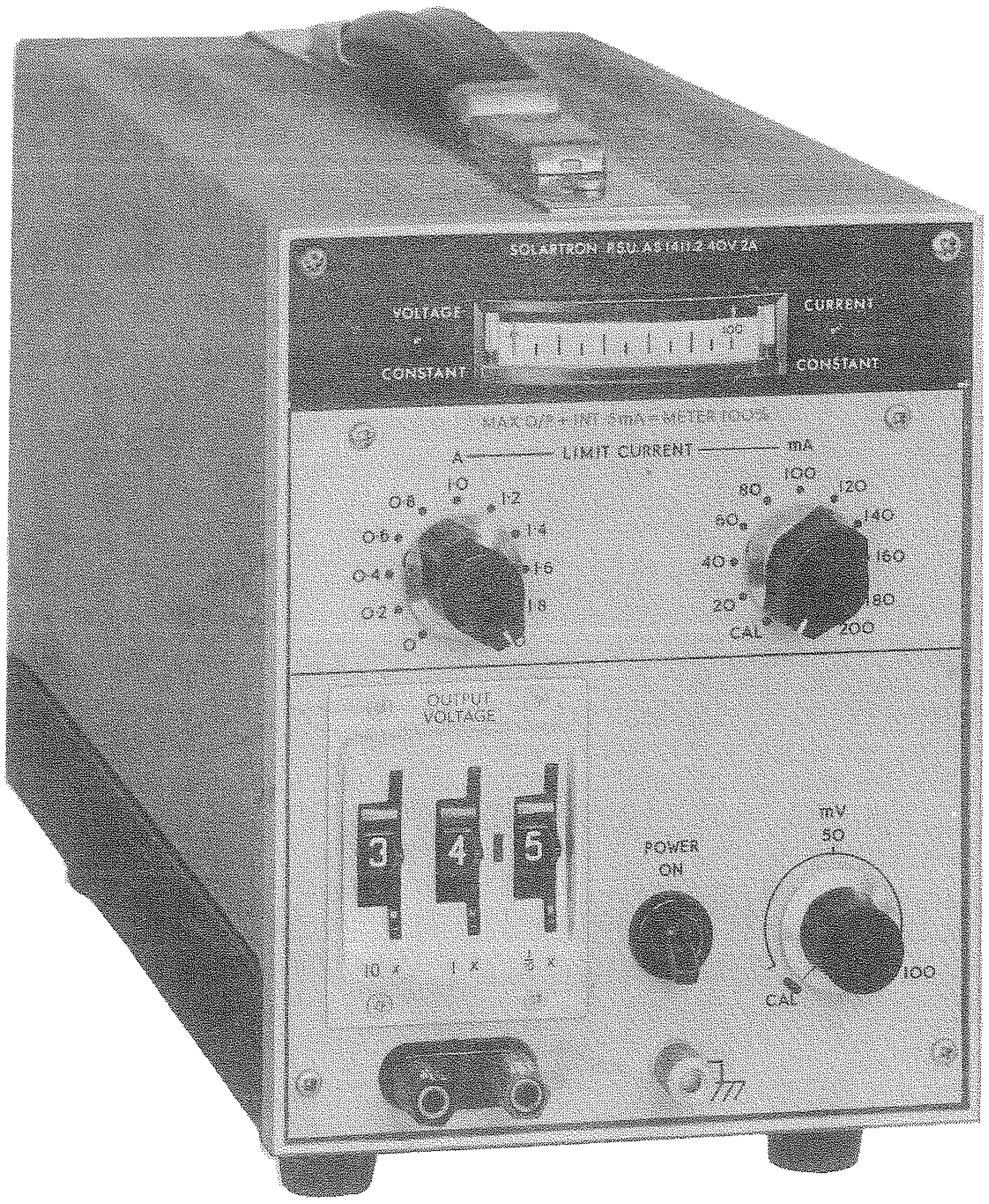
TRANSISTOR POWER SUPPLY AS 1411.2



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SECTION 1
GENERAL

The 1410 series is a range of high-performance transistor power supply units of similar performance characteristics, differing only in output rating. They are capable of operation in the constant voltage or constant current mode, and are controlled by fast-acting electronic circuits which not only afford short-circuit protection for the power units themselves, but also minimise the possibility of damage to any equipment powered by the units. External voltage sensing, voltage and current programming, and mode indication facilities are provided. The mechanical design has been standardised on a common height and depth, and the widths of the individual units made a sub-division of the working width of a standard 19-inch rack. All units are available in bench or rack-mounting form, and can also be supplied as twin units.

Specification

Voltage and Current Ranges:

Type No.	Voltage Range	Current Range
AS1410.2	0-30	0-1A
AS1411.2	0-40V	0-2A
AS1412.2	0-40V	0-5A
AS1413	0-40V	0-0.5A
AS1414.2	0-60V	0-1A
AS1416	2x0-30V	2x0-0.3A

NOTE: AS1416 is a double unit and the specification refers to either section.

Voltage Selection: Three decade setting of voltage in 10V, 1V and 0.1V steps.
Calibration accuracy ±1% (typically 0.25%).
All units (except AS1416) have an additional 0.1V continuous coverage at any point of the range.

Current Selection: All models provide switched selection of current.

AS1410.2, 1411.2, 1412.2, 1414.2.

Main Selector: Ten steps of 10% of maximum output current.

Fine Selector. Ten steps of 1% of maximum output current.
These controls give a combined upper limit of 110%.

AS1413: Ten settings : 10, 20, 40, 60, 80, 100, 200, 300, 400 and 500mA.

AS1416 : 10, 15, 20, 30, 45, 60, 100, 150, 200, and 300mA.

Setting Resolution: Calibration accuracy ±1% (typically 0.25%) or 1mA.
1.5mV on volts except AS1416.2.

Calibration Accuracy:
10mV/V (typically 2.5mV/V)
10mA/A (typically 2.5mA/A).

Temperature Coefficient:
$100\mu V/V/^{o}C$
$100\mu A/A/^{o}C$ i.e. 0.01% per ^{o}C.

Long Term Stability:
0.5mV/V/1000 hrs.
0.5mA/A/1000 hrs i.e. 0.05% in 1000 hrs.

Ambient Temperature Range: $0^{o}C$-$50^{o}C$.
These units are designed to give extremely long life and stability of parameters over this ambient range. If required, units will operate at higher temperatures with some reduction of total life.

Remote Facilities:
(a) Voltage sensing
(b) Voltage programming
(c) Current programming
(d) Mode indication and/or alarm.

Isolation: Outputs are isolated and can be floated at potentials up to 600V from chassis.

Master/Slave Facilities: Several units can be connected for series and/or parallel operation subject to isolation limitations.

Power Requirements: 100-125V/200-250V.
44-66Hz.
Input VA is approximately equal to regulated watts times three.

Maximum Mains Deviation from Nominal: ±10%.

Constant Current Mode

Ripple and Noise $500\mu A$ rms.

Stability Ratio (Improvement Factor)
10,000:1 (percentage change of mains supply against percentage change of power supply unit output).

Output Resistance
Of the order of 500K Ω or better.

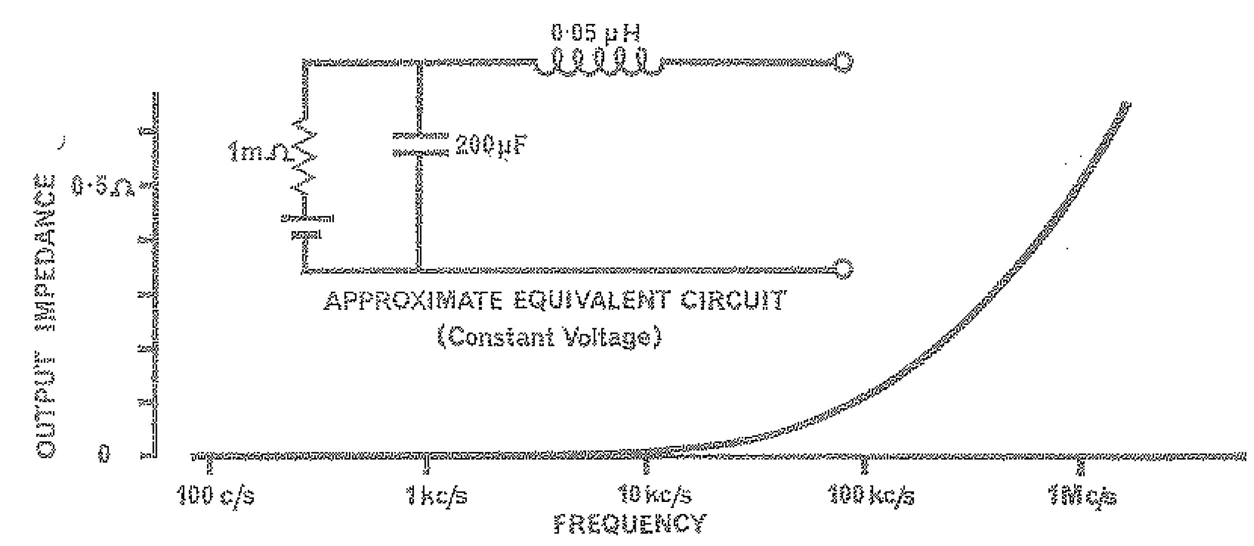
Constant Voltage Mode

Ripple and Noise Less than $200\mu V$ rms.

Stability Ratio (Improvement Factor)
10,000:1 (percentage change of mains supply against percentage change of power supply unit output).

Load Regulation: 0.005% at maximum voltage output for 80% current change of unit's maximum.

Output Impedance (Magnitude):
100kHz - 100 milliohm
1 MHz - 500 milliohm
This corresponds to the impedance characteristic of a few inches of appropriate output connecting lead.



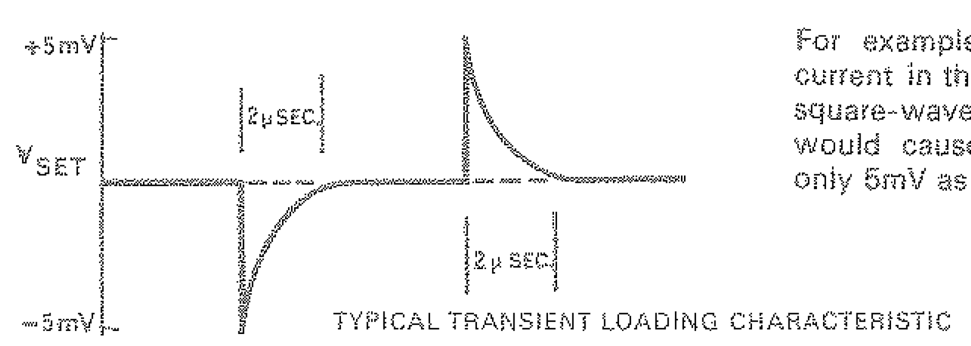
Pulse Loading Characteristics:

Transient Recovery Time: 2μs for recovery to within DC regulation limits. This figure is maintained even for full load changes in either direction.

Voltage Transient Amplitude The maximum voltage deviation produced by any pulse loading condition will not exceed the value as given by the product of the current change and the appropriate AC impedance. The actual value, V_T may be calculated from

$$V_T = L.\frac{di}{dt}$$

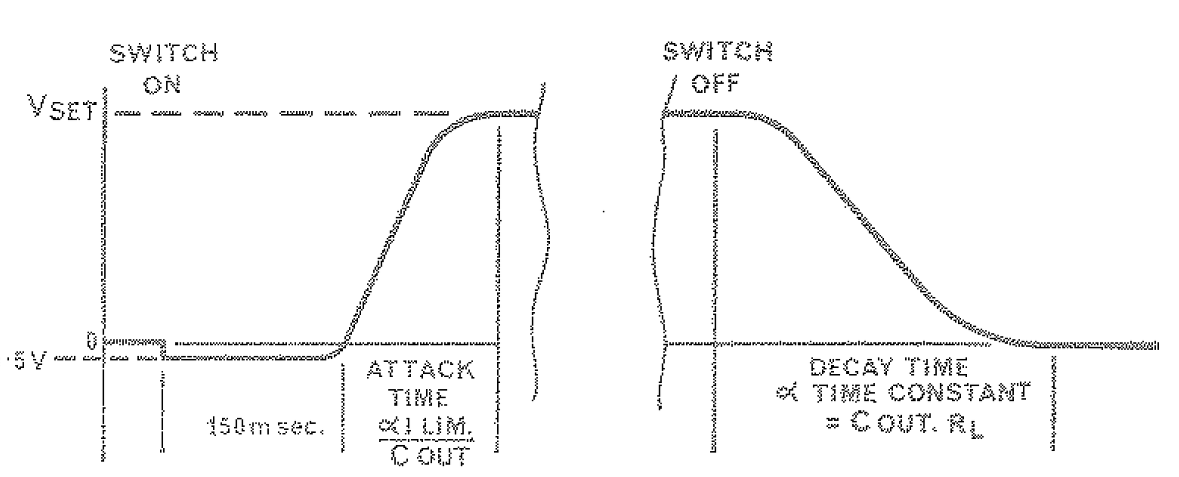
where L is the effective series inductance of the power supply (as specified) and $\frac{di}{dt}$ being determined by the load.
For example, a 0.1 amp load current in the form of a 100kHz square-wave with 1μsec edges, would cause a disturbance of only 5mV as shown.



For example, a 0.1 amp load current in the form of a 100kc/s square-wave with 1μsec edges, would cause a disturbance of only 5mV as shown.

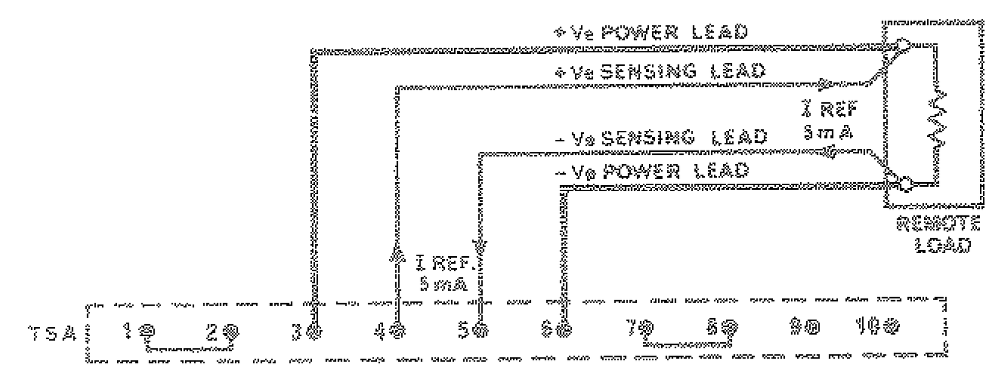
Switching Characteristics:

Main Supply: The diagram below shows the complete absence of overshoot and the insignificant undershoot which occurs when the mains supply is switched.



Voltage Controls: Similar 'attack' and 'decay' times occur when a voltage change is commanded, either by manual re-adjustment of the controls or by remote programming. The 150mS delay naturally does not occur in these circumstances.

Remote Voltage Sensing: This facility is provided to overcome the effect of resistance in the connecting leads. It may compensate for a voltage drop of up to 500mV. In the event of the feedback leads accidentally becoming open circuit, the output is cut-off automatically.



Parallel Operation: Any number of units, irrespective of type, can be connected in parallel to provide increased current capacity. The control amplifier of the unit chosen for the master is fully operative. Those of the slave units control their series elements to share the load in the ratios of the appropriate current limit selectors.
N.B. The voltage of the group cannot exceed the capability of the lowest rated unit.

Output Modulation: The output voltage will follow a voltage applied to the remote programming terminals 2 and 4, and similarly the available output current will follow a signal voltage on 7 and 8. As an approximation, the maximum value product of the amplitude and frequency may be taken as 1000 volt cycles per second. The upper frequency limit is of the order of 300Hz for small signal amplitudes and 10Hz for large amplitudes. Thus input signals with frequency components in excess of the indicated figures will not be faithfully reproduced.

Applications using this facility would be with servomechanisms, for instance, where it is required to operate high power devices from a low power signal source, and the output must be accurately related to input.

Dimensions and Weight:

AS	Max. Output	Dimensions	Weight
1410.2	30V 1A	A	12lb (5.4kg)
1410.2T	2x(30V 1A)	C	24lb (10.8kg)
1411.2	40V 2A	B	17.5lb (7.9kg)
1411.2T	2x(40V 2A)	D	35lb (15.8kg)
1412.2	40V 5A	C	32lb (14.5kg)
1413	40V 0.5A	A	12lb (5.4kg)
1414.2	60V 1A	B	17.5lb (7.9kg)
1413T	2x(40V 0.5A)	C	24lb (10.8kg)
1414.2	60V 1A	B	17.5lb (7.9kg)
1414.2T	2x(60V 1A)	D	35lb (15.8kg)
1416	2x(30V 0.3A)	B	14.5lb (6.6kg)
1416 T	4x(30V 0.3A)	D	29lb (13.2kg)

	Width	Height	Depth
A	4.25in.(10.8cm)	7in.(17.8cm)	14.5in.(36.8cm)
B	5.6in. (14.2cm)	7in.(17.8cm)	14.5in.(36.8cm)
C	8.5in. (21.6cm)	7in.(17.8cm)	14.5in.(36.8cm)
D	11.2in.(28.4cm)	7in.(17.8cm)	14.5in.(36.8cm)

Standard Rack Nests (Height $8\frac{3}{4}$ in.(22.3 cm) are available to rack mount up to four 4.25 in.width units, three 5.6 in.width units or two 8.5 in.width units.
Note: These units are natural convection cooled and it is necessary to ensure adequate ventilation to restrict the ambient temperature in their immediate vicinity to less than the stated maximum.

SECTION 2

OPERATION

Installation

The instrument is supplied as a fully-assembled and electrically set-up unit ready for installation. The mains transformer is provided with split primary windings capable of parallel or series connection to accommodate mains inputs within the range 100, 105, 110, 115, 120, 125 volts or 200, 210, 220, 230, 240, 250 volts. The unit will tolerate a mains voltage deviation of ±10% from the nominal input as determined by the connection of the primary windings. When received by the purchaser, the unit will be set-up for operation from a nominal input of 240 volts, and is therefore ready for use on any mains input within the range 215 - 265 volts.

The procedure for transformer tap changing for operation from 100 - 125 volt supplies is given below.

(1) Check presence, continuity, and rating of mains fuse carried in holder on the back-plate of the unit.

TABLE 1

200-250 Volts Supplies

Unit	Fuse Rating
AS1410.2	2.5A
AS1411.2	2A Slo-Blo
AS1412.2	5A
AS1413	1A
AS1414.2	2.5A
AS1416	2.5A

(2) Connect mains plug to mains lead, red to line (L), black to neutral (N), and green to earth (E).

Transformer Tap Changing

If the unit is to be operated from a supply within the nominal range 100 - 125 volts, the connections to the primary windings of the mains transformer must be changed in accordance with the directions given in sub-paragraphs (1) - (5) following.

(1) Remove two Phillips screws from each side of the unit - two or three from the top - and lift-off the upper U-shaped cover. (On AS 1412.2 only, remove bottom by unscrewing two rear feet).

(2) Place unit left-side uppermost on bench to give access to underside of mains transformer. (AS 1412.2 bottom uppermost).

(3) Referring to the circuit diagram, parallel the two primary windings (transformer tags 1 - 10), in accordance with the required nominal mains input (100, 105, 110, 115, 120 or 125 volts).

(4) Replace upper cover (or bottom) and secure in place.

(5) Remove existing fuse from holder carried on the unit back-plate, and replace with a fuse of the appropriate rating.

TABLE 2

100-125 Volts Supplies

Unit	Fuse Rating
AS1410.2	7A
AS1411.2	7A
AS1412.2	10A
AS1413	4A
AS1414.2	7A
AS1416	4A

Operating Instructions

Controls and Connectors

Front Panel

Power On

A double-pole switch applying the mains voltage to the mains transformer primary.

Note: No output switch is fitted in order to avoid degradation of output resistance characteristics.

Output Voltage Selectors

Three thumb-wheel switches setting the desired maximum output voltage level in digital steps of 10, 1, and 0.1 volts respectively. The switch positions are numerical indexed to provide digital read-out of voltage setting.

Analogue Voltage Control

A variable resistor providing continuous control of voltage setting between 0 and 100mV which is additive to the limit set on the digital voltage selection switches.

NOTE 1

On early versions of the series, the analogue voltage control provides a continuous, additive coverage from 0 - 10V. A switch automatically operated when the analogue voltage control is turned clockwise from the CAL position, shorts-out the final section of the internal voltage-setting chain to ensure that the output voltage demanded from the unit will remain within its maximum rating. A second pole of the switch closes an analogue voltage indicator lamp circuit to provide visual warning that the analogue resistor is operative, and therefore that the digital read-out displayed by the output voltage selection switches is invalidated.

NOTE 2

Analogue Voltage facility is not provided on the AS 1416 unit.

Output Current Selectors

Two 11-position rotary switches; the additive settings of which determine the maximum output current passed to the load. The A (Ampere) selector provides an adjustment of 10 steps each of 10% of the unit's maximum rated output current. The mA selector provides an adjustment of 10 steps each of 1% of the unit's maximum rated output current. With the A selector in the "0" position, and the mA selector in the CAL position, only sufficient current to supply the internal 5mA load is available, and any attempt to draw load current will reduce the voltage at the output terminals to zero.

NOTE 1
A 1% step digital limit output current control is not provided on the two units having a maximum output current rating of less than one ampere. The one control provided on these units is not graduated in 10% increments, but as follows:-

AS1413: 10, 20, 40, 60, 80, 100, 200, 300, 400, and 500mA.
AS1416 : 10, 15, 20, 30, 45, 60, 100, 150, 200, and 300mA.

NOTE 2
Early models of the power unit are provided with an analogue control in place of the stepped mA selector. This consists of a variable resistor providing continuously variable coverage from 1% to 10% of the maximum output current rating of the unit, which current is additive to that set by the digital output current limit selector. The control scale is marked at 1, 5, and 10% settings. When set to the CAL position (fully counter-clockwise) the current limit is defined solely by the digital limit selector.

Output Current Meter
A moving-coil meter with ten divisions scaled from 0 to 100. The full-scale deflection is automatically switched to the limiting value of output current as set by the limit selectors.

Voltage Constant/Current Constant
Indicator Lamps
Two neon lamps giving visual indication of the operational mode of the unit.

NOTE: On the AS 1416 twin output unit, voltage constant indicator lamps are not provided. CURRENT CONSTANT indicator lamps are provided on each output.

Output and Earth Terminals
The positive and negative sides of the output are taken to the red and black terminals respectively. Either side of the output may be grounded by linking the appropriate output terminal to the metal chassis terminal. All three terminals are drilled to accept a 4mm banana plug.

Rear Panel
Fuse Holder
A screw-in holder carrying a 5/8-inch cartridge fuse. ($1\frac{1}{4}$-inch on AS 1412.2).

Terminal Strip, 10-Way
Provides connections to internal circuit points to permit external voltage sensing, voltage programming, current programming, or parallel operation of two or more units.

NOTE
Two 10-way terminal strips are fitted on twin power units.

Terminal Strip, 3-Way
Gives external access to one set of changeover relay contacts to provide external visual indication of operational mode, i.e. constant voltage or constant current, aural alarm of the change from one mode to the other, and/or automatic "lock-out".

Operation
Preliminary Check
(1) Set the 'A' digital current limit selector to the "0" position, and the 'mA' digital current limit selector to the CAL position.

Note: 10mA position on the AS 1413 and AS 1416 units.

(2) Apply mains power to unit by setting the POWER switch to ON.

(3) Check that the panel meter registers f.s.d. to indicate that the unit is fully operative.

Note: Half-scale deflection on AS 1413 and AS 1416 units.

(4) Depress POWER switch to "off" position.

Selection of Operational Mode
The mode of operation, constant current or constant voltage, taken-up by the unit is determined automatically by,

(1) the output voltage V_c demanded,

(2) the output current limit I_m, and

(3) the ohmic resistance R_L of the load applied.

In general, with a voltage setting V_c and a current setting I_m, the mode will be constant voltage for load resistance greater than $\frac{V_c}{I_m}$, and constant current for load values less than $\frac{V_c}{I_m}$.

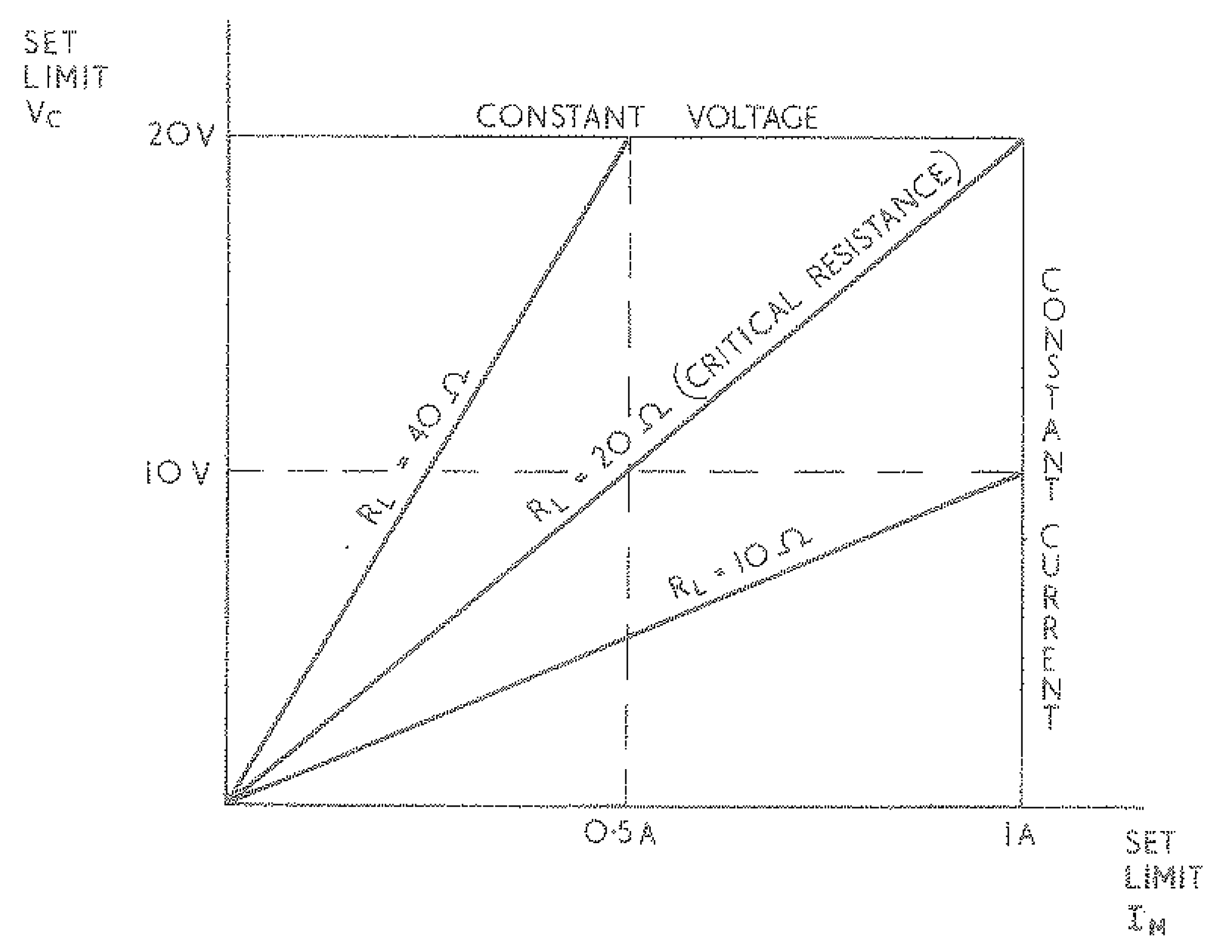


Fig. 2.1. Constant V/Constant I Characteristic.

The characteristic for arbitrary set voltage and current limits of 20V and 1A respectively is given in Fig. 2.1. For this specific condition, the characteristic shows that for a load resistance greater than 20 ohms, the unit will operate in the constant voltage mode, whilst for a load resistance of less than 20 ohms, it will operate in the constant current mode. The transition from one mode to the other normally occurs within 0.5% of the selected maximum load current.

High Performance Requirements
Constant Voltage Operation
The use of adequate gauge wire for power leads is essential if the low output resistance is to be maintained at the load. A graph (Fig. 2.2) of cable volts-drop per ampere-foot run is given for guidance.

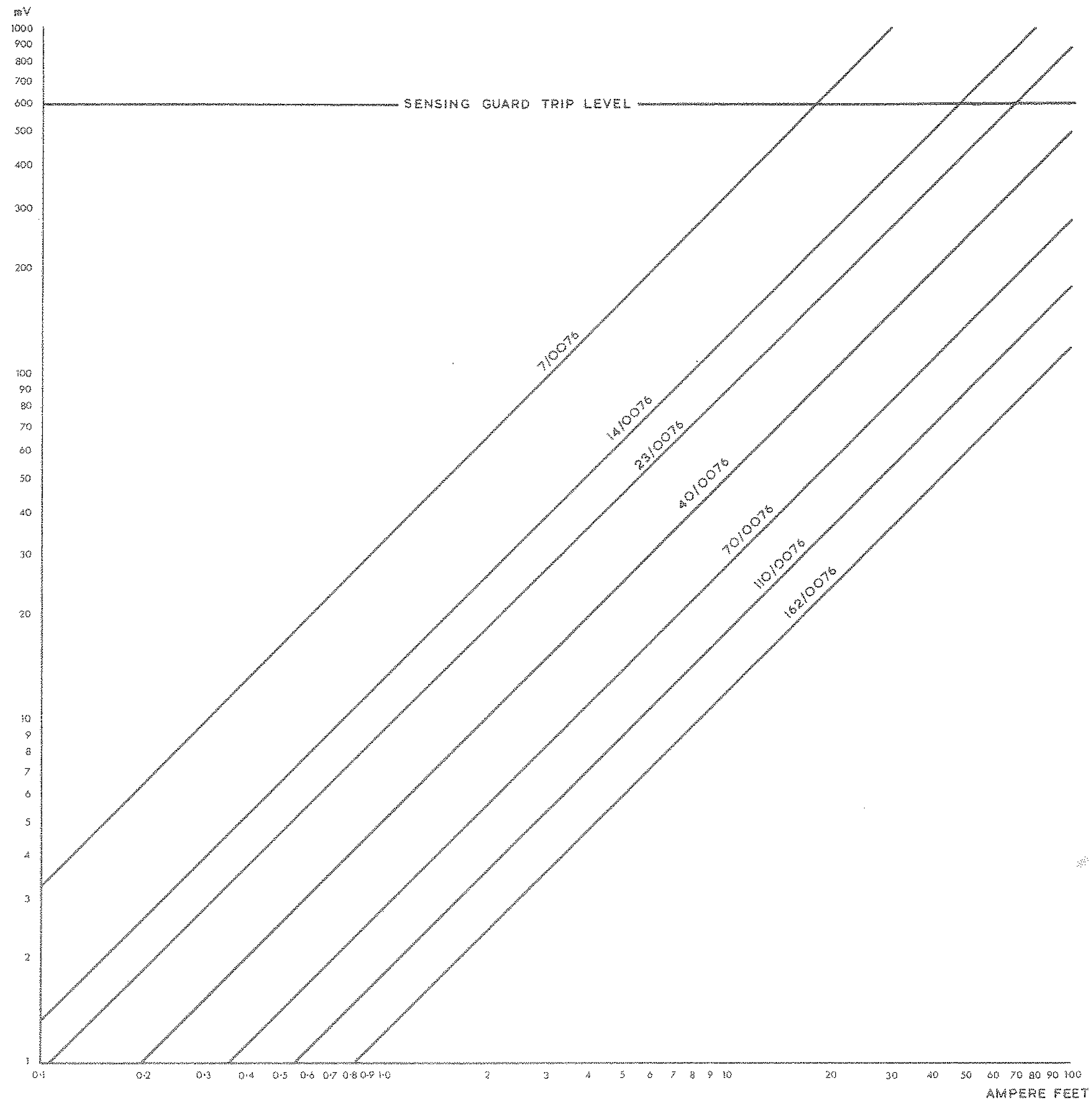


Fig. 2.2. Cable Volts Drop vs. Ampere/Foot Run Graph.

In circumstances where lead inductance becomes significant, the a.c. impedance can be minimised by the connection of a decoupling capacitor across the load-end of the leads.

Circulating earth currents will cause increased ripple level and their effect can be minimised by earthing the power unit and the associated equipment at one point only, and by decoupling long power leads.

Constant Current Operation

Owing to the high output impedance exhibited by the unit in this mode of operation, the gauge of wire used for power leads is governed only by normal heating considerations. The internal shunt capacitance gives a low a.c. impedance at the output terminals under all conditions. The remarks concerning earth currents given in the paragraph above are also applicable to the constant current mode of operation.

Local Control

Constant Voltage Operation

(1) On the 10-way terminal strip mounted on the unit rear panel, link terminals 1 to 2, 3 to 4, 5 to 6, and 7 to 8.

(2) Set OUTPUT VOLTAGE digital selection switches and/or analogue voltage control to the required output voltage V_C.

(3) Set the current limit selector(s) to the required current limit I_m.

(4) Connect load to output terminals, observing polarity and, if required, ground either side of the supply by linking the appropriate output terminal to the adjacent chassis terminal.

(5) Set POWER switch to ON.

(6) Check that the VOLTAGE CONSTANT indicator lamp lights to confirm that the unit is operating in the required mode.

(7) If required, read-off the load current from the panel meter. The full-scale reading will be equal to the limiting value I_m as set by the current limit selector(s).

NOTES

(a) The panel meter shows an internal standing load current of 5mA, which figure must be deducted from the total current reading to obtain the external load current.

(b) If the load resistance becomes less than $\frac{V_c}{I_m}$ the unit will go into the constant current mode, the presence of the overload being evidenced by the extinction of the VOLTAGE CONSTANT lamp and the lighting of the CURRENT CONSTANT lamp. The unit will automatically revert to the constant voltage mode when the overload is cleared.

Constant Current Operation

(1) On the 10-way terminal strip mounted on the unit rear panel, link terminals 1 to 2, 3 to 4, 5 to 6, and 7 to 8.

(2) Set the current limit selector(s) to the required constant load current, I_m.

(3) Set the OUTPUT VOLTAGE digital switches and/or the analogue voltage control to the required upper voltage limit V_c.

(4) Connect load to output terminals, observing polarity and, if required, ground either side of the supply by linking the appropriate output terminal to the adjacent chassis terminal.

(5) Set POWER switch to ON.

(6) Check that the CURRENT CONSTANT lamp lights, and that the VOLTAGE CONSTANT lamp is extinguished.

NOTES

(a) The panel meter registers f.s.d. at all times on constant current operation.

(b) Any great enough increase in load resistance (i.e. above $\frac{V_c}{I_m}$ will cause the unit to go into the constant voltage mode, the transition being evidenced by the extinction of the CURRENT CONSTANT lamp and the lighting of the VOLTAGE CONSTANT lamp. The unit will automatically revert to the constant current mode when the loading returns to normal.

External Control

General

A 10-way terminal strip, mounted on the rear panel of the unit, gives external access to certain points of the internal circuitry to permit the unit to be adapted for the external control of certain functions, namely,

(1) voltage sensing

(2) voltage programming

(3) current programming.

The relative positions of the terminals in the unit circuitry are given in the simplified schematic diagram (Fig. 2.3) to enable the operator to more readily appreciate the significance of external connections made to these terminals. Terminals 9 and 10 do not appear on Fig. 2.3, since these are not associated with the external control facilities, but with the parallel operation of two or more units.

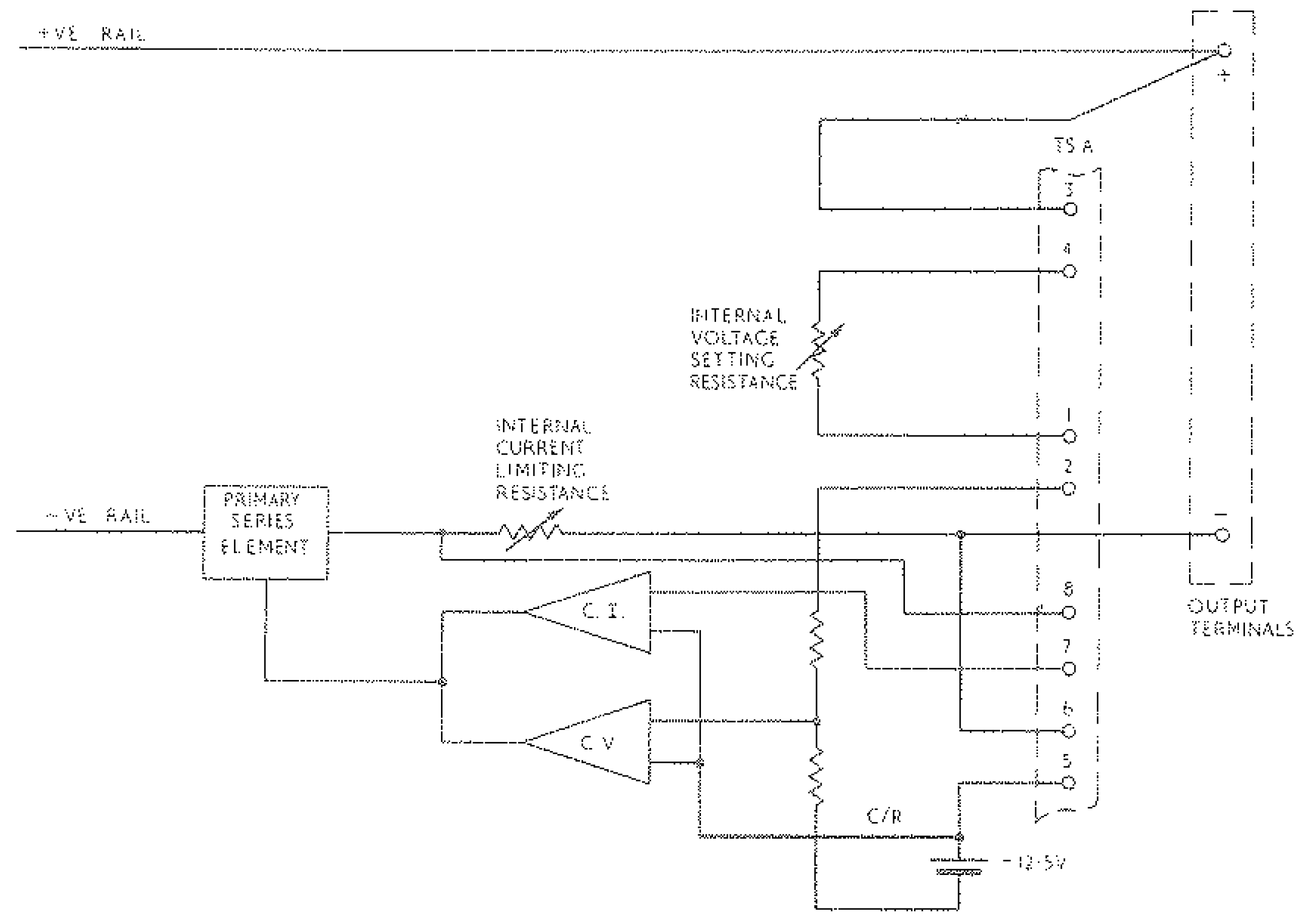


Fig. 2.3. External Control Arrangements.

External Voltage Sensing

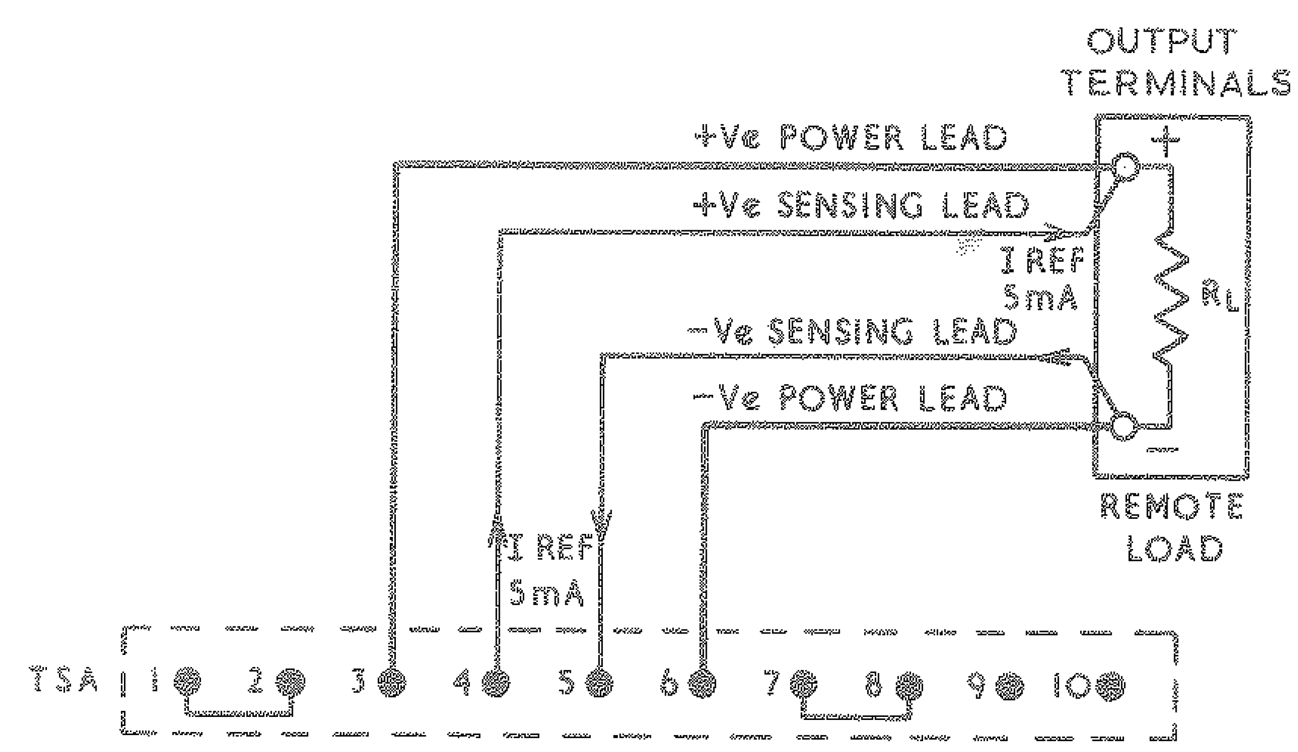


Fig. 2.4. External Voltage Sensing Connections.

This method of operation can be used when working in the constant voltage mode to effect improved regulation at the load. It provides for the internal voltage setting resistance to be independently connected to the load terminals, not via the leads carrying the load current, thus eliminating the effect of the voltage-drops developed across power-carrying leads.

(1) Remove links between terminals 3 and 4, and between terminals 5 and 6.

NOTE

Terminal 1 remains linked to terminal 2, and terminal 7 to terminal 8.

(2) Connect terminal 4 to positive side of load, and terminal 5 to negative side of load.

(3) Proceed as for constant voltage operation as detailed on page 2.3.

NOTE

An automatic overload circuit restricts the voltage drop developing between the voltage sensing and power terminals to approximately 600mV maximum by limiting the available load current.

External Voltage Programming
Resistance Controlled

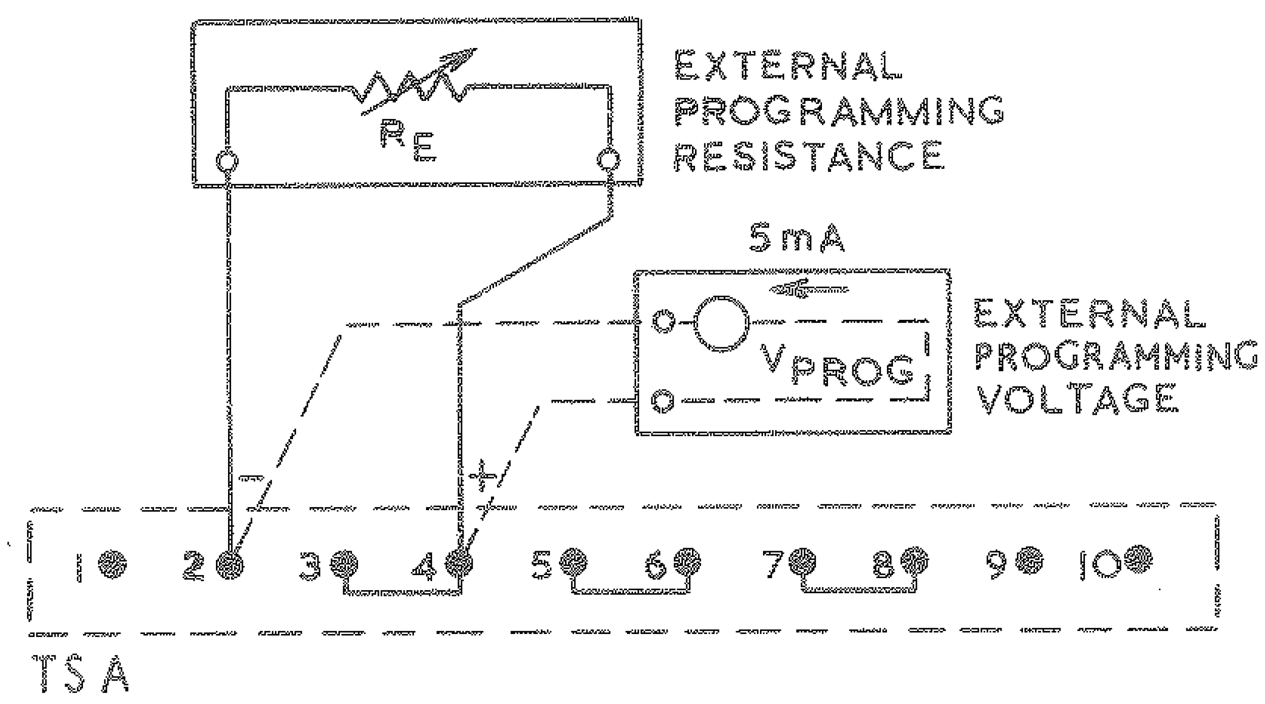


Fig. 2.5. External Voltage Programming Connections.

External voltage programming can be used on constant current or constant voltage working. For operation in this mode, the internal voltage-setting resistance chain is disconnected from circuit and an external resistance substituted. The panel-mounted voltage selection facility is thereby rendered inoperative, and control is transferred to the external resistance. The value of the external resistance required can be calculated at the rate of 200 ohms per output volt. The maximum permissible values of external resistance for the various units are listed in Table 3. The accuracy of the output voltage obtained in these circumstances is naturally dependent upon the tolerance and stability of the components comprising the external resistance.

(1) Remove the link between terminals 1 and 2.

NOTE
The links between terminals 3 and 4, 5 and 6, and 7 and 8 must be left in place.

(2) Connect external programming resistance between terminals 2 and 4.

NOTE
An open circuit at this point can give high output volts, and should be avoided.

(3) Proceed as for constant voltage or constant current operation as detailed on page 2.3 and 2.4, except that voltage change, if required, must be made by adjustment of the external resistance.

TABLE 3

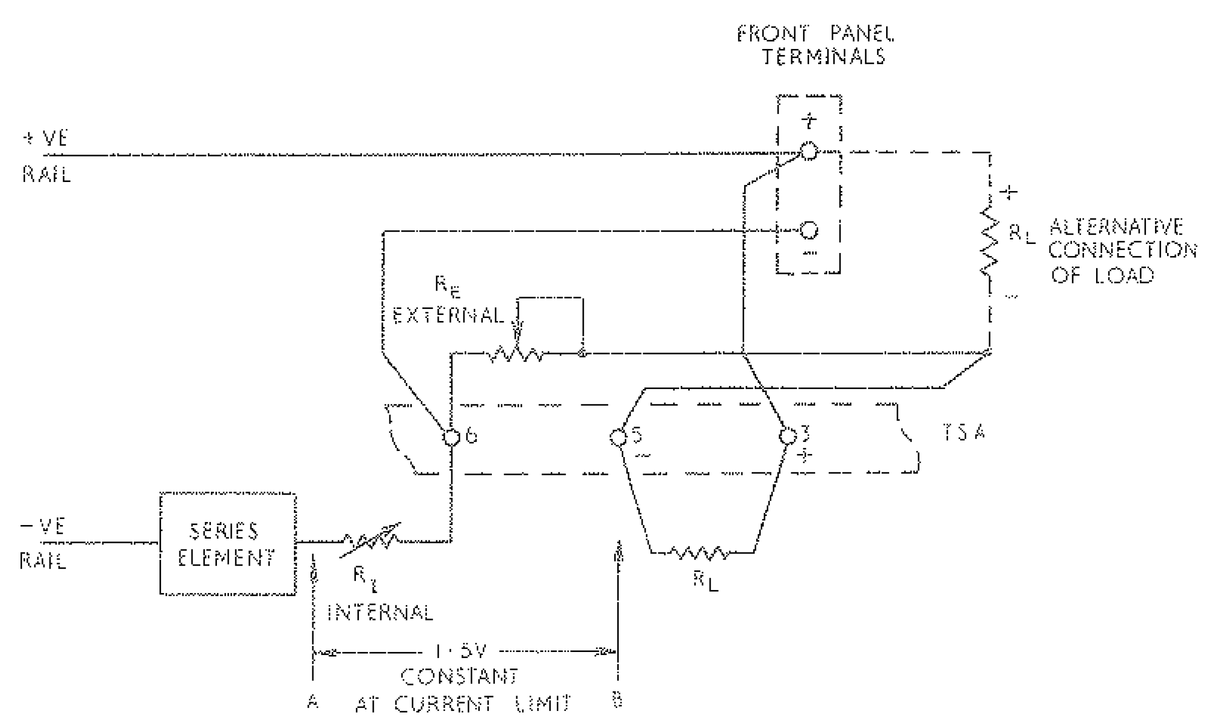
MAXIMUM PROGRAMMING RESISTANCE VALUES

UNIT	MAX. RESISTANCE	MAX. OUTPUT
	Ω	V
AS1410.2	6000	30
AS1411.2	8000	40
AS1412.2	8000	40
AS1413	8000	40
AS1414.2	12000	60
AS1416	6000	30

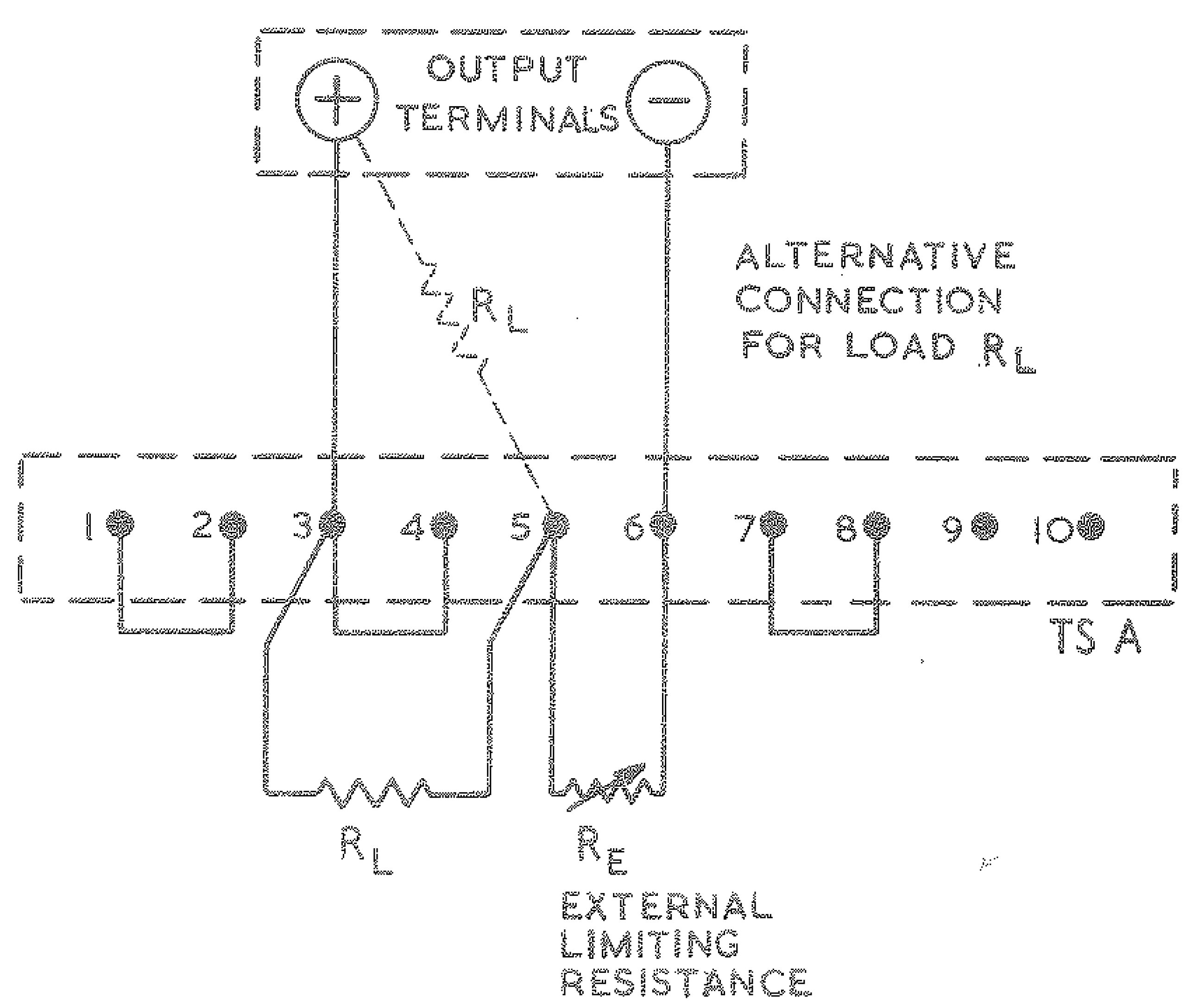
If required, programming may be performed by the application of a voltage between terminals 2 and 4, in place of the external resistance. The linking arrangements are the same as given in previous column for resistive programming. The output voltage will be equal to the programme voltage, and is subject to the limits laid down in Table 3. Polarity must be observed, terminal 4 being positive (+), and terminal 2 negative (-). A current of 5mA will be driven through the source of programme voltage.

External Current Programming
Resistance Controlled

External current programming can be used on constant current or constant voltage working. For operation in this mode, an external current sensing resistance R_E is introduced in series with the internal limiting resistance R_I to enable the value of programme current I_p to be reduced below the maximum limit I_m as set by the panel controls. The basic arrangement is shown in Fig. 2.6(a), from which it will be seen that it is impossible to inadvertently short-circuit the internal limiting resistance and cause damage to the unit by



(a) Principle



(b) Connections

Fig. 2.6. External Current Programming, Resistance Controlled.

demanding an infinite current. When the voltage drop across the total programming resistance R_T rises to 1.5 volts, the power unit transfers to the constant current mode. By Ohm's law, the value of R_T required for a given programmed current I_p is $\frac{1.5}{I_p}$ ohms. Furthermore, if the unit is set for a maximum or limit current I_m, the value of the internal programming resistance R_I is $\frac{1.5}{I_m}$ ohms. The required value of external programming resistance R_E can now be determined from the formula $R_E = R_T - R_I$. For example, assuming that the unit is to be operated with a set maximum current I_m of 2 amperes, with provision for reduction to a programmed current I_p of 0.25 amperes, then :-

$$R_E = R_T - R_I$$

$$= \frac{1.5}{0.25} - \frac{1.5}{2}$$

$$= 6 - 0.75$$

$$= 5.25 \text{ ohms.}$$

Alternatively the value of external resistance R_E necessary to give any programme current I_p within the current range of the 1410 series power units, can be deduced, in three steps, from the graph given in Fig. 2.8.

(1) Read-off value of internal resistance R_I with respect to the maximum limit current I_m.

(2) Read-off value of total resistance R_T with respect to the programme current I_p.

(3) Subtract value of R_I obtained in (1) from value of R_T obtained in (2) to give value of required external resistance R_E.

When calculating programming resistance values, the programmed current should allow for the 5mA internal standing current : e.g. if 5mA load current is required 10mA should be programmed. Since the effective external resistance includes that of the connecting leads and the terminal contact resistance, it is essential that the gauge of wire used for the leads is commensurate with the maximum current to be controlled, and with the length of run between the control resistor and the power unit. Refer Fig. 2.2 for guidance on cable voltage-drops.

Connections

(1) On the 10-way terminal strip, remove link from between terminals 5 and 6.

NOTE
The links between terminals 1 and 2, 3 and 4, and 7 and and 8, must be left in place.

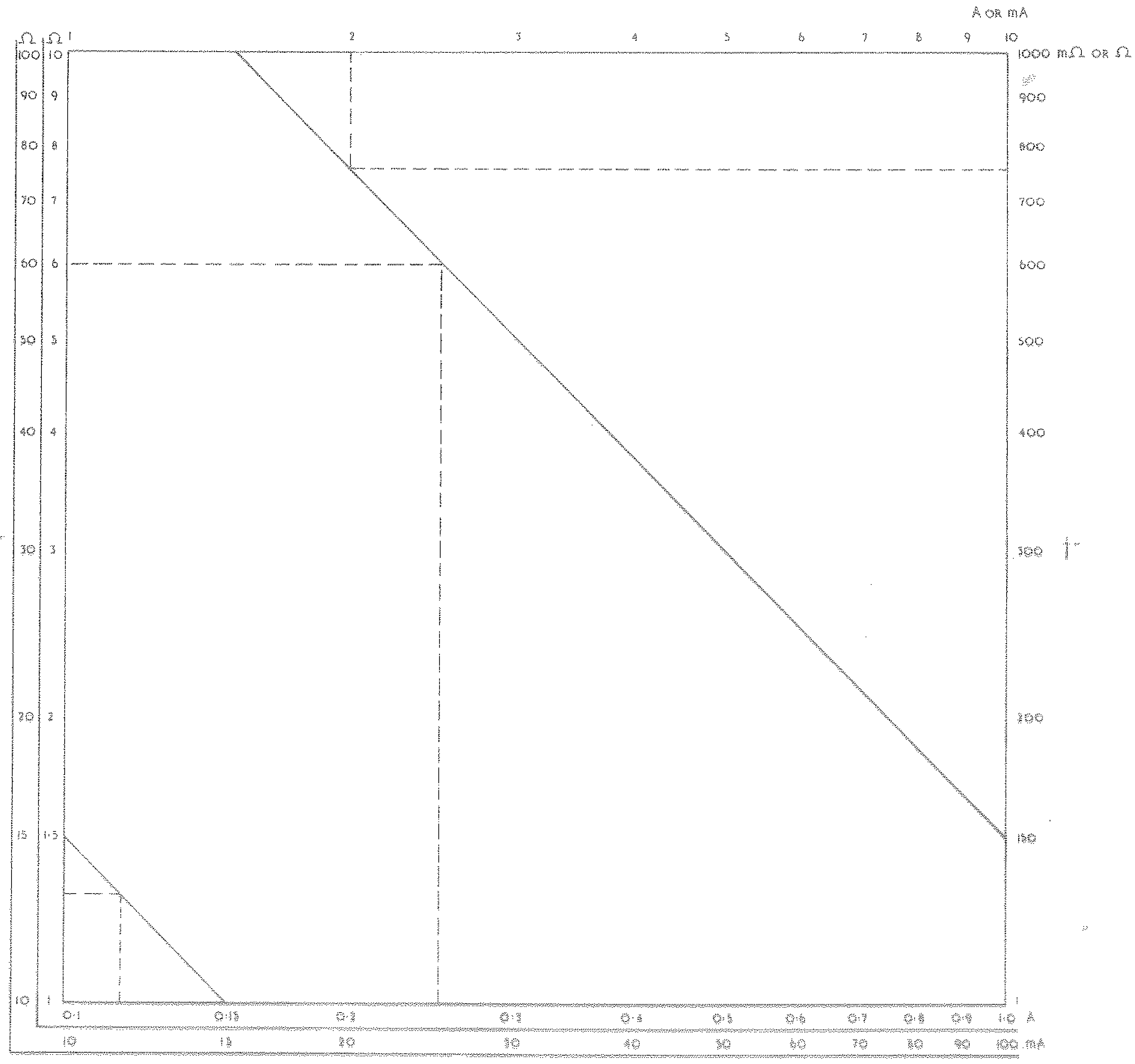


Fig. 2.8. Current vs. Resistance Graph.

(2) Connect external limiting resistance between terminals 5 and 6, using adequate gauge of wire. Refer Page 2.3, Fig. 2.2.

(3) Connect positive side of load to terminal 3 on the 10-way terminal strip, and the negative side of load to terminal 5 on the 10-way terminal strip.

NOTE
If more convenient, the positive side of the load can be connected to the positive output terminal on the unit front panel, but the negative side must be connected to terminal 6 via R_E.

(4) Proceed as for constant voltage constant current operation as detailed on Page 2.3 and 2.4. All panel controls are operative, but the effective current limit will be reduced from that set on the two panel current controls, by the introduction of any external resistance.

Voltage Controlled

Alternatively, external current programming can be performed by insertion of a voltage signal, not to exceed 1.5V, in series with the input to the current comparator amplifier. Fig. 2.7 shows the connection points with their correct polarity and indicates the principle of operation.

The effective control voltage input to the comparator amplifier is the sum of the external programme voltage and the voltage developed across the selected internal control limit resistor R_I. The comparator amplifier may be brought into action at current values less than the front panel setting of the current limit switches. For instance, with 1.5V programme input applied between terminals 8 (+) and 7 (-) current will be cut off since no additional drop is required across the selected limit resistor to make-up the 1.5 current control voltage. With OV programme input the limit level will be as set on the front panel, and for any intermediate programme voltage the effective limit will be linearly reduced.

The deflection sensitivity of the front panel meter is controlled only by the front panel current limit switches and the meter reading indicates the true current flowing, reaching full scale only when the external programme voltage is at zero.

Caution

The polarity of the control voltage must not be reversed otherwise damage will be caused to the power unit. A diode across the terminals 7 and 8 is a useful safety precaution.

External Indication of Operational Mode

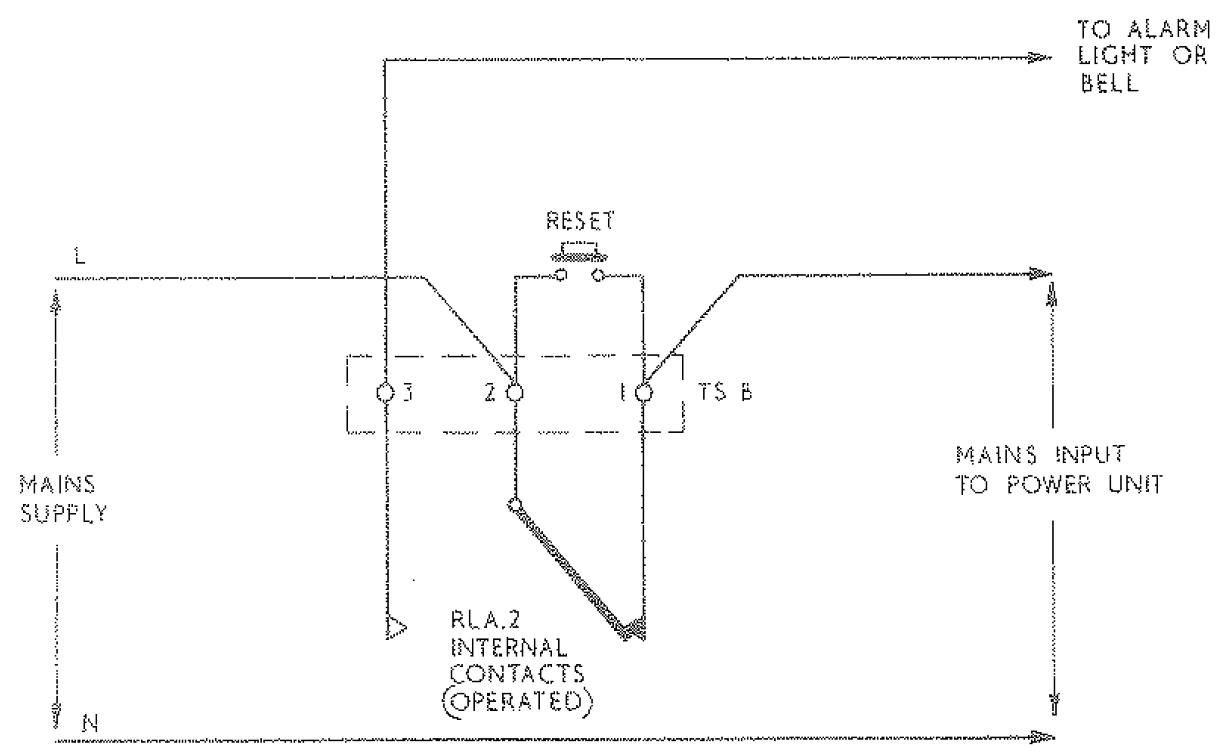
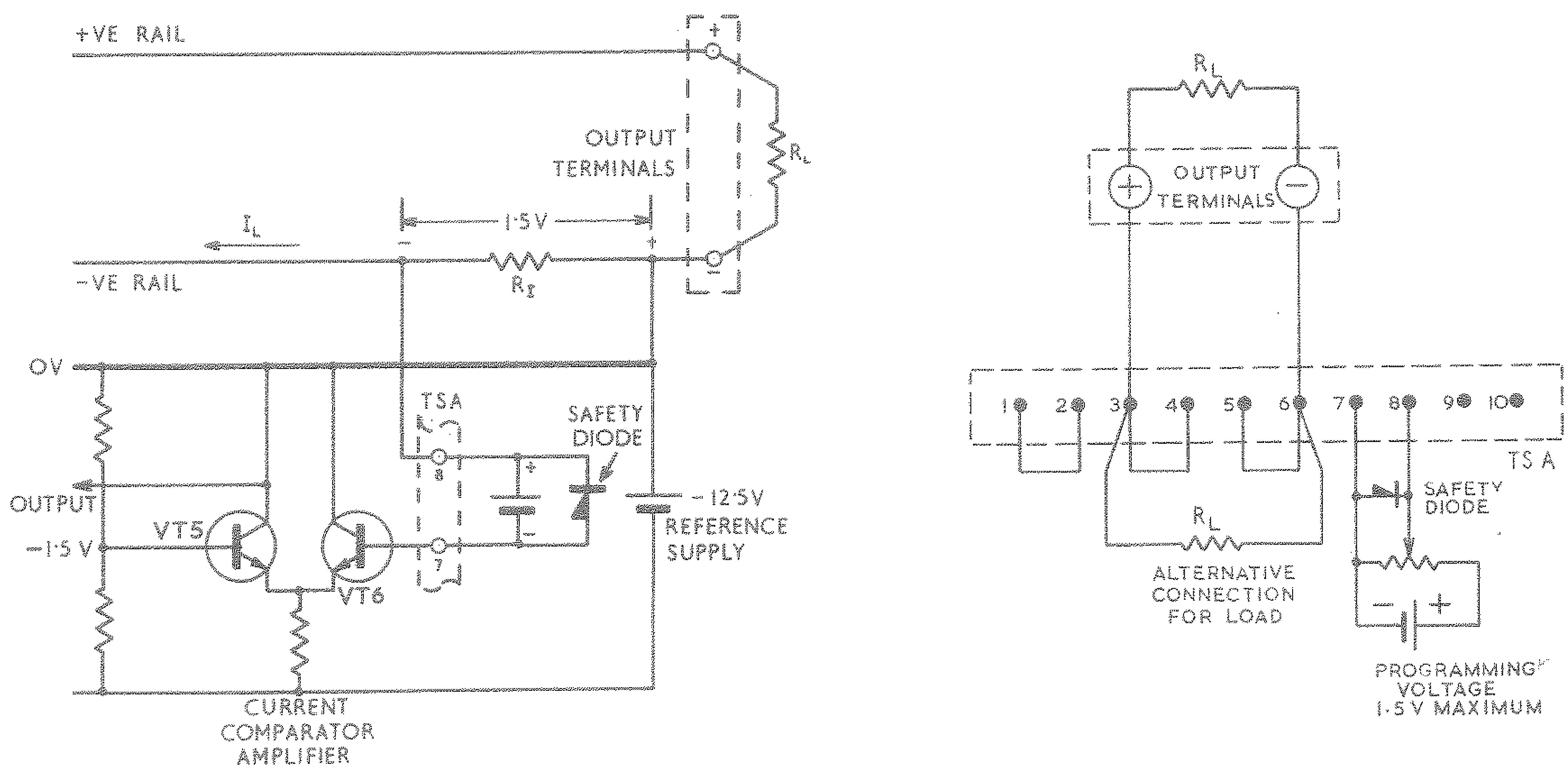


Fig. 2.9. Automatic Lock-Out and Alarm Constant V Mode.

An auxiliary set of change-over contacts of the relay switching the internal VOLTAGE CONSTANT/CURRENT CONSTANT indicator lamps is extended to a 3-way terminal strip on the unit rear panel for the purpose of external mode indication. No supply voltage is present on the terminals, the connections for which are:-

Terminal 1 } Connected when voltage constant.
Terminal 2 } Connected when current constant.
Terminal 3



(a) Principle.

(b) Connections.

Fig. 2.7. External Current Programming, Voltage-Controlled.

The relay contacts are rated for 230 volts, 1 ampere. Alternatively, the contacts can be used to effect automatic "lock-out" of the power unit in the event of lapse from the constant voltage mode, together with warning that the transition has taken place. A suggested arrangement for providing these facilities is given in Fig. 2.9. When operating in the constant voltage mode, the power unit relay RLA is energised, and the mains input to the unit is applied via the contacts connected to terminals 1 and 2. Should the circuit conditions change to cause the unit to go into the constant current mode, relay RLA/2 will "drop-out", and contact RLA. 2 will changeover to:-

(1) remove the mains input from the unit, and

(2) energise the alarm device via terminal 3.

The mains supply to the unit can now only be reinstated by operation of the reset push-button. An auxiliary relay must be used if the mains current drawn by the unit is in excess of the rating (1A) of the internal relay contacts.

Two or more units of the same of different types can be connected in parallel to provide increased current capacity.

Parallel Operation

The units may be operated in parallel in either of two modes.

(a) Direct connection, in this case the units are paralleled and the voltage selectors of both units set to the desired voltage.

Note: Since the voltage selectors have a 1% tolerance some adjustment of the fine voltage control may need to be made to ensure that the load current is shared equally. Neglect of this fine adjustment will not damage the units but a small step in voltage level may occur as the most heavily loaded unit switches to constant current.

(b) Master Slave operation

When operating in this fashion, the control amplifier of one unit only (the "master") is fully operative, and controls the series elements of the remaining unit or units ("slaves"). The digital current limit selectors on each unit must be set to the upper limit, i.e. the maximum current rating of the individual units. Any type of unit will serve as the "master", when differing types of units are being operated in parallel. Local or remote mode indication is provided by the "master" unit only.

(1) On the 10-way terminal strip of the "master" unit, link terminals 1 and 2, 3 and 4, 5 and 6, and 7 and 8.

(2) On the 10-way terminal strip of the "slave" unit(s), remove links between terminals 1 and 2, 3 and 4, and 5 and 6. Link terminal 5 to 10, and terminal 7 to 9. Terminal 7 remains linked to terminal 8.

(3) Link "master" terminal 10 to "1st slave" terminal 2, and "1st slave" terminal 10 to "2nd slave" terminal 2, etc., until all units are linked in this manner.

(4) Parallel all positive output terminals, and also all negative output terminals.

(5) Set all OUTPUT VOLTAGE selectors to the required voltage. This must be the same on all units.

(6) Set the current limit selectors such that their sum equals the required limit value.

(7) Proceed as for constant voltage or constant current operation as detailed on Page 2.3 and 2.4.

Cautions

1. When two units are operated in parallel, it is essential that the "master" unit be switched-on before the "slave" unit. Conversely, when removing power, the "slave" unit must be switched-off before the "master" unit. In installations employing more than one "slave" unit, following the switching-on of the "master" unit, the slave units must be switched in descending order, viz:- "1st slave" then "2nd slave" then "3rd slave", etc. When removing power from the installation, the switching sequence must be reversed, viz:- "3rd slave", then "2nd slave" then "1st slave", and finally the "master" unit.

Failure to observe these precautions may result in damage to the power units.

(2) In Master/Slave operation the transient response of the combined units will be slower than that specified for a single unit, due to the introduction of a large capacitor to maintain stability under all conditions.

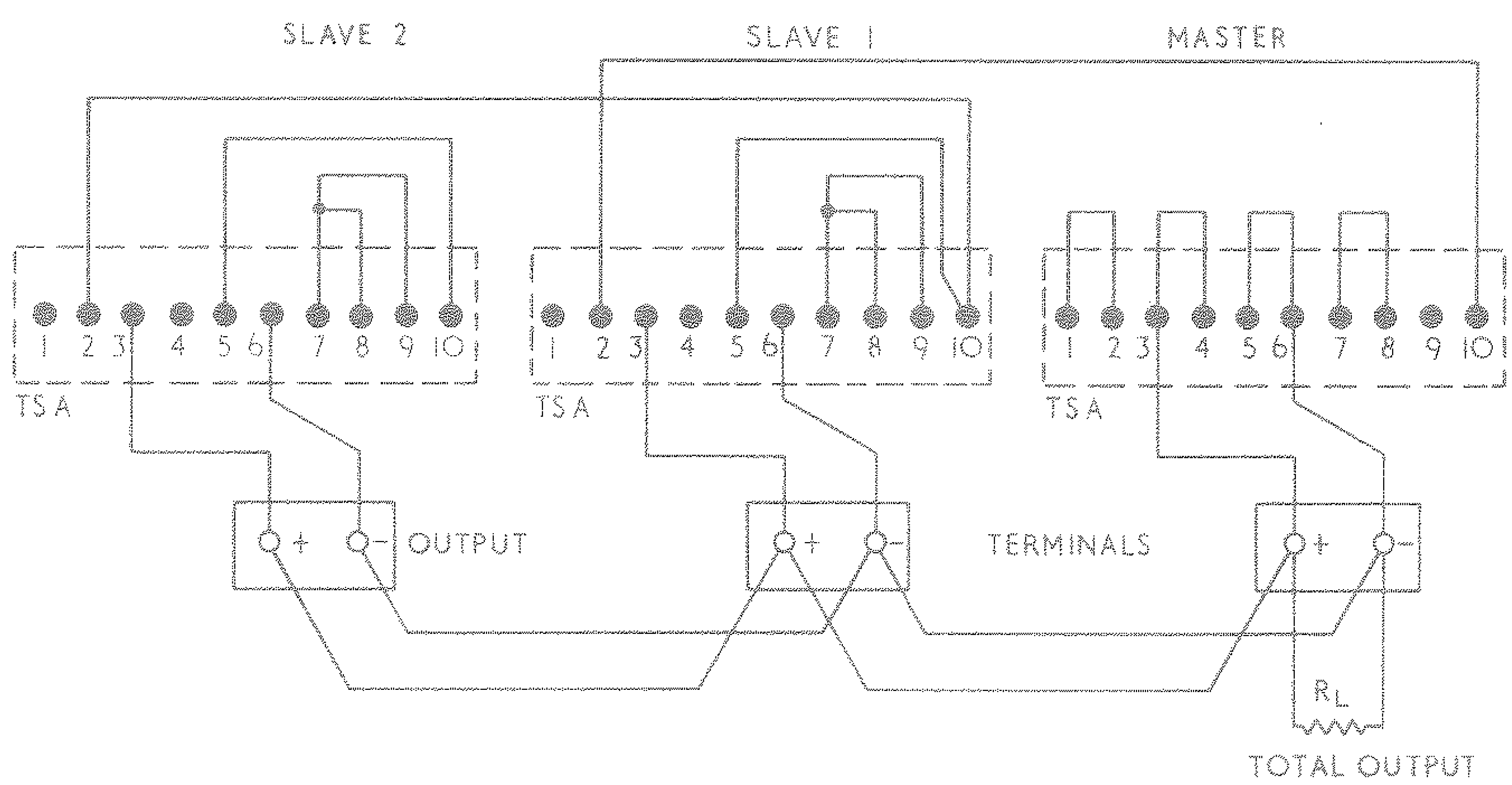


Fig. 2.10. Parallel Operation Connections.

Series Operation

Two or more units of the same or different types can be connected in series to provide increased voltage capability. The proportion of the output voltage contributed by each unit can be set by the voltage selection controls. When differing types of units are connected in series, the set current limit must not exceed the maximum output current of the lowest rated unit in the chain. Since the control amplifiers in all units are operative, no rear panel (master/slave) connections are necessary, and mode indication is provided on all units.

(1) On the 10-way terminal strip of each unit, link terminals 1 and 2, 3 and 4, 5 and 6, and 7 and 8.

(2) Connect all output terminals in series.

(3) Set the OUTPUT VOLTAGE selectors, so that the sum of their individual settings is equal to the required output voltage.

(4) Set the required current limit on each unit.

Caution

This must not exceed the maximum output current of the lowest rated unit in the chain. Failure to observe this requirement may result in damage to a unit in the event of short circuit.

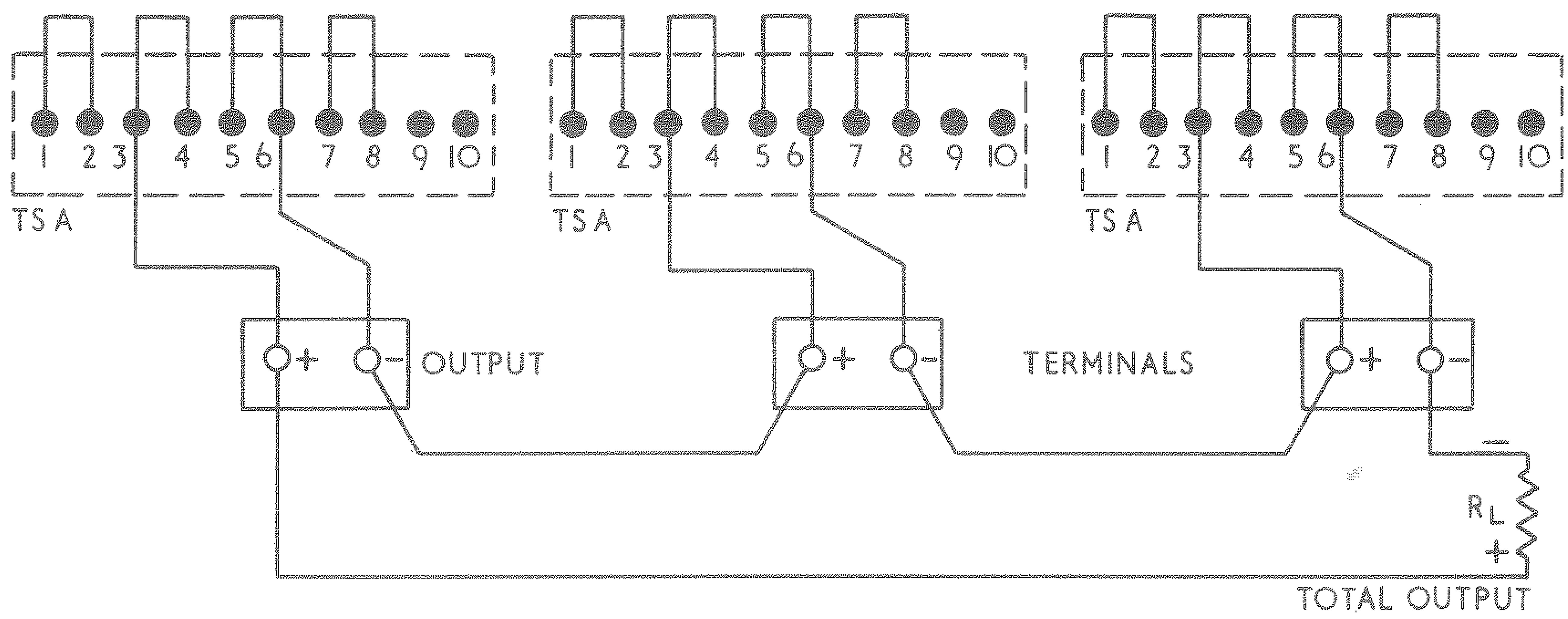


Fig. 2.11. Series Operation Connections.

SECTION 3

TECHNICAL DESCRIPTION

General

The circuit consists basically of a primary series control element fed with a steady direct voltage from a secondary series control element. (Fig. 3.1).

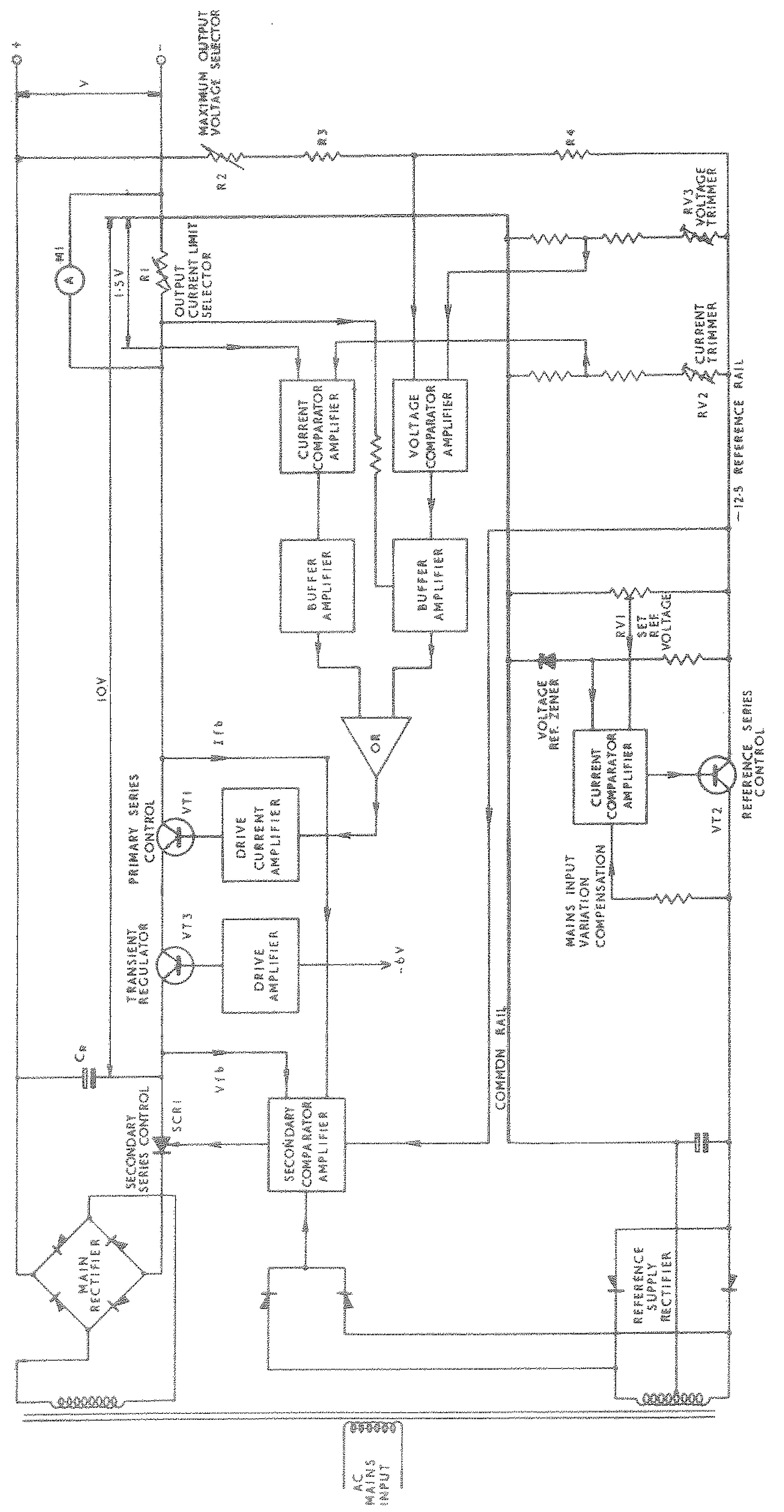


Fig. 3.1 Block Diagram AS 1411.2 Power Supply Unit.

Secondary Series Control

The function of the secondary series control is to maintain a constant voltage drop across the primary regulator independent of output conditions. It regulates the average current flowing into the reservoir capacitance C_R, so that the voltage at the reservoir terminals is maintained at the sum of the output voltage, plus a constant 10 volts, (dropped across the primary series element VT1 and current sensing resistor R1). The secondary series element takes the form of a silicon controlled rectifier SCR1, the firing angle of which is controlled by a mains synchronised blocking oscillator triggered by the output from the secondary comparator amplifier.

Primary Series Control

The primary element governs the output voltage and current in accordance with commands set-up on the operator's voltage and current controls R2 and R1. This primary series control element is driven by a voltage comparator amplifier when the unit as a whole is operating in the constant voltage mode, or by a current comparator amplifier when operating in the constant current mode.

The primary series control section is a fast-acting electronic circuit performing a number of functions, viz,

(1) Setting the output voltage to that level demanded by the operator on the panel selector R2, and

(2) stabilising the output voltage against changes caused by load variations and reservoir ripple, or,

(3) limiting the load current at that level set by the operator on the panel selector R1, and,

(4) stabilising the output current against load variations and reservoir ripple.

Functions (1) and (2) are initiated by a voltage control channel, functions (3) and (4) by a current control channel, all operating through the medium of a controllable series element connected in the negative supply rail. This series element consists of a power transistor VT1 driven on its base by a control signal from the amplifier, appropriate to the operational mode (constant voltage or constant current) in which the unit is working.

Operational Mode, CV or CI

The operational mode assumed by the unit is determined automatically by:-

(1) The output voltage V_c demanded,
(2) the set output current limit I_m, and,
(3) the resistance R_L of the load applied.

The transition from one operational mode to the other occurs at a critical value of load resistance equal to $\frac{V_c}{I_m}$. When the load resistance is greater than this critical value the unit will of its own volition operate in the constant voltage mode, and will automatically transfer to the constant current mode should the load resistance be reduced below the critical value. Conversely, a cross-over from constant current to constant voltage operation will occur if the value of load resistance is raised above the critical value. The constant voltage/constant current characteristic is shown graphically in Fig. 2.1.

Constant Voltage Mode:

The voltage comparator amplifier receives signals from a voltage sampling chain R2, R3, R4, effectively connected across the output terminals. The resistance of the first section (R2) of the chain can be varied in steps by the output voltage selector to provide increments of 10, 1, or 0.1 output volts. Load variations do not cause the output voltage to depart from the set level because the current signal developed across the current sampling chain supplies a correcting drive to the series element VT1 via a voltage comparator buffer amplifier. So long as the load current does not reach the limiting value set by the output current limit selector R1, the unit will operate in the constant voltage mode under the control of the voltage comparator amplifier, the current comparator exerting no influence.

Constant Current Mode:

If the load current rises to the set limiting value, the potential developed across the current sensing resistance R1 will increase to 1.5 volts. This will bring in the current comparator amplifier, which takes over control from the voltage comparator. The load current will now be held constant at the set limiting value under the control of the current comparator amplifier. The load current meter M1 is connected as a 1.5V voltmeter across the sensing resistors, registering full-scale deflection when the voltage developed across R1 reaches the critical limiting value of 1.5 volts. Thus, on all ranges of the output current limit selector, the meter will register full-scale deflection when the load current rises to the appropriate limiting value, as indicated on the front panel. When the loading falls below the preset limit, the reduced signal developed across R1 will render the current comparator amplifier inoperative, reinstating the voltage comparator as the controlling agent.

–12·5 Volts Reference Supply

The input signals to the voltage, current, and secondary comparator amplifiers are each compared with reference voltages divided down from a highly stable reference supply. The regulator circuit for this supply consists of a series power transistor VT2 driven on its base by the error signal developed in a reference comparator amplifier. This amplifier effects the comparison of the supply output voltage against a primary reference voltage provided by a zener diode, simultaneously applying compensation for variations of mains input voltage. A high degree of stability is achieved by the exclusive use of silicon transistors in conjunction with cracked carbon resistors, and by the employment of a temperature compensated zener diode as the primary reference source.

External Programming Arrangements

Resistance Controlled

Facilities are provided to permit the unit to be externally programmed for either output voltage or current limit settings, or both. For external voltage programming, the internal voltage setting resistance R2 is removed from circuit, and a suitable external control resistance substituted. For external current programming, a suitable external resistance is connected in series with the internal current sensing resistance R1, thereby permitting the unit to be set to limit at any load current value less than that defined by the front panel control, which is used to set the upper limit of the programme.

Voltage Controls:

Rather than use an external resistor to programme the unit voltage or current levels it is possible to use volt-signals on the appropriate pairs of rear connection strip terminals. Voltage programming may be effected by the application of a voltage control signal equal to the desired output. Note that a suitable shunt conductance must be present in the control source to absorb 5mA from the power unit. Current Programming requires a voltage between 0 and 1.5V applied between terminals 7 and 8.

Secondary Series Control

The function of the secondary series control is to maintain a constant voltage drop across the primary regulator independent of output conditions. It regulates the average current flowing into the reservoir capacitance C_R, so that the voltage at the reservoir terminals is maintained at the sum of the output voltage, plus a constant 10 volts, (dropped across the primary series element VT1 and current sensing resistor R1). The secondary series element takes the form of a silicon controlled rectifier SCR1, the firing angle of which is controlled by a mains synchronised blocking oscillator triggered by the output from the secondary comparator amplifier.

Primary Series Control

The primary element governs the output voltage and current in accordance with commands set-up on the operator's voltage and current controls R2 and R1.
This primary series control element is driven by a voltage comparator amplifier when the unit as a whole is operating in the constant voltage mode, or by a current comparator amplifier when operating in the constant current mode.
The primary series control section is a fast-acting electronic circuit performing a number of functions, viz,

(1) Setting the output voltage to that level demanded by the operator on the panel selector R2, and

(2) stabilising the output voltage against changes caused by load variations and reservoir ripple, or,

(3) limiting the load current at that level set by the operator on the panel selector R1, and,

(4) stabilising the output current against load variations and reservoir ripple.

Functions (1) and (2) are initiated by a voltage control channel, functions (3) and (4) by a current control channel, all operating through the medium of a controllable series element connected in the negative supply rail. This series element consists of a power transistor VT1 driven on its base by a control signal from the amplifier, appropriate to the operational mode (constant voltage or constant current) in which the unit is working.

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The operational mode assumed by the unit is determined automatically by:-
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The transition from one operational mode to the other occurs at a critical value of load resistance equal to $\frac{V_c}{I_m}$. When the load resistance is greater than this critical value the unit will of its own volition operate in the constant voltage mode, and will automatically transfer to the constant current mode should the load resistance be reduced below the critical value. Conversely, a crossover from constant current to constant voltage operation will occur if the value of load resistance is raised above the critical value. The constant voltage/constant current characteristic is shown graphically in Fig. 2.1.

Constant Voltage Mode:

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Constant Current Mode:

If the load current rises to the set limiting value, the potential developed across the current sensing resistance R1 will increase to 1.5 volts. This will bring in the current comparator amplifier, which takes over control from the voltage comparator. The load current will now be held constant at the set limiting value under the control of the current comparator amplifier. The load current meter M1 is connected as a 1.5V voltmeter across the sensing resistors, registering full-scale deflection when the voltage developed across R1 reaches the critical limiting value of 1.5 volts. Thus, on all ranges of the output current limit selector, the meter will register full-scale deflection when the load current rises to the appropriate limiting value, as indicated on the front panel. When the loading falls below the preset limit, the reduced signal developed across R1 will render the current comparator amplifier inoperative, reinstating the voltage comparator as the controlling agent.

−12·5 Volts Reference Supply

The input signals to the voltage, current, and secondary comparator amplifiers are each compared with reference voltages divided down from a highly stable reference supply. The regulator circuit for this supply consists of a series power transistor VT2 driven on its base by the error signal developed in a reference comparator amplifier. This amplifier effects the comparison of the supply output voltage against a primary reference voltage provided by a zener diode, simultaneously applying compensation for variations of mains input voltage. A high degree of stability is achieved by the exclusive use of silicon transistors in conjunction with cracked carbon resistors, and by the employment of a temperature compensated zener diode as the primary reference source.

External Programming Arrangements

Resistance Controlled

Facilities are provided to permit the unit to be externally programmed for either output voltage or current limit settings, or both. For external voltage programming, the internal voltage setting resistance R2 is removed from circuit, and a suitable external control resistance substituted. For external current programming, a suitable external resistance is connected in series with the internal current sensing resistance R1, thereby permitting the unit to be set to limit at any load current value less than that defined by the front panel control, which is used to set the upper limit of the programme.

Voltage Controls:

Rather than use an external resistor to programme the unit voltage or current levels it is possible to use volt-signals on the appropriate pairs of rear connection strip terminals. Voltage programming may be effected by the application of a voltage control signal equal to the desired output. Note that a suitable shunt conductance must be present in the control source to absorb 5mA from the power unit. Current Programming requires a voltage between 0 and 1.5V applied between terminals 7 and 8.

Voltage Setting Chain

The voltage setting chain is connected in series with two fixed resistors R25, R26, and the -12.5 volts reference supply, across the output terminals as shown in Fig. 4.1.

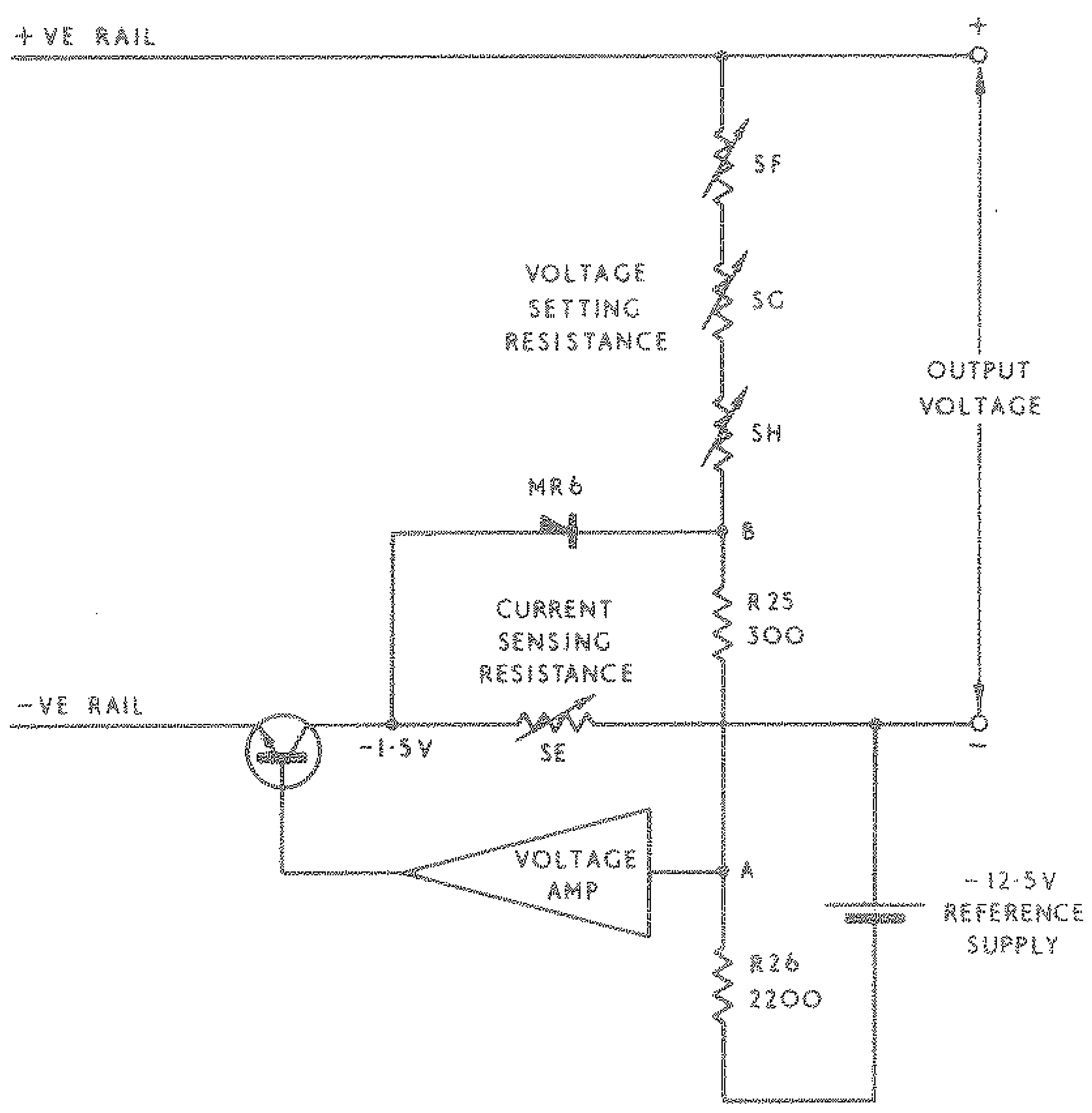


Fig. 4.1 Voltage Setting Chain.

The amount of resistance in the voltage setting chain is determined by the setting of the OUTPUT VOLTAGE digital selectors SF, SG, and SH, which introduce resistance at the rate of 200 ohms per output volt. In constant voltage operation 5mA flows in the chain under equilibrium conditions. Thus SF which introduces 2000 ohms resistors, provides 10 volts output increments. Similarly, SG and SH which introduce 200 and 20 ohms resistors respectively, effect 1 and 0.1 volt increments. The 20 ohm analogue voltage control RV3 provides a continuously variable output over the range 0-100mV. This output is additive to that set by the digital selectors. When the unit is operating in the constant voltage mode a fixed reference current of 5mA is drawn from the positive output rail. This current passes through the voltage setting chain, resistors R25 and R26, thence through the reference supply and back into the negative rail via the current sensing resistance selected by SE and/or SL. In this condition the top of R25 is a virtual earth point and the junction of resistors R25 and R26 (point A) is held at a steady potential of -1.5 volts with respect to common rail. If now the circuit conditions are modified by a demand for higher output voltage, i.e. the resistance of the voltage setting chain is increased, the consequent momentary decrease in reference current will cause point A to move negatively with respect to common rail. This signal is applied to the voltage comparator amplifier which causes the primary series element to pass more current, this extra current charging up the output capacitor towards the higher voltage. The main reservoir capacitor voltage will no longer exceed the output by 10 volts and the secondary (SCR) control circuits will be brought into operation to restore the difference back to 10V. As soon as the output voltage reaches the demanded level, the voltage chain current will return to its reference level of 5mA, returning point A to its equilibrium potential of -1.5 volts, and thereby removing the extra drive from the primary series element. A similar course of action would be initiated if the circuit conditions were modified as a result of an increase in loading causing the output voltage and hence the reference current to decrease, but in this case the drive to the comparator amplifier, will be provided mainly by the current compensation signal.

NOTE

On early versions of the unit, the analogue voltage control has a value of 2000 ohms to provide a coverage of 0-10 volts, subject to maximum output voltage limitation. Associated with this control are two ganged switches SC1 and SC2, and a neon indicator lamp ILP3. When RV3 is turned clockwise from the CAL. position, the ganged switch SC1 closes to short circuit resistor R33 (2000 ohms) to ensure that the output voltage demanded from the unit will remain within its maximum rating. A second pole of the switch (SC2) closes to apply the mains potential to the analogue voltage neon indicator lamp ILP3 to provide visual warning that the digital read-out displayed by the digital selection switches is invalidated.

Current Comparator Amplifier

The circuit is essentially the same as that employed for the voltage comparator amplifier, comprising of an input differential amplifier and a buffer amplifier. Additionally it includes a gating circuit and a driver for the mode indicator relay. The control signal developed across the current sensing resistance is applied to one side (VT6) of the input differential amplifier. The base of the other side (VT5) is held at a fixed reference potential of -1.5 volts with respect to common rail by the potential divider R13, R14 and RV2, connected between the zero and -12.5 volts reference rails. RV2 is used to set the output current limit level. When the unit is operating in the constant voltage mode, the control signal developed across the current sensing resistance will be less than -1.5 volts. In this condition, transistor VT6 will be conducting, and VT5 will be cut off, thus the collector of the latter transistor and the base of the buffer amplifier VT7 will be at a potential of zero volts. Transistor VT7 is thereby cut off, thus its collector and the anode of MR9 stand at a potential of approximately -8.3 volts (determined by the voltage divider R45, MR10, and the base emitter junction of VT8). Since the cathode potential of MR9 is prevented from going more negative than -6.3 volts by the zener diode MR12, diode MR9 is reverse-biased, and the current comparator is effectively isolated from the drive current amplifier, which now operates under the control of the voltage comparator. If the loading is increased to such an extent that the load current attains the set limiting level, the potential developed across the sensing resistance and hence the base potential of VT6 will reach -1.5 volts. This reduces the current in VT6, and turns on VT5 which develops a negative signal at its collector. This negative output is applied to the base of the buffer amplifier VT7, which draws more current through R45 and thus reduces that through MR10. The collector potential of VT7 moves towards the common rail until diode MR9 becomes forward biased and reduces the available drive to the current amplifier VT16. Some of the current from R47 is diverted to VT7 and away from VT16. The primary series control element, operating under the influence of the current comparator amplifier, now reduces the output voltage to that level necessary to hold the load current at the limiting value as set by the limit controls.

Operational Mode Indicator Circuit

Visual indication of operational mode (constant voltage or constant current) is provided by panel-mounted neon lamps selected via a normally energised relay released by the output of the buffer amplifier VT7 in the current comparator amplifier. When the unit is working in the constant voltage mode, the collector of VT7 will stand at a potential of approximately -8.3 volts. In this circumstance, the base of VT8 will be supplied with base current via zener diode MR10 and R45, and the transistor will pass current to energise relay RLA/2 wired in its collector circuit. Contact RLA.1 will be operated to close relay terminal 6 to 7, thus shorting out the CURRENT CONSTANT lamp ILP1, and permitting the VOLTAGE CONSTANT lamp ILP2 to be energised from the mains supply. When the unit transfers to the constant current mode, VT7 will pass current to short-out MR10 and R17, thereby removing the drive current from VT8 base and cutting-off that transistor. Relay RLA/2 will thereon drop out, and contacts RLA.1 will change over to extinguish the VOLTAGE CONSTANT lamp and energise the CURRENT CONSTANT lamp. The terminals of a second set of changeover contacts (RLA.2) on the relay are extended to a 3-way terminal strip TSB, mounted on the back plate of the unit, to provide remote mode indication and/or alarm facility, if required.

Current Sensing Network

The function of the current sensing network is to provide a current-dependent control signal for the operation of the current comparator amplifier, as well as feedback to the series section and its drivers. The control signal is developed across a current sensing resistance by the load current. The amount of sensing resistance introduced on any given output current limit range is such that a potential drop of 1.5 volts is developed when the load current attains the limiting level. For instance, when operating with a set current limit of 100mA, the sensing resistance will have a value of 15 ohms. The sensing resistance appropriate to the limit range in use is introduced by the additive LIMIT OUTPUT CURRENT digital selectors SE and SL. The four banks of switch SE sequentially parallel the 7.5 ohms resistors R20-R29 as the control is advanced from the 0.2A to the 2.0A position. Similarly, the four banks of switch SL sequentially parallel the 75 ohms resistors (R66-R75) across the resistors selected by SE, as the control is advanced from the "20" to the "200" mA position. Thus, with SE set to "0.2" and SL to "20", the sensing resistance is made-up of R20 (7.5 ohms) in parallel with R66 (75 ohms), giving an output limit current of 220mA.

NOTE

On early models, a continuously variable analogue output current limit control is provided in place of the mA stepped control SL. This consists of a reciprocal law potentiometer RV2, connected in series with R17 (15Ω), the whole being shunted across the sensing resistance introduced by the digital limit selector SE.

The first ("0") position of the digital current limit selector SE provides an operational check facility. When SE is set to this position, switchbank SE1F open-circuits resistors R20-R29, and providing that SL is set to the CAL. position, the effective value of sensing resistance becomes 430 ohms (R19). In this circumstance, the limiting potential of 1.5 volts will be developed by the reference current of 5mA, and any attempt to draw load current will reduce the voltage at the output terminals to zero. The operational check is performed by observing that the unit is passing the 5mA reference current as evidenced by the full-scale deflection of the internal current meter. When the unit is operating in the constant voltage mode, the potential at point B (Fig. 4.1) is held at zero potential by the voltage developed across R25 and R26 by the 5mA reference current. Since this current passes through the current sensing resistance and the total remains fixed, any reduction of this contribution must cause an equal increase in available output current. If the loading is increased to cause the unit to transfer from the constant voltage to the constant current mode, the output voltage will commence to collapse, thereby reducing its contribution to the reference current through the voltage setting and current sensing resistances. In the ultimate condition where the output voltage is reduced to zero, a total current of 4.2mA will be drawn from the reference supply via R26 and R25, part flowing through the resistors on SF, SG, SH, and the remainder through MR6. For output voltage settings of 2.4V or less no current will be drawn from MR6 since the potential at point B will not become sufficiently negative to produce forward bias. Higher voltage settings have correspondingly higher chain resistance and some of the 4.2mA will flow in MR6. In the limit, about 4mA passes through MR6 and 0.2mA through the voltage chain. It will be seen therefore that during the crossover from constant voltage to constant current there is a progressive increase of 0.8mA in available output current at any limit setting.

Current Metering Facility

The internal moving-coil meter M1 is connected as a voltmeter across the current sensing resistors R20-R29 and R66- R75. A variable trimmer resistance RV1, is connected in series with the meter, and adjusted so that the meter registers full-scale deflection when the potential across the sensing resistance attains the limiting level of 1.5 volts. Thus the full-scale deflection of the meter in all circumstances is equal to the current limit as set by the digital limit selectors SE and SL. The current drawn by the meter is 1mA at F.S.D. and its coil resistance together with RV1 makes up a total of 1500Ω.

– 12·5 Volts Reference Supply

All comparator amplifiers in the unit are referred to this highly stable rail, which is regulated against both mains input and loading variations.

The 15-0-15 volts output from a centre-tapped secondary winding of the mains transformer drives a pair of bi-phase rectifiers MR1, MR2 which feed the reservoir capacitor C1. The comparator amplifier consists of a differential input stage VT2 and VT3. The base of VT3 is referred to a voltage standard derived by dividing down the potential developed across the temperature compensated zener diode MR5. The input to VT2 (the other side of amplifier)is taken from a sampling chain R5, R6 and R7, connected between the reference and zero volts rails. An amplified control signal is developed at the collector of VT2 and applied to the base of the driver stage VT4, the emitter of which is held constant at approximately -9 volts by the zener diode. Drive from the collector of VT4 is applied to the base of the series control element VT1 in such sense as to oppose the change initiating the action. Compensation for variation in mains input voltage is applied to the base of VT2 via the potential divider R3 and R7. The unregulated side of the supply is employed for energising the mode indicator relay RLA/2.

External Voltage Sensing and Programming Facilities:

Certain points associated with the internal voltage setting chain and the internal current sensing resistance are extended to a 10-way terminal strip TSA to permit the unit to be operated with:-

(a) External voltage sensing,
(b) External voltage programming, or
(c) External current programming.

The relative positions of the external terminals in the unit circuitry are shown in Fig. 2.3-2.7. The principles and methods of operation in these modes are given in pages 2.4-2.7 and will not be further considered here. Terminals 9 and 10 on TSA are associated with the parallel working of two or more units.

Voltage Setting Chain

The voltage setting chain is connected in series with two fixed resistors R25, R26, and the -12.5 volts reference supply, across the output terminals as shown in Fig. 4.1.

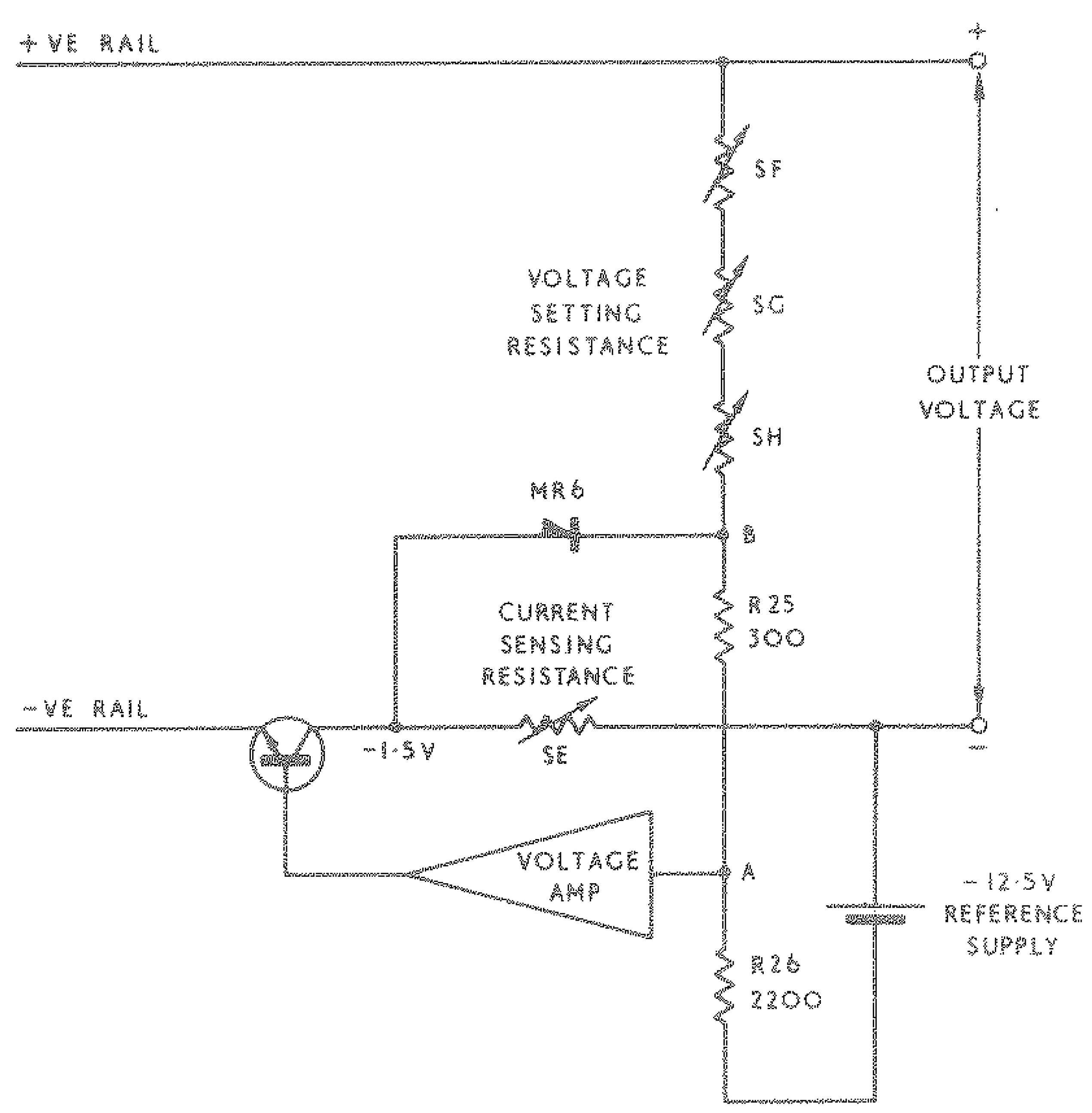


Fig. 4.1 Voltage Setting Chain.

The amount of resistance in the voltage setting chain is determined by the setting of the OUTPUT VOLTAGE digital selectors SF, SG, and SH, which introduce resistance at the rate of 200 ohms per output volt. In constant voltage operation 5mA flows in the chain under equilibrium conditions. Thus SF which introduces 2000 ohms resistors, provides 10 volts output increments. Similarly, SG and SH which introduce 200 and 20 ohms resistors respectively, effect 1 and 0.1 volt increments. The 20 ohm analogue voltage control RV3 provides a continuously variable output over the range 0-100mV. This output is additive to that set by the digital selectors. When the unit is operating in the constant voltage mode a fixed reference current of 5mA is drawn from the positive output rail. This current passes through the voltage setting chain, resistors R25 and R26, thence through the reference supply and back into the negative rail via the current sensing resistance selected by SE and/or SL. In this condition the top of R25 is a virtual earth point and the junction of resistors R25 and R26 (point A) is held at a steady potential of -1.5 volts with respect to common rail. If now the circuit conditions are modified by a demand for higher output voltage, i.e. the resistance of the voltage setting chain is increased, the consequent momentary decrease in reference current will cause point A to move negatively with respect to common rail. This signal is applied to the voltage comparator amplifier which causes the primary series element to pass more current, this extra current charging up the output capacitor towards the higher voltage. The main reservoir capacitor voltage will no longer exceed the output by 10 volts and the secondary (SCR) control circuits will be brought into operation to restore the difference back to 10V. As soon as the output voltage reaches the demanded level, the voltage chain current will return to its reference level of 5mA, returning point A to its equilibrium potential of -1.5 volts, and thereby removing the extra drive from the primary series element. A similar course of action would be initiated if the circuit conditions were modified as a result of an increase in loading causing the output voltage and hence the reference current to decrease, but in this case the drive to the comparator amplifier, will be provided mainly by the current compensation signal.

NOTE

On early versions of the unit, the analogue voltage control has a value of 2000 ohms to provide a coverage of 0-10 volts, subject to maximum output voltage limitation. Associated with this control are two ganged switches SC1 and SC2, and a neon indicator lamp ILP3. When RV3 is turned clockwise from the CAL. position, the ganged switch SC1 closes to short circuit resistor R33 (2000 ohms) to ensure that the output voltage demanded from the unit will remain within its maximum rating. A second pole of the switch (SC2) closes to apply the mains potential to the analogue voltage neon indicator lamp ILP3 to provide visual warning that the digital read-out displayed by the digital selection switches is invalidated.

Current Comparator Amplifier

The circuit is essentially the same as that employed for the voltage comparator amplifier, comprising of an input differential amplifier and a buffer amplifier. Additionally it includes a gating circuit and a driver for the mode indicator relay. The control signal developed across the current sensing resistance is applied to one side (VT6) of the input differential amplifier. The base of the other side (VT5) is held at a fixed reference potential of -1.5 volts with respect to common rail by the potential divider R13, R14 and RV2, connected between the zero and -12.5 volts reference rails. RV2 is used to set the output current limit level. When the unit is operating in the constant voltage mode, the control signal developed across the current sensing resistance will be less than -1.5 volts. In this condition, transistor VT6 will be conducting, and VT5 will be cut off, thus the collector of the latter transistor and the base of the buffer amplifier VT7 will be at a potential of zero volts. Transistor VT7 is thereby cut off, thus its collector and the anode of MR9 stand at a potential of approximately -8.3 volts (determined by the voltage divider R45, MR10, and the base emitter junction of VT8). Since the cathode potential of MR9 is prevented from going more negative than -6.3 volts by the zener diode MR12, diode MR9 is reverse-biased, and the current comparator is effectively isolated from the drive current amplifier, which now operates under the control of the voltage comparator. If the loading is increased to such an extent that the load current attains the set limiting level, the potential developed across the sensing resistance and hence the base potential of VT6 will reach -1.5 volts. This reduces the current in VT6, and turns on VT5 which develops a negative signal at its collector. This negative output is applied to the base of the buffer amplifier VT7, which draws more current through R45 and thus reduces that through MR10. The collector potential of VT7 moves towards the common rail until diode MR9 becomes forward biased and reduces the available drive to the current amplifier VT16. Some of the current from R47 is diverted to VT7 and away from VT16. The primary series control element, operating under the influence of the current comparator amplifier, now reduces the output voltage to that level necessary to hold the load current at the limiting value as set by the limit controls.

Operational Mode Indicator Circuit

Visual indication of operational mode (constant voltage or constant current) is provided by panel-mounted neon lamps selected via a normally energised relay released by the output of the buffer amplifier VT7 in the current comparator amplifier. When the unit is working in the constant voltage mode, the collector of VT7 will stand at a potential of approximately -8.3 volts. In this circumstance, the base of VT8 will be supplied with base current via zener diode MR10 and R45, and the transistor will pass current to energise relay RLA/2 wired in its collector circuit. Contact RLA.1 will be operated to close relay terminal 6 to 7, thus shorting out the CURRENT CONSTANT lamp ILP1, and permitting the VOLTAGE CONSTANT lamp ILP2 to be energised from the mains supply. When the unit transfers to the constant current mode, VT7 will pass current to short-out MR10 and R17, thereby removing the drive current from VT8 base and cutting-off that transistor. Relay RLA/2 will thereon drop out, and contacts RLA.1 will change over to extinguish the VOLTAGE CONSTANT lamp and energise the CURRENT CONSTANT lamp. The terminals of a second set of changeover contacts (RLA.2) on the relay are extended to a 3-way terminal strip TSB, mounted on the back plate of the unit, to provide remote mode indication and/or alarm facility, if required.

Current Sensing Network

The function of the current sensing network is to provide a current-dependent control signal for the operation of the current comparator amplifier, as well as feedback to the series section and its drivers. The control signal is developed across a current sensing resistance by the load current. The amount of sensing resistance introduced on any given output current limit range is such that a potential drop of 1.5 volts is developed when the load current attains the limiting level. For instance, when operating with a set current limit of 100mA, the sensing resistance will have a value of 15 ohms. The sensing resistance appropriate to the limit range in use is introduced by the additive LIMIT OUTPUT CURRENT digital selectors SE and SL. The four banks of switch SE sequentially parallel the 7.5 ohms resistors R20-R29 as the control is advanced from the 0.2A to the 2.0A position. Similarly, the four banks of switch SL sequentially parallel the 75 ohms resistors (R66-R75) across the resistors selected by SE, as the control is advanced from the "20" to the "200" mA position. Thus, with SE set to "0.2" and SL to "20", the sensing resistance is made-up of R20 (7.5 ohms) in parallel with R66 (75 ohms), giving an output limit current of 220mA.

NOTE

On early models, a continuously variable analogue output current limit control is provided in place of the mA stepped control SL. This consists of a reciprocal law potentiometer RV2, connected in series with R17 (15Ω), the whole being shunted across the sensing resistance introduced by the digital limit selector SE.

The first ("0") position of the digital current limit selector SE provides an operational check facility. When SE is set to this position, switchbank SE1F open-circuits resistors R20-R29, and providing that SL is set to the CAL. position, the effective value of sensing resistance becomes 430 ohms (R19). In this circumstance, the limiting potential of 1.5 volts will be developed by the reference current of 5mA, and any attempt to draw load current will reduce the voltage at the output terminals to zero. The operational check is performed by observing that the unit is passing the 5mA reference current as evidenced by the full-scale deflection of the internal current meter. When the unit is operating in the constant voltage mode, the potential at point B (Fig. 4.1) is held at zero potential by the voltage developed across R25 and R26 by the 5mA reference current. Since this current passes through the current sensing resistance and the total remains fixed, any reduction of this contribution must cause an equal increase in available output current. If the loading is increased to cause the unit to transfer from the constant voltage to the constant current mode, the output voltage will commence to collapse, thereby reducing its contribution to the reference current through the voltage setting and current sensing resistances. In the ultimate condition where the output voltage is reduced to zero, a total current of 4.2mA will be drawn from the reference supply via R26 and R25, part flowing through the resistors on SF, SG, SH, and the remainder through MR6. For output voltage settings of 2.4V or less no current will be drawn from MR6 since the potential at point B will not become sufficiently negative to produce forward bias. Higher voltage settings have correspondingly higher chain resistance and some of the 4.2mA will flow in MR6. In the limit, about 4mA passes through MR6 and 0.2mA through the voltage chain. It will be seen therefore that during the crossover from constant voltage to constant current there is a progressive increase of 0.8mA in available output current at any limit setting.

Current Metering Facility

The internal moving-coil meter M1 is connected as a voltmeter across the current sensing resistors R20-R29 and R66- R75. A variable trimmer resistance RV1, is connected in series with the meter, and adjusted so that the meter registers full-scale deflection when the potential across the sensing resistance attains the limiting level of 1.5 volts. Thus the full-scale deflection of the meter in all circumstances is equal to the current limit as set by the digital limit selectors SE and SL. The current drawn by the meter is 1mA at F.S.D. and its coil resistance together with RV1 makes up a total of 1500Ω.

– 12·5 Volts Reference Supply

All comparator amplifiers in the unit are referred to this highly stable rail, which is regulated against both mains input and loading variations.

The 15-0-15 volts output from a centre-tapped secondary winding of the mains transformer drives a pair of bi-phase rectifiers MR1, MR2 which feed the reservoir capacitor C1. The comparator amplifier consists of a differential input stage VT2 and VT3. The base of VT3 is referred to a voltage standard derived by dividing down the potential developed across the temperature compensated zener diode MR5. The input to VT2 (the other side of amplifier)is taken from a sampling chain R5, R6 and R7, connected between the reference and zero volts rails. An amplified control signal is developed at the collector of VT2 and applied to the base of the driver stage VT4, the emitter of which is held constant at approximately -9 volts by the zener diode. Drive from the collector of VT4 is applied

10 ms/cm, across the reservoir capacitance on the main assembly.

(2) With the output voltage set to the appropriate level as listed in sub-para. 4 Current Check (Page 5.2), the current selectors set to maximum, and the 1 ohm precision load resistance still connected, check that the waveform displayed is a 100Hz sawtooth, free from jitter, and of peak-to-peak amplitude not greater than 5 volts.

Internal Voltage

(1) Using the multimeter, check that the voltage between the negative output terminal and the emitter of VT1 is within the specified limits.

AS 1410.2, AS 1414.2	9 - 11 V, d.c.
AS 1411.2, AS 1412.2	5 - 7 V, d.c.

NOTE: This test is not applicable to the AS 1413 and AS 1416 units.

Regulation Against Mains Input Variations

NOTE: Sub-paras (1) to (7) following describe the method adopted for the selection of R3, and need only be performed if, as a result of damage, that resistor requires replacement.

(1) Remove mains supply and 1ohm precision load resistor from unit, set digital voltage selectors to maximum and 'A' LIMIT OUTPUT current selector to maximum.

(2) Connect the stepped variable resistance (item (13) of test equipment), across the position normally occupied by R3 on the printed-circuit board.

(3) Set oscilloscope sweep speed to 10 ms/cm, and Y sensitivity to 0.5mV/cm, and connect across the reference rail and pin C on the unit printed-circuit board.

(4) Apply mains voltage to the unit under test, and adjust stepped variable resistor for minimum amplitude sawtooth on the oscilloscope display. If necessary, a low-pass RC filter may be employed to remove high frequencies.

(5) Connect digital voltmeter to the output terminals, via the backing-off circuit (Fig. 5.3) to allow the digital voltmeter to be operated on a sufficiently sensitive range.

(6) Adjust Variac to swing the mains input between 216 and 264V (±10% of the nominal 240V), checking that the variation in output voltage does not exceed the specified value.

AS 1410.2, AS 1416	600µV
AS 1411.2, AS 1412.2, AS 1413	800µV
AS 1414.2	1.2mV

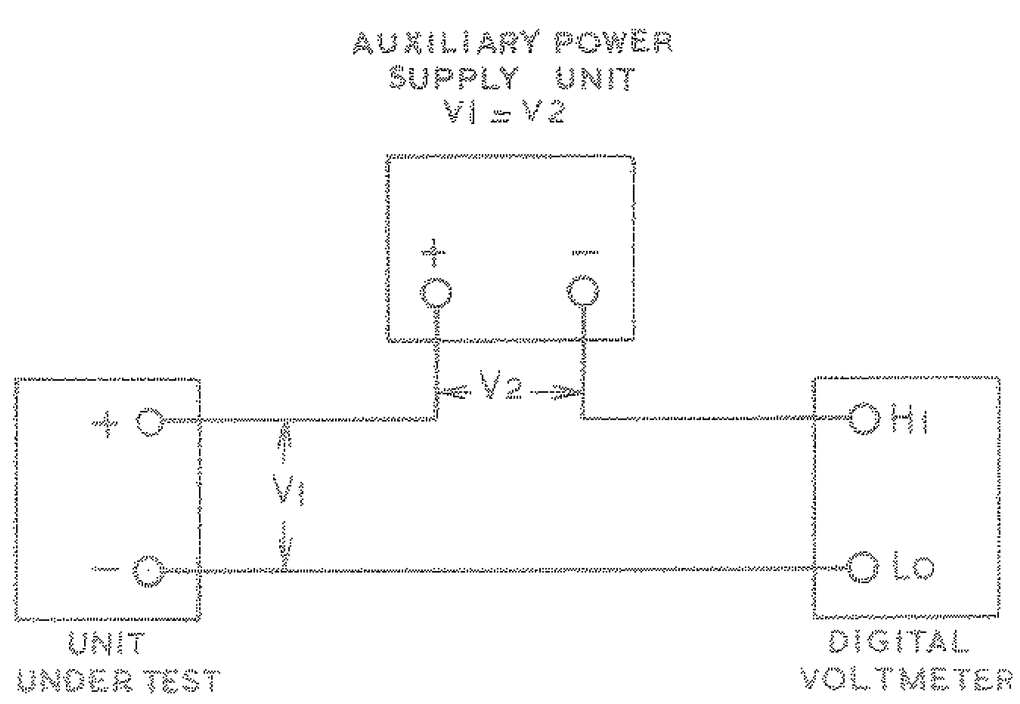


Fig. 5.3. Backing-Off Circuit.

(7) Disconnect stepped variable resistance, and fit a cracked carbon resistor of equivalent value on the printed-circuit board.

(8) Re-check by repetition of procedure detailed in sub-para. (6).

Regulation Against Load Variations

(1) Retaining the test rig of Fig. 5.3, and with both current and voltage controls still set to maximum, set mains input to unit under test to 240V by adjustment of the Variac.

(2) Connect appropriately valued and rated load resistor, as listed hereafter, to the output terminals of the unit under test, via a circuit breaker. Ensure that any voltage drop developed across the load connections will not be measured by the digital voltmeter, by connecting the meter directly across the power unit output terminals.

AS 1410.2	37 ohms, 1A (37W)
AS 1411.2	25 ohms, 2A (100W)
AS 1412.2	10 ohms, 5A (250W)
AS 1413	100 ohms, 500mA (25W)
AS 1414.2	75 ohms, 1A (75W)
AS 1416	125 ohms, 300mA (12W)

(3) Switch the load "on" and "off" by means of the circuit breaker, checking that the change in the output voltage, as read on the digital voltmeter, does not exceed the specified value.

AS 1410.2, AS 1413, AS 1414.2, AS 1416	1mV
AS 1411.2	2mV
AS 1412.2	5mV

Ripple and Noise, Constant Voltage

(1) Disconnect the digital voltmeter and the load resistor from the unit output terminals, and connect the oscilloscope across the output terminals.

(2) With the unit voltage and current controls still set to maximum, set Variac to raise mains input to unit to 264V.

(3) Check that the ripple (50Hz) and hum (100Hz) voltages do not exceed 500µV p-p, and that the spike and noise component of the ripple does not exceed 2mV p-p.

(4) Set the unit voltage selectors for zero output.

(5) Check that the ripple (50Hz) and hum (100Hz) voltages do not exceed 500µV p-p, and that the spike and noise component of the ripple does not exceed 2mV p-p.

(6) Return unit voltage selectors to maximum, and connect the appropriate load resistor, as listed under para. 2 of Regulation against Load Variation, above, across the unit output terminals in parallel with the oscilloscope.

(7) Check that the ripple (50Hz) and hum (100Hz) voltages do not exceed 500µV p-p, and that the spike and noise component of the ripple does not exceed 2mV p-p.

Ripple and Noise, Constant Current

(1) Connect the 1 ohm, 30W precision load resistor across the unit output terminals, in parallel with the oscilloscope. The unit voltage and current controls remain in the maximum settings.

(2) Check that the ripple (50Hz) and hum (100Hz) voltages do not exceed 500μV p-p, and that the spike and noise component of the ripple voltage does not exceed 2mV p-p.

Soak Test

This test when performed at time of factory test serves principally to age the voltage and current selectors and eliminate initial drift. It should not therefore need to be carried out by the operator, unless the unit has undergone an extensive repair programme.

(1) Set the power supply unit digital voltage and LIMIT OUTPUT CURRENT selectors to maximum, and short circuit the output terminals.

(2) Insert unit in 50^{o}C oven.

(3) Apply mains input to unit under test via "Variac", set to give an output of 240V.

(4) Operate unit for not less than 2 hours in these circumstances, maintaining the oven temperature within 1^{o}C of 50^{o}C.

(5) Remove unit from oven, set POWER switch to "off", and allow 30 minutes for cooling to ambient temperature.

(6) Finally repeat procedures detailed in Insulation Test and Connecting-up and Switching-on. (Page 5.2).

Digital Voltage Calibration

(1) With the digital voltmeter connected across the power unit output terminals, set the digital voltage selectors to 0 - 0 - 0. If necessary, adjust variable resistor RV3, mounted on the printed-circuit board, for a digital voltmeter reading of 0.000V ±1mV.

(2) Set digital voltage selectors to 0 - 9 - 9 (9.9V), and if necessary, adjust potentiometer RV1, mounted on the printed-circuit board, for a digital voltmeter reading of 09.900V ±1mV.

(3) Return digital voltage selectors to 0 - 0 - 0, thence successively advance to 0 - 0 - 1 through to 0 - 0 - 9, at each of the nine steps noting the unit output voltage, as registered on the digital voltmeter, against the set nominal value. The noted output voltage should be within ±1% of the selected value in each case.

(4) Repeat procedure detailed in sub-para. (3), commencing with the digital voltage selectors set to 0 - 1 - 0 and proceeding to 0 - 9 - 0.

(5) Repeat procedure detailed in sub-para. (3), with the digital voltage selectors set to 1 - 0 - 0, 2 - 0 - 0, 3 - 0 - 0, etc. proceeding to the voltage limit of the unit under test.

(6) If necessary, readjust RV1 and RV3, to equalise the positive and negative maximum deviations from the nominal.

Analogue Voltage Calibration

NOTE
The procedure detailed in sub-paras. (1) - (3) following is applicable only to later (.2) models of the units.

(1) Set digital voltage selectors to 0 - 0 - 0.

(2) Set unit output, as registered on the digital voltmeter, to 0.0000V ± 1 mV by adjustment of analogue voltage control. If necessary, slacken control knob on spindle, and set the line engraved on the knob skirt opposite the CAL. legend engraved on the panel, taking care not to alter the orientation of the knob spindle. Tighten knob on control spindle.

(3) Set analogue voltage control successively to listed positions, checking that the reading on the digital voltmeter is in each case within the specified limits.

CONTROL SETTING	LIMITS
50mV	40 - 60mV
100mV	90 - 110mV

NOTE
The following procedure is applicable only to early models, which are provided with an additive 10V output in place of the 100mV additive output provided on the later (.2) models.

(1) Set digital voltage selectors to 0 - 0 - 0.

(2) Turn analogue voltage control in clockwise direction off the CAL. position, and check that the associated indicator lamp lights.

(3) Set unit output, as registered on the digital voltmeter, to 0.0000V ±1mV by adjustment of analogue voltage control. If necessary, slacken control knob on spindle, and set the line engraved on the knob skirt opposite the CAL. legend engraved on the panel, taking care not to alter the orientation of the knob spindle. Tighten knob on control spindle.

(4) Set analogue voltage control successively to the listed positions, checking that the reading on the digital voltmeter is in each case within the specified limits.

CONTROL SETTING	LIMITS
5V	4.0 - 6.0V
10V	9.0 - 11.0V

(5) Set digital voltage selector to maximum, turn analogue voltage control just past the OV mark, and check that the output voltage is reduced by a nominal 10V.

(6) Set analogue voltage control to the CAL. position, and check that the associated indicator lamp is extinguished.

Digital Current Calibration

(1) Connect 1Ω precision resistor and the digital voltmeter across the power unit output terminals.

(2) Set digital voltage selectors to maximum.

(3) Successively set the "A" LIMIT OUTPUT CURRENT selector to each position, noting the unit load current, as registered on the digital voltmeter, against the set nominal value. The noted load current should

be within $\pm 1\%$ or 1mV, whichever is the greater, of the selected value in each case.

NOTE

The digital voltmeter reading is identical with the load current, since a 1Ω resistance is employed for the load.

(4) Repeat procedure detailed in sub-para. (3) for each position of the "mA" LIMIT OUTPUT CURRENT selector, with the "A" selector set to the "O" position.

NOTE

On early models, the stepped "mA" LIMIT OUTPUT CURRENT selector is replaced by a continuously variable analogue current control. The calibration procedure for this control is given in the following paragraph.

(5) If necessary, readjust RV2, mounted on the printed-circuit board, to equalise maximum positive and negative deviations from the nominal.

Analogue Current Calibration

NOTE

This procedure is applicable only to early models of the power unit which have a continuously variable "mA" LIMIT OUTPUT CURRENT control in place of the stepped selector fitted on later models.

(1) Set "A" LIMIT OUTPUT CURRENT selector to the "O" position.

(2) Turn analogue "mA" LIMIT OUTPUT CURRENT control fully clockwise.

(3) If necessary, slacken control knob on spindle, and set the line engraved on the knob skirt opposite the "100" engraved on the panel. Tighten knob on control spindle.

(4) Set the "mA" LIMIT OUTPUT CURRENT control successively to the listed positions, checking that the reading on the digital voltmeter is in each case within the specified limits.

CONTROL SETTING	LIMITS
10 mA	9.5 - 10.5 mA
50 mA	47.5 - 52.5 mA
100 mA	95 - 105 mA

NOTE

The digital voltmeter reading is identical with the load current, since a 1Ω resistance is employed for the load.

Output Impedance

(1) Connect sine-wave oscillator output to input of h.f. power amplifier (item 14 of test equipment), and connect the output of the power amplifier to the output terminals of the power unit under test. Connect oscilloscope across power amplifier 1 ohm resistor. Ensure that the test rig is earthed at one point only.

(2) Set oscilloscope Y sensitivity to 500 mV/cm, and sweep velocity to 10 msec/cm.

(3) Set power unit to deliver 15V, with a current limit as listed:

AS1410.2, AS 1414.2	1A
AS 1411.2	2A
AS 1412.2	5A
AS 1413	500mA
AS 1416	300mA.

(4) On the power amplifier, adjust the 100 ohm potentiometer for half-scale deflection on the power unit meter.

(5) Adjust oscillator output for 1V p-p signal on the oscilloscope.

(6) Disconnect oscilloscope from across the 1 ohm resistor, and apply instead across the power unit output terminals.

(7) Set sine-wave oscillator frequency to 100kHz, and check that the signal amplitude as measured on the oscilloscope is not greater than 100mV p-p.

(8) Sweep sine-wave oscillator frequency between 25Hz and 100kHz, checking that the response is smooth and free from resonances, and that the signal amplitude, slowly increases as the frequency is raised.

(9) Sweep sine-wave oscillator frequency between 100kHz and 500kHz, checking that the response is smooth and free from resonances, and that the signal amplitude, as measured on the oscilloscope at 500kHz, does not exceed 500mV p-p.

Pulse Response

(1) Disconnect the sine-wave oscillator from the test rig used in the previous test, and substitute in its place the square-wave generator (item (8) of test equipment).

(2) Connect oscilloscope across the power amplifier 1 ohm resistor, and set the Y sensitivity to 500mV/cm, and sweep velocity to 100µsec./cm.

(3) Set square-wave generator output level for 1V peak-to-peak across the 1 ohm resistor, with a p.r.f. of 1kHz.

(4) Connect oscilloscope across power unit output terminals, and check that the signal amplitude does not exceed 100mV p-p.

(5) Sweep the square-wave generator frequency up to 500kHz, checking that no parasitic oscillation is present.

External Voltage Programming

(1) Switch off unit under test.

(2) At the rear panel terminal strip TSA, remove link from between terminals 1 and 2.

(3) Connect external voltage programming resistor, value 4000 ohms ±1%, between terminals 2 and 4.

(4) Switch on unit inder test.

(5) Connect the digital voltmeter across the rear output terminals (3 (+) and 6 (-) on TSA), and check that the output is within ±0.4V of 20V.

External Voltage Sensing and Protection

(1) Retaining the TSA terminal strip connections made in the previous test, repeat the test procedure described in the para. Regulation against Load Variations, connecting the load resistor and digital voltmeter across TSA terminals 4 and 5.

(2) Remove load resistor from between terminals 4 and 5, and substitute a resistor value 1000 ohms ±5%.

(3) Disconnect backing-off power supply unit, and apply digital voltmeter directly across terminals 4 and 5.

(4) Check that the digital voltmeter reading is not greater than 12 volts.

Reverse Voltage Protection

(1) Switch off both test and auxiliary power units.

(2) Disconnect digital voltmeter, and both the resistors from terminal strip TSA.

(3) Connect output terminals of auxiliary power supply unit to the output terminals of the unit under test, positive to negative.

(4) Set "A" and "mA" OUTPUT CURRENT selectors on test unit to minimum value and CAL positions respectively.

(5) Set output voltage of auxiliary power supply unit to 10.0V, and the current limit control to maximum.

(6) Connect digital voltmeter across output terminals of test unit.

(7) Switch-on both power supply units, and check that the reading on the digital voltmeter does not exceed -1.0V.

External Current Programming

(1) Switch off unit under test.

(2) At terminal strip TSA, remove link from between terminals 7 and 8.

(3) Connect output terminals of auxiliary power supply unit between TSA terminals 7 and 8, positive to 8, and negative to 7.

(4) Connect precision resistor of appropriate value across the output terminals of the unit under test, in parallel with the digital voltmeter.

AS 1410.2, AS 1411.2, AS 1413, AS 1414.2, AS 1416	1 ohm
AS 1412.2	0.1 ohm

(5) Set auxiliary power supply unit to deliver an output voltage of 1.2V.

(6) Set 'A' LIMIT OUTPUT CURRENT selector of unit under test to maximum, and 'mA' selector to CAL.

(7) Switch on both auxiliary and test units.

(8) Check that reading on the digital voltmeter lies within the appropriate limits:

AS 1410.2, AS 1414.2	200mV ±20mV
AS 1411.2	400mV ±40mV
AS 1412.2, AS 1413	100mV ±10mV
AS 1416	60mV ±10mV

(9) Change voltage of auxiliary power supply unit to 0.3V, and check that the reading on the digital voltmeter now lies within the following appropriate limits:

AS 1410.2, AS 1414.2	800mV ±20mV
AS 1411.2	1.6V ± 40mV
AS 1412.2, AS 1413	400mV ± 10mV
AS 1416	240mV ± 10mV.

Fault-Finding

Fault-Finding Procedure

Widespread departures from the normal operating conditions will be present in all sections of a defective power supply unit. The presence of abnormal voltages and currents at any particular circuit point may not therefore be due to a local failure, but merely the reflection of a defect in another section of the unit. It thus becomes essential to discriminate between induced malfunctions as distinct from the prime source of defect. The distinction may not always be readily apparent as a result of the interdependence of the various parts of the feedback loop. The semiconductor active devices usually exhibit short-circuit or open-circuit fault conditions rather than partial failure. In the case of a short-circuit the input and output voltages will be identical whereas with an open-circuit they will be different and unaffected by variations in the control signal. Transistors operating in the control loop are likely to be either saturated or cut-off when working under fault conditions. For instant, a short-circuited device might have the base/emitter junction reverse biased, but still have current flowing in the emitter/collector path. In the other extreme, an open-circuited device would have apparent forward bias, but pass no current. Before commencing a systematic examination of the unit, it should be visually inspected, for obvious damage and loose connections, with particular respect to the internal connection of the power lines to the unit output terminals. The circuit sections should then be investigated in the following order.

1) -12.5V Reference Supply.
2) SCR Firing Control Circuit.
3) Transient Regulator (AS 1411 and AS 1412 only).
4) Series Regulator.
5) Voltage Comparator Amplifier.
6) Current Comparator Amplifier.

The recommended procedure in each case is to monitor the input command and reference signals, output response, response sensing, and finally the feedback amplification. In order to minimise sympathetic failure of further components it is desirable to apply the mains input to the unit via a "Variac", to enable the supply to be reduced to a low level for the preliminary investigation. As an added precaution, the main secondary of the unit transformer should be open-circuited when checking the -12.5V reference supply and the SCR firing control circuit.

Components Affecting Calibration

Virtually all components contained in the power unit have some bearing on the accuracy of the output voltage and current calibration. It is therefore recommended, that after the replacement of any component, the calibration of the unit be checked against a suitable external standard. If a degradation of accuracy is revealed, the performance of the unit can be returned to specification by carrying-out the appropriate parts of the Setting-Up and Test Procedure. Replacement components, if not identical with those specified in the components list, must be of equivalent specification.

COMPONENTS LIST

COMPONENT PARTS LIST
Abbreviations

Component	
W	Resistor Composition Insulated Grade 1
Y	Resistor Wire Wound Vitreous
E	Electrolytic
Po.	Polyester
Ce.	Ceramic

COMPONENT PARTS LIST
for
AS1411.2 Power Supply Unit

Main Chassis

Cct. Ref.	General Description				Solartron Part No.
R2	W	100	$\frac{1}{4}$W	5%	170521000
R3	W	100	$\frac{1}{4}$W	5%	170521000
R7	W	510	$\frac{1}{4}$W	5%	170525100
R8	W	510	$\frac{1}{4}$W	5%	170525100
R9	W	10	$\frac{1}{4}$W	5%	170511000
R11	Y	9	50W	10%	160200043
R12	Y	9	50W	10%	160200043
R19	W	430	$\frac{1}{4}$W	1%	170424300
R20 to R29	W	7.5	$\frac{1}{2}$W	1%	170707500
R32 to R34	W	2000	$\frac{1}{4}$W	1%	170432001
R37 to R45	W	200	$\frac{1}{4}$W	1%	170422001
R46 to R54	W	20	$\frac{1}{4}$W	1%	170412001
R55	W	180k	$\frac{1}{4}$W	5%	170551800
R56	W	180k	2W	5%	170551800
R58	Y	1000	30W	5%	160200039
R64	W	10	$\frac{1}{4}$W	5%	170511000
R65	Y	1000	30W	5%	160200039
R66 to R75	W	75	$\frac{1}{2}$W	1%	170717500
R76	W	680	$\frac{1}{4}$W	5%	170526800
R77	W	10	$\frac{1}{4}$W	5%	170511000
C1	Ce	0.1	200V	-20 +80%	208450017
C2	E	3500	70V	-20 +100%	208600079
C3	E	3500	70V	-20 +100%	208600079
C5	To Spec				B14120052
C6	To Spec				B14120052
C7	To Spec				B14120052
C8	Po	2.2	250V	10%	208200025
C9	Ce	1500p	750V	20%	208400095
C10	To Spec				B14120052
C11	Po	470p	125V	$2\frac{1}{2}$%	210124700

RV1	250	$\frac{1}{2}$W	10%	110026041
RV3	20	$\frac{1}{2}$W	2%	110031390
VT1	2N3055	RCA		300552340
VT2	2N3055	RCA		300552340
VT6	2N3053	RCA		300551800
VT7	2N3053	RCA		300551800
MR1 to MR6	40110	RCA		300522150
MR7	1S131	Texas		300520860
MR8	40109	STC		300522040
MR9	OAZ243	Mullard		300520170
MR15	25/10AF	STC		300522660
TL1	Terminal Assy Black			355000540
TL2	Terminal Assy Red			355000530
TSA	Barrier Strip 10 Way			355610020
TSB	Barrier Strip 3 Way			355603070
T1	Transformer			301070040
RLA	Relay 1250 ohms			300650550
FS1	Fuse 2A			360105100
FS2	Fuse 2A			360101100
M1	Meter			B14100044
ILP1	Lamp 29L			300720170
ILP2	Lamp 29L			300720170

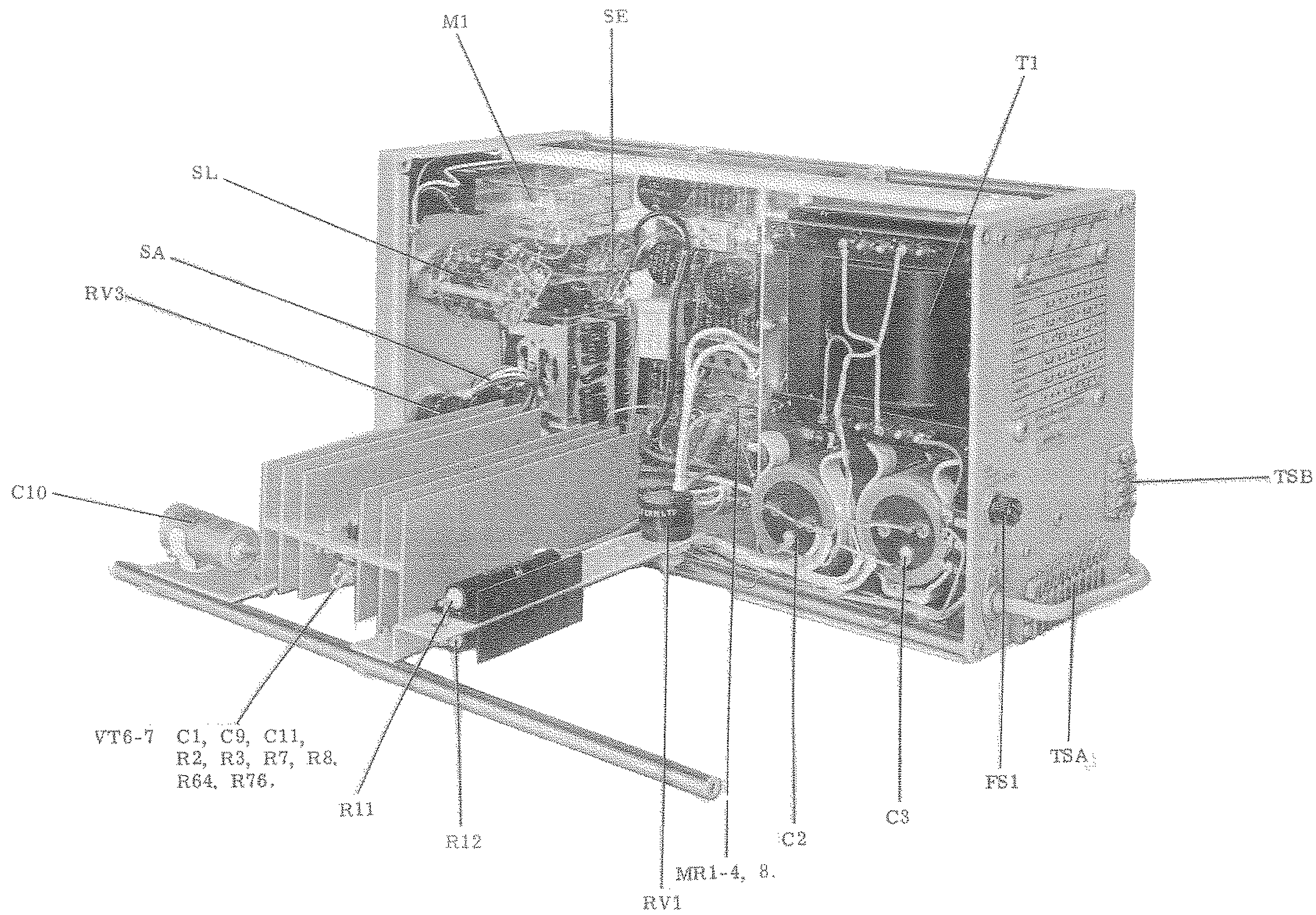
COMPONENT PARTS LIST
for
AS1411.2 Power Supply Unit

Printed Circuit Board

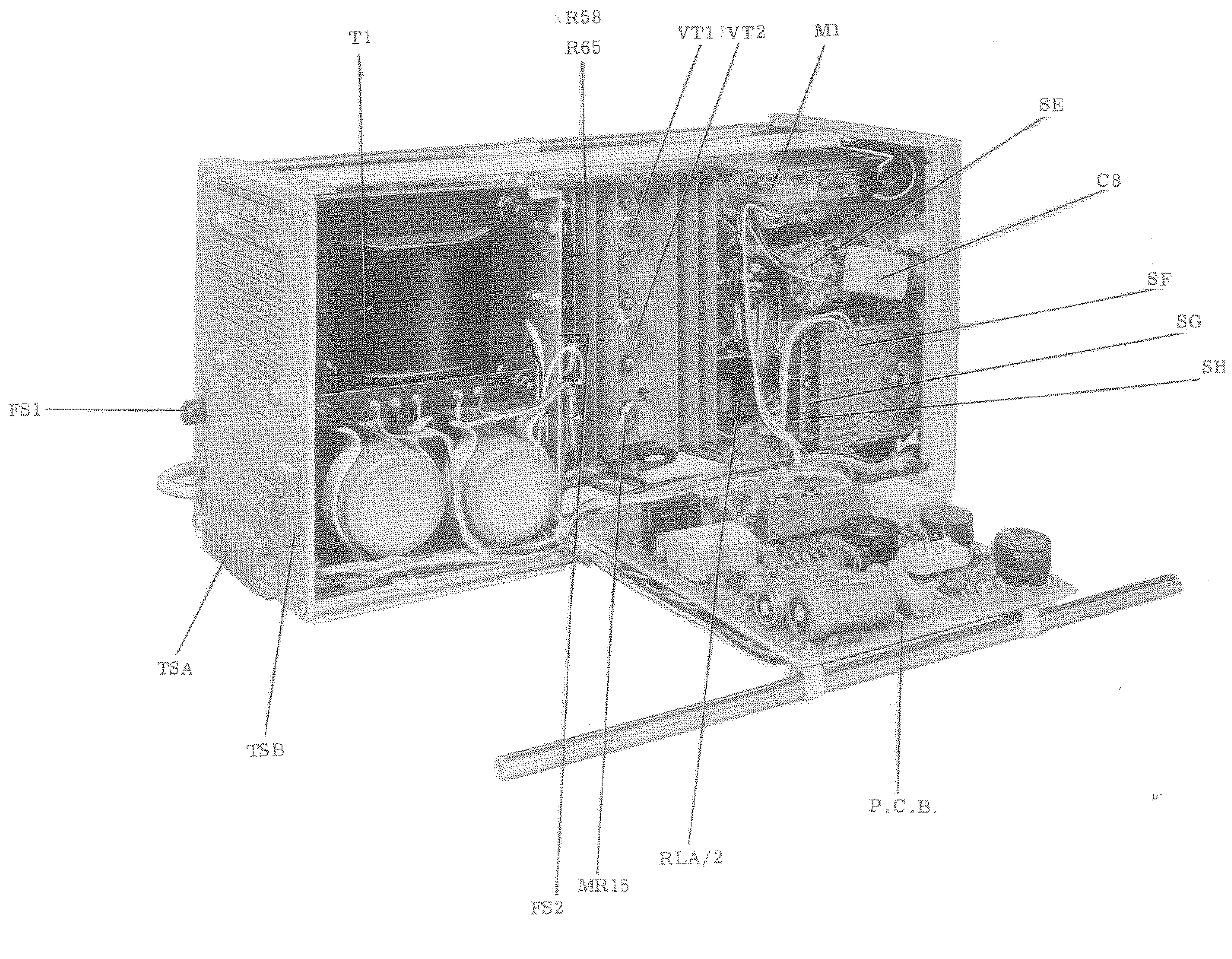
Cct. Ref.	General Description				Solartron Part No.
R1	Y	2700	2.6W	5%	173432701
R2	Y	330	2.6W	5%	173423301
R3	W	27k	$\frac{1}{4}$W	5%	170542700
R4	W	2200	$\frac{1}{4}$W	1%	170432200
R5	W	2200	$\frac{1}{4}$W	1%	170432200
R6	W	2200	$\frac{1}{4}$W	1%	170432200
R7	W	10	$\frac{1}{4}$W	1%	170411000
R8	W	5100	$\frac{1}{4}$W	5%	170535100
R9	W	5100	$\frac{1}{4}$W	5%	170535100
R10	W	2700	$\frac{1}{4}$W	5%	170532700
R11	W	1500	$\frac{1}{4}$W	1%	170431500
R12	W	150	$\frac{1}{4}$W	1%	170421500
R13	W	300	$\frac{1}{4}$W	1%	170423000
R14	W	1800	$\frac{1}{4}$W	1%	170431800
R15	W	1000	$\frac{1}{4}$W	5%	170531000
R16	W	5100	$\frac{1}{4}$W	5%	170535100
R17	W	8200	$\frac{1}{4}$W	5%	170538200
R19	W	100	$\frac{1}{4}$W	5%	170521000
R20	W	100	$\frac{1}{4}$W	1%	170421000
R21	W	300	$\frac{1}{4}$W	1%	170423000
R22	W	1800	$\frac{1}{4}$W	1%	170431800
R23	W	5100	$\frac{1}{4}$W	5%	170535100
R24	W	1000	$\frac{1}{4}$W	5%	170531000
R25	W	300	$\frac{1}{4}$W	1%	170423000
R26	W	2200	$\frac{1}{4}$W	1%	170432200
R27	W	18k	$\frac{1}{4}$W	5%	170541800

R28	W	5.1	¼W	5%	170505100
R29	W	100	¼W	5%	170521000
R30	W	510	¼W	5%	170525100
R31	W	510	¼W	5%	170525100
R32	W	8200	¼W	5%	170538200
R33	W	5100	¼W	5%	170535100
R34	W	56k	¼W	1%	170445600
R35	W	2200	¼W	5%	170532200
R36	W	2200	¼W	5%	170532200
R39	W	18K	¼W	5%	170441800
R44	W	2000	¼W	1%	170432000
R45	W	2700	¼W	5%	170532700
R46	W	5100	¼W	5%	170535100
R47	W	2700	¼W	5%	170532700
R48	W	100	¼W	5%	170521000
R50	W	39	¼W	5%	170513900
R51	W	820	¼W	5%	170528200
R52	W	820	¼W	5%	170528200
C1	E	500	25V	-20 +100%	260785001
C2	E	100	25V	-20 +100%	260781000
C3	Po	.047	125V	10%	220344700
C4	Po	330p	125V	10%	210223300
C5	Po	2.2	250V	10%	208200025
C6	E	100	25V	-20 +100%	260781000
C7	E	100	25V	-20 +100%	260781000
C8	Po	2.2	250V	10%	208200025
C10	E	500	6V	-20 +100%	260085001
RV1		250	½W	10%	110026041
RV2		1000	½W	10%	110026061
RV3		1000	½W	10%	110026061

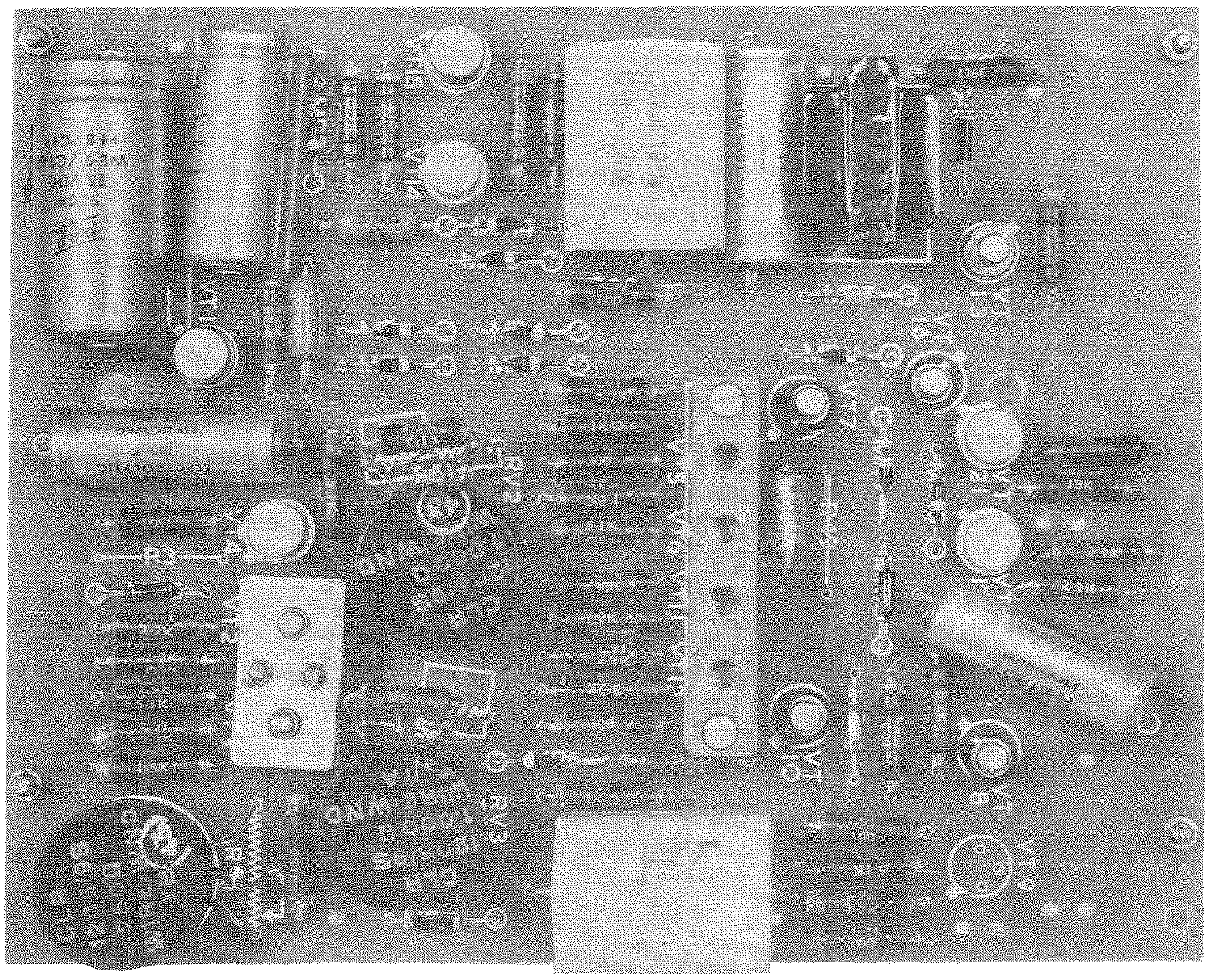
MR1	1S921	Texas	300522620
MR2	1S921	Texas	300522620
MR3	1S921	Texas	300522620
MR4	1S921	Texas	300522620
MR5	1N935	Motorola	300520870
MR6	1S921	Texas	300522620
MR7	1S44	Texas	300522590
MR8	1S921	Texas	300522620
MR9	1S921	Texas	300522620
MR10	1S2039A	Texas	300522360
MR11	OAZ243	Mullard	300520170
MR12	OAZ243	Mullard	300520170
MR13	1S921	Texas	300522620
MR14	1S921	Texas	300522620
MR15	1S921	Texas	300522620
MR16	1S921	Texas	300522620
VT1	2N3053	R.C.A.	300551800
VT2	SA56	Plessey	300551760
VT3	SA56	Plessey	300551760
VT4	2S302	Texas	300550630
VT5	BSY95A	S.T.C.	300552880
VT6	BSY95A	S.T.C.	300552880
VT7	SM6526	Motorola	300552590
VT8	SM6526	Motorola	300552590
VT9	Not fitted		
VT10	SM6526	Motorola	300552590
VT11	BSY95A	S.T.C.	300552880
VT12	BSY95A	S.T.C.	300552880
VT13	SM6526	Motorola	300552590
VT14	2S301	Texas	300550860
VT15	2N3053	R.C.A.	300551800
VT16	SM6526	Motorola	300552590
VT17	2S301	Texas	300550860
VT21	2S301	Texas	300550860
T1	Transformer B.O.		303010040

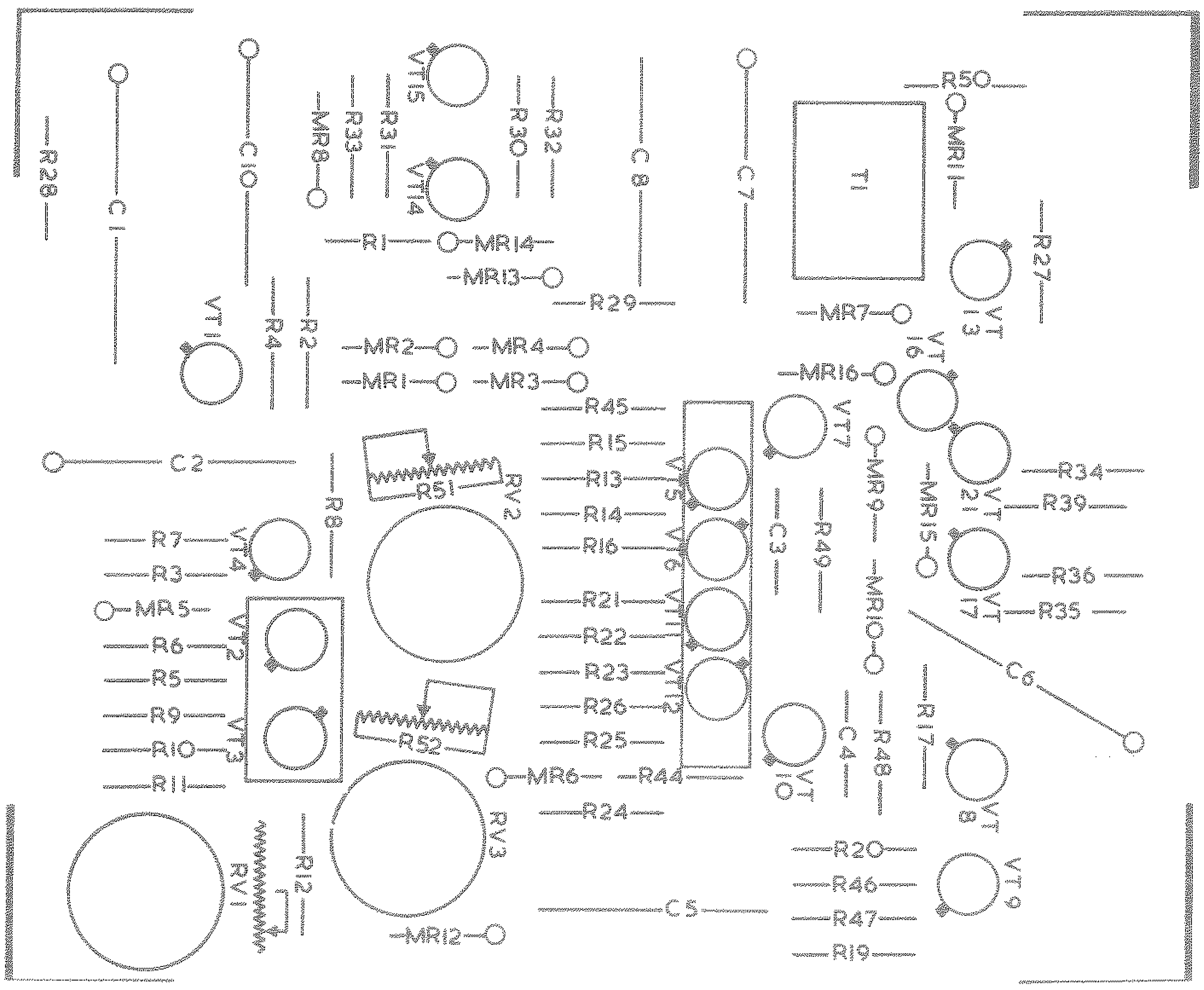


Dgm. 1. AS 1411.2 Right-Hand Side.

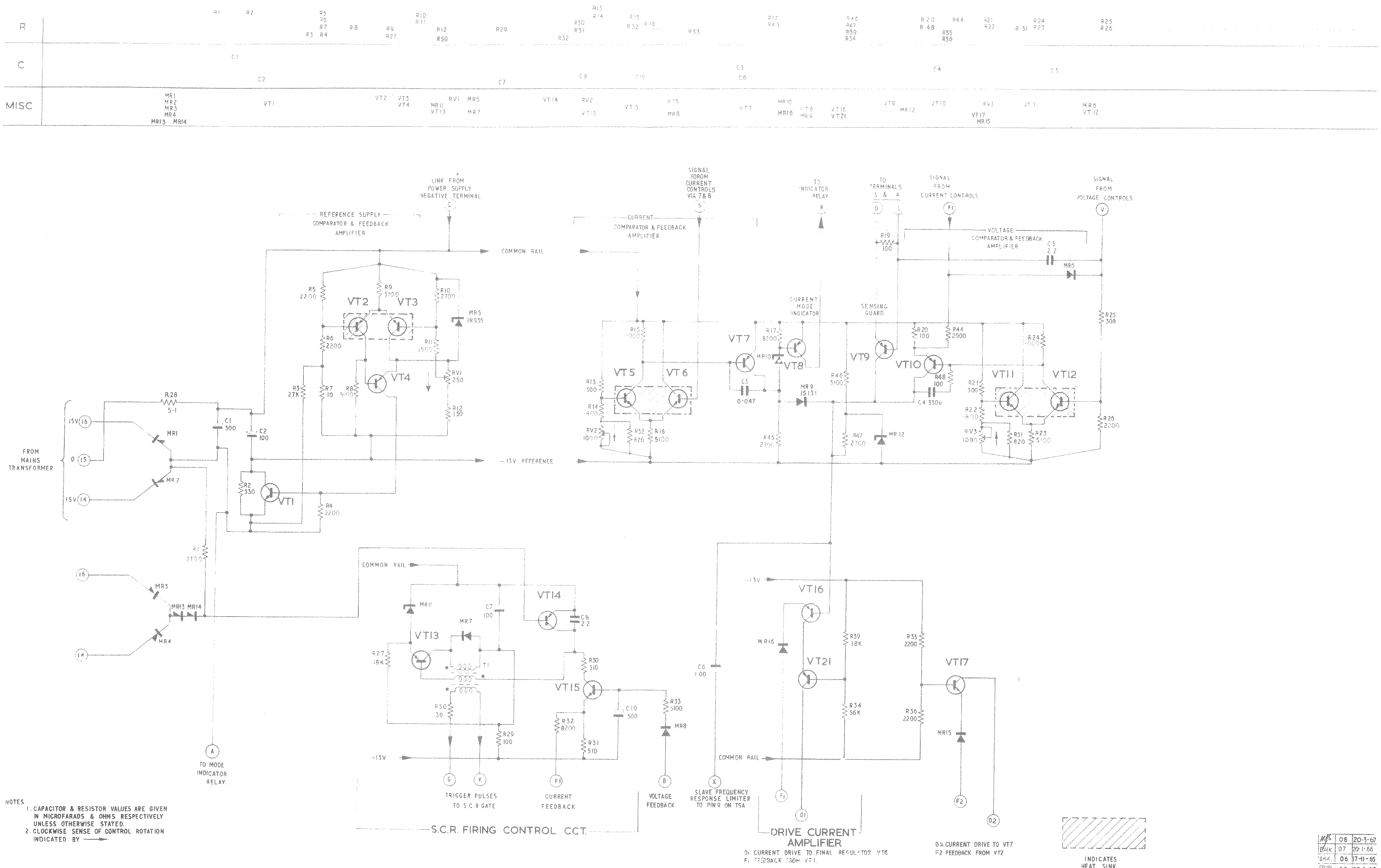


Dgm. 2. AS 1411.2 Left-Hand Side.





Dgm. 3. Printed-Circuit Board.



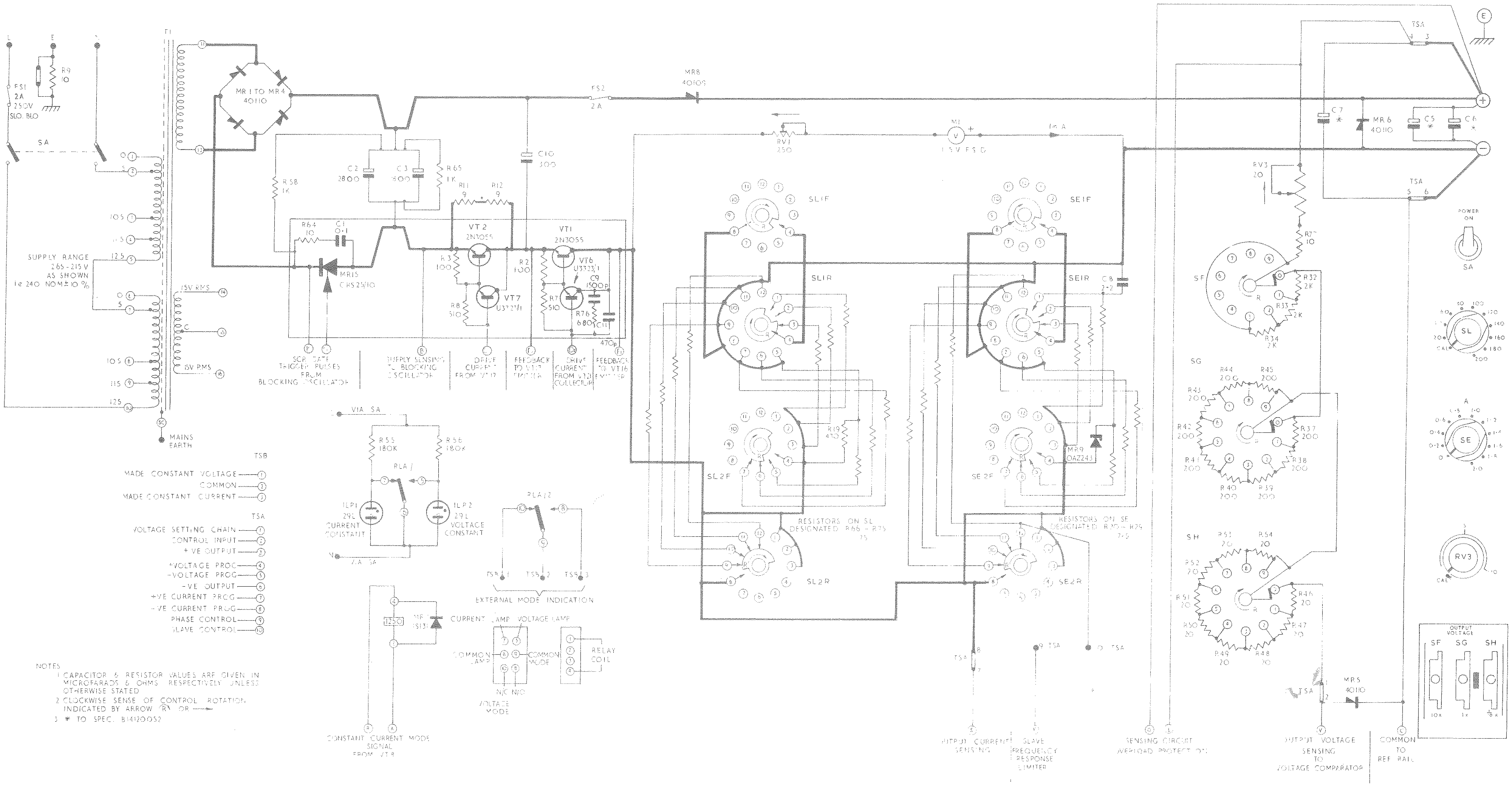
NOTES

1. CAPACITOR & RESISTOR VALUES ARE GIVEN IN MICROFARADS & OHMS RESPECTIVELY UNLESS OTHERWISE STATED.
2. CLOCKWISE SENSE OF CONTROL ROTATION INDICATED BY ⟶

MODN	ISSUE	DATE
	08	20-3-67
	07	20-1-66
	06	17-11-65
	05	23-8-65
	04	9-12-64
	01	29-9-64

DC1411 9301

THEORETICAL CIRCUIT DIAGRAM
COMPARISON & CONTROL SECTIONS
AS 1411



R	
C	
MISC	FS1 SA MR1 MR4 MR15 ILP1 PLA/1 ILP2 MR7 VT2 VT7 PLA/2 VT1 VT6 FS2 MR8 SL1F SL1R SL2F SL2R RV1 M1 SE1F SE1R SE2F SE2R MR9 SF SG SH RV3 MR6

ISSUE	DATE
11	15-12-65
10	
15	17-3-67
14	23-6-66
13	19-4-66
12	18-2-66

D14117000

THEORETICAL CIRCUIT DIAGRAM
POWER & COMMAND SECTIONS