INSTRUCTION MANUAL FOR

N.Z. MINISTRY OF DEFENCE (ARMY)
POWER SUPPLY (REGULATED), DIRECT CURRENT
30 Volt 60 Amps.
Type ASR/40/NZ

Manufactured by -
Redfern Radio,
4113 Great North Road,
Glen Eden, Auckland, 7
New Zealand.

December, 1979

Specification No. DCEP-AR-015
Stores ref. 6130-98-106-2979

CASA modular systems
P.O. Box 38-828
PETONE, Wellington
New Zealand
PHONE: (64-4) 9393 777
FAX: (64-4) 9393 778
e-mail: sales@casa.co.nz

PART 6 PRACTICAL OPERATION AND CALIBRATION Contd.

PART 7 DISMANTLING OF EQUIPMENT

PART 7 TECHNICAL DESCRIPTION

PART 8 MAINTENANCE AND REPAIRS

PART 6 PRACTICAL OPERATION AND CALIBRATION Contd.

PART 7 DISMANTLING OF EQUIPMENT

PART 7 TECHNICAL DESCRIPTION

PART 8 MAINTENANCE AND REPAIRS

DIAGRAMS

GENERAL DESCRIPTION

Part 1

(1) Description

This power supply is designed for the requirements of the New Zealand Army for an automatically regulated direct current power supply having a nominal maximum output of 32 Volts 60 Amperes. The power supply is intended to be used as the primary source of power for a 400 Watt, single sideband transmitter receiver radio station.

The power supply is self contained and has no accessories.

(2) Cabinet Assembly

The cabinet is a 19" inch rack or deck mounting assembly. The overall front panel dimensions are 482mm wide and 177mm high. Overall depth from front pilot lamp cover to the rear terminals is 482mm.

The cabinet is fitted with a bottom rear removable mounting bar and two right angle brackets which are bolted to the right and left hand rear sides of the front panel to allow for deck mounting in vehicles, etc. The weight of the unit is approximately 65 K/g.

(3) Cabinet Assembly Cooling

Due to the compact internal construction the power supply is fitted with two internal blowers. A blower is mounted at each rear corner of the cabinet. Air is drawn through the rear circular air vents and directed through high temperature components, heat sinks, etc. and expelled through side vents arranged to provide optimum cooling for these components.

In order to provide proper cooling air flow it is essential that the top cover lid is tightly screwed in position at all times. Warning. Do not cover or obstruct the air vents at the rear or sides as this will reduce air flow and lead to a rapid rise in internal temperature when the power supply is operated at high current loads.

(4) Cabinet Assembly Internal Component Layout

The basic component layout is shown in Fig 1.

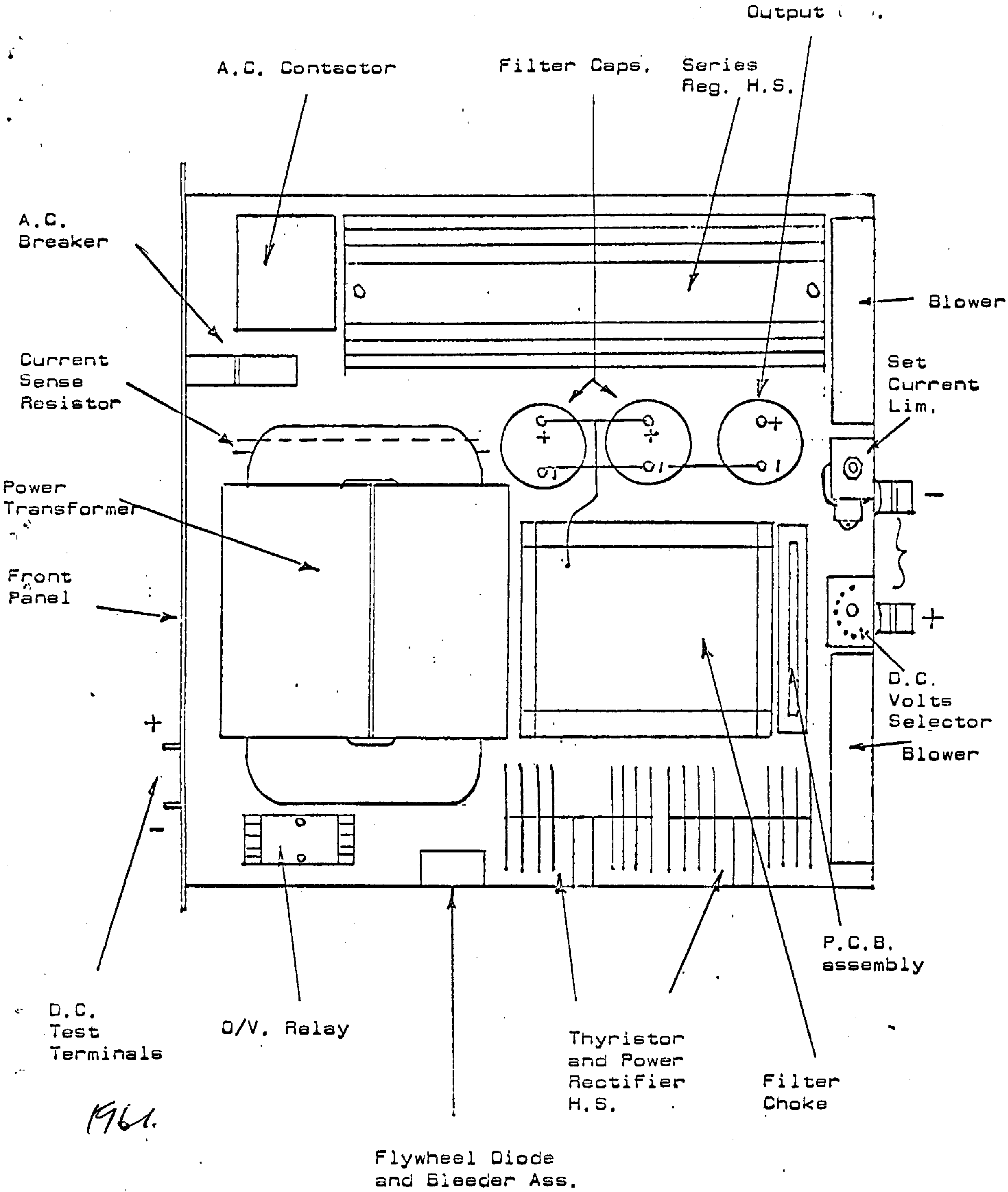
The phase controlled rectifiers and power rectifiers share two vertical mounted heat sinks mounted on the rear right hand side. These heat sinks are live to the AC potential of the mains transformer secondary winding. The rectifier heat sinks are supported and insulated from the main cabinet by four red fibre insulated pillars 25mm diam by 30mm high.

The insulation pillars are screwed to the side of the cabinet by M4 x 12mm countersunk head screws.

Immediately in front of the rectifier heat sinks is mounted a small radiator holding the flywheel diode and bleeder resistor assembly.

(5) Cabinet Assembly Inductive Components

The main rectifier transformer is flat mounted on two brackets welded to the chassis base. This transformer rated at 3.7KVA is wound on a strip wound grain oriented core to reduce size and weight compared with a conventional transformer. The windings are constructed of class H 150°C material to provide maximum reliability. The transformer core is split into two C shaped halves. The interface gaps of the core halves are precision ground and cemented with epoxy p 2



1961.

INTERNAL COMPONENT LAYOUT

(5) Cabinet Assembly Inductive Components Contd.

The transformer is held in position by two steel mounting straps securing each end of the core to the chassis brackets by four 10mm x 100mm bolts.

The filter choke is mounted directly to the rear of the main transformer on two brackets welded to the chassis base.

The choke is wound with 10mm x 2.1mm fibre glass insulated copper strip. The core of the choke is made of two E lamination stacks butt gapped and cemented with epoxy resin glue to eliminate choke hum.

The chokes are secured by four bolts consisting of ¼" whitworth x 4 inch threaded rods. The top mounting straps of the choke secures the modification label holder plate.

The remaining inductive component is the auxiliary voltage transformer supplying low level AC voltages to the electronic circuit boards.

(6) Cabinet Assembly Control Circuit Boards

The electronic control printed circuit board plugs into a 22 way socket mounted on the printed circuit assembly bracket.

This bracket is secured at the rear of the choke by countersunk head M4 x 10 screws through the chassis base.

The top corners of the printed circuit board are secured to the printed circuit mounting bracket by two M3 x 12 screws and two spacer pillars. The pillars are fitted with two insulating bushes at the printed circuit board end.

The voltage control and overvoltage protection circuit board and switch is part of a separate assembly mounted on the rear panel.

(7) Cabinet Assembly Filter Capacitors

The main filter capacitors are two 56,000 MFD 50V capacitors connected in parallel by copper straps. The output capacitor is a 22,000 MFD 40V electrolytic, this supports the output bleeder resistor and a protection diode.

(8) Cabinet Assembly Pass Regulator Heat Sinks

The series regulator transistors are mounted on two heat sinks stacked on top of each other. The heat sinks extend horizontally along the left hand side. These heat sink radiators are secured to two brackets welded to the chassis base by two ¼" whit by 4" hexagon head bolts with 15mm x 70mm spacers holding the heat radiators apart.

The chassis brackets are fitted with insulating blocks tapped with ¼" whitworth holes to take the mounting bolts. This allows the entire heat radiator assembly to be insulated from the chassis.

Each heat radiator holds four pass transistors and a driver transistor. The pass transistors are parallel connected. Each transistor plugs into a socket and secured by M3 x 12 screws.

(9) Cabinet Assembly Predriver Transistor

The pre-driver transistor plugs into a socket mounted underneath the printed circuit board socket on the printed circuit board bracket.

(10) Cabinet Assembly Current Sensing Resistor
The current sensing resistor is a special component ·004 Ohm mounted inside the left hand side chassis bracket supporting the main transformer.

(11) Cabinet Assembly Relays and Circuit Breakers
The main on/off contactor is mounted behind the on/off switch, the over voltage protection relay plugs into a socket mounted on the right hand side of the main transformer.

The AC circuit breaker plugs into a socket screwed to a mounting bracket near the on/off switch. The mounting bracket is held by a nut and bolt in the chassis base and a long 5/32" whit screw through the front panel.

PART 2 DESCRIPTION OF CONTROLS

(12) On/Off Switch
This is labelled power/on, a single pole switch mounted on the left side front panel. This switch isolates the AC main power from the power supply.

(13) Neon Pilot
Labelled power/on. This is an amber coloured pilot using a MES neon lamp. This lamp lights up when the power/on switch is turned on. The neon can be replaced from the front panel by unscrewing the amber cap.

(14) Circuit Breaker
A 20 Amp thermal circuit breaker with push button reset protects the AC input to the power supply.

The circuit breaker can be manually tripped by pressing the red button and reset by pushing the yellow button.

(15) D.C. Test Terminals
Two Belling and Lee terminals labelled red + positive and black - negative are mounted on the front panel for test purposes.

These terminals are wired through to the rear cabinet load terminals and are provided as a convenience on the front panel to allow connection of voltmeters, oscilloscopes, etc. to monitor the performance of the power supply.

The terminals can be used to operate small loads such as lamps up to 5 Amps only.

Warning. The test terminals must not be used to supply normal loads, battery charging, etc. The wiring to these terminals has a maximum capacity of 5 Amps.

Connection of large loads or short circuiting could burn out this wiring and make repairs very difficult.

(16) Fault Indicators
Three light emitting diode indicators of sufficient intensity for daylight viewing are provided to give an indication of certain fault conditions.

(17) Overload Indicator
This lamp turns on when the current loading on the power supply reaches the limit value set for the power supply. This is normally 65 Amps. When the warning lamp turns on, the power supply Automatically operates as a constant current supply, and the load current does not further increase.

If the loading on the power supply is heavily increased above the current limit point or a short circuited output occurs the warning lamp will start flashing.

When this occurs the load should be disconnected.

(18) Overvoltage Indicator
If the output voltage of the power supply is approximately three volts above the value set by the internal Set DC Voltage switch for a period of more than approx. 250 milli-seconds the main contactor will trip off to protect the load and power supply.

The over-volts lamp will light up to indicate the fault condition.

An overvoltage trip can be caused by an internal fault or by external conditions. This is dealt with in section (44).

To reset after an overvoltage trip, the load must be disconnected and the power supply is switched off and on again. Provided the fault has disappeared, the normal output will be restored and the over-voltage lamp will turn off.

(19) Over Temperature Indicator
A temperature switch calibrated at 112°C is fitted to the top of the main transformer, if the temperature at this point should rise above 112°C this switch opens and cuts off the main contactor. The temperature lamp will turn on to indicate the fault. When an overtemperature trip occurs, the blower fans remain operating to remove the excess heat.

When the temperature falls below the limit set by the switch the power supply will automatically reset.

The over-temperature protection will only operate under extreme environmoental conditions of tropical and desert operation.

Field experience may indicate the later desirability of using lower temperature switches in place of the 112°C unit installed.

(20) Rear Terminals
The main load carrying terminals are mounted on the rear panel.

The positive terminal + red, and negative terminal - black are bakelite insulated screw terminal with colour coded caps.

These terminals have a maximum DC rating of 100A.

To make a suitable connection see installation section

The earth terminal employs a wing nut type connection.

PART 3 PRESET CONTROLS

(21) Set D.C. Voltage
This is a screw driver slot operated rotary switch mounted on a bracket with a calibrated scale under the rear top lid.

The switch allows the output voltage to be adjusted in 1 volt steps between 26 Volts DC and 32V DC. The voltage calibration of this switch is very accurate and most voltages in this range are accurate to within ± .1V of set value. The screw driver slot points to the voltage on the calibration scale.

A check voltmeter may be connected to the test terminals when carrying out adjustments.

(22) O.P. Voltage Calibration RV1
This control is located on the main circuit board PC1A at the bottom right corner. This control accurately sets the output voltage for the power supply see section (46) dealing with calibration.

(23) DIFF Voltage Calibration RV4
The control is located on the top right hand corner of the main circuit board PC1A.

This control sets the differential voltage across the series pass regulator transistors.

This voltage is normally set at 6V.

Warning this control must not be adjusted by other than a qualified technician.

Incorrect adjustment of this control by unqualified persons can result in overheating or damage to regulator transistors.

(24) Trip V. Control RV3
Located under RV4. This control is adjusted to cut off the power supply output if the voltage across the pass transistors exceeds a set value. This control forms part of the overcurrent protection system.

(25) Cal O/V RV5
Located on the voltage calibration and O/V protection circuit board, mounted on the set DC voltage switch bracket. This control sets the 3V overvoltage trip discrimination.

This control is inaccessible and being factory set should not require further adjustment.

(26) Set Current Lim RV6
This control is located on a bracket with red label under the rear cover.

The control adjustment is set to limit the maximum output current to 65 Amps as specified. A locknut is fitted to the screw driver operated adjustment.

Warning Unauthorised adjustment of this control could lead to excessive output current capability, up to 80 Amps. This could damage the regulator transistors and rectifiers.

PART 4 INSTALLATION

(27) Initial Inspection

As soon as equipment is received, inspect for any EXTernal damage that may have occurred in transit.

This check should confirm that there are no broken Knobs, pilot lamps, scratches, loose screws or components.

Remove the top cover secured by 16 M3 x 6 screws a d lockwashers and check that no internal components are loose. Replace the lid and screws.

(28) Mounting

The supply should be rack or deck mounted in a horizontal position. If rack mounting is employed, remove the deck mounting bracket bolted to the front panel rack mounting slots. Store the brackets in a safe place, as replacements would have to be specially made. Due to the weight of the unit it is adviseble to provide some rear cabinet support when rack mounting is used. This rear support could be secured with the rear cabinet mounting bar.

If deck mounting is used, the mounting centres for the front panel brackets and rear cabinet mounting bar, see fig. 2, is approx. 425mm front to back, the front mounting holes centres are approx. 459mm. The rear mounting holes centres are approx. 454mm.

It is recommended that the power supply is placed on the deck and the mounting holes into the deck are drilled through the centres of the holes in the brackets and rear mounting bar.

Locate the cabinet in a position allowing adequate air flow through the rear and side vents.

If the power supply is fitted in vehicles subject to considerable vibration, tests should be made to determine if anti-shock mounting is required.

The most fragile external parts of the cabinet are the ventilation grills, care should be taken that these are not pierced by projectionsin adjacent equipment.

If the equipment is used in the field it is recommended that the power supply not be operated in direct sunlight. A canvas topped vehicle is suitable. Continuous direct sunlight absorbtion will raise the temperature of the metal cabinet and increase the thermal burden on the cooling system unnecessarily.

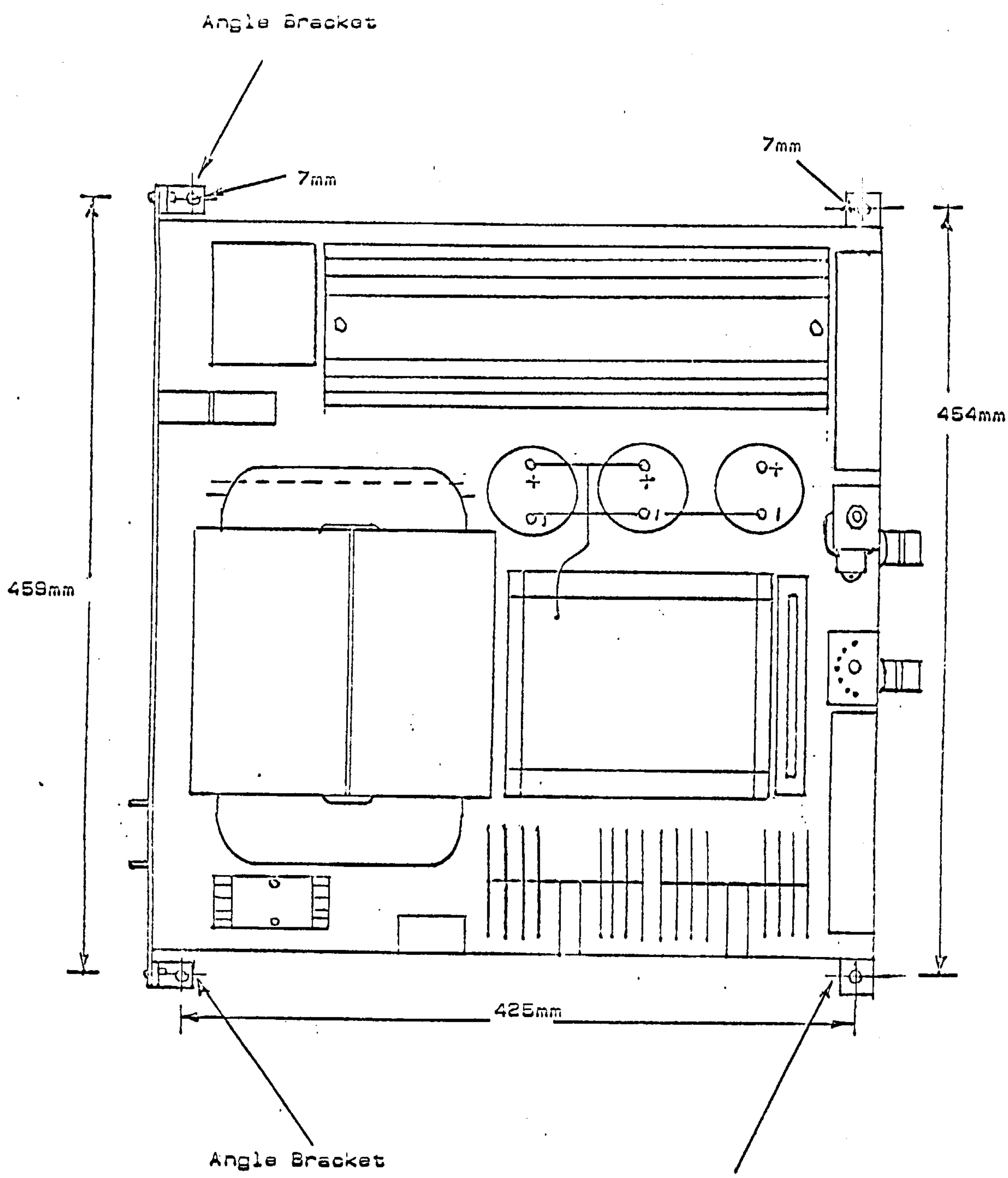
The equipment blower inlets are not fitted with dust filters as the power supplies are designed to operate with a considerable amount of dust entry. However continuous accumulation of dust and grit will impair operation of the contactors and switches at some point and some care should be taken to avoid dust.

(29) Cabling Input

Approx. two metres of TPS 2.5mm three core flex fitted with an enzide three pin rubber plug is provided for the mains input lead. Due to the regulation range of the power supply long extension cords can be used to connect the power supply to the supply system. The power supply has been tested on flexes up to 26 metres long with satisfactory operation.

If the power supply is being used on stiff power sources such

PG 8.



Deck Mounting Centres

FIGURE 2

(30) Cabling Output

Due to the high current and low voltage output on the DC side some care should be taken in providing low loop resistance of the DC cables to reduce voltage drop in the DC connecting leads.

The ultimate D.C. regulation of the system is almost entirely determined by the resistance of the connecting cables.

It is suggested that flexible welding cable be used a 100 Amp cable lug or similar fitting should be made up as shown in fig 3 with the eye cut out and crimped and soldered to the power supply ends of the positive and negative cables.

The cables should be carefully colour marked and labelled positive and negative to obviate the risk of reverse polarity connections to the power supply and load equipment.

Warning if the output of the power supply is connected to batteries it is extremely important that correct polarity of connections is assured. Note a blocking diode will not protect the power supply against reverse current damage if a battery is reverse connected.

The cable lugs should be sleeved over most of their length to prevent touching or short circuiting the output terminals of the power supply.

The positive and negative terminals should be hand tightened onto the cable lugs. Use of pliers or vice-grip wrenches to increase the tension may crack the bakelite insulation and strip the brass screw threads.

Both positive and negative terminals are isolated from earth.

An 8mm terminal with wing nut is provided as a separate earth.

PART 5 - COMMISSIONING and TESTING

(31) Preliminary

This is a check to ensure the equipment as received from the manufacture will operate the users equipment and appears to operate correctly. It is not a detailed performance check. This is normally only carried out on a batch sample or annual maintenance.

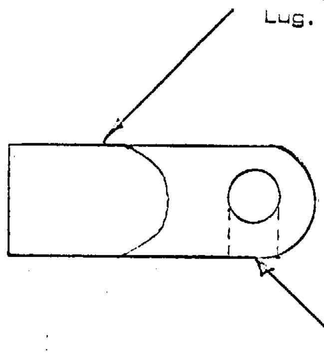
The commissioning procedure is outlined followed by detailed performance tests.

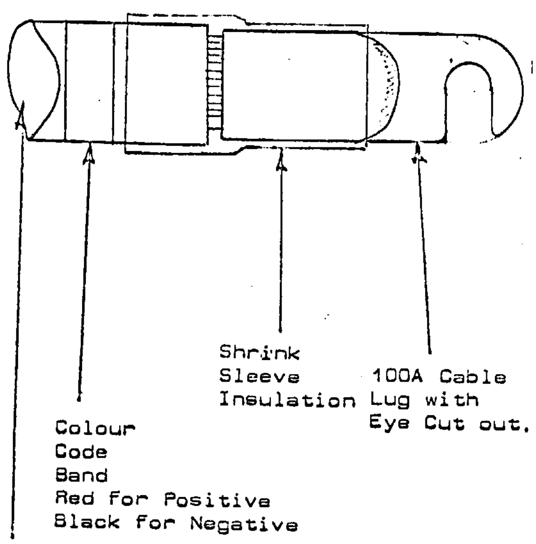
(32) Commissioning Test on Mains Supply

This should be carried out on normal AC mains.

Test equipment. Connect an accurate DC voltmeter to the front panel test terminals. A digital voltmeter is preferable. The AC mains should be in 230V ± 10% range.

A load capable of drawing 50 Amps at 28V DC should be available, an additional load to increase the current to at least 65 Amps should be available to be added to the 50 Amp load. Connect a 0-100A DC ammeter in series with the load to monitor the current.





SUGGESTED D.C. POWER CABLE TERMINATION METHOD

FIGURE 3

(32) Commissioning Test On Mains Supply Contd.

Procedure Check wiring for correct polarity. Do not connect load. Make sure the power on switch is off, Check that the circuit breaker is on.

Switch on the power supply, note at this point transformer inrush current may cause a circuit breaker trip out, if this occurs reset the breaker until it holds in. (Note if necessary operate the power supply through the long extension cable to prevent tripping).

Check that the amber pilot lamp turns on and that the blowers start up.

Note that there is a delay of up to 5 seconds before the DC output appears.

Check that the DC output is 28V, this has been set at the factory before despatch.

The DC voltage should be within ± .1V accuracy. Check that the warning lamps are all off.

Connect the 50 Amp load, note that the DC output voltage may dip and will recover. After the DC output has recovered check the voltage, this should be 28V DC ± .1V DC.

Connect the additional load to increase loading to at least 65 Amps. Check that overload warning lamp lights up at 65 Amps ± 1A.

Note that if the overload lamp is on, the DC output voltage will fall proportionally in order to maintain the limit current at 65 Amps. Disconnect the extra load.

(33) Commissioning Test, Portable Field Generator

This is an important test as the field generator is a limited power source of variable frequency imposing severe conditions on the power supply.

As the field generator has limited power capacity it may not be able to support a DC output load of 65 Amps, the test load under this operation may be selected to some value within the capacity of the generator. The minimum input voltage for the power supply is 184V AC. The field generator must be able to supply this value at the maximum test load current selected.

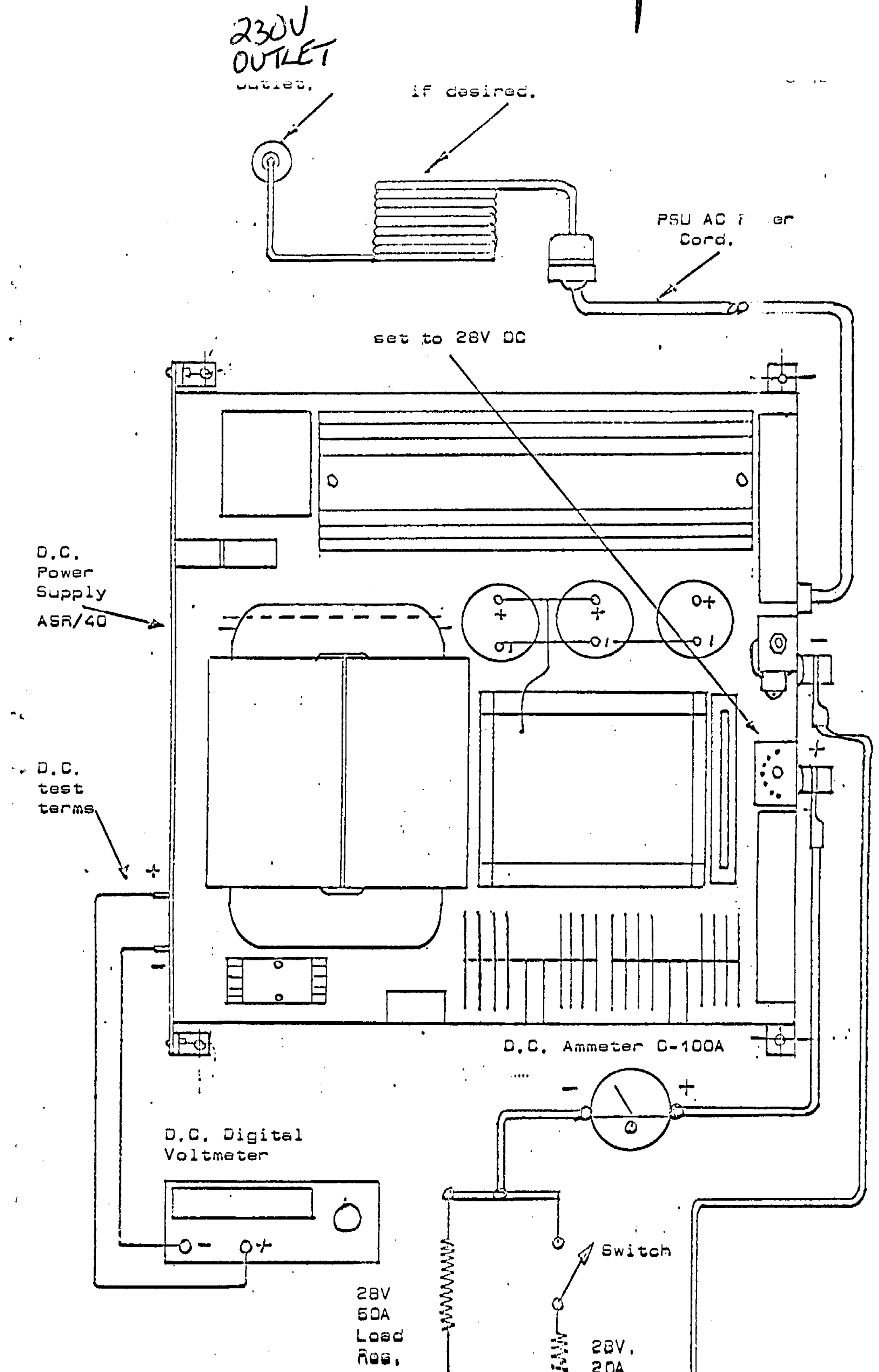
Carry out commissioning tests on normal AC mains first.

For commissioning on field generators, remove top lid from power supply.

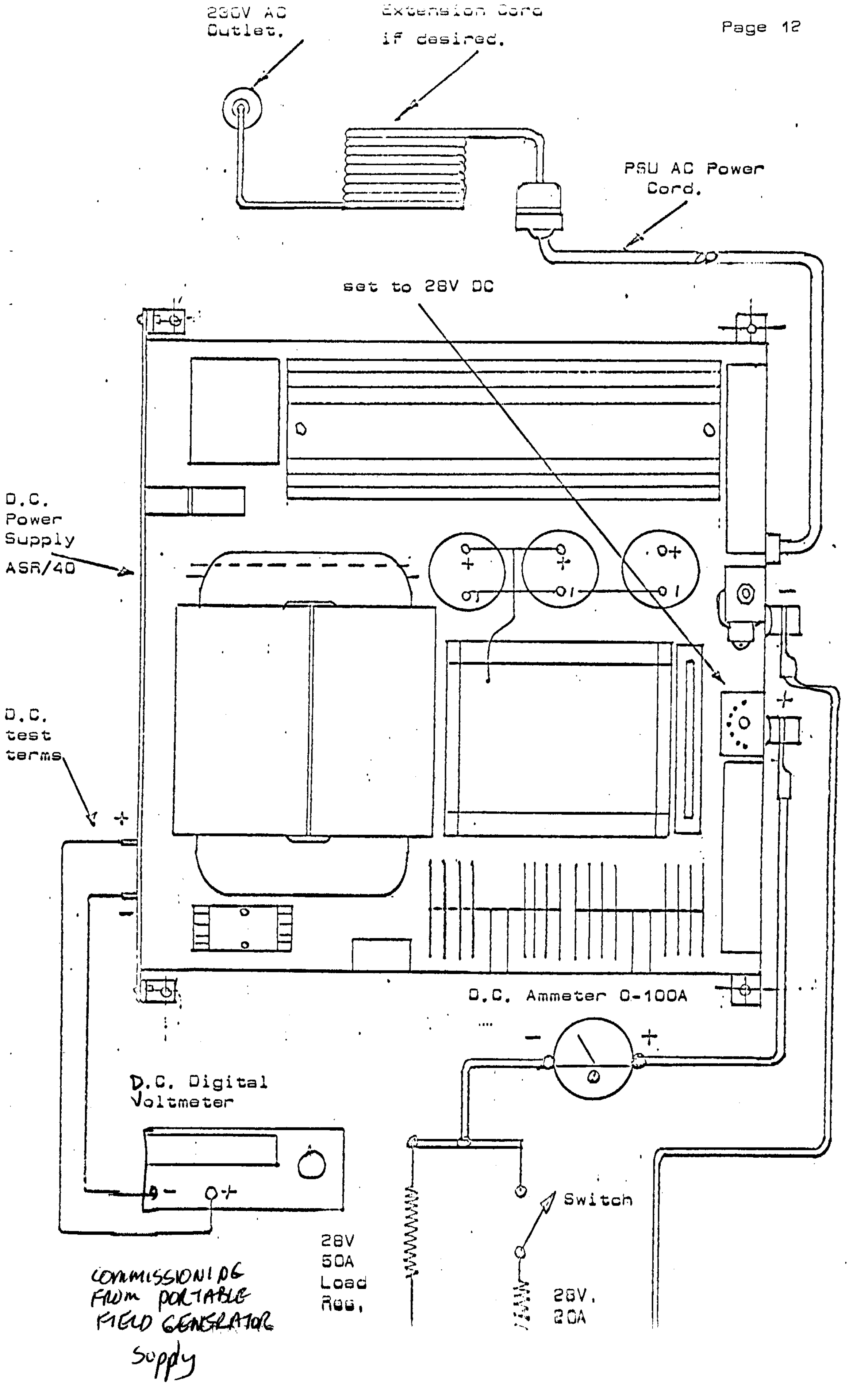
Connect a DC voltmeter 0-100V DC across the terminals of the main filter capacitors, note the positive terminals of these capacitors are strapped together and are connected to the filter choke output. Connect the power supply to the field generator via an extension cable.

onnect A DC voltmeter across the test terminals.

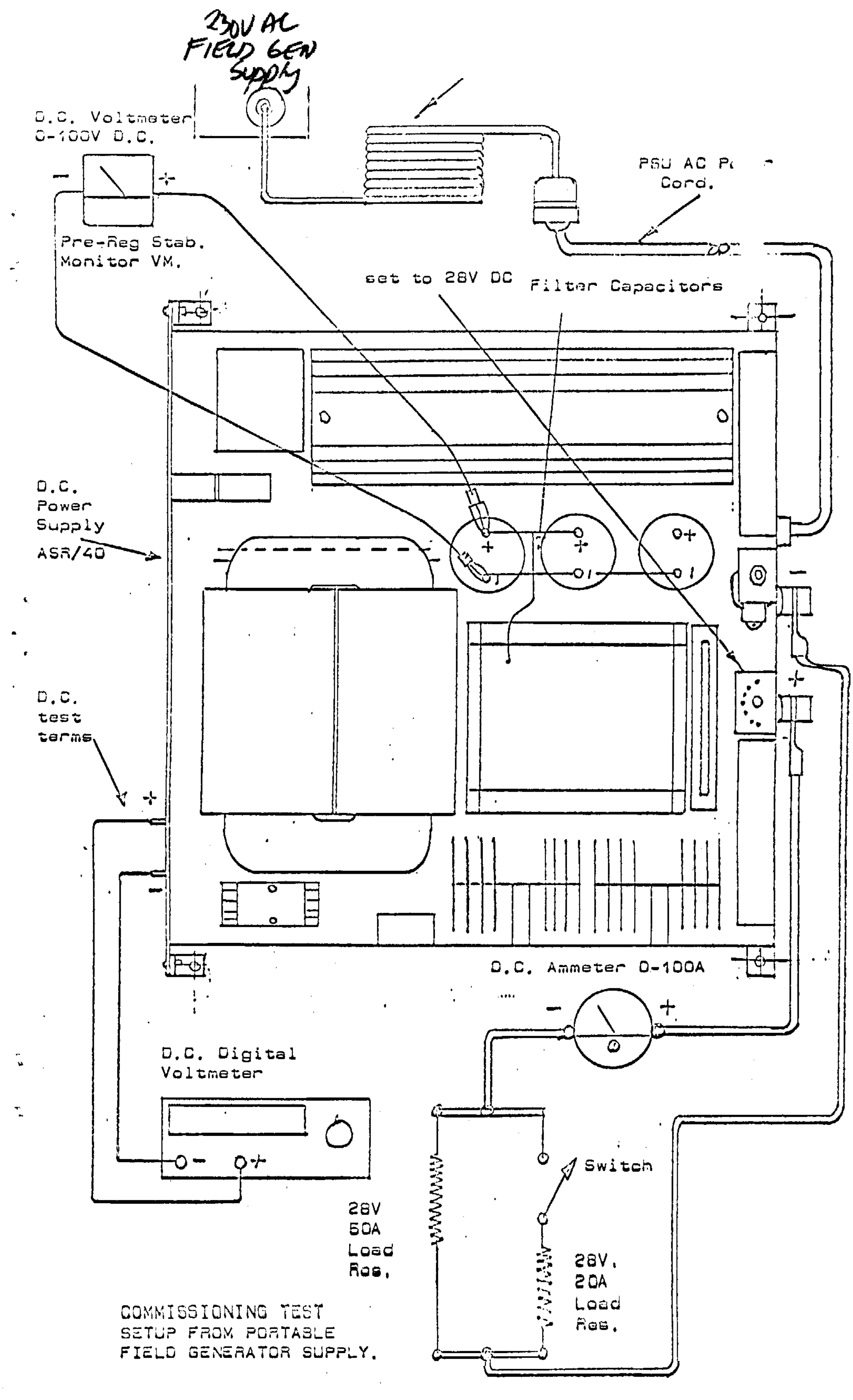
PG 12



COMMISSIONING TEST SETUP.
FROM A C MAINS


230V AC
Outlet.
Extension Cord
if desired.
PSU AC Power
Cord.
set to 28V DC
D.C.
Power
Supply
ASR/40
D.C.
test
terms
D.C. Ammeter 0-100A
D.C. Digital
Voltmeter
Switch
28V
50A
Load
Res.
28V.
20A
COMMISSIONING
FROM PORTABLE
FIELD GENERATOR
Supply

PG 13



COMMISSIONING TEST
SETUP FROM PORTABLE
FIELD GENERATOR SUPPLY.

(33) Commissioning Test, Portable Field Generator Cont

Procedure Start up field generator and stabilise no load output to 230V AC.

Observe the voltmeter connected across the filter capacitor carefully. Switch on the power supply, the voltage across the capacitor should rise initially to about 40V then slowly fall to about 25 Volts before stabilising at a value about 6V above the DC output voltage, thus for 28V DC output the filter capacitor voltage should be 34V.

If the DC voltage across the filter capacitor rises above 50V DC and does not fall back to the correct stable point, switch off the power supply and refer the problem to the manufacturer. Do not run the capacitors in excess of 50V DC as they could be damaged.

Correct operation of the power supply on field generators is dependent on maintaining the correct 6V difference between the DC output and input voltage to the filter capacitors.

If the DC capacitor voltage regulates correctly and stabilises at the 6V difference, load tests can be carried out to complete commissioning tests.

These tests are normally all that is needed and the top cover can be replaced.

(34) Performance Tests

Static Voltage Regulation

A variable auto-transformer such as a variac of 5KVA rating together with an AC check voltmeter is required. A digital voltmeter or precision differential voltmeter such as Marconi type TF2606 or models made by Hewlett Packard of Fluke should be connected across the test terminals to monitor the voltage regulation.

A water cooled test load resistor should be constructed of .5 Ohm resistance capable of carrying 60 Amps, ie 1.7KW.

Test Procedure

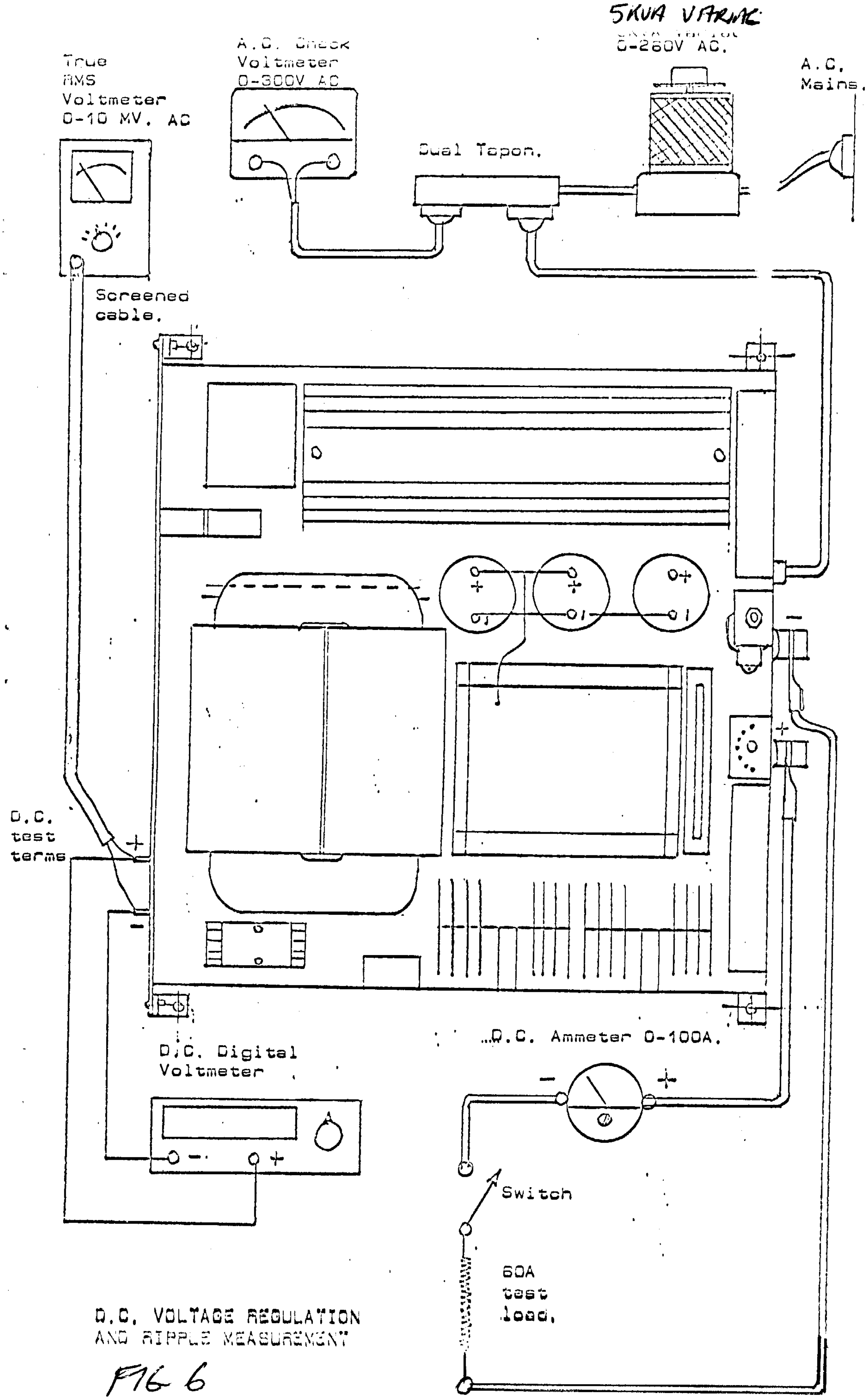
Set the AC input to 230V with variac and test AC voltmeter. Connect the DC load to the power supply output. Switch on the power supply, allow a few minutes running for warm up, read the DC output on the digital or differential voltmeter. Increase the AC input to 230V + 10% ie 253V read the change in DC output, this should not change by more than ± .3% ie for 28V DC 84mV. Typically the change will be less than 10mV.

Reduce the AC input to 230V AC - 20% ie 184V allow the DC change to settle and read the difference, this should not alter by more than ± .3% ie less than 84mV.

A similar test for no load/full load regulation is carried as follows.

Set the AC input to 230V. Check the DC output voltage with load connected.

Remove the load allow the DC voltage to settle for a few seconds, record the chage in voltage reading. The same test should be applied at 230V + 10% and 230V - 20% ie 253V AC and 184V AC. The output voltage variation should not exceed ± .3%. Typically the change is less than 10mV.



D.C. VOLTAGE REGULATION
AND RIPPLE MEASUREMENT

FIG 6

pG 16

(35) Ripple Voltage Measurement

The ripple should be measured with a true RMS voltmeter such as Hewlett Packard type 3400A.

Set the input AC voltage to 230V AC.

Connect the 60 Amp load, check that the over-load indication lamp is off, connect the RMS voltmeter to the test terminals and measure the ripple voltage. The value should not exceed 10mV. Note the test load should be resistive. If electronic equipment is used such as a test load, the ripple measurement may not be correct as many loads such as transmitters, motors, inverters, etc. can inject spikes and noise voltages back into the DC power leads producing a false reading.

An oscilloscope may be used to check ripple but an accurate RMS reading is not possible due to complex ripple waveform.

(36) Transient Response

This is a difficult measurement to perform unless a slow sweep storage oscilloscope is employed. This power supply employs a thyristor phase control pre-regulator with choke capacitence filtering. The time constant of this type of system is longest for zero to full load change. This is not a realistic test condition as the response time improves rapidly as the minimum load is increased.

The test should be carried out for say a ¼ to full load change ie 15 - 60 Amps over a number of sweeps using a mercury switch to connect the extra load on and off.

The average of a number of sweeps should give a response time of less than 50 milli secs for the output voltage to recover to within ± 5V of the set value.

(37) Frequency Descrimination Tests

These can be carried out with a field or engine driven generator where the frequency of supply can be varied over the range 45 Hz to 55 Hz.

The performance checks under sections 34 to 36 repeated for this frequency range to confirm that the power supply operates within its specification.

PART 6 PRACTICAL OPERATION AND CALIBRATION

(38) Printed Circuit Board.

The main printed circuit board should not be unnecessarily removed from its socket and replaced.

This applies on routine inspection and cleaning of equipment. Although the printed circuit board has plug in guides, it is possible if the boards are not plugged in correctly to get misalignment of the circuit board output tracks and the socket connectors.

This can cause erratic and unreliable operation.

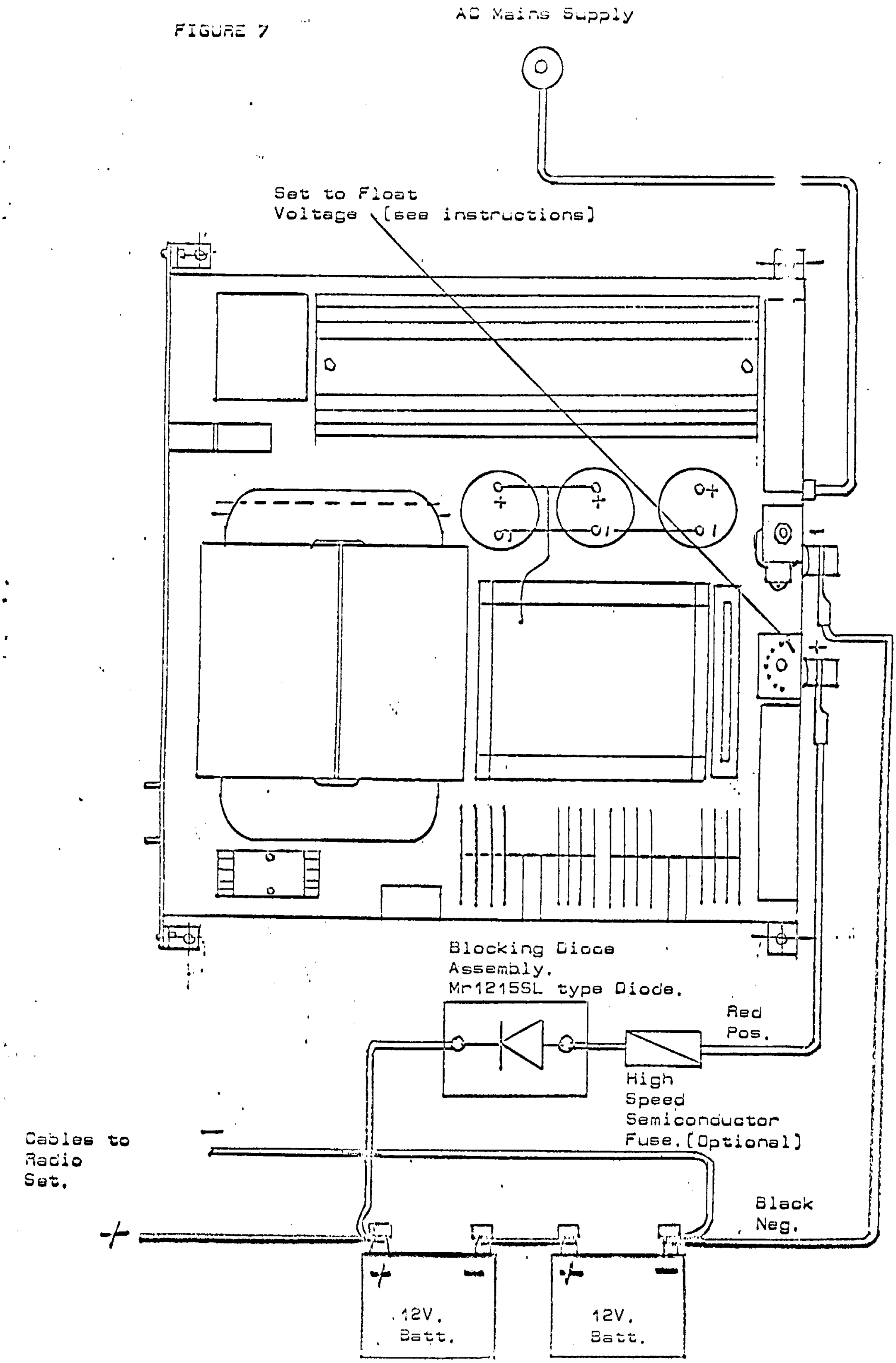
Circuit boards should only be removed and checked by qualified maintenance technicians. See part

(39) Battery Charging

The power supply can be used to float charge a lead acid battery provided the following precautions are taken.

SYSTEM FOR FLOAT CHARGING BATTERIES

FIGURE 7



(39) Battery Charging Contd.

(1) A blocking diode must be connected between preferably the positive output of the power supply and the positive terminal of the battery. The diode isolates the battery from the power supply and prevents the battery discharging back through the power supply, if the power supply is switched off. If the diode is not included, the discharge current could damage components in the power supply.

The diode should be mounted in a ventilated box on a adequately sized heat sink insulated from the box. The diode should be of about 100 Amp 200V DC rating. If a positive lead blocking diode is used, connect the anode of the diode to the positive output terminal of the power supply and the cathode to the positiveterminal of the battery.

(2) The output voltage of the power supply must be set to give the correct float voltage for the battery taking into allowance the voltage drop across the diode.

As the diode drop for a silicon rectifier is about .6V DC and the float voltage for a 24V lead acid battery at about 2.2V per cell is 26.4V the nearest power supply output setting would be 26.4V + .6V = 27V.

In practice some trials may be necessary to determine the most suitable float voltage value to give the best results with any particular battery.

(3) If the battery becomes discharged with the power supply turned off or disconnected, reconnection of the power supply may cause its output to go into full output 65 Amps current limit, with the over-load indicator lamp turned on. This does not indicate a fault or overload, as the battery picks up charge the current will drop below 65A, the overload lamp will turn off. As the battery approaches full charge, the charge current will taper off to a trickle.

As heavy charge current demands may be made on the power supply by a flat battery the current limit current should be checked with an ammeter or installation to ensure it is correctly set. A check should be made to determine if a portable field generator set can support the load imposed by a discharged battery initially recharging at 65 Amps.

(4) Where a power supply is float charging a battery via a blocking diode and in addition an external load such as a radio set is installed. The input to the radio should be obtained directly from the battery.

Warning a blocking diode will not protect the power supply from damage if the battery is reverse connected by mistake.

If there is any risk of inexperienced operaters making mistakes with battery connections,a special high speed type semi-conductor HRC fuse link should be fitted in the battery charging leads.

Such a fuse of about 80A rating may protect the blocking diode and internal power supply power rectifiers being destroyed but the power supply front terminal shunt diode and the protective diodes in the series pass regulators could still be damaged.

(40) Parallel Operation Fig 8.

Two or more power supplies may be connected in parallel if the following precautions are taken.

(a) Both power supplies must be set to the same output voltage setting. If necessary these should be trimmed (see calibration) to be matched to within .1V.

(b) Each power supply must be fitted with a blocking diode to a common positive or negative load busbar. This will prevent one power supply feeding a reverse current into another in the event of one or more being switched off and will prevent circulating currents due to slight output voltage unbalances.

If the power supplies were not fitted with electronic current limiting it would be impossible to connect their outputs in parallel. This is due to the fact that it is not possible to obtain perfect output voltage balance also there are differences in diode voltage drops. The resultant unbalances would cause the power supply with the slightly higher output to take the full load current and sustain damage.

The current limiting circuit makes parallel operation possible because the power supply with the higher output voltage will take the load up to its current limit at this point its output voltage drops forcing other power supplies connected to start sharing load current.

(41) Circuit Breaker Tripping

The strip wound transformer cores used in the power transformer results in an efficient transformer for its size but has the disadvantage of a sharp knee in its B/H loop.

This can result in high inrush currents on switch on, if contact happens to be made at a zero point in the AC sine wave input.

The circuit breaker is rated at 20A for close protection of the power supply. Thus if the power supply is run from a 'stiff' mains source, switch on tripping may be frequent.

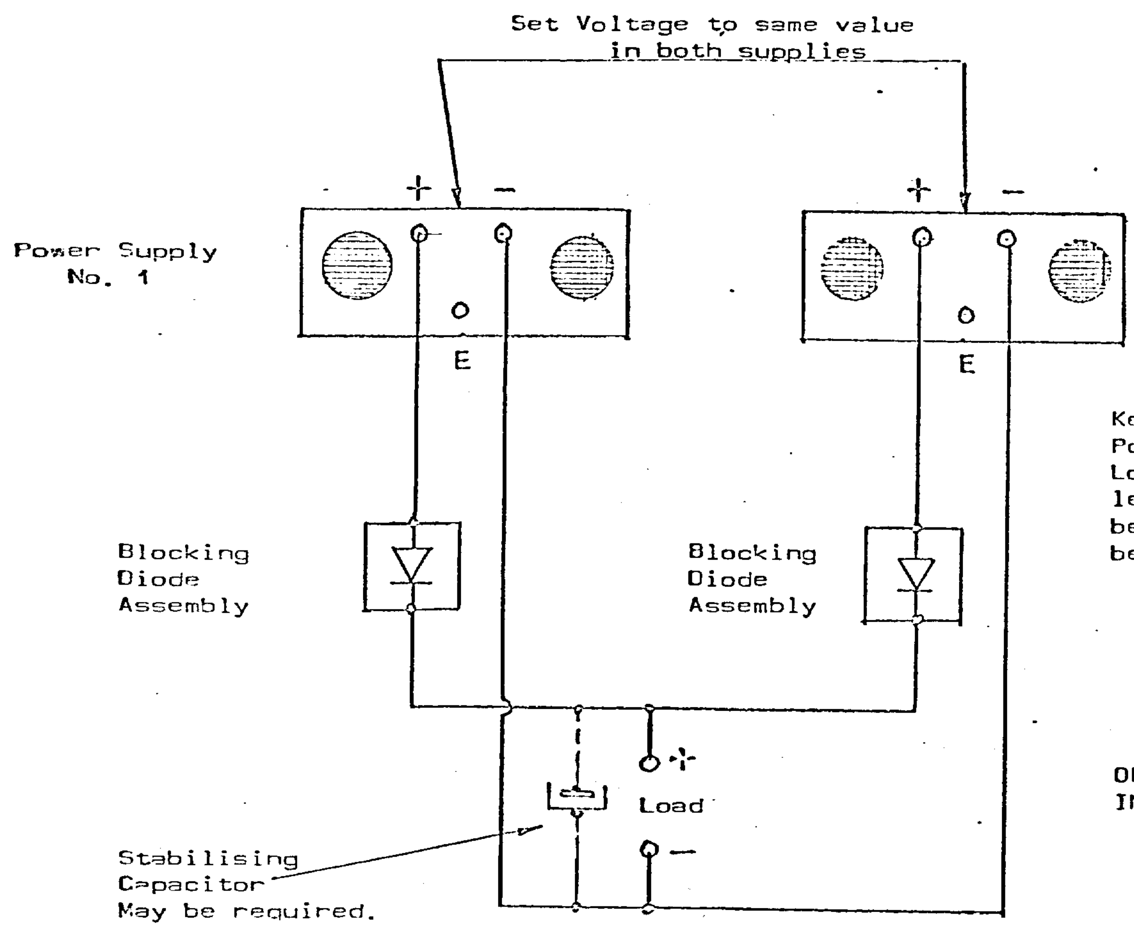
On a relatively soft power source such as a field generator the switch on transient will not be sufficient to trip the breaker and no switch on problems from these supplies can be expected. It has been found that if a long extension flex is used with a stiff power source the resistance of this flex is sufficient to limit the inrush current to below the tripping level of the circuit breaker.

(42) Short Circuit Protection

The power supply has a high speed electronic trip circuit to back up the current limit circuitry and rapidly shuts off the power supply output if a dead short is placed across the load terminals. However even with the protection afforded, there is a considerable amount of transient energy discharge when a power supply of this capacity is shorted.

This could weld the shorted ends together and the rapid rate of change of current even in a circuit of low inductance can produce voltage spikes that may damage electronic components. For this reason care must be taken in equipment installation to avoid short circuits.

PG20.



Keep all leads between Power Supplies and Load Terminals equal length to maintain best current balance between Power Supplies.

OPERATING POWER SUPPLIES IN PARALLEL

FIGURE 8

(42) Short Circuit Protection Contd.

Short circuit testing of the power supply is not recomended.

If a heavy short circuit occurs the overload light emitting diode will flash and the inductive components will be heard to make a thumping noise as the electronic trip protection continuously operates when the power output attempts to recover into the short.

(43) Insulation Testing at High Voltage

High voltage breakdown insulation or megger tests should be confined to the primary side of the mains transformer only.

Solid state equipment employs semi-conductor devices that operate at low voltage, the junctions of many of these devices can be damaged if reverse voltages force quite low currents through the junctions. Semi-conductors subjected to these stresses may operate satisfactory for a while but fail prematurely in service. The output electronic circuits of this power supply are isolated from chassis ground, and have a high resistance to ground, however if for instance 2KVis applied between positive output and ground sufficient leakage current up to a few hundred micro-amps could flow via semi-conductor junctions to cause possible damage and subsequent unreliability in service.

The output terminals are RF decoupled to earth via two .047MFD 1000V capacitors.

It is recommended that any insulation tests carried out on the DC side of the power supply be done at less than 150V.

(44) Overvoltage Tripping

Occasional overvoltage tripping may occur in service which can be reset by the procedure of switching the power supply off and on again.

Cause of spurious over voltage tripping could be :

(1) Dirty arcing connections in the output circuit injecting high voltage spikes back into the D.C. output terminals, of sufficient amptitude to activate the protection circuit.

(2) Reverse current loading.

Certain active loads such as DC motors, inverters, class B amplifiers etc can deliver a reverse current to the power supply during a portion of its operating cycle, thus a positive pulse can be fed back into the positive terminal for instance from such equipment, which exceeds the power supply positive forward voltage. Thus in effect the load attempts to pump a current back into the supply. This is indicated by the power supply producing what can be described as a spongy regulation characteristic, for instance when the load is connected, the output voltage appears to rise slightly, and the voltage control has a limited effect in constant voltage mode. What has happened is that the load is pumping back a positive voltage which adds to the power supply voltage, and incorrectly signals the comparison amplifier in the regulator to increase the output voltage in error. If sufficient energy is pumped back, the supply output can fly up due to loss of regulation, and cause a trip out.

To avoid these effects it is essential to add additional fixed resistor pre-loading to the power supply output so that the power supply supplies forward current through the entire operating cycle of the load.

(44) Overvoltage Tripping Contd.

(3) High R.F. voltages appearing on the D.C. line. This can be caused by faulty earthing of transmitters mistuning and poor filtering of the transmitter DC circuits.

(4) Incorrect adjustment of the set O/V cal control RV5 giving too low a trip threshold.

If continuous O/V trip off occurs every time the power supply is switched on which can not be reset, an internal fault is indicated.

(45) Pre-Regulator Voltage Differential
The power supply has been adjusted to automatically maintain a differential of 6 volts across the series regulator transistors, this value has been chosen to give optimum transient response and regulation speed without excessive regulator dissipation.

For a continuous load of 60 Amps the power dissipation in the series regulator is 6 x 60 = 360 Watts.

This heat dissipation is adequately removed by the blower fan. However if the differential is incorrectly set to say 8 Volts, the dissipation rises to 480 Watts and overheating can occur.

The differential can be set as low as 3 Volts, this will reduce dissipation to 180 Watts, giving a lower operating temperature and improved efficiency. However the transient response to sudden load changes is affected, also higher output ripple will occur on field generators at low AC output voltages because of ripple break through.

(46) Calibration of Output Voltage Fig. 9.
Connect an accurate digital or differential voltmeter across the test terminals.

Remove the top cover of the power supply, disconnect any load, adjust the set DC output voltage switch to 32V.

Switch on power supply and allow about 5 min warm up. Check the DC output voltage.

The DC reading should be within ± .1V of 32V. Locate the OP Volts Calibration RV1 see sect (22) and adjust the output until exactly 32.00 Volts is obtained.

Adjust the output voltage switch back to 28V and check that the output is within the range 28V ± .1V. As the output voltage steps are set by a precision resistor voltage divider chain one calibration at 32V will accurately adjust the other voltage steps.

(47) Calibration of Differential Fig. 9.
Connect a 0-10V DC voltmeter between the positive terminal of the main filter capacitor and the positive output test terminal.

The voltmeter positive lead should be connected to main filter capacitor end.

Switch on the power supply and allow the DC reading on the voltmeter to settle.

If the reading is not 6V locate the Diff Voltage Calibration RV4 control, see sect (23) and adjust this control to obtain a differential of 6V.

pg 23

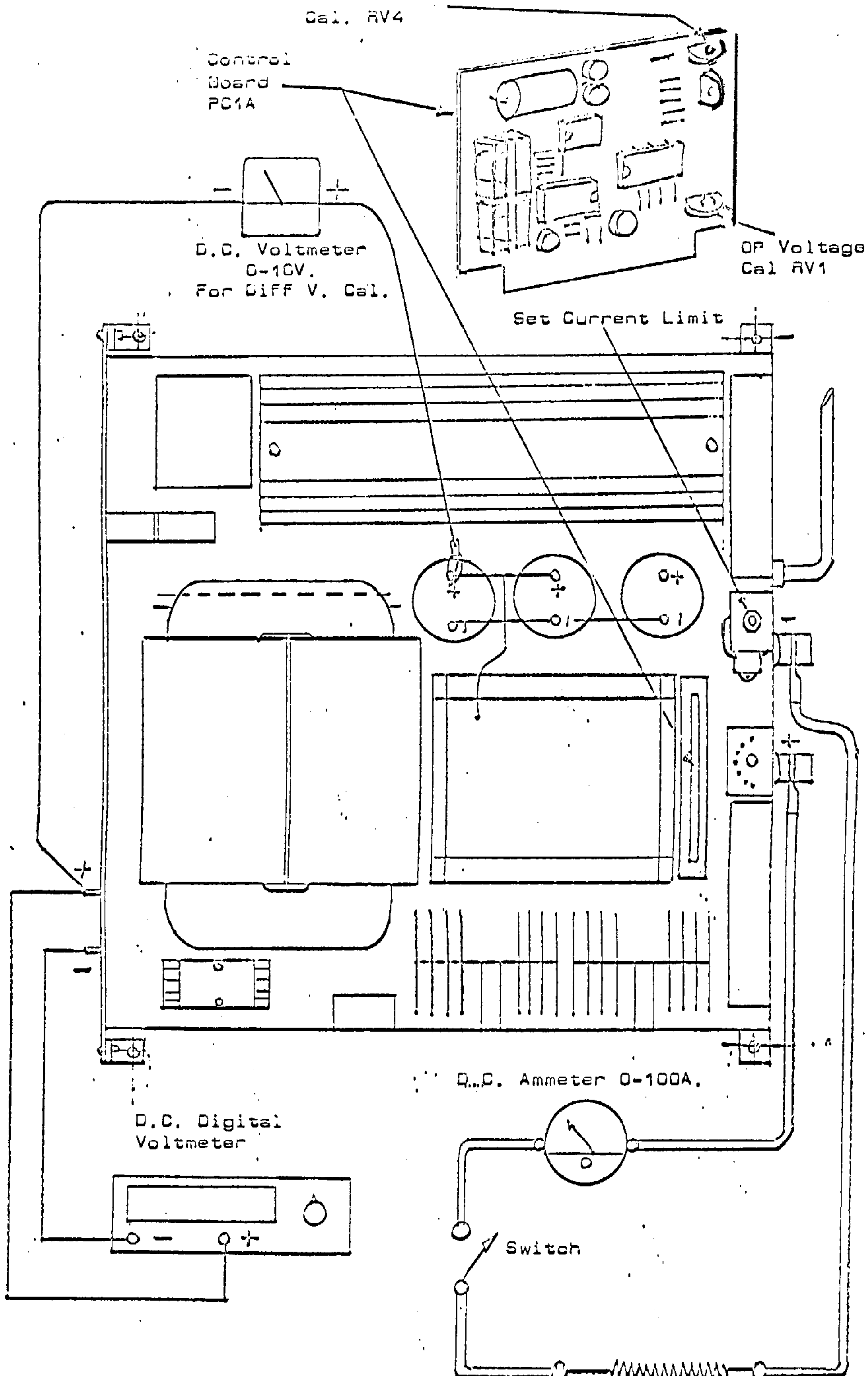


FIG 9

TEST SETUP FOR CALIBRATION
OF OUTPUT VOLTAGE, DIFF.
VOLTAGE AND CURRENT LIMIT.

pg 24

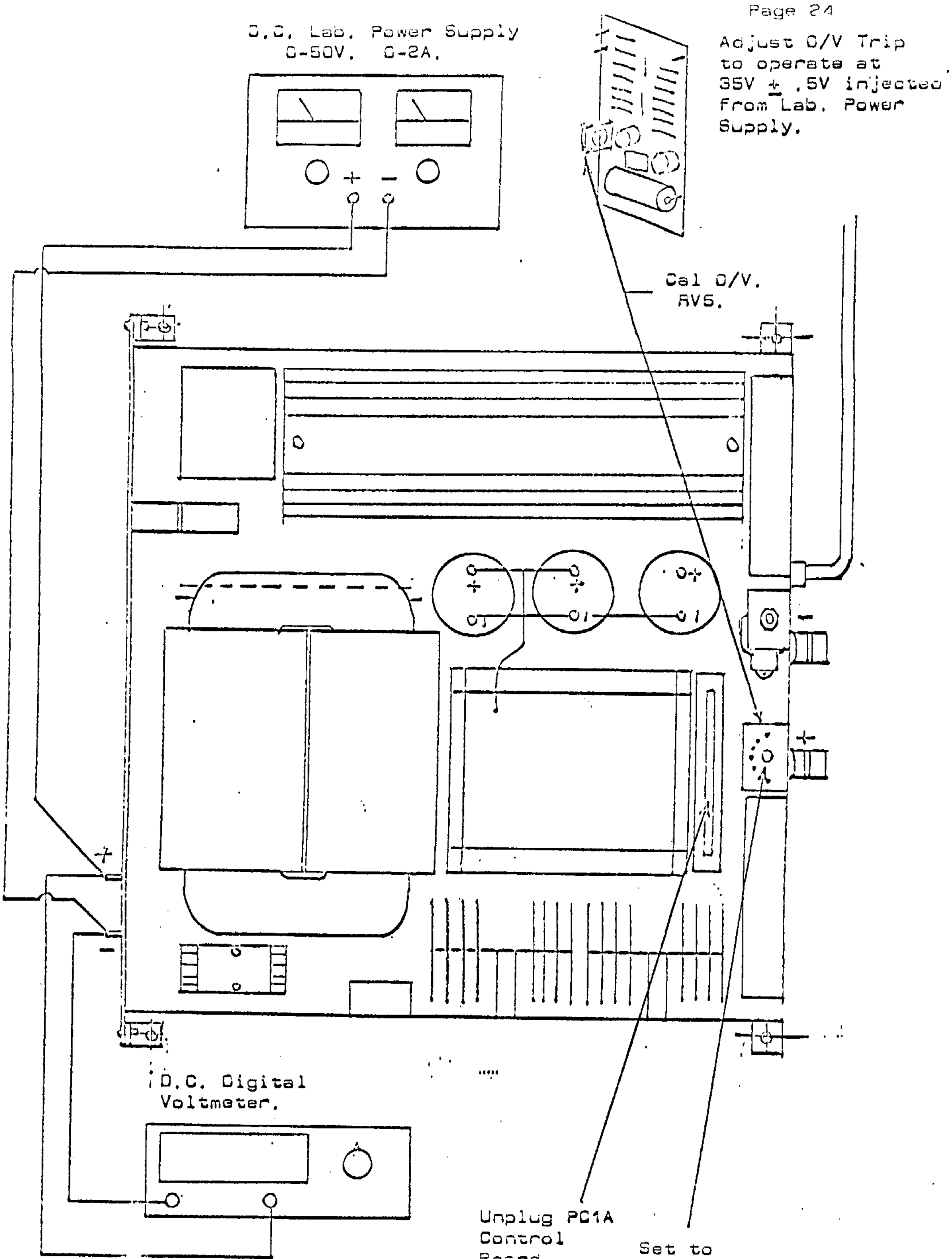


FIG 10

TEST SETUP FOR CALIBRATION

(48) Calibration of Current Limit Fig. 9.

Construct a water cooled test resistor capable of drawing 65 Amps at say 30V ie .46 - .5 Ohm. Connect an accurate 100 A D.C. ammeter in series with the load.

Remove the cover from the power supply loosen the lock nut on the Set Current Lim turn this control with a screw driver to about the ¼ way position. Switch the Set DC output voltage switch to the 32V position, turn on the power supply and connect the load. Check that the over load indicator lamp is on indicating current limit. The ammeter reading should be less tham 65 Amp if the current limit control has been set to ¼ position. Now adjust the control until 65 Amps is indicated, the overload lamp must be on.

Tighten the locknut, disconnect the load and readjust output voltage back to 28V or other value required.

(49) Calibration of Overvoltage Trip Fig. 10

It is not recommended that this calibration be carried out unless absolutely necessary.

To carry out the test, remove the top lid, unplug the printed circuit control board.

Set the set DC output voltage switch to 32V. Connect an accurate DC voltmeter to the test terminals. Connect a 0-50V DC variable laboratory DC power supply of at least 2 Amp capacity across the test terminals, make sure the voltage is set to zero.

Switch on the power supply. Slowly increase the DC voltage from the variable supply, until the contactor trips off, causing the over-volts indicator to light up. Check the voltmeter reading, this should be at 32 + 3V = 35V ± .5V. If the trip voltage deviates more than ± .5V from the set value of 3 volts above the output voltage setting, locate the Cal O/V control RV5 mounted on the printed circuit board under the voltage selection switch bracket. Adjust this control with a short screw driver while carrying out the previous test procedure until the correct trip differential is obtained.

Disconnect the test voltmeter and lab power supply. Switch off the power supply, replace the control circuit board, reset the voltage range switch to normal operating value, check out operation and replace top cover.

PART 7 DISMANTLING OF EQUIPMENT

(50) Introduction

Due to the very compact construction specified for this power supply, a considerable amount of dismantling will be required to replace such items as rectifiers, etc. The correct procedure should be carried out in the correct order otherwise repairs will be very difficult.

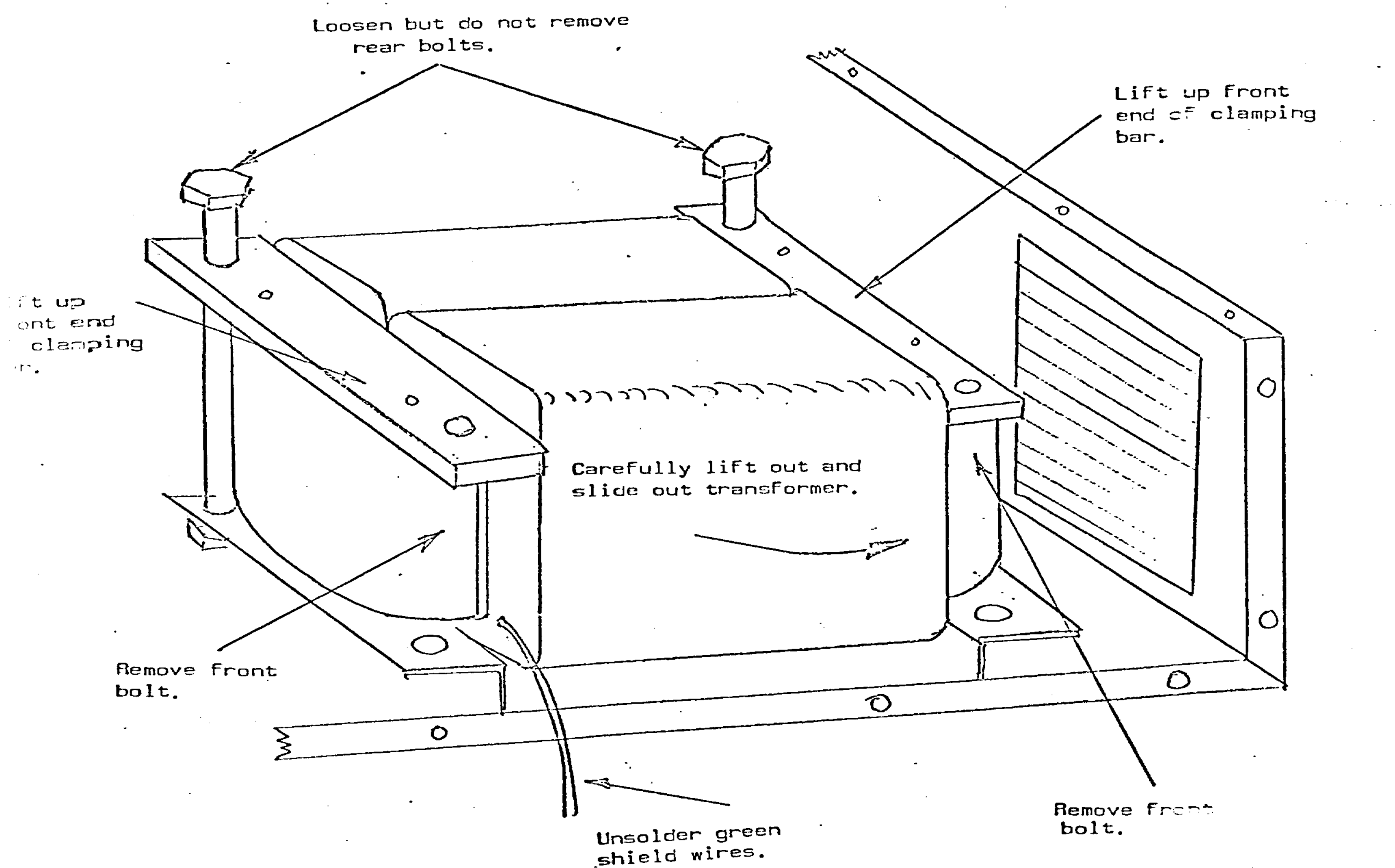
(51) Dismantling Procedure Fig. 11.

Remove the top cover secured by 16 M4 x 6 metric screws and lockwashers.

Place the power supply on a level bench surface. To remove front panel.

(1) Unscrew the long 5/32" screw securing the circuit breaker to the front panel.

PG 26



MAINS TRANSFORMER REMOVAL

Figure 11.

(51) Dismantling Procedure Fig.41 Contd.

(2) Remove the 10 M6 x 12 metric screws securing the front panel to the chassis front and tilt the loose panel forwards as far as possible and put a prop under the panel. Cover the back of the tilted panel with a sheet of cardboard to protect rear panel wiring. If desired the wiring can be disconnected from panel components after carefully noting the terminations and the panel completely removed.

(3) To remove the transformer. Disconnect all cables terminating on to the brass bolts on the formica terminal strips mounted at each end of the power transformer.

After all cables are clear of the brass screws, remove the formica terminal strip from the transformer top end mounting plates. Loosen the M10 x 100 hexagon bolts securing the transformer to the chassis mounting brackets. Loosen with a tube spanner from the top. Important do not remove the two rear bolts from their nuts as access to these nuts is very difficult.

Remove the two front hexagon bolts from their nuts. It is now possible to slide the transformer out of the mounting, leaving the top end mounting strips still loosely secured at their rear ends. by the loose rear hexagon headed bolts. Note, disconnect the green shield wire first.

Lay the mounting bars on the chassis mounting brackets.

Handle the power transformer carefully. If it is dropped or jarred the epoxy resin core glue seal could crack, resulting in a difficult transformer reassembly and re-sealing operation.

To remove the choke. Unscrew the modification plate from the top of the choke. Disconnect the choke wires.

Unscrew the nuts from the top of the choke mounting corner bolts only.

Do not remove the bottom nuts as their inaccessability will make replacement difficult. Remove the formica barrier strip from the top rear of the choke remove the metal choke mounting strips.

Lift the choke out vertically, leaving the mounting bolts behind with bottom nuts still attached.

Once the transformer and choke is removed access is possible to the rectifier heat sinks and most other components.

The transistor heat sinks can be removed by unscrewing the end bolts disconnecting the yellow leads to the filter capacitors lifting up the top heat sink tilting it over and unsoldering the white base drive wire, and removing the bottom heat sink and spacers in the same way.

(52) Reassembly

The choke, transformer and control panel is reassembled in the reverse order.

pg 28

PART 7 TECHNICAL DESCRIPTION

(53) Start Up and Overvoltage Protection Circuit Fig 12
The operation of this circuitry is described in Fig. .

The A.C. mains supply is applied when the power on/off switch is turned on.

Contacts RY1 are normally closed allowing A.C. current to magnetise coil RYC/3 of the main contactor. The contacts RYC1/2 close allowing AC voltage to be applied to the primary of the mains transformer.

When the contactor RYG/3 pulls in its contacts RYC3 open to isolate the over temperature indicator lamp from its DC supply.

When the main on/off switch is turned on, AC is applied to the primary of the auxiliary transformer. The secondary of this transformer consists of two windings, one set supplies the main regulator board PC1A the other winding supplies a bridge rectifier, from which DC is derived to operate the overvoltage protection board and indicator LED's.

The overvoltage detector consists of an integrated circuit voltage comparator type LM311.

The - inverting input of the comparator is fed with a precision reference positive voltage derived from a reference diode unit type LM336Z producing a reference of approx. 2.5V.

The non inverting input of the comparator is connected to the positive DC output terminal of the power supply via a precision resistor voltage divider chain consisting of R4, the cal O/V RV5 control and the divider resistors R12/R17 consisting of 1% tolerance 1.8K Ohm resistors. Normally the reference voltage at the inverting input of the comparator is higher than the input to non inverting input. Thus the output of the comparator is low, transistor Q10 is switched off, RY1, RY3 and RY4 contacts remain held on.

If an overvoltage occurs on the output of the DC supply at a level determined by the setting of the volts range switch.

The voltage level on the non inverting input of the comparator will rise above that on the inverting input (2.5V). The comparator output switches high, Q10 conducts allowing overvoltage relay RY/4 coil to switch contacts RY1 RY3 and RY4 over.

When contacts RY1 open, the main contactor turns off removing AC from the main transformer, RY3 contacts 7 and 11 close, connecting pin 14 of coil RY/4 to negative common locking the relay on continuously.

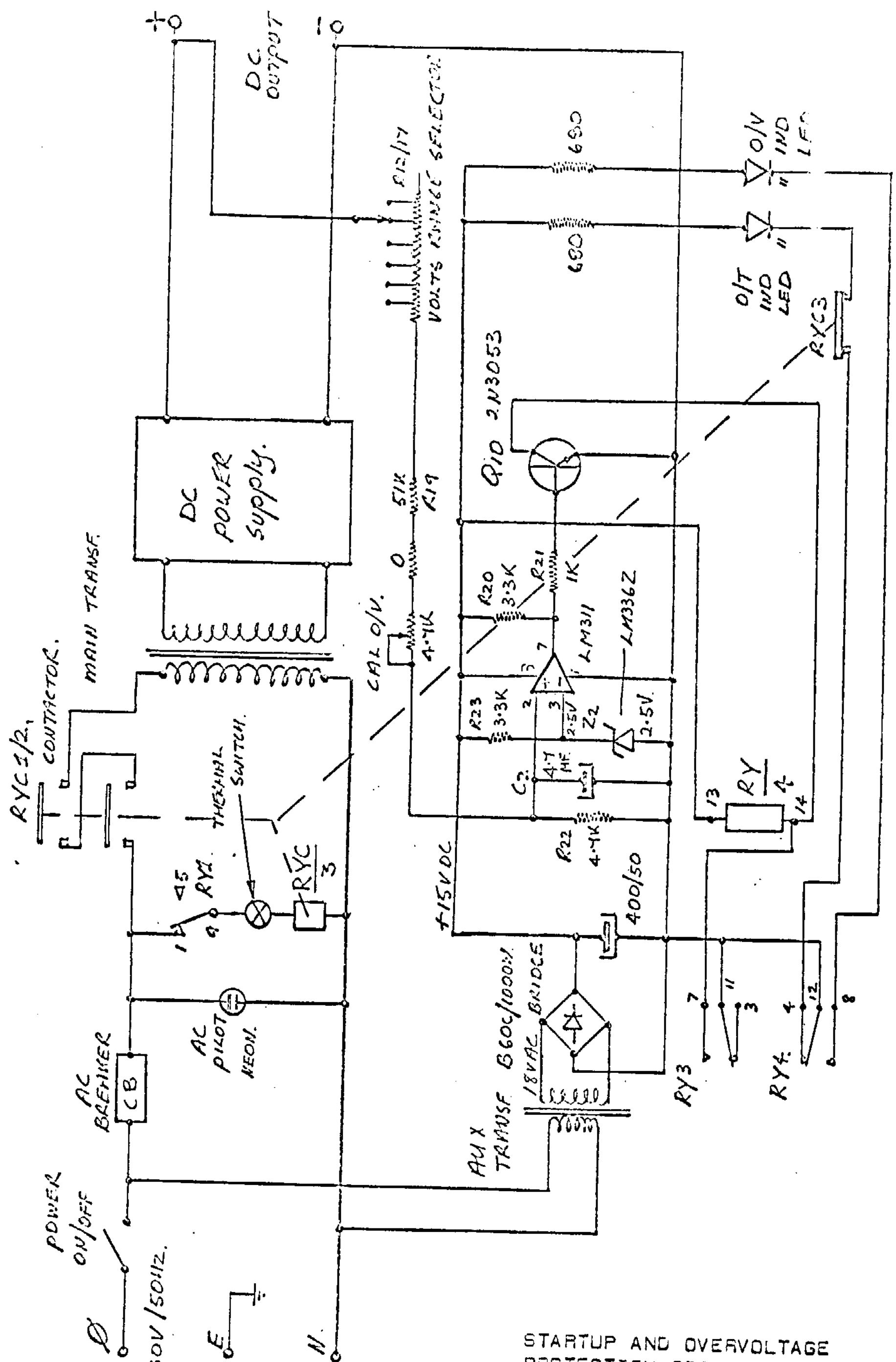
RY4 contacts 8 and 12 close allowing the O/V indicator LED to turn on, indicating the fault condition.

To unlatch RY/4 it is necessary to turn the power switch off and on again.

Provided the overvoltage fault has cleared the overvoltage protection circuit will revert to the standby state.

The divider chain is arranged so that the trip voltage level is three volts above the normal DC output voltage setting of the power supply. C2 provides a slight time delay before the comparator switches, to prevent false switching on voltage transients appearing across the power supply output terminals.

pG 29



STARTUP AND OVERVOLTAGE PROTECTION CIRCUIT.

FIGURE 12

pG 30.

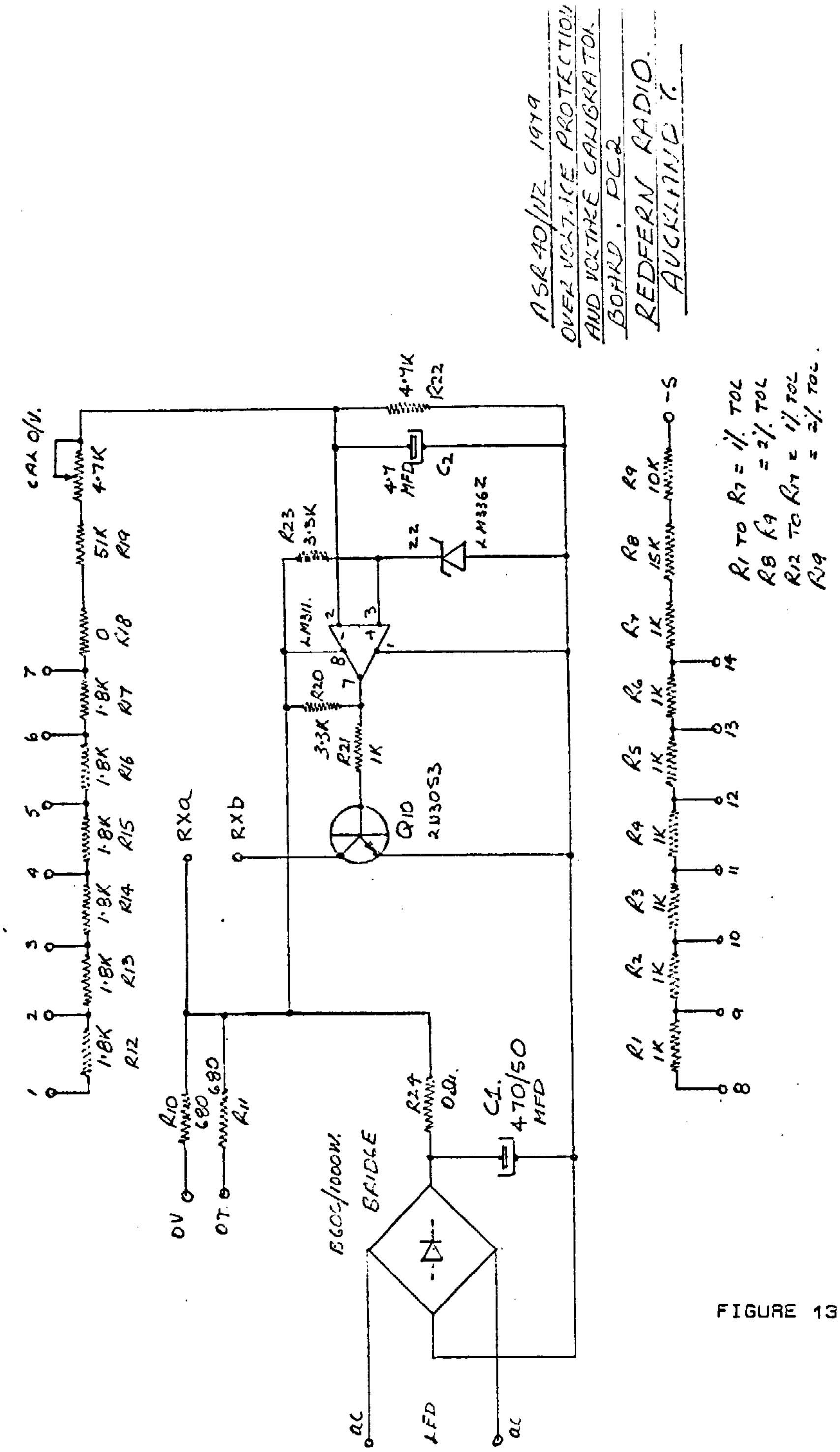


FIGURE 13

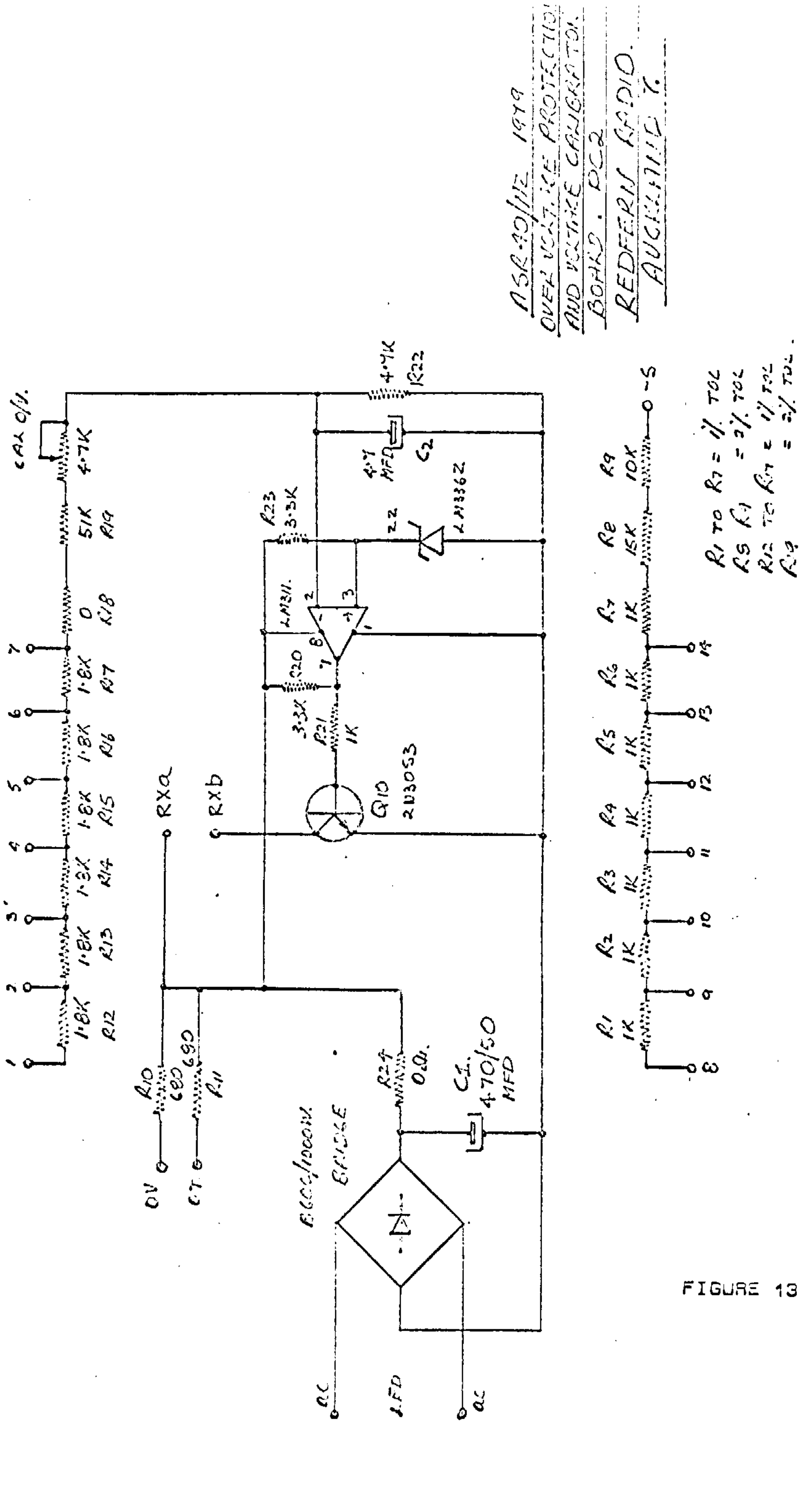

ASR40/NZ 1979
OVER VOLTAGE PROTECTION
AND VOLTAGE CALIBRATOR
BOARD. PC2
REDFERN RADIO.
AUCKLAND N.Z.
RXa
RXb
Q10
2N3053
LM311
C1
470/50 MFD
C2
R22
4.7K
R23
3.3K
R24
0.5Ω
R10
680
R11
680
0V
C.T
A.C
A.C
R19
51K
4.7K
CAL O/V.
R1
1K
R2
1K
R3
1K
R4
1K
R5
1K
R6
1K
R7
1K
R8
15K
R9
10K
-5
R12
1.8K
R13
1.8K
R14
1.8K
R15
1.8K
R16
1.8K
R17
1.8K
R18
0
R20
R21
1K

FIGURE 13

pG 31

(54) Thermal Switch
The thermal switch is mounted on the top of the mains transformer. This switch is a bi-metal type permanently on The switch is in series with the contactor coil RYC/3. If the switch temperature exceeds 112°C the bi-metal contact opens turning off the main contactor.

At the same time contacts RYC3 close turning on the over-temperature LED indicator.

The blower fans keep running after an over-temperature trip. When the thermal switch temperature drops below 112°C, the contactor will reclose, starting up the power supply.

(55) Regulating System, Functional Diagram
The basic operation of the power supply can be explained with reference to fig 14.

The input AC is applied to the power transformer which has secondary windings scaled to produce correct supply voltage for the operation of the regulator. The main power rectifiers are phase controlled thyristors SCR1 and SCR2 connected as a full wave rectifier. The conduction angle of these thyristors are controlled by firing pulses generated by the tracking pre-regulator. For small conduction angles the firing pulses are delayed, each thyristor conducts late in each half cycle, and the resultant rectified DC voltage applied to the filter capacitor is low, conversely for higher DC output the firing angle is advanced increasing the DC voltage across the filter capacitor. These firing pulses must be synchronised accurately in relation to the zero crossing points of the AC input sine wave, the syronchronising transformer provides the reference wave to the tracking pre-regulator to permit synchronisation.

The tracking pre-regulators monitors the voltage drop across the series regulator transistors and automatically adjusts the firing angle in order to maintain a relatively constant voltage drop across the pass transistors. By this means power dissipation in the pass transistors can be kept to a minimum. This reduces heat dissipation, heat sink size and allows the technical advantages of the series regulator type power supply to be used on a supply voltage input ranging over a wide range. The resultant efficiency is much higher than the usual series regulated power supply.

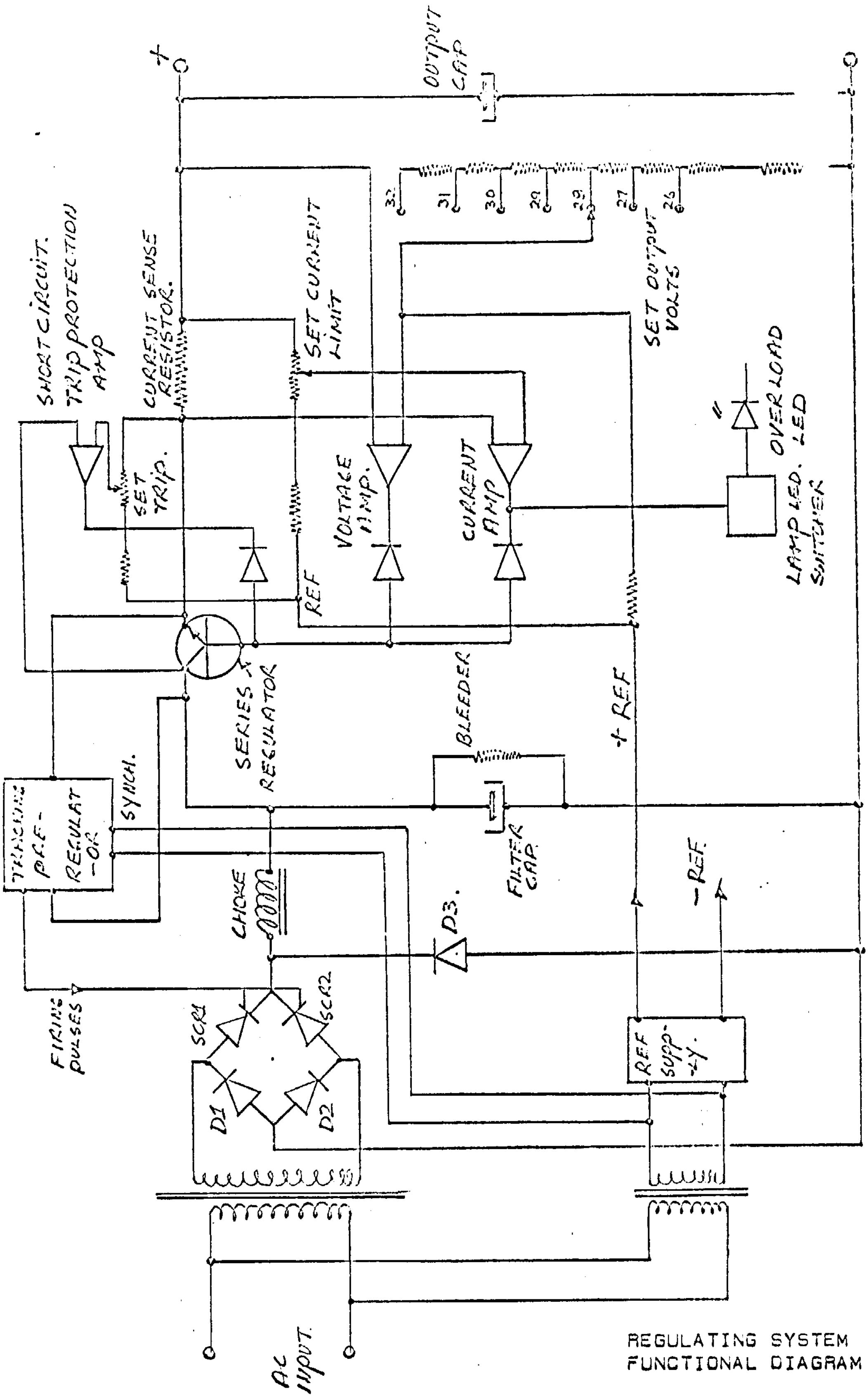
The output of the pre-regulator has high ripple content and coarse DC regulation. The series regulator takes the output of the coarse regulator and provides a precision regulated output with high response speed and negligible ripple content.

(56) The series regulator uses a bank of parallel connected transistors as a variable electronically controlled resistor in series with the positive output of the pre-regulator.

The voltage control amplifier compares the DC output voltage of the power supply to a reference voltage, the value of which is selected by a precision resistor divider chain. The difference voltage is used to control the conduction of the pass regulator transistors, to maintain a constant output voltage.

(57) The Current Amplifier Functional Diagram
The inputs to the current control amplifier are connected across the current sensing resistor. One input is balanced against a reference voltage provided by the current limit control slider.

p632



REGULATING SYSTEM
FUNCTIONAL DIAGRAM

FIGURE 14

(57) The Current Amplifier Function Diagram Contd.

Normally the current control amplifier is inactive, however when the current exceeds a pre-determined amount, this amplifier becomes active, robs the voltage amplifier of control and reduces the conduction of the pass regulator transistors to limit the current.

(58) Short Circuit Trip Protection Amplifier
This amplifier has a similar action to the current control amplifier, the trip amplifier monitors the voltage drop across the regulator transistors, when this exceeds a pre-determined amount the amplifier output becomes active and over-rides both the voltage and current control amplifiers, shutting off the series regulator.

(59) Phase Controlled Rectifier Action
Phase controlled rectifiers or thyristors are used in a half controlled bridge rectifier power supply.

Thyristors have the property of remaining non conducting to an applied forward voltage, until a positive firing voltage is applied between the gate and cathode junctions.

The firing pulse initiates conduction in the forward direction, the thyristor will remain conducting even if the firing pulse is removed. The thyristor will stop conducting if the anode cathode applied voltage is reduced to zero or reversed. The device will remain non conducting until retriggering during a period when forward voltage is applied.

Refer to Fig. 15 Ignoring the effect of MR3 L & C the rectifier output wave forms are shown in Fig 16 a b c & d in relation to the A.C. input waveform. In Fig 16a the top and bottom thyristors are triggered alternatively by trigger pulses 1 and 2 synchronised to the supply frequency. The large trigger delay angle α results in thyristor conduction in the cross hatched areas shown, note that the D.C. level Ed. is low.

In Fig. 16b the trigger delay angle is small, the cross hatched areas are larger hence the mean D.C. output voltage Ed. is high. Hence the mean D.C. output into the load can be regulated by controlling the position of the trigger pulse delay angles

The mean recitified output voltage of the circuit of Fig 15 can be expressed

$$E_D = \frac{E_m}{\pi}\left(1 + \cos\alpha\right) \cdots\cdots (1)$$

Components inductance L and capacitor C are added to the circuit Fig 15 to remove the ripple component from the output D.C. voltage. Inductance L acts as a energy storage component, during the non conducting intervals of Fig 16 a & b load current is shut off, the magnetic field across L collapses, inducing a reverse voltage across the source, and hence reducing the amount of energy expended in the load. Fig 16 d shows the negative component added to the rectifier output during the intervals

The addition of freewheeling diode MR3 bypasses the direct current from the A.C. side when ever the voltage goes negative, thus ensuring that all the inductor energy is expanded in the load. The output voltage is never negative, harmonic content in the outpit is significantly reduced and the current is much smoother. The diode MR3 improves the firing of the thyristors.

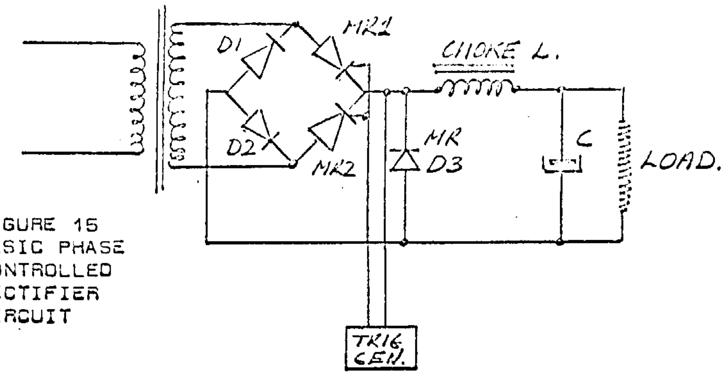


FIGURE 15
BASIC PHASE
CONTROLLED
RECTIFIER
CIRCUIT

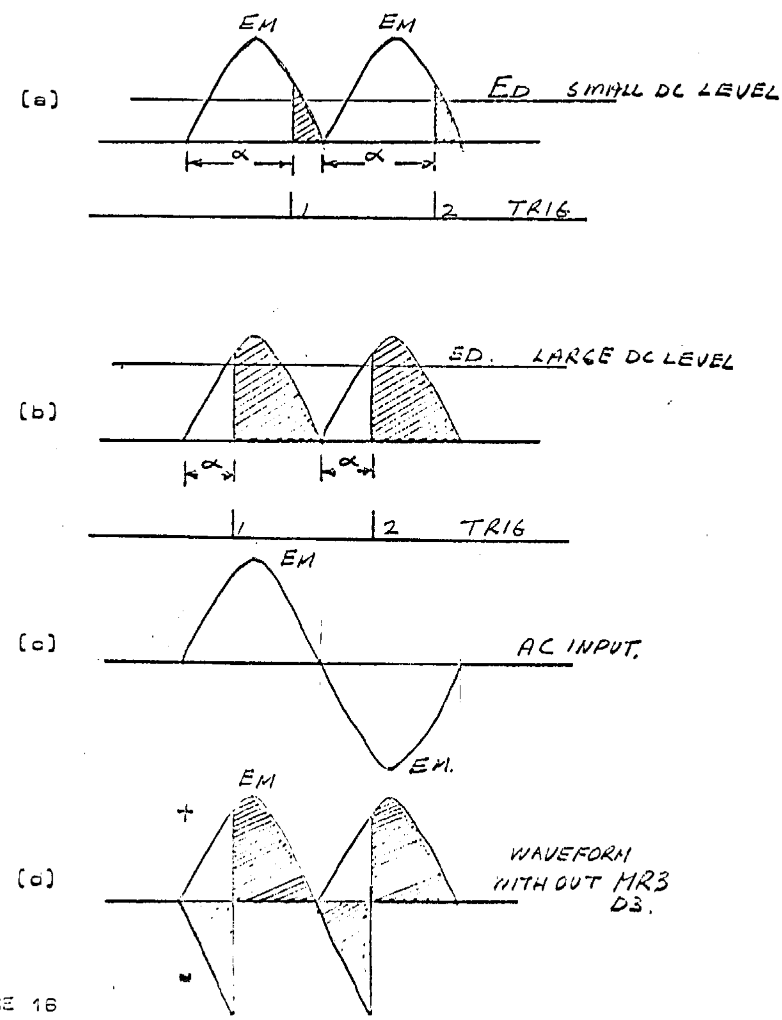


FIGURE 16
RECTIFIER CIRCUIT

p635

(60) Pre-Regulator Circuit

The pre-regulator circuit is a closed loop DC regulator using phase controlled thyristors in which the DC output is automatically adjusted by conduction control of thyristors to maintain a constant voltage drop across the series pass regulator transistors.

Refer to the circuit diagram of Fig 17, and the waveforms of Fig 18.

The auxiliary transformer secondary is centre tapped and feeds a bridge rectifier which provides both positive and negative outputs referred to the common centre tap, which is connected to positive output side of the series regulator.

The positive supply is filtered by C1 and regulated to 15V + output by a 7815 three terminal voltage regulator. The + 15V rail supplies components such as operational amplifiers on the control board. The negative output is filtered and regulated by zener Z1 to provide - 12V for the operational integrated circuit LM324.

(61) Synch

In Fig 17 the negative going ripple waveform is fed via R31 to a biased transistor amplifier Q9. The tips of the ripple waveform bias Q9 to conduct, and produces a train of narrow negative going zero crossing pulses, Fig 18/2 at the collector. These pulses are fed to the trigger comparator input pin 2 of the 555 Timer Integrated circuit.

(62) Ramp Generator

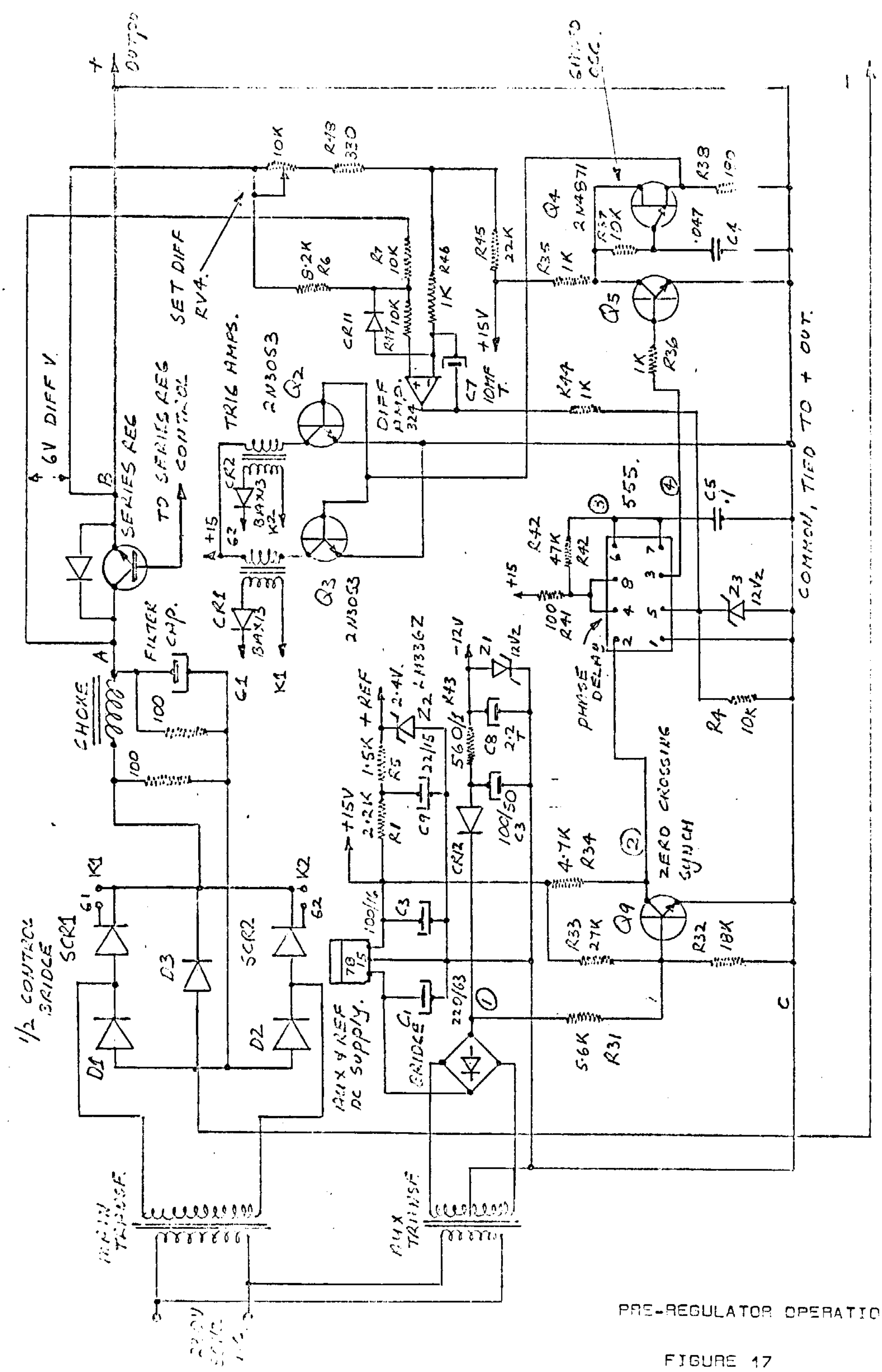
When the input voltage to the trigger comparator falls below 1/3 Vcc ie 5V the comparator output triggers an internal flip-flop so that its output sets low. This turns the capacitor discharge transistor "off" and drives the digital output to a high state at pin 3, see Fig 18 At the same time the ramp capacitor starts to charge and the voltage at pins 6/7 starts to rise at an exponential rate, Fig 18/3, this rate is determined by the time constant of R42 C5.

When the capacitor voltage reaches approx. 2/3 Vcc ie 10V the thresh-hold comparator resets the flip flop. This action discharges the timing capacitor and turns the digital output at pin 3 to the low state. Once the flip flop has been triggered by a zero-crossing pulse and cannot be retriggered until the timing period has been completed.

By applying a D.C. control voltage to the threshhold comparator and adjusting its value. The comparator can be made to reset the flip-flop at any predetermined point on the ramp, thus the width of the digital output pulse can be varied by a DC control voltage. As the control voltage increases positively the digital output pulse, fig 18/4 widens.

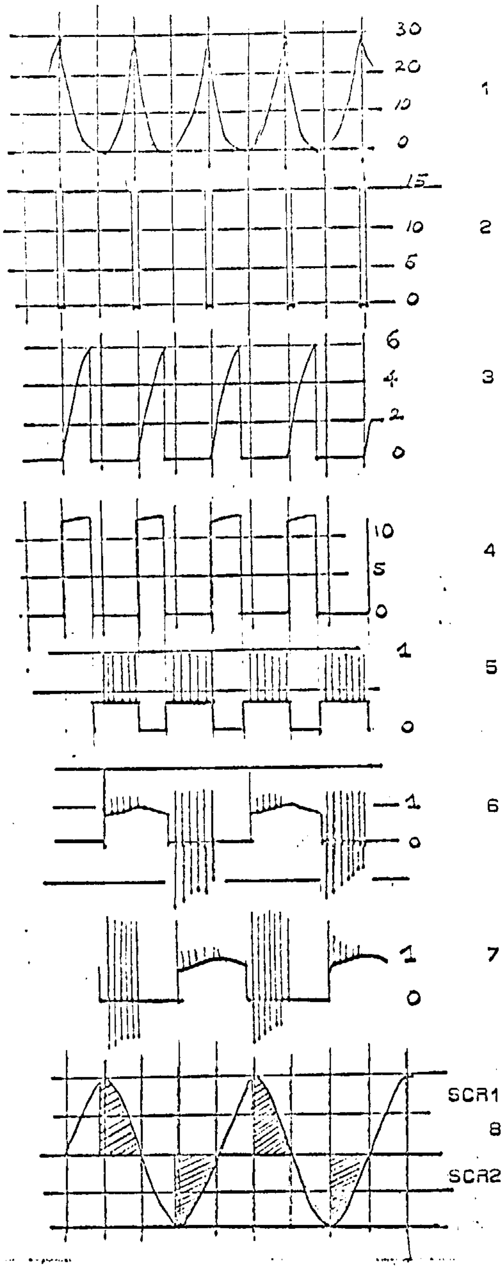
The digital pulse is applied to the base of Q5 transistor which gates the unijunction oscillator Q4. When the base of Q5 is driven positive via R36 the transistor is driven into saturation hence its collector voltage is held low. Under this condition there is no positive voltage available to allow unijunction Q4 to oscillate. During the negative or off periods of the waveform in Fig 18/4 Q5 is turned off, hence its collector voltage is high,, this allows Q4 to generate a burst of oscillation and a train of short pulses appears at the B1 junction of Q4 see Fig 18/5.

p6 36



PRE-REGULATOR OPERATION

FIGURE 17



1 Waveform at Input to R31 Fig. Zero Crossing Detector

2 Waveform at Pin 2 555 Phase Delay IC. Zero Crossing Synch Pulse

3 Waveform at Pin 6/7 555 Phase Delay IC. Ramp Wave Form.

4 Waveform at Pin 3 555 Phase Delay IC. Gating Pulse to Burst Generator.

5 Waveform at Top of R38, Output of Gated Burst Generator.

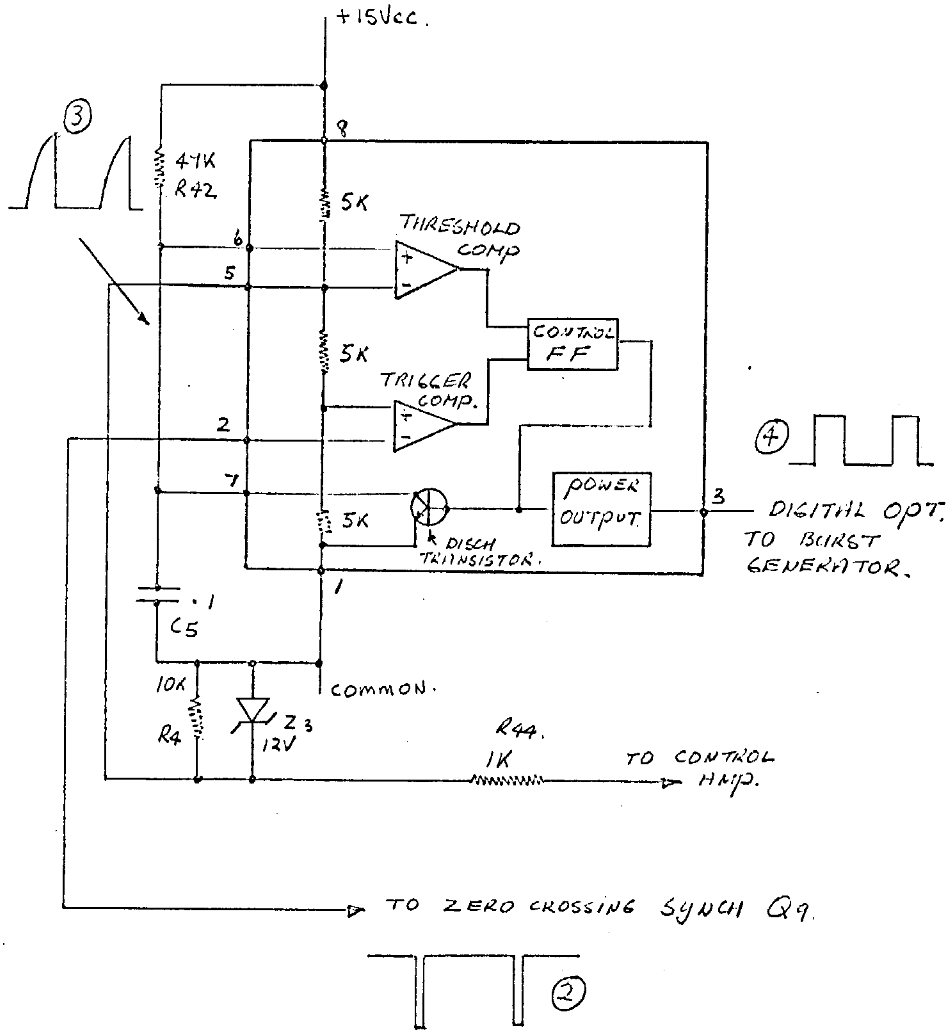
6 Firing Pulse Waveform between Gate and Cathode of SCR1.

7 Firing pulse Waveform between Gate and Cathode of SCR2

8 Diagram showing Conduction intervals of SCR1 and SCR2 Cross Hatched.

PRE-REGULATOR WAVEFORMS.

FIGURE 18/ 1, 2, 3, 4, 5, 6, 7 and 8.



555 TIMER OPERATION.

FIGURE 19.

(62) Ramp Generator Contd.

The train of pulses appear every half cycle of the AC input wave, each burst terminates at the end of each half cycle and the beginning of the ramp. The burst is retriggered at the termination of the ramp this point being set by the control voltage. The burst pulses are amplified by triggered amplifiers Q2 and Q3 and fed via trigger transformers to the gate/cathode electrodes of SCR1 and SCR2.

Note that the firing of each thyristor coincides with the first pulse in each burst train and not with the trailing edge of the digital output pulse Fig 18/4. The arrival of the first pulse output of Q4 is delayed after initiation of Q4 by the charge time constant of R37 C4. However the delay is constant and does not affect the operation of the system.

Note, during the period after each thyristor fires gate current results in a voltage DC pedestal with the tips of the remaining pulses in the burst sitting up on the pedestal.

The pedestal extends beyond the zero crossing point but the thyristor ceases conduction once its anode voltage goes negative.

(63) Voltage Control

The control voltage for the ramp is obtained from the output of a differential amplifier type LM324, this integrated circuit contains four operational amplifiers but only one is used in the pre-regulator.

The + non inverting input of this amplifier is connected to the output of the pre-regulator filter capacitor point A via a voltage divider R7 R6.

The inverting input is supplied with a positive reference voltage from the + 15V supply via voltage divider R47, R48 and the set diff control RV4. The common point of this reference is the output of the series regulator point B.

The output of the difference amplifier varies the conduction angle of SCR1 and SCR2 to produce a voltage at the output of the pre-regulator which reduces the difference between the amplifier inputs to zero.

Thus by adjusting the reference voltage at the inverting input -, of theamplifier by setting RV4, the output voltage of the differential amplifier will alter the conduction of the SCR's to readjust voltage at point B to bring the system back into balance.

RV4 is set to produce a constant drop of 6V across the series pass regulator.

Thus if the output of the power s pply is loaded, the series regulator control will increase the conduction of the pass transistor. The resistance of the series regulator will decrease reducing the voltage drop across A & B, this will momentarily unbalance the inputs to the pre-regulator control amplifier, its output voltage will shift to increase the conduction time of SCR1 and 2 causing the voltage at point A to increase to take up the load.

P6 40

(64) Pre-Regulator Protection and Stabilisation

Certain components are added to protect the pre-regulator difference amplifier inputs.

Resistors R46 R47 buffer the inputs, CR11 conducts if the non inverting input voltage is suddenly shut off, and prevents excessive difference voltage damaging the amplifier.

Zener diode Z3 prevents the output of the difference amplifier driving the 555 timer beyond its control range. This can produce abnormal operation of the 555 Timer, resulting in full conduction of the SCR's and a high uncontrollable voltage at the output filter capacitors.

Under AC mains operation the pre-regulator control is not driven into this area of operation. However a high impedance AC supply such as a field generator has been found to produce this condition due to its slow regulation speed, when a DC power supply is switch on.

The pre-regulator control system is basically a servo-loop, the choke inductance and filter capacitance forms a long time constant circuit. When the power supply is unloaded, the L C time constant is only lightly damped and the circuit could oscillate. The 100 Ohm. bleed resistors across the filter capacitors prevent this, however hunting can occur in the feedback loop due to the inability of the output to rapidly follow a fast control signal from the control amplifier.

The control speed of the differential amplifier is slowed down to match the time constant of the filter system by use of a lag capacitor C7 between output and inverting input of the difference amplifier.

The value of capacitance is chosen to allow a slight degree of hunting or oscillation as this produces the fastest pre-regulator response speed.

This hunting may be observed by connecting an oscilloscope across the main filter capacitor and observing the ripple waveform has a low frequency oscillation superimposed.

(65) Series Regulator Circuit Operation Constant Voltag
The series regulator accepts the coarse DC regulated high ripple ie up to 1V pk/pk output of the relatively slow responding pre-regulator and processes it to a precision regulated, very low ripple fast reponse DC output.

Figure 20 shows the basic feedback principal used. The AC input after passing through a power transformer is rectified and filtered. By feedback action the series regulator transistor alters its voltage drop to keep the regulated DC output voltage constant in spite of changes in unregulated DC, the load and the disturbances.

The comparison amplifier continuously monitors the difference between the voltage across the voltage control Rp and the output voltage Eo. If these voltages are not equal, the comparison amplifier produces an amplified difference (error) signal. This signal is of such a magnitude and polarity as to change the conduction of the series regulator, thereby changing the current through the load resistor until the output voltage equals the voltage Ep across the voltage control.

Since the net difference between the two voltage inputs to the comparison amplifier is kept at zero by feedback action the voltage across resistor Rr is kept equal to the reference voltage Er. Thus the programming current Ip flowing through Rr is constant and equal to Er/Rr.

The input impedance of the comparison amplifier is very high, so essentially all of the current Ip flows through Rr and Rg. Because Ip is constant, Ep and hence the output voltage is variable and directly proportional to Rp.

As shown in Fig 20 the input reference voltage Er is connected to the summing point S via resistor Rr and the output voltage is fed back to this same summing point through resistor Rp since the input impedance is very high all the current Ip flows through Rr Rp.

As a result:

$$I_p = \frac{E_r - E_s}{R_r} = \frac{E_s - E_o}{R_p} \qquad (1)$$

As the series regulator transistor is connected as a unity gain emitter follower the output of the comparison amplifier is Eo.

Then multiplying both sides by Rr Rp, we obtain :

$$E_r R_p = E_s R_p + E_s R_r - E_o R_r \qquad (2)$$

Fig20 yields a second equation relating the amplifier output to its gain and voltage input :

$$E_o = E_s \, (-A) \qquad (3)$$

which when substituted in equ (2) and solved for Es yields :

$$E_s = \frac{E_r \; E_p}{R_p + R_r \, (1+A)} \qquad (4)$$

Normally the loop gain is very high, in excess of 10,000

$$\text{Let} \quad A \rightarrow \infty \qquad \text{Then} \quad E_s = 0 \qquad (5)$$

p642

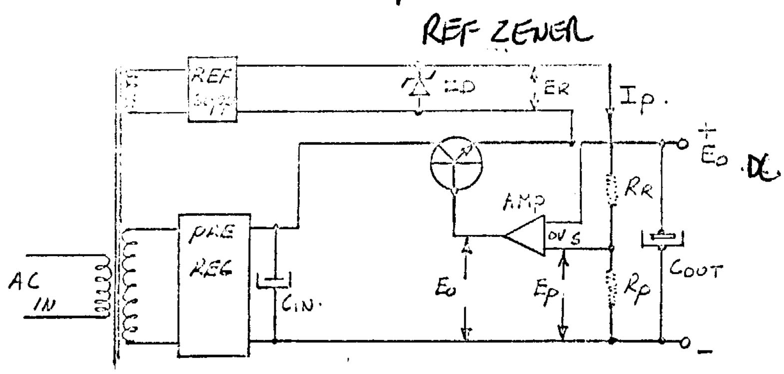


FIG 20 CONSTANT VOLTAGE REGULATOR

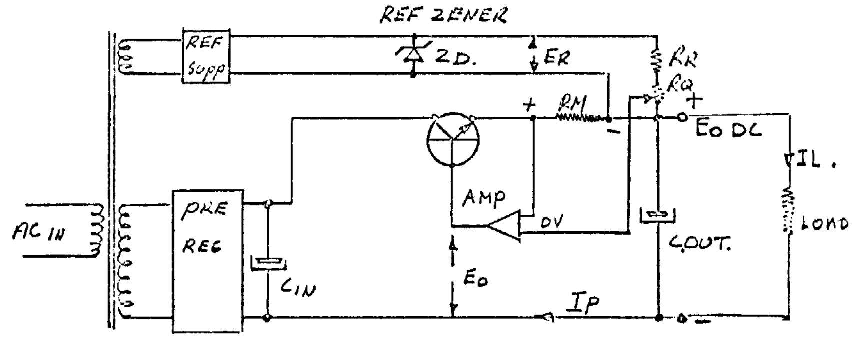


FIG 21 CONSTANT CURRENT REGULATOR

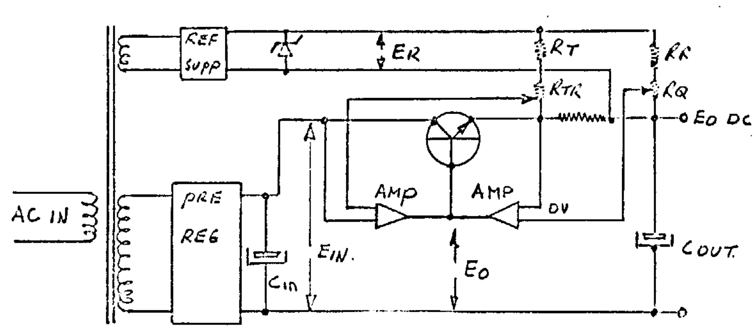


FIG 22 OVERLOAD TRIP PROTECTOR

pG 43

This important result means that the two input voltage of the comparison amplifier are held equal by feedback action In practice Es is at most a few millivolts.

Subst $E_s = 0$ into Equ (1)

$$E_o = E_r \frac{R_p}{R_r} \qquad (6)$$

This is the well known gain equation for an operational amplifier.

An output capacitor Cout is placed across the output terminals of the supply to reduce the AC output impedance to a very low value. Thus the phase shift through the output terminals is independent of the phase angle of the applied load. This assures feedback stability and prevents power supply oscillation on reactive loads.

(66) Series Regulated Power Supply Constant Current Limit

Fig 21 illistrates the elements of a constant current power supply. Many of these elements are similar to those in section (65). The feedback loop acts continuously to keep the two inputs to the comparison amplifier equal. The inputs are the voltage drop across Rr Rq tapped from the slider of Rq, and the Ir drop developed by the load current I1 flowing through the current monitoring resistor Rm. If the two voltages are momentarily unequal, then the comparison amplifier output changes the conduction of the series regulator, which in turn corrects the load current and voltage drop across Rm until the error voltage at the comparison amplifier input is reduced to zero.

Momentary unbalance at the comparison amplifier are caused by adjustment of current control Rq or instaneous output current changes due to external disturbances. Regulator action of the feedback loop will increase or decrease the load current until the change is corrected.

The point at which the maximum current is held content is determined by setting current control Rq.

(67) Overload Protection Trip Circuit

Although the circuit of Fig 21 will limit the maximum current to a constant set value in the event of a severe overload or short circuit across the output terminals the series regulator will be subjected to the full input voltage Ein in the event of a short circuit and if IL is set by Rq to near maximum output, the large instantaneous Ein x IL energy appearing across the series regulator could destroy some of the regulator transistors.

A short circuit produces almost zero output voltage across the output, and the pre-regulator starts reducing Ein to maintain the input output differential to within the continuous power dissipation range, however its response speed is too slow to provide this protection at the instance of short circuit.

The shut down amplifier is similar to the constant current regulator. Resistor RTR is adjusted to trip the shut down amplifier when the voltage across the series regulator exceeds approx. 15V. This would occur on a short circuit. The ampliifer switches low in about 3 micro-seconds and shuts off the series regulator completely.

Assuming the short circuit is still maintained, the pre-regulator winds its output down to maintain the differential. When Ein falls below the trip setting of the shut down amplfier, the amplifier output

(67) Overload Protection Trip Circuit Contd.

switches high, allowing the series regulator to conduct, however this action produces a dip and surge up in the pre-regulator output which forces the differential momentarily above the trip level again, inducing another shut down.

Thus as long as the overload or short circuit is connected the shut off and attempt to restart action will continue.

This is indicated by the flashing of the overload LED.

(68) Trip Level Adjustment

If the trip level is set lower than approx. 15V, protection is further improved however false tripping may occur on momentary overloads such as when transmitters are switched on. A low trip level can cause the output to latch off when the power supply is switched on with a load connected.

The trip control RV3 is set to about ½ way, this gives adequate protection without annoying latch offs.

(69) General Series Regulator Circuit Description

Sections (65) to (68) fully covers the theoretical principals and it is only necessary to fill in the details Fig 23.

(70) Voltage Adjustment Switch

From equation (6) of section (65) it can be seen that if the ratio $\frac{Er}{Rr}$ is constant, the output voltage of the power supply is directly proportional to Rp.

The constant is adjusted by fine trimming the cal trimmer RV1 to give a programming ratio of exactly 1000 Ohms per volt, hence the resistors in the chain R1 to R9 in Fig 13 add up to 32,000 Ohms to give the maximum output of 32V DC for the power supply.

(71) Auxiliary Voltage Supplies Fig 23

The centre tapped secondary of the auxiliary supplies a bridge rectifier giving both positive and negative supply rails see section (60) for description. Diode CR12 blocks off filter capacitor C3 from the ripple source required to supply the zero crossing detector Q9.

Reference diode 73 is actually a precision voltage gap band reference integrated circuit type LM336Z. Tp3 pin is covered by a sleeve to prevent the output of Z3 shorting against one pin of control RV4.

Capacitor C9 acts as a filter for the reference Z3 supply and acts as a time constant tpgether with R1 to give a delayed build up of reference voltage output on initial switch on of the power supply.

(72) Series Regulator Transistors

The series pass element consists of eight parallel connected power transistors type 2N3772 mounted four to a heat sink together with a driver transistor for each group. The output emitters of these transistors are paralleled via 8 .08 Ohm resistors which force equal sharing of the load current.

A pre-driver transistor is mounted below the printed circuit board socket.

All power transistors plug into sockets.

pb 45

(73) Constant Voltage Regulator Fig 23

Ic (b) of the quad operational amplifier is a constant voltage comparison amplifier. This integrated circuit incorporates internal output short circuit protection and phase compensation. The control output of IC (b) is fed to the first current driver transistor Q1 via a diode or gate CR3, the cathode of which is held high by R27. CR3 conducts into IC (b) output under normal constant voltage operation. The regulator works as described in section (65).

Thus the inverting input is connected to the positive output via R48. The non inverting input goes via R18 to the summing point socket terminal (17). The reference resistor consists of RV1 and R15 while the programming resistors are in the voltage selector assembly.

Diodes CR4 CR5 together with R48, R18 protect the input circuit of the amplifier under condition of short circuit of the power supply output, transients, etc.

Capacitor C6 gives some additional roll off in the high frequency response of the amplifier to prevent parasitic oscillation in the regulator.

(74) Constant Current Regulator Fig 23

IC (c) of the quad operational amplifier is the constant current comparison amplifier.

A diode OR gate CR6 feeds the output of Ic (c) to the current driver Q1.

The regulator works as described in section (66). Thus the inverting input is connected to the + input of the .004 Ohm current sensing resistor via R16. The non inverting input is fed to the slider of the set current limit control via R17. R13 supplies reference voltage to one end of the current limit control via socket pin 21.

When the power supply is operating constant voltage, the output of IC (c) is high and Or diode CR6 will not conduct, and the power supply is under the control of voltage regulator IC (b).

When current limit occurs IC (c) output goes low, CR6 conducts and the power supply is under current regulator control.

Components R16 R17 CR8/9 protect the input to IC(c). Capacitor C10 prevents oscillations in IC (c) when it switches to current mode.

(75) Overload Trip Circuit Fig 23

IC (a) of the quad package is the trip amplifier, only portion of the pre-regulator output is fed to the inverting input via voltage divider R11 R12. Note R10 and R11 are high value resistors, necessary to protect the - input of IC (a) against the high voltage change incurred when the power supply output is shorted.

The reference for this circuit is obtained from the + 15V supply rather than the 2.4 volt reference as the + 15V is instantly available on switch on, and may be needed for circuit activation, should the power supply be switched on into a short circuit.

IC (a) is operated at very high gain to increase its speed and sensitivity, hence its output is noisy. To prevent this noise from feeding into the base of Q1 two diodes CR7/CR10 are used in series as an OR gate to give better isolation of noise pulses.