TWIN POWER SUPPLY

By G. S. SCHAJER

THE USE of integrated circuits has made it possible to make a high quality regulated supply incorporating a current limit facility using a surprisingly small number of components. Since the supplies are so simple and inexpensive, a twin power supply unit is a practical possibility, and is extremely useful especially in development work.

The current limit facility is one which is not found except in the most expensive power supply units, and it will be found to be extremely useful—sometimes in rather unexpected ways. Apart from its use as an overload protection and as a constant current source, the author has found it to be an excellent way of testing Zener diodes!

The current limit facility is nearly as accurate as the voltage regulator and, if required, the unit may be used as a constant current source.

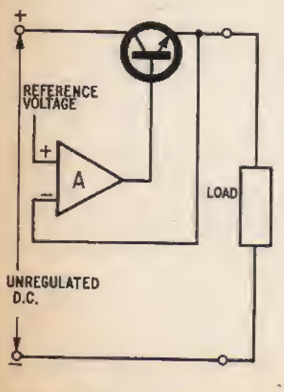


Fig. 1. The basic voltage regulator circuit

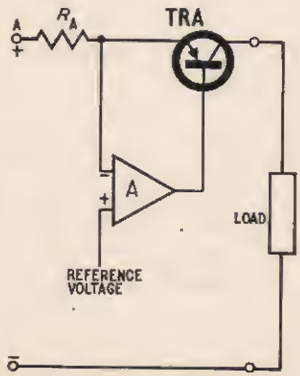


Fig. 2. The basic current limiting circuit

CIRCUIT DESCRIPTION

The integrated circuits used are the 741 operational amplifiers (op amps) which are cheap and readily available. The operational amplifier differs from the ordinary amplifier in as much as that it has two inputs, an inverting one (marked with a minus sign) and a non-inverting one (marked with a plus sign).

If there is a small difference between the voltages applied to these inputs, the output will change according to the magnitude and polarity of the difference. The op amp may therefore be used as a difference amplifier. This is the case in the circuit shown in Fig. 1, which shows a voltage follower circuit.

The output of the op amp is controlling a transistor in the supply rail of an unregulated supply. It is comparing a reference voltage and the output voltage and amplifying the difference. If the output voltage falls, the input to the transistor is increased, tending to restore the output to its original value. Similarly an increase in output will cause less current to the transistor base and thus decrease the output.

Since the op amp has a very high gain, the input need only change by a small amount for it to produce a substantial restorative action. The output thus follows the reference voltage with a high degree of accuracy.

CURRENT LIMITING

Fig. 2 shows a basic current limiting circuit. It functions in exactly the same way as the voltage regulator except that instead of the output voltage, the voltage drop across R_A (and thus the current) is compared with the reference.

The current at which the circuit limits is dependent on the reference voltage and the value of the resistor according to the relationship:

$$\text{Current limit} = \frac{\text{Reference Voltage}}{R_A}$$

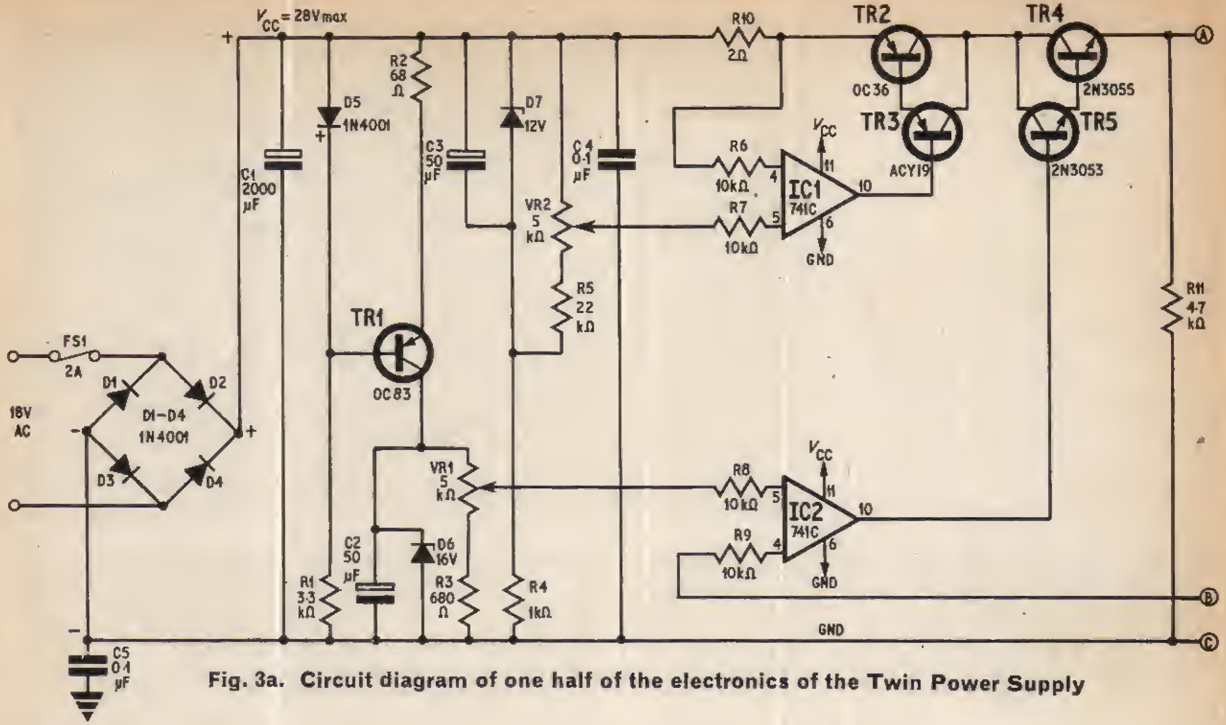


Fig. 3a. Circuit diagram of one half of the electronics of the Twin Power Supply

SPECIFICATION	
Two identical supplies with complete isolation	
Fully variable output voltage	2 to 15V
Fully variable current limit	35mA to 1A
Ripple at 15V, 1A	0·4mV
Voltage regulation	0·1%

If the circuit is operated in the region of current limiting it makes a good constant current source. Its accuracy is nearly as good as that of the voltage follower. The slight deterioration is due to the thermal instability of the resistor.

FULL CIRCUIT DIAGRAM

The voltage follower and the current source may be used together as shown in the full circuit diagram, Fig. 3a. The reference voltages are made adjustable so that the output voltage and the current limit may be adjusted.

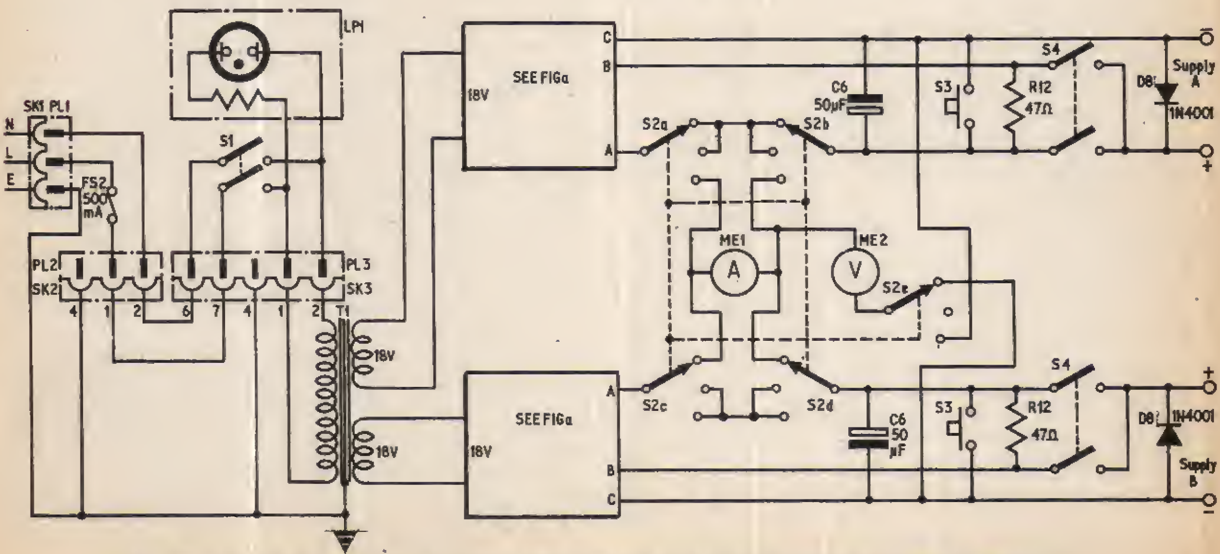


Fig. 3b. Mains input and switching arrangement for the complete Twin Power Supply

COMPONENTS . . .

Resistors
R1 3·3kΩ
R2 68Ω
R3 680Ω
R4 1kΩ
R5 22kΩ
R6–R9 10kΩ (4 off)
R10 2Ω 10W wirewound
R11 4·7kΩ
R12 47Ω
All ±10% ¼W carbon except R10

Potentiometers
VR1 5kΩ linear
VR2 5kΩ linear

Capacitors
C1 2,000μF 50V elect.
C2 50μF 25V elect.
C3 50μF 15V elect.
C4 0·1μF 250V polyester
C5 0·1μF 250V polyester
C6 50μF 25V elect.

Integrated Circuits
IC1, IC2 741C (2 off)

Transistors
TR1 OC83
TR2 OC36
TR3 ACY19
TR4 2N3055
TR5 2N3053

Diodes
D1–4 1N4001 (4 off) *or* 2A bridge rectifier
D5 1N4001
D6 16V 400mW Zener
D7 12V 400mW Zener
D8 1N4001

Switches
S1 D.P.D.T. mains toggle
S2 5 pole 3 way, make before break, rotary wafer
S3 Push to make release to break, pushbutton
S4 D.P.D.T. toggle

All the above components are for one half of the Twin Power Supply except S1 and S2, only one each of these being required

Miscellaneous
T1 Douglas MT127 0–24–30–40–48–60V 2A
ME1 1A f.s.d. 3in meter
ME2 20V f.s.d. 3in meter (or 15V if available)
PL1, SK1 Bulgin P360 mains plug and socket
PL2, SK2 B7G plug and socket
PL3, SK3 B7G plug and socket
LP1 Mains neon with integral resistor
FS1 2A fuse and holder (2 off)
FS2 500mA fuse and holder
Terminals (4 off)
0·15in matrix edge connectors and Veroboard (optional)
Case, plastic feet, paxolin panel, Veroboard, printed circuit board, power transistor insulating set (4 off)

A germanium transistor (TR1) biased by a silicon diode (D5) is used as a constant current source to feed a Zener diode (D6) thus giving a very stable reference voltage. Since the output voltage cannot be taken below 2V a resistor, R3, is connected in series with the potentiometer VR1 to make the minimum reference voltage also 2V.

The current limit reference Zener diode (D7) does not need similar stabilisation as it only operates when the load current is constant and hence the rail voltage is not changing. A maximum of 2V is required for this voltage and this is obtained from a 12V Zener (D7) and a resistor R5 in series with VR2 to produce the required voltage at the potentiometer wiper.

The outputs of the op amps do not run directly to the output transistors but via driver transistors in the super alpha pair configuration. This prevents overloading of the op amp output which can only supply 25mA. The 741 has indefinite short circuit protection which is comforting during testing.

Under extreme conditions one or other of the output transistors is dissipating nearly the full power input of the supply from the transformer, i.e. about 20W. The need for heatsinking is obvious and should be taken into account when deciding the output power required.

OUTPUT VOLTAGE MONITORING

The connection from the inverting input of IC2 is connected directly to S4 (Fig. 3b) so that the voltage drop in meters, switches and wiring does not affect the regulation of the supply. When S4 is closed the input to the op amp is connected to the output terminal and so any voltage drop across the switch due to contact resistance will similarly not affect the regulation.

When the switch is off the supply is disconnected from the output but the high impedance op amp input is still connected to the supply by R12. This enables the supply to operate so that the voltage and current limit may be set when S4 is off. The current limit set switch S3 is independent of S4.

A reverse biased diode D8 is connected across the output terminals to protect the supply from back e.m.f. when disconnecting a reactive load.

Resistor R11 is included so that the supply has a load in the absence of any external load. C6 protects against high frequency oscillation and C5 reduces mains borne interference.

THERMAL EFFECTS

The 2Ω resistor in the current limiting circuit should be a high wattage type to prevent excessive heating which causes resistance variations. A 10W type drifts by about five per cent which is reasonable; a higher wattage should be used for greater stability.

On the prototype the rail voltage off load was 28V. Under no circumstances should this voltage be exceeded by using a higher voltage transformer as this will damage the integrated circuit. On a 1A load the rail voltage drops to 21V.

Meters are provided to measure the voltage and current output of the two supplies. It is possible to switch them from one supply to the other, but without breaking the continuity of either supply, and yet maintaining the isolation between the supplies.

The circuit shows the switching arrangement required. A five pole, three way, make before break switch is used. The centre position is "off". A make-before-break switch is essential, otherwise there will be a break in continuity during switching.

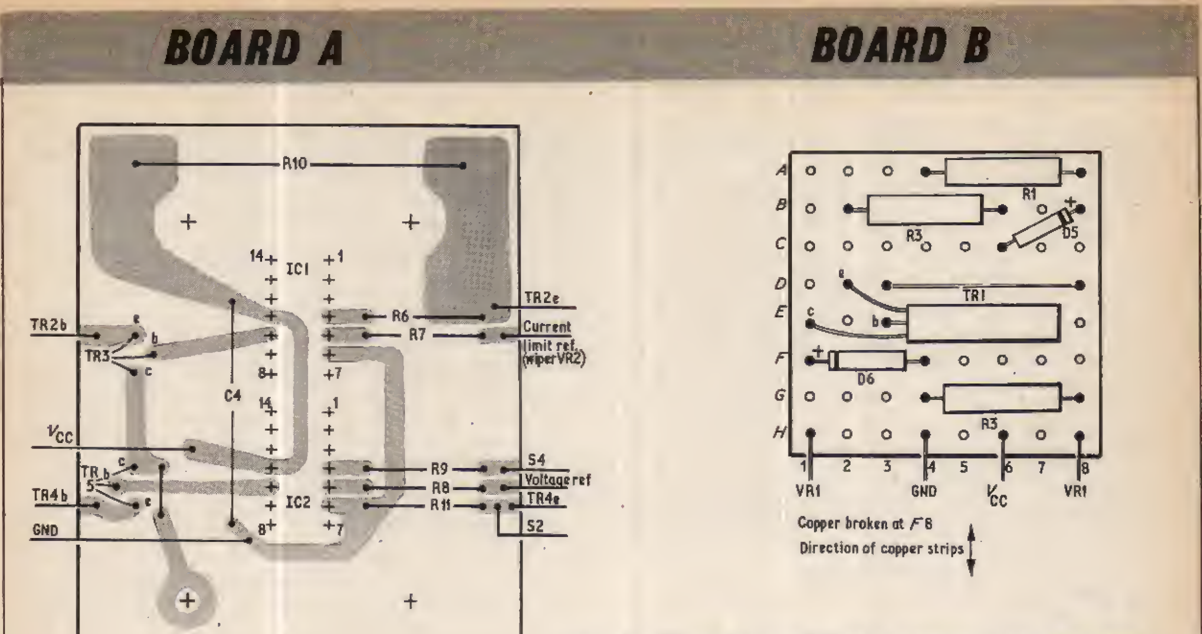


Fig. 4. Printed circuit board carrying the integrated circuits and associated components shown full size from copper side. Also shown is the Veroboard carrying the Zener diode circuit

CONSTRUCTION

The method of construction is a matter of personal choice, dictated to some extent by the materials available. Some thought should be put into planning the layout of the components and a little extra care when making up the unit is well worth the effort.

Some details are given of the construction of the prototype, together with some of the points to remember when building the supply. They are given merely as a guide and need not be adhered to rigidly.

The integrated circuits and associated components are mounted on a printed circuit board which is shown in Fig. 4. The two rows of holes for the i.c.s are easily drilled by clamping a small piece of Veroboard (0·1in matrix) to the printed circuit board and using its holes as a template. Holders for the i.c.s may be used if desired.

The Zener diodes and associated components are mounted on the front panel, attached to the tags of the potentiometers. The stabilisation circuitry for the Zener diode D6 is made on a small piece of Veroboard (0·15in matrix) which is mounted on the back of VR1 by means of its connecting wires. If the potentiometer has a metal case steps should be taken to prevent the Veroboard shorting.

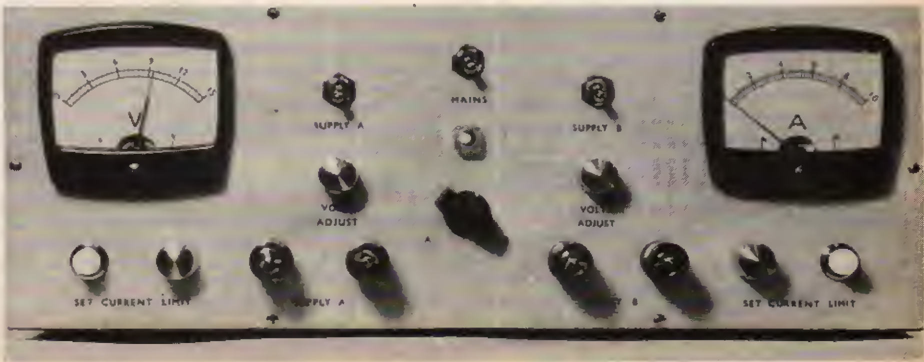
The layout of the front panel is shown in the photograph (Fig. 8). This was made from a piece of white Perspex $\frac{3}{16}$in thick. Detailed drilling details are not given as some of the components will vary according to availability. The meters shown are not generally available but SEW series 65 meters are a suitable type to use.

It is a good idea to connect the spindles of potentiometers VR1 and VR2 to the negative rails of the supplies as this reduces hum pickup. Use thick wire for the current carrying sections of the supply to reduce heating effects.

TRANSFORMER

The power is supplied by a single transformer with two isolated 18V, 2A secondary windings. This is not

Photograph of the completed Twin Power Supply



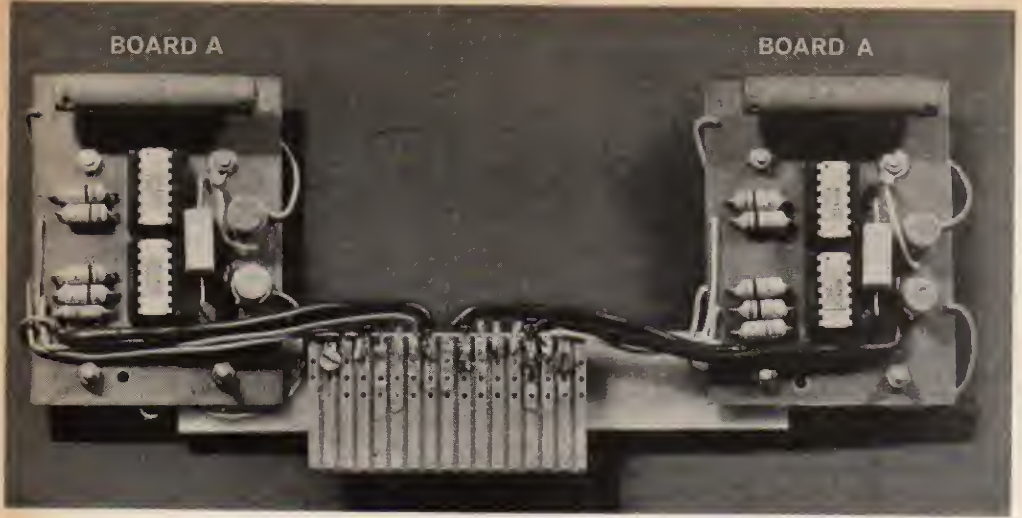


Fig. 5. Layout of the components on the back panel. Details of board A are given in Fig. 4. TR2 and TR4 are mounted under the boards on the panel

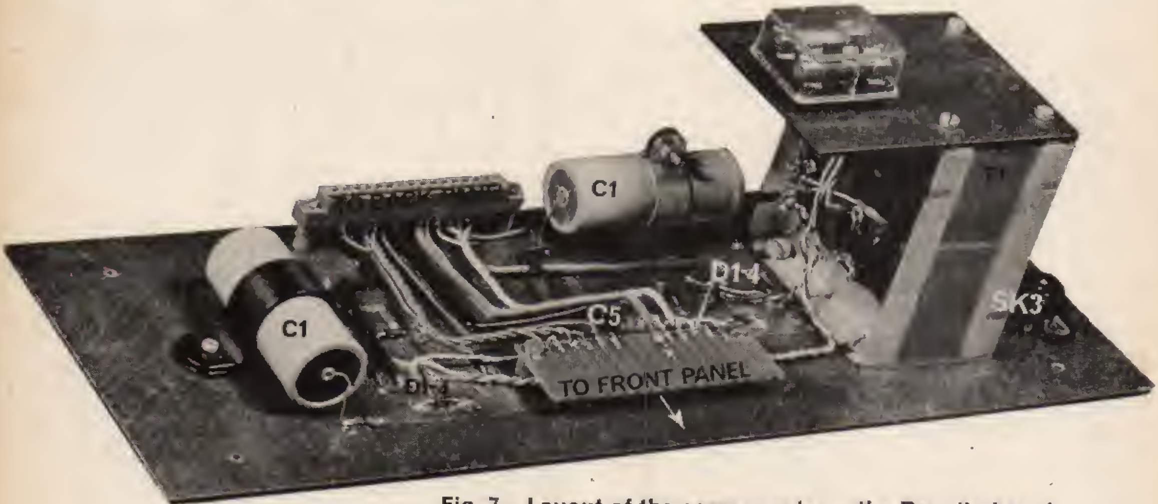


Fig. 7. Layout of the components on the Paxolin board

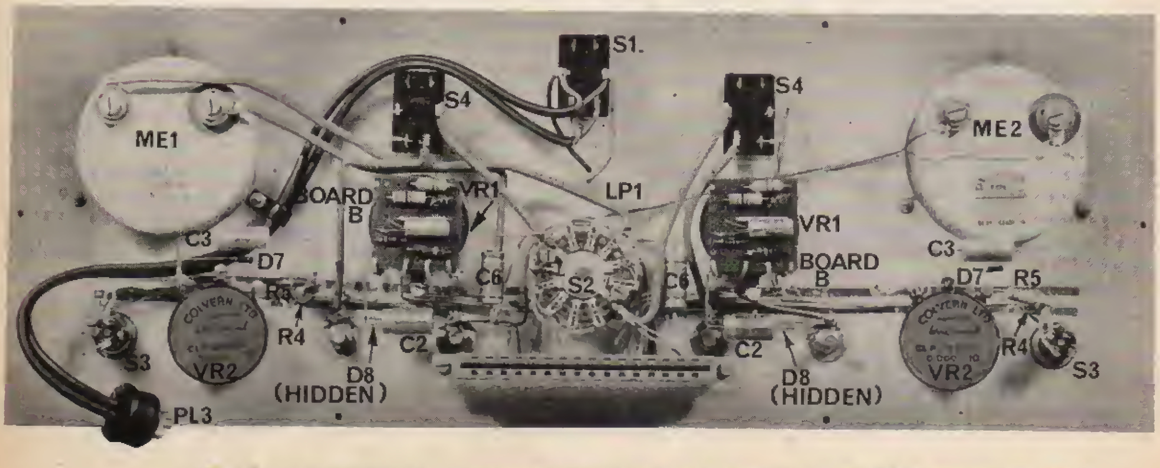


Fig. 8. Layout of the components on the front panel. Board B is shown in Fig. 4

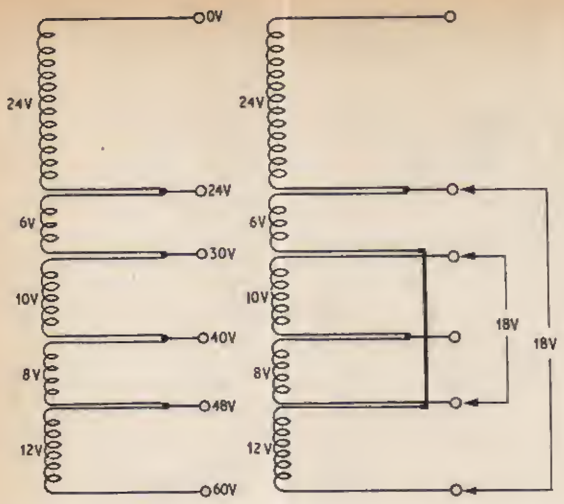


Fig. 6. Diagram showing modification to the Douglas MT127 transformer

available in this form but a simple modification to a Douglas MT127 will give the required result. The MT127 has taps at 0–24–30–40–48–60 volts and these are connected to tags.

The connections to the tags marked 30V and 48V should be carefully unsoldered and the end of the 30V winding should be connected to the beginning of the 48V winding. This is shown diagrammatically in Fig. 6.

One 18V supply is available at the tags of the 30V and 48V and the other at the tags of 24V and 60V. Check that the correct windings are being used with a continuity meter and make sure that there is complete isolation between the two windings. Alternatively two 18V, 2A transformers may be used.

PAXOLIN PANEL

The transformer, rectifiers and capacitors are mounted on a Paxolin panel which fits into the bottom of the case, Fig. 7. Discrete diodes soldered to squares of stick-down copper sheet form the bridge rectifiers but it is probably more convenient to use a ready-made 2A bridge.

The back panel is a piece of 14 s.w.g. aluminium painted matt black and this acts as a heatsink for the four power transistors, Fig. 5. The p.c.b.s carrying the i.c.s are also mounted on this panel. Mica washers to insulate the transistors as well as plastic bushes on the bolts should be used to ensure that the transistors do not make contact with the panel.

On the prototype, both the front and back panels were made removable by using offcuts of Veroboard and edge connectors to form plugs and sockets. The mains input is kept completely separate by using B7G plugs and sockets to make the connections between the front and back panels of the transformer.

TESTING THE SUPPLY

Should the supply not function check the reference voltages as any fault here will be reflected in the output. If they are alright then the fault must lie in the op amps or associated components. ★