K 3210

ALTRONICS COMPONENTS

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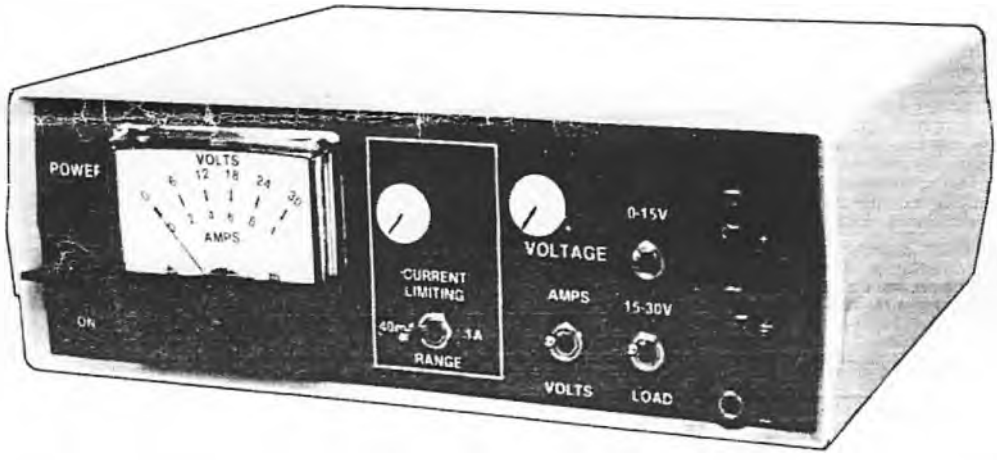
Dealers Throughout Australia

30V/1A Benchtop Power Supply
With Current Limiting



This 30V/1A power supply features variable output voltage from 3 to 30V, variable current limiting over two ranges, overload protection and switchable voltage/current metering.

SPECIFICATIONS — 30V/1A SUPPLY	
Output voltage	3-30V variable over two ranges 0-15V and 15-30V
Output current	0-1A up to 27V (see load curves) with variable current limiting
Load regulation	Better than 0.2% from zero to full load
Output ripple	Less than 2mV RMS at full load

With this power supply, you get superior specifications for very little extra money. This unit is capable of providing a full 1A output over virtually the entire voltage range. Other kit designs currently on the market provide a 1A output over only part of their voltage range due to inherent thermal limitations.

Other features of this new design include load switching, power on/off indication, and the provision of a separate ground terminal. There are two ranges for current limit plus two voltage ranges, all selected by means of toggle switches. The current limit ranges are 0.15-0.4A and 0.4-1A, while the voltage ranges are (nominally) 0-15V and 15-30V.

In practice, the current limit and voltage ranges overlap slightly to ensure continuity.

Current Limiting

The adjustable current limiting facility is particularly useful. It offers two main advantages: first, it protects the supply in the event that the output is shortcircuited; second, it protects any circuitry run from the supply from damage by excessive current due to a fault condition. There's nothing worse than having circuitry go up in smoke while you're trying to troubleshoot a tricky problem.

We elected to use a single meter and switch between voltage and current measurements.

The accompanying graph and the specification panel document the performance of the prototype. As can be seen, the load regulation is better than 0.2% from zero to full load while the output ripple is less than 2mV RMS. The maximum load current is maintained at 1A right up to 27V output, after which the load curve falls away due to transformer losses.

Design Considerations

Fig.1 shows the internal workings of the 723 regulator. It consists of a series pass transistor, an error amplifier and a voltage reference source. The error amplifier compares a proportion of the output voltage with the internal reference voltage source and continually adjusts the base current to the series pass transistor to provide a regulated output.

The maximum current rating of the series pass transistor is 150mA, so some form of external current amplification is required to provide a reliable 1A supply.

One particularly attractive feature of the 723 is the in-built current limiting cuircitry. When the output current reaches a preset value, the internal current-limit transistor turns on and reduces the base drive to the series pass device.

Thus, we have voltage regulation and current limiting circuitry all on the one IC. This simplifies the circuit design and, at the same time, avoids the thermal limiting problems of the LM317.

Circuit Details

Refer now to the main circuit diagram. The supply uses a 1A mains transformer with a multi-tapped secondary to drive a bridge rectifier (D1-D4) and two 2500uF filter capacitors. This provides a no-load voltage of either 37V or 47V, depending upon the transformer tap selected. This unregulated DC is fed to a pre-regulator stage (Q1) and to the output stage (Q2).

LED D5 and its associated 2.2K Ohm current limiting resistor provide power on/off indication. While the current through the LED will vary slightly according to the transformer tap selected, this is of no consequence.

Q1 and its associated 33V zener (D6) ensure that the maximum 40V supply rating of the 723 (IC1) is not exceeded. D6 clamps the voltage on Q1's base to 33V, thereby limiting the supply voltage to IC1 to about 32.3V. Bias for Q1 and D6 is provided by the 470 Ohm 1/2W resistor.

The series pass transistor in the 723 regulator drives voltage follower Q2 which provides the necessary current amplification. Q2 is a TIP3055 NPN power transistor with a maximum collector current trating of 15V and a Vce rating of 70V, which is more than adequate for the job at hand.

Unfortunately, having set the input voltage on Q2's collector to obtain a maximum 30V output, there is a potential dissipation problem when drawing high current at low volage. This problem was overcome by switching the secondary winding of the transformer.

Thus, for output voltages above 15V, S2a selects the 30V tap on the transformer. For outputs less than 15V, the 24V tap is selected to reduce the dissipation in Q2.

Voltage Regulation

Let's now take a look at how the voltage regulator works.

The error amplifier in the 723 is connected as a non-inverting amplifier with variable gain. The input to this amplifier is fixed at about 2.8V by the potential divider formed by the 1.8k Ohm and 1.2k Ohm resistor. The input to this divider is the reference voltage source built into the 723 chip. A 4.7uF capacitor is included to improve the output noise characteristic.

On the 0-15V range, switch 2b is closed, so the feedback resistance (the resistance betweeen the output of the supply and the inverting input of the error amplifier) can be varied between 100 Ohm and 5k Ohm. This corresponds to an amplifier gain of between 1.1 and 6.1, or an output voltage of between 3.1V and 17.4V.

With switch 2b open, the gain of the amplifier is adjustable between 5.8 and 10.8, corresponding to output voltages of between 16.5V and 30.6V.

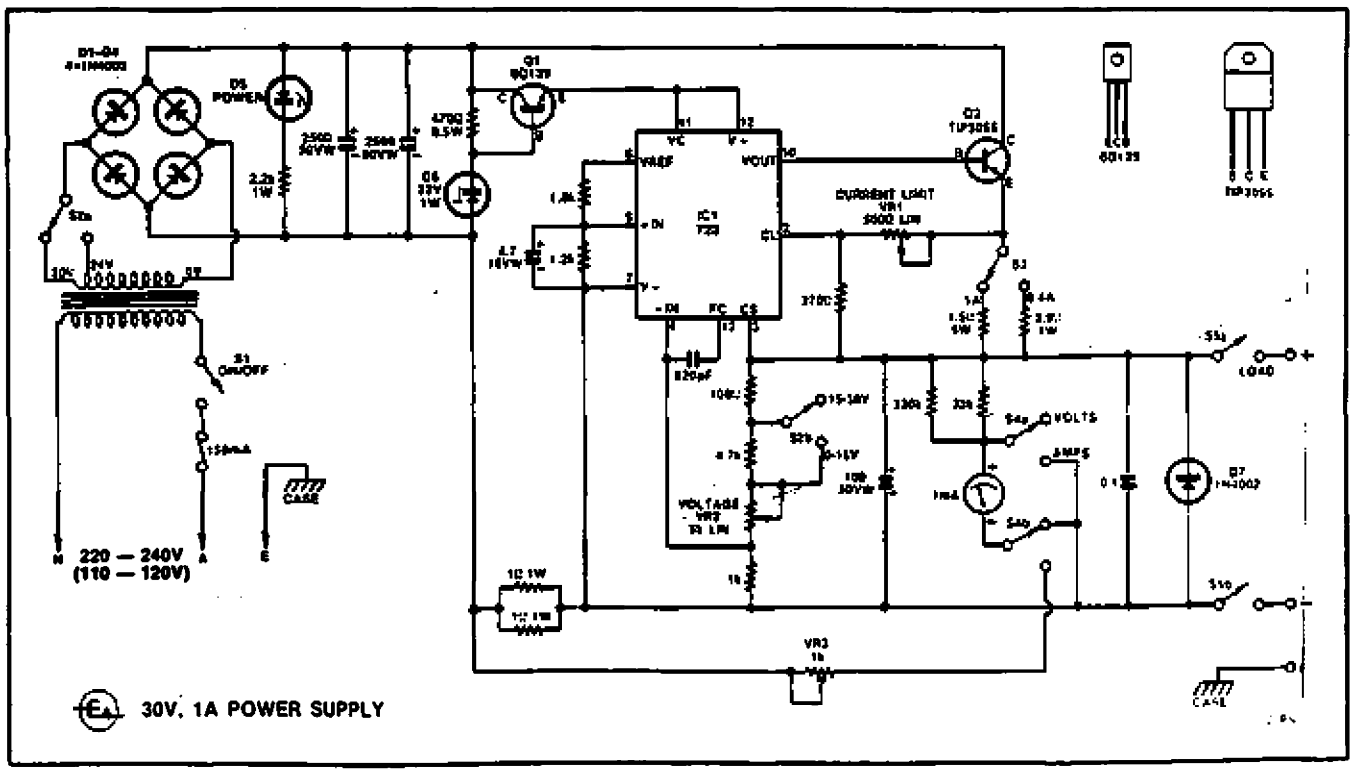
Depending upon the position of S3, the load current from the emitter of Q2 flows through either a 1.5 Ohm or 3.9 Ohm resistor to derive a voltage for the current limit function. The resulting voltage is applied to a potential divider network (VR1 and 270 Ohm in series) and thence to the base of the internal current-limit transistor in the 723.

As we've already seen, the current-limit transistor controls the series pass transistor in the 723 regulator. This, in turn, controls voltage-follower Q2. When the current reaches a preset level, the drive to Q2 is reduced and current limiting takes place.

S5 is the load switch and is used to switch the lines leading to the output terminals. This facility is particularly handy. It allows us to remove the load voltage without having to switch the supply off or adjust the voltage setting.

The 0.1uF capacitor prevents switching transients from being delivered to the output while D7 provides protection in the event that a reverse voltage (eg, from a charged capacitor) is applied to the output terminals. The 100uF capacitor ensures stability of the supply under all conditions.

The metering circuitry is quite straightforward. In the voltage mode, a 30k Ohm resistor formed by the parallel combination of a 330k Ohm and a 33k Ohm resistor is switched in series with a



30V, 1A POWER SUPPLY

1mA meter across the supply. This means that the meter will read 30V full scale. In the current mode, the meter is connected across a 0.5 Ohm resistor (made up from two 1 Ohm resistors connected in parallel) in series with the negative supply line. A 1k Ohm trimpot is used to adjust the meter so that it reads 1A full scale.

Construction

All the circuitry, with the exception of the major hardware items (switches, pots, transformer, etc) is accommodated on a printed circuit board measuring 105 x 111mm and coded 85psl.

No special procedure need be followed when assembling the PC Board although the job will be much easier if the smaller components are installed first. Note carefully the orientation of the diodes, transistors, IC and electrolytic capacitors when they are being installed. Transistors Q1 and Q2 should be mounted at full lead length.

PC stakes are used to terminate all external lead connections.

The major items of hardware can now be positioned in the case. The PC board is secured to four internal mounting posts using self-tapping screws while the power transformer is bolted to the case using machine screws and nuts. Note the solder lug under the nut nearest to the rear panel.

We used medium duty hookup wire (10 x 0.2mm) for all the wiring which carries the full supply current, and light duty hookup wire for the pot, meter and LED wiring.

Heatsinking for the power transistors is provided by the rear panel and by an external multi-finned heatsink. The heatsink used is a standard high-efficiency fan type.

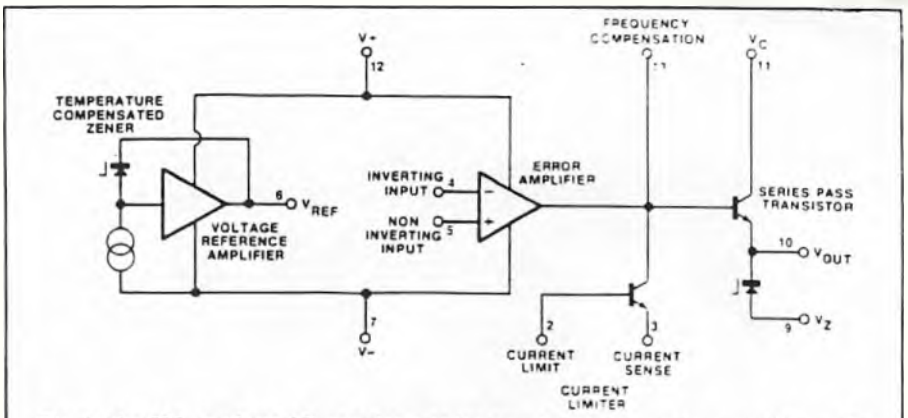


Fig. 1: the 723 regulator IC contains a series pass transistor, an error amplifier and a voltage reference source.

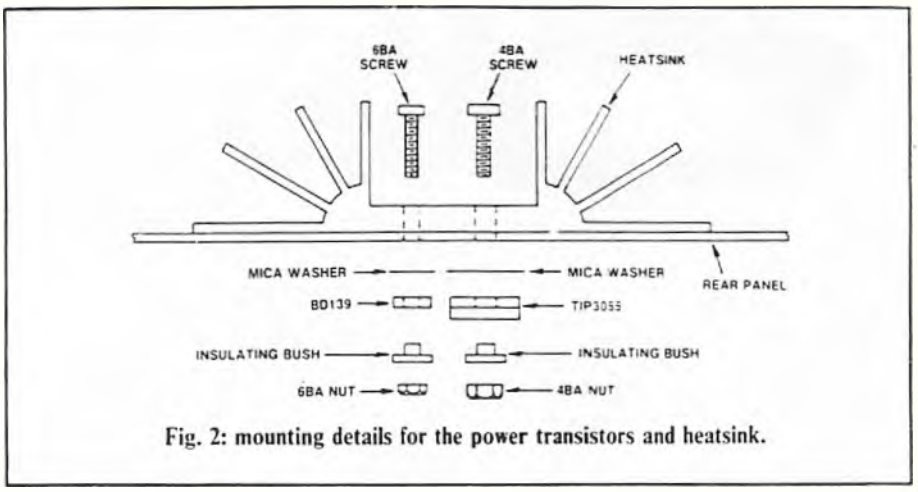
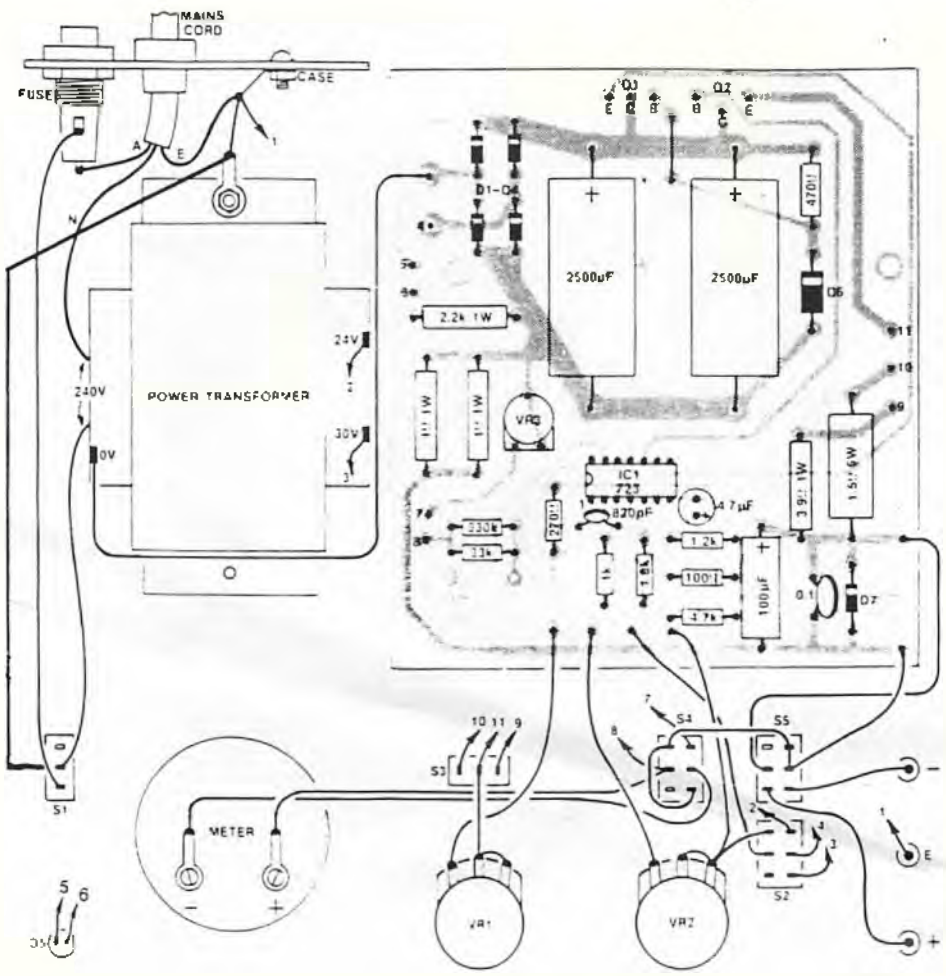


Fig. 2: mounting details for the power transistors and heatsink.

Benchtop power supply



Use medium duty hookup wire (10 x 0.2mm) for all wiring which carries the full supply current (see text). Take care with the orientation of the semiconductors and electrolytic capacitors.

Both transistors must be insulated from the rear panel using mica washers and insulating bushes (see Fig.2). Smear heatsink compound on all mating surfaces (including the rear of the heatsink), then bolt the assembly together using machine screws and nuts. Finally, use your multimeter to check that the metal tag of each device is indeed isolated from the rear panel and the heatsink.

The three-core power flex is anchored to the rear panel using a cord clamp grommet and the active and neutral wires terminated at the fuseholder and power transformer respectively. The mains earth wire should be connected to one of the solder lugs and a separate earth lead run to the rear panel.

We recommend that heat shrinkable tubing be fitted to the fuseholder, transformer and mains switch terminations. This will prevent accidental contact with the mains while the unit is being worked on. Make sure that you use mains-rated hookup wire for the connections to the mains switch.

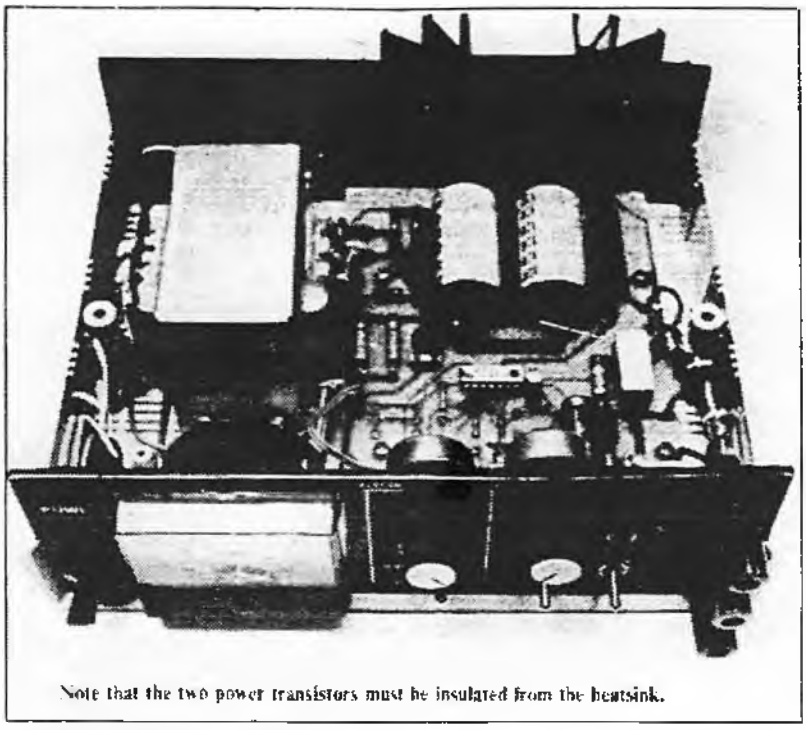
Note that the mains switch must be earthed via the 1/4 inch solder lug supplied and a wire connected to the mains earth point.

Finally, go over your work and make sure that all the wiring is correct. Everything OK? You are now ready for the smoke test!

Setting Up

Connect your multimeter acros the output, switch the supply on and close the load switch. If all is well, the power LED will light and you will be able to vary the output voltage from 3V to 30V using the range switch and the voltage control pot.

Check that the voltage reading on the supply meter and on your multimeter are the same. Note the vacant component position adjacent to the 300k Ohm and 33k Ohm resistors. This will allow you to trim the voltage readings by adding a high value resistor if neccessary.

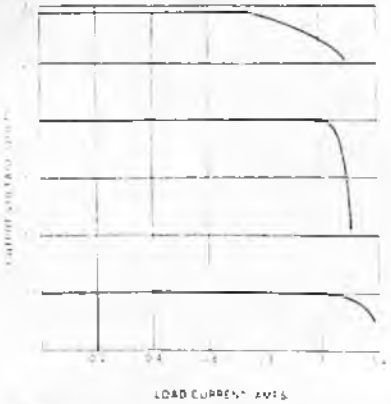


Note that the two power transistors must be insulated from the heatsink.

Assuming that all is well, open the load switch, select the 0-15V range and wind the voltage control fully anticlockwise. Now set the current limiting control to about half way on 1A range, select 1A range on your multimeter and close the load switch.

The multimeter should indicate a current of about half an amp, although the supply's meter will probably show something quite different at this stage (don't forget to switch the meter to "amps"). Adjust the current limiting control so that the multimeter reads 1A, then adjust trimpot VR3 so that the supply's meter reads the same.

Finally, vary the current limiting control and check that the meter reading corresponds closely to that on the multimeter. Your 30V/1A Power Supply is now ready for use.



These load curves plot the performance of the prototype. The maximum load current is maintained at 1A for voltages up to 27V.

Errata Notes

The mounting posts moulded into the case in the vicinity of the Transformer location must be removed to enable the transformer to be bolted firmly to the cabinet base. Use a pair of side or end cutting pliers for this task.

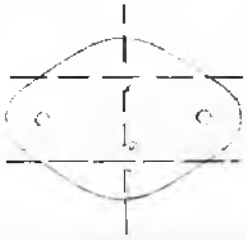
Trimpot

The printed circuit board allows use of either a horizontal type (illustrated in the component overlay) or the more commonly used vertical 10mm type.

Insulating the Output Transistors

Both Q1 and Q2 require electrical insulation from the back panel/heatsink.

A T03 mica washer (supplied) is cut with scissors, along the dotted lines as shown to make two separate mica washers.



PARTS LIST

1 PC board, code 85ps1.105 x 111mm
1 plastic case, 200 x 160 x 70mm (W x D xH), with metal rear panel, Altronics H 0480
1 mains transformer, 30VAC and 24VAC at 1A, Altronic M 6672
1 SPST 240V 2A toggle switch
3 DPDT miniature toggle switches
1 SPDT miniature toggle switch
1 MU45 01mA panel meter
3 binding post terminals: 1 red, 1 black, 1 green
1 mains cord and plug
1 cord clamp grommet
1 fuseholder, panel mount type
1 150mA fuse
1 heatsink, high efficiency fan type, 105 x 58mm
4 solder lugs
15 PC stakes
2 plastic knobs (black)
1 metre mains rated cable
2 metres hookup wire (10 x 0.2mm)
4 stick-on rubber feet

Semiconductors

1 TIP3055 NPN transistor plus mounting hardware (mica washer and insulating bush)
1 BD139 NPN transistor plus mounting hardware
5 1N4002 diodes
1 33V 1W zener diode
1 red LED plus mounting bezel
1 LM723,uA723 voltage regulator IC

Capacitors

2 2500uF 50V axial electrolytics
1 100uF 50V axial electrolytic
1 4.7uF 16V PC electrolytic
1 0.1uF metallised polyester (greencap)
1 820pF ceramic

Resistors (1/4W,5% unles stated)

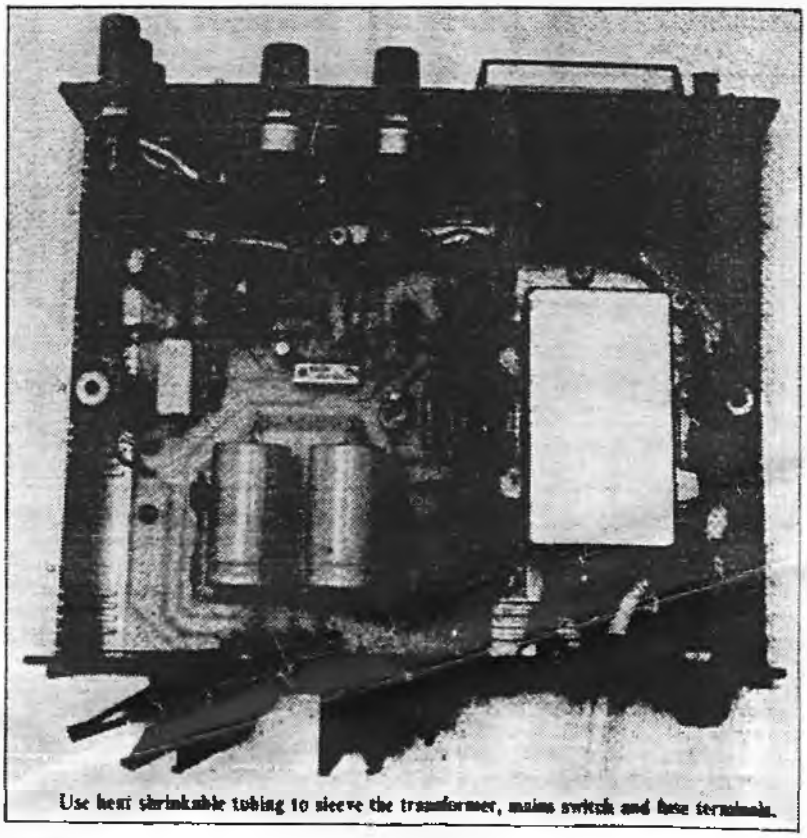
1 x 330k Ohm 1 x 33k Ohm, 1 x 4.7k Ohm, 1 x 2.2k Ohm 1W, 1 x 1.8k Ohm, 1 x 1.2k Ohm, 1 x 1k Ohm, 1 x 470 Ohm 1/2W, 1 x 270 Ohm, 1 x 100 Ohm, 1 x 3.9 Ohm 1W, 1 x 1.5 Ohm 5W, 2 x 1 Ohm 1W.

Potentiometers

1 5k Ohm linear potentiometer
1 1k Ohm miniature horizontal trimpot
1 500 Ohm linear potentiometer

Miscellaneous

Machine screws and nuts, heat shrinkable tubing, cable ties, etc.



Use heat shrinkable tubing to sleeve the transformer, mains switch and fuse terminals.