# Assembly Manual for the

# 30V/1A PROTECTED POWER SUPPLY MK II

## K-3475

Reprinted in part by arrangement with Electronics Today International from the December, 1982 edition.

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***This low cost, easy to build power supply features full protection, variable voltage output from 1.3 to 30 volts, variable current limit from zero to one amp metering of both voltage and current output.***


THE FIRST piece of test gear an electronics enthusiast or technician wants after a good multimeter is a *power supply*. But, exactly *what* does that hypothetical person want, we asked ourselves?

Obviously, a 'laboratory standard' power supply with dual digital metering, programmable voltage and current and nuclear blast proofing was not necessary. Most solid-state circuitry requires voltages between 3 V and 30 V and may require currents up to half an amp or so. Any circuitry run from the supply would need to be protected from damage by excess current should there be a fault in it, so current limiting was necessary. Current limiting also has the advantage of providing protection for the power supply if the output should be short-circuited. So, variable output up to 30 V and variable current limit were two prime goals.

Meters are a relatively expensive item. Assuming the user has a multimeter (you bought that first, remember) then the meter on the power supply only needs to read either voltage or current at any one time. Voltage metering for the supply is an obvious requirement, leaving current to the user's multimeter. But, from experience, you often need an extra meter. Thus, switched metering was desirable. Dual meters are nice, but relatively *expensive*.

## The design

The power supply is built around an LM317 three-terminal voltage regulator. This device, apart from being inexpensive and widely available, has the following desirable features: internal current-limiting (self-protection), thermal shutdown (more self-protection), adjustable output between 1.2 V and 37 V and excellent regulation figures. We elected to use the TO-220 flat pack style as it's easy to mount (one bolt). National and Motorola designate it LM317T. Fairchild have an equivalent designated uA317UC.

The regulator serves two purposes in this design — to provide a regulated voltage reference and thermal overload protection. The output current is supplied by a transistor. We used a TIP32, which also comes in a TO-220 package. This is a pnp device connected here as a 'collector follower'. This sort of circuit provides current amplification, but no voltage gain. The regulator and transistor are mounted side by side on a heatsink. If the output voltage and current limit are set to maximum and a short circuit occurs on the supply's output for a lengthy period, then a considerable amount of power will be dissipated in the transistor. The temperature of the heatsink will rise considerably, but before it can rise destructively, the internal thermal overload circuit of the regulator will operate and limit the maximum dissipation. You'll burn your fingers on the heatsink by the time that happens.

In normal use, at maximum dissipation the heatsink only gets warm to the touch.

Output voltage variation is provided more or less in the normal manner by 'tapping' the 'adj.' terminal across a resistive voltage divider connected across the regulator output (this involves R7 and RV2). Current limiting is provided by an op-amp. This senses the output current and 'short circuits' the voltage applied to the regulator's 'adj.' terminal. The regulator output, and thus the supply output, drops and only the predetermined current flows in the load on the supply output.

### Construction.

☐ Start assembly by carefully laying out and marking up the metal work. Component placement is not critical, but we suggest you keep a strict division between the mains components and the rest of the circuitry and components. Firstly, use the front panel label as a template to mark up the positions of the switches, terminals, pots, etc. Do not attach the label as yet - then drill all the necessary holes.

☐ Likewise mark up the positions of the PC board (you haven't started assembling the PCB yet, right!?) so you can use it as a template. Also mark the positions of the transformer and the MCI connector. Then drill all the holes. The rear panel holds the heatsinks and the mains fuse and a rubber grommet for the mains cord should also be mounted here.

☐ When all holes have been drilled and cleaned for burrs you can attach the front panel label. Firstly peel off the backing paper and carefully smooth the label in place across the panel, making sure it's correctly aligned as you go. You can then cut out the holes with a sharp penknife or modelling scalpel.

☐ Next step is to place the label on the meter scale. Carefully disassemble the meter and attach the label on the original meter scale following the guidelines above. Then trim the edges if necessary and re-assemble the meter taking care not to bend or brake the pointer.

☐ Mount the meter to the front panel first, otherwise you will have great difficulty in reaching the nuts that secure it as they are obscured by other components. You can then proceed to mount the switches, pots, output terminals and LEDs on the front panel.

☐ On the rear panel mount the fuseholder and the mains cable with its rubber grommet and cable clamp, leaving enough of the cable protruding inside the case so that it reaches the terminal block. Next mount the heatsink for the TIP32 transistor and the 317 regulator. Don't forget the mica washers and insulating bushes to avoid shorts. Now check with a multimeter on both the TIP32 and the 317 that the metal tag on each device is not shorted to chassis.

☐ Now you can tackle the PCB. Start by mounting all the PCB pins (23 in all), followed by the resistors. Use the colourcodes and/or the component numbers to identify each resistor. Next you can mount the two trimpots RV3 and RV4 — it is probably best to mount these in such a way that they are easy to get at later, when you have to adjust them.

## HOW IT WORKS — ETI-162

The heart of the project is the LM317 regulator, IC1. This device is used in conjunction with the main 'pass' transistor, Q1. The IC regulator compares the voltage in its output pin with that — on the 'adj.' pin and regulates the output voltage accordingly. The bias for the pass transistor is derived across resistor R3 and is due to the current drawn by the IC regulator. If the 317 detects excess voltage, for example, on its output pin, it decreases the current pulled through R3, hence decreasing the bias to Q1. In this way the 317 controls the ouput voltage and ensures good regulation for the output.

The control voltage for the 317 is derived from a potential divider formed by R7 and RV2. The electrolytic capacitor (C9) connected across RV2 is to reduce noise on the output. Diode D8 is there to discharge this capacitor in the event the output is short circuited, otherwise it will attempt to discharge via IC1 and IC2, possibly causing some damage.

Capacitor C10 is placed directly across the output to provide both circuit stability and to supply short term peak currents often required by some circuits. It also functions as a low impedance ac bypass.

Since multiple power supplies are often used to power a single circuit, it is possible for the power supply to be supplied with a reverse voltage from an external source. To protect against this, diode D9 is included. The 1 A continuous current rating of this diode should be sufficient in most cases, and it will stand very high peak forward currents.

The remaining components are related to the variable current limit feature of this supply. The main device involved is the 301 op-amp, IC2. This device compares the output voltage, which is connected to its non-inverting input pin 3, to the voltage dropped by a potential divider formed by the CURRENT SET potentiometer (RV1) and R5. For any given setting of the CURRENT pot, the voltage on pin 2 of IC2 is proportional to the output current.

When the output current rises high enough, the voltages on pin 2 of IC2 will be 'pulled' above that on pin 3 (which is at the output voltage). The output of IC2, pin 6, then swings toward the negative rail, drawing current via D6 and LED2. LED2 will light, indicating current limit is in operation. The output of IC2 pulls down the voltage on the 'adj.' pin of IC1, lowering the output voltage.

Resistor R12, diode D7 and capacitors C5, 7 and 8 are included to ensure stability in the current limit stage when it is operating. This circuit uses a feature of the LM301 whereby it is capable of working as a differential amplifier with its inputs driven right up to the positive supply rail. The positive supply for the op-amp can therefore be the main output of the power supply and vary as the output voltage is varied. To ensure that the op-amp always has a supply across it, a negative supply rail has been derived by D5 and C3, a half-wave rectifier system that generates about 10 V from a tap on the secondary of T1.

The meter switch, SW2, allows the meter to be connected either as a voltmeter or a current meter. In the voltmeter position, the meter circuit is placed directly across the output with R10 and RV4 in series with M1. RV4 allows voltage calibration of the meter. When SW2 is in the current position, the meter measures the voltage drop across R8 and R9, which have the output current flowing through them. RV3 permits current calibration of the meter.

☐ Next solder all semiconductors into place, starting with the diodes. It is most important that you get all of these the right way round, especially the rectifier diodes.

☐ The capacitors can be mounted next. There are five electrolytics and all have to mounted with the right orientation. Note that the two filter capacitors may be supplied as 2500uF or 2200uF, which is quite alright since tolerance ratings on electrolytics are usually in the vicinity of +80%, −20%.

☐ Carefully check the PCB to make sure that all components are mounted and that the semiconductors and electrolytics are correctly polarised.

☐ Before you start interwiring, C7 and R11 will have to be mounted on RV1 (the current limiting pot). Make sure to use heavy gauge wire from the transformer and the output terminals to the PCB.

☐ When all is completed you should check all your wiring carefully to avoid any mishaps when you turn the power on. If all is well you're ready to turn it on and try it out!

## Parts List

**Resistors**

- ☐ R3 .......... 33R (org-org-blk)
- ☐ R2 .......... 47R (yel-vio-blk)
- ☐ R6,7 ........ 220R (red-red-brn)
- ☐ R4 .......... 680R (blu-gry-brn)
- ☐ R1 .......... 1k8 (brn-gry-red)
- ☐ R10 ......... 27k (red-vio-org)
- ☐ R5 .......... 330k (org-org-yel)
- ☐ R11 ......... 560k (grn-blu-yel)
- ☐ R12 ......... 10M (brn-blk-blu)
- ☐ R8 .......... 1R8, 1W
- ☐ R9 .......... 2R2, 1W
- ☐ RV3 ......... 1k trimpot
- ☐ RV4 ......... 5k trimpot
- ☐ RV2 ......... 5k LIN pot
- ☐ RV1 ......... 500k LIN pot

**Capacitors**

- ☐ C5,8 ........ 68pF ceramic
- ☐ C7 .......... 100pF ceramic
- ☐ C6 .......... 0.1uF greencap
- ☐ C4 .......... 0.15uF greencap
- ☐ C9,10 ....... 10uF electro
- ☐ C3 .......... 100uF electro
- ☐ C1,2 ........ 2200/2500uF electrc

**Semiconductors**

- ☐ D6,7 ........ 1N914/1N4148
- ☐ D1-5,8,9 .... 1N4002 diodes
- ☐ 2x .......... red LED
- ☐ Q1 .......... TIP32
- ☐ IC2 ......... LM301
- ☐ IC1 ......... LM317T

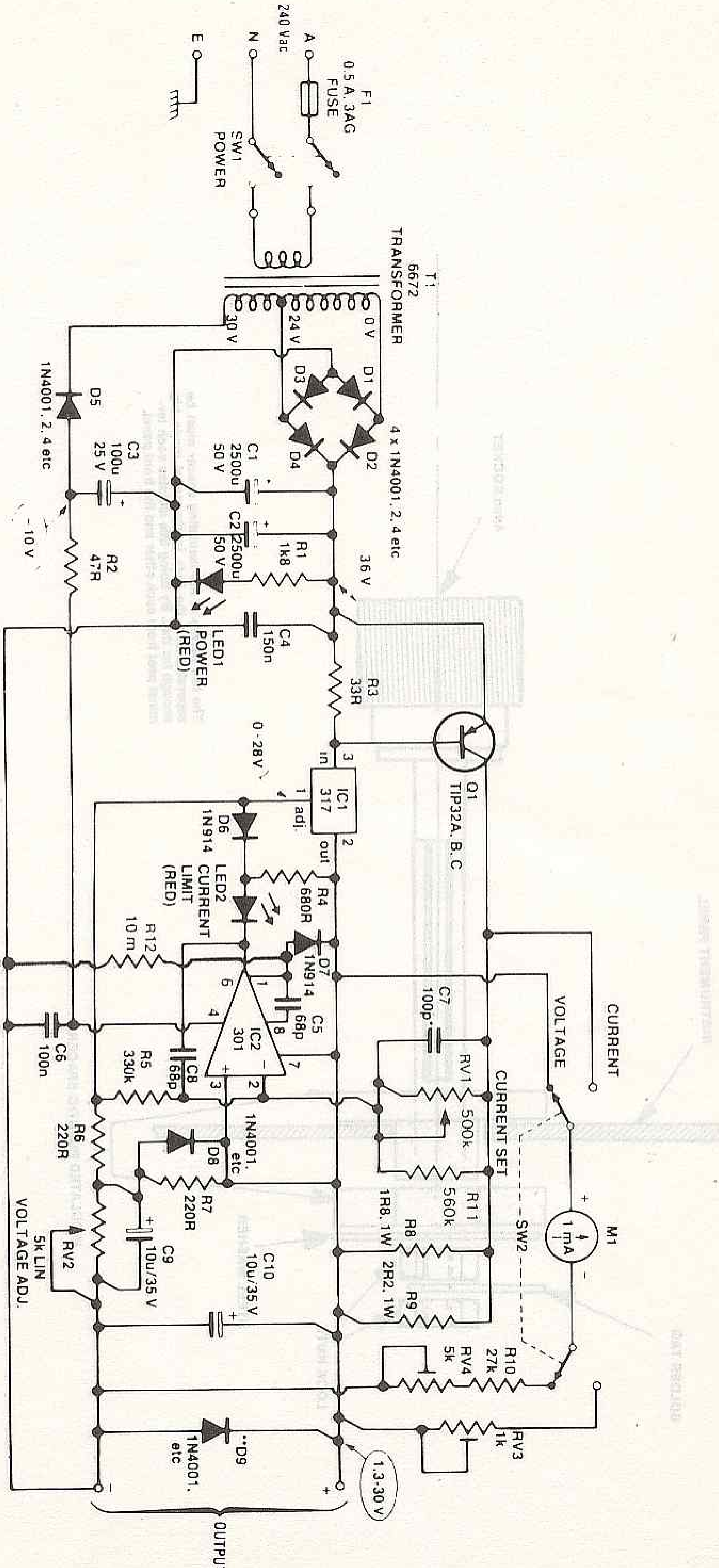
**Miscellaneous**

- ☐ 1x .......... MCI connector
- ☐ 2x .......... binding posts
- ☐ 2x .......... knobs
- ☐ 1x .......... fuse & holder
- ☐ 2x .......... DPDT switches
- ☐ 6x .......... screw, washer & nut
- ☐ 4x .......... spacers
- ☐ 1x .......... cable clamp
- ☐ 1x .......... rubber grommet
- ☐ 1x .......... solder lug
- ☐ 2x .......... LED ring/bezel
- ☐ 1x .......... PCB
- ☐ 1x .......... case
- ☐ 1x .......... mains plug & cord
- ☐ 1x .......... transformer
- ☐ 1x .......... meter 1mA FSD
- ☐ 2x .......... heatsinks
- ☐ 23x ......... PCB pins

Silicone grease, 2 and 3-colour hookup wire, spaghetti tubing and solder.

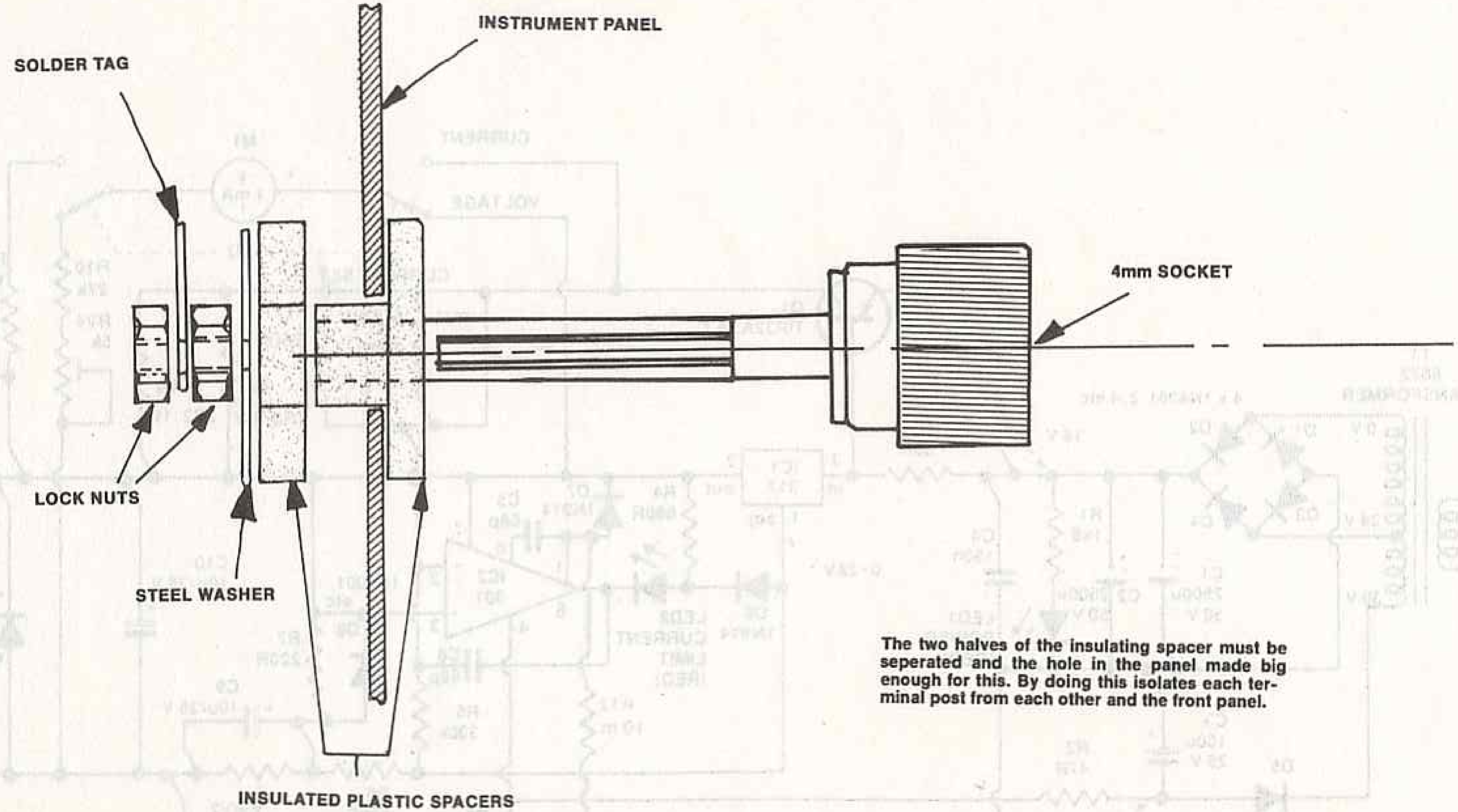
# CIRCUIT DIAGRAM





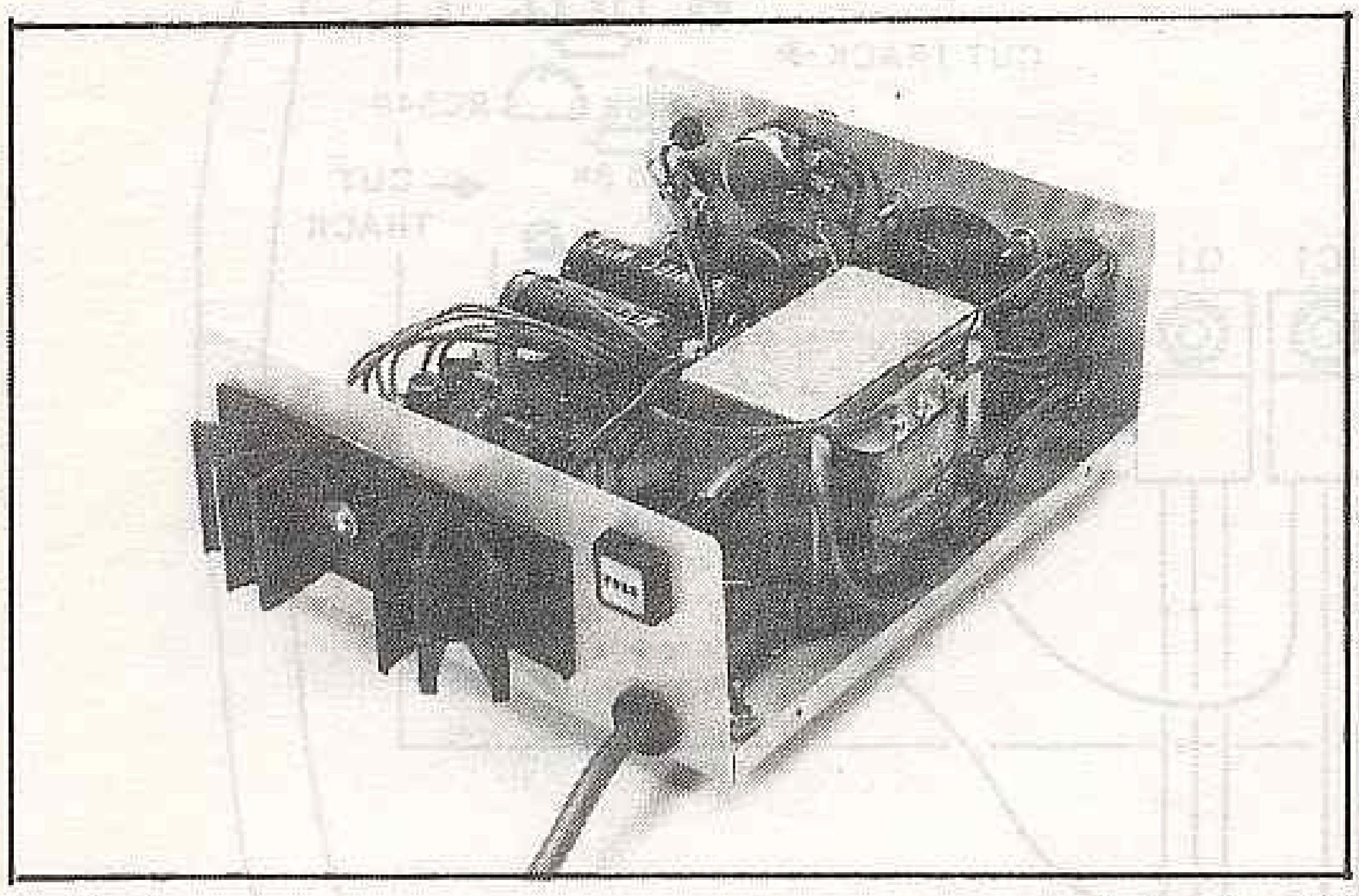
Text and Illustrations courtesy of Electronics Today International

## BANANA TERM POST

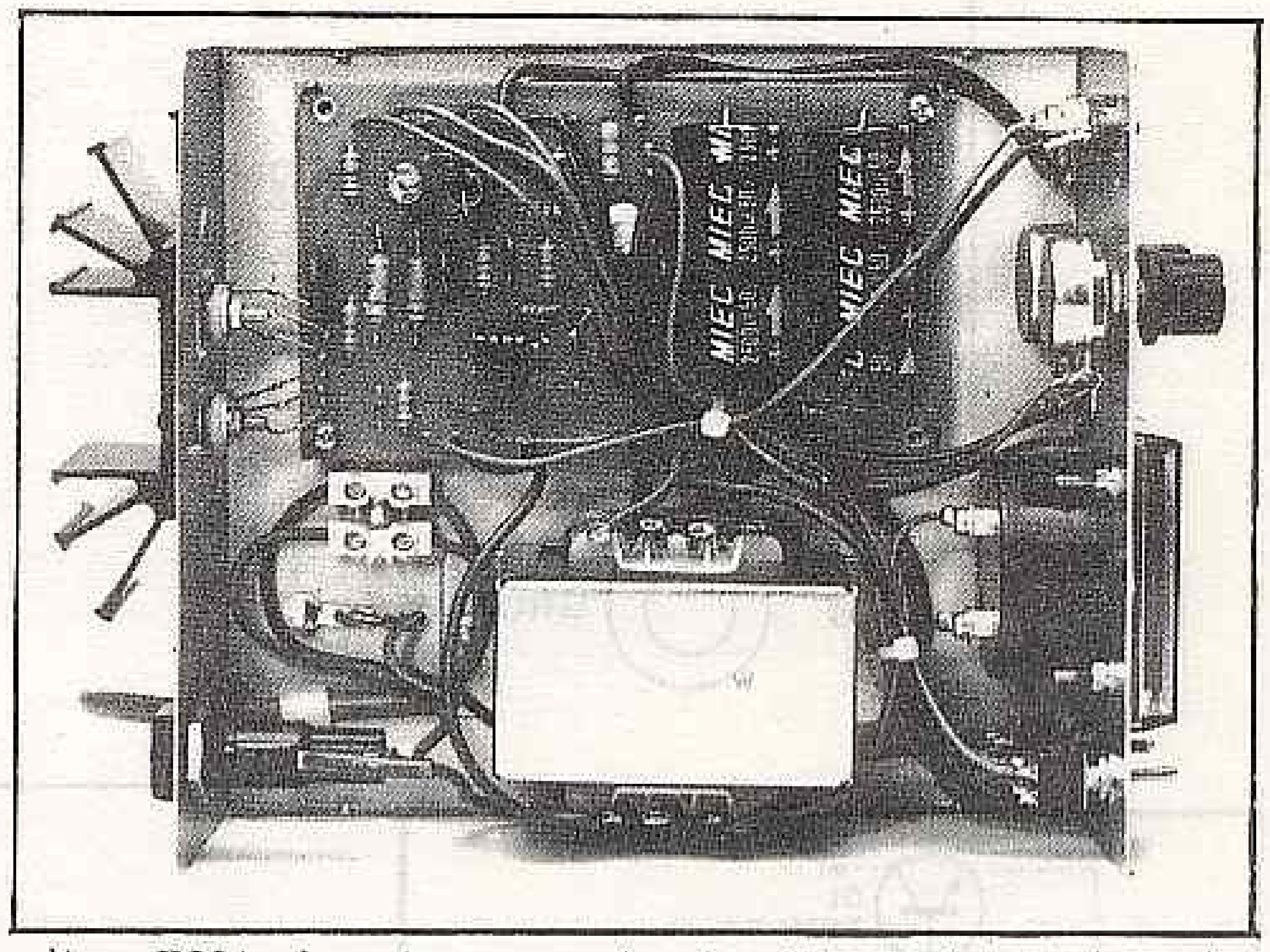



The two halves of the insulating spacer must be seperated and the hole in the panel made big enough for this. By doing this isolates each terminal post from each other and the front panel.

*Rear view of the finished unit showing the positioning of the heatsinks and the fuse.*



*Internal view of the power supply.*



## Switch on

Set the CURRENT and VOLTAGE control to about half rotation and the VOLT/AMP switch to read volts on the meter. Hook your multimeter to the output, switched to the 30 V range or a higher one, plug in and switch the power supply on. If all is well, the POWER LED should light and the multimeter will read some voltage. The power supply meter will probably read something quite different. If you don't get these indications, switch off and look for a wiring error or components misplaced or incorrectly oriented.

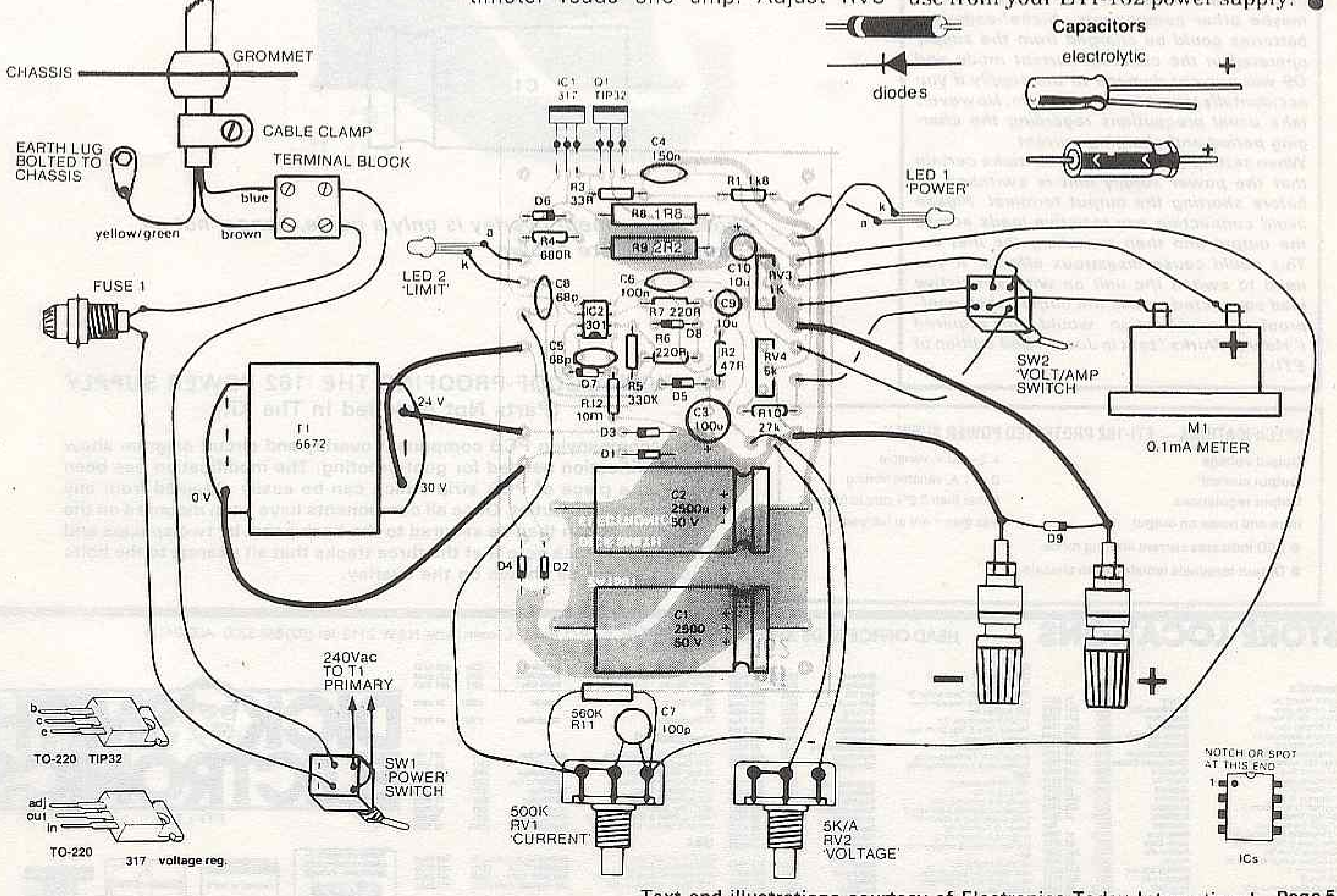
If all is well, set the VOLTAGE control so that you get a reading of 20 V on your multimeter. Then, adjust RV4 (the trimpot nearest the front panel) until the power supply meter reads the same. Vary the VOLTAGE control and check that the supply's meter corresponds closely with the multimeter. See that you get around 1.3 V at minimum and 30 V (within 0.5 V) at maximum.

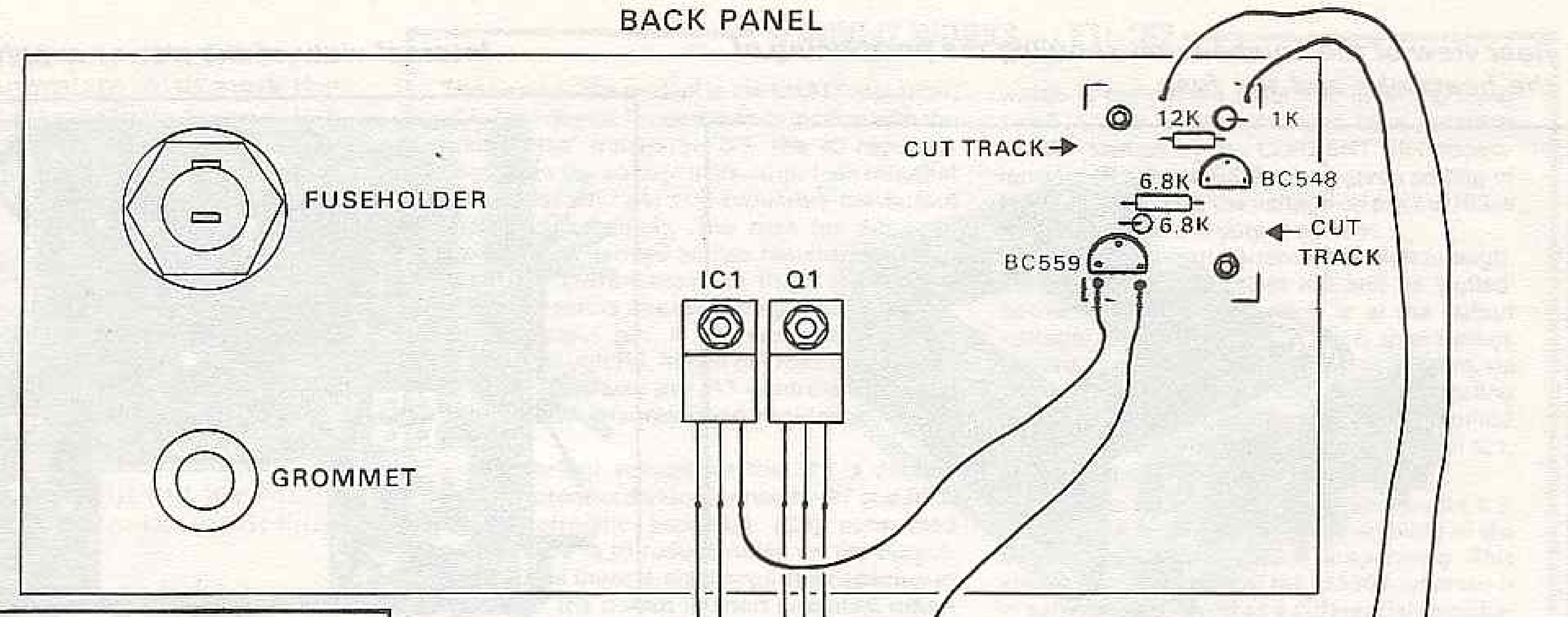
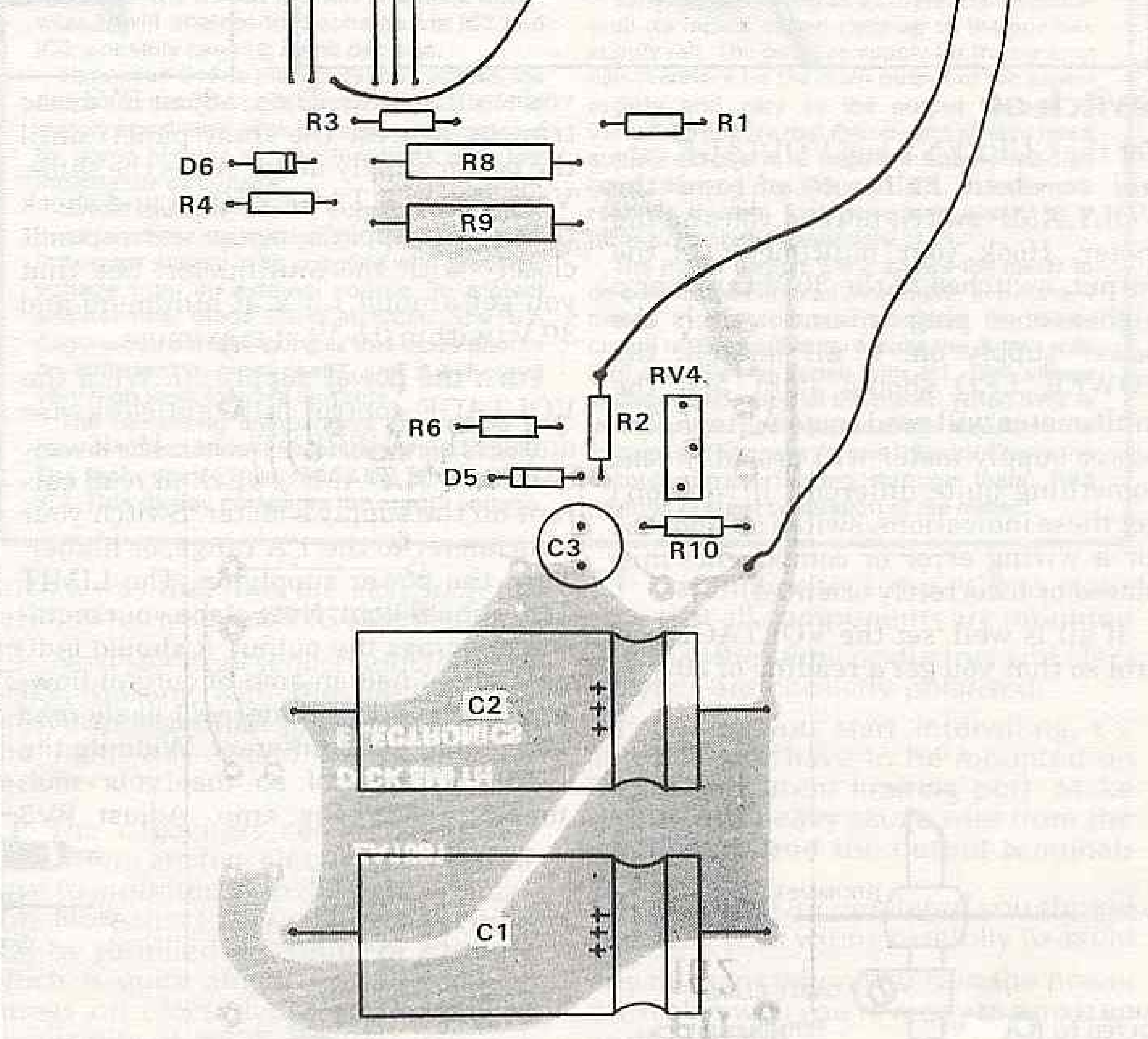
Turn the power supply off. Wind the VOLTAGE control fully anticlockwise and set the CURRENT control half way. Set the VOLT/AMP switch to read current on the supply's meter. Switch your multimeter to the 1 A range, or higher. Turn the power supply on. The LIMIT LED should light. Now place your multimeter across the output, it should indicate about half an amp of current flowing. The supply's meter will likely read something quite different. Wind up the CURRENT control so that your multimeter reads one amp. Adjust RV3 (nearest the back panel) so that the supply's meter reads the same. Vary the CURRENT control and see that the supply's meter corresponds closely to your multimeter.

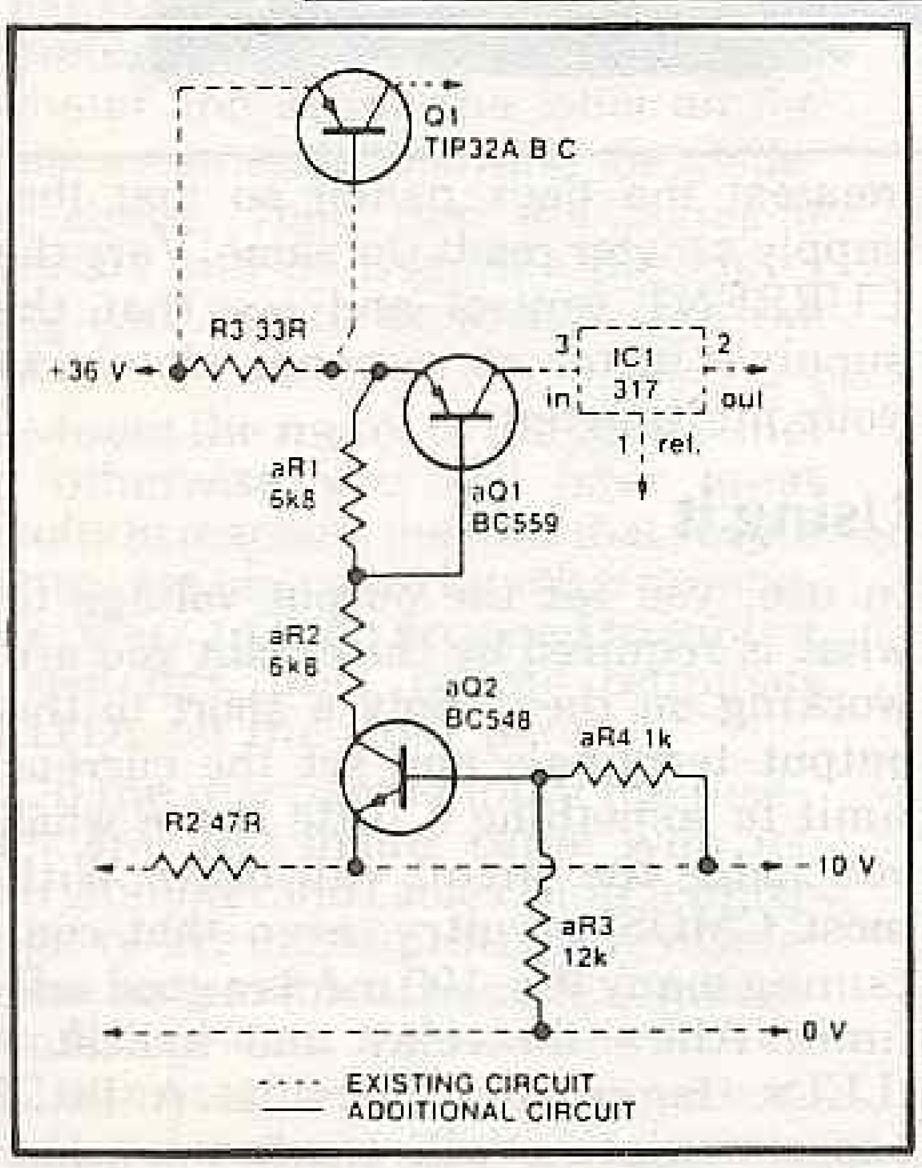
## Using it

In use, you set the output voltage to what is required by the circuit you are working on then apply a short to the output terminals and set the current limit to something a little above what you judge the circuit will draw. With most CMOS circuitry, even that containing many ICs, 100 mA is a good safe limit. Allow for relay and indicator (LEDs, lamps etc) currents. A little experimentation will teach you what to expect under a wide range of circumstances.

We trust you get many useful years of use from your ETI-162 power supply. ●




*Above component overlay is only a guide, hence, not all components are shown.*

*NOTE: This supply is not meant to be used as a battery charger so don't connect lead-acid batteries to it. Accidental reverse connection of a lead-acid car battery will destroy D9 and maybe other components. Nickel-cadmium batteries could be charged from the supply operated in the constant-current mode and D9 will prevent damage to the supply if you accidentally reverse connect them. However, take usual precautions regarding the charging period and charging current.*

*When setting your current limit, make certain that the power supply unit is switched on before shorting the output terminal. Please avoid connecting any resistive loads across the output and then switching the unit on. This could cause disastrous effects. If you need to switch the unit on with a resistive load connected across the output, then goof-proofing modification would be required ("How It Works" text in June, 1984 edition of ETI).*

## OPTIONAL: GOOF-PROOFING THE '162 POWER SUPPLY
### (Parts Not Included In The Kit)

The accompanying PCB component overlay and circuit diagram show the modification needed for goof-proofing. The modification has been done on a piece of PCB strip which can be easily obtained from any electronic retail outlet. Once all components have been mounted on the PCB strip, it can then be secured to the back panel by two spacers and two bolts. Please note that the three tracks that sit nearest to the bolts should be cut as shown on the overlay.

**SPECIFICATIONS — ETI-162 PROTECTED POWER SUPPLY**

| | |
|---|---|
| Output voltage | 1.3 — 30 V, variable |
| Output current | 0 — 1 A, variable limiting |
| Output regulations | better than 0.2% zero to full load |
| Hum and noise on output | less than 1 mV at full load |

- LED indicates current limiting mode
- Output terminals isolated from chassis