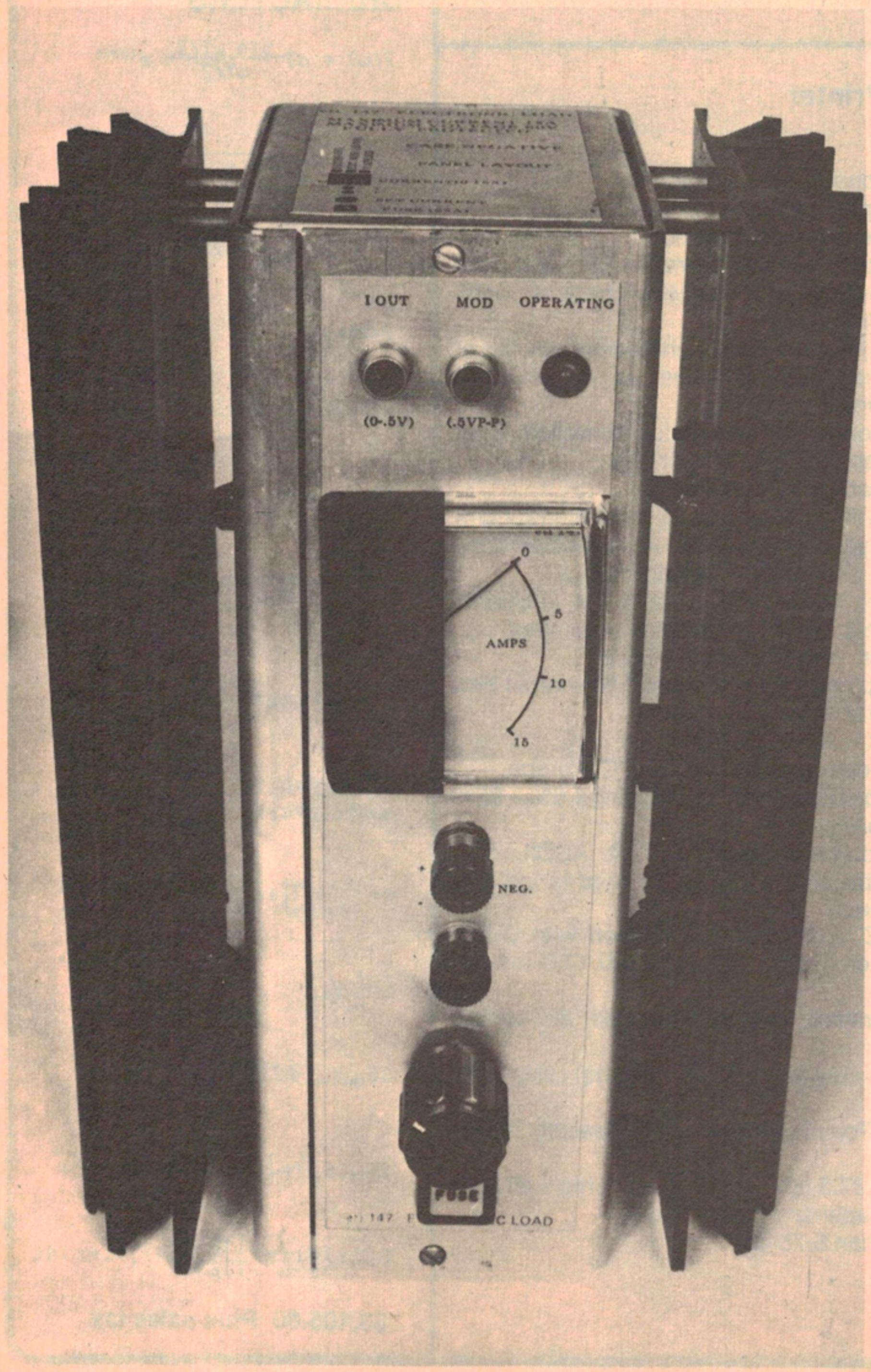
Project 147

Electronic dummy load

Jonathan Scott

With this unit you can test power supplies at currents up to 15 amps and voltages up to 60 volts. It can 'sink' up to 200 watts on a static test and you can modulate the load to perform dynamic tests.



THIS PROJECT is fundamentally a test instrument — but an unusual one. It is intended primarily for testing and 'setting up' power supplies of all varieties — from ordinary transformer-rectifier supplies to sophisticated regulated supplies. It can even be used to plot the discharge characteristics of storage batteries.

The unit employs four high power transistors connected as constant current 'sinks'. These dissipate power from the source to which the unit is connected. The characteristics of the load are controlled by controlling the base drive to these transistors. Self-destruction is avoided by the addition of protection circuitry which 'shuts down' the load if the rated current or power is exceeded. In addition, a relay will disconnect the unit if more than a safe voltage is applied.

The load can be *modulated* to vary the load current by means of an externally-applied signal. It can be modulated at frequencies up to 70 kHz. The resultant load current waveform can be monitored on an oscilloscope connected to the *current output* socket. The specifications of the unit are given in the accompanying box. We have also drawn up a graph showing the *operating area* of the unit.

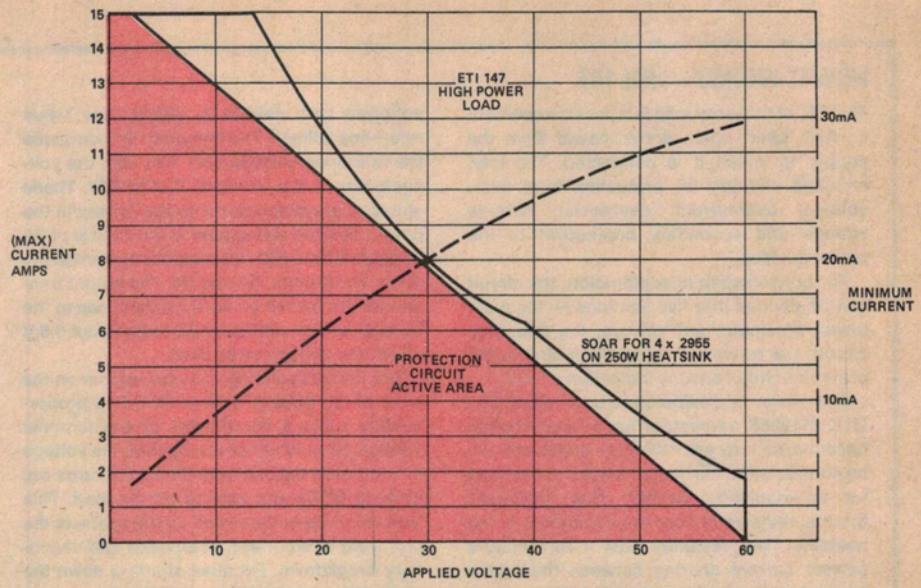
Applications

Regulated power supplies have a finite 'reaction time' following the application of a load or variation in load current. This project can be used to test the transient response, the reaction time, of a power supply as the load can be modulated. A low frequency square wave applied to the unit's *modulation input* will effectively vary the load resistance. The rise and fall times of the power supply under test can then be ascertained from an oscilloscope connected to the *current output*. Varying the level of the signal applied to the modulation input will vary the 'depth' of modulation. The load can be 'swung' from full current to zero current, or over a lesser range, and a good idea of how the supply reacts to this test can be gained.

The same technique can be used to check a power supply's regulation and to set the internal impedance.

Construction

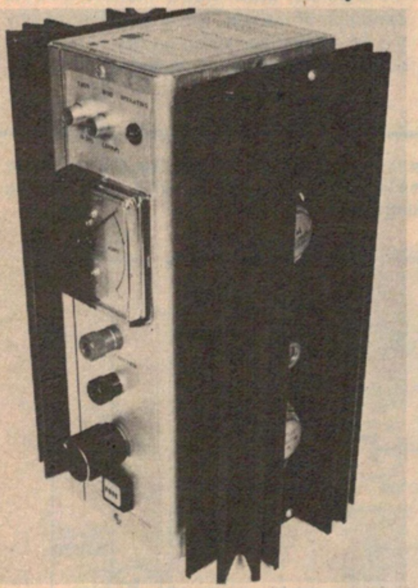
We chose to use one of the larger Horwood rectangular boxes to house the



ELECTRONIC DUMMY LOAD, PROTOTYPE PERFORMANCE SLEW RATE: 100mA/µS

project. The layout is not particularly critical and the unit could be assembled in a number of different ways. We chose the Horwood box as it proved convenient and inexpensive. It's convenient as the assembly is dominated by the 220 mm long heatsinks which have to be mounted vertically, and that's how we used the box — a little unconventional, but entirely practical. The box is designated type 34/9/DS and measures 240 mm x 100 mm x 70 mm. It comes in four pieces — the rectangular 'tube' is in two pieces and there are two end pieces. The heatsinks are mounted off the sides of the case on standoff pillars. This allows a free air flow around the vertically mounted heatsinks, ensuring good cooling efficiency.

There are several sources for suitable heatsink sections. Dick Smith Electronics stocks a 225 mm length, catalogue number H-3426. Rod Irving Electronics stocks a suitable style of



Side view showing Q9, Q10 and D2 mounted on the heatsink.

heatsink, manufactured locally, but you may have to ask for a length to suit.

First thing to do is tackle the metalwork. Carefully mark out and drill the heatsinks. One heatsink has two of the transistors mounted on it plus the BYX200R/21L diode, D2. This is a stud-mounting diode that is meant to 'press-fit' into a suitable hole in the heatsink. However, it is easier for home construction if you buy a bolt-on mount for it. These should be available from the supplier from whom you bought the diode. The transistors should be mounted well away from each other, but not too close to the ends of the heatsinks.

Having drilled all the holes in each heatsink, remove any burrs as these interfere with good thermal contact. Bolt all the semiconductors to the heatsinks using thermal compound (such as Bevaloid GS13). No insulating washers are necessary, but solder lugs should be inserted under each of the transistor mounting bolts. Although all the transistor collectors are connected directly to the case, separate wires are run from each to the pc board so as not to *rely* on the mechanical connection and so that the unit may be tested or serviced with the case disassembled. The anodising on the heatsinks is actually a good insulator, and whilst toothed washers may be used where necessary to provide an electrical connection, we felt it better to provide a direct wire to the pc board. It's certainly more reliable.

Two standoff pillars, about 10 - 15 mm long, are used to support each end of each heatsink, as can be seen from the photographs.

Next, drill the case. Front panel layout is not critical and you can arrange it to suit yourself.

Mount relay behind the front panel using a small clamp fashioned from a scrap of aluminium. You can glue it on if you wish! It should be mounted quite close to the positive terminal so that a very short, heavy lead can run from the terminal to the relay contact pins.

The pc board is mounted on standoff pillars on the panel of the case opposite the front panel. It can be mounted in any convenient position. The panels on which the heatsinks mount have a large diameter hole (9 - 13 mm) drilled in them through which the wiring to the heatsink-mounted components passes. These holes should be grommeted to prevent possible shorts to the case. Transistor Q8, a TIP31 flatpack, is mounted on the case panel adjacent to the pc board. It is insulated from the case using an insulating washer and insulated mounting bush.

All the components that mount on the front panel can be assembled next. If

— text continues page 34. ▶

SPECIFICATIONS ETI-147 ELECTRONIC LOAD

Maximum dissipation	200 watts (see graph)
Maximum voltage	60 volts
Maximum current	15 amps
Minimum voltage	2 volts
Minimum current	3 mA
Modulation range	0 to full current
Modulation sensitivity	1 V p-p or better
Mod. frequency response	1kHz - 70 kHz
Protection	see graph

HOW IT WORKS — ETI 147

The ETI 147 dummy load is a passive constant current 'sink' which draws power from the supply to which it is connected. The load includes circuitry for protection from overvoltage, overcurrent, overpower, reverse voltage and secondary breakdown of the power devices.

For convenience of explanation, the circuit can be divided into five sections — the main power dissipator and drivers, the reference circuit, the reference comparison circuit, the protector circuit and the indication circuit.

The power is dissipated in transistors Q9 - Q12. MJ2955 transistors have been chosen because, as they are PNP, their collectors can be connected to the heatsink without the need for an insulating washer. This decreases thermal resistance from the transistors to the heatsink. The resistors R24 - R27 ensure correct current sharing between the power transistors as well as forming the current sensing resistance for the protection circuit.

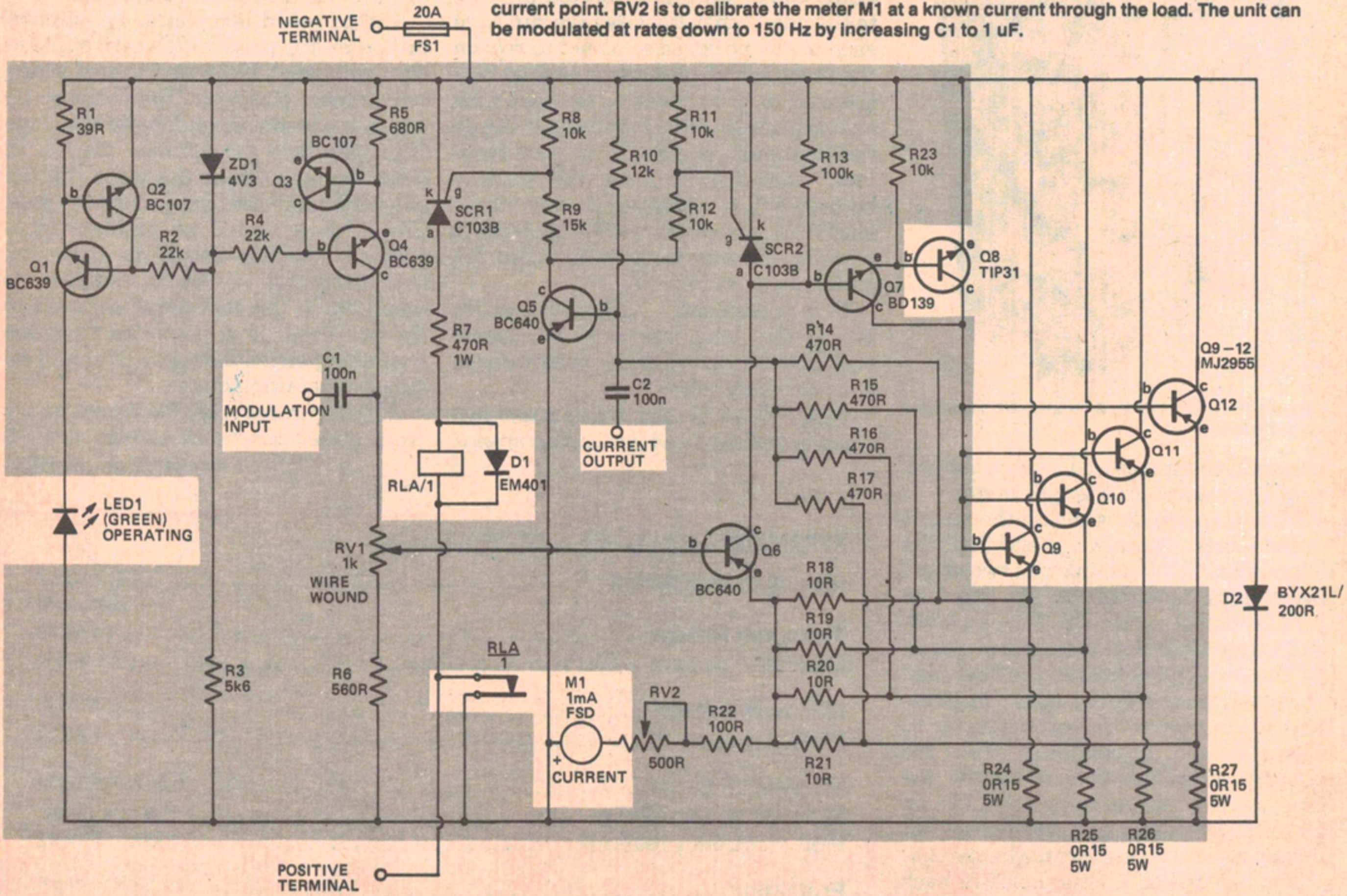
An internal reference is provided by passing a constant current — generated by ZD1, Q3 and Q4 — through R6 and RV1. Using a constant current generator allows the unit to operate over a very wide range of supply voltages, yet deliver a stable, low value reference voltage. The transistor Q6 compares the reference voltage from RV1 with the voltages across the resistors R24 to R27. These voltages are proportional to the current in the output devices and appear at the emitter of Q6 through R18 to R21. Q6 supplies current to the driver transistors, Q7 and Q8. The output transistors are turned on sufficiently to cause the voltage on the emitter of Q6 to be about 0.6 V above the voltage on its base.

The current sensing voltages appear on the base of Q5 through R14 to R17. R10 proportionally adds a component of the terminal voltage. Should either the current, the voltage or their sum exceed safe limits, Q5 turns on, tripping SCR2 and turning off the load. This 'sum-of-volts-and-current' circuit protects the unit from overcurrent, overpower and secondary breakdown. Because shutting down the load will not provide protection from overvoltage a relay is provided which operates when SCR1 conducts. SCR1 has been arranged to cut in if the current shutdown looks like being inadequate, i.e: if there is considerable voltage present. If the device protects only by current shutdown, turning RV1 to minimum will reset the circuit. If, however, the relay is operated it will be necessary to remove power to the unit before it will reset. Reverse polarity protection is provided by D2 and FS1.

The current through the load is monitored by M1 which senses the voltage at the emitter of Q6. The meter is calibrated by RV2. A LED indicating that the unit is operating is driven from a constant current source comprised of ZD1, Q1 and Q2. When the voltage is sufficient to operate the load the LED will light, giving an 'adequate voltage' indication. The LED will also extinguish if the relay drops out, indicating the need to remove power.

Finally, in order to make dynamic measurements, C1 provides the option of modulating the reference, and thus the current drawn, from anywhere between zero and full load. The actual current may be viewed with an oscilloscope connected to the output at C2. Capacitors are used here to avoid grounding these points, which would interfere with the operation of the unit. There is no reason why the dc voltage appearing on the meter could not be made available if so desired.

Circuit diagram of the electronic load. RV1 is a front panel control used to set the maximum current point. RV2 is to calibrate the meter M1 at a known current through the load. The unit can be modulated at rates down to 150 Hz by increasing C1 to 1 uF.



PARTS LIST — ETI 147

Resistors all ¼W, 5% unless marked

R1 .... 39R
R2, R4 .... 22k
R3 .... 5k6
R5, R6 .... 680R
R7 .... 470R, 1W
R8, R11, R12, R23 . 10k
R9 .... 15k
R10 .... 12k
R13 .... 100k
R14 - R17 .... 470R
R18 - R21 .... 10R
R22 .... 100R
R24 - R27 .... 0.15 ohm, 5W

Potentiometers

RV1 .... 1k wire wound
RV2 .... 500R trimpot

Capacitors

C1, C2 .... 100n greencap

Semiconductors *see text

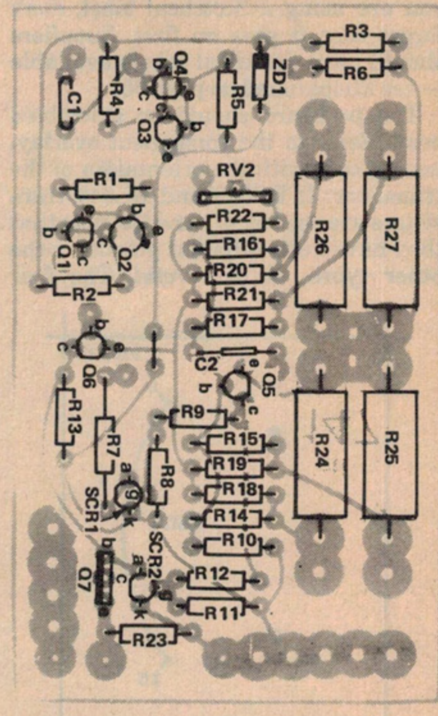
D1 .... EM401 or similar
D2 .... BYX21L/200R or similar 25A diode
ZD1 .... 4V3, 400mV zener diode
LED1 .... Green LED, TIL220G or similar
SCR1, SCR2 .... C103B or similar SCR
Q1, Q4 .... BFY50, TT801, BC639*
Q2, Q3 .... BC107, BC547 or similar
Q5, Q6 .... TT800, BC640*
Q7 .... BD139
Q8 .... TIP31
Q9 - Q12 .... MJ2955

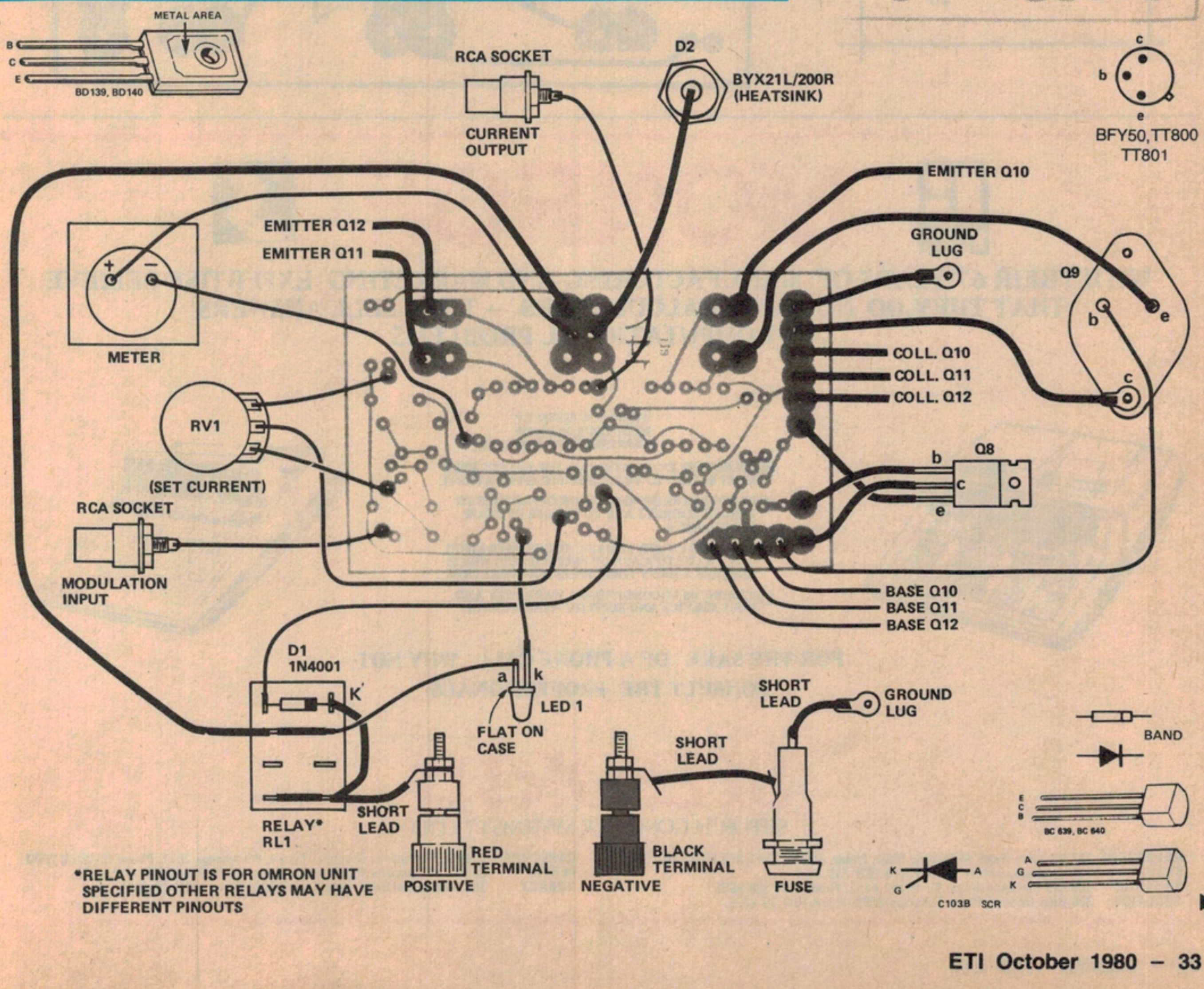
Miscellaneous

M1 .... 1 mA FSD meter, University TD48 or Minipa MU45 or similar

RL1 .... 24 V relay with 15 A contacts, see Shoparound on p.65

ETI-147 pc board; fuse holder with 20 A fuse; two RCA sockets; two screw terminals; 10 x 12 mm standoffs; two lengths 225 mm-long flat-sided heatsink (see Shoparound, p.65); Horwood box, type 34/9/DS; 15 A hookup wire.





you are using a Scotchcal label, don't forget that it goes on first. Suppliers should have Scotchcal labels available — see Shoparound on page 65.

The pc board should be assembled next. Refer to the component overlay, taking care with the orientation of the transistor. If BC639 and BC640 transistors are used for Q1 and Q4, note that they have quite different pinouts to the other types, *so be careful.* The four 0.15 ohm, 5W resistors should be mounted 5 - 6 mm off the pc board to allow free circulation of air.

Check the pc board before wiring it to the case mounted components. Heavy duty, multi-strand hookup wire should be used to wire all high current carrying connections. This includes the collector and emitter leads to Q9, Q10, Q11 and Q12, the lead to the cathode of D2, the lead from the pc board 'ground' connection to the 'ground' lug on the case, wiring to the fuse and input terminals and to the relay contacts. Heavy lines on the wiring diagram indicate where to use heavy wiring leads. We suggest 32 x 0.2 mm cable as a minimum, preferably something heavier. Remember that it may have to carry as much as 15 amps. ●