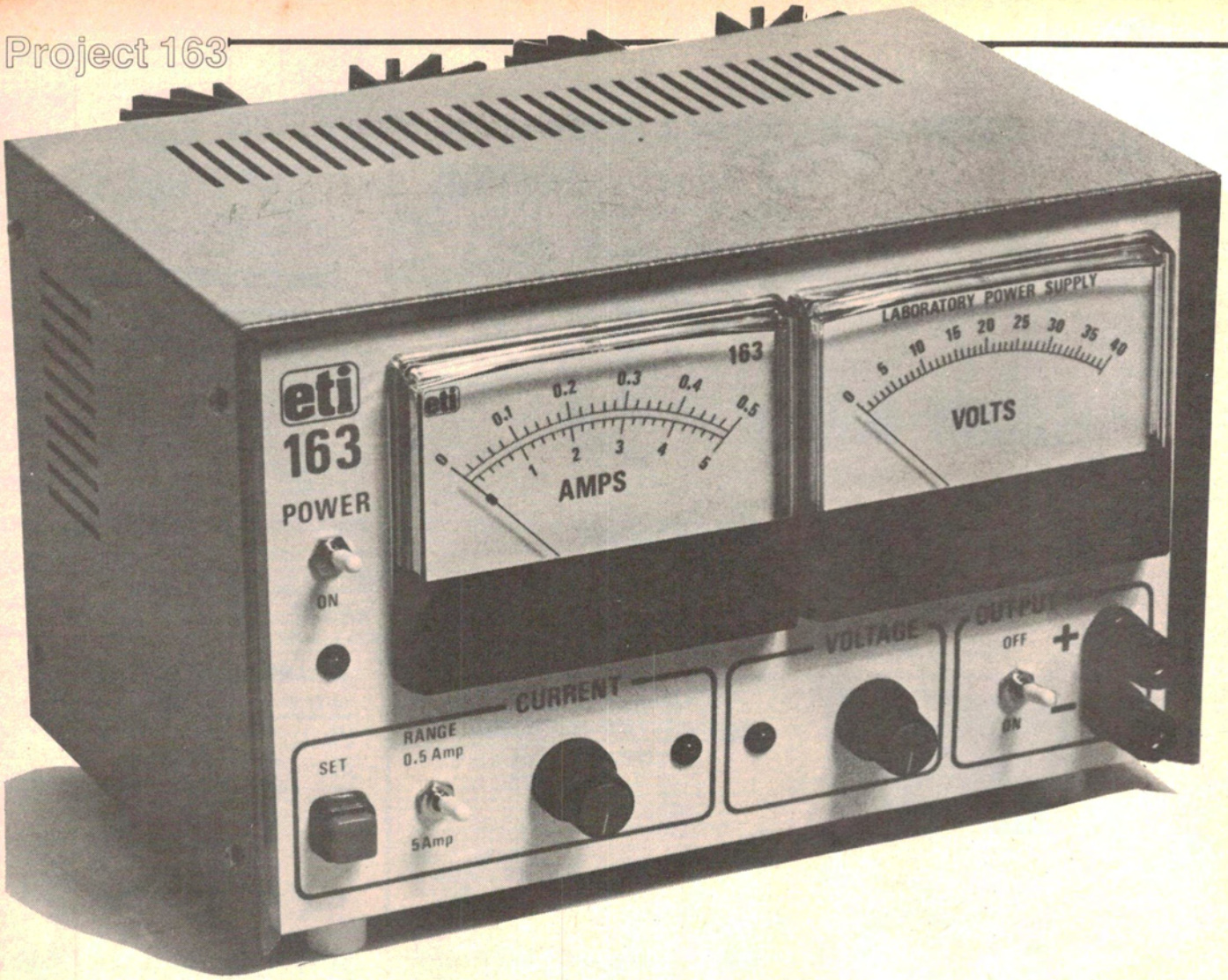


0-40 V/5 A laboratory power supply

Part 2.

Having introduced the project and the design technique chosen in Part 1, this part describes the construction and setting up.

David Tilbrook

Construction

This project is not recommended for beginners or inexperienced constructors. However, anyone with a modicum of electronics construction experience should be able to assemble this project with little difficulty.

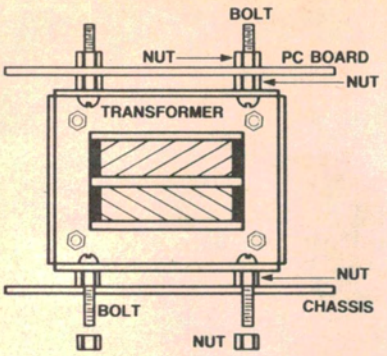
First off, no matter whether you've bought the components individually or purchased a kit, lay out all the parts and see that you have everything you need — including things like thermal compound, the right size nuts and bolts etc. Two basic grades of hookup wire are used to wire up the supply: ordinary 'light duty' (10 x 0.12 mm) hookup wire and 'heavy duty' (24 x 0.2 mm) or 'ultra heavy duty' (32 x 0.2 mm) wire. Those parts of the circuit carrying high currents are wired up with the heavy duty wire, as indicated in the wiring diagram.

The case we used is from K&W of Ballarat, Victoria, model C1066, supplied to us courtesy of Rod Irving Electronics. It is a popular and widely available case. Overall, it measures 255 x 165 x 155 mm and has a U-shaped aluminium chassis and hammertone blue steel lid with ventilation slots. It is supplied with four screw-on feet.

The chassis will need to be marked out and all holes drilled or cut out before any assembly can be commenced. Mark out the front panel according to the accompanying diagram. Centre punch all holes before drilling. Do a trial assembly of each component to see that they all fit and make any necessary adjustments.

No drilling diagrams have been given for the chassis bottom and rear panels as these will depend on the physical dimensions of the exact components used. Tackle the rear panel first. Place the two heatsinks side by side (see rear photograph), leaving room at the right for the mains fuse and power cord inlet. The two heatsinks we used were 150 mm lengths of black anodised radial fin type, manufactured and marketed by Rod Irving, No. HS3. There are similar types available. Any heatsink with suitable dimensions and rated dissipation of 1-1.3°C/watt will be perfectly adequate.

Holes will need to be drilled in the rear panel to accommodate the transistor mounting hardware, the transistor leads and bolts for securing the heatsinks. Having organised



Transformer and board mounting. How the power tranny, T1, and the pc board are mounted.

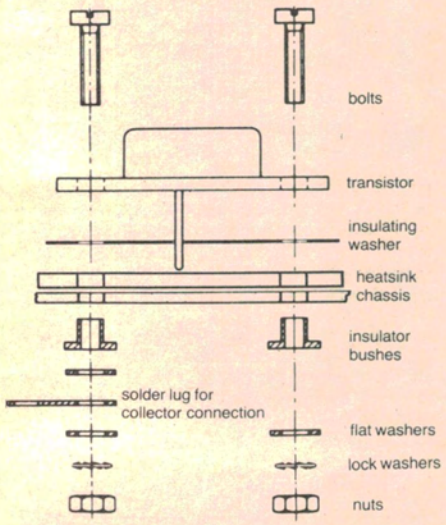
that, then locate the holes for the mains fuse holder and the power cord grommet — which should be a clamp type.

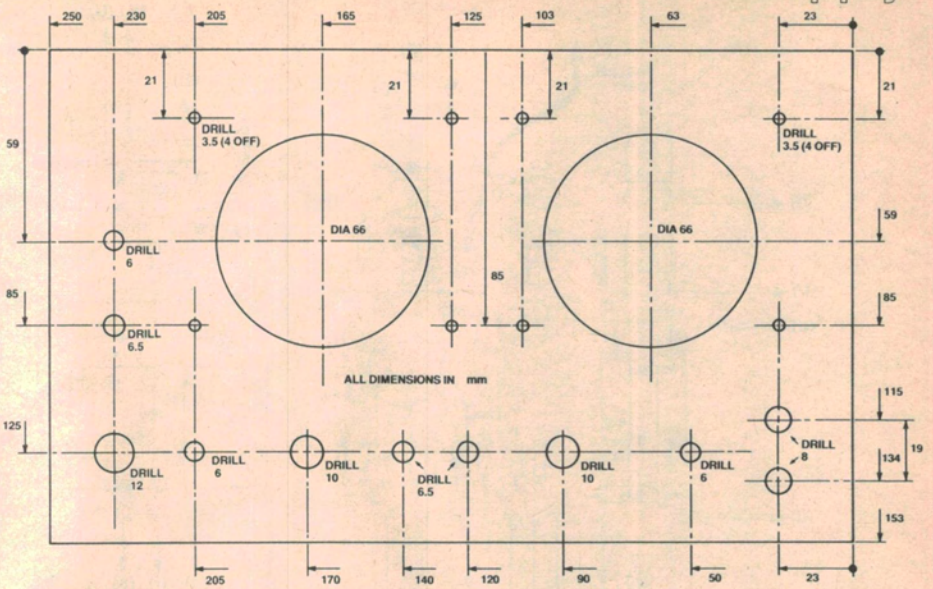
Mark out the case bottom next. Locate the mains transformer centrally between the sides and towards the rear, leaving no less than 15 mm clearance from the rear panel to the transformer bobbin. Four bolts are used to secure the transformer. Then locate and mark out the two filter capacitors, the bridge rectifier, the mains terminal block and earth bolt and the auxilliary 12 V (2851) transformer (if used). Make sure you don't foul the four case feet. Do a trial assembly to see it all fits correctly.

Remove burrs from all holes, then check that you've drilled all the required holes. Now stick masking tape across the rear (inside) of the front panel and spray paint the outside of it white. At the same time, remove the scale panels from the two meters, turn them over and spray paint them white, too. This ensures that the background for the Scotchcal labels is neutral as white Scotchcal is slightly translucent. Remove the masking tape from the chassis after the paint has dried.

Now the Scotchcal labels can be attached. Tackle the meter scales first. Peel off the backing along one edge for a little way then carefully align it on the edge of the scale panel and rub it down. Then peel off the backing further, rubbing down the Scotchcal carefully as you go. Take care not to get any, or many, bubbles under the Scotchcal label.

Transistor mounting. How to mount the two power transistors, Q3 and Q4.





Get the drill? Drilling details for the front panel.

If you do get some, they can be removed by rubbing them away towards the nearest edge. Work from the centre of the panel outwards.

Follow by applying the other meter scale Scotchcal and then the front panel. When the labels have been applied, cut out the holes using a modeller's scalpel or the like. Remember, a little patience prevents accidents. Re-assemble the meters.

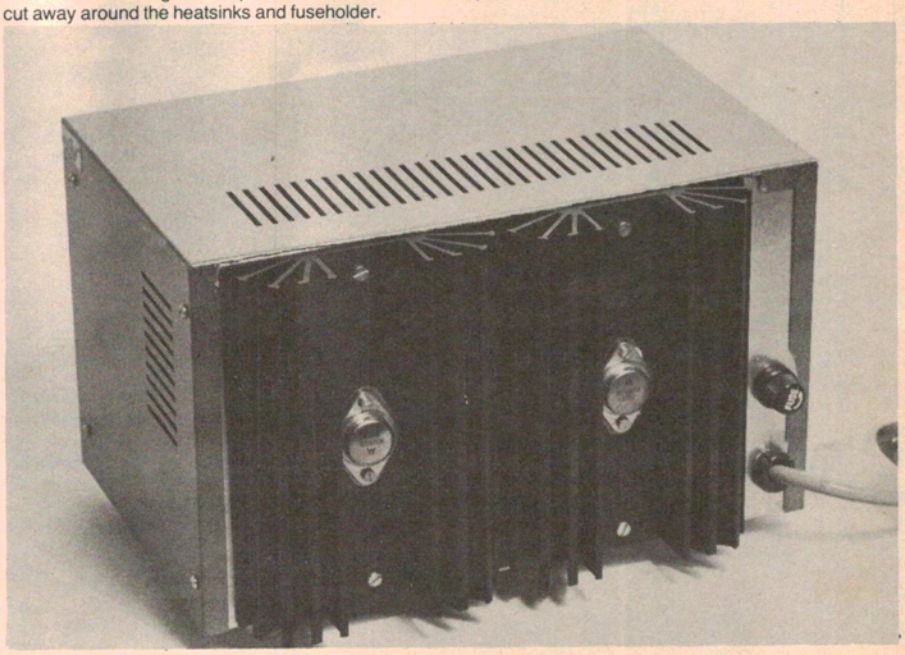
Now, you can mount all the front panel components — the meters, switches, output terminals, etc. Attach wires of appropriate length to them, as shown in the panel wiring diagram. Take care to use light duty and heavy duty hookup wire where indicated. Note that the lead from the voltage control potentiometer (RV4) to the pc board is a shielded cable. The shield braid is soldered only to the pot lug which connects to the 0 V output terminal and is left unconnected at the pc board.

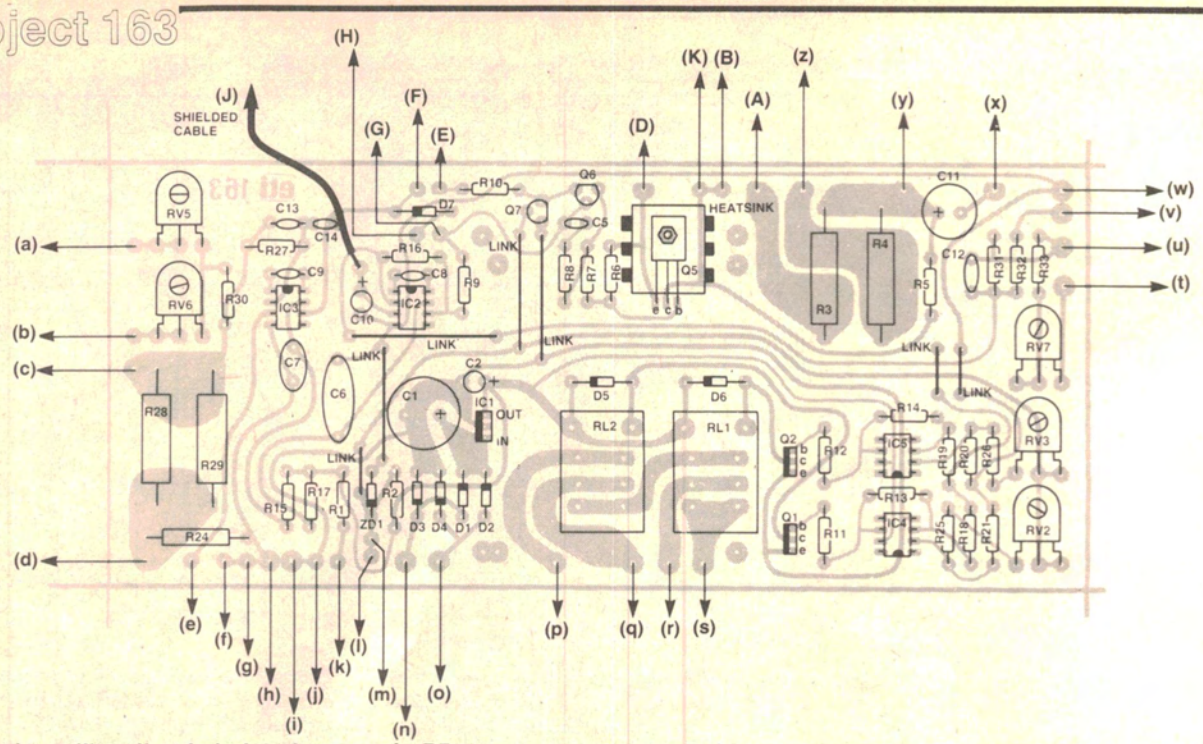
Mount the rear panel components, but leave the mains cord off for the moment. Assemble the transistors to the heatsinks and chassis as indicated in the accompanying diagram. Attach wires to the transistors as per the wiring diagram.

Mount the bridge rectifier and attach heavy duty leads of appropriate length to the lugs. Then mount the mains terminal block and the 2851 auxilliary transformer, if used. Wire the mains switch, mains fuse and mains terminal block. Sleeve the exposed fuse and switch connections. Mount the power transformer as per the diagram here, followed by the filter capacitors.

Assembly of the pc board can be tackled next. First, examine the tracks, looking for any breaks or hairline copper bridges between tracks. Check that all the holes are drilled and that they're of the correct size, particularly where the relays mount. ▶

Rear view. Showing the components mounted on the rear panel. Note that the lip on the chassis lid needs to be cut away around the heatsinks and fuseholder.





If, or when, all's well with the board, commence assembly by soldering all the resistors and capacitors in place. Make sure you place the electrolytics and tantalums the right way round. The trimpots, note, are all laid flat on the board. Solder the pins in first, then carefully bend them so that the body lays flat.

The semiconductors may be soldered in place next. Check that each is correctly oriented before you solder it in place. If you wish, IC sockets may be used. Note that Q5, the BD140, requires a small heatsink. I used a Thermalloy No. 6073B, but any similar type that physically fits will do. Smear a little thermal compound on the metal face of the transistor before assembling it. No insulating washer is necessary.

The two relays can be mounted and soldered in place next, followed by all the pc stakes for terminating the leads to the components on the chassis.

The pc board bolts on top of the transformer. Note that provision has been made on the pc board for mounting holes to suit either the Permatran or the Ferguson transformer, whichever is used. It mounts on top of the transformer, as per previous diagram.

Referring to the wiring diagram, wire up the pc board. Route all the wires carefully. Check it thoroughly when you've finished. Last of all, wire in the mains cable. Make sure the earth (yellow/green) lead is the longest so that, should the cable be accidentally pulled out, the earth lead is the last to break. ▶

PARTS LIST — ETI-163

Resistors ..... all ¼ W, 5% unless noted
- R1, 2, 6, 7, 9, 10 ... 1k
- R3, 4, 28, 29 ..... 0R22, 5 W
- R5 ..... 47R
- R8 ..... 3k9
- R11, R12 ..... 2k2
- R13, R14 ..... 1M
- R15, R30 ..... 100R
- R16 ..... 220k
- R17 ..... 100R
- R18, 19, 22, 27..... 10k
- R20 ..... 15k
- R21 ..... 33k
- R23 ..... 1k8
- R24 ..... 1R, 1 W
- R25 ..... 12k
- R26 ..... 27k
- R31 ..... 39k, 1%
- R32 ..... 5k6, 1%
- R33 ..... 33k
- RV1, RV4 ..... 10k/A panel mount pot.
- RV2, RV3 ..... 10k/A min. vert. trimpots
- RV5, RV6 ..... 500 R min. vert. trimpots
- RV7 ..... 25k min. vert. trimpot

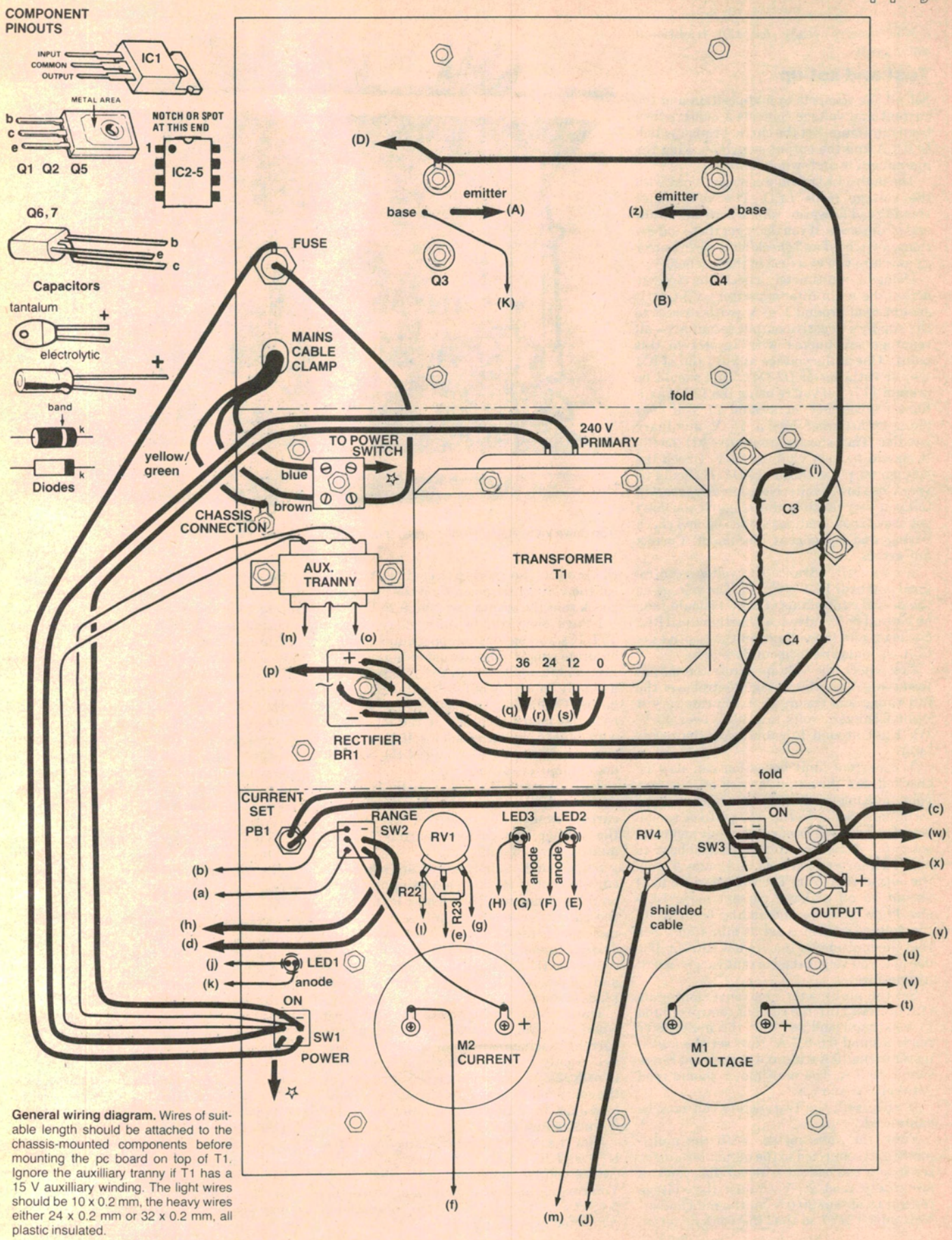
Capacitors
- C1 ..... 1000u/25 V single ended electro.
- C2, C10 ..... 10u/16 V tantalum
- C3, C4 ..... 8000u/75 V can electro.
- C5 ..... 5n6 greencap
- C6 ..... 470n greencap
- C7 ..... 100n greencap
- C8, C9 ..... 220p ceramic
- C11 ..... 100u/63 V single ended electro.
- C12 ..... 47p ceramic
- C13 ..... 1n ceramic
- C14 ..... 150p ceramic

Semiconductors
- BR1 ..... PB40, MDA2504, MDA3504 etc bridge rectifier
- D1, 2, 3, 4 ..... 1N4001, 1N4002, etc
- D5, 6, 7 ..... 1N914, 1N4148
- Q1, Q2 ..... BD139
- Q3, Q4 ..... MJ15003, MJ15024 etc
- Q5 ..... BD140
- Q6 ..... BC547, BC107 etc
- Q7 ..... BC559, BC159 etc
- IC1 ..... uA7812, LM7812 etc
- IC2, 3, 4, 5 ..... CA3130
- LED1 ..... TIL220R red LED
- LED2 ..... TIL220Y yellow LED
- LED3 ..... TIL220G green LED
- ZD1 ..... 5V1

Miscellaneous
- F1 ..... 2.5 A or 3 A fuse, type 3AG, and bayonet holder (e.g: D.S.E. cat. S-4206 or similar).
- M1, M2 ..... Minipa MU65 1 mA meter movements, or similar.
- PB1 ..... SP momentary action pushbutton, 125 Vac/6 A contacts, D.S.E. No. S-1199 or similar.
- RL1, RL2 ..... DPCO heavy duty relays, 125 Vac/10 A contacts, 12 V coil (160 ohm), Fujitsu FRL-264D012/02CK (D.S.E. No. S-7140 or similar).
- SW1 ..... DPST miniature toggle switch, 240 Vac/1.5 A contacts or greater, D.S.E. No. S-1174 or S-1168, or similar.
- SW2, SW3 ..... DPDT miniature toggle switches, 240 Vac/5 A contacts, D.S.E. No. S-1168 or similar.
- T1 ..... transformer, 240 V primary, 250 VA rating, main secondary to deliver 36 V at 5 A or better, tapped at 12 and 24 V, with auxilliary secondary of 15 V at 200 mA (or additional 2851 12 V/150 mA transformer if 15 V secondary not available).

ETI-163 pc board; K&W case No. C1066; two heatsinks — Rod Irving No. HS3 150 mm long single-sided radial fin type black anodised, or similar (1°C/watt); one Thermalloy TO-220 heatsink 6073B or similar (for Q5); two heavy duty captive-head binding posts (one red, one black); one two-way terminal block; TO3 insulating components — two sets; one clamp grommet; mains cord and plug; Scotchcal labels for meter scales and front panel; short length of shielded cable; three LED mounts; hookup wire — light (10 x 0.12 mm) and heavy (24 x 0.2 mm or 32 x 0.2 mm); 6 BA and 4 BA bolts and nuts, solder lugs etc.

Price estimate $165 — $170



General wiring diagram. Wires of suitable length should be attached to the chassis-mounted components before mounting the pc board on top of T1. Ignore the auxilliary tranny if T1 has a 15 V auxilliary winding. The light wires should be 10 x 0.2 mm, the heavy wires either 24 x 0.2 mm or 32 x 0.2 mm, all plastic insulated.

Now you're ready for the traditional 'smoke test'.

Test and set-up

Set all the trimpots to mid-position and the current and voltage controls a quarter-turn from minimum. Set the current range switch to 0.5 A and the output switch on. Plug the mains cord in and switch it all on.

The mains LED should come on, along with the voltage mode LED. The volts meter should read forwards, somewhere on the low end of the scale. If you don't get these indications, switch off and check for a wiring error (make sure you've a fuse in the fuseholder!).

Using a multimeter, check the voltage across the main filter capacitors (C3-C4). It should read around 17.5 V (with respect to the supply's negative output terminal — all readings are quoted with respect to this point). Check the voltage at pin 1 (in) of IC1 (i.e: at cathodes of D2-D4). This should be around 17.5 V if you're using the 12 V auxilliary transformer, or around 21 V if your main transformer has a 15 V auxilliary winding. Then check the output of IC1 (pin 3). It should be very close to 12 V. Check the voltage on the cathode of ZD1. It should be very close to 5.1 volts. No other voltages will tell you very much at this stage. If you don't get the correct readings switch off and check wiring and component placement. Correct any errors.

If all's well, advance the voltage control until you hear RL1 'click' on. The voltage on the positive terminals of C3-C4 should then be around 36 V. Advance it further until RL2 clicks on and the voltage on the positives of C3-C4 should rise to about 54 V or so.

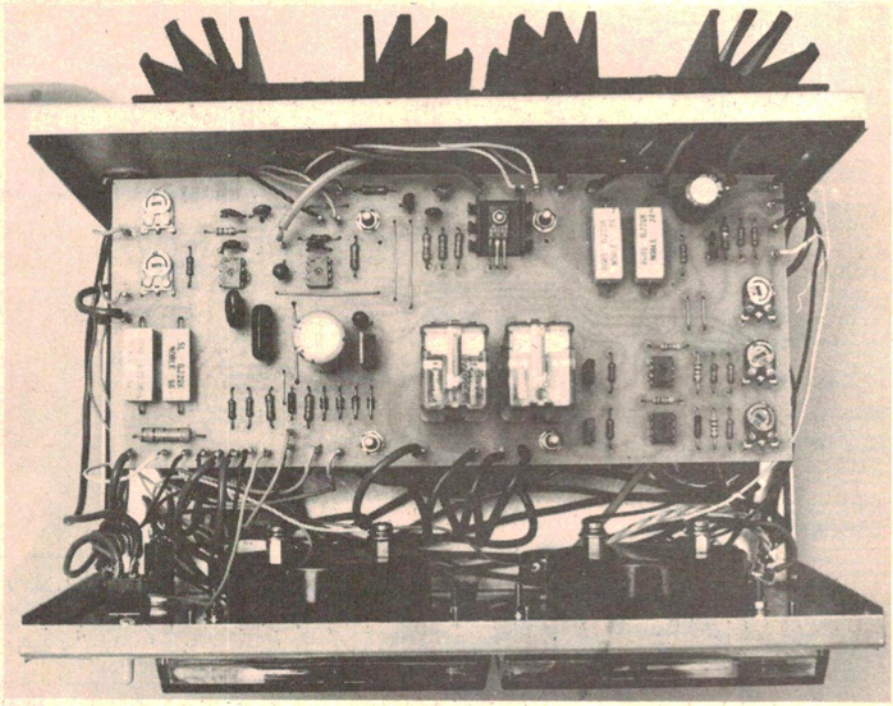
Now check the voltage across the output terminals. Vary the voltage control over the full range and ensure that you can vary it right from zero volts to a little over 40 V. We'll get around to calibrating the meter later.

The current-limit operation can now be checked. Set the output switch off. Connect your multimeter directly across the output terminals. Set it to the 5 A or 10 A range. Ensure the supply's current range switch is set to 0.5 A. Set the voltage control back to about a quarter-turn from minimum. Throw the output switch on. The voltage mode LED should go off and the current mode LED should go on. (This should also occur when the voltage control is set at minimum.) See that the multimeter reads a low current. If it doesn't, you've got the current range switch upside down.

Set the multimeter to a convenient scale (1 A or 2 A). Turn the current control around to maximum and see that the multimeter reads around 0.6-0.7 A. Now set the multimeter to the 10 A scale and the current range switch to 5 A. The multimeter should read between 6 A and 7 A.

If all's well, the two meters can now be calibrated.

First, the volts meter. With the multimeter still connected to the output terminals, set it to a convenient scale so that you can accurately read 20 V. Adjust the voltage control to obtain 20.0 V on the multimeter. Now adjust RV7 so that the volts meter on the project also reads precisely 20 V. Then set the voltage to read 5 V on the meter and check that the output's within ;0.25 V.



Top down view. Inside the lab. supply, showing board mounting and wiring.

I have done this because many devices, TTL ICs and op-amps in particular, require accurate supply voltages and most are driven from supplies of less than 20 V. With TTL ICs a supply in excess of 5.5 V can destroy the device. Calibrating the meter at 20 V ensures that the meter accuracy at the low end is sufficient to obviate problems. If it's a volt or two out on the 20-40 V end of the scale, it doesn't matter so much.

To calibrate the current meter, first set the supply's output switch off. Set the current range switch to 0.5 A and set both the voltage and current controls about a quarter-turn off minimum.

Switch on the supply output and adjust the current control to obtain a reading of 500 mA on the multimeter. Then adjust RV6 so that the current meter reads full scale. Set the multimeter to the 5 A or 10 A scale and the current range switch to 5 A. Set the current control so that the multimeter reads 5.00 A and adjust RV5 so that the current meter reads full scale.

The current control has to be re-adjusted when switching from 0.5 A to 5 A as the current sensing resistor for the 5 A range is not exactly 0.1 ohms, being made up from two 0R22/5 W resistors in parallel which are the only ones generally available. Some tolerance in values will account for a difference in any case.

Now the relay 'trip' points can be set. Turn RV2 and RV3 fully anticlockwise. Set the output voltage to something less than 10 V. You can do this adjustment using either the project's volts meter or your multimeter connected across the output terminals.

Slowly advance the voltage control until the output is 12.5 V or thereabouts. Then rotate RV3 clockwise until RL1 just clicks in. This trimpot gives a trip point range of about 3 V from about 11 V to about 14 V. You may notice the output actually drop a few hundred millivolts when RL1 pulls in, but this is of no consequence.

Having done that, slowly advance the voltage control until the output voltage reaches about 25.5 V. Then rotate RV2 clockwise until RL2 clicks in. The output will drop a few hundred millivolts when you do this, but as before, it's unimportant. This trimpot has a trip point range of about 6 V, from roughly 24 V to about 30 V.

That's it! Now you can screw the lid down and put your ETI laboratory supply proudly on the workshop shelf.

Tips on using it

Always set up the power supply with the output switch *off*. Set the output voltage to what is required by the circuit you're working on. Then set the current limit range switch to the appropriate range, press the current set button and adjust the current control so that the current meter reads a little above what you expect the circuit to draw. Don't forget to allow for relay turn-on currents, lamps, indicators and etc in the circuit.

With straight CMOS circuits, even those with a dozen or more ICs, a current limit of 100-150 mA is a good safe limit.

Beware of circuits which may draw peak currents several times the average current and set the current limit to take this into account (i.e: audio amplifiers, pulse circuits).

With a little experimentation and experience, you'll soon learn how to set up and effectively use the ETI-163 Lab. Supply. ●

Artwork. Here is full-size artwork for the pc board and the two meter scales. Unfortunately, the artwork for the front panel is too large to reproduce here. A photostat can be obtained by sending us a stamped-addressed A4-sized envelope. Scotchcal and pc board suppliers were listed on page 80 of the May issue.

You can obtain 1:1 positive or negative film of all the artwork for this project for $15 post paid from **ETI-163 Artwork, ETI Magazine, P.O. Box 21, Waterloo NSW 2017.** Make cheques or money orders payable to 'ETI Artwork Sales' and ensure you ask for **positive** or **negative** film, as you require.