Regulated POWER SUPPLY

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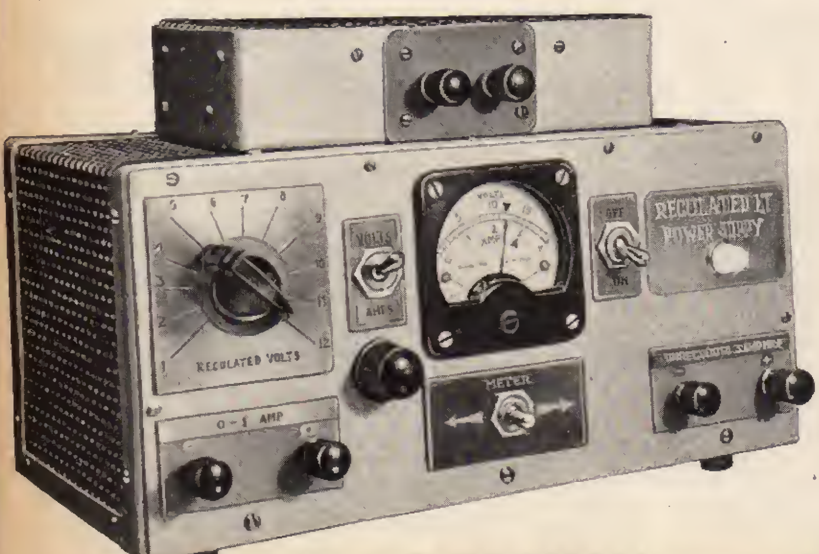


Due to the increased use of semiconductor devices for all purposes the author decided to produce a power unit, with a specification in the £20 to £30 Class, for as little cost as possible.

It was decided that a unit giving 1V to 12V at 1A with good regulation, and up to 3A unregulated would suit most purposes. Such a unit should be useful to Laboratories, Schools, Colleges, Experimenters, Radio Amateurs, Radio Servicing Workshops, etc.

CIRCUIT DESCRIPTION

The circuit diagram appears in Fig. 1. A mains transformer T1 having a 15–0–15 volt secondary winding feeds a conventional bi-phase rectifier circuit. Both of the silicon diodes D1, D2, are protected by a fuse, FS1 and FS2 respectively.

Some 23 or 24 volts (unit off load) are produced across the reservoir capacitor C1 and when S2 is in the "Unregulated" position, the appropriate terminals, TL2, TL4, are connected to C1 via the meter shunt R5 (in the negative lead to TL2).

The Volts/Amps switch S3 is shown in the "Volts" position and the meter M1 with multiplier R8 is connected across the supply lines and thus registers the output voltage.

In the "Regulated" position of S2, a three-stage d.c. amplifier is brought into circuit and provides up to 12V 1A at the terminals TL1, TL3. The final stage of the amplifier TR3 is an OC29 in series with a 5 ohm power resistor R4 capable of dissipating some 50 watts when necessary. The output voltage is adjusted to the required value by means of VR1 connected with R2 across the Zener diode D3. This diode should be suitable for 6V operation or thereabouts.

The potentiometer VR1 sets the emitter voltage of the *npn* transistor TR1, while the base has a voltage decided by the potential divider across the output terminals, VR2, R6, R7. The portion of the output which appears across R6 plus VR2 will decide the extent to which all the three stages of amplification will conduct. TR3 draws current via the power resistor R4 and adjusts the output voltage to that set by the voltage control VR1. The control VR2 can be used to calibrate the output to 12V when the unit is built, but further use of this control is mentioned below. When the output voltage is adjusted to less than 12V, a current in excess of 1A is available. Example: At 8V approximately 1·5A, and at 5V approximately 2·0A.

The collector circuits of TR2 and TR3 are returned to the negative side of C1 to eliminate collector current flow from the shunt R5. The negative busbar of the printed circuit (shown heavy in Fig. 1) draws a small amount of current through the shunt R5, but this is only about 0·1A and causes little difficulty in the use of the meter in the amps position.

By decreasing the value set by VR2 the output voltage can be increased to 20V if necessary; however, the available current is only 0·18A at this voltage but the higher voltages could be a real asset at times. Fig. 2a shows typical voltages and currents available at more than the nominal 12V. The output voltage dial will of course divide the new voltage into 12 parts. Example: If the output dial of VR1 is set to an indicated "12" and VR2 is used to give a monitored voltage of 18V, then VR1 dial can be interpreted as one division equalling 1·5V.

UNREGULATED OUTPUT

Returning to the unregulated position, Fig. 2b shows the terminal voltage fall against varying load current. A hint can be taken from this curve; it is good practice to monitor the voltage first and *do not* switch to "Amps" if the voltage is shown to be *below 14V*. In the latter event the current will be somewhat more than 4A and the meter switch S3 should therefore be kept in the "Volts" position.

DISSIPATION IN THE OC29

The OC29 power transistor (TR3) should be mounted *directly* (no micas) onto some three inches of 5in wide heatsink and no trouble should be experienced unless there are high ambient working conditions. Fig. 3 shows the dissipation of the OC29 for varying output voltage. It can be seen that regular use of this circuit for outputs of 9V or more and at low current loading would suggest the use of a dummy load on these occasions to make the combined load current about 1A.

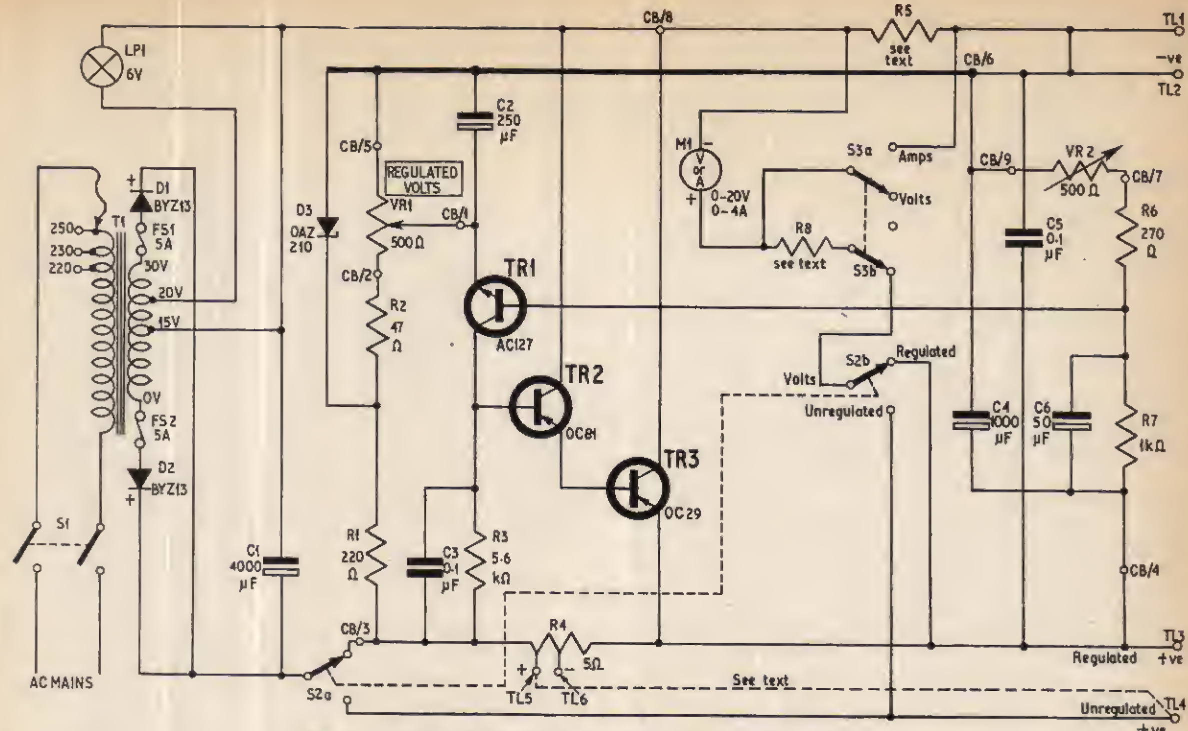


Fig. 1. Circuit diagram of the regulated power supply unit

INCREASED OUTPUT CURRENT

The dissipation in R4 increases as the output voltage is reduced by VR1. When the output voltage is down at 1V or minimum (about 0·74V) the current in R4 will be almost 3A and the power dissipation approximately 45 watts. The dissipation is a little more than 50 watts when the smaller part of R4 is short circuited.

Increased current at all voltages can be obtained by reducing the value of the power resistor R4. To this end a tapping point is fixed in order to reduce the 5 ohm resistor to 3·4 ohms when required. Terminals TL5, TL6 are used to fix a shorting link on the smaller part of R4. **CAUTION.** This facility should only be included and/or used with care and understanding. Fitting the shorting link without the drawing off of reasonable load current may rapidly burn out the power transistor TR3.

SIMULTANEOUS OUTPUTS

Switch S2a arranges that only the "Regulated" or the "Unregulated" output is available at any one time. It may be desirable to have both outputs in use at the same time and this can be arranged in a simple manner. By linking externally on the unit, connect the positive terminal (TL5) of R4 to the *unregulated* positive output terminal TL4. *On no account must the unregulated positive and regulated positive terminals become connected otherwise the OC29 will be fused instantaneously.*

SHORT CIRCUITS OF THE LOAD

Short circuits in the "Unregulated" position will blow the 5A fuses. The diodes used are a heavy current type and surge limiting resistors have not been fitted. Early tests were made to check on the short circuit current and the particular type of transformer (secondary rated at 2A) was run at 19A on short circuit to varify that diode trouble will never occur.

Short circuits in the "Regulated" position produce a short-circuit current of only 3A via R4 and no damage can result to the unit. More expensive units available on the market sometimes have circuit protection, but costs are high and 3A was not seen as a damaging current in the circumstances.

(a)

Volts	14	16	18	19	20
Amps	0·85	0·6	0·4	0·3	0·18

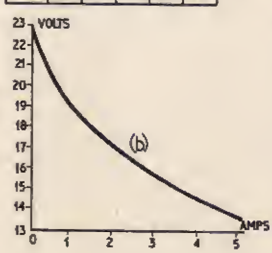


Fig. 2(a). Typical maximum load currents available at various voltages between 14–20V. (b) This curve indicates how the terminal voltage falls as the load current increases

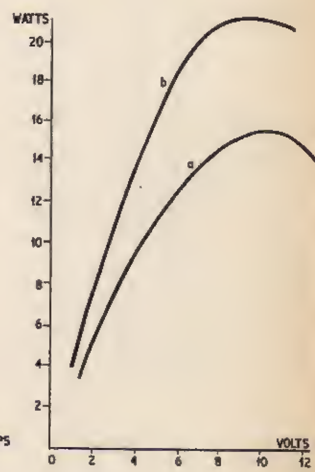


Fig. 3. Collector power dissipation at "off load" for different terminal voltages (TR3, OC29)

REGULATION OF REGULATED OUTPUT AND RIPPLE

The regulation of the output depends upon the gain of the transistors in the amplifier but the constructor should aim for a volts drop of only 25mV for a full load current of 1A (0·025 ohm output). The ripple on the output should be down to about 3mV peak-to-peak.

GENERAL LAYOUT AND CHASSIS ASSEMBLY

The general arrangement of the components can be seen in the plan view photograph, and the various diagrams explain the detail.

Fig. 4 shows constructional details for the chassis assembly, assuming the builder obtains certain components as recommended. The baseboard is ½in plywood to facilitate the general construction.

A metal cover of perforated material completes the enclosure of the unit, see Fig. 5.

WIRING DETAILS

Wiring details are given in Fig. 7. The output terminals are all isolated from the case which is connected back to the mains earth terminal (three-core cable). The heatsink for TR3 is mounted in a large slot in the rear panel and is secured in position by means of 4B.A. nylon bolts. This is shown in Fig. 4.

PRINTED CIRCUIT

The three-stage d.c. amplifier is built on a printed circuit board, see Fig. 6b for full size pattern.

The layout of components on the printed circuit board is shown in Fig. 6a. External connections are made at points 1 to 9.

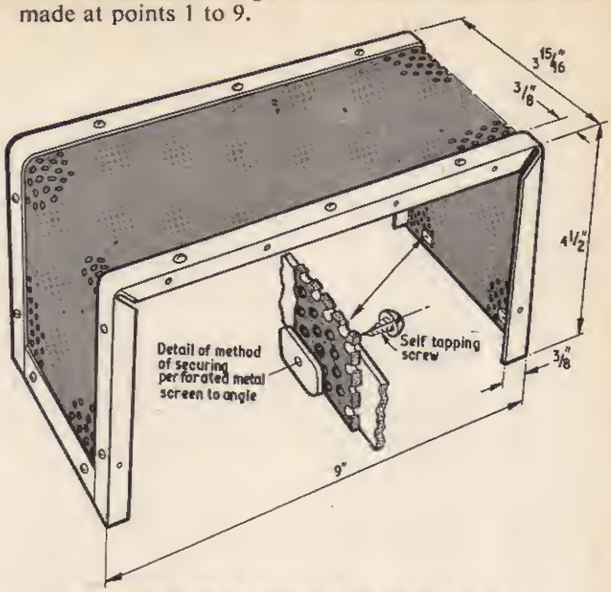


Fig. 5. Metal case to enclose main chassis assembly

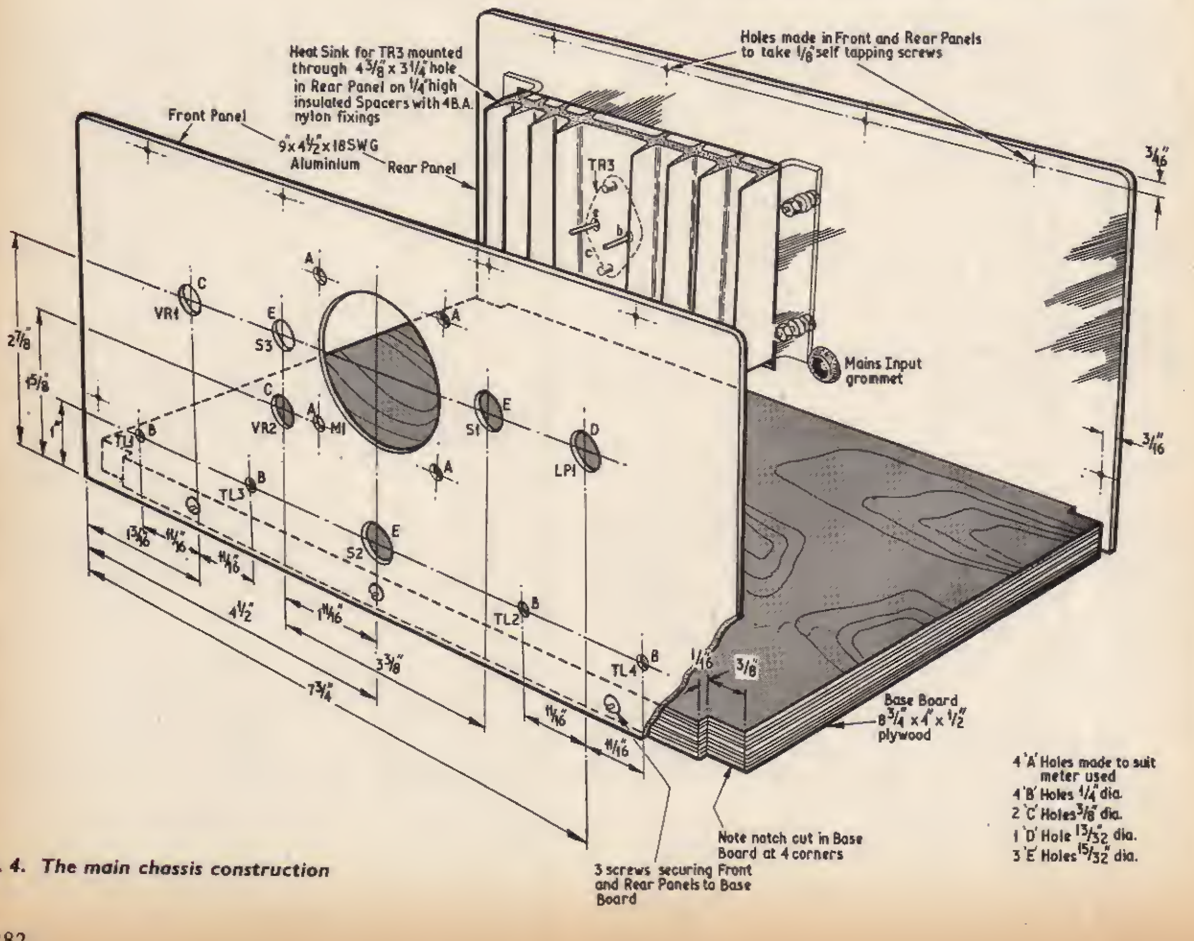
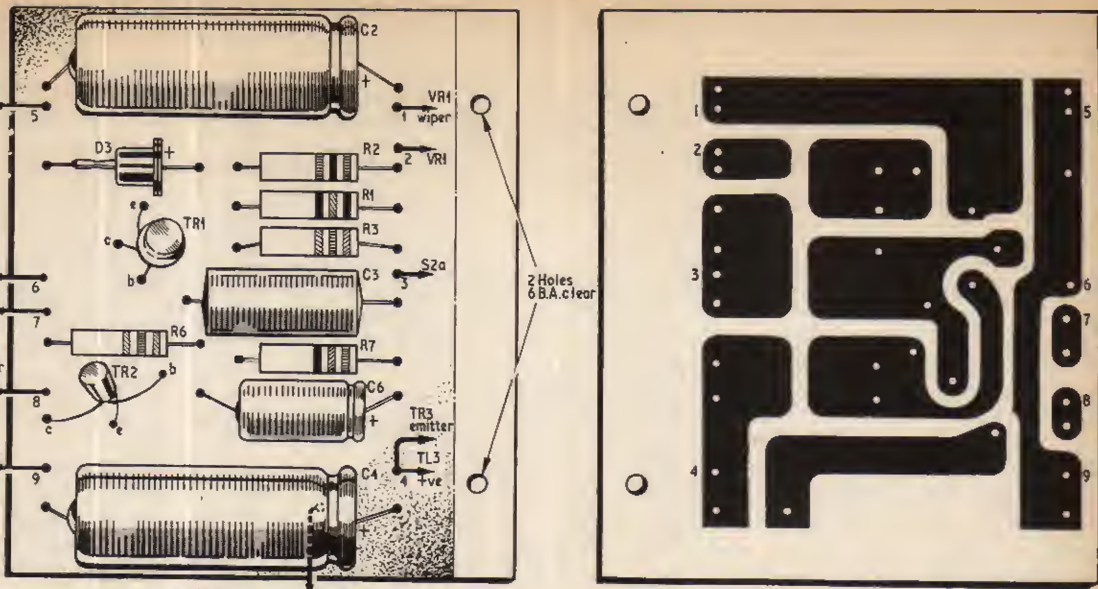


Fig. 4. The main chassis construction



(a) (b)

Fig. 6. Printed circuit board. (a) arrangement of components on plain, insulated side of board. (b) full size pattern on copper clad side of board

COMPONENTS . . .

Resistors

- R1 220Ω 1W
- R2 47Ω 1W
- R3 5·6kΩ 1W
- R4 5Ω, tapped at 3·4Ω (see text)
- R5 meter shunt (see text)
- R6 270Ω 1W
- R7 1kΩ 1W
- R8 4kΩ meter multiplier

Potentiometers

- VR1 500Ω 3W wire wound (Colvern CLR 4239/264)
- VR2 500Ω 1W wire wound

Capacitors

- C1 4,000μF elect. 25V
- C2 250μF elect. 15V
- C3 0·1μF paper
- C4 1,000μF elect. 25V
- C5 0·1μF paper
- C6 50μF elect. 15V

Transistors

- TR1 AC127
- TR2 OC81
- TR3 OC29

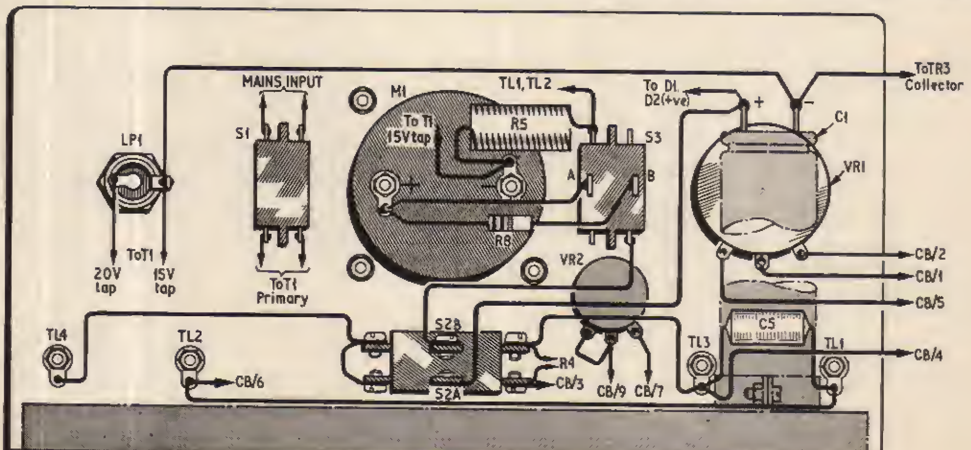
Diodes

- D1, D2 BYZ13 5A 100V peak inverse (Mullard) (2 off)
- D3 OAZ210 Zener 6V (Mullard)

Miscellaneous

- LP1 Indicator lamp 6V, with holder and coloured lens
- M1 Moving coil meter. 5mA f.s.d. modified to read 0–20V, and 0–4A (see text)
- S1–S3 D.P.D.T. toggle switches (3 off)
- T1 Mains transformer. Secondary tapped at 0, 15, 20 and 30V, 2A. (Douglas MT3AT)
- TL1–6 Terminal, chassis mounting, insulated (3 red, 3 black)

Material for chassis and case. Heatsink



CB/1 etc = Printed Circuit Board connections

Fig. 7. Rear view of front panel with wiring details

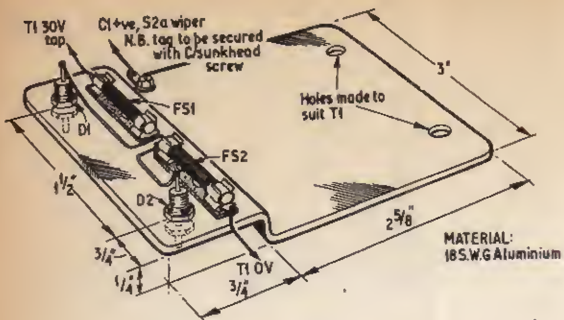
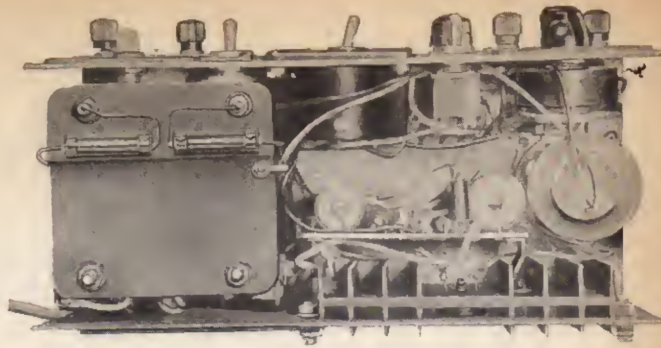


Fig. 8. Details of the heatsink for D1, D2 which is mounted on top of transformer T1



General layout and disposition of components

The diodes D1, D2 are mounted on a heatsink which is bolted to the top of the mains transformer by means of nylon nuts and bolts. The two fuses are also accommodated on this heatsink, but are insulated electrically by their plastics base, see Fig. 8.

The printed circuit can be seen edgewise; it is mounted with an angle bracket onto the wood base board. The large reservoir capacitor C1 is seen on extreme right-hand side.

The separate housing for the power resistor R4 is described in Fig. 9b. Alternatively, six 21 ohm resistors could be distributed throughout the main unit as described under the heading "Power Resistor" to eliminate the need for this additional box.

METER SHUNT (R5)

Heavy gauge resistance wire can be used to make a suitable shunt for the 4A range of the meter. The wire should carry 3A without undue heating. The shunt can be prepared before building it into the circuit in the following manner.

Pass 4A d.c. through 12in of chosen material with the positive end of the méter moving coil connected to the wire intended for joining to S3a. The negative end of the moving coil is now connected to the shunt within some ½in of the other point. Slide the negative wire along the shunt wire until a full scale deflection is obtained on M1. Solder the negative lead at the precise point found. Leave an additional ½in of shunt material in order to solder the heavy, low resistance lead which will connect the shunt to the negative terminal of C1.

POWER RESISTOR (R4)

Fig. 9a shows the construction of the power resistor R4. A ceramic former is wound with 10ft of 23 s.w.g. oxy-ferry wire.

Alternatively, four 21 ohm 10W resistors can be arranged in parallel to produce the required 5 ohms, and two further identical resistors added to give the lower value.

The power resistor is fitted inside a separate housing, made of metal with a perforated top cover, see Fig. 9b. This housing is secured to the top cover of the main unit. The bottom of the housing is open and leads from the main unit are brought up through the perforated metal cover and connected to R4.

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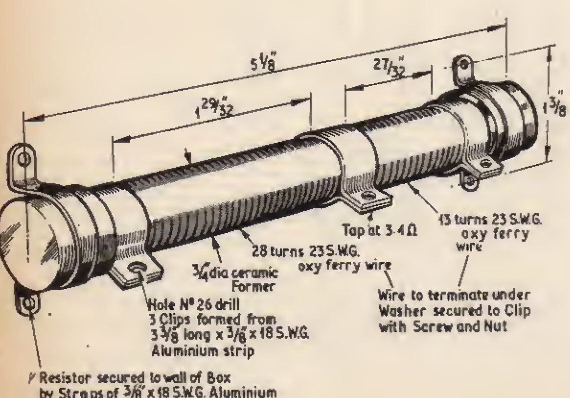

Fig. 9a. The construction of the power resistor R4

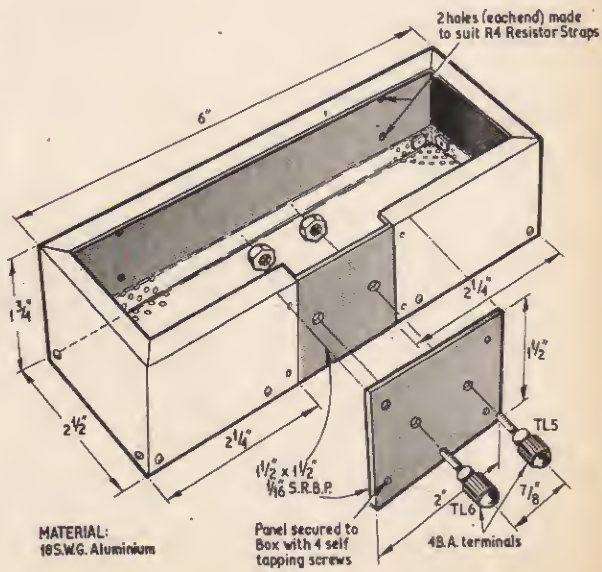

Fig. 9b. Metal housing for the power resistor

REGULATED POWER SUPPLY

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	VOLTS						mA	A
	A	B	C	D	E	F	I_2	I_1
No load current	1.0	0.17	14.2	0.68	0.47	2	65	2.7
	2.88	0.145	11.4	0.5	0.38	6	40	2.1
	5.8	0.12	7.0	0.36	0.28	12	18	1.4
1A Load	0.99	0.165	14.1	0.61	0.40	2	36	1.9
	2.86	0.143	11.3	0.41	0.30	6	18	1.3
	5.78	0.119	6.9	0.23	0.17	12	3.5	0.32

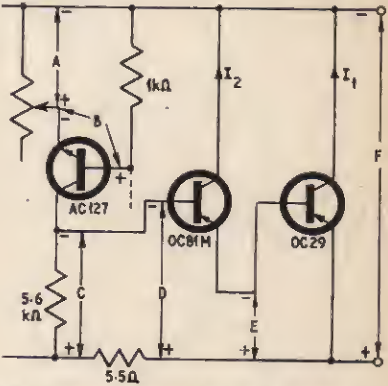

Fig. 10. Test measurements for fault-finding

CALIBRATION OF OUTPUT VOLTAGE

After checking the voltmeter accuracy against an AVO or similar instrument known to have good accuracy itself, the Regulated Volts dial should be adjusted as follows.

Switch S2 to "Regulated" and S3 to "Volts" and turn VR1 until 1V is obtained at the output (best seen on the AVO). Loosen the knob and rotate to indicate 1V on the calibrated dial. Lock the pointer knob grub screw while indicating the correct 1V. Rotate VR1 until the dial indicates 12V output. Now adjust VR2 until 12V output (measured) is obtained.

VOLTAGE CHART

Fig. 10 gives typical voltages at six points in the d.c. amplifier circuit for three different output voltages. Reference to these voltages and to the currents of the super-alpha pair TR2, TR3 should assist in any fault-finding. ★