4–20 VOLTS REGULATED POWER UNIT

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THE power supply described uses the same feedback principles as in closed loop control systems and is capable of delivering 1A at any voltage between 4V and 20V. A separate 45V d.c. output is also available making the power supply particularly suitable for audio amplifier work where good regulation is required for the low voltage pre-amplifier stages and a higher d.c. supply required for the power output stage, generally of the order of 45V, the regulation of this not being so critical.

Three pairs of sockets for the regulated output have been provided to enable the power supply to supply several loads with the minimum of inconvenience. These outputs have been left floating and a separate earth socket provided such that the supply can be connected to give a positive output with respect to earth or a negative output with respect to earth. The negative output of the 45V supply is connected in common with the negative output of the regulated supply.

Variable current limiting from 0·2A to 1A is included making the power supply particularly suitable for development work and also giving it protection from short-circuit surges.

Principle

The principle of negative feedback is used in systems where accurate control is required. The system could be a positional servo as used in rudder control of a model aircraft, speed control of an electric motor, temperature control of a blast furnace or cooker or as in this example, voltage stabilisation. In each case a sample is taken of the final output, a comparison made with some reference, then corrective adjustments made to reduce the error.

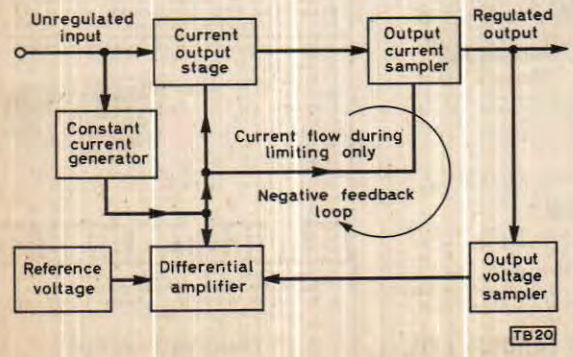

Fig. 1: Block diagram showing function of stages in the power unit.

The block diagram of Fig. 1 illustrates the principle of voltage control where the controlling device is in series with the output current. The output is monitored by a sampler and the sample voltage compared to a reference voltage by a differential amplifier.

The differential amplifier amplifies the difference such as to starve the output stage of base current if the sample voltage is greater than the reference. As a transistor is basically a current amplifying device complete control of the output current can be achieved by controlling the base current of the current output transistor.

Current Output Stage

Transistors are current amplifying devices and in general the more current they are capable of handling the less gain they have. A power transistor capable of passing 1A can have a typical β (current gain) of only 10 which would mean that the base current would still be rather high for the differential amplifier to handle, being in the region of 100mA. The current output stage is simply a configuration of two transistors, Tr3 and Tr4, Fig. 2, to give high output current capability with high current gain.

Constant Current Generator

The output current of this circuit, Tr2, is constant and sufficient to supply the maximum base current of the current output stage with a little extra for the differential amplifier.

The circuit uses the principle that as the base-emitter junction of a transistor is a forward biased diode then it will present a low voltage drop (0·7V in the case of silicon transistors). The zener diode potential will therefore be applied almost completely across R6. The resulting current through R6:—

$$I = (V_z - 0{\cdot}7)/R6$$

will pass through the transistor without loading the zener diode.

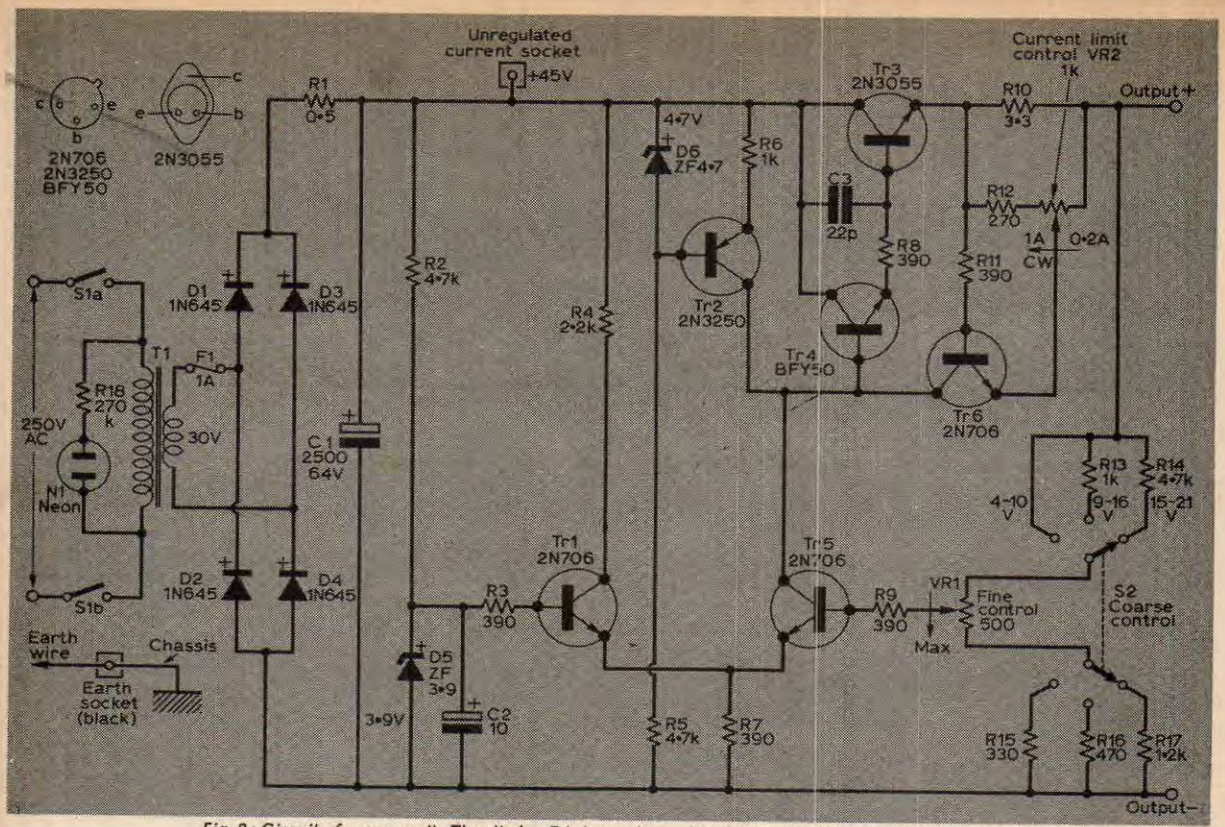

Fig. 2: Circuit of power unit. The diodes D1-4 may be replaced by a single bridge rectifier unit.

Bias current for the zener diode will be supplied by R6. A constant current output of 4mA was sufficient to supply the output stage and the differential amplifier.

Differential Amplifier

The differential amplifier, Tr1 and Tr6, is coupled to the base current circuitry of the current output stage. It takes current surplus to that required to maintain the correct amount of output current.

The amplifier amplifies the difference between its two inputs hence the term "differential amplifier." In this case it is used as a current control device.

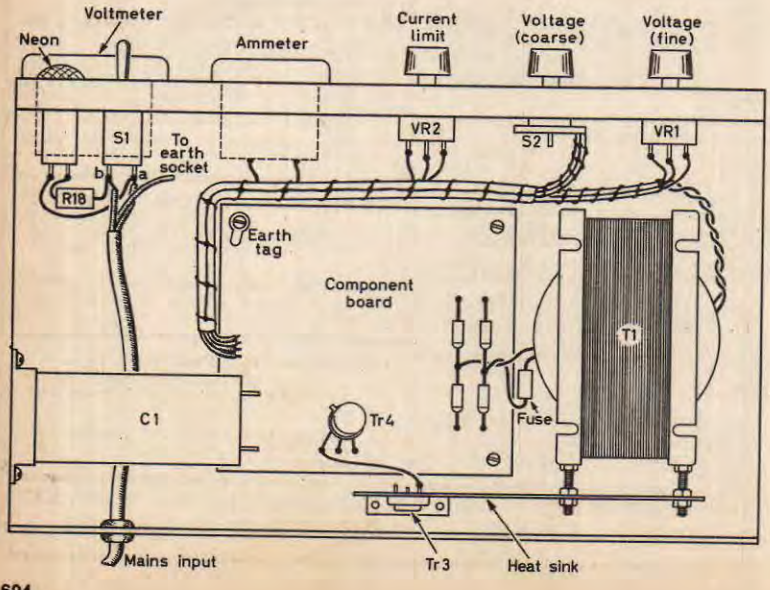

Fig. 3. Layout of unit constructed by the author. See Fig. 4: for details of the component board.

Reference Voltage

This is obtained from a zener diode, D5, an attempt being made to keep the diode current constant by connecting a capacitor across it. This is necessary as low wattage zener diodes have a high series internal resistance resulting in their output voltage varying with current.

The regulated output voltage of the power supply would normally be preferred to supply bias current to the zener but as this will be switched over wide ranges in this case, bias current has been supplied from the unregulated input through a 4·7kΩ resistor R2 giving a bias current of 10mA.

Output Sampler

The resistor chain is strapped across the output voltage and the tapping point will always be at 3·9V. There are three separate resistor chains in order to reduce the sensitivity of VR1.

It is worth mentioning that the output of this power supply can never be less than the reference voltage generated by D5. If 3·9V is not low enough then a 2·7V zener may be used for D5 and if necessary, the sampling chain recalculated.

Construction

Not much information need be given on the construction of this unit since much will depend upon the dimensions of the components used. Fig. 4 shows the layout of the component board and the interconnections with the remaining components.

Fig. 3 illustrates the general layout of the power unit as built by the author. Note that the transistor case of Tr3 forms the collector connection and must be insulated from the heat sink with the mica insulation kit generally supplied with the transistor. Check after assembling the transistor and heat sink that there is no conducting path between the transistor case and the heat sink.

The heat sink used here is made from aluminium sheet $4\frac{1}{2} \times 2\frac{3}{4}$in. bolted to the main chassis.

It is worth adding that where wire-wound resistors are used there is always a tendency for oscillation to occur. These resistors, from the nature of their construction, are slightly inductive. Often this effect can be corrected by the addition of a small capacitor of 20 to 100pF coupled across the resistor to tune out the effect of the inductance. ■

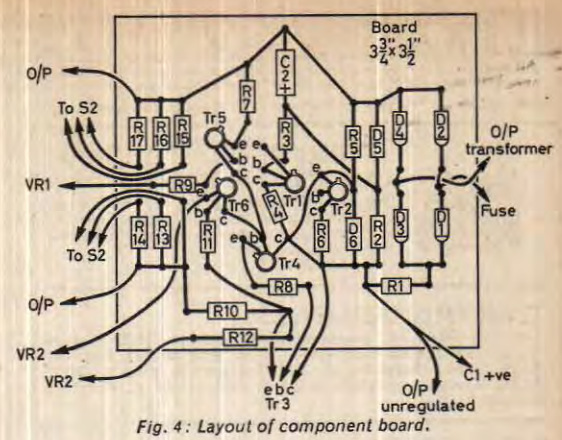

Fig. 4: Layout of component board.

★ components list

Resistors

R1	0·5Ω	R7	390Ω	R13	1kΩ
R2	4·7kΩ	R8	390Ω	R14	4·7kΩ
R3	390Ω	R9	390Ω	R15	330Ω
R4	2·2kΩ	R10	3·3Ω3W	R16	470Ω
R5	4·7kΩ	R11	390Ω	R17	1·2kΩ
R6	1kΩ	R12	270Ω	R18	270kΩ

All resistors except R10 are ½W
VR1 500Ω linear carbon pot
VR2 1kΩ linear carbon pot

Capacitors

C1 2500μF 64V C2 10μF 25V
C3 22pF polystyrene

Semiconductors

Tr1 2N706 or BC107, 2N930 or 2N2484
Tr2 2N3250 or BCY30, 31, 32 or 2N3250
Tr3 2N3055 or BDY 38, with insulating washer etc.
Tr4 BFY50 or 2N1711, 1613 or BFY51
Tr5 2N706 or BC107, 2N930 or 2N2484
Tr6 2N706 or BC107, 2N930 or 2N2484
D1 1N645 D4 1N645
D2 1N645 D5 ZF3·9 (400mW)
D3 1N645 D6 ZF4·7 (400mW)

Miscellaneous

Transformer 30V 2A (Type MT3AT). S1, 2 pole 2 way toggle switch. S2, 4 pole 3 way, make before break wafer switch, used as 2 pole 3 way. Sockets, red (4), black (5). Neon lamp, Q1332 (Bulgin) or equivalent; some equivalents have built-in resistor —if so delete R18. Fuse holder with 1A fuse. Veroboard, plain, $3\frac{1}{2}$ x $3\frac{1}{2}$ in., 0·1 in. matrix. Aluminium chassis, $10\frac{1}{2}$ x 9 in., panel 12 x 9 in., heat sink $4\frac{1}{4}$ x $2\frac{3}{4}$ in. Voltmeter 20V, ammeter 1A, if required.