

VK Powermate

Build this 5-amp power supply and retire that messy battery



In the last year or so there has been a growing demand for a power supply to run amateur-band transceivers which run from a nominal 12V supply. The supply featured provides 13.8V DC at up to 5 amps. It has very good line and load regulation, over-voltage protection and negligible hum output.

by LEO SIMPSON

More often than not, radio amateurs are running high-performance "mobile" transceivers from a car battery teamed with a trickle charger. Such an arrangement is reasonably satisfactory, provided the amateur is not "on the air" for long periods which would tend to discharge the battery. Even apart from this, operating from a car battery is not the safest method nor does it provide 13.8V.

The VK Powermate presented here is adjusted during construction to give an exact 13.8 volts output. For load variations from zero to 5 amps, the output voltage drops by less than 30 millivolts. To put it another way, the output impedance is less than 6 milliohms. Hum and noise is less than 5 millivolts peak-to-peak at 5 amps. Both the above parameters, regulation and ripple rejection, apply for mains voltage variations from 220 to 260 volts and the line regulation for this range is 4mV or less.

This performance is maintained with little variation over a wide temperature range.

The odd figure of 13.8 volts DC is selected because the majority of transceivers are rated to give maximum RF output with this voltage. Originally, transceivers of this type were designed primarily for use in cars where a

nominal 12V supply is available from the battery.

However, since the electrical system in a car normally runs at between 13 and 14 volts, the manufacturers of transceivers long ago decided to rate all their equipment for about 13.8 volts. This enables considerably more power to be achieved, as much as 20 per cent more, than would be available if the rating was at exactly 12V.

Ergo, since amateur radio operators are keen to obtain the maximum performance from their equipment, this power supply provides 13.8 volts DC.

Apart from the provision of fuses, the VK Powermate does not have short-circuit protection. Our first prototype did have a "foldback" current-limiting characteristic, which gives reduced power dissipation under short-circuit conditions, compared with a simple current-limit characteristic. Unfortunately, the line regulation was found to be inadequate so we discarded the current limiting feature.

The circuit of the VK Powermate is based on the 723 regulator integrated circuit. This was originally introduced by Fairchild as the uA723, second-



This photo shows a typical transceiver teamed with the VK Powermate.

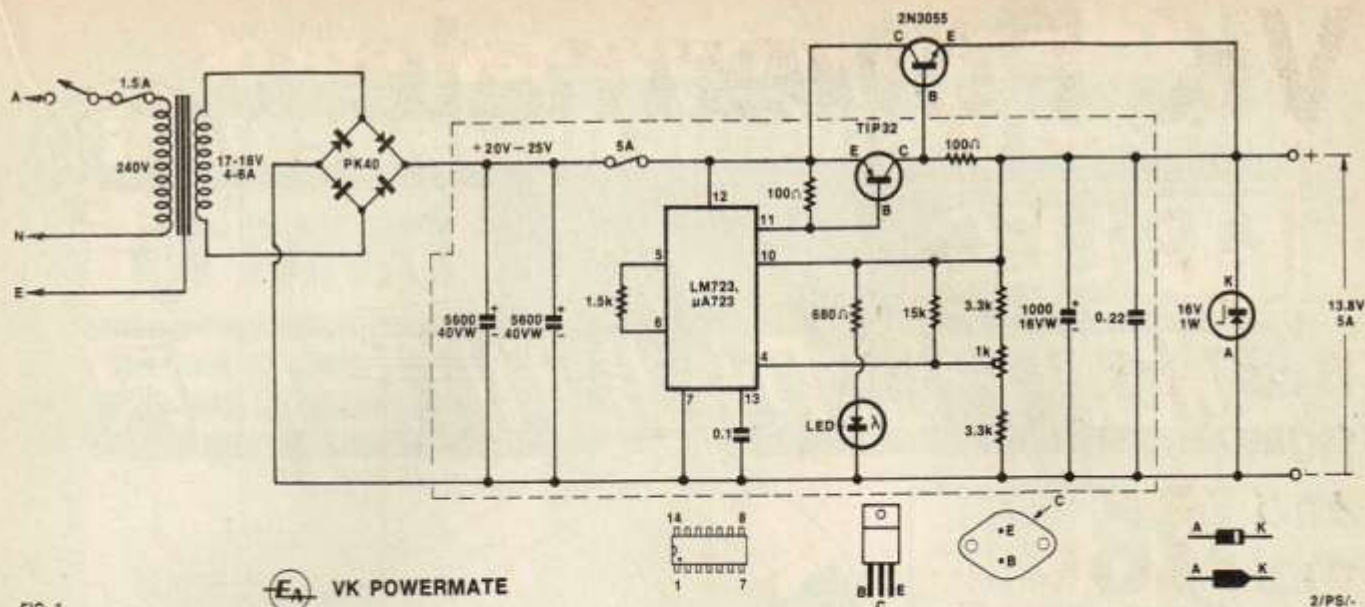


FIG. 1

VK POWERMATE

While it comprises relatively few components, this circuit gives very good regulation characteristics.

sourced by National Semiconductor as the LM723 and produced by other manufacturers with similar "723" designation.

Figure 1 shows the complete circuit diagram of the VK Powermate while figure 2 shows the schematic of the 723 regulator. The latter figure shows the 723 regulator as comprising a series pass transistor, error amplifier and reference voltage source. The error amplifier compares a proportion of the output voltage with the internal reference voltage source and makes continual adjustment to the base current of the series pass transistor.

Maximum current rating of the series pass transistor in the 723 regulator is 150 milliamps. This requires amplification by at least two transistors to obtain a reliable 5 amp supply. A first approach would be to combine the 723 with two power transistors in a Darlington configuration. This is how we did it with our first prototype.

While it is simple in concept, a problem with a Darlington "voltage follower" configuration is that it is almost impossible to saturate. This problem is compounded, in the case under discussion, by the fact that the internal output circuitry of the 723 is also a Darlington pair.

The resulting double-Darlington has four base-emitter junctions in series and needs quite a high voltage drop from input to output in order to function correctly. In other words, it has a high "drop-out" voltage, below which the ripple rejection and regulation is poor. When this factor is combined with the voltage loss inherent in a current limiting circuit, the circuit is impractical.

For these reasons we adopted a less conventional method of using the 723 to drive external power transistors. The internal series pass transistor of the 723 provides current drive to a PNP power

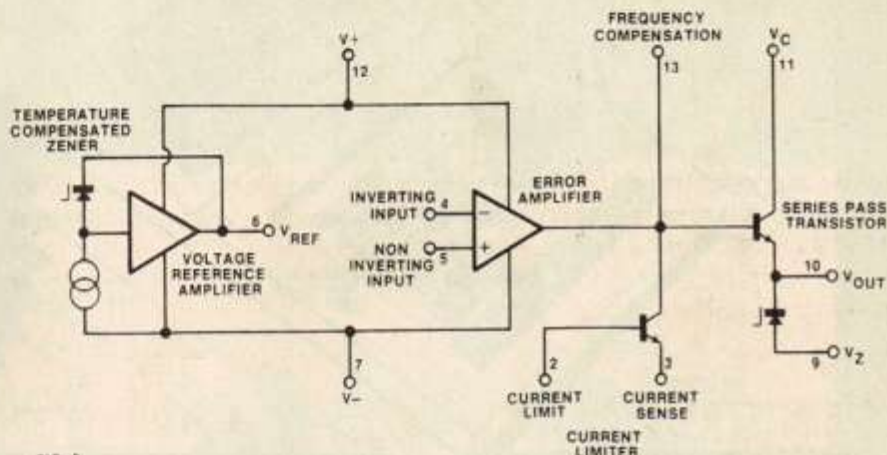


FIG. 2

transistor (TIP32) which, in turn, provides current drive to an NPN power transistor (2N3055).

This arrangement has a low dropout voltage of about 3V, which is equal to that of the 723 when used alone. Consequently, this circuit has very good line regulation without having excessive power dissipation.

Both the external power transistors have 100 ohm resistors connected between base and emitter to avoid the possibility of high temperature leakage degrading the regulation characteristic.

A 1.5k resistor is connected between pins 5 and 6 of the 723. This is included to make the source impedance feeding the non-inverting input of the error amplifier approximately equal to the source impedance of the output voltage divider which drives the inverting input. Adding this single component makes quite a worthwhile improvement to the temperature stability of the output voltage.

The output of the regulator is heavily bypassed to give a low output impedance at radio frequencies and to ensure good transient response.

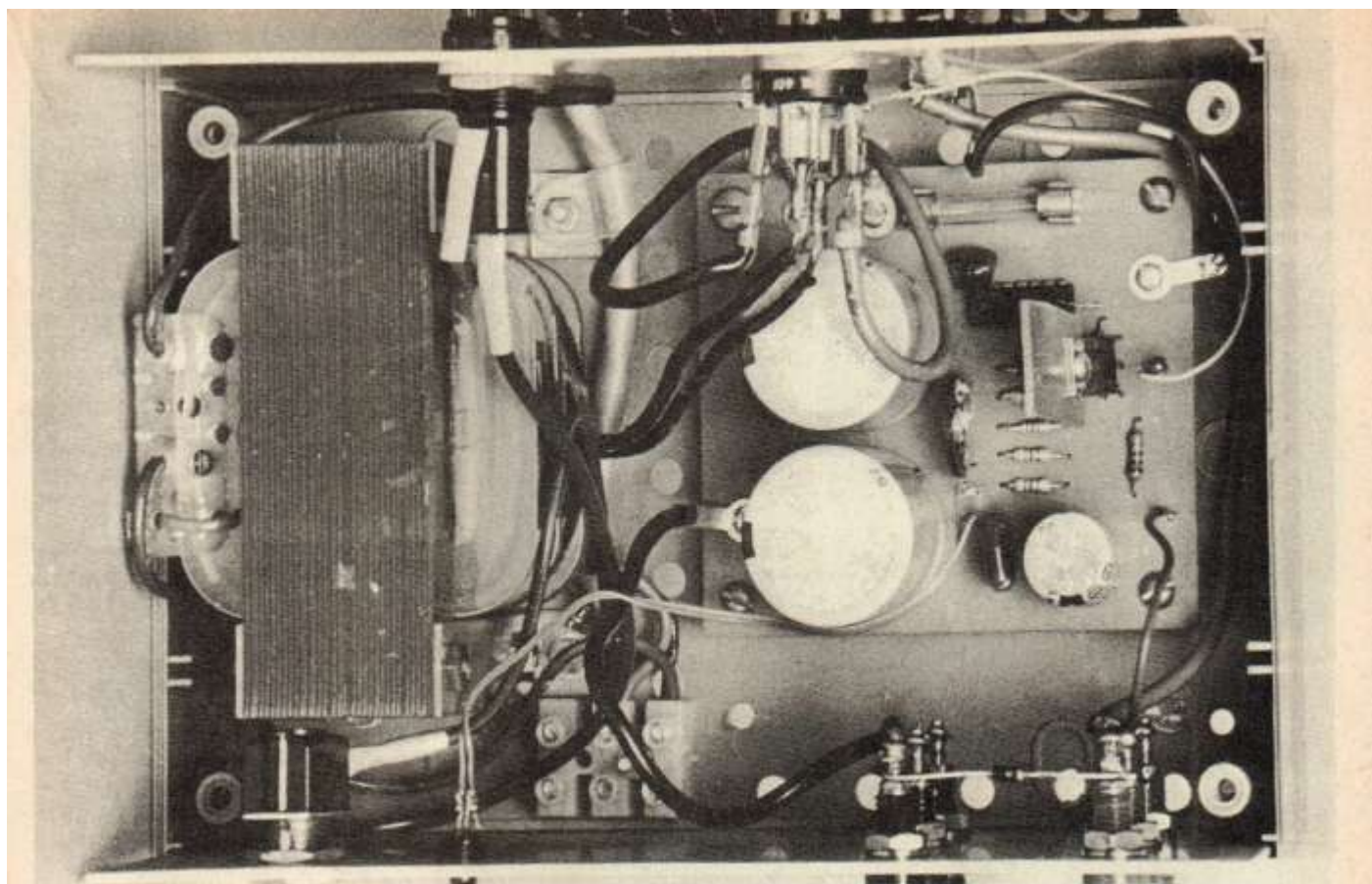
A crude but effective method of

over-voltage protection is used in this circuit. It consists of a 16V zener diode, of 1W or higher rating, wired directly across the output terminals. If, for any reason, the regulator circuit malfunctions and the output voltage tends to rise above 16 volts, the zener will draw very heavy current and blow the 5 amp fuse.

In blowing the 5 amp fuse the zener itself will go short-circuit unless it has a rating of 3 watts or more, in which case it will probably survive. No doubt there are more elegant methods of protecting transceivers against over-voltage, but this method is simple and reliable.

In other respects the circuit is quite straightforward, although a number of practical aspects need to be mentioned.

Most of the circuit components with the exception of the transformer, bridge rectifier and output transistor, are mounted on a PC board measuring 81 x 91mm. Dominating this PC board are the two 5600uF/40VW electrolytics (Elna) which have a combined ripple rating of 8.6 amps at 12Hz. Substitution of smaller electrolytics is not recommended, as their lower ripple



Use 4mm auto cable for the high-current wiring. The wiring diagram and this photograph should be closely followed.

ratings will result in reduced life expectancy.

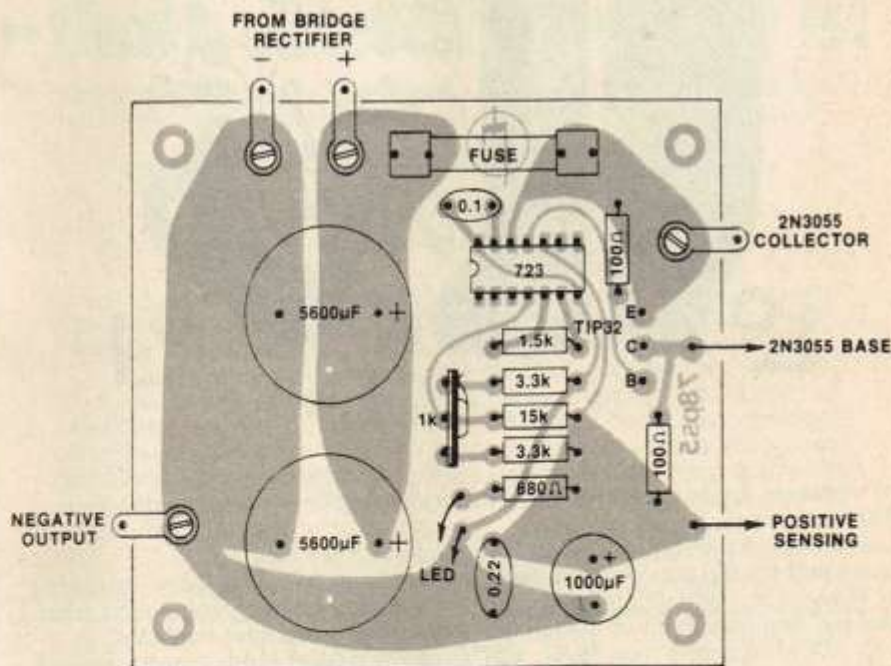
Do not substitute a less rugged transistor for the TIP32, which has a collector current rating of 4 amps. Other transistors (such as 2N3053 or BD140) will work, but on overloads they will "punch through" before the 5 amp fuse blows. And if that happens, the 723 IC will blow too.

By the same token, do not try to boost the output rating of the Powermate by increasing the fuse rating. This raises the possibility of damage to the 2N3055 before the fuse blows. If the 2N3055 does blow in these circumstances, it can easily take the TIP32 and the 723 with it. It is possible to boost the rating of the Powermate, by modifying the circuit; we discuss this later.

A small flag heatsink is fitted to the TIP32. This is made of light-gauge aluminium measuring about 20 x 30mm.

Heavy currents flow in this circuit. We had to devise an effective method of making low-resistance, high-current connections. One method is to use solder lugs. We secured the solder lugs with screws and nuts and soldered the nuts to the copper pattern of the PCB. Another method which is more elegant, is to use Utilux connectors such as we used on the bridge rectifier.

Low current connections to the PCB can be made with PC stakes. When assembling the PCB install the smaller components first.

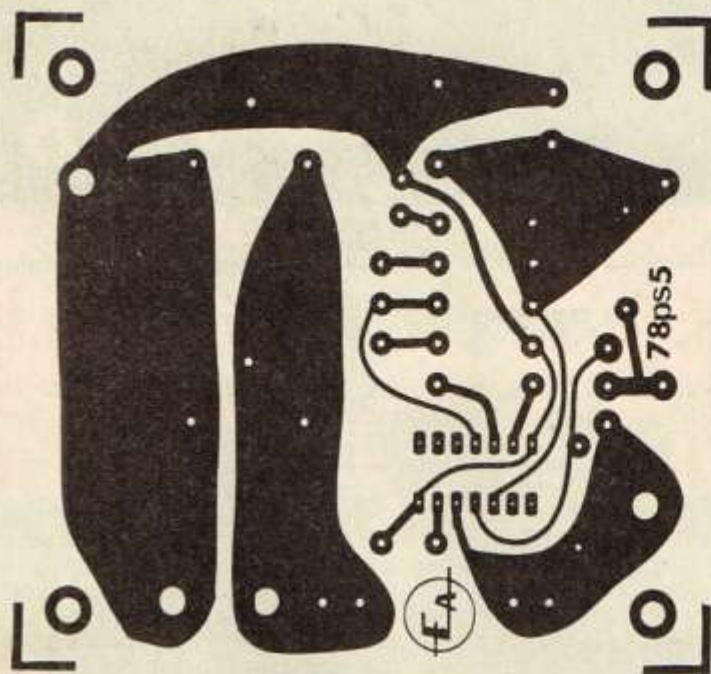
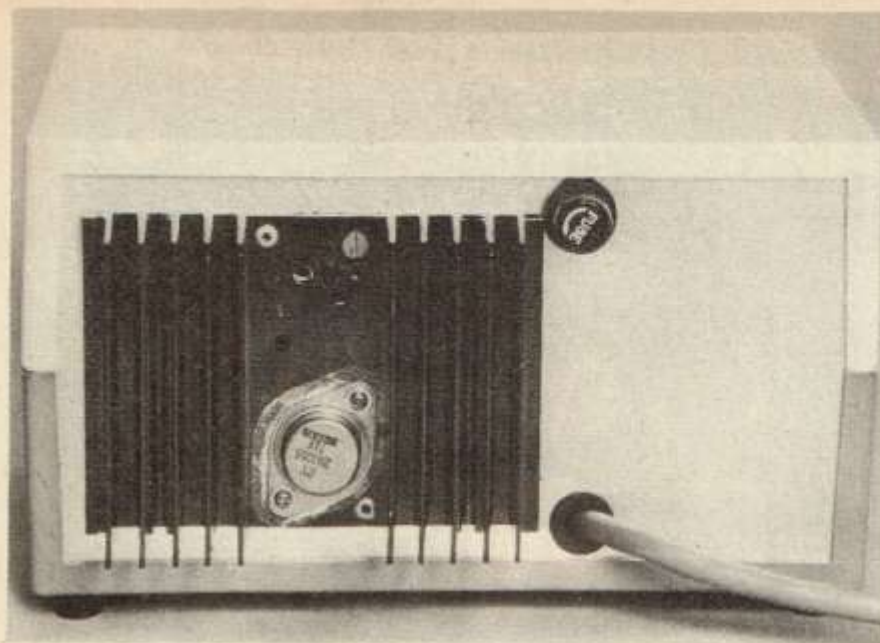


At the time of writing there were no readily available cases at reasonable prices. The one we used is made in England by Vero Electronics (part No 23507) and is quite expensive. It measures 206 x 116 x 139mm (W x H x D). No doubt most amateurs will be able to obtain a suitable case, even if they have to make it themselves.

The case should be well ventilated to dissipate heat produced by the

transformer and other components inside.

The transformer we used was kindly supplied by Dick Smith Electronics and is listed in their catalog as M-2000. It is rated 18VAC at 6 amps. While this serves very well, virtually any transformer with a secondary voltage of 17 to 18 volts at a current of 4 to 6 amps will be suitable. Most battery charger transformers with a rating of 4 to 6 amps



Actual size reproduction of the PCB pattern.

are suitable. An example is the A&R 5509 transformer.

Note that if a different transformer is substituted for the one we used, there are likely to be slight differences in the load and line regulation of the circuit.

An EDI Minibrige, type PK40F, was employed as the bridge rectifier. It has an average current rating of 8 amps. Alternatively, the bridge rectifier could be made up of suitable stud-mounted diodes.

A reasonably substantial heatsink is used to dissipate the heat produced by the 2N3055. The type we used is a single sided extrusion which is drilled to take two TO-3 power transistors. It is available from Dick Smith Electronics. We mounted the output transistor at the bottom of the heatsink while the

bridge rectifier was mounted at the top, although it is actually inside the rear panel of the case.

Use a mica washer, two insulating bushes and heatsink compound when mounting the output transistor.

Three pairs of binding post-cum-jack sockets are used for the output connections. This enables a number of pieces of equipment to be connected permanently, even though they may not all be used at the same time.

Use heavy duty insulated cable for all high current wiring. The type we used is known in the trade as "4mm auto cable". Do not install the zener diode across the output terminals until the Powermate is finished and working correctly.

Take care with the mains wiring. The

three-core mains cord should be passed through a grommetted hole in the rear of the case and anchored with a cord clamp. Mechanically terminate and solder the earth wire to a solder lug secured under one of the transformer mounting screws. The rest of the circuit is not earthed.

Terminate the active and neutral conductors plus the wires to the transformer primary and the mains switch to a three-way insulated terminal block. Make sure that the soldered connections to the mains switch and transformer primary fuse are insulated with heatshrink tubing or similar material.

When the Powermate is complete check all wiring and apply power. With

POWERMATE PARTS LIST

- 1 case, 206 x 116 x 139mm, or larger
- 1 PC board, 91 x 81mm, code 78ps5
- 1 transformer with secondary 17 to 18V at 4 to 6 amps DC
- 1 SPST mains toggle switch
- 1 3-way insulated terminal block
- 1 single-sided heatsink, 110 x 75mm
- 6 binding posts, 3 red, 3 black
- 1 3AG fuse holder and 1.5A fuse

SEMICONDUCTORS

- 1 LM723 or uA723 IC regulator
- 1 TIP32 PNP transistor
- 1 2N3055 NPN transistor
- 1 PK40 or equivalent bridge rectifier
- 1 16V 1W zener diode
- 1 LED and bezel

CAPACITORS

- 2 x 5600uF/40VW PC electrolytic
- 1 x 1000uF/16VW PC electrolytic
- 1 x 0.22uF metallised polyester
- 1 x 0.1uF metallised polyester

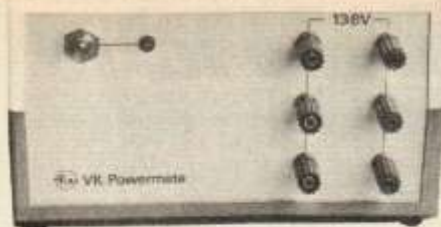
RESISTORS

- ($\frac{1}{2}$ or $\frac{1}{4}$ W, 10% tolerance)
- 1 x 15k, 2 x 3.3k, 1 x 680 ohms,
- 2 x 100 ohms
- 1 x 1k preset potentiometer
- 2 fuse clips, Swann (McMurdo) FCT
- 1 5 amp 3AG fuse
- 4 PC pins
- 5 solder lugs
- 1 flag heatsink for TIP32

MISCELLANEOUS

- 4 rubber feet, 4 6mm spacers, 1 grommet, mounting hardware for TO-3 transistor, heatsink compound, 4 Utilux quick-connectors, mains cord and three-pin plug, mains cord and clamp, heatshrink tubing, 4mm auto cable, hook-up wire, screws, nuts, lockwashers, solder.

NOTE: Component substitutions are not recommended. See text.



the aid of an accurate multimeter set the output voltage to exactly 13.8 volts. Turn off the power and wait until the LED power indicator is extinguished. Then wire the zener diode across the output terminals. Now the unit is ready for work.

During normal operation, the output transistor heatsink will become quite hot, especially if it is running at 5 amps continuously. This is quite normal. All components are within ratings.

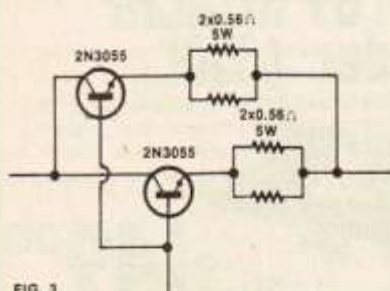


FIG. 3

Use this booster circuit and the transformer below to increase the rating to 8 amps.



As noted previously, it is possible to increase the rated output of the VK Powermate. It is fairly straightforward to boost the output to 8 amps. Substitute a higher rated transformer such as the JT 266 which is rated at 8 amps continuous. It is made by Jones Transformers Pty Ltd, c/- 22 William Street, Henley, NSW 2011.

Figure 3 shows the other required modification. Substitute two 2N3055s for the single output transistor in the 5 amp circuit. The parallel-connected 0.56 ohm resistors ensure that each transistor equally shares the load. Each transistor should be mounted on a substantial heatsink.



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