900082-II

400-WATT LABORATORY POWER SUPPLY

PART 2: MODES OF OPERATION, CONSTRUCTION AND SETTING UP

Before dealing with the construction of the PSU, this second and final instalment discusses the operation of the four modes in which the instrument can be used.

G. Boddington

THE complete 400-watt power supply as shown in the photograph consists of two identical circuits, which are built on separate printed-circuit boards. Each printed-circuit board holds four pin headers for the interconnection of the circuits and their connections to the read-outs and controls on the front panel. Each PSU has two indication instruments, one for the voltage (connected to pin 6 of K_5) and one for the current (connected to pin 3 of K_5). The voltage read-out, M_1, is connected in parallel with the output terminals, and the current read-out, M_2, in parallel with shunt resistor R_{18}.

Header K_4 connects the circuit to the two potentiometers for the voltage and current settings, and to the two LEDs that indicate the onset of the limiting circuits.

Modes of operation

As shown in the 'Main Specifications' box in last month's instalment, the power supply is capable of four modes of operation. Each of these is briefly discussed here.

Mode: Single
This mode is the simplest of the four. It requires only one printed-circuit board. Connector K_3 need not be fitted, while K_2 is wired with three fixed connections: 13-14, 15-16 and 17-18.

Mode: Independent
This mode allows the two PSUs to be used and set independently, without any electrical interconnection (except, of course, the one at the mains socket). Note that although the two circuits are linked via the flatcable between K_2 and K_3, the connections are broken by switch S_2. Each PSU circuit is capable of supplying 0 – 40 V at 0 – 5 A.

Mode: Parallel
This mode is selected by setting the mode switch to 'independent', and connecting the output terminals as shown in Fig. 9. The two high-power diodes prevent the supply with the higher output voltage pumping current into the other. To enable the PSU to deliver its maximum output current of 10 A, the out-

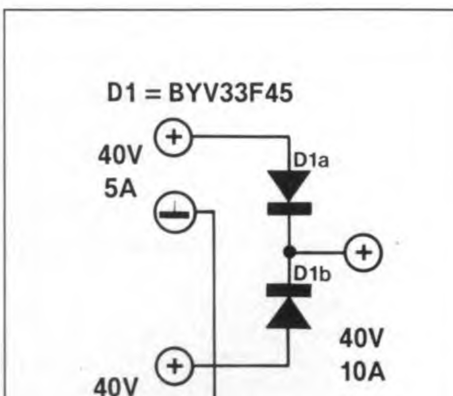

Fig. 9. In parallel mode, two diodes are used to couple the supplies. This arrangement prevents a short-circuit as a result of possible potential differences between the positive output terminals.

put voltages of the two supply circuits should be set to match as closely as possible. As shown in Fig. 9, the Type BYV33F45 from Philips Components contains two high-current Schottky diodes whose cathodes are joined and brought out to a common terminal. This component is supplied in a SOT-186 package. Where the BYV33F45 is difficult to obtain, other high-current rectifier diodes may be used, provided they are rated at a forward current of 5 A and a reverse voltage of 45 V or greater. Another important characteristic is the forward voltage drop of the diodes: evidently, this should be a small as possible since it is not compensated by the supply circuit.

Limiting circuit		LED			
Master	Slave	Master		Slave	
		U	I	U	I
Current	—	0	1	1	0
Voltage	—	1	0	1	0
—	Current	0	0	1	1

Table 1. Overview of LED indications to signal overload conditions in the two supplies.

Mode: Tracking

In this mode, one supply circuit functions as the *Master*, and the other the as the *Slave*. The diagrams in Fig. 7 (see part 1) and Fig. 10 show the interconnections made via headers K2-K3 and the mode switch, S2. On the Master PCB, only K2 is used, on the Slave PCB, only K3. The four switch contacts are set to the 'tracking' mode. The positive terminal of the Slave is internally connected to the negative terminal of the Master. The voltage at the positive terminal of the Master is fed to the Slave via R10-R11. Switch contact S2b establishes a common reference potential, so that the positive terminal of the Master and the negative terminal of the Slave are at an equal voltage with respect to the common terminal. Only the signs of the two voltages are different. This mode allows the instrument to be set up as a symmetrical supply (±0 to ±40 V), or one capable of supplying 0 to 80 V. The maximum output current is 5 A in both cases. It should be noted that the internal connection via the flatcable is not suitable for currents exceeding 100 mA or so. For higher currents, an external link must be made on the output terminals. This link can take the form of a small piece of copper or aluminium, cut to size to fit over the terminals.

The voltage limiting circuit of the Slave works conventionally on the series transistors. The current limiting circuit, however, is coupled to the Master. The connection is made via an optocoupler, IC6, to ensure electrical isolation between the supply circuits of the two opamps. When the current limiting circuit is actuated, the output voltage of the Master drops. Consequently, the output voltage of the Slave drops also. Table 1 shows which LEDs light to indicate the various overload conditions.

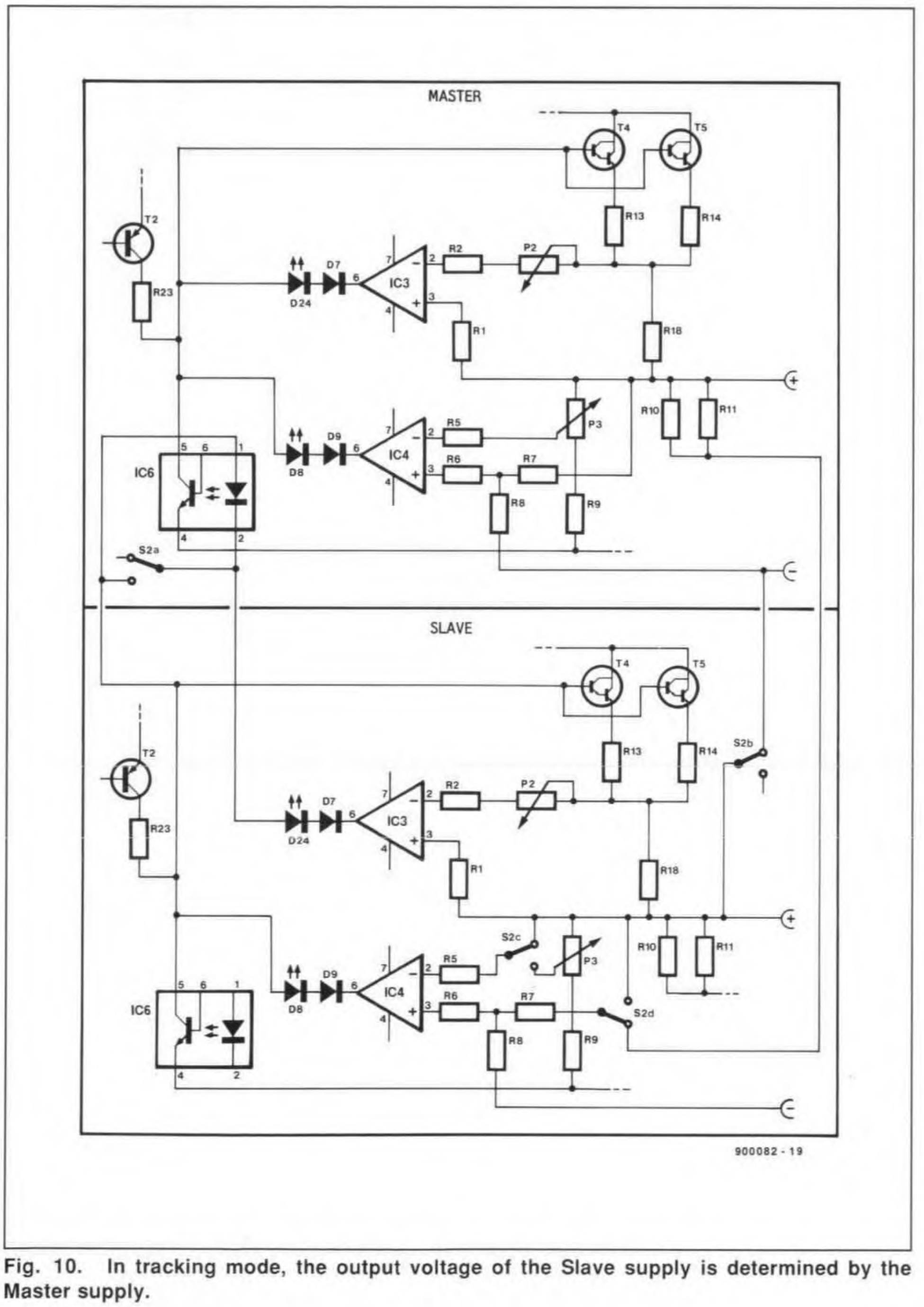

Fig. 10. In tracking mode, the output voltage of the Slave supply is determined by the Master supply.

Construction

Although the printed-circuit board for a single supply is fairly large (see Fig. 11), the construction should not present undue problems. The power resistors must be fitted at a small distance, say, 10 mm, above the board. Fit triac Tri1 with a suitably sized heatsink. Since the triac and a number of other components in the transformer preregulation circuit are at mains potential, great care must be taken to ensure the necessary insulation. **Never** bolt the triac to the bottom panel of the case, not even when using an insulating washers and a nylon screw. Whatever heat-sink you use, make sure it can not touch the screw or the nut fitted in the corner to secure the PCB.

The opamps and the optocouplers may be soldered direct to the board. Where the suppressor choke, L1, is difficult to obtain, it may be replaced by a home-made one. Simply wind about 40 turns of enamelled copper wire on a 25-mm o.d. ferrite ring core. Apply some two-component glue or epoxy resin to secure the inductor to the PCB.

On completion of the supply boards, run a thorough check on your soldering work. Check that all the polarized components (these include the box headers!) are fitted the right way around. Next, fit the boards, the buffer capacitors, the bridge rectifiers and the mains transformers on the bottom plate of

COMPONENTS LIST

ATTENTION: two required of each part listed.

Resistors:

4	10kΩ	R1,R2,R5,R6
1	22kΩ	R3
2	4kΩ7	R4,R33
3	2kΩ2	R7,R12,R23
1	8kΩ2	R8
1	470Ω	R9
2	12kΩ	R10,R11
3	0Ω22 5W	R13,R14,R18
1	220Ω	R15
1	330kΩ	R16
2	100kΩ	R17,R20
2	1kΩ	R19,R32
1	220kΩ	R21
1	1kΩ8	R22
1	2kΩ2 1W	R24
1	680Ω	R25
1	47kΩ	R26
2	47kΩ 1W	R27,R28
1	10kΩ 10W	R29
1	150kΩ	R30
1	27kΩ	R31
1	220Ω 1W	R34
1	1MΩ preset H	P1
2	2kΩ2 linear potentiometer	P2,P3a
1	220Ω linear potentiometer	P3b
1	500Ω preset H	P4
1	5kΩ preset H	P5

Capacitors:

1	100nF 100V	C1
1	100nF 400V	C2
8	47nF	C7–C10,C15–C18
2	1000μF 40V	C11,C12
2	10μF 40V	C13,C14
2	1nF 63V	C19,C21
1	330pF	C20
1	100pF	C22
1	2μF2 63V	C23
1	100nF	C24
1	470μF 63V	C25
1	10,000μF 63 V	C26

Semiconductors:

4	33V 1W zener diode	D1–D4
1	15V 0.4W zener diode	D6
2	1N4148	D7,D9
2	red LED (5mm)	D8,D24
10	1N4001	D10,D11, D16–D23
4	1N4004	D12–D15
1	ER900	Di1
1	100V 25 A bridge recti-fier (Motorola BYW61)	B1
2	BC547B	T1,T3
1	BC557B	T2
2	BDV65B	T4,T5
1	TIC263D	Tri1
1	TIC206D-P	Tri2
1	7812	IC1
1	7912	IC2
2	LM741	IC3,IC4
1	CNY17-2	IC5
1	TIL111	IC6

Miscellaneous:

1	choke 100μH 6 A (SFT1250)	L1

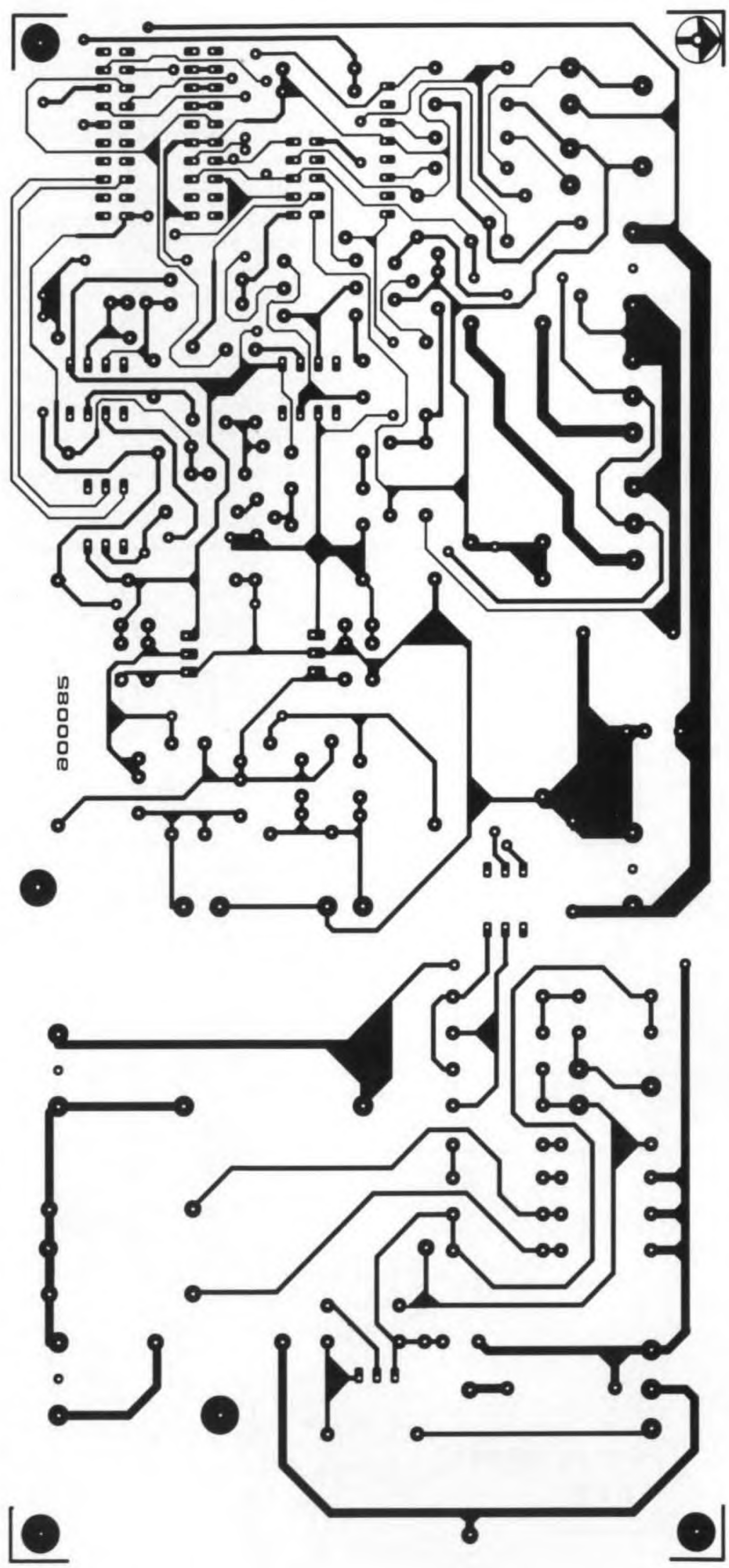

Fig 11a. Track lay-out (mirror image) of the printed-circuit board for the PSU.

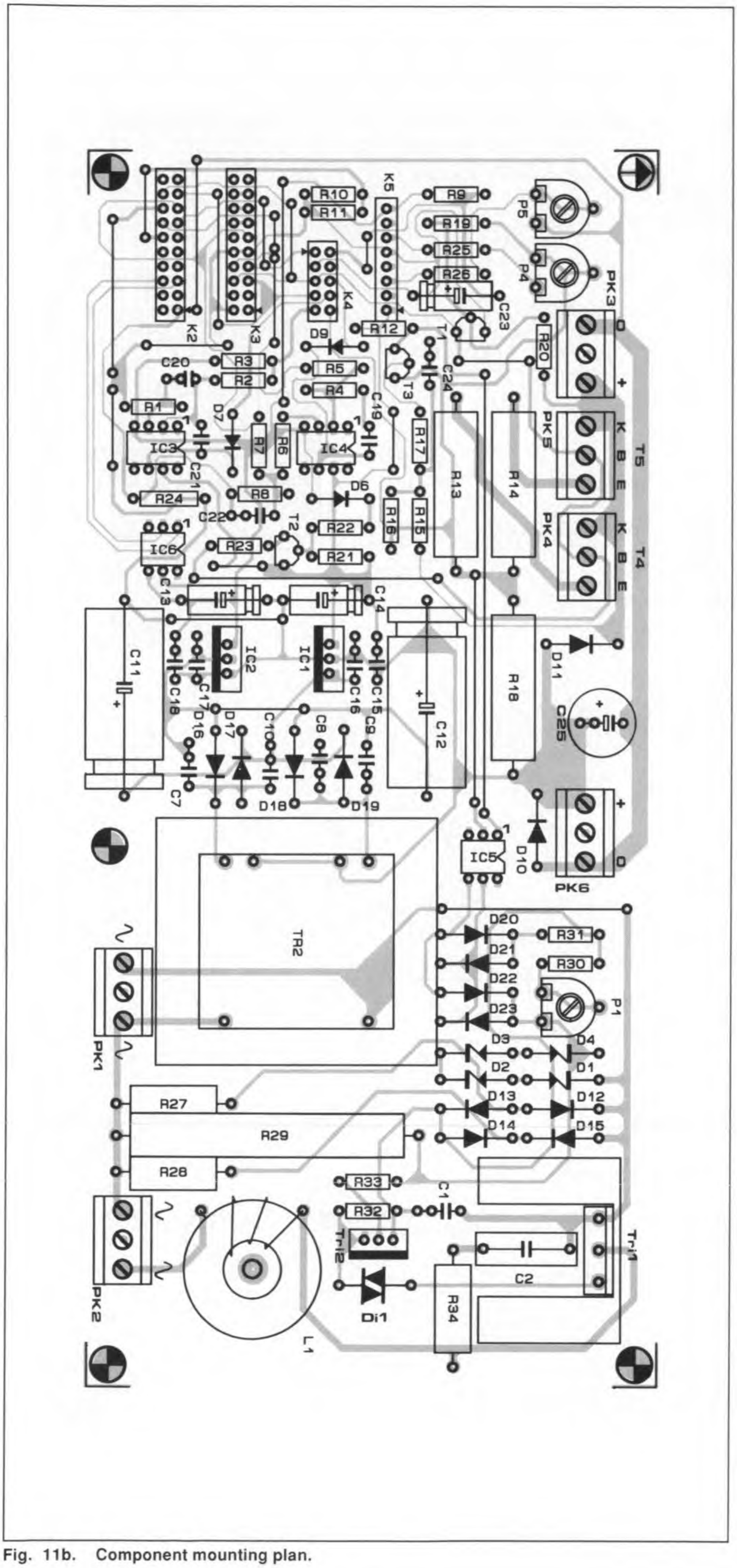

Fig. 11b. Component mounting plan.

1	toroid transformer 2×22V @5.11 A (ILP 61015 for 220V mains, or ILP 63015 for 240V mains)	Tr1
1	PCB-mount transformer 2×12V @10VA	Tr2
2	3½-digit digital voltmeter (Elektor 890117)	
2	20-way PCB mount box header	K2;K3
1	10-way PCB mount box header	K4
1	8-way SIL pin header	K5
6	3-way PCB terminal block	PK1–PK6
2	thermal insulation set for BDV65B	
1	thermal insulation set for TIC263D.	
1	heat-sink 1.1 K/W for T4/T5 (Fischer SK120)	
1	heat-sink 13 K/W for Tri1 (Fischer FK225)	
2	8-way DIL IC sockets	
1	heavy-duty wander socket (red)	
1	heavy-duty wander socket (black)	
1	printed-circuit board	900082

One required of the following parts:

1	6-pole toggle push-button	S1
1	self-adhesive front panel foil	900082-F
4	20-way IDC socket	
2	10-way IDC socket	
1	mains appliance socket with built-in fuseholder	
1	3.15A slow fuse (single supply)	
1	6.3A slow fuse (double supply)	
1	enclosure ESM ER48/13 (250-mm deep) or ET38/13 (250 or 350 mm deep).	

the enclosure. The general lay-out of the bottom plate is shown in the wiring diagram in Fig. 12 and the photograph in Fig. 14.

Cut clearances in the rear panel to enable the power transistors to be fitted to the heat-sinks. If possible use heavy-duty ceramic insulating washers and check that each transistor is electrically insulated from the heat-sink. Failing ceramic insulators, the more usual (and less expensive) combination of mica washers and a generous amount of heat-sink compound may be used. The clearance for the mains socket is located between the heat-sinks as shown in Fig. 13.

Use 1.5 mm² cross-sectional area (c.s.a.) wire for the mains connections, and 2.5 mm² c.s.a. wire for the high-current connections. To give the PSU a professional internal look, it is recommended to use solid wires of different colours because these are easily traced and bent to form rigid cable paths where necessary. Note that two wires between the three-way PCB terminals and the power transistors are crossed.

The 20-way flatcable between the Master (K2) and Slave (K3) supply is 'tapped' with an IDC connector and discrete wires that take the relevant connections to the mode switch (S2).

The PSU is housed in a 3-HU (height-units) 19-inch enclosure with a mesh cover plate. The photographs in Figs. 13 and 14 show the arrangement of the PCBs, the trans-

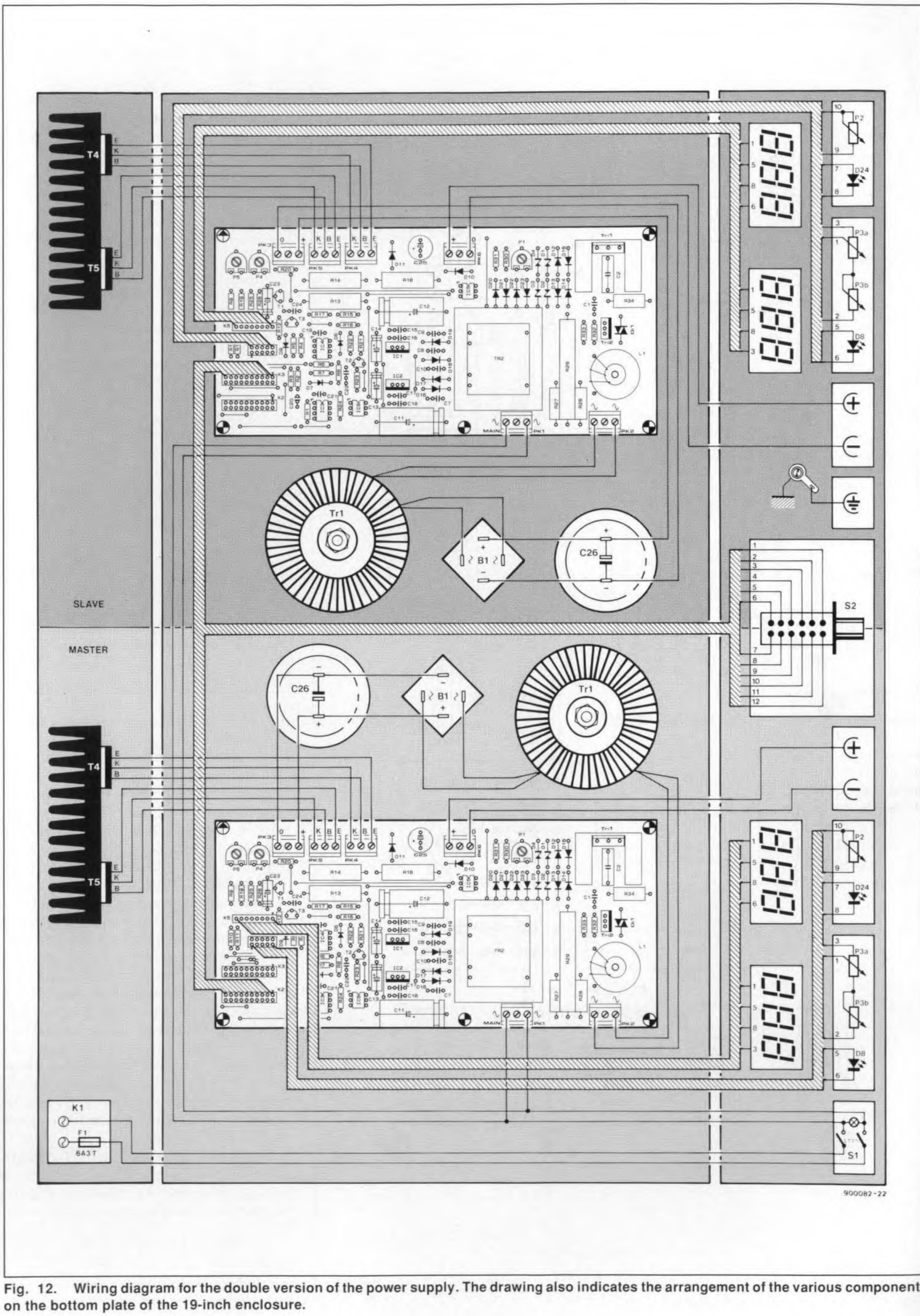

Fig. 12. Wiring diagram for the double version of the power supply. The drawing also indicates the arrangement of the various components on the bottom plate of the 19-inch enclosure.

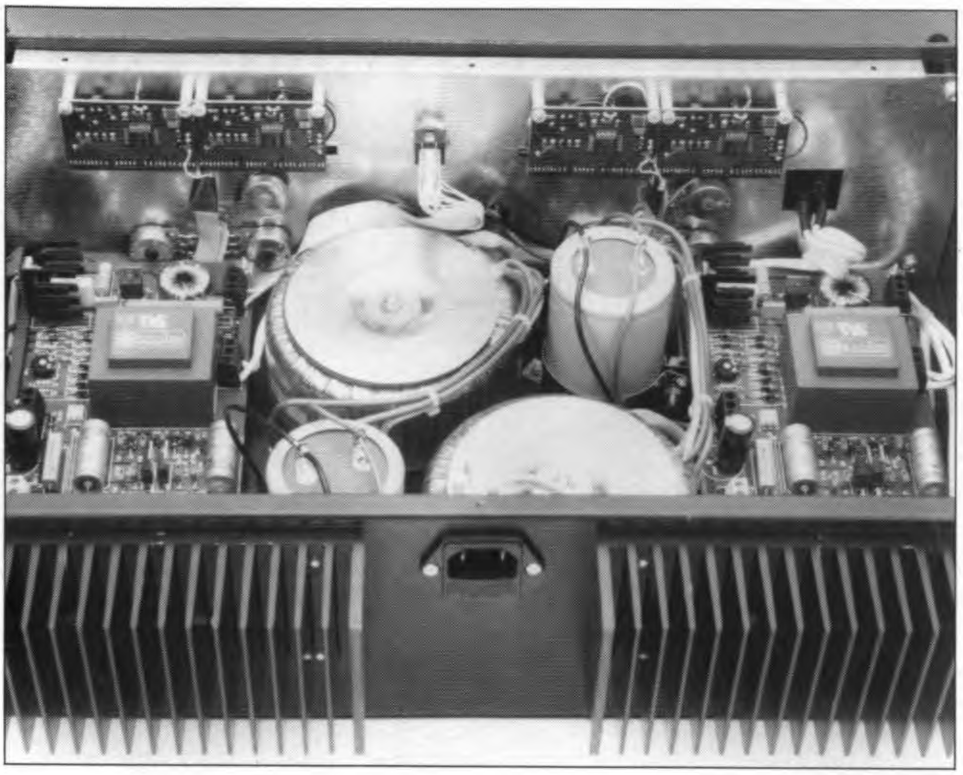

Fig. 13. Top view of the completed power supply with the cover plate removed. Note the four read-out modules mounted at the inside of the front panel.

formers, the buffer capacitors, the front-panel controls and read-outs, and the heat-sinks on the rear panel.

Voltage and current read-outs

The four read-outs can be either moving-coil meters (1 mA full-scale deflection instruments) or 3½-digit digital voltmeter modules. The modules used in the prototype are of the type described in Ref. 1. These circuits are fitted with fixed voltage regulators, which are powered by the supply (i.e., the Master or the Slave) they belong with. This supply configuration is shown in Fig. 6a in Ref. 1. The half-digit is not used here. The meter modules are connected as shown in the circuit diagram of the power supply. Note, however, that each of the current meters, M_2, must be shunted by an additional 47-Ω resistor, R_s, so that network R_s-R_{25}-P_4 passes a current between 0.9 mA and 1.5 mA, which produces a drop of 35 mV to 65 mV on R_s. The preset, P_4, is adjusted for a drop of 50 mV across R_s at an output current of 5 A. The read-out should then indicate 5.00. Both voltage read-outs in the PSU are also fitted with a 47-Ω shunt resistor.

The voltage and current indication modules are fitted on to the front panel of the 19-inch enclosure, together with their input voltage regulators and decoupling capacitors. When the read-outs are connected to the supply circuits via flatcables, each of their ground terminals must be connected to the supply ground via a separate, relatively thick, wire. This wire, which serves to prevent noise, is best fitted between the display board and the negative terminal of electrolytic capacitor C_{12}.

Alignment

Start by setting all potentiometers and presets to the centre of their travel. Connect a load to the output. The electronic load described in Ref. 2 is just the thing for this purpose. Set the current and voltage controls to nought, and null the read-outs. Next, hook up a DMM, set the output voltage to 40 V and adjust P_5 for a corresponding indication. Reduce the output voltage to 1 V, and load the supply with a 0.18-Ω/5 W resistor, connected via the DMM set to current measurement. Carefully adjust the voltage until the DMM reads 5 A. Next, adjust P_4 for a corresponding reading on the current display.

Finally, measure the voltage drop across the series transistors: this should be about 10 V. Set an output voltage of 3 V, and set the output current to maximum (P_2). Short-circuit the output terminals, and check the current. If this is about 5 A, the PSU is fully functional and ready to be taken into use. ■

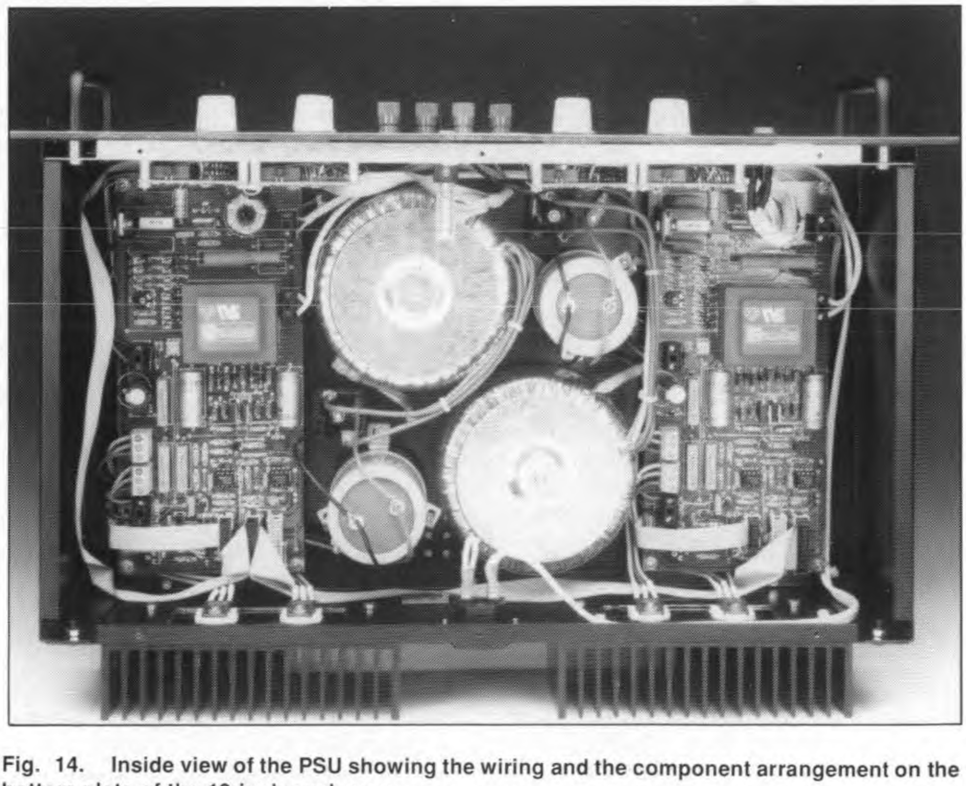

Fig. 14. Inside view of the PSU showing the wiring and the component arrangement on the bottom plate of the 19-inch enclosure.

References:

1. "3½-digit SMD voltmeter". *Elektor Electronics* November 1989.
2. "Electronic load". *Elektor Electronics* June 1990.

COMPONENTS LIST

ATTENTION: two required of each part listed.

Resistors:

4	10kΩ	R1,R2,R5,R6
1	22kΩ	R3
2	4kΩ7	R4,R33
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1	470Ω	R9
2	12kΩ	R10,R11
3	0Ω22 5W	R13,R14,R18
1	220Ω	R15
1	330kΩ	R16
2	100kΩ	R17,R20
2	1kΩ	R19,R32
1	220kΩ	R21
1	1kΩ8	R22
1	2kΩ2 1W	R24
1	680Ω	R25
1	47kΩ	R26
2	47kΩ 1W	R27,R28
1	10kΩ 10W	R29
1	150kΩ	R30
1	27kΩ	R31
1	220Ω 1W	R34
1	1MΩ preset H	P1
2	2kΩ2 linear potentiometer	P2,P3a
1	220Ω linear potentiometer	P3b
1	500Ω preset H	P4
1	5kΩ preset H	P5

Capacitors:

1	100nF 100V	C1
1	100nF 400V	C2
8	47nF	C7–C10,C15–C18
2	1000µF 40V	C11,C12
2	10µF 40V	C13,C14
2	1nF 63V	C19,C21
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1	100pF	C22
1	2µF2 63V	C23
1	100nF	C24
1	470µF 63V	C25
1	10,000µF 63 V	C26

Semiconductors:

4	33V 1W zener diode	D1–D4
1	15V 0.4W zener diode	D6
2	1N4148	D7,D9
2	red LED (5mm)	D8,D24
10	1N4001	D10,D11, D16–D23
4	1N4004	D12–D15
1	ER900	Di1
1	100V 25 A bridge recti-fier (Motorola BYW61)	B1
2	BC547B	T1,T3
1	BC557B	T2
2	BDV65B	T4,T5
1	TIC263D	Tri1
1	TIC206D-P	Tri2
1	7812	IC1
1	7912	IC2
2	LM741	IC3,IC4
1	CNY17-2	IC5
1	TIL111	IC6

Miscellaneous:

1	choke 100µH 6 A (SFT1250)	L1

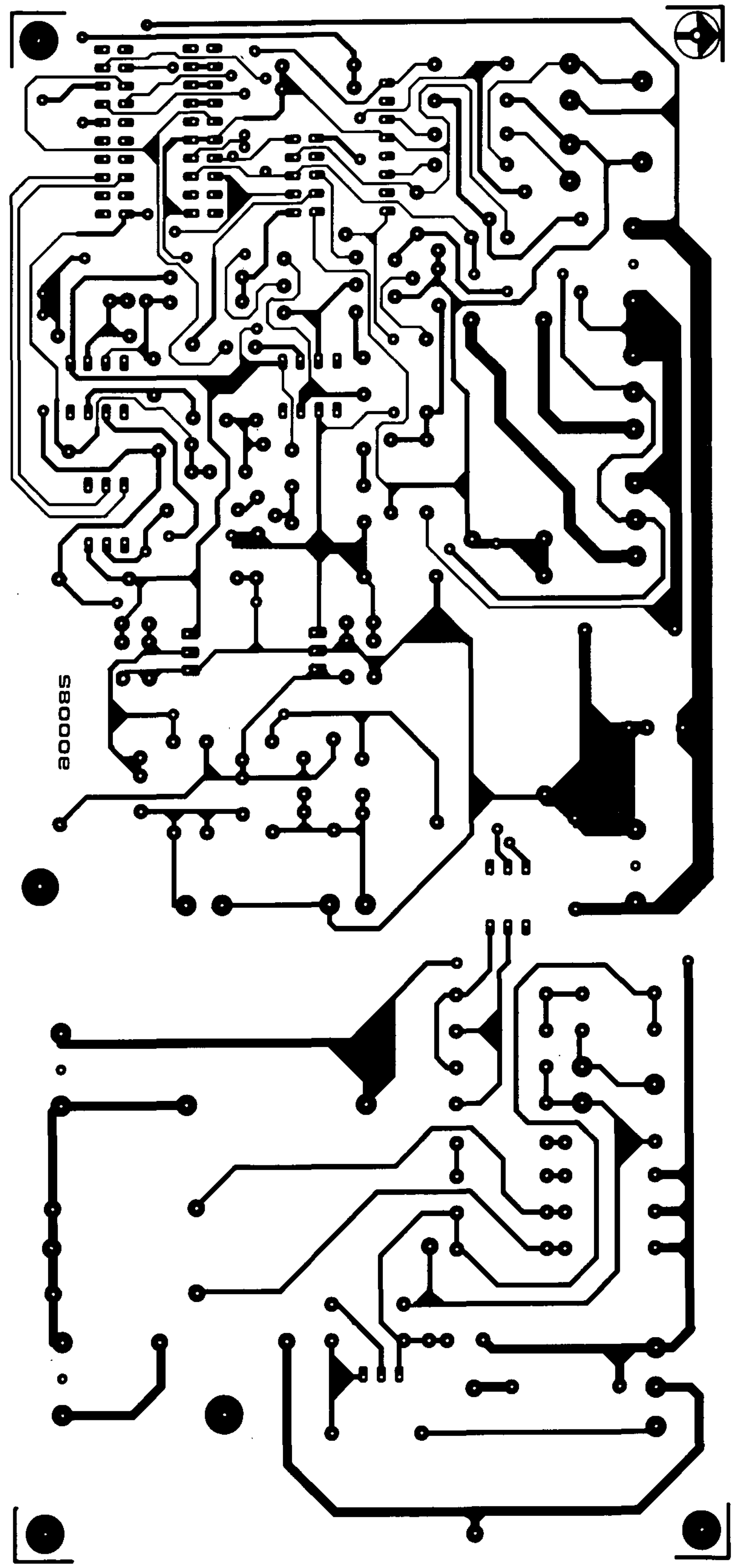


Fig 11a. Track lay-out (mirror image) of the printed-circuit board for the PSU.

CTIONS CORRECTIONS CORRE

400-watt laboratory power supply

October 1989 and November 1990

A number of constructors of this popular project have brought the following problems to our attention.

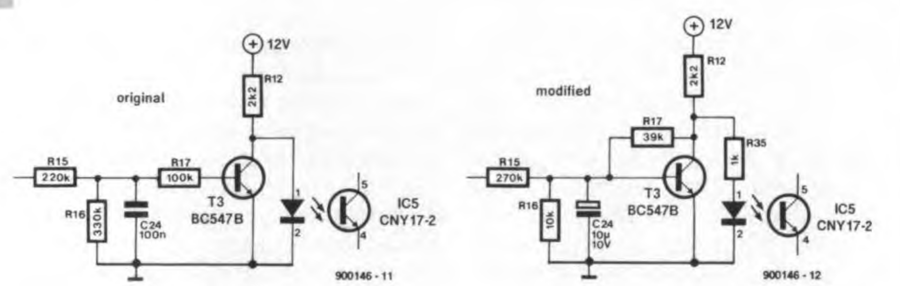
1. The onset point of the current limit circuit lies at about 3 A, which is too low. Solve this problem by replacing T1 with a Type BC517 darlington transistor, and R20 with a 82kΩ resistor.

2. Depending on the current transfer ratio of the optocoupler used, the transformer produces ticking noises. This effect, which is caused by overshoot in the pre-regulation circuit, may be traced with the aid of an oscilloscope monitoring the voltage across C26 at a moderate load current. The capacitor must be charged at each cycle of the mains frequency, and not once every five cycles. The problem is best solved by reducing the amplification of the regulation circuit. Replace R17 with a 39 kΩ resistor, and create feedback by fitting it between the base and the collector of T3. Also add a resistor in series with the optocoupler. These two changes are illustrated in Figs. 1 and 2. Lower R16 to 10 kΩ, increase C24 to 10 μF, and increase R15 to 270 kΩ.

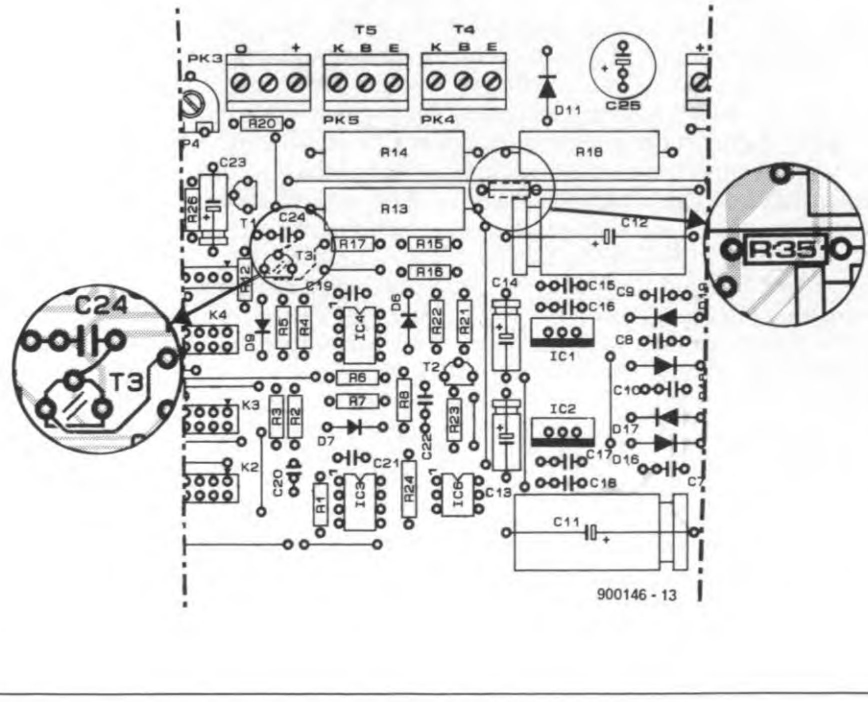
3. Excessive heating of the transformer is caused by a d.c. component in the primary winding. This is simple to remedy by fitting a capacitor of any value between 47 nF and 470 nF, and a voltage rating of 630 V, across the primary connections. This capacitor is conveniently mounted on to the PCB terminal block that connects the transformer to the mains.

4. One final point: when using LED DVMs for the voltage/current indication, their ground line must be connected to the **positive** terminal of C12.

1



2



Hard disk monitor

December 1989

In some cases, the circuit will not reset properly because the CLEAR input of IC3A is erroneously connected to ground. Cut the ground track to pin 3 of IC3, and use a short wire to connect pin 3 to pin 16 (+5 V).

Microprocessor-controlled telephone exchange

October 1990

In some cases, the timing of the signals applied to IC17 causes a latch-up in the circuit, so that the exchange does not detect the state of the connected telephones properly. Solve this problem by cutting the track to pin 1 of IC17, and connecting pin 1 to ground (a suitable point is the lower terminal of C6).

The text on the fitting of wires on the BASIC computer board (page 19, towards the bottom of the right-hand column) should be modified to read: 'Finally, connect pin 6 of K2 to pin 7 of IC3 ($\overline{Y7}$ signal).'

S-VHS/CVBS-to-RGB converter (2)

October 1990

The capacitor marked 'C37', next to R21 on the component overlay (Fig. 7b and ready-made printed circuit board), should be marked 'C39'.

In case they are difficult to obtain locally, inductors type 119-LN-A3753 (L1) and 119-LN-A5783 (L2) may be replaced with the respective types 119-ANA-5874HM and 119-ANA-5871HM, also from Toko, Inc. Suggested suppliers are Cirkit Distribution Ltd., and C-I Electronics.

EPROM simulator

December 1989

Counters IC3 and IC4 may not function properly owing to a too low supply voltage. This problem may be solved by replacing IC12 with a 7806. Alternatively, use BAT85 diodes in positions D1 and D2.

Programmer for the 8751

November 1990

The ready-programmed 8751 for this project is available at £35.25 (plus VAT) under order number **ESS 7061**, not under order number ESS 5951 as stated on the Readers Services pages in the November and December 1990 issues.