# DRILL CONTROL UNIT

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ONE of the necessary pieces of equipment when producing one's own printed circuit boards is a low-voltage drill capable of accurately drilling holes of 1mm or less. Since many of these drills draw just over 1A or so at full load (e.g. Precision Petite P1 or Reliant), some means whereby the drill can be operated from the mains supply would be highly desirable as battery operation is not particularly feasible. This is especially the case where large or numerous p.c.b.s are produced.

The Drill Control Unit to be described here is a regulated-voltage type of variable mains adaptor which will eliminate the requirement for batteries. It was designed by the author to replace his commercial variable-speed power unit, the performance of which had taken a noticeable turn for the worst: in particular, the drill would after a short period of operation, run either flat out or not at all!

Not only does the Drill Control Unit provide excellent precision-control of many types of low-voltage drill, but it also incorporates several useful features not found on commercially manufactured units.

## CONSTANT VOLTAGE

The output of the device is a constant voltage irrespective of the load, and is variable from 1·2V to 16V and the maximum recommended output current is 1·5 amps. Thus it is suitable for the two types of drill mentioned above, although the Titan drill, which apparently consumes up to 3·5A, cannot be driven from this design.

This unit also features an l.e.d. overload indicator which warns when the output current is starting to become excessive: it starts to illuminate at roughly 1·2A or so. The device however won't be damaged by temporary short-circuits but the output current should be restricted to 1·5A peak or roughly 1·2A average when in use.

Also incorporated is a footswitch circuit permitting on-off control of the drill with a suitable foot-operated switch: this can be quite handy when your hands may be occupied with a whirring drill or a printed circuit board!

## CIRCUIT

The circuit is shown in Fig. 1. The Drill Control Unit is centred around IC1, an LM317T variable-voltage regulator i.c. and the "T" suffix indicates that the T0-220 plastic package version is employed. It operates by presenting a highly-stable band-gap-type reference voltage of 1·25V across the resistor R5. Generally this resistor is chosen to have a value of 220 or 240Ω so that roughly 5mA flows through it.

The output voltage is controlled by an external resistance connected between the adjustment and ground pins; in this case this resistance is formed of VR1 with R4 in parallel.

If VR1 and R4 = $R_V$, then the output voltage in this instance is given by the formula:

$$V_{output} = \frac{1{\cdot}25\,(R5 + R_V)}{R5} = 1.25\,(1 + \frac{R_V}{R5})$$

and so with VR1 set at maximum resistance (equivalent to 2·5k when R4 is taken into account) the maximum output voltage is roughly 15·5V. The minimum output will be 1·25V.

The remainder of the circuit functions as follows. Mains voltage is stepped down by T1 to roughly 15V a.c. at full load and this is rectified into d.c. by the four rectifiers D1–4 which are arranged in bridge configuration. A chopped a.c. waveform is the result and this is smoothed by C1 to produce a rather low-quality d.c. voltage of approximately 23V at no load.

The action of IC1 then removes the substantial majority of noise from this voltage and, of course, also enables the voltage to be varied as required in order to adjust the speed of the drill.

No mains on-off switch was considered necessary although the unit is protected by a line fuse FS1 and also the l.e.d. D5 will illuminate to act as a power-on reminder.

## OUTPUT

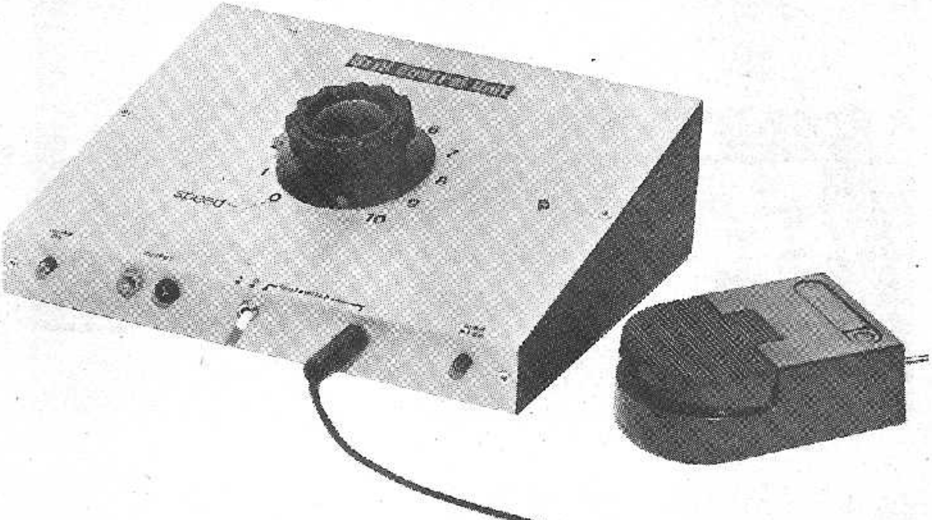
The positive output of the i.c. passes directly to SK1 but the 0V common rail is connected to S1 which acts as an on-off switch for the drill: in fact S1 is a centre-off type so of course when it is in middle position the drill is inoperative. Alternatively the footswitch socket can be brought into circuit if required, the footswitch being plugged into SK3. Otherwise, when S1 is set as shown in the circuit diagram, the drill will run continuously. In this design the 0V rail is earthed through the metal body of JK1. C2 has also been included to suppress noise.

The output current passes through R3 on its return and in so doing will cause a potential difference to appear across this resistor. The end of the resistor connected to TR1 base will also be the most positive and if the current is sufficiently large, then the voltage across R3 will cause the base-emitter junction of the transistor to become forward biased, causing TR1 to turn on like a switch. This completes the circuit to D6 and R2, causing the l.e.d. to illuminate, which acts as a simple current indicator. The current needed to do this is about 0·6V/R3, or 1·2 amps.

Thus the l.e.d. will glow when the output current exceeds 1·2A and it gives the user an idea of how near the maximum output of 1·5A the unit is operating.

## PROTECTION

The usual forms of protection are included in IC1 like thermal shutdown and current limiting (i.e. short circuit protection). However, for maximum reliability and performance to be achieved the integrated circuit, which dissipates a lot of power under worst-case conditions, needs to be adequately heatsinked. The components list indicates a suitable type.



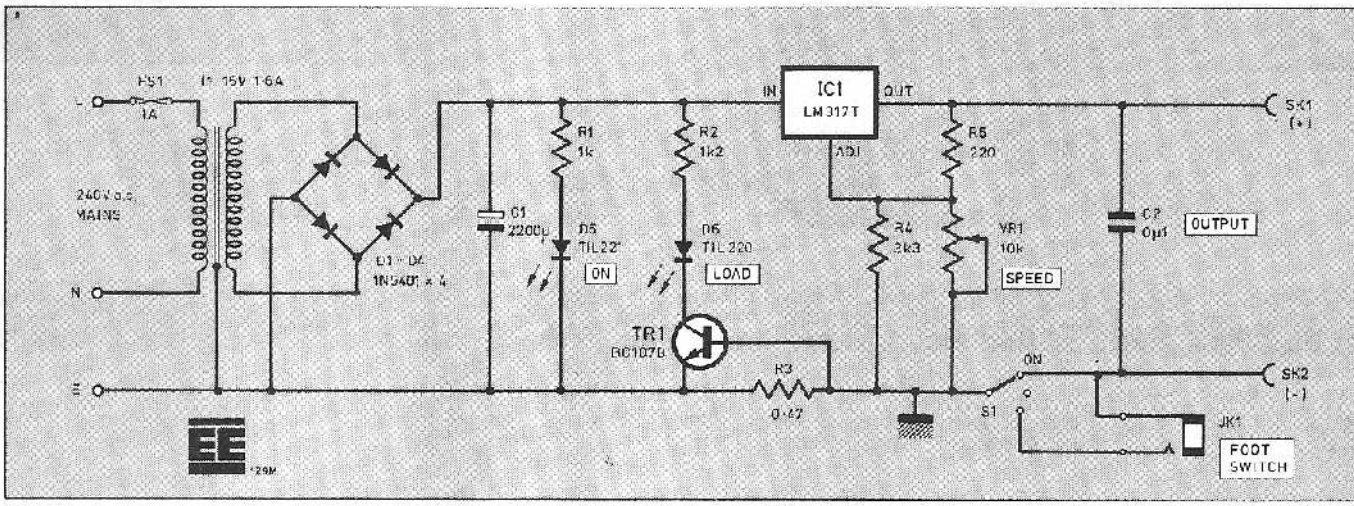
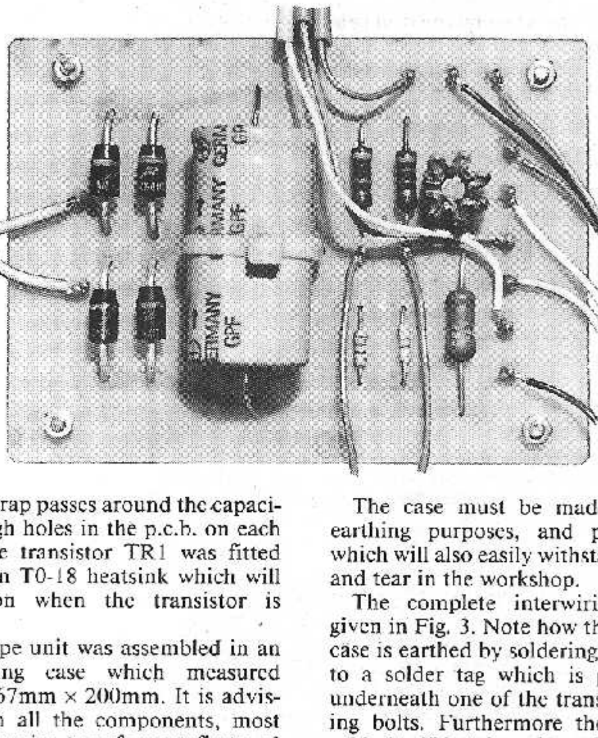



Fig. 1. Circuit diagram.

The output current of the i.c. depends amongst other things on the temperature of the chip, and whilst the approved heatsink will enable the i.c. to pass at least 1·5A, the peak current of the i.c. can exceed 2A under short-circuit output conditions. This is in excess of the rating of the mains transformer: therefore, short circuits across the output should be avoided although in reality they are permissible for brief periods. Indeed it is no coincidence that the l.e.d. D6 was designed to light at only 1·2A. This current was considered the maximum that the Drill Control Unit would encounter under normal operating conditions. It is still able to provide up to 1·5A but in normal use the device should rarely peak at much above 1·2A or so.



## CONSTRUCTION

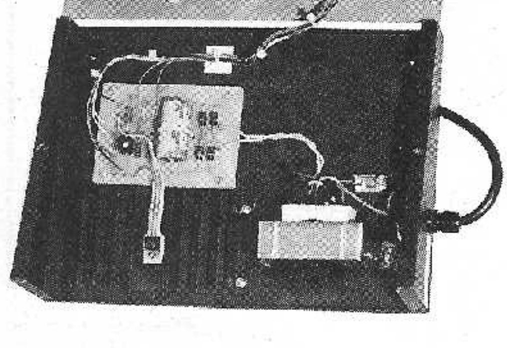
The circuit with the exception of IC1 is constructed on a p.c.b. of dimensions 93 × 72mm, see Fig. 2.

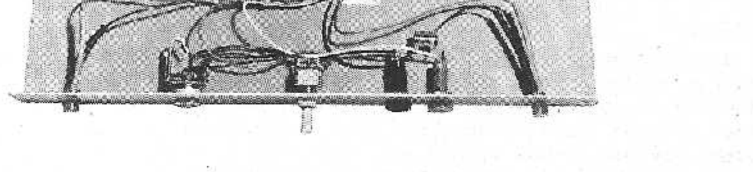
For maximum reliability, the electrolytic capacitor C1 is mechanically secured to the p.c.b. using a nylon tie-wrap of appropriate size. The tie-wrap passes around the capacitor and through holes in the p.c.b. on each side. Also, the transistor TR1 was fitted with a push-on T0-18 heatsink which will aid dissipation when the transistor is conducting.

The prototype unit was assembled in an all-steel sloping case which measured 33/82mm × 267mm × 200mm. It is advisable to obtain all the components, most especially the mains transformer, first and then select a case of suitable dimensions to fit your particular components.

The case must be made of metal for earthing purposes, and preferably steel which will also easily withstand severe wear and tear in the workshop.

The complete interwiring details are given in Fig. 3. Note how the chassis of the case is earthed by soldering the earth input to a solder tag which is placed securely underneath one of the transformer mounting bolts. Furthermore the actual mains cable itself is taken through a grommet in the chassis in order to prevent chafing of the insulation; then the cable must be fixed





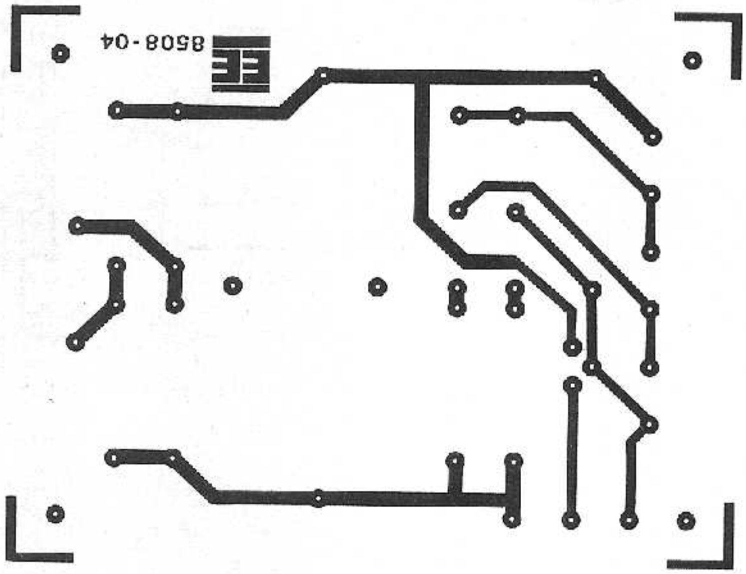



Fig. 2. Printed circuit board (actual size) for the Drill Control Unit. This board is available from the *EE PCB Service,* quote order code: 8508-04.

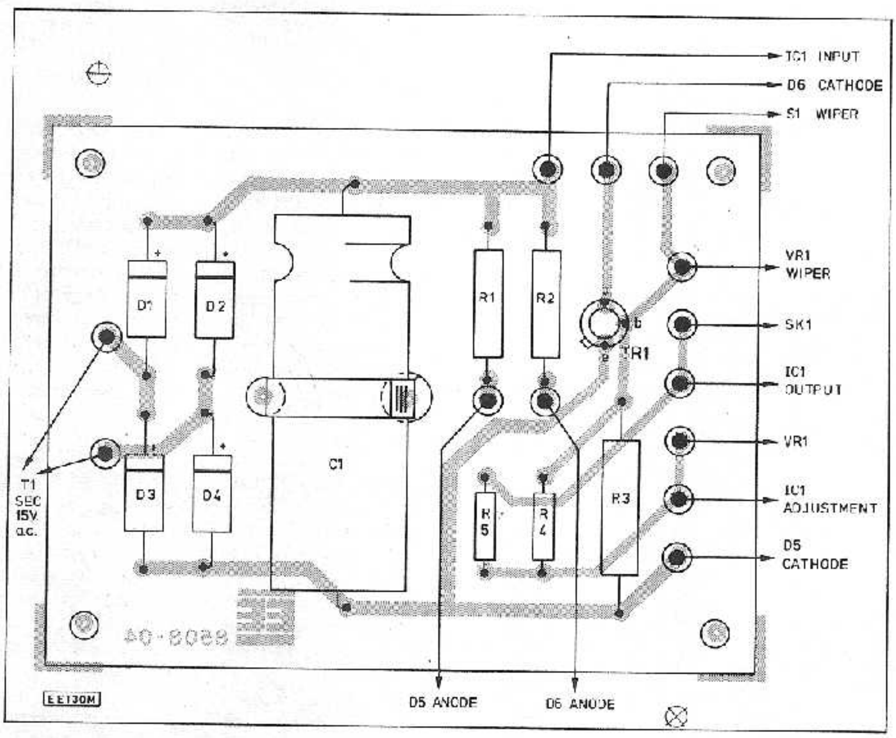



Fig. 3. Component layout and interwiring details for the Drill Control Unit.

## COMPONENTS

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**Resistors**

| | |
|---|---|
| R1 | 1k |
| R2 | 1·2k |
| R3 | 0·47R 3W W/W |
| R4 | 3·3k |
| R5 | 220 |

All ¼W 5% except R3

**Potentiometer**

| | |
|---|---|
| VR1 | 10k 1in. |

**Capacitors**

| | |
|---|---|
| C1 | 2200µ 40V axial lead elect. |
| C2 | 0·1µ polyester C280 |

**Semiconductors**

| | |
|---|---|
| IC1 | LM317T variable voltage regulator i.c., T0–220 case |
| D1–4 | IN5401 100p.i.v. 3A rectifier (4 off) |
| D5 | TIL221 0·2inch green l.e.d. |
| D6 | TIL220 0·2inch red l.e.d. |
| TR1 | BC107B silicon n.p.n. |

**Miscellaneous**

| | |
|---|---|
| T1 | mains primary, 0–15 + 0–15 2 × 0·8A secondary |
| FS1 | 1A 20mm chassis-mounting fuseholder |
| SK1,2 | 4mm socket, one each red, black (see text) |
| JK1 | 0·25inch mono jack socket |
| S1 | single pole centre off double throw toggle switch |

Printed circuit board, available from the *EE PCB Service*, order code 8507/0X, metal case, e.g. Tandy 270–266, heatsink type 10DNA 2°C/W or better, ½" T0-18 push-on heatsink, T0-220 insulation kit, control knob, interconnection wire, 3-core 6A mains cable, cable grommet and retention clip, l.e.d. lens-clips, one each red, green, 6BA p.c.b. mounting hardware, nylon tie wraps, nuts, bolts, solder tag, spacers, solder, etc.

**COMPONENTS approximate cost £20.00**

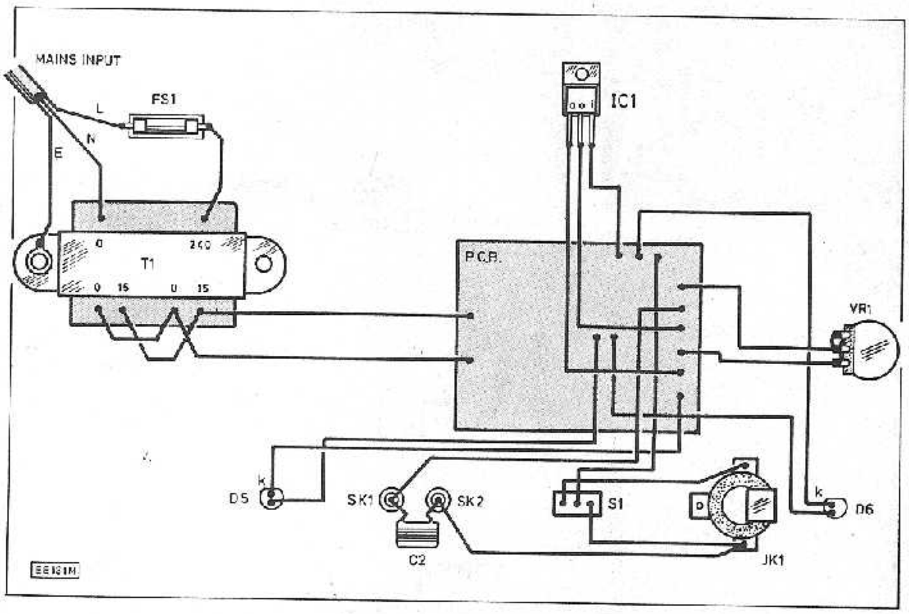


Fig. 4. Wiring diagram.

firmly using a nylon "P" clip or similar so that the cable cannot be pulled out.

The secondary windings of T1 are connected in parallel as shown to supply 15V a.c. at a total of 1·6 amps. This is then wired to the p.c.b. as shown, using heavy-duty hook-up wire (e.g. 32/0·2mm) which should be kept as short as possible.

With the exception of the small amount of mains wiring involved, for which employ at least 32/0·2mm 6A wire, the balance of the interwiring may be completed with general purpose hook-up wire. It is quite desirable to arrange the wiring into neat looms and nylon tie-wraps may be employed for this purpose.

## SOCKETS

In respect of SK1 and SK2, the reader may care to choose connectors compatible with those fitted on the drill. The author utilised two 4mm sockets on the prototype. For JK1 a standard ¼inch mono jack socket was employed to match the plug fitted on the footswitch. Readers should check the connections to their own jack sockets (if used) in case there is any variation. Notice that the 0V line is earthed courtesy of SK3, since the metal body of the socket will make an electrical contact with the chassis, which is of course earthed.

The footswitch employed by the author was clearly intended for audio or signal use but has successfully been used at up to 1·5A d.c. with no apparent ill-effect.

As previously mentioned, IC1 comes in the T0–220 pack and this is fitted to the heatsink in conjunction with a T0–220 mounting kit. The i.c. ***must be insulated*** since the heatsink is bolted to the chassis and is therefore at 0V. On the other hand the mounting tab of the i.c. is electrically connected to its output and so obviously some form of insulation is necessary if a short-circuit is to be avoided.

Concerning the approved heatsink, it was found that the sink was slightly larger than the steel case would allow once everything was bolted into place. Approximately 25mm was sawn off the heatsink using a large hacksaw. Afterwards the heatsink was sprayed matt black to reduce its thermal resistance. Also it is recommended that some ventilation holes are punched adjacent to the heatsink to permit some throughflow of air and so assist cooling.

## FINISH

To finish off the unit, letter the controls as required by using rub-down transfer lettering; naturally this is best done before any controls and fittings are placed into position. The appearance of the device will be further improved if coloured lens-clips are employed to mount the two light-emitting diodes.

Finally, an extra-long control knob of roughly 75mm diameter was fitted to the potentiometer and this enables the speed of the drill to be controlled easily, even when wearing rather cumbersome protective gloves.

With construction complete, check all the wiring and especially confirm that IC1 is properly insulated from the heatsink before plugging into the mains. Then, with mains applied, the green power-on l.e.d. should light up.

By connecting a voltmeter set to 25V d.c. full-scale deflection across the output sockets (right way round, of course) you can then ascertain that by rotating VR1 clockwise, the output voltage will be seen to vary from 1·2V to approximately 16V. Having satisfied yourself that the other functions perform correctly then the unit is complete and ready for use. □