AUTO NIGHTLIGHT

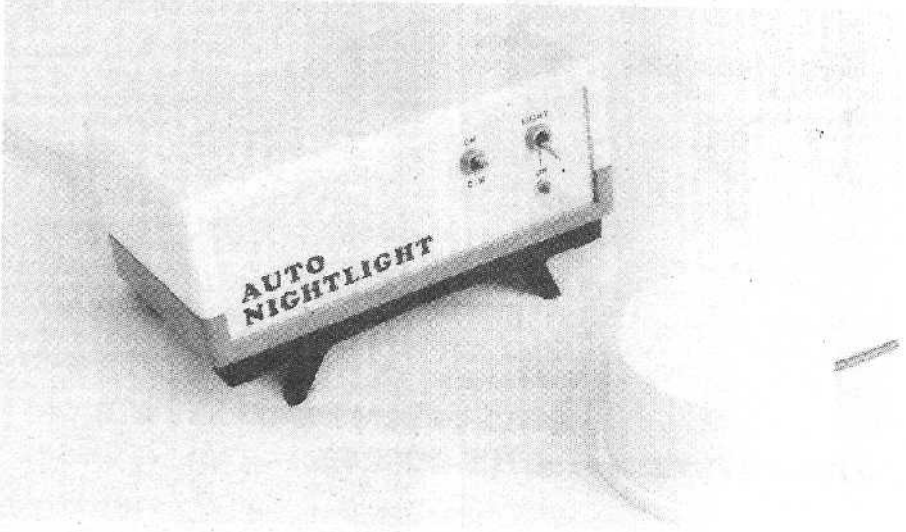
A. R. WINSTANLEY

A simple-to-build unit which operates and automatically dims a low voltage nightlight for the nursery.

DURING the early years of infancy it is often comforting to a child to be able to sleep in surroundings which are illuminated by a gentle nightlight, in order to allay any fear of the dark that the child may have. Hopefully, it is not necessary to keep the room's main light switched on, and with luck a small lamp such as a pygmy-type will have the necessary calming effect.

Often a "plug light" is used, which comprises several neon bulbs encased in a translucent plug top. These form a cheap solution, but they can obviously only be placed where the mains socket is located. An alternative is the traditional candle nightlight, but there are obvious drawbacks relating to safety and peace of mind.

The Auto Nightlight is a simple mains-powered low-level lamp but which has the added attraction of automatically dimming itself over an hour or so, if required; the design is obviously an improvement over a simple plug-type nightlight, since you can firstly select either "auto-dim" mode or "bypass' where the lamp will be continuously alight. Secondly, the lamp itself can be placed exactly where you require it – next to the cot, for instance – since the lamp operates at 12V and there are no potentially hazardous mains cables trailing everywhere.



CIRCUIT DESCRIPTION

The circuit itself is extremely straightforward and is ideal for the less experienced constructor wishing to tackle a simple mains-powered project for the first time. The circuit diagram of the Auto Nightlight is shown in Fig. 1.

Mains voltage is switched through S1, the On/Off control, and passes via a protective fuse FS1 to the primary windings of transformer T1, where it is stepped down to 9V a.c. This lower voltage is full-wave rectified by the bridge rectifier D1-D4 to produce a direct current. Capacitor C1 is a relatively large smoothing capacitor which smoothes out the ripple content of the bridge rectifier output, the net result being a d.c. voltage of approximately 15V-16V no load, 11V-12V on load.

A single pole changeover switch S2, which is a centre-off type, is biased one way. When the switch is moved to the "DIM" position, capacitor C2 charges up from the 12V supply rail; when the switch is released, it returns to the centre-off position but the charge on C2 is retained. Positioning S2 in the other direction would connect C2 continuously to the positive rail.

The Darlington transistor TR1 can be considered as two transistors in one package, as depicted by its schematic symbol. It is a very high gain transistor, a figure of 20,000 being typical. This implies that compared with a normal bi-poplar transistor, TR1 requires only a very tiny base current to saturate the transistor hard on. The Darlington in fact acts as a driver transistor for TR2, with a higher permissible collector current rating than the Darlington itself; hence, TR2 can drive a larger load than could TR1.

Once capacitor C2 is fully charged in the "DIM" mode, both transistors turn on like a switch. TR1 requires its base (b) to be 1.2V more positive than its emitter (e) because it contains two transistor junctions, whilst TR2 base must be just 0.6V more positive for that transistor to conduct.

Since the voltage at C2/R2 junction is about 12V due to the charge stored on capacitor C2, both transistors switch hard on or "saturate". This completes the circuit to lamp LP1, a 12V 2.2W bulb connected via jack socket SK1, and LP1 will therefore illuminate.

Capacitor C2 will discharge very slowly through resistor R2 via the base terminals of TR1 and TR2 to 0V. However, provided that the potential at TR1 base remains at 1.8V or more, both transistors will remain on, and hence the bulb will remain alight. Once the voltage drops to below this figure, the transistors will start to turn off, with the effect that LP1 will be seen to dim very slowly until it has extinguished altogether.

Unfortunately, it is very difficult to predict precisely the time period that will elapse before LP1 extinguishes. This is because of the very large manufacturing tolerance on capacitor C2, typically its value is 330μF −50% +100%.

The prototype Auto Nightlight started to dim after about 50 minutes or so. This was considered adequate for this application. The fact that the lamp stays fully alight for quite some time before starting to dim was also considered beneficial.

As mentioned earlier, if switch S2 is moved to the "ON" position, then the base of TR1 is connected via resistor R2 directly to the positive supply rail. In this case the dimming function is bypassed and the lamp will remain fully alight. Under these circumstances it is necessary to turn off at the mains in order to extinguish the lamp, due to the charge that is stored on C2.

CONSTRUCTION

Most of the components, including the mains transformer, are mounted onto a printed circuit board (p.c.b.), see Fig. 2. This is available from the *EE PCB Service*,

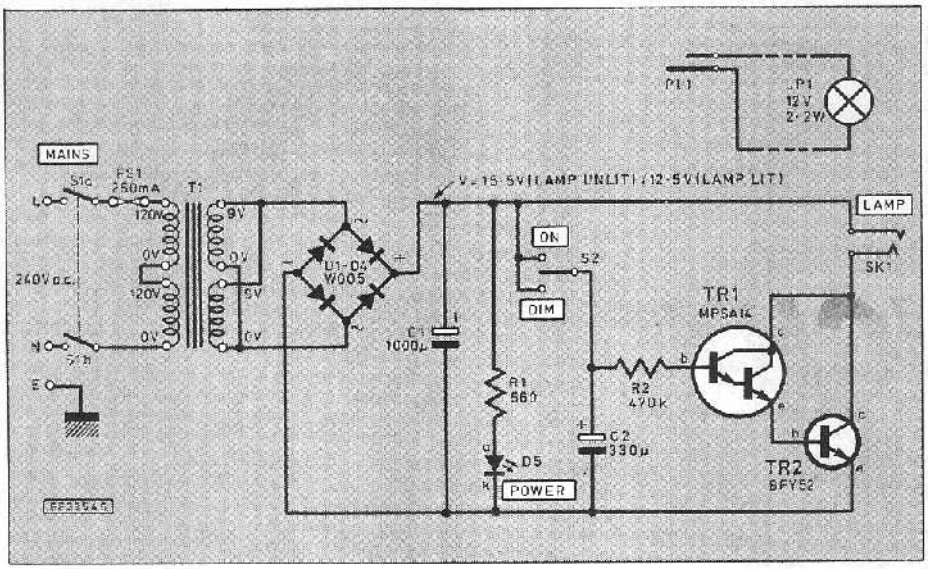


Fig. 1. Complete circuit diagram of the Auto Nightlight.

code EE779, or can be home-made in the usual manner. Only an *experienced* constructor should attempt to translate this circuit onto stripboard instead of using a p.c.b., because the board contains a mixture of mains-operated and low voltage parts.

The p.c.b. was designed, by virtue of its fixing centres, to fit into a Verobox No. 75-1238D measuring 155mm x 85mm x 60mm but any other similar case would suffice. The approved box has a top and bottom moulding in plastic but has front and rear panels made of attractive anodised aluminium.

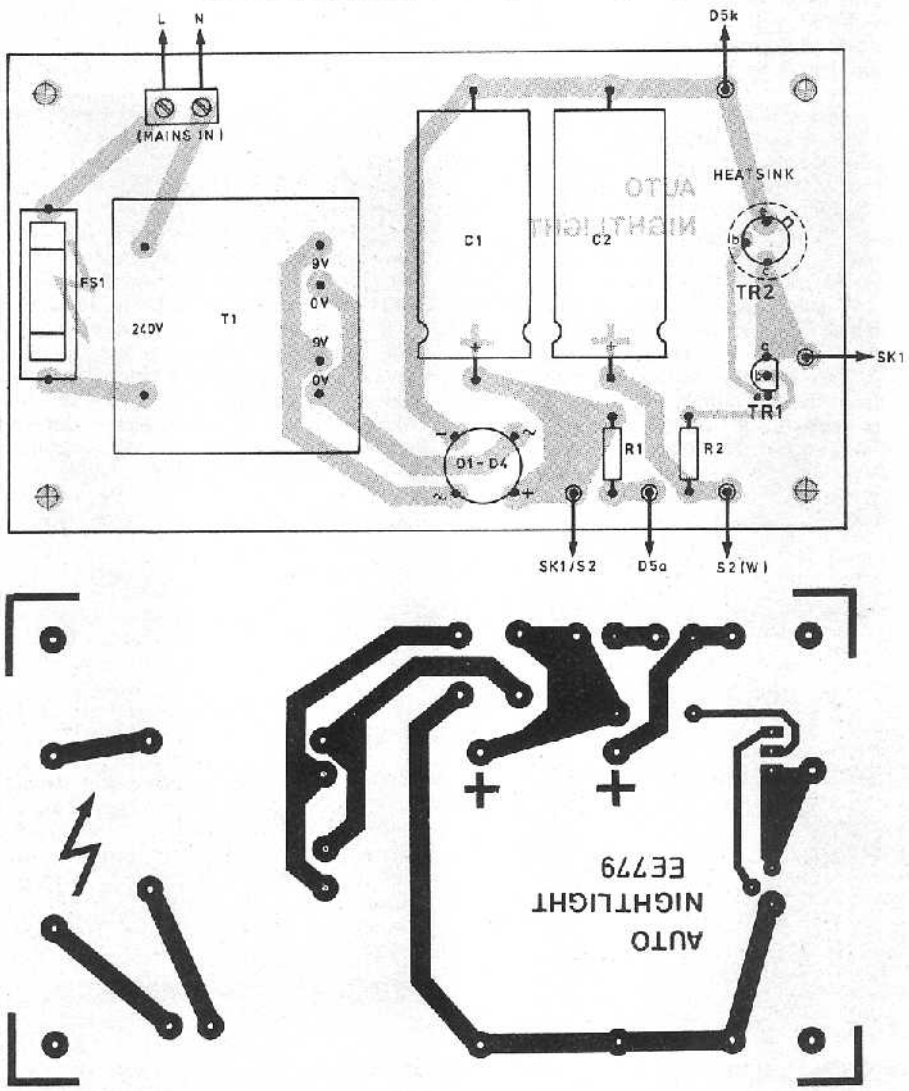
The layout of the components and full size copper foil master pattern is illustrated in Fig. 2. Even the fuse and mains transformer are p.c.b. mounted, thus reducing mains interwiring and making construction easier and safer.

It is best to start the assembly by soldering the smallest components into place, so start with the resistors and transistors, observing correct orientation of the transistor leads and taking care not to heat the semiconductors excessively. A push-on TO-5 type heatsink was fitted to TR2 to aid dissipation once the bulb starts to dim; it may be possible to omit the heatsink, otherwise fit it prior to soldering the device into place.

Follow on construction with the bridge rectifier D1-D4 and electrolytic capacitors, and here correct polarity is *essential*. Continue with the two-way p.c.b. screw terminal block, which forms the mains input for the board, then the p.c.b. fuseholder and finally the mains transformer T1.

There are differences between different makes of p.c.b. mains transformers, so it is obviously necessary to ensure that the unit purchased matches the p.c.b. pin layout. The transformer must sit snugly against the surface of the p.c.b. or damage to the copper track may result (the track could lift off eventually due to mechanical vibration).

Fig. 2. P.C.B. layout and wiring for the Nightlight.



COMPONENTS

See SHOP TALK Page

Resistors

R1	560
R2	470k

Capacitors

C1	1000µ axial elect. 25V
C2	330µ axial elect. 25V

Semiconductors

D1-D4	W005 50V 1.5A bridge rect.
D5	red l.e.d.
TR1	MPSA14 *npn* Darlington
TR2	BFY52 *npn* gen. purpose

Switches

S1	D.P.S.T. mains rated toggle
S2	S.P.C.O. centre-off toggle, biassed one way to match S1

Miscellaneous

T1	6VA mains transformer p.c.b. mounting; 240V primary, 9V 6VA secondary
SK1	3.5mm mono jack socket
PL1	3.5mm mono jack plug
FS1	250mA 20mm p.c.b. mounted fuseholder
LP1	12V 2.2W MES bulb in batten holder (see text)

Plastic case, size 155mm x 85mm x 60mm, with aluminium front and rear panel (Vero 75-1238D); single-core screened cable (or "figure-eight" twin-core flex), length to suit; 6A 3-core mains cable; mains rated 2-way p.c.b. screw terminal block; TO5 push-on heatsink; materials for lamp diffuser; connecting wire; solder etc.

Printed circuit board available from EE PCB Service, code EE779.

Approx cost guidance only **£14.50** *plus case*

CASE

Before completing the interwiring, it is necessary to prepare the aluminium front and rear panels of the box, dependent on the type of box purchased by the constructor. The rear panel is drilled to take the mains cable inlet, and this hole must be fitted with a grommet to prevent damage occurring to the cable insulation due to chafing. Further drilling is required for a

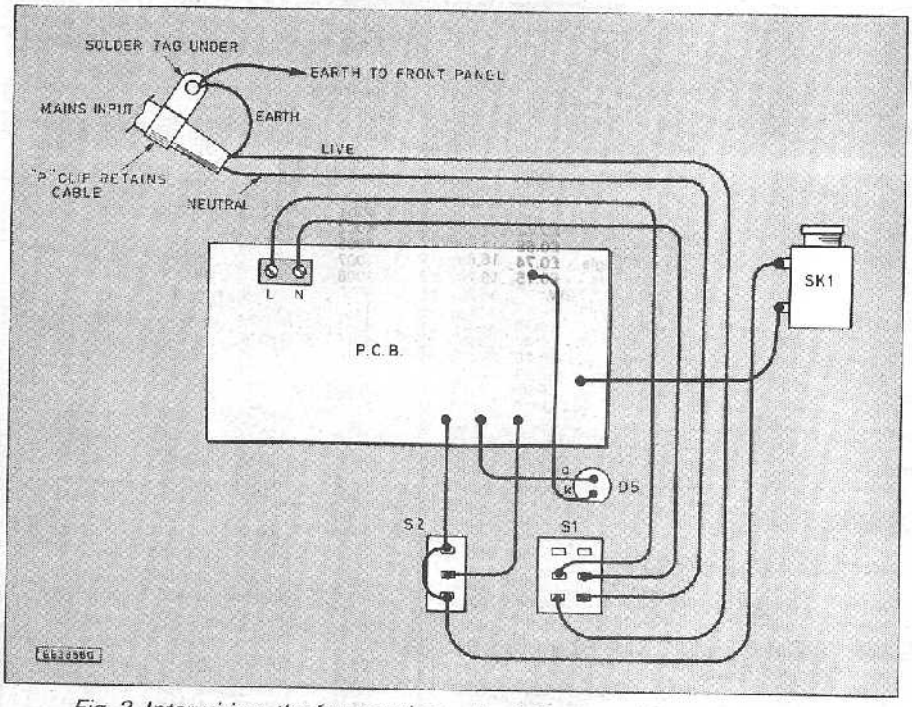


Fig. 3. Interwiring, the front and rear aluminium panels must be earthed.

"p" clip which retains the mains cable, and also a 6mm dia. hole will be required for the jack socket SK1.

The front panel is prepared to accept the toggle switches S1 and S2. If the specified switches are used, then two 6mm holes are needed. One final 6mm hole is required for the power-on indicator D5, which can be retained with an l.e.d. clip or lens bezel. If desired, the front panel can be embellished with rub-down lettering to label the controls, followed by a coat or two of protective clear lacquer.

Interwiring is completed in accordance with Fig. 3. Six amp three-core mains flex (e.g. 3 x 24/0.2mm) is employed for the mains inlet cable and the Earth input is connected via a solder tag to the "P" clip mounting bolt, in order to "ground" the rear panel. The front panel must also be Earthed for safety, and on the prototype this was achieved with an earthing wire (from the rear panel Earth tag) placed under one of the toggle switch mounting nuts.

LAMP UNIT

The lamp unit was constructed using a technique first used by the designer in *Everyday Electronics*, July 1978, no less! The lamp uses an aerosol top as a diffuser, see Fig. 4.

A batten-mounting M.E.S. bulbholder was fitted to a circular piece of 3mm plywood which had been cut to snap fit into the base of the aerosol top. A length of single-core screened cable (twin-core figure eight flex will work equally well) interconnects the lamp and the main unit, and was terminated in a 3.5mm jack plug to fit socket SK1.

Since long trailing cables at mains voltage are to be discouraged, it is best to have the mains flex as short as possible, say one metre long. But the lamp connecting wire, being at 12V d.c. can be as long as necessary, so the lamp can be positioned in any desired location.

FINAL CHECK

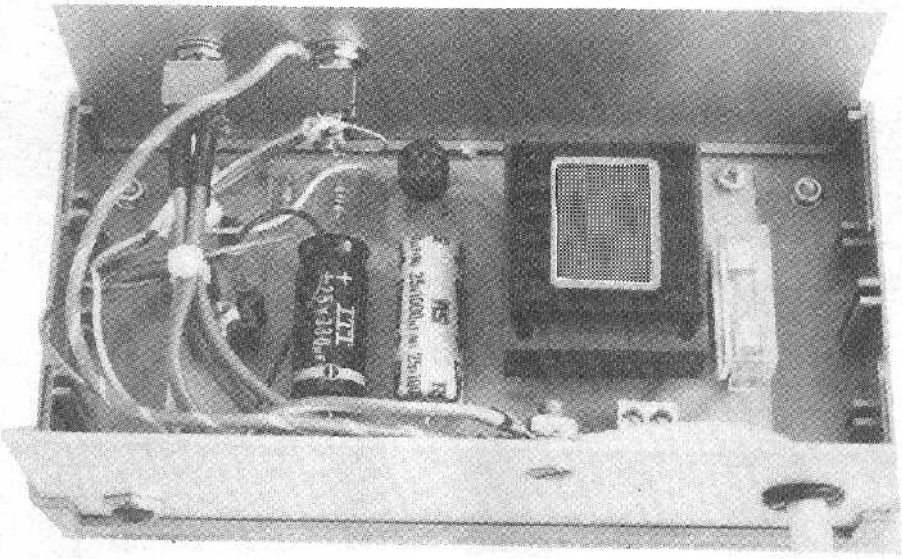
Complete the assembly of the Auto Nightlight by fitting a mains plug *fused 3A*, to the mains lead, and plug in the lamp unit to the jack socket SK1. Prior to plugging in and switching on, thoroughly check the unit for any wiring errors, particularly regarding the polarity of the electrolytic capacitors and transistors. With S1 set to "OFF", plug into the mains and switch on.

Operating switch S1 should illuminate the l.e.d. and by switching S2, the lamp should illuminate. It should stay alight even if switch S2 returns to the centre-off position.

It may be possible to time the period that elapses before the lamp gradually extinguishes. This should be about an hour or so.

As explained earlier, there is a large tolerance on capacitor C2 and if the time period is far too short or too long, then probably the easiest remedy is to raid the junk box and substitute C2 for another value (observing the *correct* voltage rating). Some trial and error may be required in extreme cases.

Finally, it is safe to connect a *second* lamp unit (12V 2.2W max.) in parallel with LP1 without any problems. Or substitute LP1 for a 5W lamp (car type), since there is adequate spare capacity on the transformer and also the output transistor. □



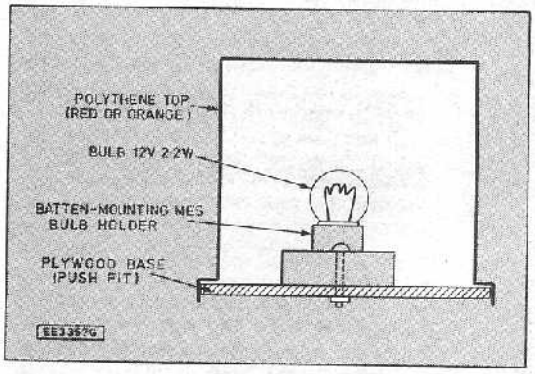


Fig. 4. Lampholder made from the top of a large aerosol can.