LIGHT BULB SAVER

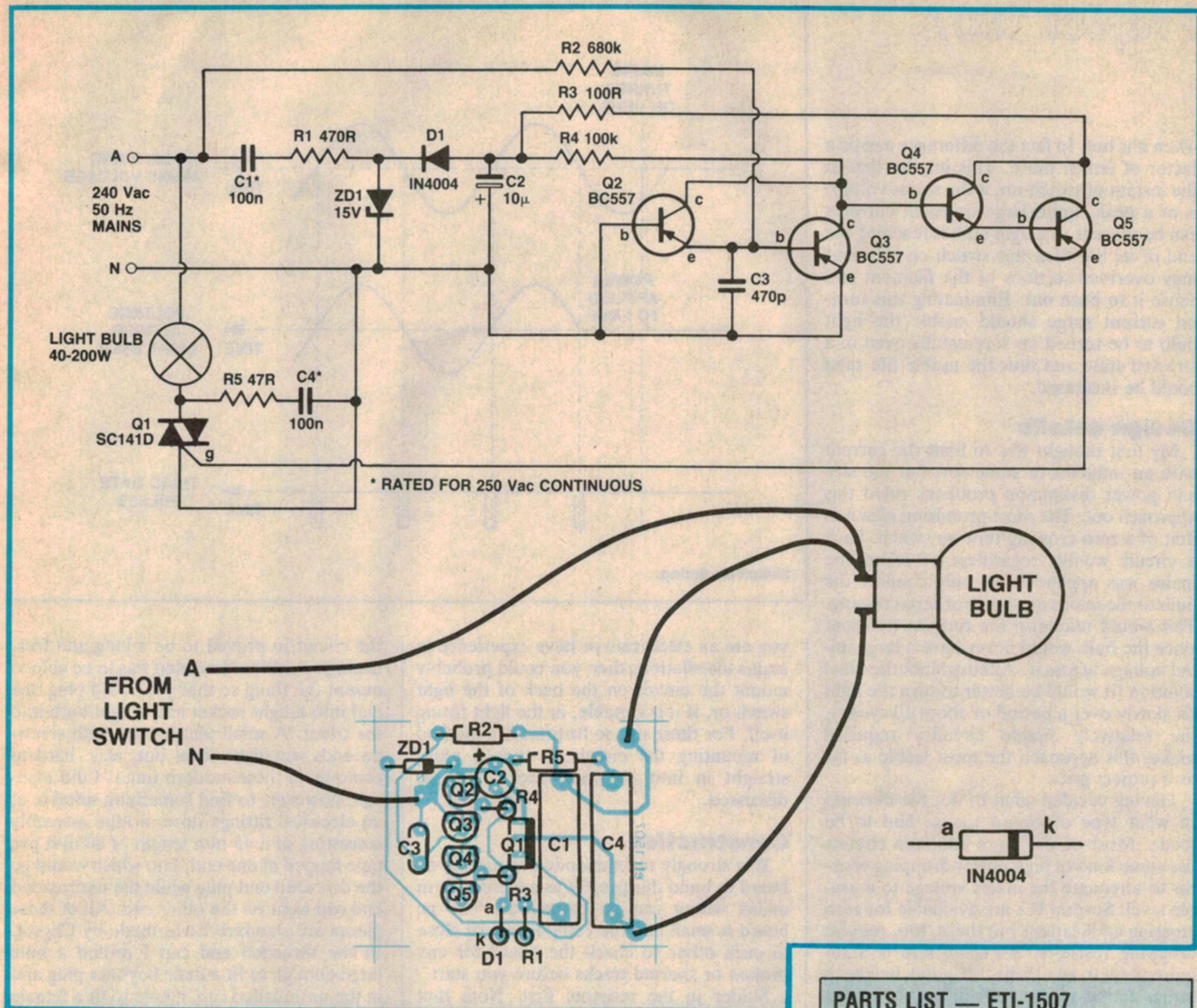
Photograph taken by Greg McBean.

Things that go 'ping' in the night are quite likely to be your light bulbs — just when you turn them on. Why is it so, we asked and why is it so irritating? The result is a circuit that avoids switch-on at those moments of peak current most hazardous to the bulb.

Robert Irwin

RETURNING HOME ONE dark and stormy night from a particularly devastating party, I encountered a situation that inspires drastic action to solve a seemingly insignificant problem. After stepping out of a taxi and weaving my way to the front door, I managed, after some struggling, to open the front door. Dripping wet and feeling delicate I searched the wall for the light switch. Flicking it, I was greeted by a quick flash, a small 'ping' and darkness. Seemed as if it were only yesterday I had replaced the bulb but here it was, blown again. Having a hall of the particularly dark, sinister, winding and decidedly unfriendly type I was tempted to sleep on the doorstep till morning but, being wet and cold drove me through unknown objects waiting to trip me in the dark and head for the shower. Negotiating the hall with only relatively minor shin scrapes and one fall I began to feel the forces of nature were not entirely against me. Ah! How wrong I was. A flick of the switch in the bathroom and 'bink', another bulb gone.

The urge to destroy eventually gave way to the creative feel which started me on a quest to extend the life of my light bulbs. After soaking in a hot, but dark, tub for an hour or so it became clear that this would be no trivial matter. Past bulb demises seemed to show that they usually go at the instant of switch on. The 'cold' resistance of a light bulb filament is far less than the resistance



HOW IT WORKS — ETI-1507

The circuit basically consists of two parts, the power supply and the zero crossing triac drive circuitry.

The power supply consists of C1, C2, D1, ZD1 and R1. When the mains swings positive, D1 is reverse biased and C1 charges up through R1 and ZD1 to about the mains peak voltage. When the mains swings negative the stored charge in C1 is 'pumped' into C2 through D1. In this part of the cycle C1 and C2 act as a capacitive divider to divide the mains down so that large currents don't flow. The charge on C2 will build up at the end of each cycle and thus the voltage will increase (in the negative sense in this case). When the voltage reaches the zener breakdown voltage the extra charge will go to ground through the zener and thus the voltage across C2 will be constant. The voltage on the negative side of C2 will thus be about −15 Vdc. Because of the high output impedance of the charge pump, the current that can be supplied continuously is only a few milliamps.

The remainder of the circuit consists of the zero crossing triac drive. The base of Q3 and the emitter of Q2 are connected together and to the mains via R2. We will call this point 'A' on the diagram. The emitter of Q3 and the base of Q2 are both connected to 0 V (neutral) and the collectors of both transistors are tied to −15 V. When point A goes positive (when the mains goes positive) Q2 will be biased on and the collector will be pulled low (point B on the circuit). When the mains tries to go negative Q3 will be turned on and once again the collectors (point B) will be tied low. The only time both transistors are off together is when point A is between +0.6 V and −0.6 V. At this time point B will swing to −15 V which will turn on Q4 and enable Q5 to deliver a negative gate pulse to the triac to turn it on. R3 will limit the current to the triac gate to about 100 mA.

R5 and C4 are connected across the triac to limit the rise time of the voltage when the mains is switched on. Too fast a voltage rise across the triac can cause it to turn on even when no gate pulse is present.

PARTS LIST — ETI-1507

Resistors................all ¼ W, 5% unless noted

R1	470R
R2	680k
R3	100R
R4	100k
R5	47R

Capacitors

C1, 4	100n 250 Vac (AEE type PME271M or similar)
C2	10µ 16 V RB electro
C3	470p

Semiconductors

Q1	SC141D triac (or similar)
Q2, 3, 4, 5	BC557
D1	1N4004 or similar
ZD1	15 V 400 mW zener

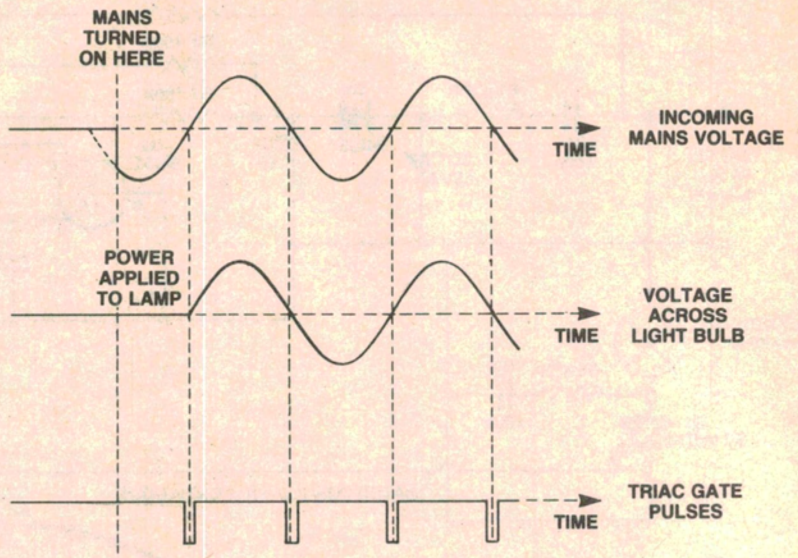
Miscellaneous

ETI-1507 pc board.

If mounting the board in the tube assembly described you will need the following: 45 mm length of 40 mm diameter pvc tube threaded at one end; threaded 40 mm diameter end plug; unthreaded 40 mm diameter end cap; male bayonet socket; female bayonet light socket; mains rated hookup wire.

Price estimate: $5-$6
(without tube assembly)

▶



Switch-on timing.

when it is hot. In fact the difference can be a factor of ten or more. This implies that at the instant of switch-on, if the mains voltage is at a peak, quite large transient currents can be present. If a light bulb is reaching the end of its life then this switch on transient may overload sections of the filament and cause it to burn out. Eliminating this turn-on current surge should enable the light bulb to be turned on successfully even in a stressed state and thus the usable life span could be increased.

Design details

My first thought was to limit the current with an inductor of some sort but the size and power dissipation problems ruled this approach out. The most promising idea was that of a zero crossing turn-on switch. Such a circuit would, regardless of when the mains was applied to it, only connect the bulb to the mains at a point of zero crossing. This would minimise the turn-on transient since the bulb would never have a large initial voltage across it. Although not the ideal solution (it would be better to turn the light on slowly over a period of about 10 cycles), the relatively simple circuitry required makes this approach the most viable as far as a project goes.

Having decided what to do, the decision of what type of circuit to use had to be made. Most of the more common circuits use some kind of high power dropping resistor to attenuate the mains voltage to a usable level. Several ICs are availiable for zero crossing applications but these, too, require dropping resistors. As small size is a requirement it would be no good having a rather bulky power resistor in the circuit and anyway, the heat dissipated in such a device would present all sorts of problems of its own.

Another approach is to use a capacitive divider network. This sort of circuit could provide a stable dc rail supplying a few milliamps to run the neccessary circuitry, and would not dissipate any significant amount of heat. The only disadvantage is the need of a capacitor which is rated for continuous connection across the mains. This type of cap is a little bulky but that can be lived with.

Having decided on a power supply, it was time to think about the zero crossing and triac drive circuitry. A project published in our June 1984 issue for a bathroom strip heater timer (designed by Ian Thomas) had a cunning little circuit which could be modified to do just what I wanted. This used two transistors to detect the zero crossing point of the mains and a further couple of transistors to provide a pulse to the triac gate. OK! I had a circuit. Now for the hard part!

When dealing with any circuitry which directly switches mains voltages it is important to ensure that it is mounted safely. If you are an electrician or have experience in mains installations then you could probably mount the circuit on the back of the light switch or, if it is suitable, in the light fitting itself. For those not so fortunate, a method of mounting the circuit so that it plugs straight in into the light socket will be discussed.

Construction

It is strongly recommended to use the pc board to build this project as any mistake in mains wiring can be dangerous. The pc board is small and the components sit close to each other so check the board for any broken or shorted tracks before you start.

Solder in the resistors first. Note that some of the resistors mount standing on end to save room. If you wish, the exposed leg of these resistors may be covered with spaghetti insulation to prevent any accidental shorts. Next solder in the capacitors. The input dropping cap and the cap across the triac are both mains rated. Be careful to get the electrolytic in the correct way round. The two diodes can go in next. Again take care to get these in right way round. Lastly, solder in the four transistors and triac.

Once the board is complete do a thorough check and make sure that all the components are in the correct positions and the right way round. Also make sure that there are no solder bridges between tracks which may cause shorts.

Installation

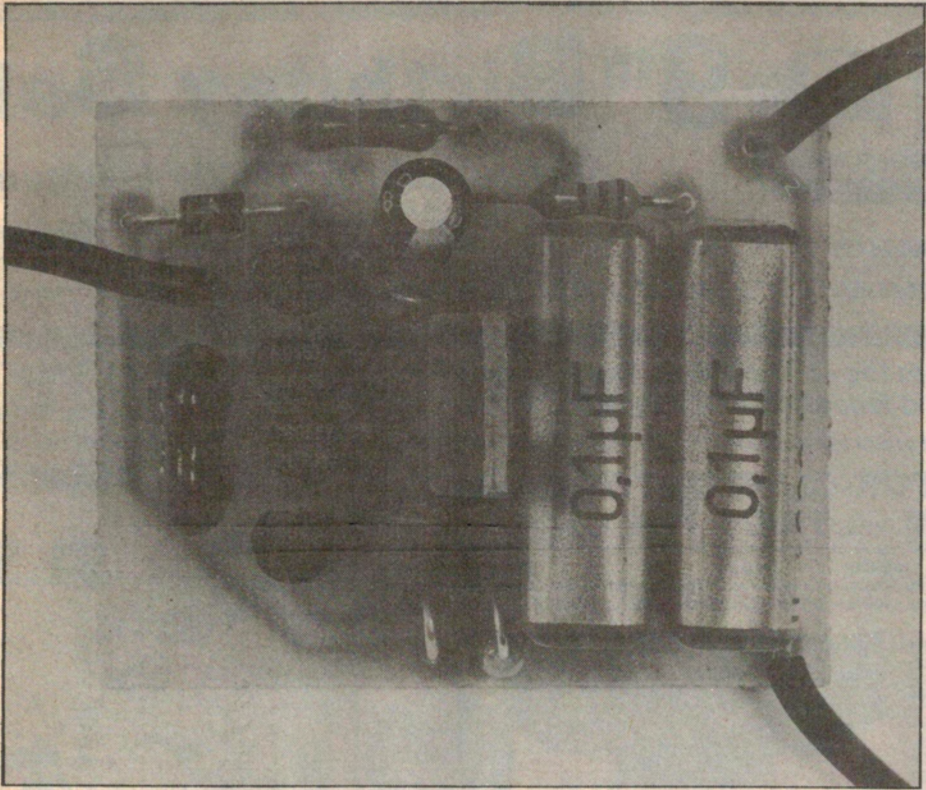
You are now ready to install the circuit. If you have the necessary expertise then you can mount the board behind the existing light switch or in the light fitting. If not follow the method of mounting the unit to plug into an existing light socket described below.

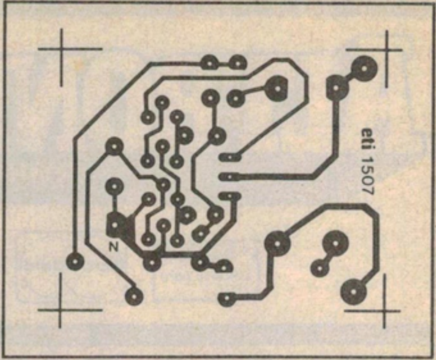
The search for some kind of case to put the circuit in proved to be a long and frustrating one. What I needed was to be able to mount the thing so that you could plug one end into a light socket and a light bulb into the other. A small plastic tube with screw-on ends would be ideal but, alas, hard to come by in these modern times. I did manage, however, to find something suitable at an electrical fittings store: a tube assembly consisting of a 45 mm length of 40 mm pvc pipe tapped at one end, into which would go the threaded end plug while the unthreaded end cap went on the other end. All of these pieces are standard items made by Clipsal. In the threaded end cap I drilled a hole large enough to fit a male boyonet plug and in the unthreaded cap, a hole to fit a female bayonet light bulb socket. The end covers for the plug and socket could then be used to fasten them into the pvc caps.

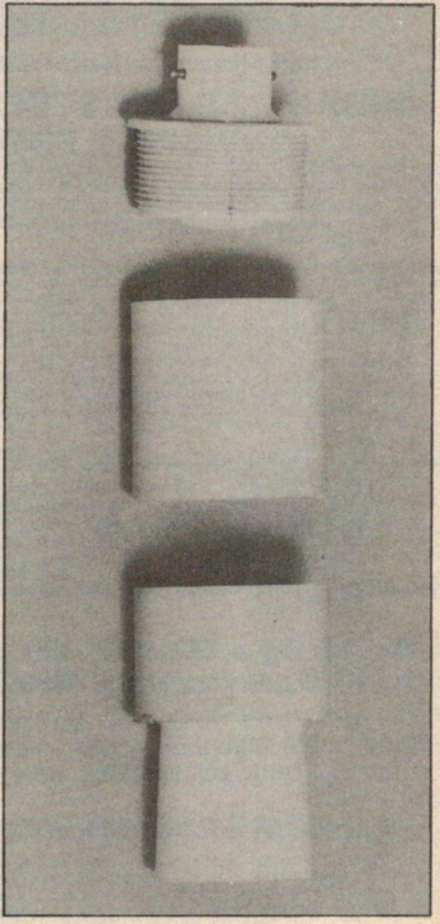
The board can then be wired up as shown in the wiring diagram and put into the tube. The unthreaded end needs to be glued in place using a special pvc cement. This should be obtainable from the same place you get the tube assembly. The threaded end can then be screwed into place and you are ready to go. I would leave enough connection wire from pc board to fitting so that the board can be pulled out of the tube for servicing without having to break off the glued end. Also, you will have to make sure that the pc board does not come in contact with the mains terminals on the plug and socket when the whole assembly is mounted. This is best done by encapsulating the pc board with insulating tape before pushing it into the tube.

The completed unit can be inserted into a light socket as would a normal light bulb. The bulb then plugs into the end of the light saver. The circuit will work with any incandescent bulb from 40 to 200 watts.

●







GETTING CROSS OVER LIGHT BULBS

Since the inception of this project many moons ago there have been quite a few 'friendly', lunchtime discussions down at the local between the various, humble staff members concerning the actual usefulness of a zero crossing turn-on in this situation. The usual line of argument follows that to really extend the life of a light bulb one must limit the turn-on transient to less than the thermal rise time of the filament. This 'soft turn-on' would then take place over several (about 10) mains cycles. Methods of doing this could range from very complex solid state circuits to a very simple pilot light bulb and LDR arrangement. The drawback of the former is self evident and that of the latter is low efficiency, power wise.

The zero crossing turn-on, as pointed out in the text, was not intended to be a magical cure for blown light bulbs. (Alas! This accursed plague will be on mankind until the lights go out for the proverbial last time.) But I maintain that a significant increase in the life of a bulb that is turned on and off frequently can be achieved with this type of circuit. Some limited testing has been done in the lab and this seems to confirm my view, but the sceptics remain unconvinced!

If any of our readers has experience in this area or would just like to add two cents worth please drop us a line. Who knows? Maybe one of the alumnae reading these hallowed pages has devoted her entire life to the pursuit of longer life light bulbs and is just aching for the chance to publish. At least it would settle all the arguments down the pub!