FLASHING LIGHT SHOW

THIS article describes a unit designed to flash up to 200 watts of mains lighting on and off in time to music. With the increasing popularity of "progressive" music which, when performed live, usually has an associated light show, it is felt that a home light show is the obvious next step after stereo hi-fi to obtaining pop concert or dance hall realism in the home. The unit can also be used as a low speed stroboscope.

The design criteria of the unit were as follows:

(a) To be capable of being connected to any existing sound system without affecting the sound system.

(b) A standard mains lighting system should be used as the display.

(c) The unit should obtain all its power from the mains without the need for batteries.

(d) The design should be compact, reasonably cheap and simple to build and maintain.

CIRCUIT PRINCIPLE

Basically the circuit consists of an audio triggered monostable switch, which operates a thyristor (SCR1) and this in turn switches the light on and off.

The monostable is triggered from the sound system, usually from a loudspeaker, and switches whenever the sound exceeds a certain level, which is normally on a drum beat. It then turns on the lights for a set time, after which is returns to its stable state, with the lights off, ready for the next trigger pulse.

The switching circuit consists of four rectifiers in a normal bridge rectifier configuration, with a thyristor connected in place of the load as in Fig. 1.

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A thyristor is basically a silicon rectifier which only conducts in the forward direction when a small voltage in the order of a few volts is applied to a third terminal called the gate or trigger. Once the thyristor is conducting, the gate voltage can be removed and the thyristor will hold itself on until the current is stopped. The reverse characteristic of the device is the same as for a normal silicon rectifier.

It can be seen that when the thyristor is turned off, the switched circuit is in effect open circuit between A and B. However, when the thyristor is triggered (turned on) the circuit becomes, in effect, a short circuit between A and B.

It should be pointed out that if an a.c. signal is applied to the circuit, as is of course the case, then the trigger pulse has to be re-applied with every half cycle, as the current through the thyristor drops down to zero between each half cycle.

Hence, by connecting the switch circuit in series with a mains bulb, it can turn the bulb on and off by means of a small trigger voltage. It is, however, more convenient, as will be seen later, to put the mains bulbs in series with the thyristor itself as in Fig. 2.

This has no effect on the light output of the bulbs as it simply means they are receiving a full wave rectified mains supply instead of an a.c. mains supply.

TRIGGERING

According to the type of thyristor used, a trigger voltage in the order of 3 volts at 20mA, relative to the cathode, is required. It was found that the thyristor used could be triggered directly by connecting it across a loudspeaker. However, the lights only stayed on for the duration of each loud sound and they tended to be rather erratic when the music contained loud vocal work. Also the gate current drawn by the thyristor was sufficient to cause a slight crackling sound from the loudspeaker as the device switched on and off. Furthermore, the continuous switching caused slight radio interference and rather reduced the life of the bulbs.

It was therefore decided to incorporate a monostable between the signal source and the thyristor in order to hold the lights on for a certain period before letting them turn off again. This has the effect of making the lights switch on and off more rythmically, and it is also more kind to the bulbs and suppresses radio interference.

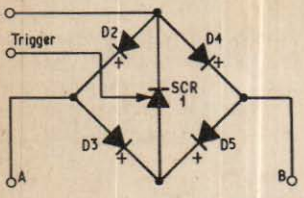


Fig. 1. Thyristor switching circuit

MONOSTABLE

The overall circuit diagram is shown in Fig. 2.

When the monostable is in its stable state, TR2 is on and TR1 off. A negative trigger pulse of sufficient magnitude applied to the base of TR1 will turn it on and its collector voltage will drop towards zero volts. This voltage change is transmitted via C2 to the base of TR2, turning TR2 off. Transistor TR2 then remains off until C2 has charged up, via R5/VR2, to a voltage sufficient to turn it on again; when this happens the circuit reverts back to its stable state.

TRIGGER TRANSISTOR

An output is taken from the collector of TR2 and fed via the trigger transistor TR3 to the gate of the thyristor. The purpose of TR3 is to act as a power amplifier to switch the thyristor, which otherwise may upset the working of the monostable.

When the monostable is in its stable state with TR2 on, TR3 is turned off and hence the gate of the thyristor is at the same potential as the cathode. When the monostable changes state TR3 is turned on and the gate of the thyristor is connected via R8 to the positive supply thus triggering it and turning the lamps on.

CONTROLS

It has already been pointed out that the "on time" of the monostable and hence that of the lights is decided by the time constant $C_2(R_5 + R_{VR2})$. By making

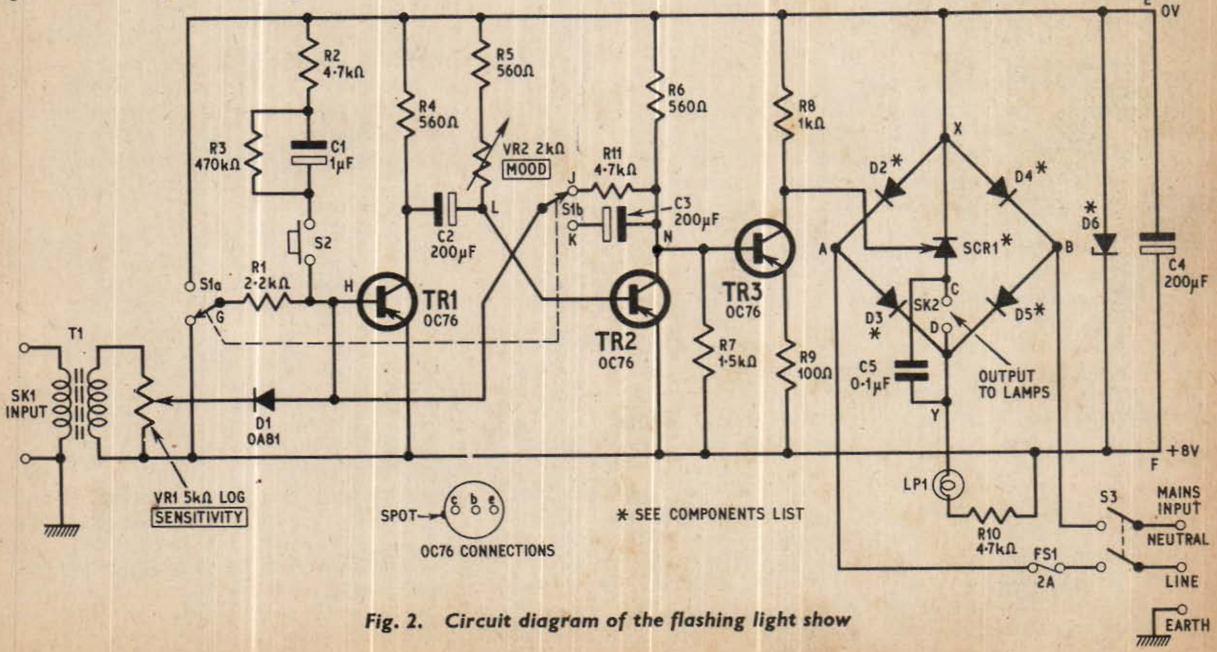
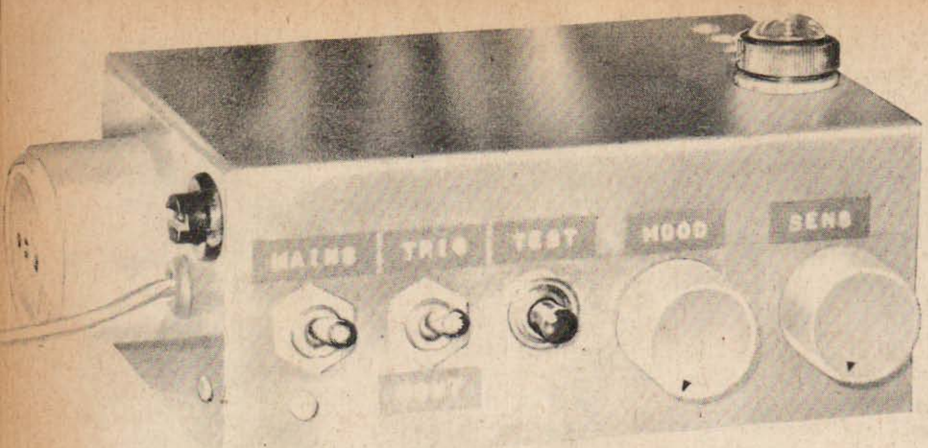


Fig. 2. Circuit diagram of the flashing light show



It should be noted that the flashing light display described in this article could produce an effect, on a few people, that may cause fainting. This usually only occurs when high power flashing lights are used for long periods in conditions of low ambient light.

$C_2 = 200\mu F$, $R_5 = 560$ ohms and $R_{VR_2} = 2$ kilohms the on time of the lights can be varied between 0·112 and 0·512 seconds which has been found to be an adequate range. Potentiometer VR2 is called the "mood" control as it determines the length of the flashes and is adjusted to suit the mood of the music.

It is also very easy to convert the monostable into an astable multivibrator and this is achieved by S1. When S1 is closed the circuit is free running and hence the lights are continuously switched on and off like a slow running stroboscope. With S1 in this position, R11 is replaced by a 200μF capacitor (C3) and also R1 is taken to the 0V supply line instead of the + 8V supply line, thus converting the circuit to a multivibrator. When S1 is in the trigger position, the monostable operates normally, being triggered from the audio signal.

A test button S2 is provided to apply a trigger pulse to the monostable in order to test the unit. This is not essential and can be left out.

The other controls are the on/off switch (S3) and the sensitivity control (VR1), both of which are self-explanatory. The best way to set the sensitivity control is described later in the article.

TRANSFORMER DETAILS

It should be realised that the whole of the circuit is at approximately 240 volts d.c. below earth due to the action of the rectifier circuit, and hence the circuit *must* be connected to the signal source via an isolating transformer. The transformer used should have a winding ratio of about 1 : 1, and the breakdown voltage between windings must be greater than 500 volts.

Probably the best transformer to use would be a speaker isolating transformer which is made for just this type of job. However, speaker transformers tend to be unnecessarily bulky and expensive due to the power and frequency requirements. If a transformer of this type is used the case would have to be enlarged to accommodate it. A mains isolation transformer could also be used but may also be rather large and possibly expensive.

The prototype unit used a government surplus transformer that measured 1¼in × 1in × 1in having a winding to winding and winding to case insulation of 500 megohms, measured at 1,000 volts. The transformer has a winding ratio of 2 to 1 and is a miniature valve interstage transformer; it is housed in a metal case and has insulated ceramic stand off terminals. If a transformer with a slight step-up ratio is used, it should be connected so that it steps up the signal coming into the circuit.

The output from the transformer is passed via VR1 and a diode to the base of TR1. The diode ensures that only negative pulses are applied to the base of TR1, otherwise the monostable would be switched back to its stable state prematurely by positive pulses.

POWER SUPPLY

It was decided to derive the power supply for the monostable and trigger transistor from the mains supply rather than from batteries for two reasons. Firstly, because the transistors require a fairly large current, and secondly because a rectified mains supply was already present in the circuit. This brings us to the reason for putting the mains bulbs in series with the thyristor. By doing this the voltage appearing between the points X and Y in Fig. 2 is always the full wave rectified mains voltage irrespective of whether the thyristor is on or off. If the bulbs were put in series with the complete switch then when the thyristor was on the rectified voltage would drop to almost zero.

The rectified voltage is applied via a 4·7 kilohm 10 watt dropping resistor to an 8 volt Zener diode giving a stabilised 8 volt supply to power the transistor circuitry. A 200μF capacitor is connected across the Zener diode and this provides adequate smoothing. The circuit draws approximately 15mA in the off state and 35mA in the on state, the extra current in the on state being the trigger current in the thyristor.

VOLTAGE DROPPER

The mean d.c. value of the rectified mains voltage appearing between X and Y was measured to be 210 volts. Hence the voltage drop across R10—the 4·7 kilohm dropping resistor—has to be 202 volts, which means a current of 43mA must flow through R10. Hence the Zener diode has to pass 28mA when the circuit is in the off state. A Zener diode with at least 50mA rating should therefore be chosen.

If a Zener diode with a current rating appreciably higher that 50mA is used, then some or all of the dropping resistance R10 can be replaced by a small mains bulb. This replacement resistance depends on the surge rating of the Zener, because a bulb passes a large surge current when it is switched on as the cold resistance of the filament is lower than the hot resistance. By leaving some resistance in series with the bulb the surge is reduced. An example of the calculation for a series resistor and lamp is as follows.

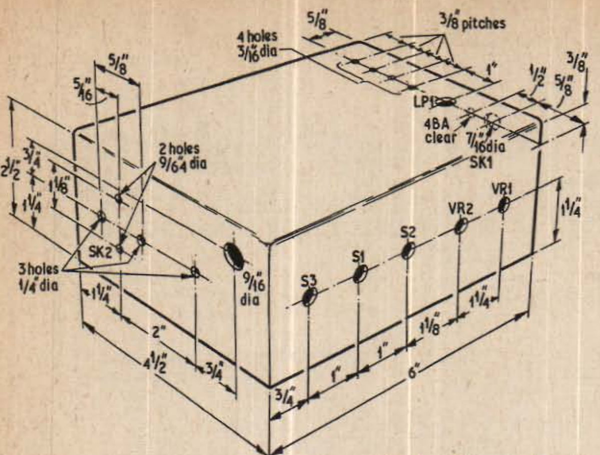


Fig. 3. Chassis details

The hot resistance of a 15 watt mains bulb is given by

$$R = \frac{V^2}{W} = \frac{240^2}{15} = 3 \cdot 9 \text{ kilohms}$$

We want the total resistance to be approximately 4·7 kilohms. Therefore the series resistance should be 1 kilohm.

A reasonable assumption for the cold resistance of the bulb is 1·5 kilohms (bearing in mind that the current will never reach the value given by the cold resistance, owing to the filament heating up). Hence current surge will be approximately 100mA.

Thus we need a Zener diode with a surge rating of 100mA if a 15 watt bulb in series with a 1 kilohm resistor (of 2·5 watts rating) is used as a voltage dropper.

This arrangement is convenient because one can obtain coloured miniature bulbs of 15 watts rating for mains indicator use.

CONSTRUCTIONAL DETAILS

The unit should be constructed in a totally enclosed, 6in × 4in × 2½in, aluminium case. The drilling details for the case are given in Fig. 3. These can, of course, be altered in order to suit particular components, but it is felt that the layout shown can be used with most parts and enables the unit to be fitted into the smallest box possible, yet leaves it very easy to work on any particular part of the circuit.

In the prototype unit most of the electronics, including the thyristor and rectifiers, were fitted on two plug-in printed circuit boards; Veroboard can just as well be used and wiring details for Veroboard panels are shown in Figs. 4 and 5.

It should be pointed out that if the thyristor and rectifiers are to be used at anything near their full rating, then they should be mounted on heatsinks. The prototype unit used 3 amp rectifiers and thyristor and is capable of switching 300 watts for several hours continuously. This, however, tends to make the rectifiers rather hot and it is suggested that 200 watts is taken as maximum if the rectifiers are mounted on a printed circuit board; 200 watts is ample for most domestic rooms.

PLUG-IN BOARDS

Having all the circuitry on plug-in boards makes construction easy, enables two layers of components to be fitted in the case, and facilitates easy servicing. The bottom board contains the monostable, and the top board (looking from underneath) houses the trigger and switch circuit. The transistors used can be almost any low power, *pnp* switching transistor capable of passing 25mA. Great care should be taken in assembling the thyristor and rectifier board as some of the

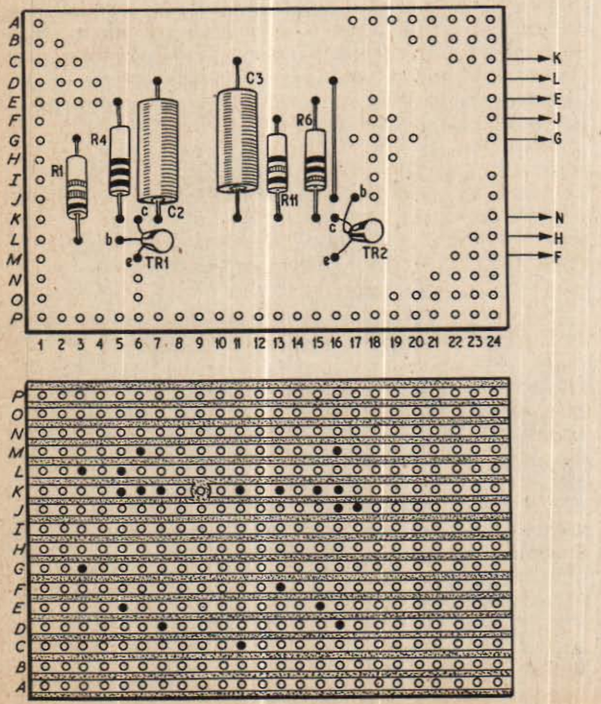


Fig. 4. Layout and wiring of the monostable Veroboard panel

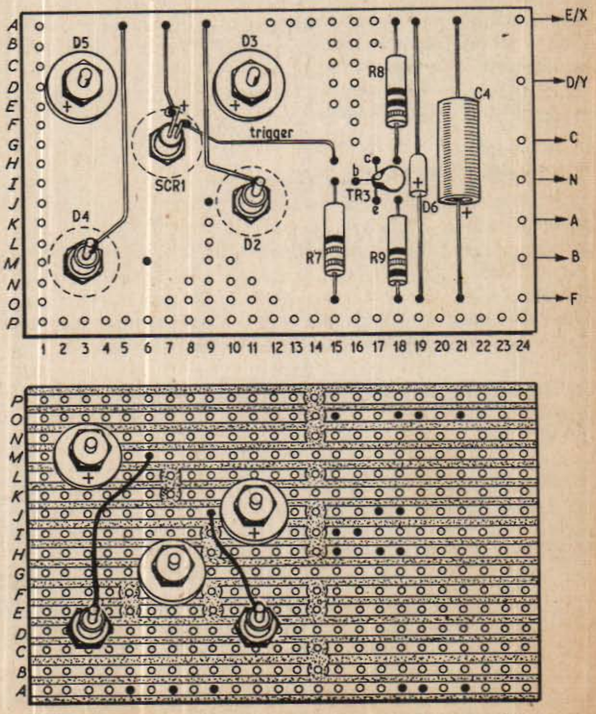


Fig. 5. Layout and wiring of the switching and trigger Veroboard panel

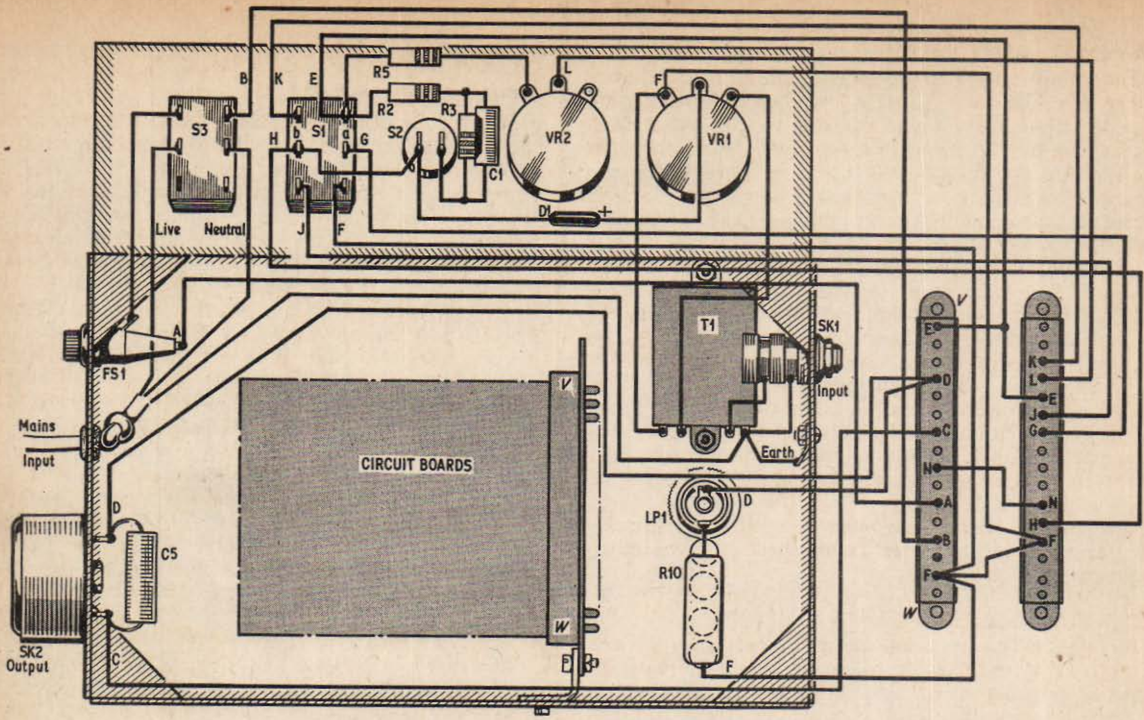


Fig. 6. Component layout and wiring of the chassis mounted components

COMPONENTS . . .

Resistors

R1	2·2k Ω	R7	1·5k Ω
R2	4·7k Ω	R8	1k Ω
R3	470k Ω	R9	100 Ω
R4	560 Ω	R10	4·7k Ω 10W wire wound
R5	560 Ω	R11	4·7k Ω
R6	560 Ω		All ± 10%, ¼W carbon, except R10

Potentiometers

VR1 5k Ω log.
VR2 2k Ω linear

Capacitors

C1 1μF elect. 10V
C2 200μF elect. 10V
C3 200μF elect. 10V
C4 200μF elect. 10V
C5 0·1μF paper 450V

Semiconductors

D1 OA81
D2–5 400 p.i.v. 3 amp silicon rectifiers (4 off)
D6 Zener diode 6 to 12V 50 mA (see text)
TR1–3 OC76 or equivalent (3 off)
SCR1 400 p.i.v. 3 amp thyristor

Switches

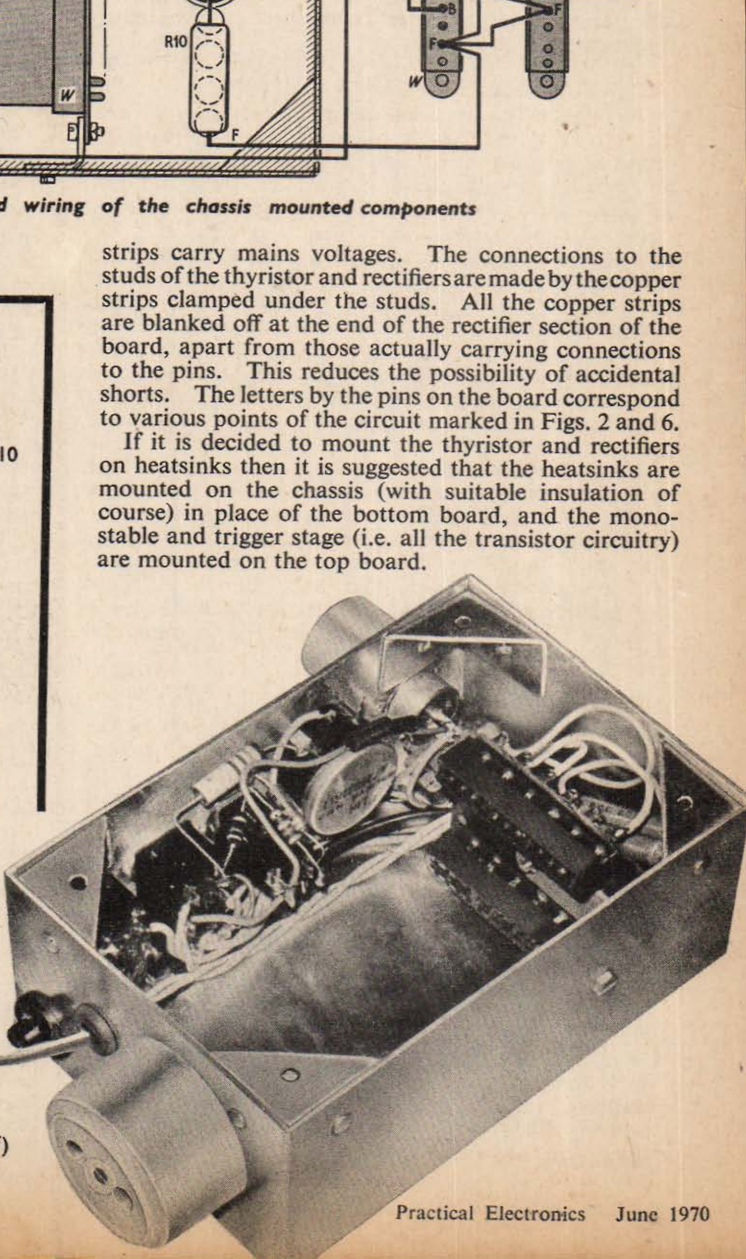
S1 D.P.D.T. toggle
S2 S.P.S.T. pushbutton
S3 D.P.D.T. toggle

Miscellaneous

T1 Transformer (G. W. Smith, see text)
LP1 6V 40mA pilot lamp and holder
SK1 jack socket
SK2 2 pin mains socket
Control knobs (2 off)
Case (see text)
Veroboard 2½in × 3¾in, 0·15in matrix (2 off)
Connectors, edge type for Veroboard 16 way (2 off)

strips carry mains voltages. The connections to the studs of the thyristor and rectifiers are made by the copper strips clamped under the studs. All the copper strips are blanked off at the end of the rectifier section of the board, apart from those actually carrying connections to the pins. This reduces the possibility of accidental shorts. The letters by the pins on the board correspond to various points of the circuit marked in Figs. 2 and 6.

If it is decided to mount the thyristor and rectifiers on heatsinks then it is suggested that the heatsinks are mounted on the chassis (with suitable insulation of course) in place of the bottom board, and the monostable and trigger stage (i.e. all the transistor circuitry) are mounted on the top board.



LAYOUT AND WIRING

The layout and wiring details of the unit are shown in Fig. 6. The wires from the switches and other components mounted on the chassis to the Veroboard sockets are best soldered to the sockets before they are fixed inside the chassis. If the wires are laced together to form a loom, it makes the construction much neater and also enables the sockets to be easily removed from the chassis if necessary. The sockets are in fact sold as Veroboard edge connectors and accept standard Veroboard. They can be mounted on a small right-angled bracket similar to that shown in Fig. 6.

The pilot light (if a resistor is used to drop the voltage for the 8V supply) is a standard 6V 40mA bulb and is wired in series with the dropping resistor R10. The size of hole required for the pilot light obviously depends on the type of holder used and hence no dimension has been put on Fig. 3. The four holes in the chassis next to the pilot light are ventilation holes to dissipate the heat from R10.

A three core mains lead *must* be used to supply the unit, and the chassis *must* be earthed by connecting the earth lead to a solder tag.

ADDITIONAL LIGHTING

By wiring one or more bulbs in parallel with the thyristor the unit can be made to alternate the light between two bulbs, or sets of bulbs, i.e. instead of just one set of bulbs that are either on or off, two sets of bulbs varying between set 1 on, set 2 off, and set 2 on, set 1 off are displayed. The relative brightness of the two sets of bulbs can be altered by varying the number of bulbs in each set.

If one 60W bulb is wired in parallel with the thyristor and two 60W bulbs, paralleled together, are put in the normal position in series with the thyristor, then when the thyristor is off, the single bulb will be almost full on and the pair of bulbs almost off. When the thyristor is on then the single bulb will go off and the pair on.

If just one 60W bulb is put in series and one in parallel with the thyristor, then when the thyristor is off both bulbs will be half on. When the thyristor is on, the bulb in parallel will be off and the one in series on; this gives a softer effect than the previous system.

The whole system can, of course, be made brighter by increasing the ratings of all the bulbs but keeping them in the same configuration, bearing in mind the limitations previously discussed.

SETTING UP

The idea is to set the sensitivity control so that the unit just triggers in the loudest peaks of the music, which is normally the drum beat. The mood control, which varies the "on" time of the lights has to be adjusted to suit the type of music and the effect required, e.g. for slower, relaxing music the most soothing lighting is required and this is obtained by setting the mood control to give the longest "on" time which means the lights flash slowly. If the mood control is set for a shorter "on" time with the same music, it will be found that the lights will flash more regularly, probably giving two flashes to every one before.

For faster music, it is necessary to decrease the "on" time in order to get the lights to flash on each beat.

For a really "progressive" or high impact effect the "on" time wants to be made a minimum and the sensitivity turned up a little above the triggering position. This makes the lights follow the notes rather than the beat of the music. ★