MAINS DELAY SWITCH

By A. R. WINSTANLEY

An adaptable time switch with delays of up to one hour.

THIS project was originally inspired by a "snooze timer" on a digital clock/radio which switched off the radio after a delay of up to one hour. It was thought that a general purpose unit might find several uses in the home. Alternatively a "dedicated" unit could be built for a specialised application, using the principles outlined in this article.

IC THEORY

The device is centred around the NE555 timer i.c. in its monostable mode. This configuration is illustrated in Fig. 1.

A monostable is a circuit which has only one stable state. It can be triggered into its other state temporarily by an external trigger signal, but the monostable will return to its steady state after a certain delay. In Fig. 1, this delay period is determined by the formula;

$$T = 1{\cdot}1\,R \times C$$

where R is in ohms
C is in farads
and T is the delay in seconds.

The value of T can lie between microseconds and hours, but in general, the maximum delay which the NE555 can be considered to generate accurately is one hour.

The triggering signal is applied to the i.c. at pin 2. To trigger it, this pin must be taken down to a potential of less than one-third the supply rail voltage. In the Mains Delay Switch, the i.c. is triggered by shorting pin 2 to ground (zero volts).

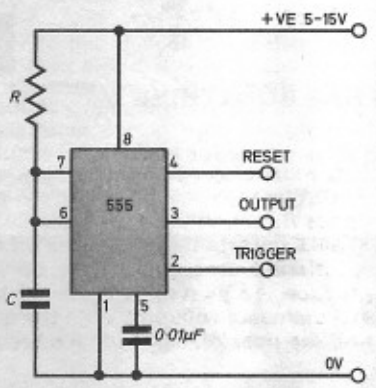


Fig. 1. Typical configuration for the 555 timer i.c. as a basic monostable.

Once the i.c. has been triggered into its timing state, if now further triggering signals are applied to pin 2, then this will have no effect on the output unless the i.c. happens to "time out".

Once the timing period T is up, the i.c. will return to its stable state. If it is desirable to cut short the timing period, this can be effected by shorting pin 4, the reset pin to ground.

The output of the monostable is available at pin 3. When the i.c. is in its stable state, this pin is almost at ground potential. When the i.c. is triggered, the voltage at pin 3 immediately rises to that of the supply rail voltage. From the output we may drive more timers, small bulbs, relays or other *output* devices.

Pin 5 of the i.c. can normally be left unconnected or taken to 0V via an optional 0·01μF capacitor. Finally, the supply rail connections; pin 8 must be connected to the positive rail, and pin 1 to 0V. The i.c. will operate correctly from any supply voltage between 5 and 15V d.c.

START HERE FOR CONSTRUCTION

The whole of the circuit is arranged on 0·1 inch matrix stripboard, 24 strips by 37 holes, and construction should commence here, Fig. 3.

Start by drilling clearance holes in each corner to take the mounting supports—take care when drilling them to ensure that the corners of the board will not break off.

Now lay the drilled board on the base of the box and mark out the drilling centres on the bottom of the case. This will ensure that the board will align perfectly with the mounting holes when it is mounted in the case. Next make all the breaks in the copper strips, using either a hand-held drill or the proper Vero-tool. Now insert all the Veropins, if used.

SOLDERING

It is most advisable to use an i.c. socket with the integrated circuit, and this should now be soldered into place. The jumper wires should be soldered into place, using insulating sleeving if you think that there is a danger of the wires touching other components.

Now solder in all of the components, the large capacitors should be soldered in last of all. Note carefully the polarity of the diodes and capacitors.

Carefully inspect the underside of the board, checking for things like whiskers of solder bridging adjacent strips, wrongly-polarised components etc. Finally insert the i.c. into its socket, taking care to get it the right way round.

TIMING COMPONENTS

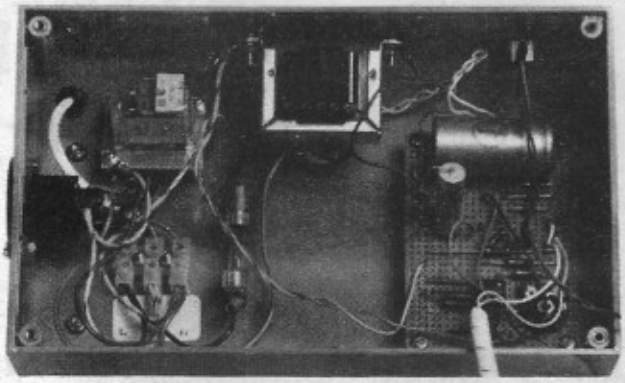
The timing resistors R3 to R7 are mounted on the terminals of the rotary switch. Because 1-pole 6-way switches are not available, then one half of a 2-pole 6-way switch must be used. Resistors R10 and R11 are mounted on their respective indicator lamps.

CASE

The delay switch was housed in a very attractive "Mini Console" type case of dimensions 215×130×75mm. Any strong plastic or metal case will do, but if a metal one is chosen, then make sure it is well earthed during final wiring up.

FRONT PANEL

The front panel of the case should now be prepared to take all the switches and lamps. It can be



Positioning of components within the plastics case.

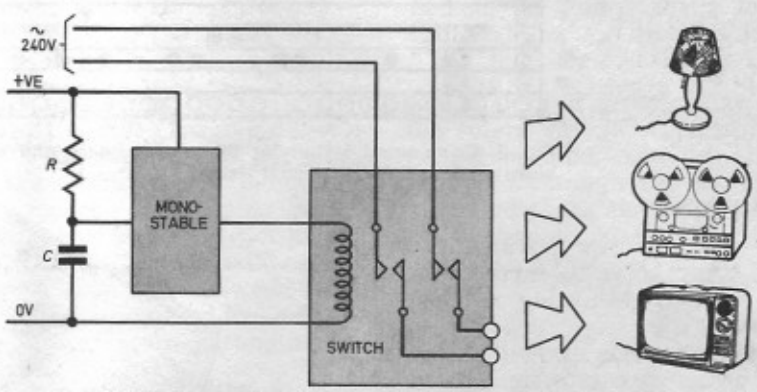
It was discovered, using the Mini-Console, that it was not too easy to arrange the switches on the front panel so that they would not touch any internal devices in the box once the lid was in place.

If therefore a similar case is used, then an interior and front panel arrangement roughly like the prototype's should be used. A great deal of care must be exercised when arranging the components around the box. Of course, if a larger case is used, then no difficulties should be met in this respect.

lettered with Letraset or similar transfers and then sprayed with clear lacquer to protect the transfers. Another possible method is to cover the front panel with clear adhesive film, of the type used on book covers.

The case should now be drilled to take all the internal fixtures. A hole is drilled in the back to take the mains input cable, this hole should have a grommet inserted

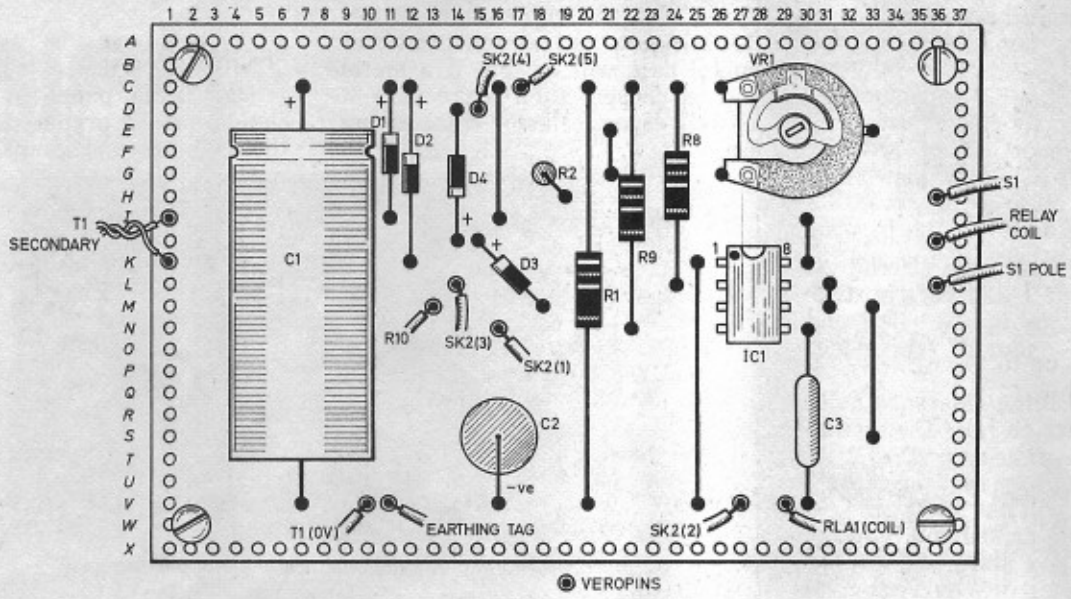
HOW IT WORKS



A monostable forms the basis of this design. When power is first applied to the circuit, the SWITCH operates and the capacitor *C* is charged up via *R*. When a certain voltage on the capacitor is reached the MONOSTABLE detects this and turns off the SWITCH.

Different time delays may be selected by altering the value of *R*. In practice the SWITCH is replaced by a heavy duty relay which is able to switch mains voltages. With the addition of a manual switch and a remote unit the possible applications are numerous.

MAINS DELAY SWITCH



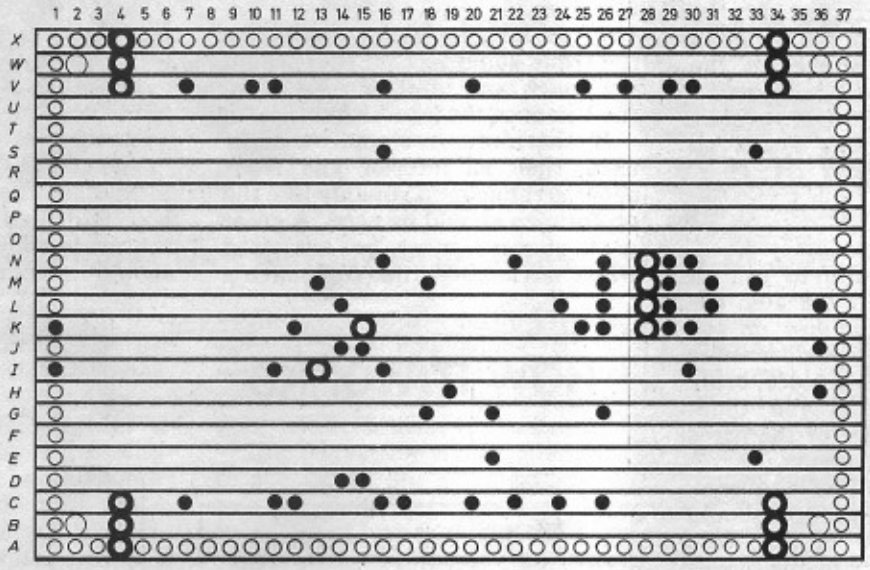


Fig. 3. Component layout for the circuit board and underside of the stripboard showing breaks in the copper tracks.

The completed unit showing front panel controls.

into it. A small hole may also be drilled for the DIN socket.

The mains outlet socket was mounted on the side of the case, but constructors may need to fix it elsewhere, depending on the type used.

The specified relay was mounted using a special aluminium sub-chassis. However, these are not now generally available. Therefore, either the relay cover could be glued upside down to the base of the case, or otherwise the special 2-pole changeover socket must be bought with it.

If another type of relay is used, then it is left up to the individual's ingenuity to mount it.

WIRING

The mains cabling should be soldered to the relay before it is put into place. The joints on the relay contacts must be of a high quality—they must not be "dry" or physically weak. Sleeving should be used over the joints to prevent any possible shorts occurring. The e.m.f. suppressor diode is mounted straight across the relay coil. Make certain that it is soldered the *right way round*. If you are particularly unlucky, you could destroy the i.c. if it is connected incorrectly.

The transformer is earthed by means of a solder tag under one of its mounting bolts. The 0V rail is earthed similarly, using a flying lead terminated at the same solder tag. The front panel is earthed by means of a solder tag under the panel at one corner via one of the panel fixing bolts.

All interwiring between the circuit board and front panel can be carried out using general-purpose lightweight hook-up wire as detailed in Fig. 4. For the rest of the wiring, mains cable should be used, with a rating to suit the sort of loads likely to be used. It is advised that wire with a *minimum* 6A at 250V rating is chosen.

Put a fuse in the plug, again depending on the sort of loads likely to be used. Check **carefully** *all* of the wiring before proceeding to the testing stage.

TESTING

When all of the wiring has been thoroughly inspected, the unit should be tested using, if possible, an ohmmeter set to a low ohms range.

COMPONENTS

Resistors

R1 2·2kΩ
R2 2·2kΩ
R3 to R7 680kΩ (5 off)
R8 2·2kΩ
R9 2·2kΩ
R10 47Ω
R11 47Ω
All ¼W carbon ± 5%

Potentiometer

VR1 470kΩ horizontal preset

Capacitors

C1 1500μF 25V elect.
C2 330μF 16V elect.
C3 0·01μF polyester

See Shop Talk page 373

Semiconductors

IC1 NE555V timer i.c.
D1 to D5 IN4001 (5 off)

Miscellaneous

T1 mains/0-6V, 0-6V 500mA secondary
RLA 185Ω 12V coil with two sets of normally open contacts rated at least mains 3A, (Doram 348-920) see text
LP1 240V mains neon
LP2, 3 6V 60mA LES bulb with holders (2 off)
FS1 2A fuse with chassis mounting holder
SK1 3 pin mains socket (size as required see text)
SK2 5-pin DIN socket
S1 2-pole 6-way rotary switch
S2, 3 single pole push to make release to break push switch (2 off)
S4 single pole push to make, release to break
Stripboard 0·1 inch matrix, 24 strips × 37 holes; "Miniconsole" type case or similar; mounting hardware for relay; one large round knob; i.c. socket; 6BA hardware and solder tags; connecting wire; solder.

COMPONENTS FOR REMOTE UNIT

PL1 5 pin DIN plug to suit SK2
S5 single pole toggle switch
S6, 7 single pole push to make, release to break (2 off)
Five core screened cable; small plastic box, 65 × 40 × 25mm or similar

Check to see that there is a virtual short circuit (low resistance) between the earth pin of the plug and the transformer mounting bolts, socket earth pin, relay mounting bolt and the front panel when fitted. There should exist infinite resistances between the live pin of the plug and live output of the socket; the same applies to the neutral line.

AUTO OPERATION

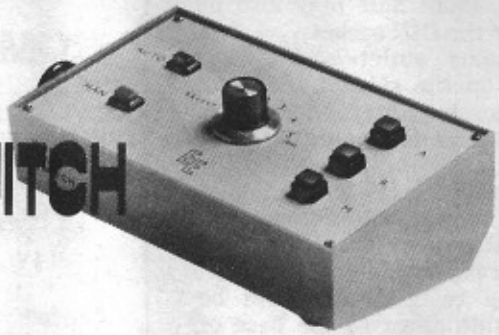
With testing completed, the delay switch can now be plugged in. Pressing the AUTO button will cause the AUTO lamp to light up, and also the relay to click in. Pressing the RESET button should reset the time delay. Preset VR1 can be set to give a desired preset delay when the rotary switch is placed in the PRESET position. You can, if you want, go through the switch settings and check the delay settings —this should take about $1\frac{1}{2}$ hours!

MANUAL OPERATION

Check that the MANUAL switch operates the relay manually and also illuminates the MANUAL lamp. If the remote unit is also used, check that it too switches the relay on and off.

You can now fix the front panel into place. The device should be operated under test conditions for about half an hour or longer, and then, if all appears well, can be put into use afterwards.

MAINS DELAY SWITCH



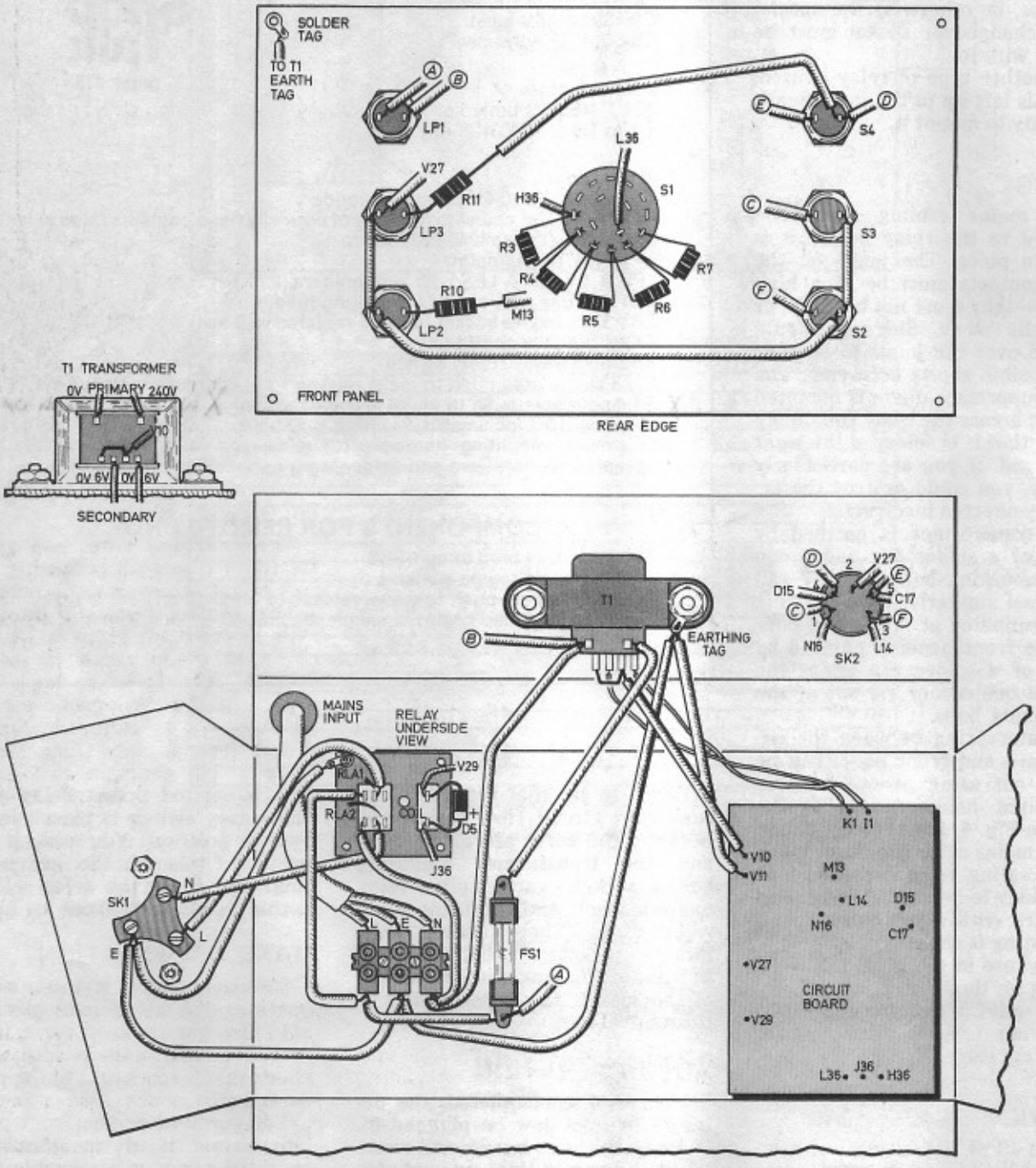


Fig. 4. Interwiring details for the front panel, relay, fuse, circuit board, mains socket and mains transformer. The mains transformer connecting tags are shown more clearly in the small diagram on the left. Note that a mains neon LP1 has been included in the wiring diagram but this does not appear on the author's prototype as shown in photographs.

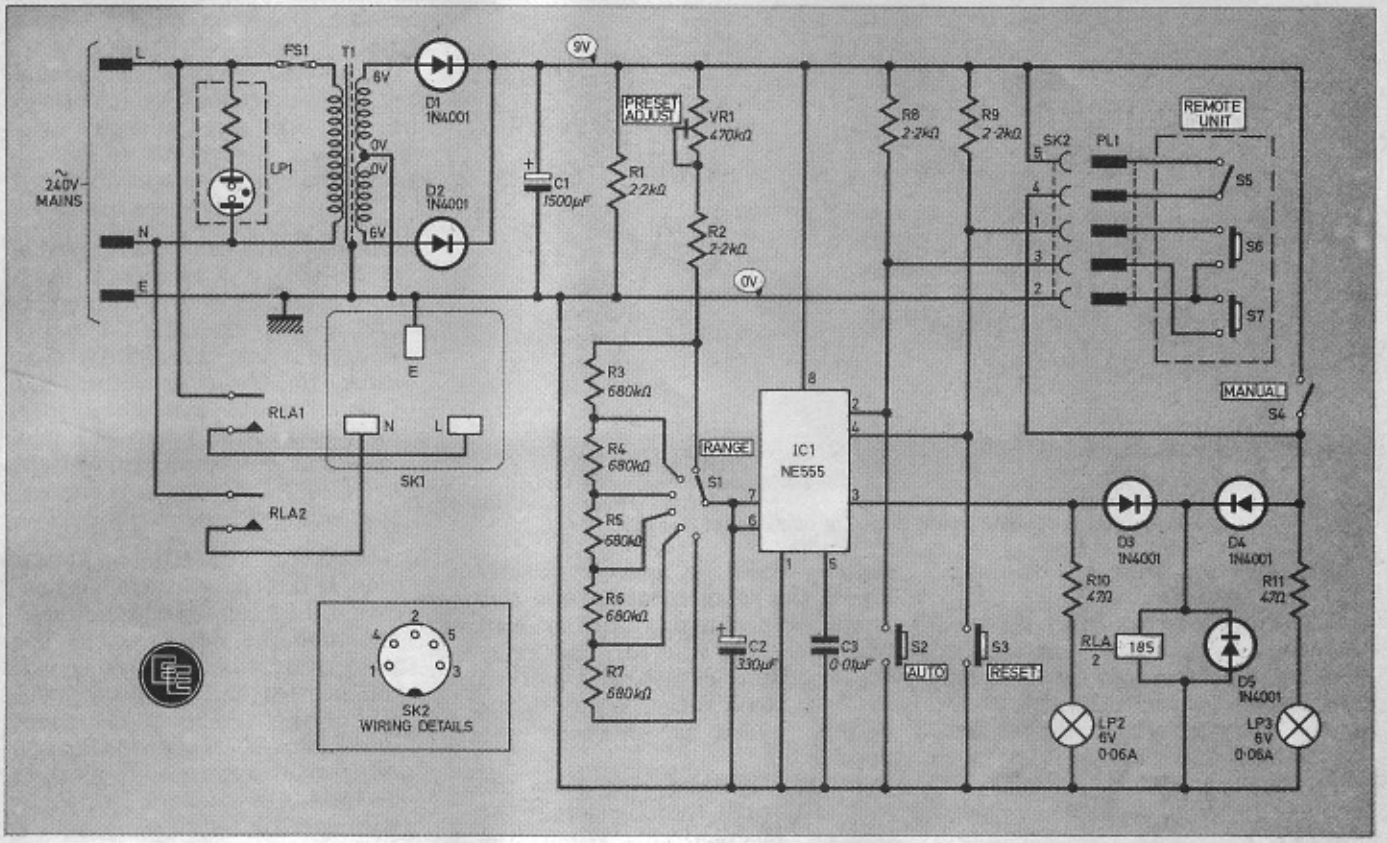


Fig. 2. The complete circuit diagram for the Mains Delay Switch.

CIRCUIT DESCRIPTION

The complete circuit diagram of the Mains Delay Switch is shown in Fig. 2. If we compare this with Fig. 1, we can see that *R* is formed by R2, VR1 and R3 to R7; *C* is actually C2. The capacitor remains fixed in value, but the rotary switch S1 can select different values of *R*, thereby varying the monostable period to give different time delays.

The preset VR1 has been included so that one timing period, which has previously been preset, can be chosen when the delay switch is used for a particular function. Using the values of *R* and *C* shown in Fig. 2, delay intervals of roughly 5 minutes can be expected. This means that the maximum delay obtainable is about 30 minutes. The formula for *T* given earlier will give only the approximate delay. In practice component tolerances result in differences between calculated values of *T* and those actually obtained.

The timing sequence is initiated by pressing S2. Switch S3 can be pressed to reset the time delay. The two resistors R8 and R9 bias the trigger and reset pins to the positive supply rail and prevent false triggering by line transients, etc. If the reset pin is not used, it is usual to connect it straight to the positive line.

The output of the i.c. operates a relay, RLA which applies the mains voltage to the output socket through the contacts RLA1 and RLA2.

Important notes about the socket and relay are given later on.

POWER SUPPLY

The timer operates from a 9V supply, and draws about 180mA of current maximum, depending on the relay used.

Because the circuit will demand at *least* 120mA for quite long periods, it was decided that the i.c. should operate from a mains derived supply. Modifications to allow a battery to be used instead are detailed at the end of the article. The use of a mains supply does, however, obviate the need for battery replacements, and should be incorporated if at all possible.

MODIFICATIONS

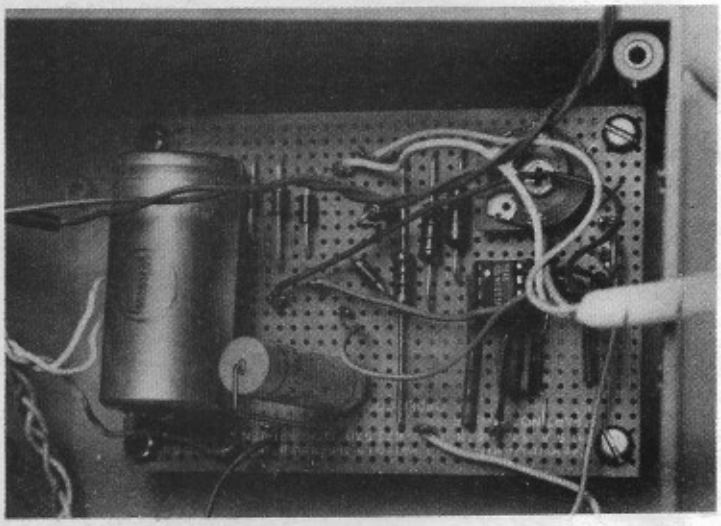
The following notes are given for those who wish to modify the unit to suit their own requirements.

The specified relay will theoretically switch loads of up to 3A, but to do so would result in severe contact wear. If heavy loads are likely to be switched, e.g. a photographer's enlarger lamps, then a heavier duty relay MUST be used. For example an "Octal" (348-756) or "H/D Open" (348-835) from the Doram range would appear to be suitable, having 10A contacts. Under no circumstances must a relay having a coil resistance of less than 75 ohms be used.

MAINS SOCKET

The mains socket may also need uprating. The type used on the prototype was rated at 5A, and it would appear that the next size up would be a standard 13A square pin type, in which case a larger case may well be needed.

In general, if any modifications are carried out which enable the delay switch to drive heavier loads, then you must make certain that all mains-carrying components are likewise up-rated. This includes



Close-up of the circuit board showing component layout.

the mains-input cable, interconnecting wire and terminal block.

Further protection may be provided by inserting a fuse in the live lead to the output socket. Fuse FS1, which protects the timer circuit and transformer, should *not* be changed or omitted.

MANUAL CONTROL

In many instances a "manual over-ride" control would prove to be useful. This would switch on the mains load irrespective of the state of the monostable. Some sort of indicator lamp should also be incorporated which illuminates when the manual switch is on.

There are several methods of inserting a manual control. A switch could be placed directly across the relay contacts, and this would apply mains to the load regardless of whether the relay was operating or not. This method involves some rather tricky mains wiring, which is generally undesirable.

Another method is to place the manual switch directly across the trigger push-button. When the manual switch is closed, the i.c. would be fed with a constant trigger signal. As soon as the i.c. had timed out, it would retrigger; the relay would not have time to drop out. Unfortunately, when the manual switch was opened, the relay would remain operative until the i.c. had completed its timing period, unless the device was reset. This is true only if the triggering period is less than the *RC* timing period.

A superior method of manual control was designed, which allows the relay to be operated by a single-pole switch. This is S4 in the circuit diagram, and its operation can be explained in three sections:

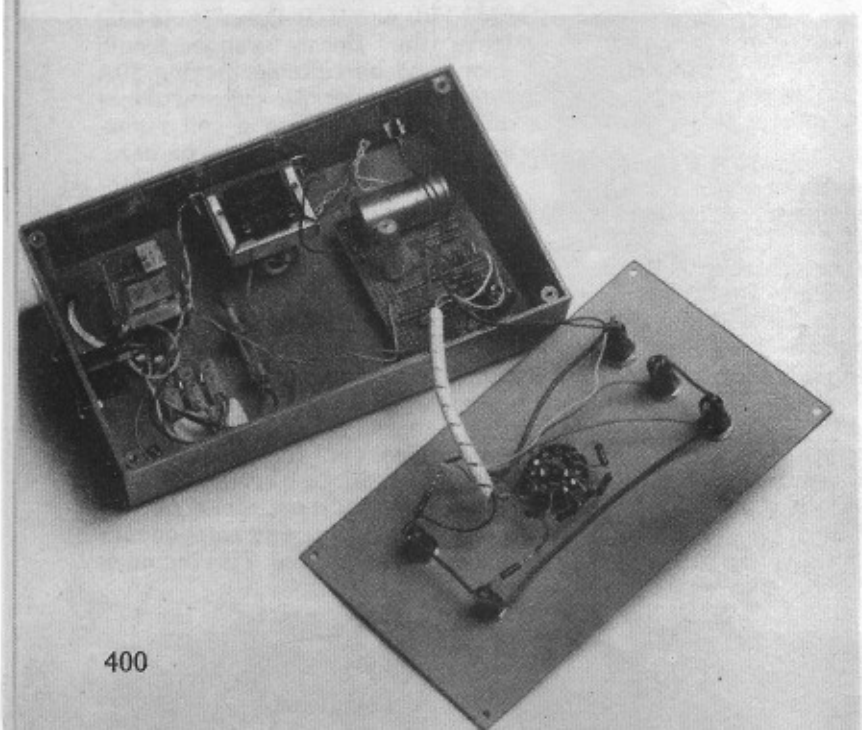
a. AUTOMATIC DELAY OPERATION ONLY. When the i.c. is triggered, pin 3 goes high and source current is able to flow through D3 to the relay, but not through D4. The relay therefore operates. ~~LP1~~ (the "auto" indicator) illuminates as well. Lamp ~~LP2~~ (the "manual" indicator) cannot light because D4 blocks any current that would otherwise pass.

b. AUTOMATIC AND MANUAL OPERATION. If the manual switch is now closed, LP3 can illuminate, showing that the delay switch has been overridden. The relay will remain switched on, and LP2 will still be alight. When the i.c. times out, LP2 will extinguish, but the relay will remain in operation because the manual switch is still closed.

c. MANUAL MODE ONLY. If the i.c. is untriggered, and S4 is now closed, the relay will switch on and LP3 will light up. Current cannot "sink" into pin 3 because D3 is now reverse-biased, so that it does not allow current of a significant magnitude to flow. Diode D3 also prevents LP2 illuminating when the manual switch is closed.

Finally, diode D5 prevents back e.m.f., generated when the relay coil suddenly switches out, from reaching the rest of the circuit.

The completed delay switch with the front panel removed. Note the timing resistors mounted directly on the switch S1.



DIFFERENT DELAYS

Different timing values can easily be arranged, using the formula given at the beginning of the article. The delay is largely determined by the resistance between R3 to R7, and this resistance can be altered at will, but should not exceed 11MΩ with a 9V rail.

The value of C2 can also be changed, as needed. If the time switch is to be used where only one delay is ever needed, then the rotary switch could be omitted and R3 to R7 replaced with a jumper wire. This means that VR1 is the timing resistor, and should be preset to give the required delay.

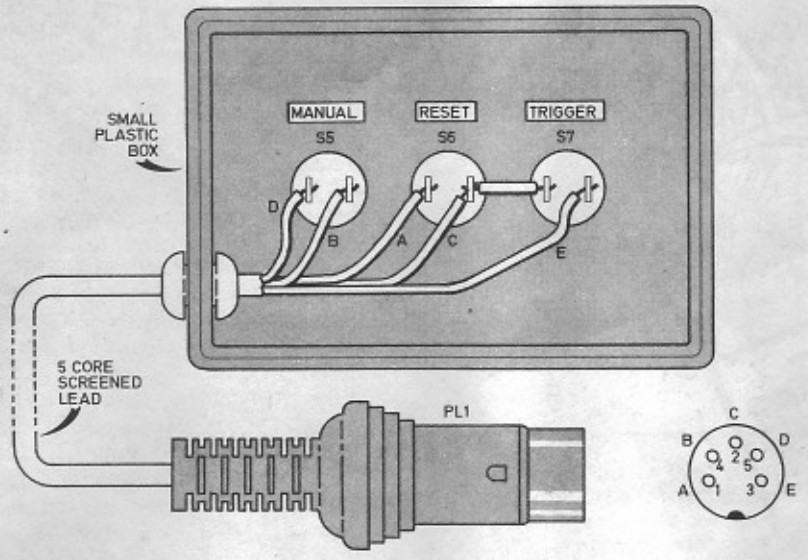


Fig. 5. Wiring details for the Remote Unit.

If shorter delays, less than 2 minutes are wanted, then the value of VR1 should be reduced to 220kΩ.

Resistor R2 should always be included as shown in the circuit diagram. Its presence ensures protection for the i.c. in the event that the timing resistor is shorted out.

RELAY

The specified relay operates from a nominal supply of 12V. In fact it has an operating range of 8 to 17V, and switches with ease at 9V. However, 6V bulbs cannot be used directly with a 9V rail, of course, because they would quickly burn out. Therefore a series 47 ohm resistor is included with each bulb to facilitate 9V operation.

The transformer specified in the parts list has two separate secondaries (wired to give 6-0-6V), each of which is rated at 500mA. This is more than enough to do the job. If available, a transformer rated at 6-0-6V at 200mA could be used, but it will be found that it will get very warm during operation.

No mains neon was included with the prototype, because it was thought that there were enough lamps and switches already! A neon would serve as a reminder that the unit was plugged in, and so the wiring diagram will assume that a neon is used.

BATTERY OPERATION

For those not wishing to incur further expense on transformers, etc, battery operation is feasible providing certain modifications are carried out to reduce the operating current of the circuit. First, the indicator lamps could be replaced with standard light emitting diodes and series resistors.

A further reduction must be effected by using a relay with much higher coil resistance—for example, a relay with a coil resistance of 1640 ohms. Using this relay the l.e.d.s reduce current consumption to just 20mA. If battery operation is opted for, then FS1, T1, D1 and D2 can be omitted. Capacitor C1 should be replaced with a smaller capacitor of 100μF in value.

REMOTE UNIT

The remote unit used with the prototype enables users to switch the relay on and off manually, and allows remote trigger and reset facilities. It was not thought worthwhile to extend the indicator lights to the remote unit.

Five-core cable will be required, and this should be terminated in a five-pin DIN plug. Cable length can easily be in excess of 6 metres, which should be enough for most needs. The wiring for this unit is shown in Fig. 5.

FURTHER APPLICATIONS

The delay switch can if calibrated correctly, be used as an exposure timer in conjunction with a photographer's enlarger. This will almost certainly entail recalculating the values of the timing resistors and capacitor, using the formula given.

In fact it might be a good idea to use all presets instead of fixed resistors, thus allowing exact calibration to be achieved. Ensure that the pilot lights will not interfere with the photographic processes in the darkroom.

SLEEP TIMER

The delay switch could also be used with mains radio as a "sleep timer", so that one can fall asleep with the radio playing. If you select a particularly boring programme on the radio, you might fall asleep even sooner!

It might be useful in controlling exterior lights, particularly if the lights happen to be fixed to garden shed walls. In this case, you could leave the shed and arrive indoors with the outside area illuminated —very useful in the winter months!

Alternatively, the unit could be used to drive a small lamp mounted in the garage. The lamp could be triggered for a short delay, allowing you to see to lock the car door at night and retire to the house without having to switch off any lights.

No doubt readers may well find other uses for what is potentially a very versatile unit. ⌑