Economical Appliance Controller

Save energy and control your power consumption with this helpful Watt miser.

By Phil Walker

AFTER this winter's snow, frost and electricity bills you're probably looking for ways to save a little money without losing comfort or convenience. This project is designed so that electric heaters or other appliances can be set to turn on a little before they're actually needed.

The device could also be used to control other devices such as tape recorders, radios and so on where the precise timing isn't too critical.

Operation

The device operates by dividing the AC frequency (60 Hz) by 180,224 to get a signal with a period of about 1 hour. The actual division required was 180,000 but the 180,224 was more easily achieved and the error involved was less than 60 seconds in the maximum period of 9 hours delay.

This 1 cycle per hour signal advances a divide-by-10 counter which has 10 separate outputs. Each output is active for 1 hour and only one is active at a time. One of the outputs is selected to drive the AC power switching triac giving an 'on' period of 1 hour after a selectable off period. It's also possible (if SW4 is on) to have the output come on permanently after its set delay (this is always the case on the 9 hour delay setting).

To use the device, set the number of hours of delay with SW3, select whether '1 hour only' or 'permanently on' operation is required with SW4 and press SW2 to start the device working.

Installation

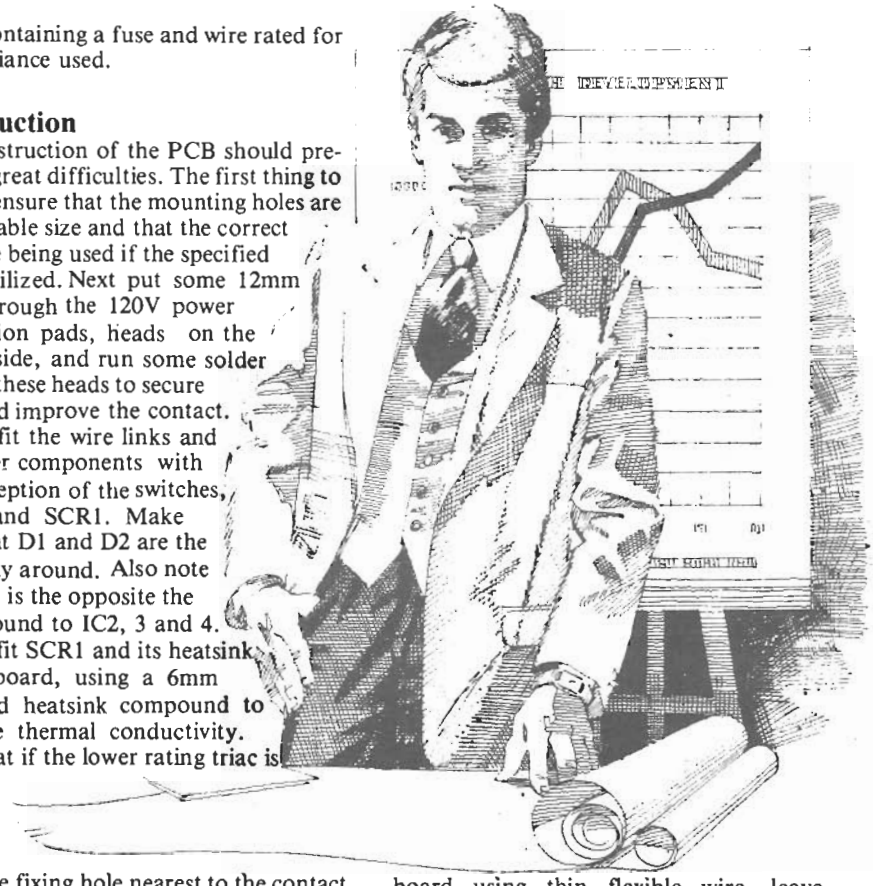
When using the device, the AC supply must be fed from a plug or switched fuse outlet containing a fuse and wire rated for the appliance used.

Construction

The construction of the PCB should present no great difficulties. The first thing to do is to ensure that the mounting holes are of a suitable size and that the correct ones are being used if the specified box is utilized. Next put some 12mm bolts through the 120V power connection pads, heads on the copper side, and run some solder around these heads to secure them and improve the contact.

Now fit the wire links and the other components with the exception of the switches, LED1 and SCR1. Make sure that D1 and D2 are the right way around. Also note that IC1 is the opposite the way around to IC2, 3 and 4.

Next fit SCR1 and its heatsink to the board, using a 6mm bolt and heatsink compound to improve thermal conductivity. Note that if the lower rating triac is used, the fixing hole nearest to the contact pads should be used and vice versa. Connect SW3, if the contacts are on a 22mm diameter circle they may be connected straight to the board, otherwise short lengths of stiff wire should be used. If all else fails you could attach the switch to the cover of the box and connect it to the board using thin flexible wire, leave enough to remove the lid when fitted.



Attach some lengths of flex (6") to the PCB at the remaining switch positions (SW2 and SW4), LED1 position and transformer connections. Fit the transformer into the corner of the box and then the cable glands, neon, AC switch

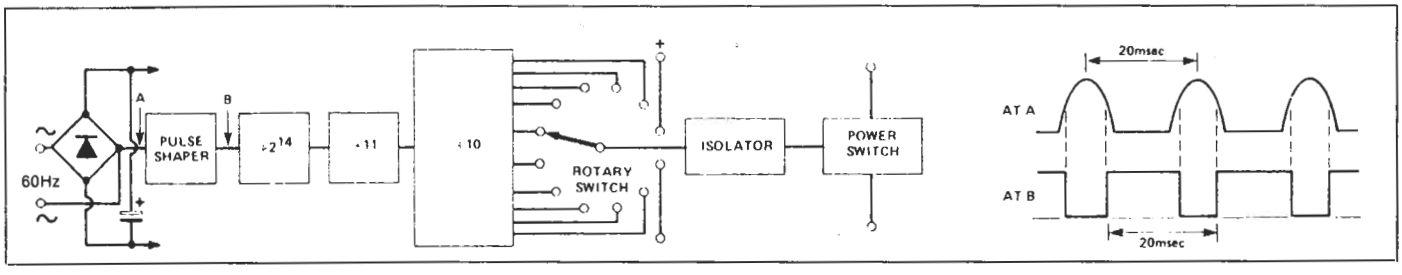


Fig. 1 Block diagram of the unit.

Fig.2 Pulse shaper action.

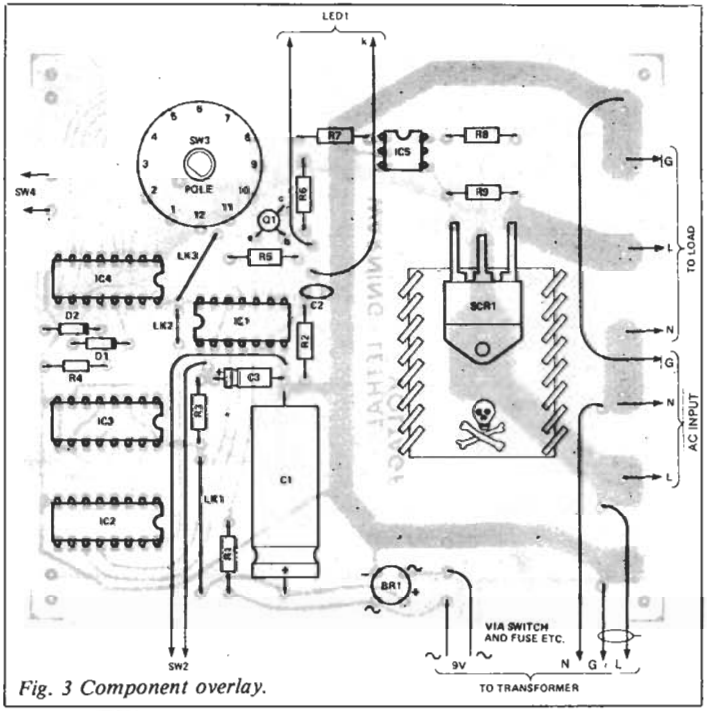
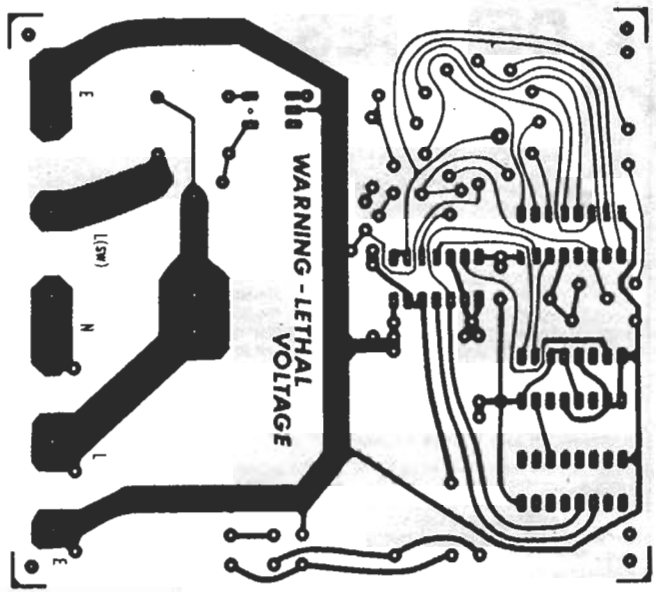


Fig. 3 Component overlay.



The PCB for the Appliance Controller.

and fuseholder into the end-plate.

Finally fit SW2, SW4 and LED1 to the lid of the box and cut a hole through to take the SW3 spindle.

It is advisable to solder eyelets to the 120V leads to fit on to the PCB bolts; alternatively the ends of the wires should be soldered to stiffen them.

NOTE: As a 120V are present, care must be taken that no ungrounded metal parts are accessible from the outside and that clearances between live and grounded parts are maintained under all circumstances.

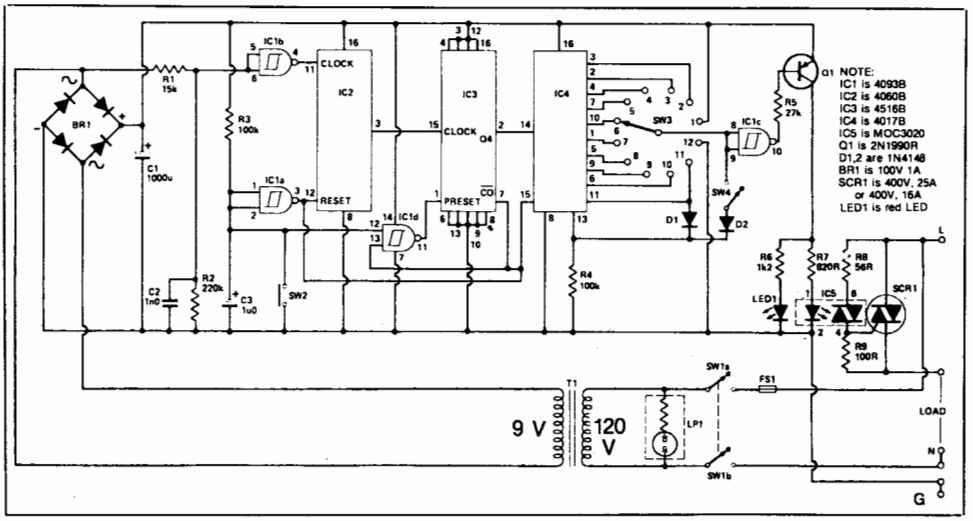


Fig. 4 Circuit diagram of the appliance controller.

Parts List

Resistors (all 1/4W, 5%)

R1	15k
R2	220k
R3,4	100k
R5	27k
R6	1k2
R7	820R
R8	56R
R9	100R

Capacitors

C1	1000u 40V axial elect.
C2	1n0 ceramic
C3	1u0 63V axial elect.

Semiconductors

IC1	4093
IC2	4060
IC3	4516
IC4	4017
IC5	MOC3020
Q1	2N1990R (TO18 package)
D1,2	1N4148
BR1	100V, 1A bridge rectifier
SCR1	400V, 25A or 400V, 16A
LED1	3mm red LED

Miscellaneous

SW1	DPDT AC on/off miniature rocker
SW2	1 pole push-to-make, momentary action
SW3	1 pole, 12 way rotary wafer switch, contacts on 22mm diameter circle
SW4	SPST toggle switch
FS1	1A anti-surge fuse and panel fuse holder (20mm)
LP1	120V panel mounting neon indicator with internal resistor
T1	6VA transformer (9V secondary, 120V primary)

PCB; case to suit; 2 cable strain reliefs; 3 16-pin and 1 14-pin IC sockets; TO-220 heat-sink; knob; nuts, bolts, spacers etc.

How It Works

IC1a takes the raw AC 60 Hz signal applied to the bridge rectifier and converts it to a train of pulses at the same frequency. This is divided by 16,384 by IC2. Further division is done by IC3 which is connected with IC1c to divide by 11.

This is accomplished by loading 1011 binary into IC3 each time it counts down to 0000 binary. At the Q(4) output of IC3 there is a signal which has a period of 20 mS x 16,384 x 11 = 3,604,480 mS = 3,604.48 seconds. This signal is applied to the clock input of IC4, a divide-by-10 device with 10 decoded outputs. The output of IC4 selected will change every 3,604.48 seconds (about 1 hour) until the '9' output (pin 11) is high. At this time further clocking of IC4 is prevented by a signal at pin 13 via D1.

SW3 selects which output of IC4 drives the output power switch. This varies from permanently on (position 1), through zero delay (position 2), up to 9 hours delay (position 11), to permanently off (position 12).

If SW4 is open then in the 0 to 8 hour delay positions the output will be on for 1 hour after the set delay only, whereas if SW4 is closed or a 9 hour delay is selected the output will stay permanently on after the delay period.

IC1c takes the output signal from SW3 and drives Q1 and thus IC5. IC5 is an optically isolated triac which enables us to have the logic circuitry safely at ground while switching the AC power with SCR1.

The last part of the circuit is that around IC1a and IC1d. This is the reset circuitry which ensures that the time period will be consistent and start when SW2 is released. IC2 and IC4 are reset to 0 by IC1a, while IC3 is set to 1011 (decimal 11) by IC1d.

■

NEW IDEAS

Use a clock radio as an appliance controller

DO YOU THINK THAT YOUR CLOCK RADIO should do more than just turn on its tiny internal radio (if its radio still works!)? Well, I have a solution. With this easy modification, you can use the clock to turn on any device of your choice automatically. If you are a heavy sleeper who doesn't usually wake up when the alarm rings, you can use this modification to "customize" your alarm to turn on lights, sirens, or anything else that may help you wake up more easily. As an added feature, a three-conductor cable allows you to remotely control one or two sets of devices.

I should point out right away that you do not have to cannibalize a clock radio that you are satisified with. Many surplus outlets (many of which advertise in the back pages of **Radio-Electronics**) offer the clock "guts" from clock radios. However, if you have a clock radio without a working radio, then this sure beats throwing it out!

The circuit for the modification, shown in Fig. 1, is fairly simple. We'll start with S1 and S2 which are the remote-control switches that are mounted at the end of a three-conductor cable. When one of those switches is closed, it will set its half of the flip-flop made up of IC1-a and IC1-b. That causes the output of IC2-b to go high, which, in turn, enables either IC1-c or IC1-d. That causes one of the relays to turn on, which drives one of the triacs that power the output sockets. (However, if you close both remote switches at the same time, though, the flip-flop becomes unstable.)

Switch S3 is part of the clock. On most clocks, it is a normally-open switch that closes when the alarm "rings." If the switch on your clock is a normally-closed type, don't worry—all you need to do is tie it to +5 volts and tie the 1K resistor to ground.

The resistor–capacitor network rejects all pulses (glitches) from the switch that are not long enough to charge the capacitor. When a long-enough pulse is sensed, IC4-a is clocked and Q is set. That enables IC1-c and IC1-d through IC2-b, which turns on the last device used, according to the S–R flip-flop. To turn off the alarm, either open S3, or close either S1 or S2. That causes IC3 to reset the alarm flip-flop. When S4 is pressed, the last device that was used turns on for as long as it is held down.

An eight-volt transformer is used to develop 12-volts peak across the 4700-μF capacitor. I used two panel lamps to illuminate the clock's face, but they are, of course, optional.

If you don't want to use the remote switches to shut off the alarm and instead want to use only S3 for that purpose, then you can eliminate IC3 and IC4 and connect S3 directly to IC2-b. If you need to control only one device instead of two, and also don't want S1 and S2 to shut off the alarm, then you can eliminate all of the IC's and connect the switches directly to the relays or the triacs.—*Donald H. Delorie, Jr.*

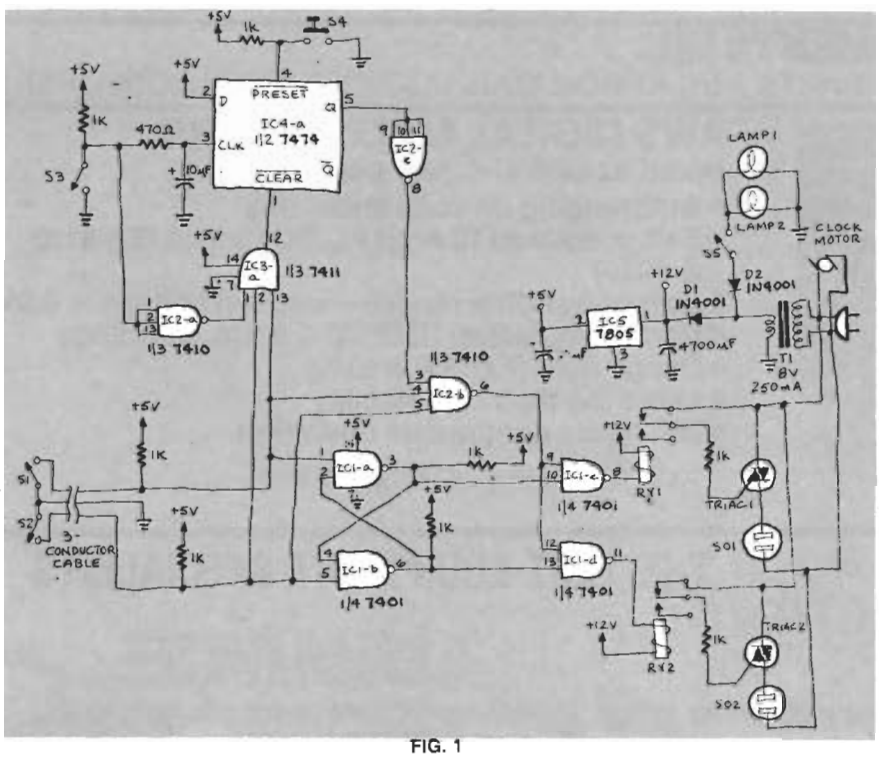


FIG. 1

NEW IDEAS

This column is devoted to new ideas, circuits, device applications, construction techniques, helpful hints, etc.

All published entries, upon publication, will earn $25. In addition, Panavise will donate their *model 333*—The Rapid Assembly Circuit Board Holder, having a retail price of $39.95. It features an eight-position rotating adjustment, indexing at 45-degree increments, and six positive lock positions in the vertical plane, giving you a full ten-inch height adjustment for comfortable working.

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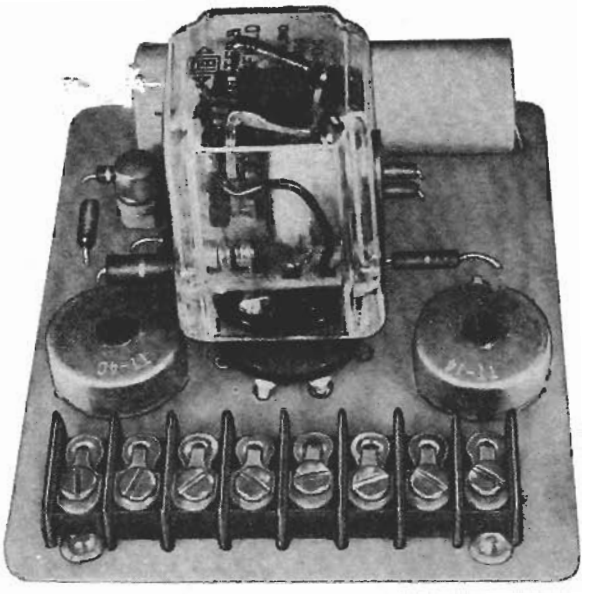


COVER STORY

BUILD THE SUPERTROL

For . . .
- Automatic start switching
- Interval timing
- Voltage Sensing
- Delayed Stop Action
- Etc., etc., etc.

By DON LANCASTER

ASK NOT what the Supertrol can do, but rather, what it cannot do. For here is a circuit with an abundance of useful applications. The Supertrol is primarily a free-running master sequence generator, suitable for an exhibit or display, which provides a completely adjustable on/off ratio of from 50 milliseconds to 10 seconds. Husky 10-ampere relay contacts provide dual complementary—off/on, on/off—outputs.

Change around a connection or two and the Supertrol becomes a sensitive voltage level detector which opens or closes a relay with a positive snap action as the input voltage exceeds 2 volts, or drops below 1 volt.

Add a d.p.d.t. switch and once again change some connections around and you have a time-delay relay or an interval timer—depending upon your choice of output contacts. With this arrangement you can turn on a load once for a predetermined time interval, or get a continuous output at the end of an adjustable 0- to 20-second time interval.

How It Works. The Supertrol's actual circuit (Fig. 1) is nothing more than a jazzed-up version of a basic Schmitt trigger as described on page 44. Transistors *Q2* and *Q3* comprise the Schmitt trigger while *Q1* is an emitter follower used to keep charging capacitor *C1* from loading down the circuit. The capacitor charges through potentiometer *R11*, so that this control determines the relay's *on* time. Similarly, *R12*, which provides a discharge path for the capacitor, determines the relay's *off* time.

Most of the resistors added to the basic circuit are for stabilizing purposes, and to help eliminate current surges from the power supply and the unit's control circuitry. Capacitor *C2* helps to speed up the turn-off operation, while *D1* protects *Q3* from voltage spikes due to the inductance of the relay coil.

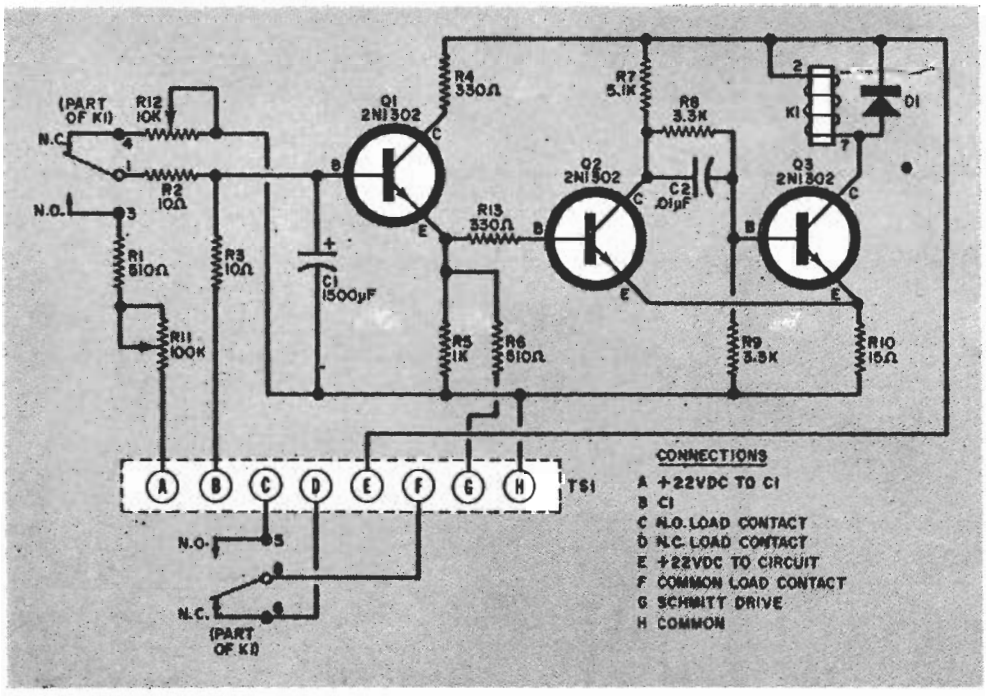


Fig. 1. The Supertrol is a practical application of the well-known Schmitt trigger circuit. A technical explanation of the triggering operation appears on page 44. Relay K1 is the workhorse of the Supertrol and the second set of contacts (octal pins 5,6, and 8) are used to operate other circuits up to a drain of 10 amps. The author brought all control wiring functions out to a terminal strip, but this may be eliminated if the Supertrol is to be used for only one job.

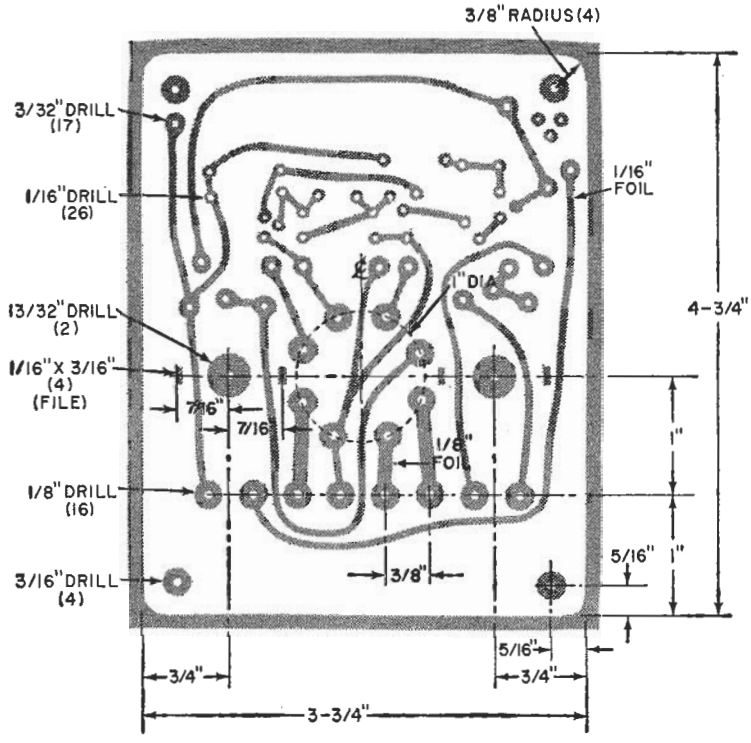


Fig. 2. A printed circuit board can be etched following the outlines shown in this drawing. Use of this outline should be predicated on the physical size of capacitor C1, location of the terminals for the octal socket to hold K1, and whether or not the builder uses twist-tab potentiometers for R11 and R12. Point-to-point wiring can be used in place of a printed circuit without encountering any problems.

PARTS LIST

C1—1500-μF, 6-volt d.c. electrolytic capacitor
C2—0.01-μF disc capacitor
D1—750-mA, 200-PIV silicon diode
K1—24-volt d.p.d.t relay, 400-ohm coil, with 10-ampere contacts (similar to Potter & Brumfield KRP11DG)
Q1, Q2, Q3—2N1302 transistor or similar unit
R1, R6—510-ohm, 1-watt resistor
R2, R3—10-ohm, ½-watt resistor
R4—330-ohm, ½-watt resistor
R5—1000-ohm, ½-watt resistor
R7—5100-ohm, ½-watt resistor
R8, R9—3300-ohm, ½-watt resistor
R10—15-ohm, ½-watt resistor
R11—100,000-ohm twist-tab potentiometer (similar to Centralab TT-40)
R12—10,000-ohm twist-tab potentiometer (similar to Centralab TT-14)
1—3" x 4" x 5" box, or printed circuit board, or both*
1—8-terminal barrier strip (similar to Cinch Jones 140-Y)
Misc.—Octal PC tube socket, knobs (2), threaded rivet-type standoffs (4), solder, 22½ volt battery or a.c.-operated d.c. supply—see below.

*An etched and drilled circuit board, complete with all mounting hardware, is available for $2.50 postpaid in the U.S.A. from DEMCO, Box 16297, San Antonio, Texas 78216

Construction. The Supertrol can be built on a printed circuit board or on a punched phenolic circuit board, and can be housed in a small plastic container or in a metal box. If a printed circuit board is preferred, one can be purchased from the source indicated in the Parts List. If you want to etch your own board, you can do so following the layout given in Fig. 2, and the parts can be mounted as shown in Fig. 3.

For printed circuit construction, be sure to use the specified twist-tab potentiometers since the PC board has been laid out with holes drilled for these units.

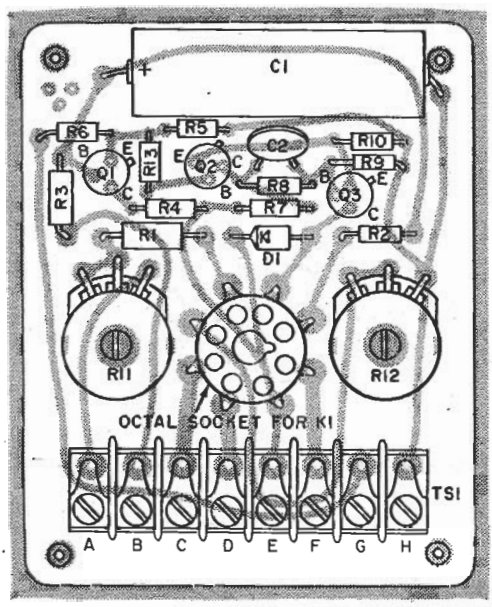


Fig. 3. If you make or buy a printed circuit board the components should be positioned as shown. The 3 spare holes in the corner mount a socket to hold Q1 when this transistor is not in the circuit.

POWER SUPPLY PARTS LIST

C1—500-μF, 25-volt electrolytic capacitor
D1—750-mA, 100-P.I.V. silicon power diode (similar to Motorola 1N4002)
R1—4700-ohm, ½-watt resistor
T1—Power transformer: primary, 117 volts; secondary, 18 volts, 100mA, or higher (similar to Stancor TP-1 or Knight (Allied Radio) 54 A 3987

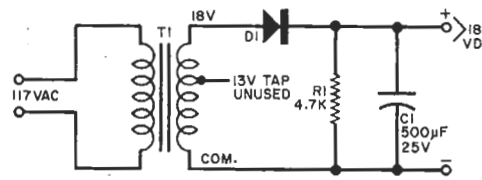


Fig. 4. For continuous duty operation, this power supply can be substituted for the 22½-volt battery. The circuit will work on 17 to 24 volts d.c.

Suitable standoffs can be used to mount the circuit board in its enclosure, if one is used, or else support it on a table or other surface.

While transistors *Q2* and *Q3* can be wired directly to the circuit board, *Q1* should be installed in a socket since it has to be removed from the circuit during certain applications. After completion, the circuit can be tested by hooking it up as shown in Fig. 5. With power applied, it should start oscillating at about 1 hertz. If it does not, adjust *R11* and *R12* as necessary.

If the Supertrol is to be used only on occasion, and if you do not want to go through the expense of building an a.c.-operated power supply, you can operate the unit with a 22½-volt battery which can be housed with the circuit board in the same enclosure. If, on the other hand,

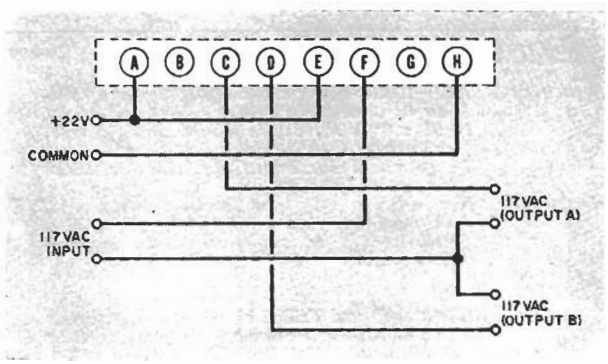


Fig. 5. To test the Supertrol, connect a 22½-volt battery with the plus side going to terminal strip points A and E, and the negative side of the battery to point H. The circuit should start oscillating at about 1 hertz. If the relay does not start clicking, juggle R11 and R12 until the relay has a rhythmic beat. As explained below this circuit is also used to make the Supertrol a display sequence generator.

you plan to use the Supertrol on a fairly continuous basis, you may want to build the power supply shown in Fig. 4 using the parts shown on the accompanying Parts List. The output voltage from this supply will be up to 24 volts depending on the load.

Applications. To have the Supertrol function as a display sequence generator, make the connections shown in Fig. 5, enabling one set of relay contacts to alternately switch the "hot" side of the 117-volt a.c. line between Outputs *A* and *B*. The *common* side of the line goes directly to the load, and there is no connection between this set of contacts and the rest of the Supertrol circuit. The switching time required to go from *A* to *B* is determined by the adjustment of *R11* and *R12*. This circuit is ideally suited for running exhibits and displays.

The connections required for a voltage level detector function are shown in Fig. 6. Here, emitter follower *Q1* must be removed from its socket. This enables the circuit to turn on whenever the input signal exceeds 2 volts or turn off when the signal drops below 1 volt. Input impedance is approximately 1000 ohms. Relay contacts *C* and *D* are used as required to provide power for an alarm bell, signal light, etc.

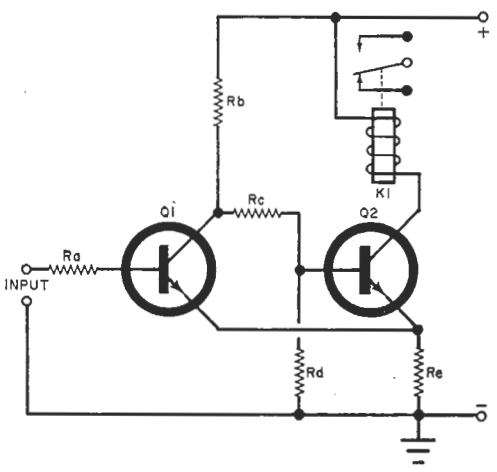
(*Continued on page* 94)

CIRCUIT THEORY

To understand the secret behind the Supertrol's success, consider the Schmitt trigger circuit shown at right. The circuit and biasing arrangement is such that Q1 is normally OFF while Q2, which controls relay K1's current, is normally on.

If a positive voltage—say about 2 volts—is applied to base resistor Ra, Q1 turns on, causing Q2 to turn off due to reverse biasing applied across Rc and the increase in the voltage across emitter resistor Re. This causes the relay, which acts as Q2's collector load, to drop out as the current falls to zero or to any value below its pickup point. The circuit will revert to its original quiescent state whenever the voltage at the input falls below the tripping level, and the relay will pull in again.

By placing a relatively large capacitor in Q1's base circuit (see Fig. 1), and a charging path from a battery through the relay contacts and a couple of current-limiting resistors, the circuit can be made to free-run by the charge and discharge of the capacitor, enabling Q1 and Q2 to change state at a predetermined interval. The rate at which the transistors change state is established by the charge and discharge rate of the capacitor; and this, in turn, is a function of the resistor values chosen. It can be seen that if a potentiometer is substituted for at least one of the resistors, the charging time can be varied at will.



THE "SUPERTROL"

(*Continued from page* 44)

In this application, the connection from the battery to terminal *A* is broken to prevent *C1*, which is rated at 6 volts, from charging up and shorting out. If you want to replace *C1* with a capacitor of higher voltage rating, say 25 volts, then the connection at point *A* need not be broken. It is important that you put *Q1* back in its socket before applying power to the circuit.

The connections for an interval timer or a time delay relay are the same as required for the voltage level detector (Fig. 6), except that the relay contact selection must be as shown in Fig. 7. This circuit also includes a d.p.d.t. switch, used to control the load power while charging capacitor *C1* is being shorted out. In position 2, power is applied to one set of contacts to enable the capacitor to charge sufficiently to trigger the Schmitt trigger circuit. The charging time is, of course, determined by the setting of *R11*. When *C1* charges to its upper trip point, *Q1* conducts and the relay switches power from the interval output to the delay output. When the switch is flipped to position 1, the capacitor is shorted through a resistor, and the circuit is reset.

The hookup shown in Fig. 7 can be used for a darkroom photo timer, as a delay relay to allow the filaments of a transmitter to warm up before plate voltage is applied, or as a starting relay for a generator or a fluorescent lighting system. You can also use it in a driveway or hallway lighting circuit to extinguish the lighting by delay action. By varying *R11*, the circuit can be made to introduce a time delay varying from 50 milliseconds to 10 seconds.

To keep the load from oscillating, an additional relay can be added to the output connections to lock up on its own contacts and thereby provide a continuous stable output. Another approach to this problem is to reset the switch to position 1 approximately 8 seconds or so before the oscillation starts. —30—

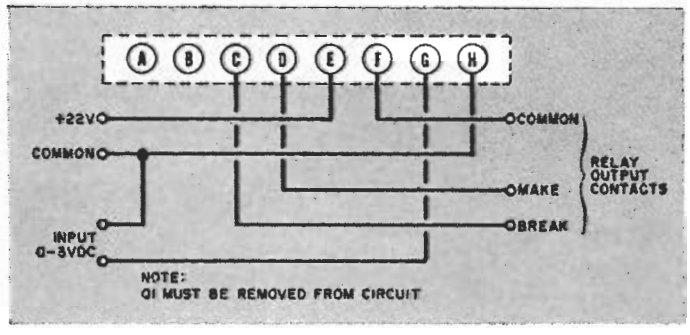


Fig. 6. Remove transistor Q1 and make the external connections in this diagram and your Supertrol becomes a low voltage sensor. An input of 2 volts turns the circuit on and a drop below 1 volt turns the circuit off. This circuit could be used as an alarm.

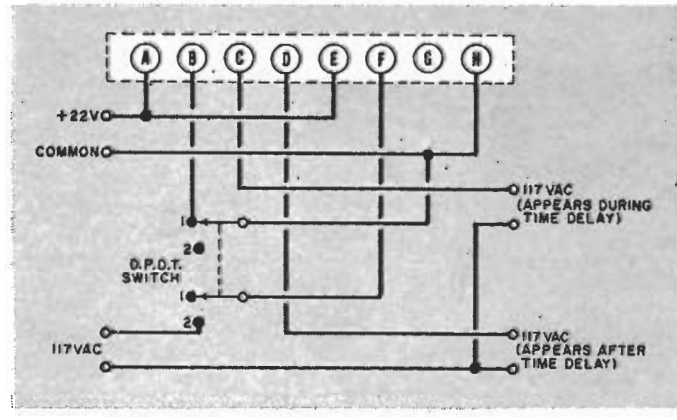


Fig. 7. The most practical application of the Supertrol is as an interval timer. However, this requires an external d.p.d.t. toggle switch wired into the circuit as shown here. Timing begins with the switch in position 2. Circuit reset is position 1.