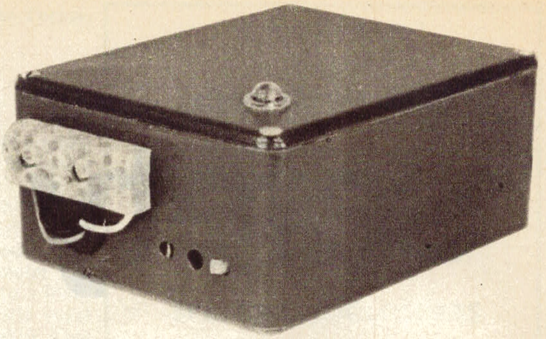
# Build this simple Proximity Switch



by LEO SIMPSON

**Here is a simple and low cost project, designed especially for our beginners and junior readers, but likely to be of interest to many others. It is fully solid-state, and very suitable for both domestic and industrial use. An ideal application would be as a "touch plate" door chime.**

The simple device to be described in this article has many intriguing uses around the home, in industry and in advertising displays. The basic idea is that it can ring a bell, sound a buzzer, switch on lamps or apply power to equipment whenever a person's hand is brought close to its sensor plate.

Around the home, it may be used as a novel door chime unit, or as a "surprise" gimmick for parties. Imagine the fun if a bell were to ring whenever a guest reaches into the bowl of sweets, or sits down in that mysteriously unoccupied armchair!

In the industrial field, the unit could be used to detect items moving down a production line, either for counting or to actuate machinery. This type of device is often used as the basis of the "touch buttons" fitted to some automatic elevators.

The device can be used for sales promotions. Placing a sensor plate behind a shop window allows it to be triggered by people on the footpath. In response, the unit can turn on lights over display stands, actuate slide projectors or endless loop tape machines. It can also be used as an attention alarm on shop counters. (In fact, this unit is almost identical to that used on the counter in the editorial office at "Electronics Australia".) An alternative use of a counter or display stand to actuate warning signs. A sign reading "Please do not touch" could thus be made to light when a person tries to disobey an instruction. Just think how many a museum could use!

The unit is very simple, and uses only three semiconductor devices. These are all PNPN or "thyristor" devices: a silicon controlled-rectifier or SCR, a complementary SCR (or alternatively a controlled-switch) and a symmetrical breakover diode, otherwise known as a Diac. Before describing the circuit operation, let us briefly outline the operation of these devices.

The SCR is one of the family of semiconductor devices known as thyristors. It can be regarded as a special type of rectifier diode which conducts in one direction only. What sets it apart from a normal diode is that when it is forward-biased, it will not conduct until it is triggered into doing so by a small positive voltage applied between its third "gate" electrode and the cathode. With a sine wave voltage applied between anode and cathode, an SCR can be triggered into conduction at any instant during the positive half-cycles. At the end of each positive half-cycle, the SCR turns off as the voltage polarity reverses.

The complementary SCR is very similar to an SCR, except that it has a gate electrode which is associated with the anode rather than with the cathode. The silicon controlled switch or SCS is virtually a combination of the two, having both an "anode gate" and a "cathode gate". Either can initiate conduction.

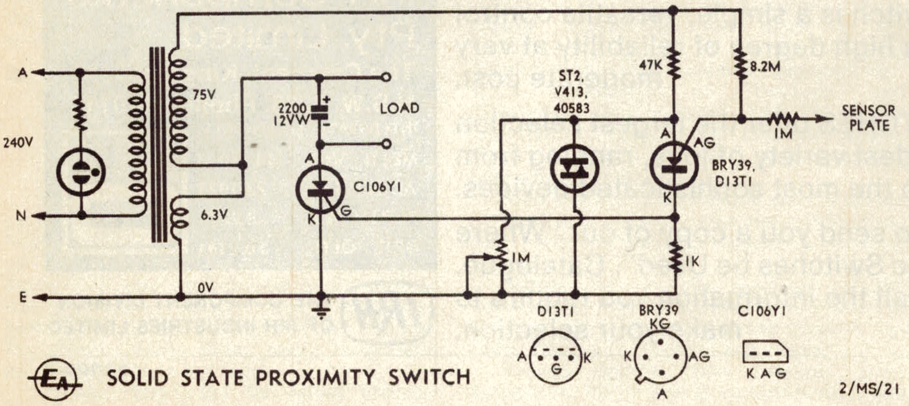
The symmetrical breakover diode is aptly named because when a voltage across it of either polarity exceeds a certain value, the diode "breaks over" or conducts with a negative resistance characteristic. Typical breakover voltage lie between 30 to 40 volts. The symmetrical breakover diode or Diac, as it is more commonly referred to, is most often used in Triac phase control circuits where it discharges a capacitor into the gate of the Triac. However, in the present circuit the Diac is used primarily for voltage limiting.

Referring now to the circuit diagram, a power transformer having a 6.3V @ 1A and a 75V winding is required. The two windings are connected so that their voltages add and the complementary SCR is connected across the total, in series with the 47K and 1K resistors. The cathode side of the winding is connected to earth. (Note that when an SCS is used, the cathode gate is not connected.)

Now for the complementary SCR to switch on during positive half-cycles of the AC waveform. the anode gate must be made negative with respect to the anode. If a person touches or brings their hand close to the sensor plate which is connected to the gate via the 1M resistor, triggering occurs because of the increase in capacitance between the gate and earth. The increase in capacitance causes the phase lag of the sinusoidal voltage appearing at the gate to increase with respect to the voltage at the anode, until the voltage difference between the anode and anode gate is sufficient to cause triggering.

## PARTS LIST

*1 diecast box, 4 5/8 x 3¾ x 2in.*
*1 mains transformer, 70V @ 30mA, 6.3V @ 1 amp*
*1 C106Y1 silicon controlled-rectifier*
*1 D13T1 complementary SCR or BRY39 SCS*
*1 V413, 40583 or ST2 Diac*
*1 2200uF/12VW electrolytic capacitor*
*1 1M preset potentiometer*
*1 x 8.2M, 1 x 1M, 1 x 47K, 1 x 1K (¼ or ½ watt resistors)*
*1 12-lug length of miniature tagboard*
*1 neon pilot bezel assembly*
*Plastic terminal block, mains cord, three-pin mains plug, mains cord clamp, solder lug, screws, nuts, hook-up wire, spaghetti sleeving, solder, etc.*




*Above is the circuit for our Proximity Switch, which can be used to ring an electric bell, light a lamp, or operate many other devices, as described in the text.*

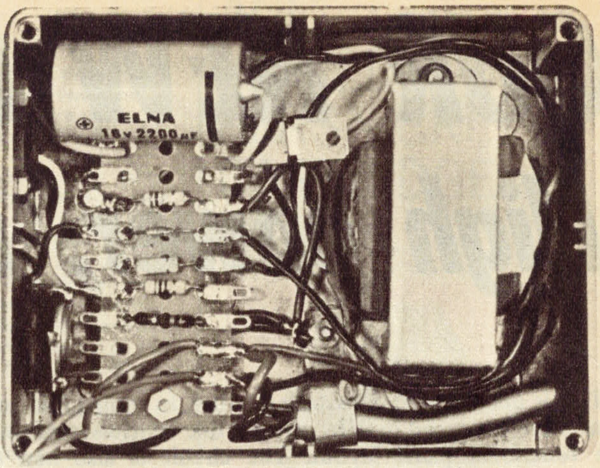
Because the Diac is connected from the anode of the complementary SCR to earth, the voltage appearing at the anode is a clipped sine wave with a peak-to-peak amplitude of 60 to 80 volts. This means that the phase shift between the anode and gate voltages can only cause the anode voltage to assume a positive differential with respect to the gate during that period of the positive half-cycles before the Diac "breaks over". This means that, because of the Diac, the triggering produced by gate circuit capacitance always tends to occur early in each positive half-cycle, to give the circuit an all-or-nothing switching characteristic.

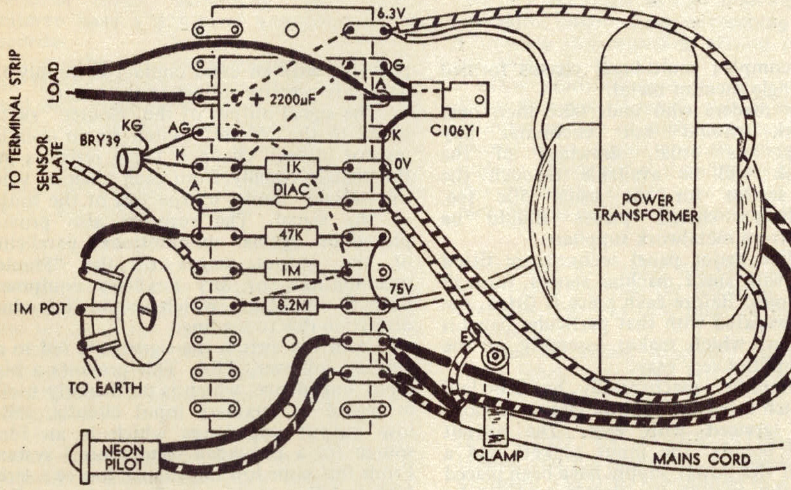
The 1M preset potentiometer shunting the Diac forms a voltage divider with the 47K resistor, and functions as a sensitivity control. When the pot is adjusted for maximum resistance, the circuit is most sensitive to gate circuit capacitance and vice versa. If the pot is adjusted to very low resistance values, the circuit will not function as the anode voltage will always be low.

Since triggering can only occur in the early part of each positive half-cycle, radio frequency interference is minimised. However, this is not the only reason for incorporating the Diac.

When the complementary SCR fires, the 47K and 1K resistors form a voltage divider across the sine wave input. The voltage appearing across the 1K resistor then forward biases the gate-cathode junction of the SCR, to trigger it on. The voltage across the 1K resistor should be as large as possible, within reason, to ensure reliable SCR triggering. Also, to ensure good sensitivity to capacitance changes, the complementary SCR gate circuit must operate at a high impedance. Both these requirements mean that the sine wave input from the transformer should be as large as possible. However, the maximum voltage ratings of the D13T1 device are plus or minus

*At right is an interior view of the prototype, housed in a diecast box made by STC.*




*Above is the complete wiring diagram showing the BRY39 SCS installed. If a D13T1 "programmable unijunction" or complementary SCR is used instead, a small modification to the layout will be needed.*

40 volts and this would be exceeded by a sine wave input voltage of 30 volts. Thus the Diac allows us to use a relatively large input voltage and still protect the complementary SCR.

While the Diac protects the complementary SCR anode from excessive voltage excursions, it does not offer similar protection for the anode gate. However, if the anode gate does go into "reverse breakdown", its dissipation is kept to negligible levels by the 8.2M series resistor.

Some readers may point out that the BRY39 device (an SCS) which is shown as an alternative to the D13T1 has much higher voltage ratings, and thus could be used with higher input voltages, without the Diac. While it is true that the BRY39 could be used with transformer input voltages up to 49 volts, a higher voltage is really necessary for good results. In any case it is the clipping action of the Diac on the anode voltage of the complementary SCR which gives the circuit its desirable all-or-nothing switching action.

If the Diac was not included in the circuit and supposing that the voltages were within the ratings of the device used, both it and the SCR could be triggered at any instant during the positive half-cycles of the AC input. This would mean that varying the stray capacitance of the sensor to earth would vary the output voltage as seen by the SCR load. However, with the Diac in circuit, the combination must fire early in the half-cycle and thus the load voltage tends to be independent of the trigger capacitance, once the latter becomes sufficient to cause triggering.

The load used for our prototype was a low voltage electric bell. Consequently, the input for the SCR is 6.3 volts AC. When the SCR fires, it applies half-wave rectified DC to the bell, and this is filtered by a 2200uF capacitor. Note that because of the AC supply the complementary SCR/SCR combination will continue to fire and apply voltage to the load only while there is sufficient capacitance in the gate circuit to cause triggering. As soon as the capacitance is reduced below a certain value the combination will revert to the non-conducting state. If the SCR was required to "latch on" it would have to be fed from a DC supply.

Note that the AC voltage at the anode of the SCR must be in phase with the voltage fed to the anode of the complementary SCR, otherwise the SCR will not be capable of conducting when triggered. To ensure that the voltages are in phase, all that is required is to connect the 6.3 volt winding and the 75V winding so that their voltages add. This may easily be determined using a multimeter.

The bell we used as the load draws an average current of 500mA at 6 volts, and is eminently suitable for the transformer shown. Any lamp, buzzer or other indicating device drawing this order of current may thus be used with the unit, without modification. Loads requiring a higher current should not be used, however, to avoid exceeding the RMS current rating of the SCR. If heavier loads are required, the C106Y1 should be used to trigger a higher-power SCR, or to operate a small relay.

The construction of the proximity switch is quite straightforward. It is housed in a diecast metal box measuring 4 5/8 x 3¾ x 2in, as made by Eddystone or STC. These are available from most parts suppliers. The transformer we used was a Ferguson type PF 2235, which has a centre-tapped 150V winding at 30mA and a 6.3V winding at 1 amp. The A & R PT 5890 is similar and would also be suitable.

The transformer in the prototype was a very snug fit in the diecast box, with about

**(Continued on page 150)**

 . . . from p 43

1/16in clearance between the top of the transformer and the lid. Readers using transformers other than those specified should therefore check that components fit their case before buying.

The preset sensitivity potentiometer is mounted at one end of the case, which is drilled to allow screwdriver access. All the other components are mounted on a 12-lug length of miniature tagboard. The SCR is soldered directly into circuit and does not require any additional heatsink. The pigtails of the 1000uF capacitor should be sleeved with spaghetti to avoid the possibility of shorts. The layout shown in the diagram shows a BRY39 in circuit. If a D13T1 is used, the layout will have to be rearranged slightly to accomodate the different lead configuration.

The mains cord should be passed through a grommeted hole in the case and securely anchored with a mains cord clamp. Note that the case and the circuit **must be earthed** via the mains cord, otherwise the device may fail to work. A neon light assembly incorporating a limiting resistor is mounted on the case lid to indicate that the unit is functioning.

The output leads to the load and the lead to the sensor plate are terminated on a short length of plastic terminal block. Note that shielded cable cannot be used for the sensing lead otherwise the complementary SCR and SCR will remain continuously turned on due to cable capacitance. Similarly the sensor lead should not be too long, otherwise there will again be excessive stray capacitance.

When the unit is completed and ready for installation choose a location which required a minimum of lead length to the sensor plate. The leads to the bell are not critical. The sensor plate should be kept as far away as possible from earthed objects, otherwise sensitivity will have to be compromised. It may either be concealed or left visible. Note that the sensor plate may be touched directly, with no danger of electric shock, because of the high values of resistor used in the gate circuit.

With the unit installed and the sensor plate connected, it is only necessary to adjust the preset potentiometer to the point where the bell just fails to ring in the quiescent state. If the user now places his hand in the close vicinity of the sensor plate, the bell should ring.