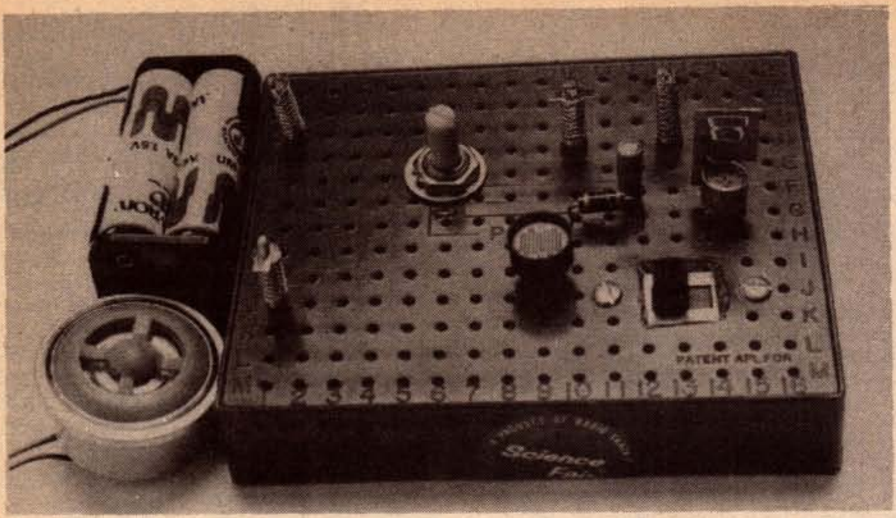


The simple intruder alarm as it appears when constructed from the Science Fair kit, as sold in Tandy stores. It can be built up in a more permanent form, however, and put to serious use. The layout is not critical and the parts can be arranged to suit each individual applications.

Especially for beginners:

A Simple Intruder Alarm

Here is a simple little project that can be built purely for its instructional value, or as a fun gimmick for the home. Alternatively, it could be built up in a more permanent form and put into service as a storeminder — alerting the owner whenever anyone enters the shop!

by WALTER NEVILLE

The idea behind the project is as old as it is useful: A narrow beam of light, as often as not shining across an open doorway, is focussed on a light sensitive cell. While ever the cell is thus illuminated, the associated circuitry remains substantially inert, hopefully drawing very little current from the battery, or other type of supply.

However, if the beam of light is interrupted, as by someone walking through the doorway, the circuitry is activated to sound an alarm, operate a signal light — or open a trapdoor in the floor, if you really wanted to!

Before the solid-state (or transistor) era, this kind of gadget involved a fair amount of circuitry. The light-sensitive element was usually a gas-filled phototube, constructed on the manner of an ordinary radio valve. The associated circuitry involved one or more amplifier stages, which required the provision of both a heater voltage and an anode supply voltage, typically of around 100 volts. This made it desirable to operate the unit from the AC mains, involving a power transformer, a rectifier and one or more filter capacitors. To operate the bell or signal light, some kind of relay was usually required in the valve anode circuit and, all told, it added up to a fairly complicated project.

The availability of solid-state devices has changed all that, making possible something as simple and straightforward as the project here illustrated. There is no phototube, as such, no amplifying valves or transistors, no relay, and no power requirements beyond what can be supplied by a modest battery.

Let's look at the circuit diagram:

In place of the one-time phototube is a cadmium-sulphide cell — in this instance a small cylindrical device measuring about 12mm in diameter and 6mm deep, with two wires protruding fron the rear face. Cadmium sulphide (or CdS) cells come in different shapes and sizes but, electrically, they are essentially alike.

The external leads connect to either edge of a small wafer making up one face of the cell, and on which is deposited the photosensitive layer. When little or no light is falling on the wafer, the resistance between the two connecting leads is very high, being typically 1 megohm or more. With increasing amounts of incident light, the resistance falls progressively to a much lower figure — typically 100 ohms or less.

In the accompanying circuit, the photocell is shown connected in series with a 100k potentiometer across 6V DC, as would normally be obtained from four series-connected dry cells.

With no light falling on the cell, its resistance would be high and the voltage at the junction of the cell and potentiometer would be quite close to 6V. However, with increasing light, the voltage would fall towards 0V, depending on the setting of the potentiometer. This voltage, varying with incident light, is applied through a 4.7k resistor to the gate (G) or control electrode of a silicon controlled rectifier, shown as SCR.

"What," you may well ask, "is a

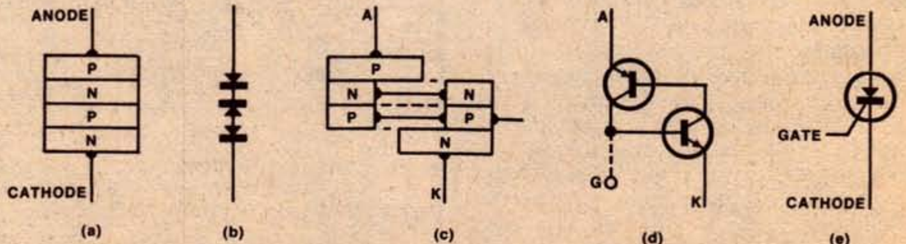


Fig. 1: Apart from anything else, this project provides a practical lesson in SCRs or silicon controlled rectifiers. A four-layer semiconductor (a) equivalent to three back-to-back diodes (b) would seem to be a particularly futile device. But it emerges in a quite different light, if seen as two intimately coupled transistors (c) and (d). The normal schematic symbol for an SCR is at (e).

silicon controlled rectifier?".

To answer this question anything like adequately would involve plunging more deeply into device theory than can be justified here and the reader who wants to really follow it up could do so in the Electronics Australia Handbook "Fundamentals of Solid State" by Jamieson Rowe. However, let's try for a somewhat simplified explanation:

Basically, a silicon control rectifier (or "SCR" or "thyristor") involves four distinct layers of silicon, doped respectively P,N,P,N, as illustrated in Fig. 1. Obviously, three P-N junctions are involved, with the centre one in opposite polarity to the other two. In fact, Fig. 1a could be likened to 1b, which provides the same sequence of P-N junctions, but in three separate silicon diodes.

The arrowhead portion of the diode symbols in Fig. 1b indicate the direction (and the only direction) in which each diode can conduct current, using the traditional concept of current flow from positive to negative. It would seem that, with one diode connected back-to-front, the configuration in 1b would not conduct current in either direction — unless, of course, the applied voltage was sufficicent to cause diode breakdown.

This must lead to the inference that Fig. 1b would be a futile combination of components. But, to contrive a multi-layer device such as Fig. 1a would seem to be even more futile: an elaborate way of producing a virtual open circuit, or a switch in the open position!

That last phrase, by the way, was not included for mere emphasis. In certain conditions, the multi-layer device in Fig. 1a can indeed simulate a switch in the "off" position.

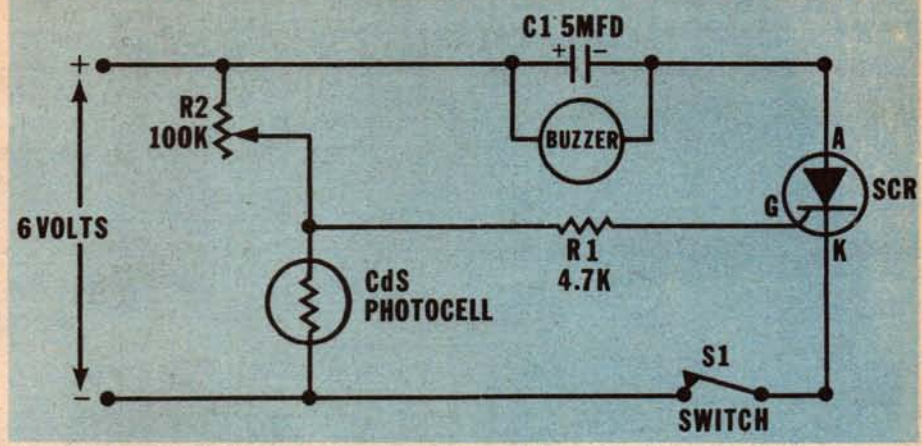
It transpires, however, that the multi-layer device (1a) can be regarded in another way: as two transistors in a paeudo series configuration, but sharing a common N layer and a common P layer, as illustrated in Fig. 1c.

If simulated by separate transistors, the circuit would look like Fig. 1d. If you examine the configuration closely, you will note that the output (collector) or each transistor is connected to the input (base) of the other. As a result, any small current in one is amplified by the other and fed back in such a way as to increase the effect; in short, a positive feedback loop.

Behind this observation lies the secret of the silicon controlled rectifier: by providing a separate connection to an internal junction region, it is possible to promote a small current flow in each of the two virtual transistors. By virtue of their cross-connection, each amplifies the small output current of the other, so that both are driven rapidly to saturation — therefore to high current conduction.

As a result, a silicon controlled rectifier has two states:

FIG. 2 SCHEMATIC DIAGRAM - LIGHT OPERATED ALARM



Here is the circuit diagram, reproduced directly from the "Science Fair" brochure. In the normal condition, light falls on the photocell, causing it to exhibit low resistance and holding the SCR gate close to the negative potential. When the light beam is interrupted, the resistance of the cell rises, the SCR gate approaches the +6V supply and the SCR switches on, thereby causing the buzzer to sound.

1. With no current fed to the internal junction (the "gate" or "G") the device looks like an open circuit, being analogous to back-to-back silicon diodes (Fig. 1b) or to silicon transistors with no forward bias, therefore no collector current and no means of driving each other to current saturation. It can maintain this "off" state indefinitely, if not deliberately "triggered" into conduction.

2. If a forward bias is applied to the gate and gradually increased, relative to the anode voltage, a point will be reached where the virtual transistors begin to conduct. The moment this happens, they drive one another almost instantaneously into saturation, so that the silicon controlled rectifier conducts heavily. Once "turned on" it will remain in the conductive state indefinitely, irrespective of gate voltage, for as long as the anode voltage is maintained.

"The kit has paid for itself a hundred times over. When they stop for the red light, they invariably pick up a couple more items!" (Adapted from Electronics Weekly.)

Because an SCR has these two distinct states, and operates like a switch that is either open or closed, it can often be used to control directly an alarm, a light or other device which is compatible with its voltage and current ratings. The need for a separate relay is thereby reduced.

After that spell of SCR theory, we can look again at the main circuit diagram:

An SCR is wired in series with a buzzer and an off-on switch across a 6V battery supply. If that was all there was to it, the SCR would look like an open circuit and nothing would ever happen.

However, the gate is wired to the junction of our photocell and a potentiometer, as mentioned at the beginning of the article. With light shining on the cell, its resistance is low and this tends to keep the gate close to the negative side of the supply, and the SCR non-conducting.

If the potentiometer resistance is now gradually reduced, a point will be reached where the SCR is turned on and the buzzer will sound. Backed off just slightly from this point, the SCR will be held in the non-conducting state by the resistance of the CdS cell, and therefore by the amount of light falling on it.

But let the light beam be interrupted and the buzzer will sound.

Quick! A customer has just come through the door!

At this point the alert reader may come up with an objection: If an SCR, once turned on, stays that way, will not the buzzer continue to sound, even after the light beam is restored?

A good question, but there's an equally good answer:

By its very nature, a buzzer becomes an open circuit on every cycle, so that when operating it is continually making and breaking the supply to the SCR anode. Thus the SCR really drops out of conduction on every cycle, allowing

(Continued overleaf)

A Simple Intruder Alarm — continued

the gate to inhibit conduction — or to turn the SCR off — the moment the light beam is restored.

Why the capacitor across the buzzer? If for no other reason, it is wise to bypass any buzzer, relay or other such device in the anode circuit of an SCR, in order to suppress inductive voltage spikes which might exceed the SCR voltage ratings.

As you may have guessed from the picture at the head of this article, the project was inspired originally by an Archer kit, (No. 28-128) — sold in Australia through Tandy stores. At $7.95 for everything as pictured, excluding the batteries, it is probably the easiest way to acquire the necessary bits and pieces. It comes complete with a pamphlet describing the construction and setting up on a step-by-step basis, and anyone who can solder should be able to put it together.

However, if you do want to buy elsewhere, the potentiometer, switch and electrolytic capacitor are standard items. The CdS cell and SCR in the original kit are not branded but we imagine that almost any such cell and any small SCR that you are likely to come across will serve the purpose. Archer provide a small heat sink — about 1cm square — for their SCR and you could follow suit by snipping one from a scrap of tinplate. Allow enough extra metal so that you can clip it around the SCR body.

The buzzer may pose more of a problem, since a low voltage, low current type is required. The original is simply marked "3V" and shown as a "Science Fair" or "Archerkit" part number 99-5-007. We note, however, that Tandy list a low voltage buzzer in their catalog and this would probably serve the same purpose. (Part 273-004, $1.39).

The original kit drew 1.1mA from the 6V source when idling, and 225mA when the buzzer is sounding. Since the latter condition is highly intermittent, battery drain for the unit itself is no problem. For a permanent installation, a logical course would be to run it from four D-cells or a lantern battery, much as one does with door chimes.

The light source is another matter. For purposes of demonstration, the original pamphlet assumes the use of a torch or any other light source — even daylight — that allows the CdS cell to be shadowed. For longer term use, such as a door minding situation, it would be almost essential to resort to mains operation, preferably a low voltage lamp run via a transformer, and to contrive some kind of beam.

In fact, while the circuitry can remain exactly as shown, the physical form of the unit can be a challenge for the builder's ingenuity.

Our suggestion would be to build the alarm unit into a small box which can be mounted unobtrusively in a position where the beam will be broken by a person crossing the threshold. Paint it a dark, flat colour, so that it will not be readily illuminated by stray light.

The cell itself should be mounted deep inside the box and preferably at the rear of a tube painted flat black internally. This arrangement tends to reduce illumination from ordinary ambient light, while still leaving the cell accessible to a deliberately arranged beam. With a little more ingenuity, the tube can be made somewhat larger than the cell, and a small magnifying glass so placed inside it that it will focus the beam onto the surface of the cell.

For the light source, it may be possible to use the front section of a small but well-focussed torch, but to operate the globe from a suitable mains transformer. This, too, could be set back in a tube, painted in flat black, to confine stray light. Again, a small magnifying glass, critically placed in the tube, may sharpen the focus of the beam.

Last but not least, a piece of red filter glass or even red perspex across the light source and the cell tube can render the beam less visible, without compromising its effectiveness. (For further observations along this line, see the "Simple Projects" chapter in our "Basic Electronics" handbook).

As we said earlier, this can all be a test for your ingenuity, for not too many dollars or outlay. Have fun!