Elementary Electronics

Light beam relay

Light beam relay systems have always intrigued our younger readers, and the present generation is no exception. Whether you use it for a serious alarm system, or just for fun or a novelty, you will find it an intriguing project.

by ROSS TESTER

A common request from readers is for a device which will detect intruders as they enter a driveway. The need for such a device appears to be increasing as, seemingly, undesirable types are becoming more daring and more numerous. It is quite common these days to hear of cars being stolen from inside a person's property.

Our light beam relay would go at least part of the way to prevent this. If it is placed across the entrance to a driveway, an intruder will have to cross it in order to reach the car. And by the time he has unlocked it, the owner should have been able to summon assistance.

In the January "Elementary Electronics" we published a series of one transistor circuits which included a simple burglar alarm. Using the same basic circuit we can make a light beam relay system; a device which has many possible uses. It may form part of a burglar alarm system itself, may serve as a shop minder, or as the basis for many novelty displays.

In the burglar alarm, we described how door and window switches could be used to hold a transistor in the off mode by removing the forward bias from the base. This system works much the same, except that we have replaced the switches with a light dependant resistor, or LDR. A beam of light aimed at the LDR from an incandescent globe provides control.

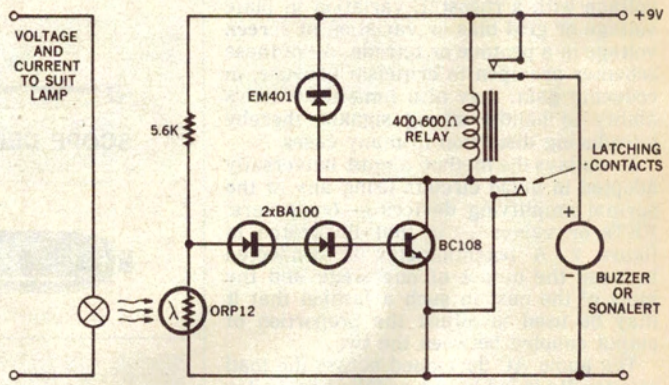
Briefly, an LDR works as follows: In its normal (dark) state, the cadmium sulphide (CdS) of which the LDR is made can be regarded as a normal semiconductor. That is, most of the electrons of the atoms are situated in the "valence" bands and are not free to move around for conduction. So the LDR exhibits a high resistance, typically around 10 megohms.

When light strikes the LDR, the electrons are excited, and some of them are raised from the valence band into a conduction band where they are available for conduction. Hence, the resistance lowers. The stronger the light, the more excited the electrons become, and the greater the number available in the conduction band. Hence the resistance lowers still further. The minimum resistance obtainable depends on the particular LDR, but ranges from approximately 75 ohms up to 300 ohms.

If you found the previous explanation rather heavy going, do not worry. Just remember that in darkness, the resistance of the LDR is very high. In bright light, it is quite low.

By placing the LDR between the base and emitter of a transistor, we are able to control the forward bias on the base. When light shines on the LDR, the base of the transistor is almost at the same potential as the emitter (minimum forward bias); because of the very low resistance between them. Therefore the transistor will not conduct. But if a shadow passes across the LDR, (such as that from a person walking in front of it) the resistance of the LDR rises, and the base voltage is raised. This biases the transistor on, and current flows from emitter to collector, through the relay, closing its contacts.

The transistor would be turned on only for the time the shadow is across the LDR. If this light beam relay was used as a shop door minder, or similar application, it would only be necessary to add a buzzer or similar alarm to the relay. Every time someone came into the shop (and interrupted the beam) the buzzer or alarm would be activated briefly.



The circuit is based on the burglar alarm circuit in the January issue. Its operation is most easily understood by visualising the LDR as a substitute for the door and window switches.

However, if you were considering using this device as a burglar or intruder alarm, some sort of latching circuitry would be necessary to keep the alarm functioning. A very short buzz might go unnoticed, particularly if it had to wake someone from sleep.

There are several ways of providing this latching function. For example, a simple R-C circuit to keep the relay closed for a certain time, then drop out; or a "slugged relay" which, in itself, takes a certain time to drop out; or, perhaps, a network to hold the transistor base biased for a fixed time regardless of the resistance of the LDR.

However, we elected to take the simple way out. We simply wired in an extra set of contacts on the relay to bypass the transistor, and therefore hold the relay on until it was turned off manually. This method does create the inconvenience of having to turn it off, but it has two advantages; the alarm must be investigated (it cannot be ignored) and, perhaps more importantly, it does not add to the cost.

There are other uses to which the light beam relay may be put, but we will leave them to the ingenuity of the individual. We might warn you, however, that if you are not used to dealing with mains circuitry, it is best to leave it alone.

The light beam itself may come from many sources. For simplicity, we first used a small incandescent torch globe, but found that the range was rather limited.

We then tried various other light sources, and eventually settled on a 6 volt car tail or brake light as being the best. These have two major advantages — there are many variations in wattage available, from three to 24 or so, and the filament is quite small.

The smaller our source of light, the closer we can come to producing a parallel beam, with the aid of a lens, and make most use of the available light.

One disadvantage of the higher current lamps is that they dissipate a lot of heat. This means that they must be adequately ventilated however they are housed. If you follow our later suggestion to house them in cardboard tubes, we suggest that the back of the tube be left open with perhaps a few holes drilled between the lamp and the lens.

Mounting the brake light should be no problem. Any automotive wrecking yard would be able to supply a brake light holder from a wrecked car — in all probability with the brake light still inside.

If you use such a light, it is more than probable that you will require a transformer to run it. The light would draw too much current to make battery use feasible. The transformer must be able to supply the required current on a continuous basis. The current drawn by the lamp can be worked out by Ohm's law from the marked wattage rating.

The transformer must have a rating of at least 3 amps to run an 18 watt, 6 volt bulb continuously. Transformers which fall into this category include the Ferguson PF162, PF476 and the A&R 5508. The A&R has a maximum current rating of 4 amps, so would suit lamps up to 24 watts.

If an automotive globe has a nominal 6V rating it is quite in order to use it with a 6.3V transformer. These lamps are designed for use in electrical systems where the voltage may rise to 7.5V, or even higher in some circumstances.

If you are contemplating only a short distance of operation, a brake light is not really necessary. We were able to make a six volt, 300mA globe operate the relay from across our laboratory — wider than would be necessary for protection of one door. The brake light would operate the relay over a much greater distance. It is possible to arrange a system of mirrors which will allow complete protection of a doorway. All that is necessary is to set the mirrors so that a beam of light is reflected back and forth across the doorway, with the LDR at the top and the lamp at the bottom. In other words, if any part of the beam is broken, even by something very small going through the doorway, the LDR will react and the relay operate.

By using suitable optical systems, we can make this light beam really operate over quite long distances.

The performance of the LDR can be greatly improved by the use of a lens. A lens, placed at the correct focal point, will focus the light onto the area of the LDR which contains the light sensing CdS cell. This means that the cell presents a much larger capture area to the available light.

If a lens is also associated with the lamp, results will be even better. In theory a lens should be able to produce a parallel beam of light from the light source, assuming a perfect point source. Since we cannot provide a point source we will actually create a slightly diverging beam, but this is still a lot better than no beam at all.

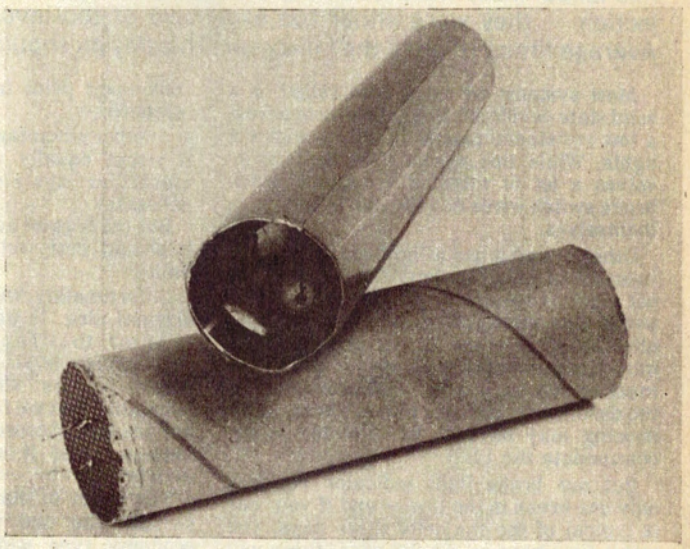
The lenses we used were purchased from one of our advertisers, Deitch Bros, of 70 Oxford St, Sydney. They are 1½ inch diameter, with a focal length of about two inches. They are priced at fifty cents each. Larger lenses (2½ inch dia) are available for $1.50, or $2.50 per pair. These lenses should do an even better job.

Another point worth considering is that the beam can be made quite invisible until the intruder is actually in its path — by which time he has triggered the alarm. By recessing the light and lens into a long, thin tube which is painted a matte black on the inside, it becomes almost impossible to detect the light coming from the tube unless you were looking directly at it.

A method of making the light even harder to detect is to use infra-red filters over the light source. This will reduce the light output somewhat, but it will still be adequate for many applications. Infra-red filters are available from photographic suppliers and are not unduly expensive. This subject was dealt with in detail in an article, "Invisible Light Beam Relay Systems", February 1963 (File No 2/LR/4). Copies are available for 50c each.

Construction of the light beam relay should not prove difficult. The electronic components, except the LDR, may be placed on a tagstrip using the layout we have shown.

The LDR and lens tube may be made the same way as ours, or some readers may have different ideas. We first made a tube the same size as the lens with cardboard and brown paper, and painted the inside black. Then we made another tube which would slide over the first one. A circle of Veroboard was cut the same size as the larger tube. The LDR was soldered exactly in the middle, and the Veroboard was fixed to the end of the tube with Bostik.



A housing for the LDR and lens can be made from two cardboard tubes. The upper one contains the lens, the lower one the LDR. Note the piece of Veroboard cemented in the end.

The two tubes assembled. The outer one was salvaged from a roll of plastic wrapping, the lower one made to fit.

The long tubes, with their black interior, also help to minimise the amount of ambient light which reaches the LDR. This can otherwise seriously affect the range over which the system will operate.

When the paint on the smaller tube had dried, we forced the lens into it, approximately one inch from the end. All we had to do then was focus the lens onto the centre of the LDR. This was simple — as the LDR changes with light intensity, we just connected a multimeter (on x100 range) to the LDR, pointed the tubes at the window, and slid the inner one in and out until we had maximum deflection of the meter.

The same system may be used for making, and adjusting, the light tubes. To focus the light, point it at the LDR, and adjust the light for maximum reading of the meter.

We did not use a reflector for the lamp, as we considered them to be too expensive for this project. However, if you do obtain one (again, from a wrecking yard) it may be used instead of going to waste. A reflector and lens assembly makes much better use of the available light.

A number of readers have reported difficulty in obtaining a 500 ohm relay which would pull in when used on the original burglar alarm. We imagine that the same problem may occur with this unit.

One Sydney retailer informs us that he has obtained a relay from STC (type AFO) which was able to do the job. Its resistance is 430 ohms, and works quite satisfactorily on a 9 volt supply. In our original unit, we used an ex-disposals relay (obtainable from a computer wrecker). In its original condition it would not pull in, but we removed one of the sets of contacts to lessen the spring tension and found it to be quite satisfactory.

The alarm unit can take a number of forms. The most obvious is the conventional bell or buzzer, and this should be adequate in most cases. Other possibilities are a small audio oscillator and speaker (Signal Oscillator, May 1962, File No 1/MS/4) or the commercially available "Sonalert" made by Mallory. Although the latter is a dearer unit (about six dollars) it produces a very effective note, and offers a high order of reliability, a particularly valuable feature in commercial installations.

So there it is — a simple light beam relay which is economical to build and should be quite reliable in service.