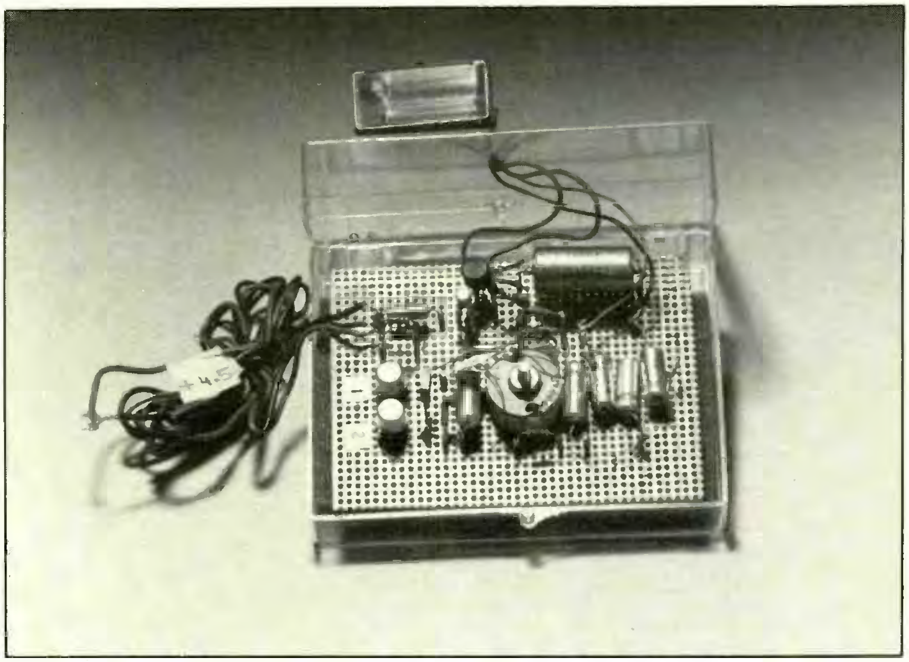
A Day/Night Safety Beacon

Based on electronic photoflash circuitry, this portable safety device can be seen by oncoming traffic both day and night

By Anthony J. Caristi



One can't be too careful when it comes to safety, especially when exposed to highway or road dangers while traveling. The portable Safety Beacon to be described here will come in handy as a safety device for a disabled automobile, a bicycle or other vehicle. Unlike ordinary warning lights, its piercing flashing light, based on electronic flash circuitry, can be easily seen day or night from a long distance. It commands attention, while not "blinding" oncoming traffic. On a bicycle or motorcycle, it can be left on continuously to alert automobile drivers.

Its built-in battery makes it completely independent of any other power source for full portability. Powered from three fresh C-size cells, it will provide about 100 hours of operating time. Current drain is far less than that required by a common three-cell flashlight. To further enhance the Safety Beacon, you have the option of using rechargeable nickel-cadmium cells to even eliminate the bother or having to periodically replace the spent cells. And if you wish to operate the project from a 12-volt automative electrical system, a simple modification is all that's required.

How It Works

A xenon flashtube like those commonly used in many types of cameras is the heart of the Safety Beacon. Power for flashing the tube is provided by a simple dc-to-dc converter that steps up the low battery potential to about 250 volts dc.

Xenon flashtubes produce light when a capacitor charged to a relatively high voltage is suddenly discharged through them. The energy expended in the flashtube is proportional to the voltage and capacitance. In this project, this energy is low (about 0.333 watt-second) to assure long flashtube life and to produce a bright but not blinding flash.

In the dc-to-dc converter shown in Fig. 1, you must wind the transformer identified as *T1*. Note that *T1* has three separate windings. In this circuit, *Q1* and *Q2* are forced into oscillation by positive feedback to their bases from the upper winding labeled 1/2/3.

Due to the relatively high turns ratio between the primary (4/5/6) and secondary (7/8) windings of *T1*, the switching action of *Q1* and *Q2* induces a high voltage into the secondary circuit. This voltage is passed through the *D1/D2/C3/C4* voltage-doubler circuit. Here, each capacitor is charged to about 125 volts, and the sum of the charges (250 volts) is fed to flashtube *FT1*.

Although a high voltage is present across *FT1*, the flashtube won't conduct (flash) until it's triggered by a very high potential of (4000 volts or more) applied to the "trigger" electrode. (The trigger voltage is not dangerous because it has no current behind it.)

Autotransformer *T2*'s primary is

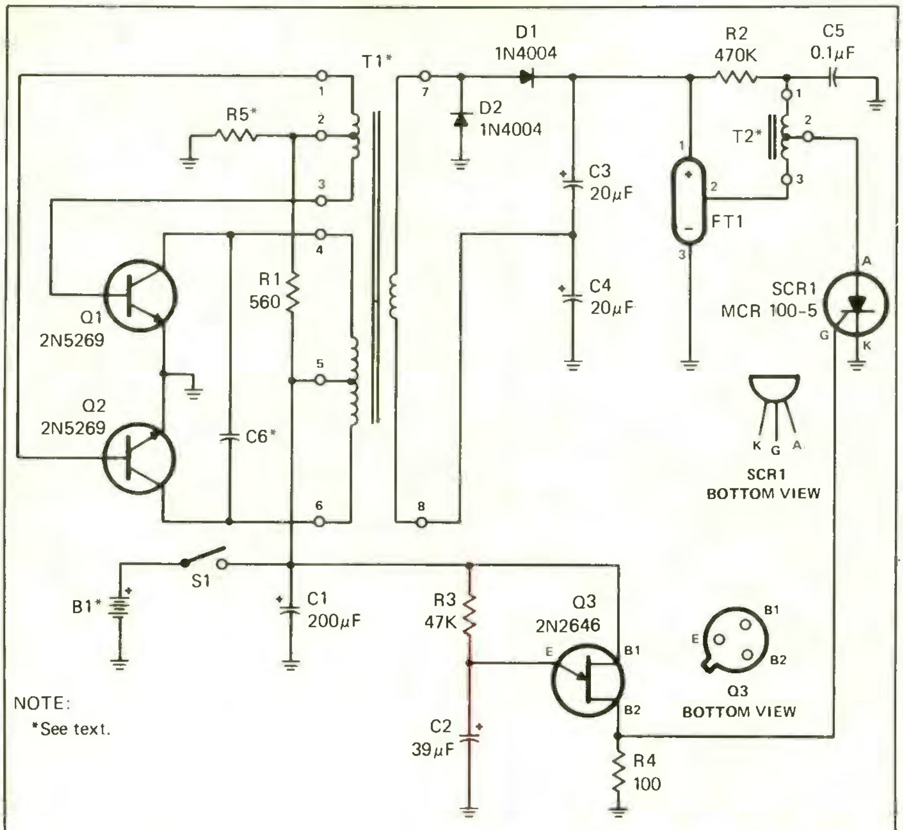


Fig. 1. This is the project's overall schematic diagram.

PARTS LIST

Semiconductors

D1,D2—1N4004 rectifier diode

Q1,Q2—2N5296 or similar transistor

Q3—2N2646 or similar unijunction transistor

SCR1—MCR 100-5 (Motorola) or similar silicon-controlled rectifier

Capacitors

C1—200-μF, 15-volt electrolytic

C2—39-μF, 10-volt electrolytic

C3,C4—20-μF, 150-volt electrolytic

C5—0.1-μF, 300-volt Mylar or ceramic

C6—0.22- or 0.0047-μF, 100-volt disc (see text)

Resistors (¼-watt, 10% tolerance)

R1—560 ohms

R2—470,000 ohms

R3—47,000 ohms

R4—100 ohms

R5—68 ohms (12-volt units only—see text)

Miscellaneous

FT1—250-volt flashtube (Radio Shack No. 272-1145 or similar—see text)

S1—Spst slide or toggle switch

T1—Hand-wound transformer on TDK P2215 Z52H pot core (see text)

T2—Trigger transformer (Triad No. PL-10 or similar) Printed-circuit board or perforated board and solder posts; transistor sockets; heavy-duty stranded hookup wire for power leads; suitable enclosure; hookup wire; No. 30 and No. 36 enameled wire; machine hardware; solder; etc.

Note: The flashtube and trigger transformer are available as Cat. No. 3RS0430 from Hi Tek Sales, 119R Foster St., Peabody, MA 01961. The following are available from A. Caristi, 69 White Pond Rd., Waldwick, NJ 07463: pc board for $6.75; pot core/bobbin for T1 for $6.75; 2N2646 transistor and MCR 100-5 SCR for $2.75 each. Add $1.00 S&H.

the winding between terminals 1 and 2. To generate repetitive flashes, unijunction transistor *Q3* is connected as a very-low-frequency relaxation oscillator, via *C2*, *R3* and *R4*.

When power is applied to the circuit and *C2* charges to about half the battery voltage, *Q3* suddenly conducts from emitter (E) to base 1 (B1). This dumps the charge stored in *C2* into *R4*. Capacitor *C2* then begins to recharge, and the process is repeated once every 4 or 5 seconds, as determined by the *R3/C2* time constant.

A capacitive-discharge circuit is made up of *T2*, *C5* and *Q4*. Charging of *C5* to 250 volts is accomplished through *R2*. Though *T2* is also connected to *C5*, current can't flow in the transformer primary because silicon-controlled rectifier *SCR1* isn't yet triggered into conduction.

When *Q3* switches on, the regulating voltage spike that appears across *R4* is also applied to the gate (G) terminal of *SCR1*. This causes the SCR to switch on and suddenly apply the 250 volts stored in *C5* to *T2*'s primary. The *C5/T2* primary (LC) circuit dissipates the charge as a burst of oscillation.

Since *T2* has a step-up ratio, when the charge on *C5* is being dissipated, the energy at the secondary is at least 4000 volts. This potential, applied to the trigger electrode of *FT1*, causes the flashtube to conduct, allowing most of the energy stored in *C3* and *C4* to be converted into heat and light. It's this conversion that produces the flash. The cycle repeats for as long as power switch *S1* is closed and there's sufficient voltage in *B1* to excite the circuit. The repetition rate is 4 or 5 seconds.

Construction

Begin construction by fabricating transformer *T1* (see box for details). Once the transformer is ready, wire the circuit on either a printed-circuit board or on perforated board using solder posts. The pc board (see Fig. 2 for the actual-size etching-and-drilling guide) is recommended if you want a very compact project. Other than this, since there's nothing critical with regard to layout, either method can be used with success.

If you use a pc board, refer to the diagram in Fig. 2 for component

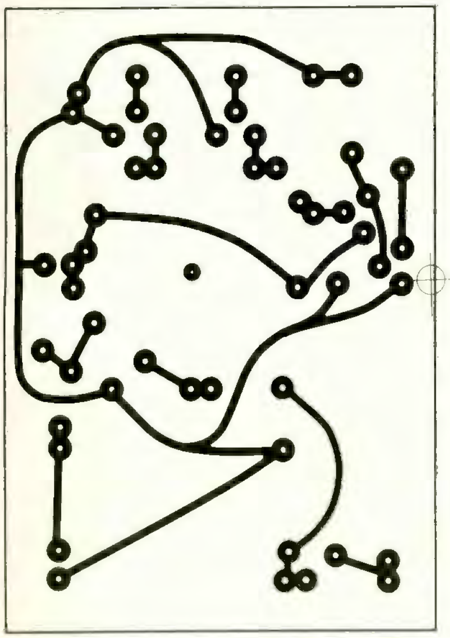


Fig. 2. Etching-and-drilling guide.

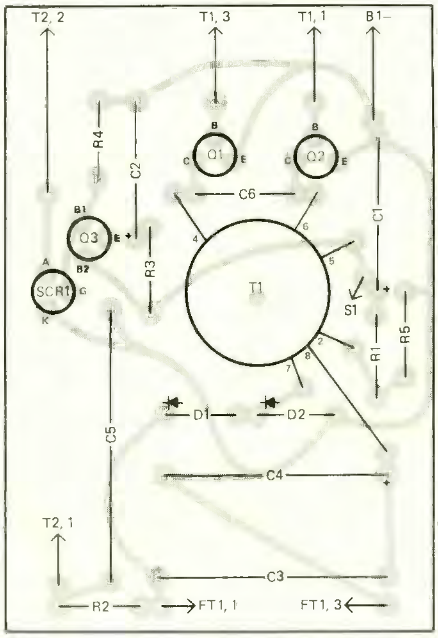


Fig. 3. Components-placement guide.

placement and orientation. If you go the perf-board route, you can use the same layout shown in Fig. 3, but you'll have to refer back to Fig. 1 for wiring details and leave extra room for wiring. Regardless of the wiring method you use, pay careful attention to the polarization of the diodes, electrolytic capacitors and battery, and to lead designations for the transformers, flashtube, transistors and SCR. Also, it's a good idea to use sockets for the transistors and SCR to simplify servicing the circuit should this ever become necessary and to facilitate the steps in the checkout procedure.

When mounting *T1* on the circuit board, be very careful to avoid overtightening the hardware, or the very

Winding The Transformer

The only component the Safety Beacon calls for that isn't readily available from the usual parts sources is transformer *T1* in Fig. 1. Though you must wind this transformer yourself, the task isn't particularly difficult. The materials you need are readily available and consist of a pot-core/bobbin assembly (see Parts List for type and availability), some No. 30 and No. 36 enameled wire and thin tape.

Wind the 1/2/3 feedback turns (see Fig. 1) first. This winding consists of 10 turns of enameled wire with a tap at the fifth turn. Wrap exactly 10 turns of wire onto the pot core's bobbin and add 7" to this amount. Clip the wire and unwind it from the bobbin. Fold the wire exactly in half.

Carefully scrape away, down to bare wire, ¼" of the enamel coating from both ends and centered at the fold. Scrape away ¼" of enamel from both ends of another 3" length of wire and twist one end of it together with the bared wire at the fold. Solder the center-tap connection and wrap it with insulating tape.

Now, starting 3½" from one end, wrap exactly 10 turns of this wire around the bobbin. Use pieces of tape with the numerals 1, 2 and 3 on them to identify the beginning, center tape and end wires, respectively. When you're finished winding this coil, you should have two leads that measure 3½" and one that measures 3" in length. Remember the direction in which you wound this coil (draw an arrow pointing in this direction on the bobbin). Wrap a couple of turns of thin, preferably Mylar, tape over the feedback coil.

Next comes the primary winding, which must be "bifilar" wound. That is, two lengths of wire used to make this coil must be wound at the same time to achieve the tightest possible coupling between the two coil halves. (Tight couplings minimizes voltage spikes that appear across *Q1* and *Q2*.)

The 4/5/6 primary winding in Fig. 1 consists of 13 double turns of wire if the project is to be powered from a 4.2-to-4.5-volt source or 27 double turns if it's to be powered from a 12-volt source. Cut a 48" length of wire for the 13-turn or 96" wire for the 27-turn primary. Fold the wire exactly in half and remove ¼" of enamel from the ends and center fold exactly as described above for the feedback winding.

Starting at the center-tap lead and holding the wires together, wind the correct number of turns on the bobbin in the *same* direction as you wound the feedback coil. Label the ends of this winding with numbers 4 and 6 tags and the center tap with a number 5 tag. Then wrap a couple of turns of thin tape over the winding.

The 7/8 secondary winding in Fig. 1 is made up of 240 turns of No. 36 enameled wire wound in either direction. Be sure to accurately count the turns as you wind the wire onto the bobbin, since the number of turns will determine the dc potential that will be applied to the flashtube. When winding is done, secure the coil with a couple of layers of thin tape. Then scrape away ¼" of enamel from both wire ends and label these wires with the numbers 7 and 8.

Place the bobbin assembly inside the pot core, arranging the winding leads so that they don't obstruct assembly. Then secure the two halves of the pot core with a couple of layers of tape. You can now install the transformer on your Safety Beacon's circuit board, referring to Fig. 1 for wiring details.

brittle core may crack or shatter. Also, place a fiber washer between the head of the screw and the core.

The flashtube and trigger transformer can be obtained from the source given in the Parts List, or you can salvage them from the electronic photoflash of an old camera. If your trigger transformer has isolated windings (separate primary and secondary leads), simply connect one primary wire to the low potential side of the secondary and attach these to the "hot" or + side of *C5*.

The value of *C6* will be different for a 12-volt than it is for a 4.5-volt unit. Use a 0.0047-microfarad capacitor for a 12-volt power source, a 0.22-microfarad capacitor for a 4.5-volt source. This capacitor *must* have a rating of at least 100 working volts. Also, for the 4.5-volt supply unit, omit *R5*; use 68 ohms for a 12-volt supply unit.

Power for the Safety Beacon can be from three common C or D cells connected in series to provide 4.5 volts. Alkaline cells, of course, will provide longer operating life than will carbon-zinc cells. If you prefer, you can use three rechargeable Ni-Cd cells to provide 4.2 volts. *(Caution: Do not use more than 4.5 volts to power the low-voltage unit.* To do so will dramatically shorten flashtube life and will result in excessive voltage being applied to the circuit's components). Current drain from the battery is about 100 milliamperes, which provides an operating life of 100 hours from one set of C cells.

Checkout

Before placing your Safety Beacon into service, you must check it out for proper operation. All you need for this procedure is a dc voltmeter with at least a 1-megohm input and the ability to measure 10 to 300 volts.

Remove *Q1* and *Q2* from the circuit. Connect the voltmeter across *C2*, with the positive probe touching the positive lead of the capacitor. Set the voltmeter's range selector to a position that will allow you to read 10 volts. Apply power to the circuit; the voltmeter's indication should slowly rise to a little more than half the input voltage and then suddenly drop to almost zero. This rise and fall should repeat every 4 or 5 seconds as *Q3* oscillates. If you don't obtain the proper indications, check the *Q3/R3/C2/R4* circuit and especially for proper lead connections for *Q3* in its socket. Do *not* proceed with checkout until you obtain an indication that *Q3* is oscillating.

Turn off the power. Then plug *Q1* and *Q2* in their sockets. *Caution: High voltage is present in this circuit. Therefore, for the remainder of this procedure, make ure you don't touch any of the circuitry or the flashtube.*

Connect the positive probe of the meter to the positive side of *C3* and the negative probe to the negative side of *C4*. Set the meter to allow you to read 300 volts or more. Apply power to the circuit; the reading should slowly rise toward 250 volts and, after 4 or 5 seconds, the flashtube should flash, causing a drop in the meter reading to about 50 volts. This sequence should repeat at 4- or 5-second intervals.

If you obtain the proper high voltage but the flashtube doesn't flash, check *Q3* to make sure that it's oscillating at a rate of one cycle every 4 or 5 seconds. Also, check *Q4*'s orientation and the wiring to trigger transformer *T2*. If everything looks okay, you may have a defective flashtube or one not rated to flash with a 250-volt dc potential. If possible, try another flashtube.

If you don't obtain a high-voltage reading across *C3* and *C4*, the most likely cause is the *Q1/Q2* oscillator circuit. The phasing of *T1*'s 1/2/3 feedback winding may be reversed because you inadvertently wound the turns in a different direction from that of the primary. If reversing wires 1 and 3 doesn't help, reconnect the wires to their original points. Review the winding instructions given in the box to determine if you made an error in winding.

If you're satisfied that the transformer is properly wound, check the orientations of *Q1, Q2, D1* and *D2*. If possible, try two new transistors for *Q1* and *Q2*.

Mount the circuit-board assembly in a suitable enclosure. Then decide where and how to mount the flashtube to assure that it will be seen by other traffic on the road. This will require different mounting techniques for different vehicles and situations. If you're using the Safety Beacon in a vehicle whose electrical system is to power it, you'll have to run power heavy-duty stranded leads to it from a convenient tap-off point in the vehicle's electrical system. In any event, make sure that you house the flashtube so that its glass envelope is protected and that its power leads are well shielded to prevent electrical shock. **ME**