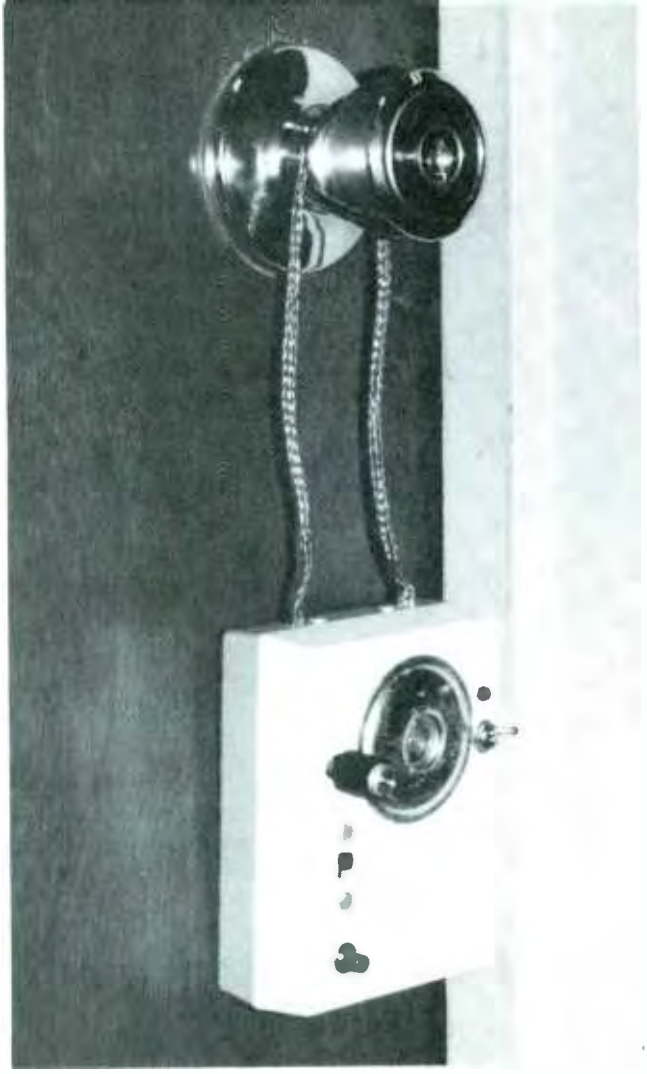


Build....

PANOPLY

Protect your person and your property with this unique device. To trigger it, all an intruder need do is touch a doorknob.

By Richard Erickson and Arthur Sheiman

THERE'S A DEVICE THAT CAN BE USED TO PROTECT BOTH your person and your privacy. Called the Panoply (after a medieval suit of armor or protective covering), the device is really a sonic panoply. It protects via an alarming panoply of sound that is emitted even before an intruder can fully penetrate the room, area, or premises. It does that by electronically sensing the presence of an intruder as he barely touches a doorknob, even if he is wearing insulating material such as gloves or boots. The Panoply is highly portable. In addition to providing protection at home, it can be transported and used on trips or at the office. Best of all, the Panoply is inexpensive; its cost to make is only about $30.

Theory of Operation

The schematic diagram of the Panoply is shown in Fig. 1. The circuit is powered by two nickel-cadmium C cells, B1 and B2, connected in series to yield about 2.5-volts. A battery charger is an important part of the device (for reasons that are described later in this article). For the values shown in the schematic diagram (Fig. 1), a suitable unit is listed in the Parts List. The recharging circuit consisting of B1, B2, R9, and jack J1 can be modified to accept chargers of different output voltages and currents.

The heart of the Panoply is the oscillator consisting of R3, R4, C3, C4, Q1, and T1 (see Fig. 1). Diodes D1 and D2 conduct on alternate half cycles. No matter which diode is conducting, C4 is effectively in parallel with C3. Capacitors C3 and C4 form a resonant circuit with the transformer T1's F3-F4 winding; the resonant frequency of the circuit is roughly 1 to 2 MHz.

Transformer T1, which is wound on a toroid, has a 3-turn primary and three secondary windings of 17 turns each. About ⅛ of the signal at the collector of Q1 is fed back to its base via the transformer coupling between the primary and the first secondary winding. The secondary of T1 works as an impedance transformer.

The signal at the collector of Q1 (Fig. 1) appears across one of the secondary windings to B+. Any impedance on the far end of the secondary appears across all three windings to B+. This results in a 9-to-1 impedance reduction; any impedance on the far end of the secondary winding appears nine times smaller to the oscillator. Resistor R4, the sensitivity-adjustment potentiometer, controls the loop gain of the oscillator circuit by controlling the gain of the transistor amplifier. The oscillator is set so that it just begins to oscillate by adjusting R4. That's the key to how the circuit works.

The door you wish to protect against intruders is connected via a copper braid to the transformer secondary. When an intruder touches the door, his capacitance to ground appears in parallel with C3 and C4, which puts the oscillator out of resonance, causing the circuit to stop oscillating.

The circuit made up of D1, D2, C5, and R5 (Fig. 1) rectifies the oscillator signal. When the unit is oscillating, the rectified signal on the base of Q2 keeps Q2 on, which keeps SCR1 from conducting. When the oscillation ceases, and after C5 discharges through R5, Q2 turns off and SCR1 conducts, turning either buzzer BZ1 or light-emitting diode LED1 on. (That depends upon the setting of S3, the mode-control switch.) The SCR1 continues to conduct until the reset switch, S2, is closed.

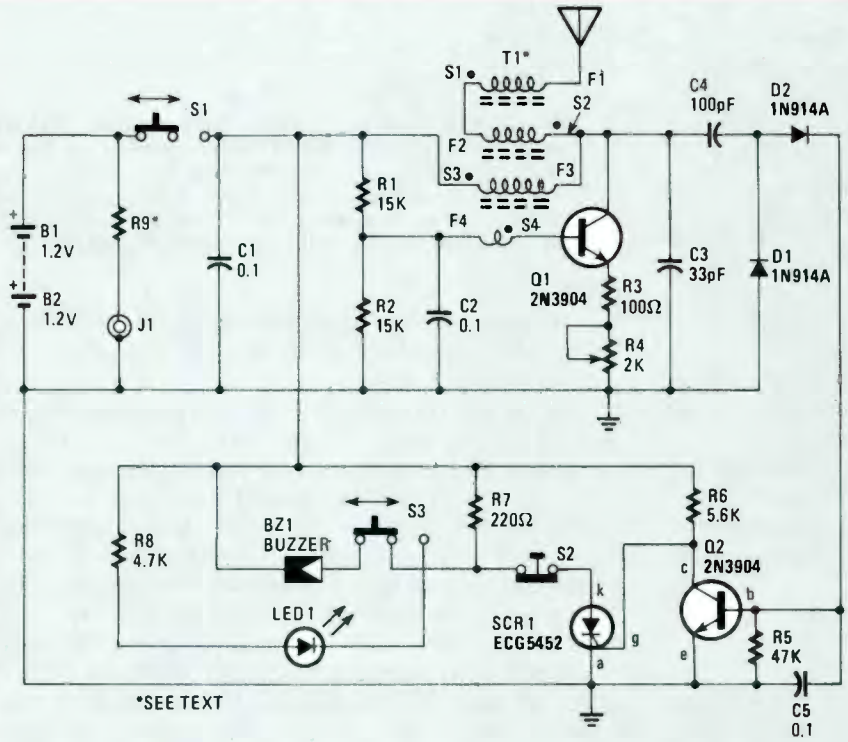


FIG. 1—SCHEMATIC DIAGRAM of the Panoply. Transformer T1 is hand wound on a toroid as described in the text. One of the three secondary windings of that transformer connects to a copper braid that is looped around a doorknob.

PARTS LIST FOR PANOPLY

SEMICONDUCTORS

D1, D2—1N914 silicon diode
LED1—Red, light-emitting diode
Q1, Q2—2N3904 transistors
SCR1—ECG 5254 silicon controlled rectifier (Sylvania)

RESISTORS

(All fixed resistors ¼-watt, 5%, units unless otherwise specified)
R1, R2—15,000-ohm
R3—100-ohm
R4—2000 to 5000-ohm, linear-taper potentiometer (Radio-Shack 271-217, or equivalent)
R5—47,000-ohm
R6—5600-ohm
R7—220-ohm
R8—4.7-ohm
R9—See text for computation details

CAPACITORS

C1, C2, C5—0.1-μF, ceramic disc
C3—33-pF, ceramic disc
C4—100-pF, ceramic disc

ADDITIONAL PARTS AND MATERIALS

B1, B2—Ni-Cd C-type rechargeable cell
BZ1—1.5-volt buzzer (Radio-Shack 273-0004, or equivalent)
J1—miniature phone jack
S1—SPST, slide switch
S2—SPST, normally-closed, momentary push-button switch
S3—SPDT, slide switch
T1—see text
Case (see text), perforated construction-board or printed-circuit materials, RG-8/U coax braid, battery recharger (Radio-Shack 273-1651, or equivalent), toroid (see text and ordering information below), magnet wire, wire, solder, etc.

If you can not obtain the toroid form it is available from the authors. Send a check for $2.00, payable to either author, and a stamped, self-addressed envelope to ERS Industries, 45-38 220 Place, Bayside, NY 11361. A completely wound T1 is also available from the authors for $5.00.

Of the remaining components in Fig. 1, C1 and C2 bypass the power supply. Switch S1 is the power switch. Resistors R1 and R2 develop the bias for Q1. Resistor R8 limits the current through the LED1. Resistor R3 limits the current through Q1. Resistor R6 limits the current through Q2 and the gate of SCR1. Resistor R7 keeps the SCR on; it is necessary if the current through the LED1 is less than the holding current of SCR1. It is also necessary if a mechanical buzzer is used, as was the case in the units the authors constructed. Mechanical buzzers interrupt themselves by repeatedly opening and closing the circuit. When closed they conduct about twice as much as their nominal current rating. When open, of course, they conduct no current at all. The buzzer used in the Panoply circuit is rated at 1.5-volts, 300 mA.

Charging Current

The standard charging current for Ni-Cd cells is about 1/10 their ampere-hour rating. In the five units the authors have built, 1.2-AH cells were used. That implies a charging current of of 120 mA. That current times the value of R9 must equal the charger output voltage minus the 2.5-volts (the battery voltage). If the Ni-Cd cells were 100 percent efficient,

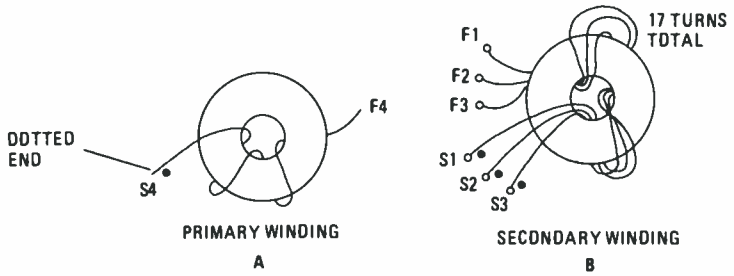


FIG. 2—THE PRIMARY and secondary windings of T1 are wound on a toroid. Details of how the primary winding is done are shown in A, of how the three secondary windings are done are shown in B, and of how the windings are interconnected is shown in Fig. 1. Ordering information for the toroid is given in the text and the Parts List.

charging time would be 10 hours (120 mA × 10 hours = 1.2 AH). However, nothing is 100 percent efficient.

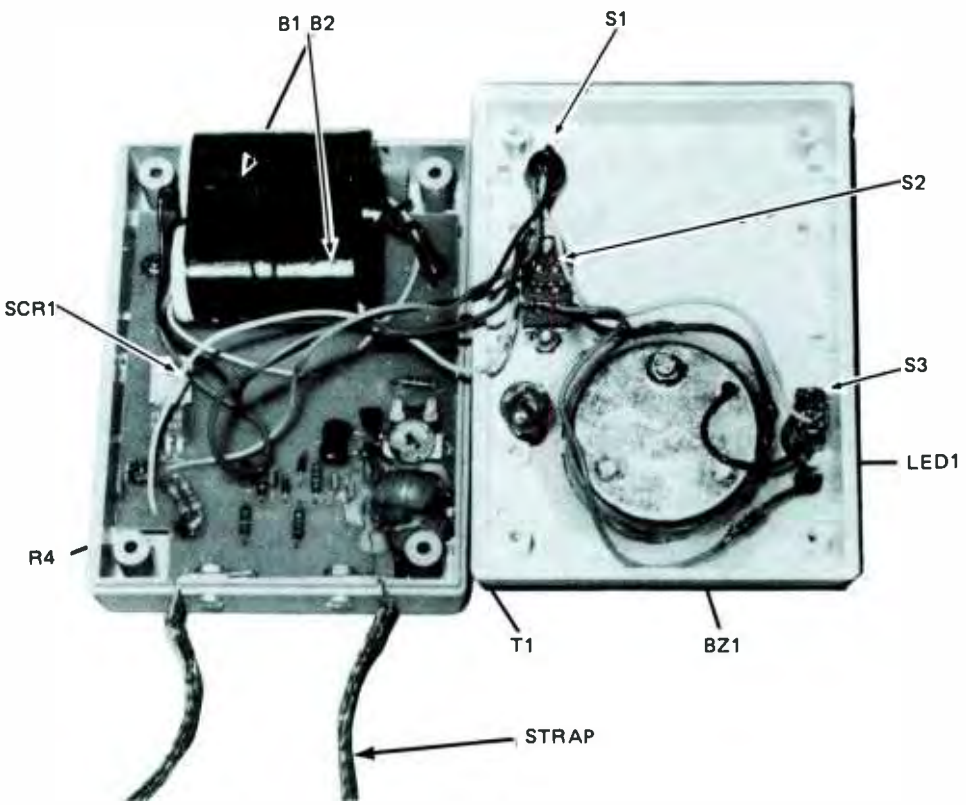
The standard *fudge factor* is 20 percent to 40 percent yielding a charging time of 12 to 14 hours. Of course, if the charger cannot output 120 mA, or if the circuit draws more than 120 mA, the charge time will vary inversely with the factor by which the charging current differs from 120 mA. Bear in mind that higher charging rates lower battery life. For that reason, charging currents are almost always kept below 33% of the ampere-hour rating.

Construction

Five Panoply's have been successfully built and installed into a Unibox 130 (GC Electronics) enclosure. That sturdy plastic case comes in five two-tone color options and measures 4.38 × 3.25 × 1.5 inches. If you use a different case, be sure that it is no smaller than the above dimensions.

The toroid for T1 is the most unusual item required. It is manufactured by Indiana General (part number F627-8-Q1) and is distributed by Permag Corporation (400 Karin Lane, Hicksville, NY 11801). If you can not obtain that item or a suitable substitute, the authors would be happy to supply it (see Parts List for ordering information). Any substitute toroid should have an initial permeability of about 100 and a maximum permeability of 400, or more, at frequencies up to at least 10 MHz.

The primary winding of T1 is wound with 24-AWG wire, while the secondary windings are wound with 28-AWG magnet wire. (If using Radio Shack magnet wire, use 26-AWG for the primary winding and 30 AWG for the secondary windings.) As shown in Fig. 2A, 3 turns are wound on the toroid for the primary winding. Note that the winding starts with the wire entering one side of the toroid and ends with the wire leaving the other side. As those familiar with the right-hand rule will realize, flux will be induced in opposite directions in the toroid depending on which end of the wire has the more positive voltage. To keep track of that difference, one of the ends is arbitrarily declared to be the *dotted end* (see Fig. 2). Next, three equal lengths of 28 AWG wire are wound side-by-side, as a group over the primary winding turns, to form 17 turns. As with the primary, the secondary-winding wires enter the toroid on one side and leave on the other (see Fig. 2-b). The side of the toroid declared the dotted end for the primary is also the dotted end for all the secondary windings. Finally, the ends of the magnet wire are carefully stripped and connected together, resulting in the transformer configuration shown in the schematic diagram in Fig. 1.



INTERIOR VIEW of the Panoply highlights the neat con struction technique of the authors. Note that the circuit is mounted on a printed-circuit board. However, perforated-construction board is perhaps more suitable for a circuit of this type and that construction technique is recommended.

It doesn't matter which of the secondary-winding wires is chosen to correspond to a particular secondary winding. When connecting the secondaries, be sure to pay careful attention to the dot convention that you have established.

If you wish to substitute for the SCR specified in the Parts List, any substitute you select should have gate threshold currents of 200 μA or less, gate turn-on voltages of 0.8 volts or less, and on-state current ratings of 4 amperes *rms*, or more.

The layout of the Panoply circuit is not critical, and because the wiring is not extensive, perforated construction-board can be used to build the circuit; that construction technique is quite reliable and even recommended for this small circuit. PC-board construction is another alternative, although the design of a suitable pattern is left to the reader's own talents and imagination. The author's unit, shown in the photos used a printed-circuit board.

THE PANOPLY and battery charging unit ready to go. The holes required to mount all cabinet-mounted components were cut in the plastic case with a hot soldering-iron tip and awl. Note the coaxial-cable braid at the top of the unit; it is looped around a doorknob to link the knob with the Panoply.

On the front panel of the completed unit (see photos) the author mounted a large buzzer BC1, LED1, reset switch S2, power switch S1, and mode-control switch S3. A sensitivity-adjustment potentiometer, R4, is also mounted on the front panel. On the bottom is jack J1. Finally, on the top is an 8-inch length of copper braid which loops around the doorknob to sense intruders.

Mounting of all the cabinet-mounted components is easiest if you own the appropriate drilling and punching tools. But even if you do not own such tools, with improvisation, the construction is still not too difficult. All holes can be made using a soldering iron and an awl. The soldering iron is used to melt large cuts and holes in the plastic; the awl is used to punch and bore smaller holes (for screws). Before melting any plastic, be sure that the work area is well ventilated, because potentially dangerous fumes may be released. Also, be aware that after the soldering iron cools, some plastic residue will be left on the tip. Either use a spare tip or be prepared to scrape the residue off with a file or sand paper.

When melting holes in the plastic with the soldering iron, a rim of hot plastic will form around the hole. If quick action is taken, that rim can be cleanly removed with needlenose pliers. Otherwise it will be necessary to file or cut away the rim when it hardens.

Holes made too large can be salvaged by mounting the component with some five-minute epoxy. Epoxy should be used in any case to bond the buzzer, BZ1, and light-emitting diode, LED1 securely to the case, and to mount the thumb-wheel potentiometer, R4.

The copper braid, which is looped around a doorknob when the unit is in use, is the shield of RG-8/U coaxial cable. The braid should be separated from the rest of the coax, cut to about 10 inches, and inserted through two small slits in the top of the enclosure. If the slits are small enough, tinning the last inch of each end of the braid will be enough to prevent it from being pulled back out of the enclosure. Otherwise the braid will have to be punched and screwed into place.

Operation

To use the unit, with the door open, the Panoply is hung on the inner doorknob of the home or room to be protected. Set the mode-control switch to select the LED1 and then turn the device on. Adjust the sensitivity-adjustment potentiometer until the slightest touch on the outer doorknob will set of the unit. Note that in this procedure, each time the unit is set off the LED1 will light and remain lit until the reset switch is pressed. Once the unit is properly adjusted, the door should be closed and the mode-control switch flipped to select the buzzer. Now, when the outer doorknob is touched, a very loud alarm will sound, alerting you to an intruder's presence.

To improve the sensitivity of the device, leave the battery recharger connected to the unit; doing that will extend the groundplane of the Panoply. It is not necessary to have the charger plugged-in to a wall outlet.

The Ni-Cd batteries that power the unit normally last about two months before requiring a recharge. To fully recharge dead batteries requires about 12 to 14 hours. The unit may be operated while the batteries are recharging.

The Panoply will function without any problems on nonmetallic doors with nonmetallic doorframes. Operation is not possible on all-metal doors, because the loading of the metalic door on the Panoply circuit completely overwhelms any loading an intruder might cause. Operation is possible with nonmetalic doors mounted in metal doorframes, although the door will require a minor modification: The plunger of the doorknob (the bolt) must be insulated from the metal doorframe. That can be done by placing a single layer of electrical tape in the cavity in the doorframe into which the bolt is inserted when the door is closed. Once that is done, the doorframe can be used as a convenient ground plane for the device. Attaching a short clip-lead from J1 to the doorframe will result in incredible sensitivity.

Construction of the Panoply is one way the electronics hobbyist can apply his unique skills to the problem of providing security in this security-conscious world. Despite the simplicity of the device it can be remarkably comforting that it is *standing guard* on trips and lonely nights! ■