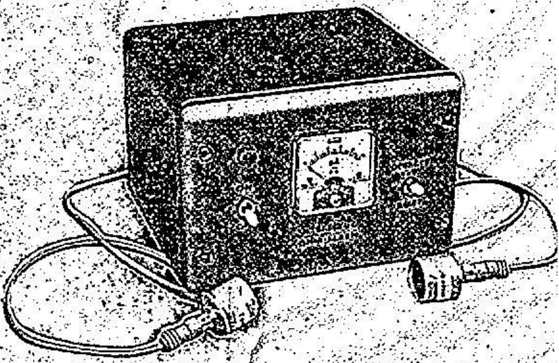
COVER STORY

BUILD THE ULTRASONIC OMNI-ALARM

Fail-safe protection... silent sound beam triggers alarm when disturbed



By DANIEL MEYER

YOU CAN'T hear it; you can't see it; you can't feel it; you can't smell it; and you can't taste it; but you can make it work for you. It really isn't mysterious; it just seems that way. What is "it"? The beam in the Ultrasonic Omni-Alarm, an all-purpose, all-sensing, always-ready alarm system. The system can be used as an intruder alarm, fire alarm, or as a counter or controller in an industrial process or production line. It can also be employed to demonstrate the use of ultrasonic sound and should make a good science project.

The alarm consists of a transmitter that broadcasts an inaudible ultrasonic beam of "sound" and a receiver on the same chassis that detects this "sound." The "sound" is a 25-kc. note, which is about 10 kc. above most people's hearing range. In many respects the system is similar to the common light source and photocell alarm system, but with several important advantages. The ultrasonic beam cannot be "fooled" with a flashlight, nor is it affected by sunlight. Ultrasonics works equally well in pitch darkness and in broad daylight.

Two transducers, one from the trans-

PARTS LIST

*C1, C5—100-µf., 15-volt electrolytic capacitor**
*C2—30-µf., 15-volt electrolytic capacitor**
*C3, C7, C9, C11—0.05-µf., 50-volt ceramic disc capacitor**
*C4—0.003-µf., 5% polystyrene capacitor**
*C6, C8, C10—0.01-µf., 50-volt ceramic disc capacitor**
*C12, C13, C14—5-µf., 15-volt electrolytic capacitor**
*D1, D2—1N34 germanium diode (or equivalent)**
*D3, D4—50-volt PIV, 750-ma. silicon rectifier**
I1—Neon pilot light with built-in resistor
*K1—Printed-circuit-type d.p.d.t. relay (Price Electric 206-14P or equivalent)**
K2, K3—Relay—see text
*L1—15- to 25-mh., variable inductor with 10% tap (DEMCO 3E-027-1)**
M1—0-15 volt d.c. voltmeter (Lafayette 99 G 5047 or equivalent)
*Q1, Q6—2N3706 transistor (Texas Instruments, or equivalent)**
*Q2, Q3, Q4, Q5—2N3708 transistor (Texas Instruments, or equivalent)**
*R1, R4, R6—470-ohm, ½-watt resistor**
*R2—47,000-ohm, ½-watt resistor**
*R3, R19—4700-ohm, ½-watt resistor**
*R5, R18—1000-ohm, ½-watt resistor**
*R7, R11, R15—100,000-ohm, ½-watt resistor**
*R8, R16—10,000-ohm, ½-watt resistor**
*R9, R13—27,000-ohm, ½-watt resistor**
*R10, R14—2200-ohm, ½-watt resistor**
*R12—10,000-ohm trimmer resistor (CTS X-201 or equivalent)**
*R17—15,000-ohm, ½-watt resistor**
R20—Resistor—see text
S1, S2—Miniature s.p.s.t. toggle switch
SO1—2-prong socket (optional)
T1—Low-voltage transformer: 110- to 120-volt primary; 20-volt CT secondary (Stancor TP-2 or equivalent)
1—Chassis (Bud CU-465 or equivalent)
*1—Circuit board (DEMCO #128)**
*2—25-kc. ultrasonic transducers (DEMCO E-25)**
Misc.—Wire, solder, nuts, bolts, connectors, spacers, etc.

NOTE: Most of the parts listed above are standard and should be available from your local dealer. If you have any difficulty in obtaining them, you can contact DEMCO, Box 16297, San Antonio, Texas 78216 for the following: a kit of all the parts marked with an asterisk for $20; an etched and drilled fiberglass circuit board like that shown in the photo for $3.50; any of the parts used—price list available from DEMCO on request.

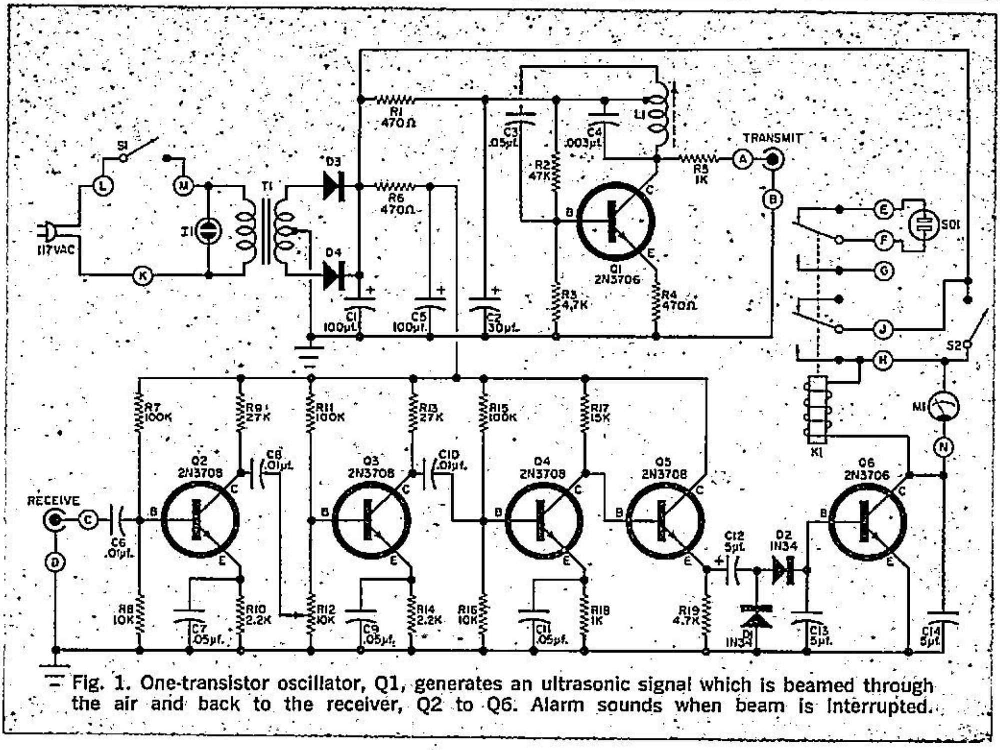


Fig. 1. One-transistor oscillator, Q1, generates an ultrasonic signal which is beamed through the air and back to the receiver, Q2 to Q6. Alarm sounds when beam is interrupted.

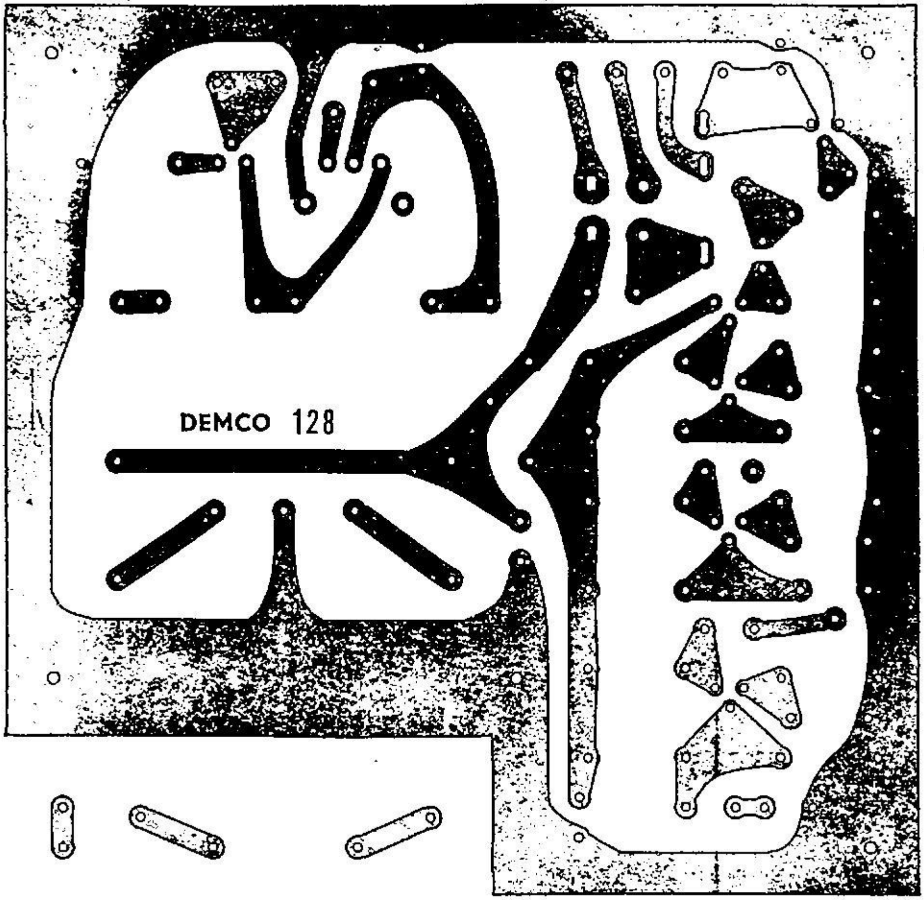


Fig. 2. Actual size photo of conductor side of printed circuit board. Components can be mounted on any type of chassis, but care should be exercised to prevent stray leakage, or coupling.

mitter and one from the receiver, can be placed up to 50 feet apart to protect a large area. Any interruption of the beam causes an alarm. Even a fire in the area between the transducers can create enough air turbulence to set off the system.

How It Works. The transmitter portion is nothing more than a single transistor oscillator circuit (*Q1*) which directly drives the output transducer connected to terminals *A* and *B* (Fig. 1). Coil *L1* and capacitor *C4* make up a resonant tank tuned to 25 kc. Feedback from the coil to the base of *Q1* through *C3* helps sustain the oscillations. Resistor *R8* isolates the transducer from the tuned circuit and prevents variations in the transducer and its cable capacitance from affecting oscillator operation too much.

The receiver, consisting of transistor circuits *Q2* through *Q6*, picks up the signal from the input transducer, amplifies it, and energizes relay *K1*. Transistors *Q3* and *Q4* are conventional common emitter amplifier stages. Potentiometer *R12* acts as a level and sensitivity control. Transistor *Q5* is used as an emitter follower and provides the low output impedance needed to drive the half-wave voltage-doubler rectifier consisting of *D1*, *D2*, *C12* and *C13*. The resulting d.c. voltage is used to turn *Q6* "on." Transistor *Q6* drives the alarm relay.

The circuit is arranged so that the relay is held in at all times when there is a signal present. A drop or absence of signal causes the relay to open, and the

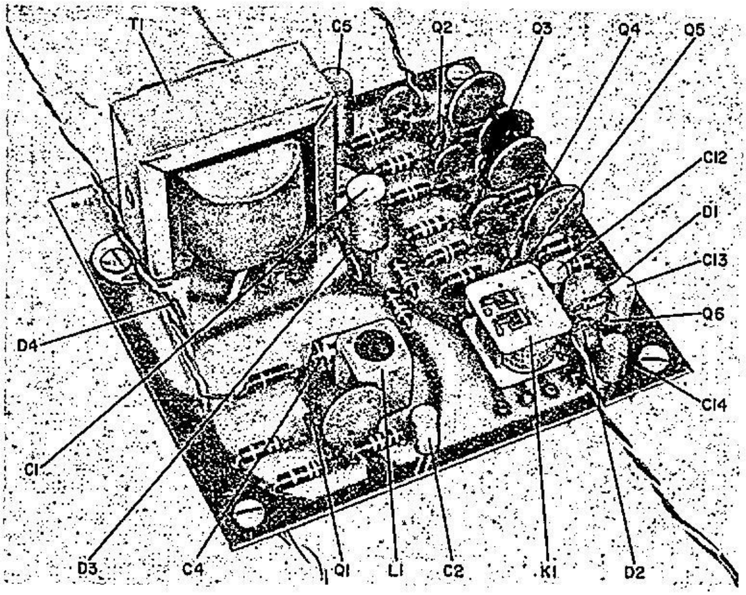


Fig. 3. No attempt at conserving space is made. Relatively large open areas reduce undesirable coupling between transmitter and receiver. Component location on the board is easy to determine, but the callouts sprinkled around the photo may give you more confidence as you drop in each part. Be sure to observe polarity of diodes and electrolytics.

alarm to sound, or a counter to operate, etc. This is a type of "fail safe" operation, in that a defect in the system, power failure, transducer failure, circuit failure, etc., will cause the alarm to sound. The circuit is compromised if the same power source is used to activate the external alarm. However, this condition can be easily remedied, as described in the installation instructions.

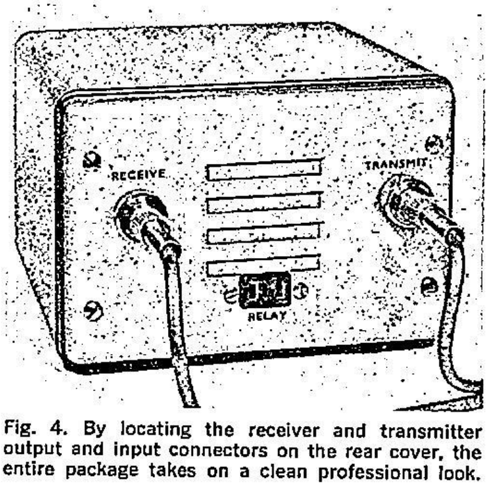


Fig. 4. By locating the receiver and transmitter output and input connectors on the rear cover, the entire package takes on a clean professional look.

Switch *S2* must be placed in the *Reset* position (closed) before the system will operate. With the switch in this position, the relay will kick in and out every time the sound beam is on and then broken. For counting or other activities requiring self-resetting, the switch should be left in the *Reset* position. But for alarm purposes, the switch should be

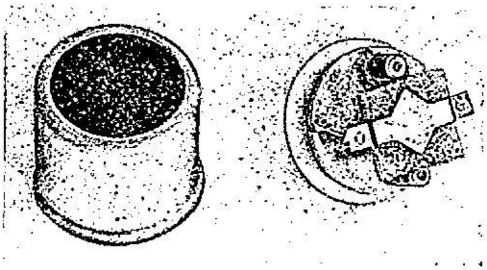


Fig. 5. If vibration of hardware in the transmitting transducer creates an audible sound, carefully open case and insert small piece of foam plastic.

placed in the *Reset* position only long enough for the relay to kick in.

Once the relay is "on," move the switch to the *Operate* position; relay contacts *J* and *H* will continue to complete the relay circuit and hold the relay "on" until the beam is interrupted. When the beam is broken, the relay opens. The relay will not close even if the beam is restored, and the alarm will sound continuously until the switch is manually

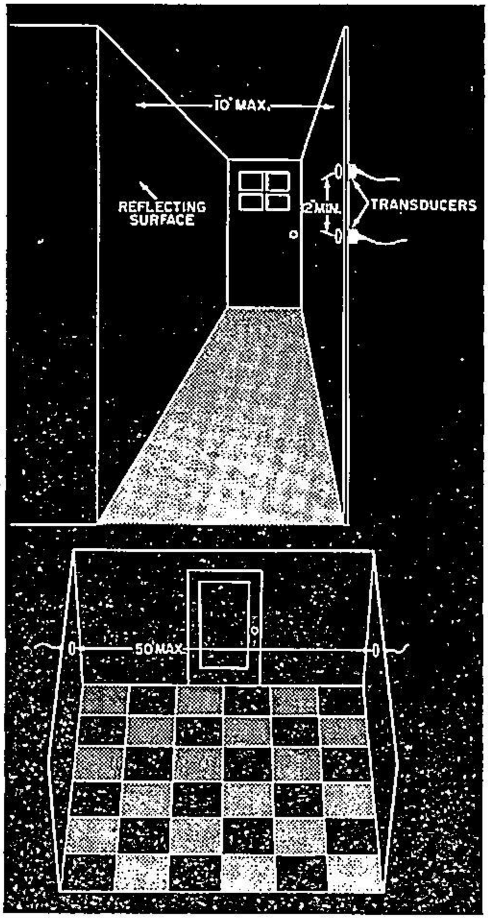


Fig. 6. To cover a narrow passageway, both transducers can be mounted on the same wall; for a wider area, up to 50', the direct-path technique is used.

placed in the *Reset* position once again.

Power for the transmitter and receiver is derived from the 117-volt line, stepped down by *T1*, rectified by *D3* and *D4*, and filtered by *C1*, *R6*, and *C5*, and by *R1* and *C2*. Actually, any 12-volt d.c. supply, able to deliver about 50 ma. of current will do. Batteries can also be used.

Construction. Although an etched and drilled circuit board is available, you can make your own board, using the actual size photo (Fig. 2) as a guide, or mount the parts in any manner more convenient for you. If you do change the layout, avoid stray coupling between the transmitter and receiver sections, but in any event observe polarity of electrolytic capacitors and diodes.

After all the parts are mounted on the circuit board, connect wires to points *A* through *M*. These should be about 8 inches long. Twist together leads *A* and *B*; *C* and *D*; *E*, *F* and *G*; *K*, *L* and *M*; and *J*, *H* and *N*.

Mount the switches and meter on the front panel, and the transducer connectors and alarm connector on the back panel, as shown in the photos. Use shielded microphone cable and appropriate connectors for the transducers. For a 50-foot spread, each cable need be only 25 feet long. A phono plug connects the transducer to the cable. Any type of cabinet can be used to house the circuit.

Adjustment. Mount the transducers about 20 feet apart. Turn the sensitivity control fully clockwise (viewed from the knob side) and turn on the power. Place S2 in the *Reset* position and advance gain control *R12*. As the control is turned counterclockwise, the meter reading should increase; and at approximately 8 volts, the relay should be heard to click in. If the relay does not close—or if the reading doesn't reach 10 volts—at the full counterclockwise position of the gain control, the slug in *L1* should be adjusted.

Use a nonmetallic alignment tool to turn the slug about halfway into the coil form. Now slowly turn the slug out of the form and watch the meter reading. When the reading reaches 10 volts, reduce sensitivity and keep adjusting until a peak or maximum reading is obtained. Turn the alarm *off* and back *on* to be sure that the adjustment is stable. If the meter reading does not return to the same place or is zero, tune for the second highest reading.

If you find that the best transmitter adjustment causes the transmitting transducer to make audible sounds, damp the transducer. The high drive level can cause the crystal or internal parts of the transducer to "sing" at an audible frequency. Carefully open the transducer case by straightening the crimped edge on the back of the transducer to remove the cover. Then carefully insert a piece of foam plastic (not rubber) under the crystal as shown in Fig. 5. The pad should be approximately 3/8" square by

(*Continued on page* 82)

ULTRASONIC OMNI-ALARM

(*Continued from page* 45)

1/16" thick. Replace the cover and seal the seam with rubber cement to prevent the transducer case from rattling.

If everything seems to be in working order, set the sensitivity control to obtain a 10-volt reading and have someone take a walk to break the path between the transducers. The meter reading should drop to zero and the relay should drop out.

Installation. You can mount the transducers for direct or for reflected beam operation as shown in Fig. 6. Direct-type operation is more effective over greater distances. With the reflected-type setup, both transducers can be mounted on the same wall to cover hallways and small rooms. Do not use more cable than necessary for the receiving transducer; the longer the cable, the more capacitance it has; and the greater the capacitance, the greater the loss in signal to the receiver. If the system is to be used as an intruder alarm, mount the transducers high enough and in such a way that a cat or a dog will not break the beam and cause a false alarm—unless you would like to know about the uninvited four-legged visitor.

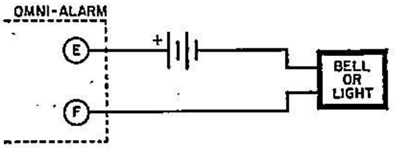


Fig. 7. Simple alarm circuit can be compromised by cutting one of the wires. Use of a battery causes the alarm to sound in the event of a power failure.

Keep the beam as far away from heating or air conditioning ducts as possible. Although this system will tolerate some air motion, violent or turbulent motion can set it off. The Omni-Alarm cannot normally be used outside, especially in a windy place—the "sound" beam can be blown away enough to cause the alarm to trip.

Any type of alarm device that can be activated by a switching action can be connected to the relay contacts. Perhaps the simplest arrangement is that of a bell or light connected to points *E* and *F* as shown in Fig. 7. But while this hookup will work fine, it can be put out of commission simply by cutting the wires.

If you want to make the installation tamperproof, you can enclose the external alarm and its circuitry in a locked steel box, mounted high above ground level. The alarm will sound if an intruder breaks the beam, cuts or shorts the wires, or if there is a power failure. Two identical relays are used as shown in Fig. 8.

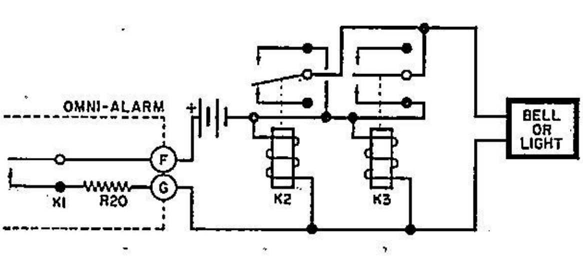


Fig. 8. Fail-safe external alarm system will cause an alert if the wires are cut or shorted, if the battery is weak, or if the power line should fail.

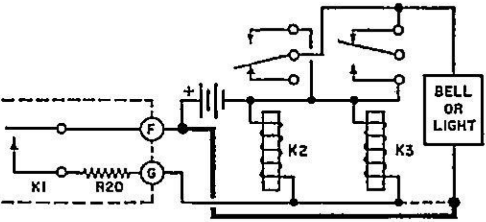
All relays have a higher pull-in than drop-out current, and you can take advantage of this characteristic. Resistor *R20*, installed in the alarm control unit, is selected to allow a small current to flow through *K2* and *K3*, which is too small to pull in the relays, but large enough to hold them in. Set the alarm and manually close the contacts of *K2*. Now, if anyone cuts the wires or breaks the beam to open *K1*, *K2* will open and sound the alarm. If someone shorts the wires, *R20* is bypassed and *K2* closes, and sounds the alarm.

If you want to be real "mean," you can put a Microswitch in the bottom of the case. Then the alarm will sound if the case is picked up. An added safety feature inherent in this type of circuit is that the alarm will sound when the batteries approach their end life.

To obtain pinpoint control in a production line setup, you can insert one or both of the transducers into one end of a 1"-diameter plastic tube. This reduces the range. Distances of one to three feet can be monitored without feedback problems. —30—

CIRCUIT NOT FAIL-SAFE

Your fail-safe external alarm system ("Ultrasonic Omni-Alarm," April, 1966") fails to ring a bell, or I fail to see the light. If *K1* in Fig. 1 of the article opens, or if wires *F* and *G* (Fig. 8) are cut but not shorted together, there is no possible current path to the bell or the light. To make the circuit work as described, I removed the wire indicated by the



dashed line in the drawing, and I connected the jumper wire indicated by the heavy solid line.

A1C R.D. NOTARI
McConnell AFB, Kan.

Good catch, R.D.. The alarm cannot sound—or the lamp light—if points F and G are opened as in the original schematic drawing. Your slight modification rectifies the problem nicely.

Build Your Own Ultrasonic Burglar Alarm

By HERB COHEN

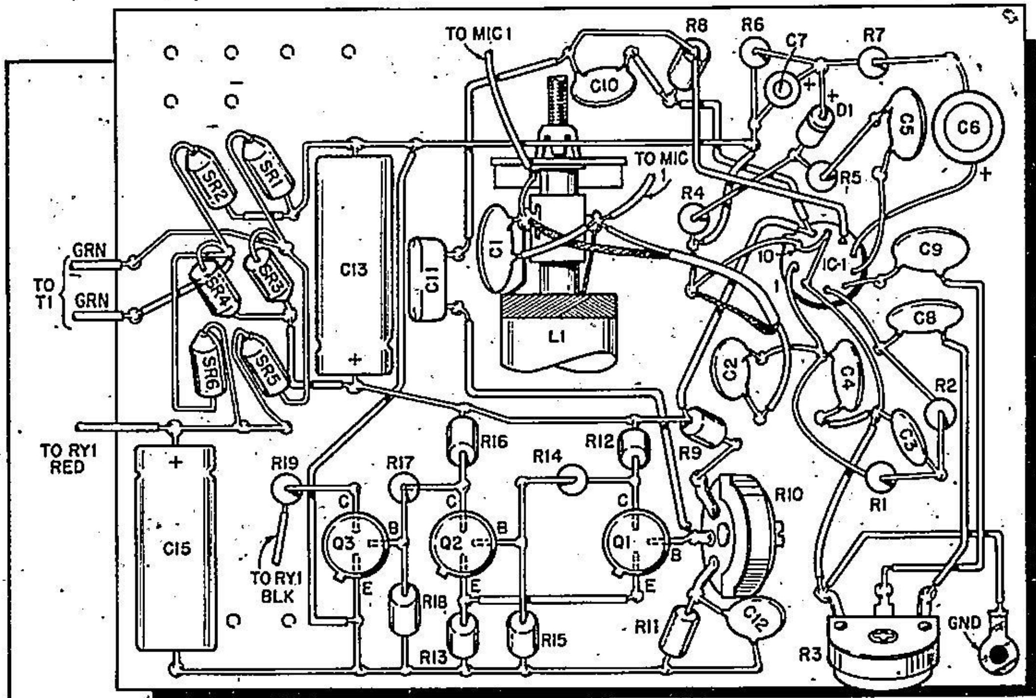
IT'S after midnight. The house is quiet. But trouble is lurking in the shadows. A burglar hiding in the shrubbery approaches a window and starts to open it. He looks carefully for switches, wire strung across the window sill and light beams. Not finding them, he starts to enter. The instant he sticks his hand inside an alarm goes off to alert you of the danger.

Inside a store a shoplifter hides during the day. After the store has closed he leaves his lair and starts for the jewelry counter. As soon as he moves an alarm goes off outside to summon the police.

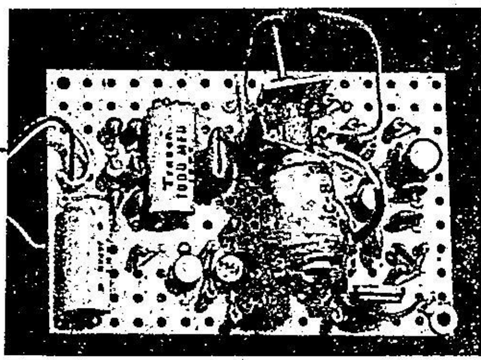
In your office a prowler intent on cracking the wall safe looks for the usual light beams, switches on the door jamb and wire strung across the room. Not seeing them he heads toward the safe. As he moves towards it an alarm goes off.

What is it that detects the person in each of these situations? It's an invisible spider web of silent sound coming from our ultrasonic burglar alarm system and it fills the room. Our alarm also can be used as a proximity detector or even a fire alarm.

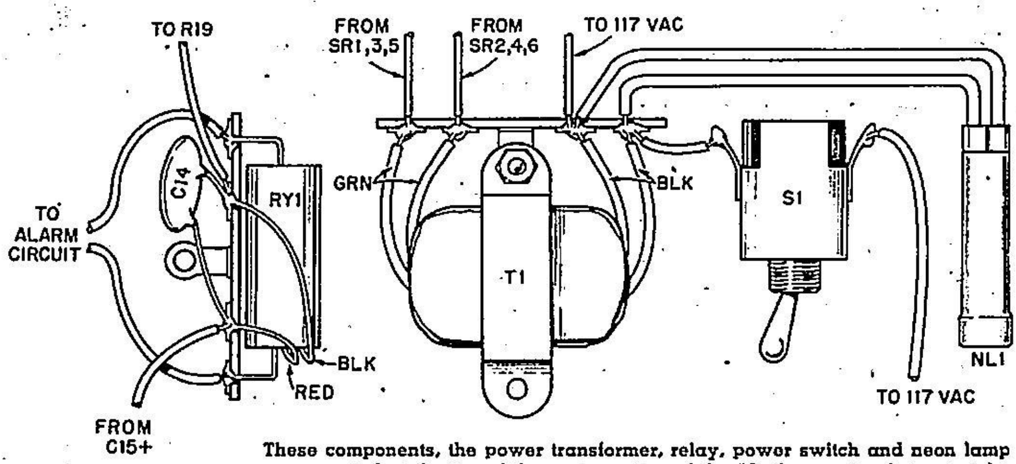
The system consists of a transmitter and a receiver. The transmitter sends out an ultrasonic sound which fills the room. Waves reflected by the walls, ceiling, floor and ob-



Receiver circuit board is 4 x 5 in. To conserve space, we mounted resistors on end rather than flat. In pictorial we show wiring on top of board; however, as you can see in photo below, wiring in our model is on rear of board.



Build Your Own Ultrasonic Burglar Alarm



These components, the power transformer, relay, power switch and neon lamp are mounted at the top of the main section of the Minibox as in photo at right.

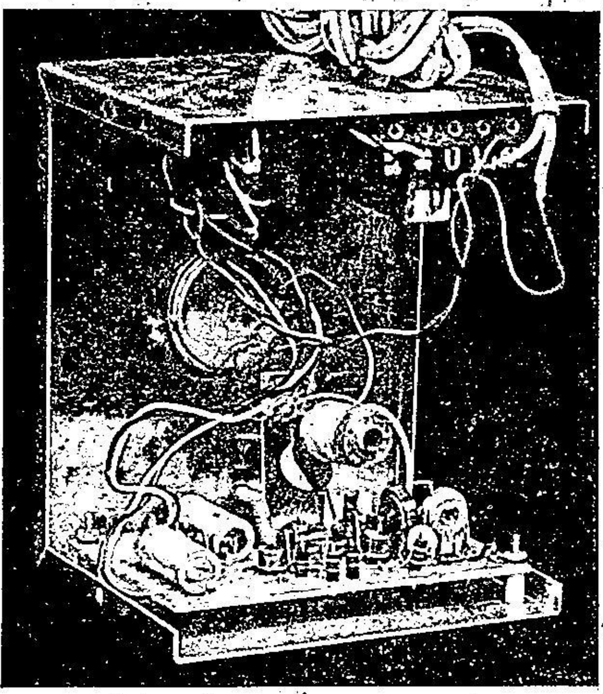
jects are picked up by the receiver. Any phase or amplitude change in the reflection of the wave appears to the receiver as an amplitude modulation of the signal.

The receiver amplifies the signal and then demodulates it. A Schmitt trigger shapes the demodulated signal and feeds it to a relay driver amplifier, which actuates a small reed relay.

The alarm is sensitive enough to detect the air turbulence that is caused by fire. Connect an oscilloscope to the third-amplifier output (pin 7) of the IC, and you'll be able to see the effect of normal air currents in a perfectly quiet room. The receiver can cover a 120° arc and is sensitive enough to pick up an intruder at a 20-ft. distance.

How the System Works

The transmitter sends out a 17-kc ultrasonic signal which will saturate a small room. The receiver picks up not only the direct signal from the transmitter, but the waves that are reflected by walls, ceiling and other objects in the room. The many waves which have traveled different distances, have different phase relationships at the receiver. The receiver's microphone algebraically adds the amplitude and phase relationships of all the waves and produces a signal which the receiver sees as a single reflected wave.



Rear view of receiver. Note how circuit board is mounted with ¼-in. spacers. Transformer and relay are installed in top of cabinet away from coil L1.

If an object in the room moves, its reflected wave, as seen by the receiver, will change in amplitude and phase. The amplitude change depends on the position of the object in relation to the receiver and transmitter. The phase change depends on the speed of the object and the wavelength of the transmitted signal.

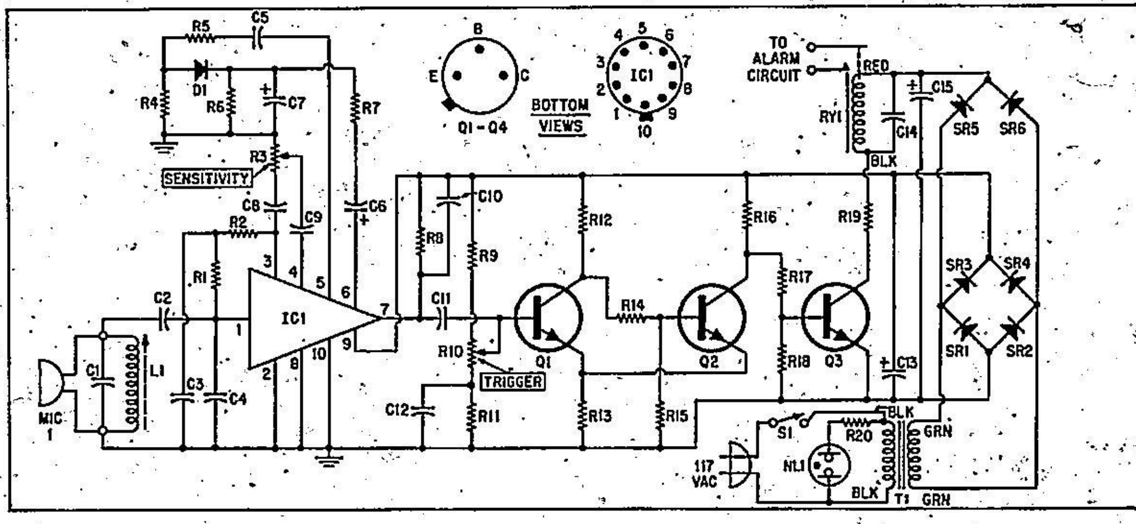
Since the wavelength of a 17-kc signal is about 0.8 in. an object moving at several feet-per-second toward the receiver, will cause phase reversals in its reflected wave at a rate of 30 to 50 cps. These phase reversals will alternately add to and subtract from the total received signal and appear to modulate the signal at a low audio rate.

Crystal mike MIC1 is tuned to 17 kc by L1 and C1. Capacitor C2 feeds the input signal to the first amplifier of IC1. The signal is amplified and the output at pin 3 goes to *sensitivity* pot R3. This pot determines the level of the signal which is sent to the second amplifier input at pin 4.

The output of the second amplifier is demodulated by D1. It is then filtered by C3, which also attenuates the high frequencies and noise in the modulation envelope. The third amplifier in the integrated circuit is used as a straight amplifier for the demodulated signal. The signal is then fed to the Schmitt trigger (Q1, Q2). Capacitors C4 and C10 are RF bypass capacitors. Potentiometer R10 is a trigger-level pot for the Schmitt trigger.

The Schmitt trigger, which is a regenerative switch, converts the demodulated signal into square waves which feed relay-driver Q3 and relay RY1. Relay RY1 is a reed relay which is used to control an external relay. It has a contact rating of 500 ma. An ordinary relay mounted in the same cabinet as MIC1 will, on closing, cause acoustic feedback and send the system into oscillation. The reed relay's contact closing is almost inaudible.

The transmitter is a standard emitter-coupled oscillator which is powered by a 9-V transistor-radio battery. Crystal microphone MIC2 is connected across the tank circuit. The efficiency of the oscillator and the transducer are so high that the battery drain is only 1.5 ma. This enables the battery to operate the transmitter continuously for one week without replacement.



Output of IC1 is fed to Schmitt trigger (Q1,Q2) which converts demodulated signal into square waves that feed relay-driver transistor Q3. Q3 energizes reed relay RY1 which is used to control an external relay.

Build Your Own Ultrasonic Burglar Alarm

The transmitter can also be powered from the receiver power supply. Connect two wires across C15 and run them to the transmitter. At the transmitter install a decoupling network consisting of a 200-ohm resistor and a 200-μf capacitor.

Construction

The receiver was constructed on perforated circuit board and eyelets were used for mounting parts. This method proved much cheaper and quicker than using a home-brew printed-circuit board.

The CA3035 integrated circuit should be mounted in a 10-pin socket so you don't have to solder directly to the IC's leads. Transistor leads can be pushed through the eyelets and soldered. However, do not push the transistors flush to the board or the eyelets will short to the transistor case. Let the transistors sit about ⅛ in. above the board.

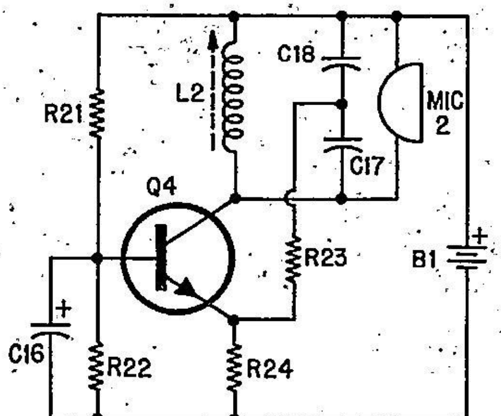
The circuitry layout is not critical, but try to duplicate ours. However, the position of L1 may be a bit touchy. Inductor L1 should be placed well away from the power transformer or it will pick up hum. Mount the microphones in the cabinets in 1⅜-in. dia. punched holes. Epoxy cement can be used to hold the mikes in place. The power-transformer secondary has a center-tap lead which is not used. It should be cut short and taped so it will not touch the cabinet.

Five-lug terminal strips, with center lug mounting, were used for the AC terminals and the relay connections. The relay itself is mounted by its contact leads. This means they should not be slack or the relay will have a tendency to vibrate when the contacts close and cause acoustic feedback.

Adjustments

To start with, turn on the receiver but disconnect the 9-V battery from the transmitter. Turn R3 counterclockwise for minimum sensitivity. Now turn R10 so that the relay closes. Back off on R10 so that the relay

Transmitter is emitter-coupled oscillator whose ultrasonic frequency is determined by L2. MIC2 is crystal mike. It works well as ultrasonic speaker.



PARTS LIST

B1—9 V battery
Capacitors: 50 V or higher unless otherwise indicated
C1,C17—.01 µf, ceramic disc
C2,C3,C5,C8,C9,C10,C14—.04 µf ceramic disc
C4—.005 µf ceramic disc
C6—100 µf, 6-V electrolytic
C7,C16—5 µf, 6-V electrolytic
C11—.25 µf ceramic disc
C12—.002 µf, ceramic disc
C13,C15—1,000 µf, 10-V electrolytic
C18—.1 µf ceramic disc
D1—1N34A diode
IC1—CA3035 integrated circuit (RCA)
L1,L2—1.5-10 mh adjustable width coil (J. W. Miller 6322, Lafayette 34 T 8852)
MIC1, MIC2—Crystal-microphone cartridge (Lafayette 99 T 4509)
NL1—NE-2 neon lamp and holder
Q1,Q2,Q3—2N696 transistor
Q4—2N2270 transistor
Resistors: ½ watt, 10% unless otherwise indicated
R1,R2,R20—100,000 ohms
R3—2,000 ohm linear-taper potentiometer (Mallory Minitrol MTC-23L1, Lafayette 33 T 1645 or equiv.)
R4,R5—5,600 ohms, 5%
R6,R14,R21—10,000 ohms, 5%
R7—680 ohms
R8,R16—3,000 ohms, 5%
R9—62,000 ohms, 5%
R10—5,000 ohm, linear-taper potentiometer (Mallory Minitrol MTC-53L1, Lafayette 33 T 1647 or equiv.)
R11—6,800 ohms
R12—5,000 ohms, 5%
R13—330 ohms
R15—2,700 ohms
R17—2,200 ohms, 5%
R18,R22—1,000 ohms, 5%
R19,R24—100 ohms
R23—510 ohms, 5%
RY1—SPST (normally-open contacts) miniature (1 in. long x 7/16 in. dia.) reed relay. Coil: 250 ohms, 40 ma. Available for $4.95 (postage included) from Round Hill Associates, Inc., 325 Hudson St., New York, N.Y.
S1—SPST switch
SR1-SR6—Silicon rectifier; minimum ratings: 750 ma, 50 PIV
T1—Filament transformer, secondary 6.3 V @ 0.6A
Misc.—Perforated circuit board, flea clips, 5 x 2¼ x 2¼-in. Minibox, 6 x 5 x 4-in. Minibox, integrated-circuit socket (Cinch-Jones 10-ICS)

opens again. The Schmitt trigger is now set just below its threshold. If RY1 closes unpredictably, back off on R10 a bit until the relay is just into its stable *off* position.

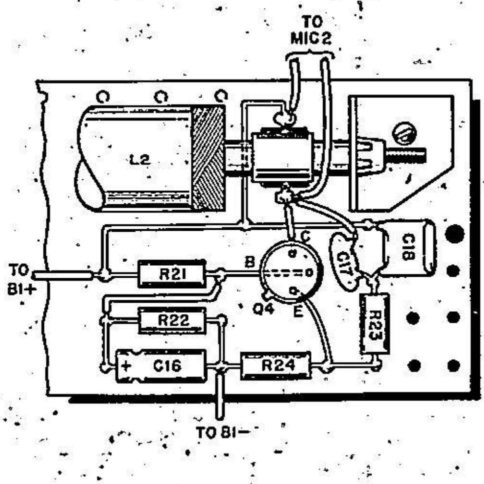
Next, connect a scope from pin 5 of IC1 to ground and slowly turn R3 clockwise toward maximum. If oscillation breaks out connect a 200-ohm resistor across R3. If the 200-ohm resistor does not stop the oscillation, back off on R3 until the oscillation stops. Now connect the scope to the junction of R5/C5 and ground. The transmitter should be about 10 ft. from the receiver. Fire up the transmitter and observe the pattern on the scope. Next, adjust the core of L2 on the transmitter until the pitch of the sound is beyond the range of your hearing. To our ears the frequency was about 17 kc. If the waveform is saturated (flattened at the top and bottom) back off on R3 until the waveform is clean. Now adjust L1 for maximum signal and back off on R3 if the signal saturates.

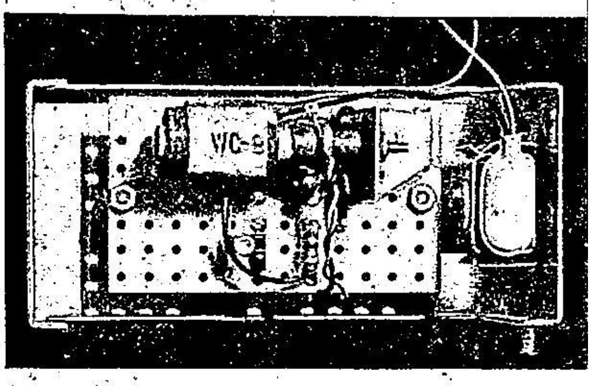
A final adjustment should be made with the transmitter in its more-or-less permanent location. If used to detect the opening of a door, the transmitter should face the door and be about 4 ft. from the receiver.

The receiver should also face the door, and all final adjustments should be made from the rear of the receiver, so as not to block the mike. Adjust R3 so that the waveform is saturated. Now back off on R3 until the peak-to-peak signal voltage is half the saturated voltage.

[*Continued on page* 113]

Layout of transmitter's parts on 2 x 3-in. piece of perforated board is not critical. Bracket holding L2 is made from a piece of scrap aluminum.





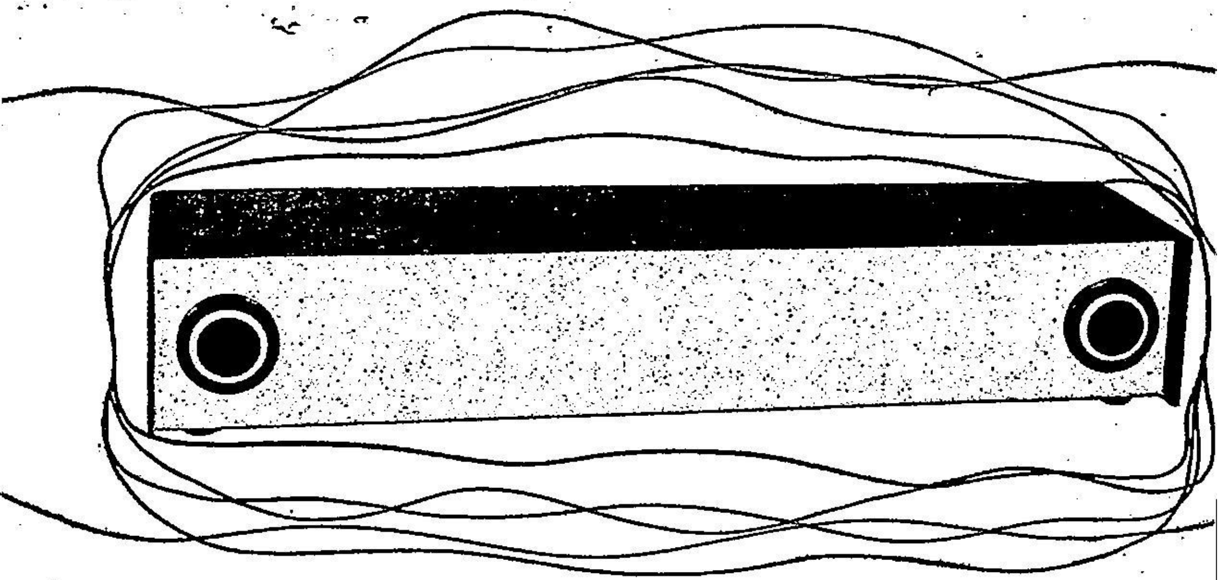
Transmitter. Parts placement differs a bit from that in pictorial, but it isn't important. Mount board in main section of Minibox with ¼-in. spacers.

Ultrasonic Burglar Alarm

Continued from page 89

You're now ready for the final test. Stand in front of the receiver about 5-ft. away from it. Now walk toward the receiver. The relay should close. You may have to experiment with the placement of the receiver and the adjustment of R3 and R10 for maximum sensitivity and stability. Relay RY1 should only be used to actuate an external relay, which can operate a bell or any other alarm device.

Keep in mind that spurious responses could be caused by a slowly moving curtain, the movement of a rattling window pane, or the noise of a steam valve.



ONE-STEP Motion Detector

*Ne plus ultra*sonic intruder alarm

BY DANIEL MEYER

IT WOULD TAKE all ten fingers—and maybe a couple of toes—to count the various types of intruder alarm systems that can be leased, purchased, or home-built. None, however, is better than an ultrasonic system of the type used in areas of tight military security. The "One-Step Motion Detector" described here is such a system. When you have the One-Step for protection, it is not necessary for the intruder to break a wire or tape or even touch anything to set off the alarm—and there are no visible or invisible light beams to be broken. All the intruder has to do is take one step into the protected area and his very presence disturbs the ultrasonic field to actuate the alarm circuit.

Built around integrated circuits to reduce cost and construction complexity, the One-Step generates a signal with a frequency of 40 kHz (far above the limit of human hearing) and aims it at the area to be protected. (The area covered is in the shape of a 50° cone fanning out from the detector to a distance of about 15 feet.) The receiver portion of the detector uses the 40-kHz output as a reference and compares it with the frequency reflected from the protected area. If there is no movement in the area, there is no difference between the radiated frequency and the reflected frequency, and no alarm is given. If the two do not agree, the receiver actuates the alarm circuit.

Besides detecting intruders, the One-Step can be used for other alarm purposes. Since the air turbulence caused by flames is sufficient to create a Doppler shift, you can use One-Step as a fire detector. A wild-life photographer can use the device and let the alarm signal trip a camera shutter and photoflash. One-Step can also be used to activate a counter to indicate the passage of objects or to open a door as a person or object approaches. You can even use it to detect rodents or other small animals.

Any type electrical or electronic alarm

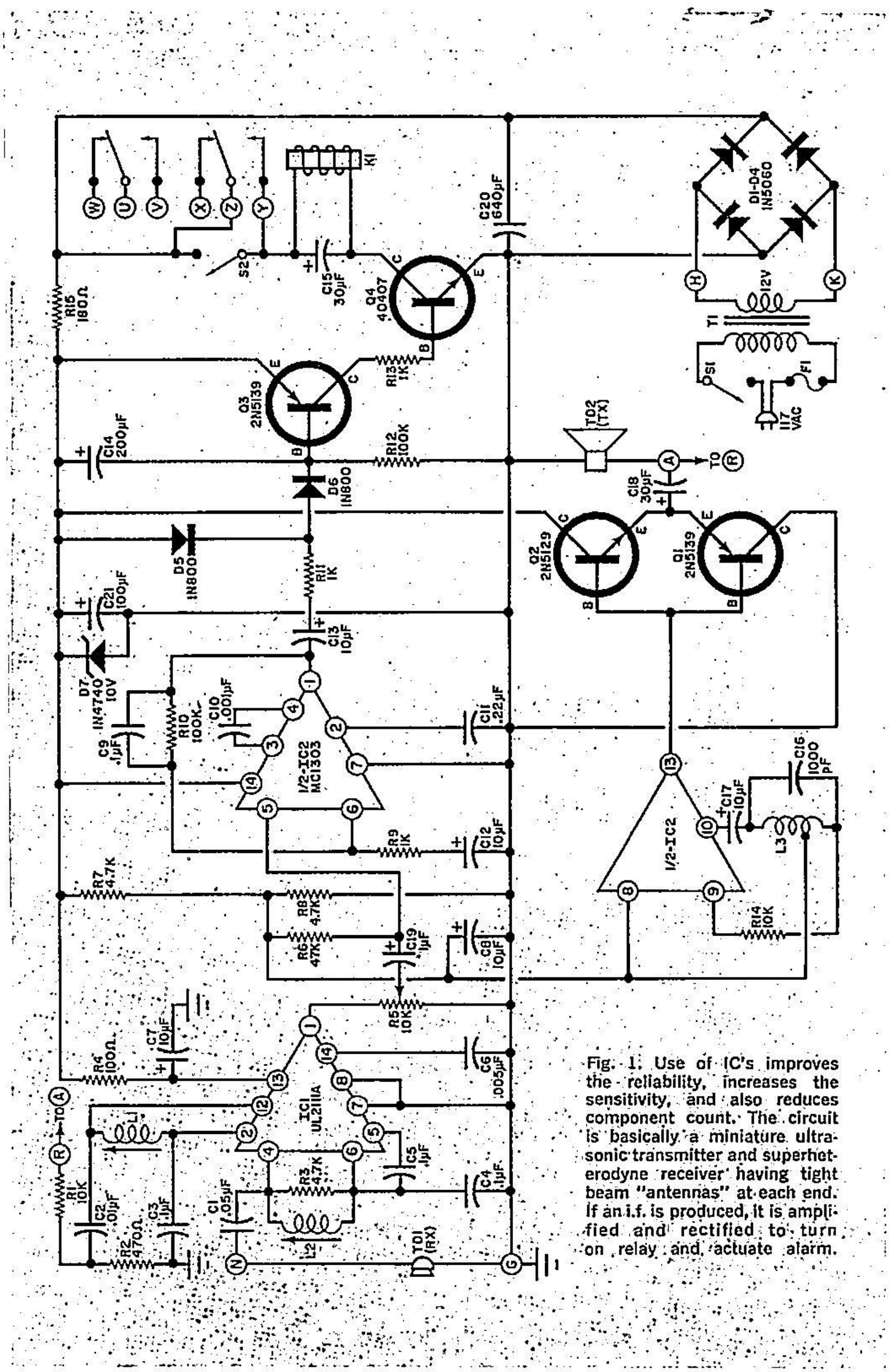


Fig. 1. Use of IC's improves the reliability, increases the sensitivity, and also reduces component count. The circuit is basically a miniature ultrasonic transmitter and superheterodyne receiver having tight beam "antennas" at each end. If an i.f. is produced, it is amplified and rectified to turn on relay and actuate alarm.

circuit can be used with One-Step. The external circuit is controlled by normally open or normally closed 1-ampere contacts on the relay in the detector.

Construction. Most of the circuitry of the One-Step (see Fig. 1) is contained in two integrated circuits so construction of the device is much simpler than if discrete components were used throughout. To further simplify construction, make or buy the printed circuit board whose foil pattern is shown in Fig. 2. Mount the components on the board as shown in Fig. 3. Use a 35-to-50-watt soldering iron, 60/40 alloy resin-flux solder, and take care in soldering.

The detector shown in the photos was built in a U-shaped metal enclosure 13" × 2½" × 2½", though any type of enclosure will do. Drill holes at each end of the channel for *TD1* and *TD2*. With the transducers in place, mount transformer *T1*, fuseholder for *F1* and an outlet for the connection to the external alarm circuit at one end of the chassis. Drill another hole for the power cord. Put a grommet in the hole before installing the cord.

Mount the printed circuit board on four insulated standoffs. Make a pair of transducer connectors by using twisted pairs with conventional phono plugs at the ends. Connect the board to the external components.

If you want to have a remote reset, connect a s.p.s.t. switch (*S2*) to terminals Y and Z. For automatic reset, connect a jumper between these two

ANIMALS AND ULTRASONICS

In most commercial installations of ultrasonic alarm systems, the ultrasonic generator is left on all the time and only the alarm circuit is de-activated when detection is not desired. This may not be such a good idea around the home or anywhere pets are considered. While humans cannot hear the 40-kHz signal, animals can; and, although it affects different animals in different ways, it's best to keep it turned off when not in use to avoid discomfort to them. Remember also that, when you are using the detector, it can be activated by animals, causing false alarms. In fact, they may be attracted to it.

PARTS LIST

C1—0.05-µF capacitor
C2—0.01-µF capacitor
C3,C4,C5,C9—0.1-µF capacitor
C6—0.005-µF capacitor
C7,C8,C12,C13,C17—10-µF, 15-volt electrolytic capacitor
C10—0.001-µF capacitor
C11—0.22-µF capacitor
C14—200-µF, 6-volt electrolytic capacitor
C15,C18—30-µF, 15-volt electrolytic capacitor
C16—1000-pF polystyrene capacitor
C19—1-µF, 50-volt electrolytic capacitor
C20—640-µF, 25-volt electrolytic capacitor
C21—100-µF, 15-volt electrolytic capacitor
D1-D4—1N5060, 1-ampere diode
*D5,D6—1N800, silicon diode (General Electric)**
D7—1N4740, 10-volt, 1-watt zener diode
F1—1-ampere fuse and holder
*IC1—Integrated circuit (Sprague ULN2111A)**
*IC2—Integrated circuit (Motorola MC1303)**
K1—D.p.d.t. relay, 12-volt, 300-ohm coil, 1-ampere contact rating (Price Electric 22E121-FF or similar)
*L1-L3—15-20-mH coil (Wee Coil Inc. 387-2000 or similar)**
Q1,Q3—Transistor (National Semiconductor 2N5139)
Q2—Transistor (National Semiconductor 2N-5129)
Q4—Transistor (RCA 40407)
R1,R14—10,000-ohm
R2—470-ohm
R3,R7,R8—4700-ohm
R4—100-ohm
R6—47,000-ohm
R9,R11,R13—1000-ohm
R10,R12—100,000-ohm
R15—180-ohm
(*All resistors ½-watt*)
R5—10,000-ohm printed-circuit potentiometer
S1,S2—S.p.s.t. switch (S2 optional)
T1—Filament transformer, secondary 12 volts 2 amperes (Stancor P-8130 or similar)
TD1,TD2—40-kHz transducer (Massa MK-109 or similar)
Misc.—Spacers (4), transducer connectors (2), line cord, mounting hardware, etc.
Note—An etched and drilled printed circuit board for $3.50 and a complete kit of parts including punched chassis for $37.25 are available from Southwest Technical Products Corp., 219 W. Rhapsody, San Antonio, TX 78216.
**Also available from Southwest Technical Products are: DHD-800 diode (20¢); 15-20-mH coil ($2); ULN2111A integrated circuit ($2); MC1303 integrated circuit ($5.25); 40-kHz transducer ($4). These prices are for single units.*

WHAT IS DOPPLER SHIFT?

Doppler shift is a change in the observed frequency of a train of waves (acoustical or electromagnetic) caused by the relative motion of either the source, the medium through which the wavetrain passes, or the observer. The most common example of Doppler shift occurs when the sound of a train's whistle is higher in frequency as the train approaches and lower as it passes.

Doppler shift is the principle used in police radar systems to measure the speed of vehicles. It is also used to measure the relative velocity of stars and the rotational speed of planets or satellites. Certain types of military radar systems also operate on the Doppler principle.

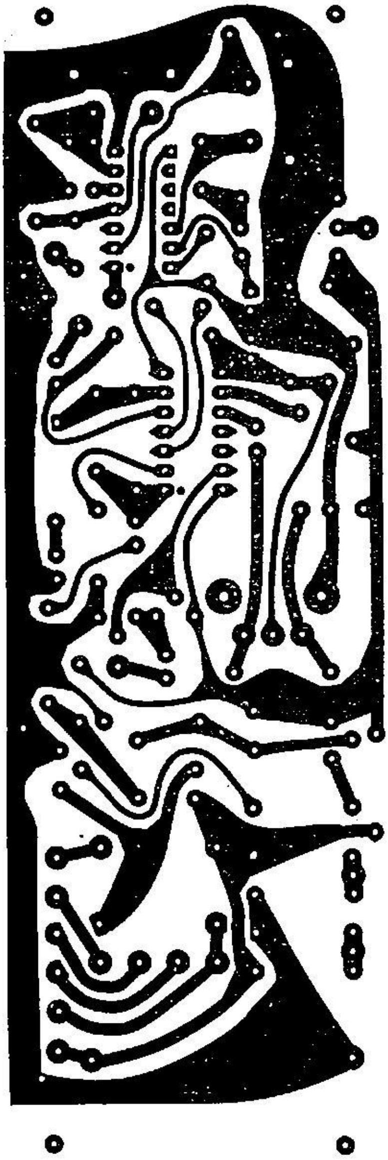
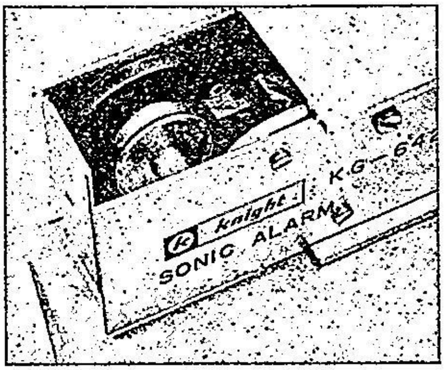


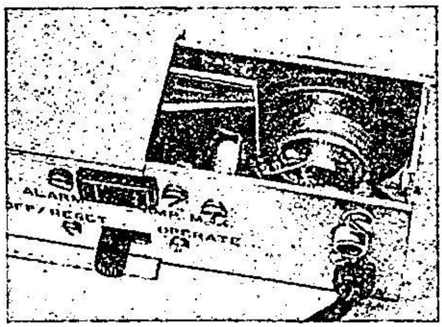
Fig. 2. Actual size printed circuit foil pattern for ultrasonic alarm. Due to circuit complexity, the use of a foil pattern prevents wiring errors.

OTHER ULTRASONIC ALARMS

Ultrasonic alarms are getting popular. Besides the several commercial versions, the Knight/James Kit KG-642 Sonic Intrusion Alarm (Allied Radio, $69.95) is also available. The unit measures 2" x 2" x 12" and operates at a frequency of 40 kHz, covering an area of 100 square feet (10' x 10'). Using 10 discrete transistors and an SCR, the KG-642 has provisions for 12-volt operation and will switch on an external alarm of up to 117 volts at five amperes using its internal relay. The two transducers are positioned at each of the long front face while all operating controls and a switched power outlet are at the rear.



The kit goes together with relative ease (case is extruded aluminum) and operation is quite good within the protected area.



Still another ultrasonic alarm, the Delt-Alert (Delta Products, Inc.) will be described next month in The Product Gallery.

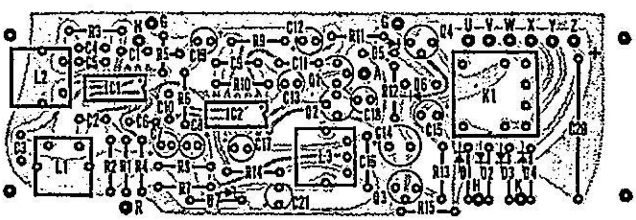
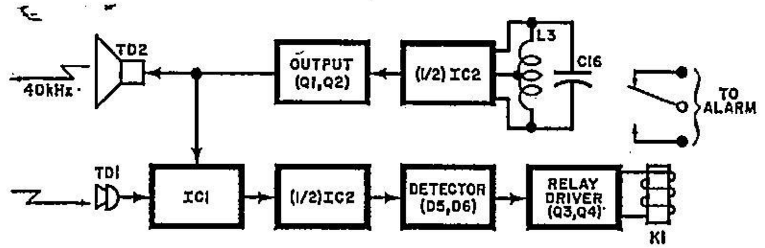


Fig. 3. When installing components, be sure that the diodes, IC's, and electrolytic capacitors are installed correctly.



HOW IT WORKS

The transmitter portion (at the top of the diagram) consists of a 40-kHz ultrasonic oscillator, formed by half of *IC2* and tuned circuit *L3-C16*, and a complementary emitter follower, *Q1* and *Q2*. The output drives ultrasonic transducer *TD2*. The beam from *TD2* is cone-shaped, about 50 degrees wide.

The receiver portion of the One-Step has two inputs: one is the 40-kHz signal generated in the transmitter and the other is the observed frequency (Doppler shifted or not) existing in the area covered, and picked up by *TD1* (which also has a 50-degree pattern of coverage). In integrated circuit *IC1*, the detected (observed frequency) signal is amplified and mixed with the 40-kHz reference from the transmitter. As long as the two frequencies are identical, there is no output from *IC1*. However, if there is any motion within the protected area, the signal picked up by *TD1* is Doppler shifted from the reference. The difference produces a beat frequency which is a function of the rate of change of the target motion. The output of *IC1* is a low-frequency audio signal, usually between 10 and 50 Hz.

The output of *IC1* is applied to level control potentiometer *R5* and then to the second half of *IC2*, where it is amplified. The gain of this amplifier is determined by the ratio between resistors *R9* and *R10* and its frequency response is determined by *C9*, *C10*, and *C12*.

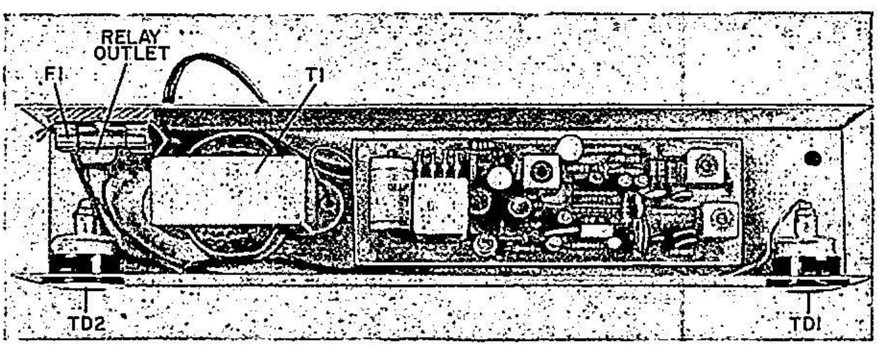
The amplified low-frequency signal, present only when there is motion in the protected area, is rectified by *D5* and *D6*. Capacitor *C14* then integrates the signal, thus making it necessary for the motion to continue for a second or so before the signal is high enough to operate the relay driver circuit (*Q3* and *Q4*). This helps to suppress false signals due to line-voltage variations, or random air motion within the protected area. The relay is normally energized so that any attempt to disable the system by cutting the power will cause the alarm to sound. The second pole of the relay may be used to activate an external alarm. The load is restricted only by the current-carrying capacity of the relay contacts. The built-in power supply can handle one ampere at 12 volts d.c. to an external load. The power supply is a conventional full-wave bridge rectifier with capacitor-input filtering. Zener diode *D7* stabilizes the amplifier circuit and prevents supply loading and line-voltage variations from affecting circuit operation.

terminals. The isolated relay contacts (at board terminals U, V, and W) are connected to the external outlet. Make sure that a jumper is connected between terminals A and R to provide the receiver with the reference signal.

Place a metal cover, suitably painted or covered with contact material, over the completed chassis.

Installation. Since the transmit and receive transducers have 50-degree cones of usefulness, they must be "aimed" to achieve the best results. The sensitivity of the detector decreases with distance and air movement. Obviously, the larger the area to be included, the more important it is to avoid air currents from heat-

(*Continued on page* 104)



The prototype One-Step was constructed within a long slim metal cabinet. The transducers should be a foot or so apart and arranged so that the beams overlap to cover protected area.

MOTION DETECTOR

(*Continued from page* 61)

ing and cooling ducts or heavy drafts around doors. Final location depends on the area and what you want to detect.

Once a location has been determined, connect the detector to the alarm circuit and apply power to the system. Set the gain control (*R5*) so that the external alarm is energized when a person takes about two steps into the protected area *at the maximum range*. If you make the system too sensitive, false alarms may result from slight air motions.

The external alarm circuit is activated for the amount of time that is required for *C14* to discharge. A small air disturbance in the area covered produces a short alarm signal. A longer disturbance produces a longer alarm. The amount of time the alarm is on can be reduced by lowering the value of *R12*—at the expense of some sensitivity. —30—

OUT OF TUNE

"One-Step Motion Detector" (March 1970). The following information on testing the unit was inadvertently omitted from the article: The slugs in *L1* and *L2* should be flush with the top of the cans. Coil *L3* slug is set about ⅛" in from the top. Temporarily connect a 1000-ohm resistor between point A and the center of the transmitter phono plug. Connect an a.c. voltmeter (or scope) between the transducer side of this resistor and ground. Adjust *L3* slug with a non-metallic tuning tool until a dip is noticed on the readout. Remove the resistor and reconnect the lead. Coils *L1* and *L2* are used as r.f. chokes.

SOURCE FOR DUAL OP AMP

The address of the supplier in the U. S. A., of the TBA231 dual op amp (*IC1* in my article "Listen to a New World of Sounds with Ultrasonic Detector," July 1978) has been changed to SG-ATES Semiconductor Corp., 79 Massasoit St., Waltham, MA 02154; Tel: 617-891-3710. Note also that the Fairchild μA739 can be used. —*Brian Dance.*