ELECTRONIC PEST CONTROL

ULTRASONICS FORCES RODENTS AND INSECTS TO DEPART FOR QUIETER SURROUNDINGS

BY LYMAN GREENLEE

MANY experiments have been conducted by various schools and commercial enterprises to determine the effect of ultrasonics on insects, rodents, birds, and other small animals. Unlike chemical poisons that kill unwanted pests but also may be harmful to household pets and humans, low-intensity ultrasonics does not kill and leaves no undesirable contaminants.

One Japanese manufacturer is marketing an ultrasonic device for rodent (rat) control which is claimed to have an effective area of more than 225 square yards. The 19.5-kHz, 15-watt ultrasonic signal makes life so uncomfortable for the rodents that they leave to look for more peaceful surroundings. Experiments have shown that ultrasonic radiation is effective on insect pests (including mosquitoes) as well as rodents.

There are still many things to be learned about the use of ultrasonics. Among them are: the best frequency to be used; whether to use pulses (if so, what rate) or a continuous tone; whether the ultrasonic signal should be on all the time or for some period each day; how much power is needed for effective control; what is the effective range per watt of audio output; and finally, and most important, the effect on human beings exposed to the ultrasonic energy. It may be in this area that danger lies.

The ultrasonic pest control system described here provides a good starting point for experimentation in this new area of non-chemical control. Essentially, the output of an ultrasonic square-wave generator is amplified and fed through a gating circuit to drive a power amplifier, which supplies the speakers. Experiments have shown that a square wave is more effective in insect control than a sine wave (probably because of the harmonic content) and that in some cases, a pulsed circuit is more effective than a continuous wave. The power amplifier should be capable of putting out 15 to 20 watts of usable power in the ultrasonic region. In the prototype, the author used the "Li'l Tiger" amplifier described in the December 1967 issue of POPULAR ELECTRONICS. However, any good hi-fi amplifier with the proper high-frequency characteristics may be used. The selection of the speakers is very important. With ultrasonics, it is easy to burn out the speaker. Each speaker called for in the Parts List will safely handle up to 5 watts of ultrasonic energy—even that may be too much in hot weather or with inadequate ventilation. (It might be a good idea to put a 1 or 1.5 ampere fuse in the circuit to prevent burnout.)

Generator and Timing. The circuit shown in Fig. 1 includes the ultrasonic square-wave generator, the timing circuits, and the required IC power supply. Integrated circuit *IC1* is a dual two-input gate wired to form a square-wave generator. The frequency is determined by the coupling capacitors, *C1* and

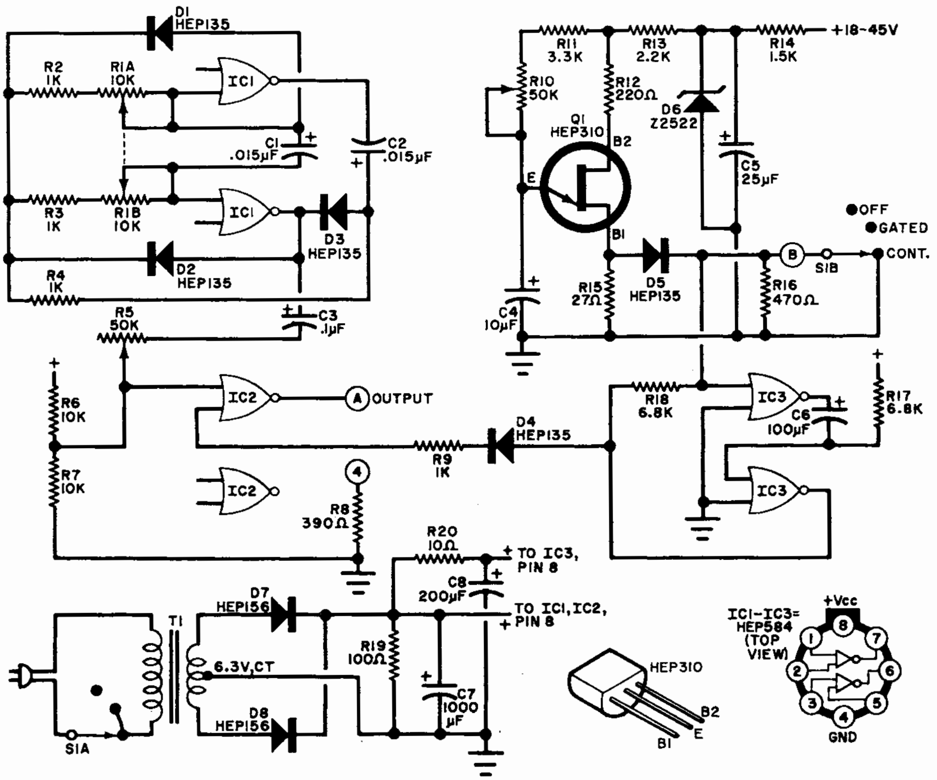


Fig. 1. Oscillator circuit offers choice of gated or continuous operation.

PARTS LIST

C1,C2—0.015-µF, 100-volt Mylar capacitor
C3—0.1-µF, 100-volt Mylar capacitor
C4—10-µF, 25-volt electrolytic capacitor
C5—25-µF, 50-volt electrolytic capacitor
C6—100-µF, 3-volt electrolytic capacitor
C7—1000-µF, 6-volt electrolytic capacitor
C8—200-µF, 15-volt electrolytic capacitor
D1-D5—HEP135 diode
D6—HEPZ2522 zener diode (18V, 1W)
D7,D8—HEP156 diode (1A, 100V)
IC1-IC3—Dual two-input gate (HEP584 or µL914)
Q1—HEP310 unijunction transistor
R1A,R1B—Dual 10,000-ohm potentiometer
R2-R4,R9—1000-ohm resistor
R5—50,000-ohm, PC-type potentiometer
R6,R7—10,000-ohm resistor
R8—390-ohm resistor
R10—50,000-ohm, PC-type potentiometer
R11—3300-ohm resistor
R12—220-ohm resistor
R13—2200-ohm resistor
R14—1500-ohm, 1-watt resistor
R15—27-ohm resistor
R16—470-ohm resistor
R17,R18—6800-ohm resistor
R19—100-ohm, 1-watt resistor
R20—10-ohm resistor
S1—2-pole, 3-position rotary switch
T1—Filament transformer; secondary: 6.3-VCT at 1.2A
Misc.—Circuit board, press terminals, multi-lug terminal strips, suitable chassis, mounting hardware, optional 117-volt indicator lamp, knobs, handle, line cord, etc.
Note—A kit of components is available from Negeye Engineering Labs., Box 1036, Anderson, IN 46016, for $29.75 (plus $2 for postage to Alaska, Hawaii, or Canada). Order Bugshoo Kit 1 Timing Components.

C2, in conjunction with the ganged frequency control potentiometers, *R1A* and *R1B*. Using the component values shown, the range will be about 4 kHz to 60 kHz. The output of *IC1* is applied to half of *IC2*, which is used as both a preamplifier and a disabling gate. Potentiometer *R5* is a gain control preset to the value required to drive the power amplifier. The second input to *IC2* is a gating signal from *R9*. When the latter is positive, the two-input gate is disabled and the output is blocked.

The gating signal is derived from a unijunction relaxation oscillator (*Q1*) whose

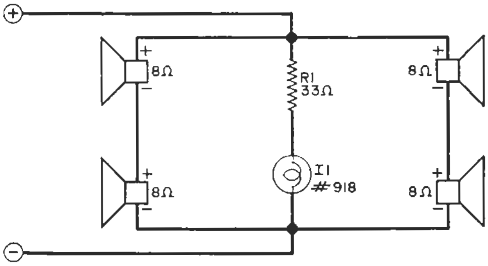


Fig. 2. Four 8-ohm speakers must be wired as shown to provide 8-ohm load.

PARTS LIST

Speaker—Olson Electronics S-846, 2⅜" tweeter Jensen, Model TE-40 "Sono-Dome" Allied Radio Shack, Ultra-Tweeter University MS Supertweeter or T-203W Sphericon Tweeter
R1—33-ohm, ½-watt resistor
I1—Indicator lamp, 12V, 0.035mA (Sylvania 918)
Note—A kit of four special speakers is available for $24 from Negeye Engineering Labs., Box 1036, Anderson, IN 46015. Order Bugshoo Kit 3, Speakers.

period is determined by *R10*, the pulse rate control. When the positive going pulse across *R15* is fed to the *IC3* timing gate (wired as a monostable), the gate cuts off until *C6* discharges. Repetition rate with the values shown is 1 to 10 pps.

The conventional low-voltage supply provides power only for the IC's, while the UJT power comes from an external power amplifier. The ultrasonic audio output (gated or continuous, depending on the setting of *S1*) is available at point A.

Construction. Either a printed circuit or a perf board can be used for the project. If a perf board is used, the IC's are mounted on push-insert terminals and the UJT should have a socket. Potentiometers *R5* and *R10* are of the PC type and should be fixed to the board. Other than the IC power supply, components are wired point-to-point using terminals where required. The mounting of components in the prototype is shown in the photograph.

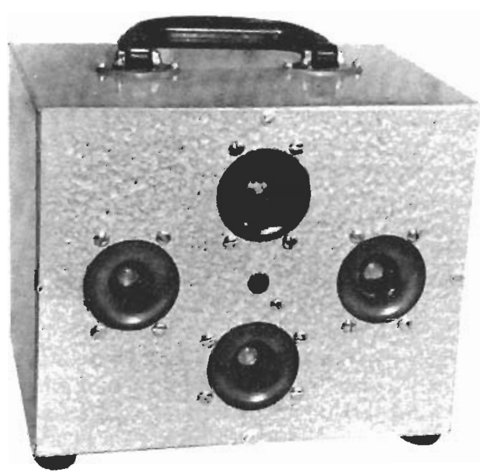
The two power supplies (one for the IC's and one for the power amplifier) are built up on multi-lug terminal strips on the U-shaped chassis. The voltage-regulating network for the UJT, consisting of *R14, R13, D6,* and *C5* is also built up on a multi-lug terminal strip.

The four tweeter speakers are mounted in suitable holes on the rear panel of the main chassis. As each speaker has an impedance of 8 ohms, the four are wired as shown in Fig. 2, to provide an 8-ohm load for the amplifier. Be sure that the speakers are wired in phase as shown.

The indicator lamp in the speaker circuit provides a visual indication when the speakers are working because they cannot be heard on the high-frequency range. The speakers can be mounted in a cluster as shown or separated to cover four small areas. Because of the high frequencies involved only a very small baffle is required.

Why use four speakers? Tests show that the four speakers produce three times as much acoustical output as one speaker with the same drive to the amplifier. It was also found that a single speaker could not carry the full output without burning up after a few minutes.

Adjustment and Use. Test the power amplifier and speaker system by feeding an appropriate audio signal into the amplifier and running the test generator frequency up from the audible range to about 30 kHz. If convenient, monitor the output at the ultrasonic frequencies by using a scope or VTVM. Otherwise, you must assume that, if the audio system seems to be working properly through the audio range, it is working at the ultrasonic frequencies. Disregard any distortion you may see on the scope waveform.



Arrange drivers as shown for best dispersion and maximum acoustical output.

Now connect the generator and gating board output (point A) and the ground to the power amplifier. With power applied to the board and with *S1* set to "continuous"

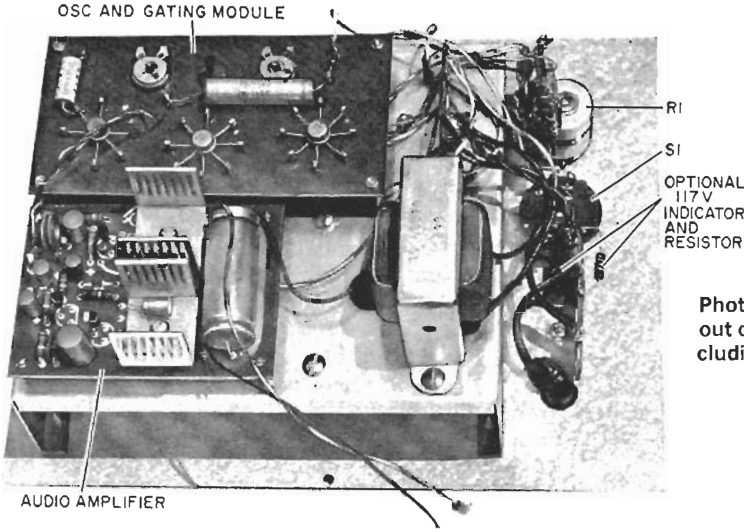


Photo shows typical layout of subassemblies, including audio amplifier.

output, adjust *R5* for the output required to drive the power amplifier properly. (With the Li'l Tiger, this is about 1.5 volts rms.) Place *S1* in the gated position and adjust *R10* for the desired trigger timing. Shut down the system as soon as you think you have the correct pulsing rate.

To prevent speaker burnout at the ultrasonic frequencies, adjust R5 for a maximum of 10 volts across the speaker coils, when the line voltage (nominally 117 volts) is at its daily maximum. (Remember that line voltage can be greater than 117-volts at some time of the day or night.) Another protection technique is to use a one-ampere slow-blow fuse in series with the speakers. If the fuse blows, lower the amplifier input level via R5.

Do not listen to the output for long periods of time—even though you think you are hearing only a series of clicks. The system is emitting a relatively powerful burst of ultrasonic energy which may be harmful to your hearing or nervous system. The main beam from the speakers should be aimed only where the pests are expected to be. Be sure that you are not just aiming at some suspected pests and that the beam is not going past that area and reaching people or household pets farther away.

To test the system on rodents, start with some controlled experiments by selecting a place where the rats or mice are known to run. Put out some bait to get them to come in numbers. After they know where the food is and are used to coming for a free meal, aim the speaker cluster at the food and turn on the device. Note the effect on the remainder of the bait the next time around. You may have to adjust the frequency or the rep rate to arrive at the maximum repulsion.

In any ultrasonic control device, the frequency and timing are very important. Different pests respond to different frequencies; and while many rodents respond to frequencies of 10 kHz or more, some insects require up to 25 kHz for maximum effect. Little is known about the pulse rate, so you will have to experiment. Mosquitoes, for example, are repelled by ultrasonic energy; but they are attracted by a humming sound at about 2 kHz.

Since 25 kHz is about the top for speaker efficiency, put a mechanical stop on the dual frequency control (*R1*) at this point.

To test the system on mosquitoes or bugs, let the device operate outside for an hour or so before you go out. Then turn it off before you go out. It may take some experimenting (with both frequency and pulse rate) to find out just what the ultrasonic system will do.

Remember. Though you may not hear anything from the system but a series of clicks, powerful bursts of ultrasonic energy are being transmitted. This energy can cause annoyance to acoustically sensitive people—even though they are a considerable distance away. Also remember that many household pets, particularly dogs, may have strong reactions if they wander into the ultrasonic beam area. ◈

Note: *The author reserves all rights to any patentable features of this device.*

A Bug Trap You Can Make

By PETER F. DEXTER

Do night-flying insects bug your outdoor activities? This trap can make your patio, porch, or yard more livable this summer. Attracted by the bluish light, insects are sucked into the bag and trapped by a small fan mounted under the lamp. Cost of operation is around five cents a day with average electric rates, or about half that if you use the optional photocell control.

How to build it. The motor can be any small 10-20 watt, 120-volt AC motor that runs at 1,500-3,000 rpm. An old phonograph motor works well. Such motors are also available from electronics suppliers—like Olson Electronics (Akron, Ohio) and Burnstein-Applebee (Kansas City, Mo.).

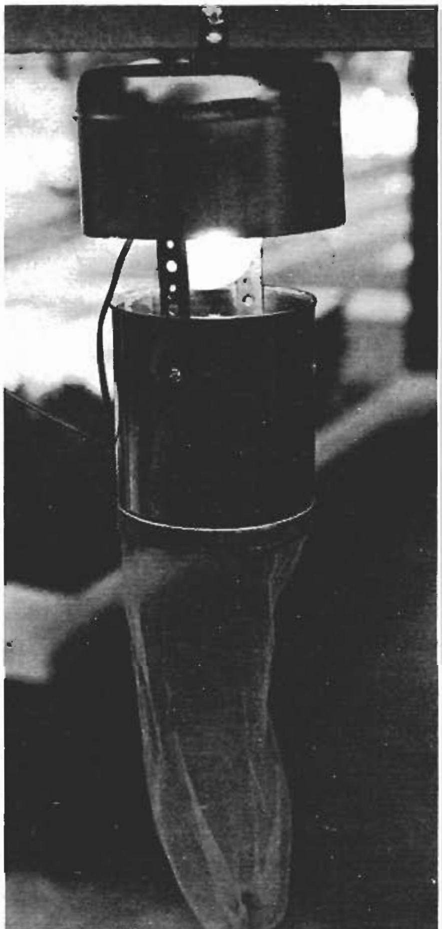
Cut a two-blade propeller from thin, flat aluminum or tin-can stock measuring ¾" by 4½". Drill an appropriate hole for the motor shaft and attach to the shaft using glue and a faucet washer on each side.

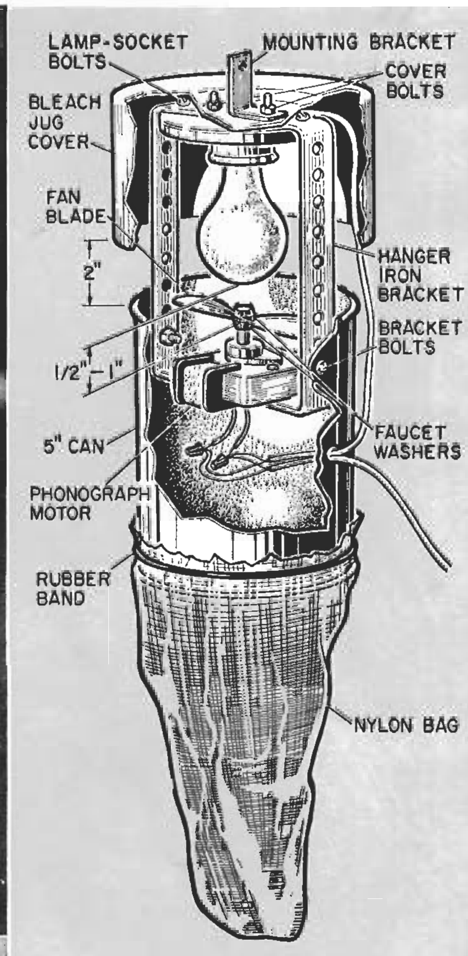
Form the motor and lamp-support bracket from perforated pipe-hanger iron. The bracket should provide for ½" to 1" clearance between bulb and fan when they are mounted. Attach about a foot of lamp cord to the socket, and bolt the socket to the bracket after first inserting the cover bolts.

Remove both top and bottom from the tin can and bolt the bracket assembly inside it. Fan should be positioned ½" below top edge of can. Drill a hole through the side of the can under the motor, install a rubber grommet, and insert the power cord and leads from the lamp socket.

Cut the cover from the bottom of a bleach jug. A coat of spray paint in dark green, brown, black, or a color to match the house will make it less obtrusive. For the bag, cut out a section of undamaged hose 18" long. Tie a knot in one end, turn the bag inside out, and fasten to the can with a rubber band.

The optional photocell-controlled trap is identical in construction (and wiring) to the standard trap, except that both frame and cover are lengthened about 2" for the control socket. PS





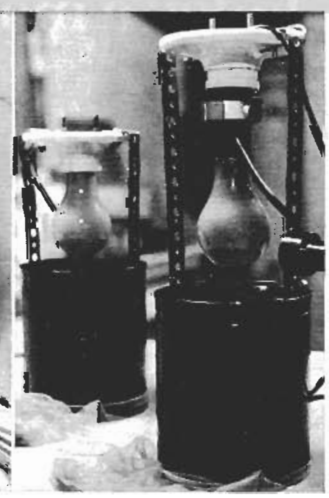
Bend fan blades so normal rotation of motor causes downward air flow. Blade pitch can be 30 to 45 degrees.

MATERIALS LIST

A 5"-dia. can, one-gallon round bleach jug, 2½' of perforated hanger iron, two solderless connectors, two rubber faucet washers, 60-watt "daylight" incandescent bulb (blue tinted), porcelain or plastic socket, lamp cord (18-2) and plug, six ¾" roundhead bolts and nuts, small AC motor (phonograph or similar), one ladies' nylon hose, heavy rubber band, piece of ¾" by 4½" flat tin or aluminum, exterior paint.

Bracket shaped from pipe-hanger iron supports the motor and lamp. Wrap part of the top of the bracket with tape to prevent shorts.

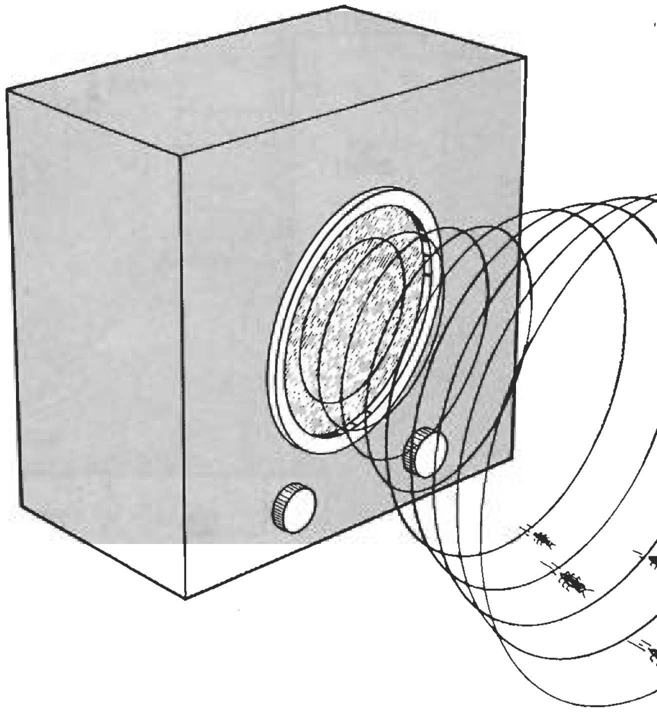
Wiring connections are made as shown in underside view of can. Remove top, bottom from can. Wire in parallel.



A taller support bracket, as shown in the trap at the right, is required if you decide to use a photocell to control light automatically.

ALL ABOUT

ULTRASONIC PEST-REPELLERS



ROBERT F. SCOTT

The claims made for those ultrasonic pest repellers seem fantastic at first glance—but they really work. In this article, we'll find out what makes those devices "tick".

OVER THE YEARS, THERE HAVE BEEN many articles published that proclaimed that ultrasonics, either in the form of pulses or a sweep signal, can be used as an effective insect and rodent repellent. I've always been skeptical of such claims and placed them in the same category with those electronic devices claimed to prevent swallows from nesting on the courthouse roof and prevent pigeons from defiling the Stonewall Jackson statue on the town square. Nevertheless, I filed those articles away for investigation sometime in the future.

Last summer, my hunting and fishing club took possession of a farmhouse that had been abruptly abandoned about a year ago. The house was absolutely overrun with mice and roaches that were bold enough to scamper about in full daylight. We were at a loss as to how to get rid of them.

Ultrasonic pest repellents had begun to appear in mail-order advertising and our club president suggested that we try one. Those devices, according to the literature, generate a signal that sweeps over a frequency range of approximately 22 kHz to 65 kHz, develop sound pressures ranging from 115 to 152 dB, and repel pests in areas of 2500 to 3500 square feet. Power consumption is typically 2 to 4 watts. Prices range from $30.00 to $70.00, plus shipping.

At first, I scoffed at the suggestion that we purchase an ultransonic pest repeller, but agreed to try one since they were available for a 30-day trial and full refund. The $30.00 model was available from several sources under names that include Pest Control, Pest-Elim 1500, and Westronix. We ordered one and it came within a few days. It was shipped in a plain unmarked carton and we were surprised to find that it did not carry a trade name or model number. We installed it in the clubhouse. Within two weeks, mice and roaches were nowhere to be seen—even when lights were suddenly turned on in a dark room. Now, we consider the clubhouse completely free of pests. Not a sign of them: even in the darkest corners and crannies.

Now that the pest repeller had done its work, I began to speculate on its circuit. An early article on the use of ultrasonics in insect and rodent control ("Electronic Pest Control", by Lyman Greenlee, *Popular Electronics*, July 1972) indicated that the repeller needed a power amplifier delivering 16–20 watts in the ultrasonic region and special high-power tweeters. Certainly that little plastic box didn't contain a 20-watt power amplifier or high-power tweeters. Also, a 16–20-watt power amplifier drawing only 4 watts from a supply would be about as close to "per-

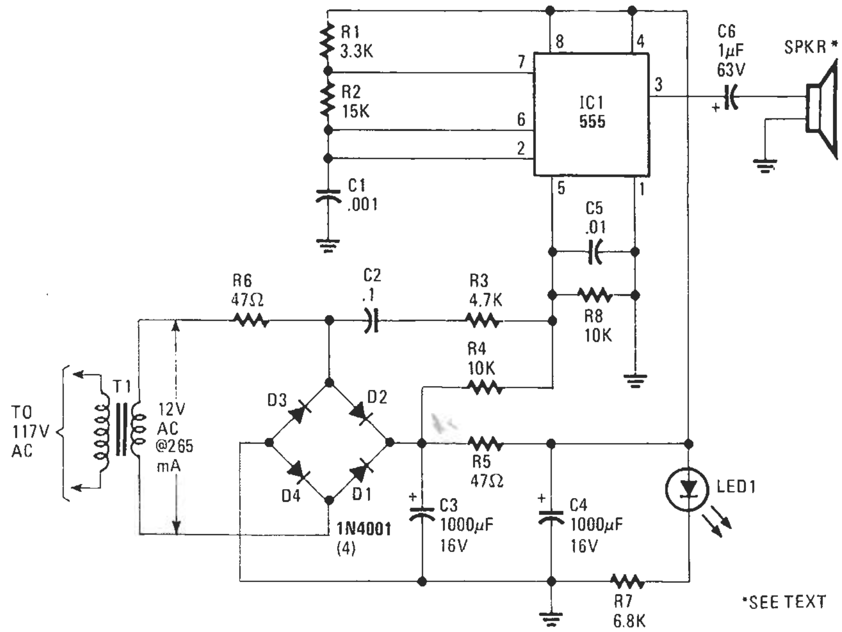


FIG. 1—SCHEMATIC DIAGRAM of a popular ultrasonic pest repeller. Despite its simplicity, the device was remarkable effective.

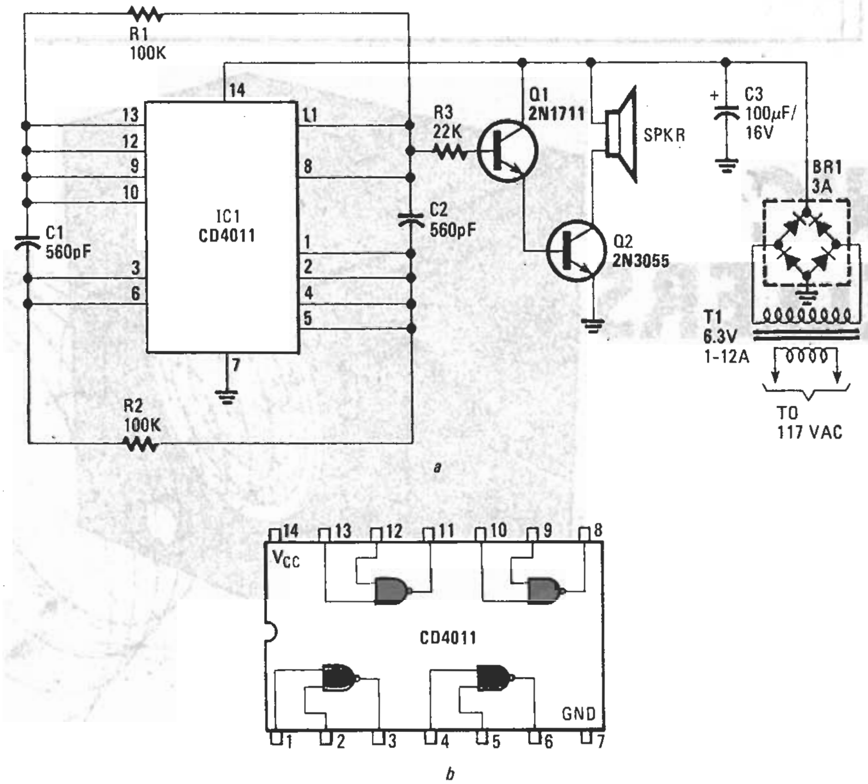


FIG. 2—THIS PEST REPELLER, of French design, is built around a CD4011 quad NAND gate. The schematic diagram is shown in *a*; a block diagram of the IC is shown in *b*.

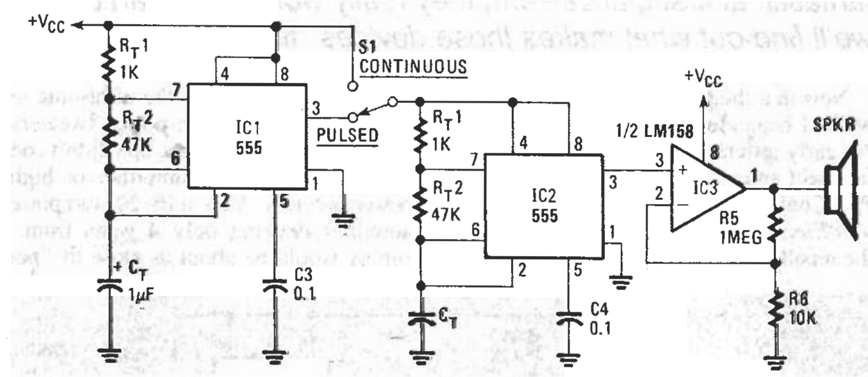


FIG. 3—THIS CIRCUIT IS ideal for experimenting with ultrasonic signals. It can supply either a pulsed or continuous output.

petual motion" as one can come. Thus, I couldn't wait to pry open the repeller's 6¼ × 4¼ × 1¼-inch plastic case and see what made it "tick".

Figure 1 is the circuit of the device we tested. We were quite surprised to find that the circuit was simply a 555 timer IC connected as a squarewave generator. Its base frequency is approximately 45 kHz, as determined by the values of R1, R2, and C1.

The 45-kHz "carrier" is frequency modulated by a modified trapizoidal voltage waveform applied to pin 5 of the 555 timer. That modulating voltage is developed by a network consisting of C2, R3, and R4 connected across one leg of the bridge rectifier. A check with an oscilloscope showed a sweep of approximately 20 kHz on each side of the base frequency. That sweep of from 25 kHz to 65 kHz is surprisingly close to the 22–65-kHz range specified in the ads. The speaker is a 2 inch piezoelectric tweeter.

How the French do it

The circuit in Fig. 2 is a pest repeller described in the French electronics magazine, *Le Haut Parleur*. In the article, the author claims that frequencies in the range of 20 to 40 kHz cause highly uncomfortable cavities to form in brain fluids and blood vessels of mice and insects, causing them to beat a hasty retreat. Radiated power levels can be as low as ⅓ watt.

Looking more closely at the circuit, a quad two-input NAND gate is connected as multivibrator operating at around 40 kHz. With the minimum of filtering used in the power supply, a residual 120-Hz sawtooth on the line from the power supply modulates the ultrasonic frequency. Two Darlington-connected NPN transistors provide some power amplification and drive for the speaker.

Circuit for experimenters

If you want to experiment with the effects of continuous or pulsed high-frequency signals, the circuit in Fig. 3 is ideal; it can provide either a continuous or pulsed output. It was developed by Signetics and described in *Electronic Products Magazine*.

Looking at the circuit, one 555 timer, IC2, generates the ultrasonic squarewave at a recommended 20 kHz. That signal can be supplied continuously or pulsed on and off by a second 555, IC1.

Experimenting with frequency and duty cycle is easy. Duty cycle is the "on" time compared to the total period, and can be set from slightly above 50% to almost 100%. In the astable multivibrator circuit, the duty cycle is set by the timing resistors, R_T1 and R_T2, and is equal to $R_T1 + (R_T2/R_T1) + 2R_T2$.

The on time is close to 100% when R_T1 is chosen to be as small as practical while limiting the current through the discharge transistor to the maximum specified in the data sheet. (The discharge transistor, which is on-board the 555, is an open-collector NPN device with the collector going to pin 7 and the emitter to ground at pin 1. The maximum current through it varies with different manufacturers so you should check the maker's data sheet to be sure.)

If you want a duty cycle of less than 50%, connect a general-purpose silicon diode such as the 1N914 across R_T2 with its anode at pin 7 and cathode at pin 6. That effectively shorts R_T2 while timing capacitor C_T is charging, and the duty cycle is now $(R_T2/R_T1) + R_T2$ and it can be varied from around 0 to nearly 100%. The frequency of the squarewave generator can be found from $1.44/C_T(R_T1 + 2R_T2)$, where resistance is in megohms and capacitance in microfarads.

If you want to vary the duty cycle of the oscillator while keeping the frequency constant, use the basic circuit shown in Fig. 4.

In that circuit, a single potentiometer is used for the two timing resistors. In that scheme, it is possible to set the value of one of the two "timing resistors" to zero. As that is undesirable, two resistors, R1 and R2, have been added to set minimum values for those timing resistors.

Use the basic circuit shown in Fig. 5 when you want to vary frequency while keeping the duty cycle constant at approximately 50%. The variable element used in that circuit, R_T-a and R_T-b, is a two-gang linear potentiometer. Note that the value of the two variable elements are

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PEST REPELLERS

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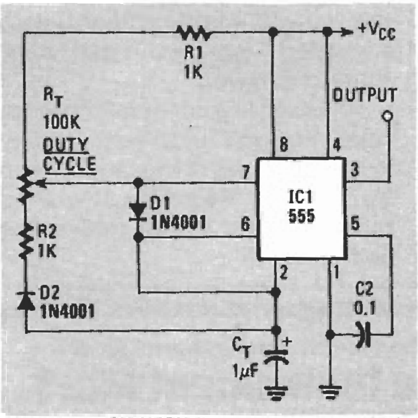

FIG. 4—IF YOU WISH TO VARY the duty cycle while keeping the frequency constant, replace the timing resistors with a single potentiometer.

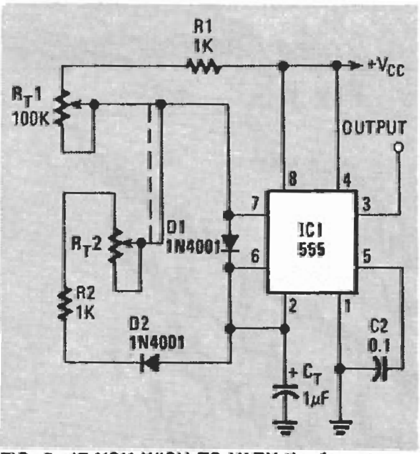

FIG. 5—IF YOU WISH TO VARY the frequency, but keep the duty constant, at about 50%, the 555 circuit can be modified as shown.

equal at all times.

Returning to our basic circuit, the power amplifier, IC3, may be any convenient type with response reaching into the ultrasonic region. You might consider using a low-power IC amplifier such as the Sprague ULN3705 or 3784B, or the National LM380, LM383, or LM384.

The output transducer may be an inexpensive tweeter. Piezoelectric types should be given special preference. You'll find several approriate transducers listed in the catalogs put out by many of the mail-order firms advertising on the back pages of this magazine.

When experimenting with ultrasonic frequencies, be aware that if the frequency is too close to the audible range, the signal may be annoying, and possibly painful, to house pets and some people—particularly girls and young women. Due to the nature of ultrasonics, those effected may not be aware of the source of this discomfort. So, be alert to the condition of those around you when you are experimenting. **R-E**