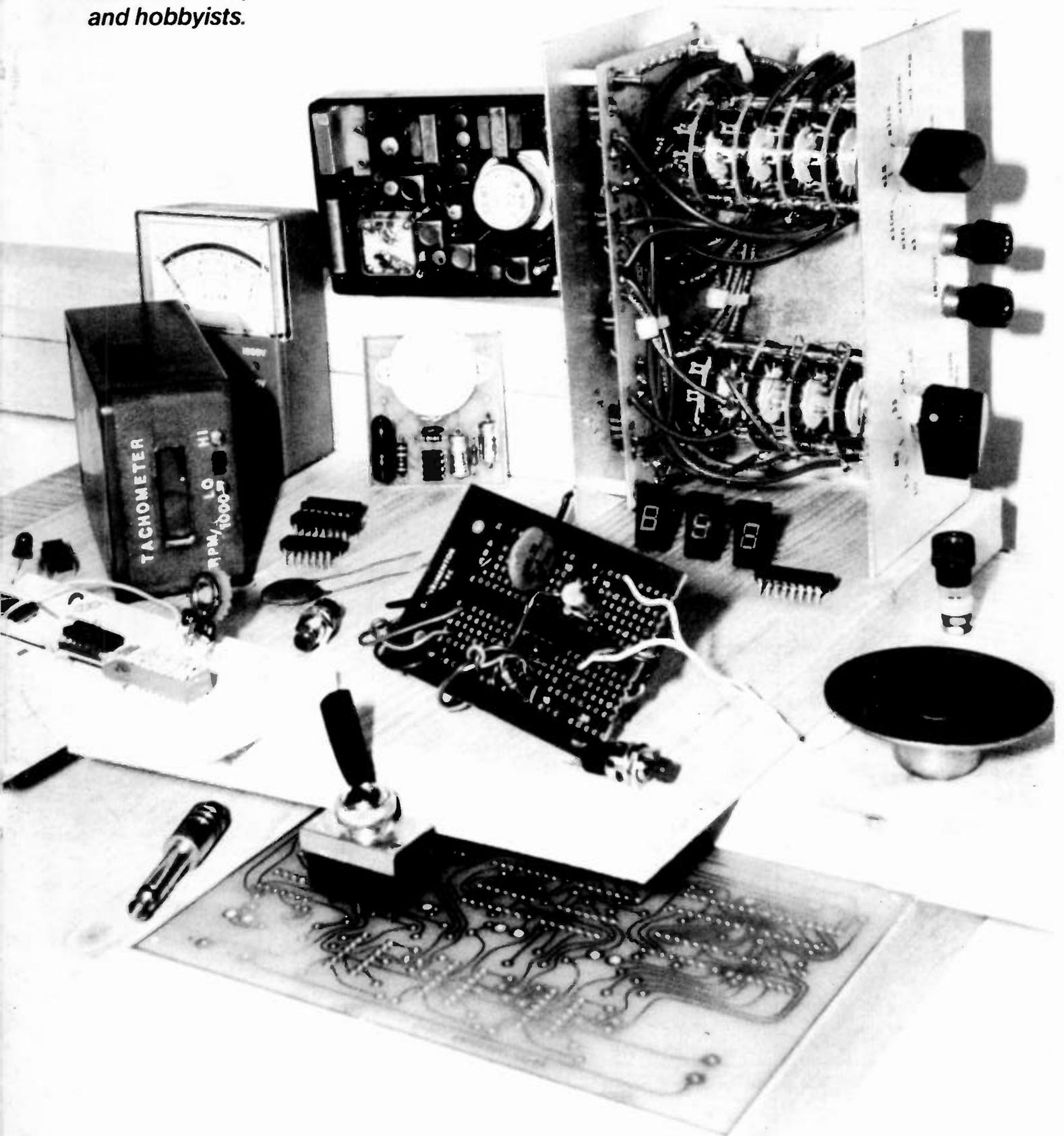


NEW IDEAS

44 great circuits for
electronics experimenters
and hobbyists.



New Ideas

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By the Editors of RADIO-ELECTRONICS

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Contrast Meter for

IF YOU'RE AN AMATEUR PHOTOGRAPHER who enjoys developing his own pictures, you have probably found it necessary to choose the right paper to fill certain requirements. If you're among the fortunate few who can afford a densitometer, then you have nothing to worry about. But if you're like most of us and cannot afford that piece of equipment, then perhaps this easy-to-build substitute is for you.

The contrast meter can be used to help you choose the right grade of paper for your photographic needs. The circuit, built from readily available parts, will work well with almost any photocell and 1-mA panel meter you choose.

The circuit is powered by a dual 15-volt power supply. If you have trouble in getting the parts to build the power supply, then the design can be modified to use a dual 12-volt supply by changing the values of resistors R1, R6, and R7 to 8200 ohms, 180 ohms, and 560 ohms respectively. The only critical components are resistors R3 and R4, which should be test-

TABLE 1

DENSITY RANGE		Paper Grade
(I _s)	(I _n)	
>1.4	<4	0
1.2-1.4	4-6	1
1.0-1.2	6-10	2
0.8-1.0	10-16	3
0.6-0.8	16-25	4
>0.6	<25	5

Air-Motion Detector

A WIND DETECTOR AND INDICATOR COULD be put to good use by many hobbyists. For example, those with radio-controlled model boats or planes could use such a device to help make go-no-go flight decisions; a ham radio operator could use one to warn him that his antenna system was in danger of crashing down around him; a kite flyer could use such an indicator to announce good kite-flying days. I'm sure that by the time you have read this far, you've already come up with your own application for a wind sensor.

The sensing circuit can be built to detect either steady or fluctuating air flows. The heart of the circuit (above in Fig. 1) is a Radio Shack piezo buzzer (part number 273-060) and an LM324 quad op-amp. Note that the red wire from the piezo element should be connected to capacitor C1, and the black wire to ground.

When a current of air hits the piezo element, a small signal is generated and is fed through C1 and R1 to the inverting

Photography Buffs

ed to ensure a good 1:3 ratio.

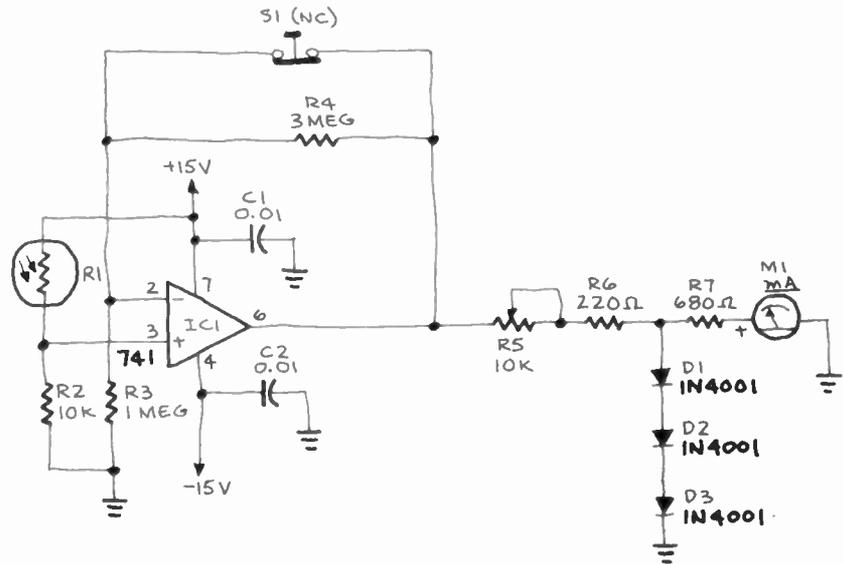
One leg of the photocell (R1) is tied to the +15-volt supply and the other end is connected to ground through resistor R2, forming a voltage-divider network. The non-inverting input of the 741 op-amp, IC1, is tied to the junction formed by R1 and R2, while its inverting input is grounded through resistor R3. When switch S1 is pressed, another divider network is formed, reducing the the voltage applied to the inverting input of the op-amp (more on that later).

When light hits the photocell, its resistance begins to decrease causing a greater voltage drop across R2 and a higher voltage to be presented to the non-inverting input of IC1. That causes IC1 to output a voltage proportional to the its two inputs.

The circuit gives a meter reading that depends on the intensity of light hitting photocell R1; therefore, R1 should be mounted in a bottle cap so that the light must pass through a 1/16-inch hole. Potentiometer R5 is used to adjust the circuit for the negative you're working with.

The diode chain, D1-D3, is used to protect the meter in case direct room light hits the photocell. If the dark resistance of the cell is less than about 1 megohm, it may be necessary to use four diodes, instead of the three shown, to get a full scale reading. If the internal resistance of the meter is less than 90 ohms, you may only need two diodes.

The density range of the negative can be expressed as the logarithm (log) of the



light intensity (I) through the clearest (shadow) area minus the log of I through the densest (highlight) area. In the form of an equation: density range = $\log(I_1/I_2)$.

By using a simple table of antilogs, you can avoid the need of a log amplifier to determine the correct paper grades corresponding to the specific density ranges.

To use the contrast meter, focus the negative in the enlarger with the lens diaphragm wide open. Then place the photocell under the lightest portion of the negative. Using potentiometer R5, adjust the meter for full-scale deflection. Now, without changing the setting, place the photocell beneath the darkest portion of

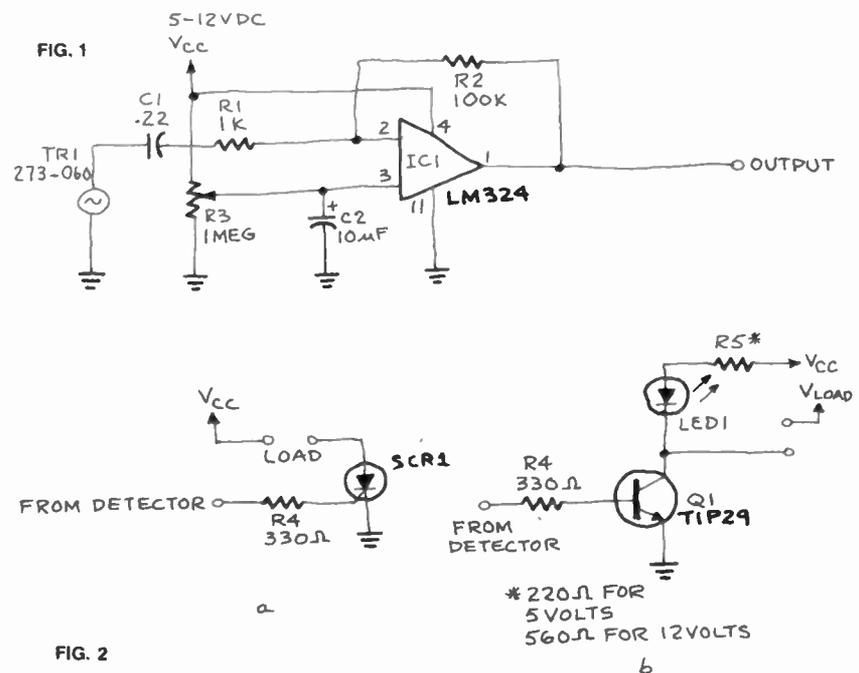
the negative and read the meter. If the meter now shows less than ten percent of the full-scale reading, it may prove to be very difficult to read accurately.

When that happens, it will be necessary to push switch S1. Pressing S1 removes the short across resistor R4. Because R4 is three times the value of R3, only 1/4 the voltage applied to that leg of the circuit will appear at the inverting input of the op-amp, resulting in a reading four times as great. Now simply divide that reading by 4 and compute the ratio of the first and second measurements. And then refer to the table above to find the right paper grade for that negative. —Phillip Albrow

input (pin 2) of one section of the LM324. That causes the output (pin 1) to go high. Resistor R3 is used to adjust the sensitivity of the detector. The circuit can be made sensitive enough to detect the wave of a hand or the sensitivity can be set so low that blowing on the element as hard as you can will produce no output. Resistor R2 is used to adjust the level of the output voltage at pin 1.

The detector circuit can be used in various control applications. For example, an SCR can be used to control 117-volt AC loads as shown in Fig. 2-a. Also, an NPN transistor, such as a TIP29, can be used to control loads as shown in Fig. 2-b. I have driven such loads as incandescent lamps, solenoids, and relays with the setups shown.

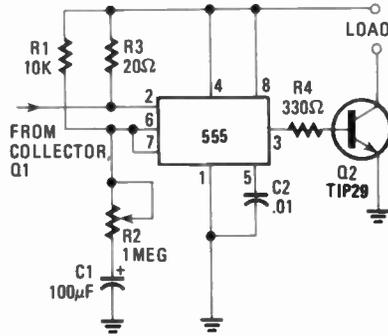
The control circuits discussed above work well when there is a constant air flow. However, in situations where the air flow fluctuates—because the output will fluctuate with the wind source—a latch-type circuit may be necessary. One such circuit is shown in Fig. 3. The fluctuating



output of the NPN transistor activates the 555 timer, and allows the load to be driven for a certain length of time—as determined by the setting of potentiometer R2—without an input.

There are a great number of possible applications for the air detector circuit and it also makes a great building block for more complex circuits. For example, a solid-state weather vane could be constructed using a group of sensors—each facing a different direction—to turn on direction-indicating lights or LED's. A digital wind-speed indicator could also be built.

—Chris Mabry



Musical Telephone Ringer

THE DEVELOPMENT OF IC'S HAS BROUGHT with it many novelty circuits and gadgets. And often those circuits serve no purpose other than to entertain. Although this telephone-ringer circuit is a novelty, it doesn't fall into that category. The melody ringer can be used in place of, or as an extension to, your present ringer system.

When the phone rings, the circuit will play one of twenty-eight tunes (as selected by the user). The tunes are certainly a step above the old clanging bell—which at times can be quite startling. Some of the tunes, which are listed in the table, are ideal for special occasions.

As we can see from the ringer schematic, the heart of circuit is IC1, General Instrument's AY-3-1350 melody-synthesizer IC. Since power consumption is extremely low in the standby mode, the entire circuit can be powered by a single 9-volt transistor-radio type battery. IC2 is a TCM1512 telephone ring detector IC that is powered by the telephone line.

The circuit's operation begins when IC2 senses a ring pulse on the telephone line. The detector (internally) rectifies the ring signal and then outputs a voltage to relay RY1 (a SPST reed-type relay with 5-volt contacts), causing its contacts to close. That pulls pin 12 (the ON/OFF control) of IC1 low (logic "0"), causing it to output a signal—the selected tune—to transistor amplifier Q2. The amplified signal is then fed to the speaker.

The melody continues to play either until the tune is finished (at which time IC1 returns to the standby mode), or until someone takes the phone off the hook. Taking the phone off the hook discontinues the ring pulses to IC2, which opens RY1. When the relay contacts open, pin 12 of IC1 goes high, returning the circuit to the standby mode.

Continuity Tester

MAKING CONTINUITY CHECKS CAN BE A tedious undertaking, especially if you happen to be working with wire-wrap circuits. Of course, you could use an ohmmeter to do the job, but continuously turning your head back and forth to read the meter can be a real pain in the neck! There is a way that you can check continuity (and make sure that the resistance is less than about one ohm) without "twisting your head off." All you need do is rig up an audible continuity tester.

Power for the circuit is provided by a single 9-volt, transistor-radio type battery. At the heart of the circuit are two LF411 op-amp IC's: One op-amp, IC1, is used along with resistors R1 and R2 to form a ground reference for the circuit; in effect, producing a 4.5-volt split supply. The other op-amp (IC2) is configured as a comparator whose output used is to source current for the buzzer.

Resistors R4 and R5 form a voltage-divider that provides a reference voltage that is applied to pin 2 of IC2. The circuit to be tested is connected between points A

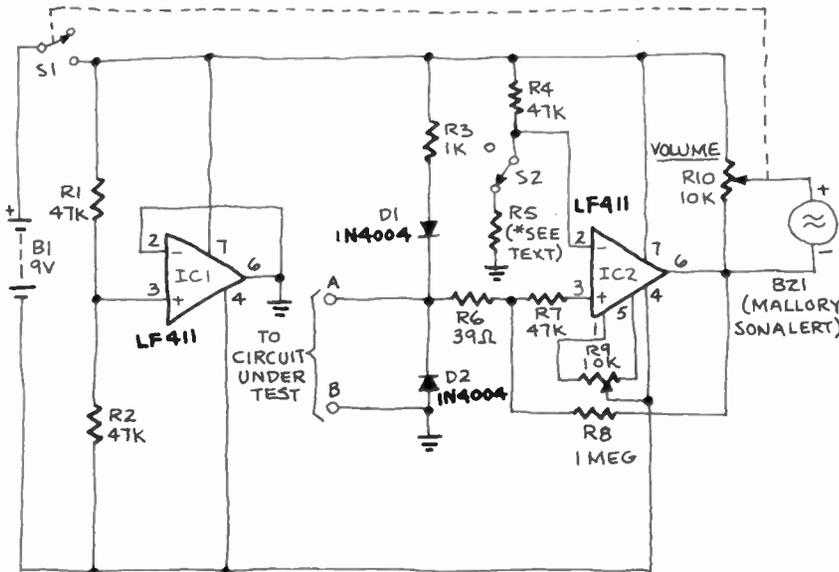
and B via jumpers. The resistance offered by that circuit along with resistor R3 forms a second voltage divider. That leg of the circuit provides the voltage that's presented to the non-inverting input (pin 3) of IC2.

When a non-continuous (open) circuit is connected across points A and B, the voltage appearing at pin 3 of IC2 will be high; therefore, its output will be high and no current flows through buzzer BZ1. However, when a continuous circuit is connected to points A and B, the input to pin 3 will be low, thereby causing the output of IC2 to go low. That completes the current path for BZ1, and causes a sound indicating a complete circuit.

Diodes D1 and D2 along with resistor R7 provide protection for the unit

To calibrate the unit, connect a 47-ohm resistor at R5 and a 1-ohm unit at across points A and B. Now adjust potentiometer R5 until the buzzer just comes on. Resistor R9, which adjusts the circuit's sensitivity, should be a multi-turn, trimmer potentiometer. The maximum current through the circuit being tested will be about 4.5 milliamps.

—Ron McCabe



Plant-Water Monitor

ONE OF THE MOST CRITICAL FACTORS IN A plant's well-being is the amount of water it receives. Just looking at the soil can be misleading because it's the moisture at the root level that's critical. Thus, soil that's dry at the top of the pot could be quite moist at the root level and adding more water could put the plant in jeopardy.

That's where this project idea comes in. It's a plant-water monitor and is used to test the moisture of the soil at root level. When the soil is moist, an LED glows. If the moisture falls below a certain predetermined level, the LED begins to flash. If there is still less moisture, the LED turns off.

The device can be built on a small piece

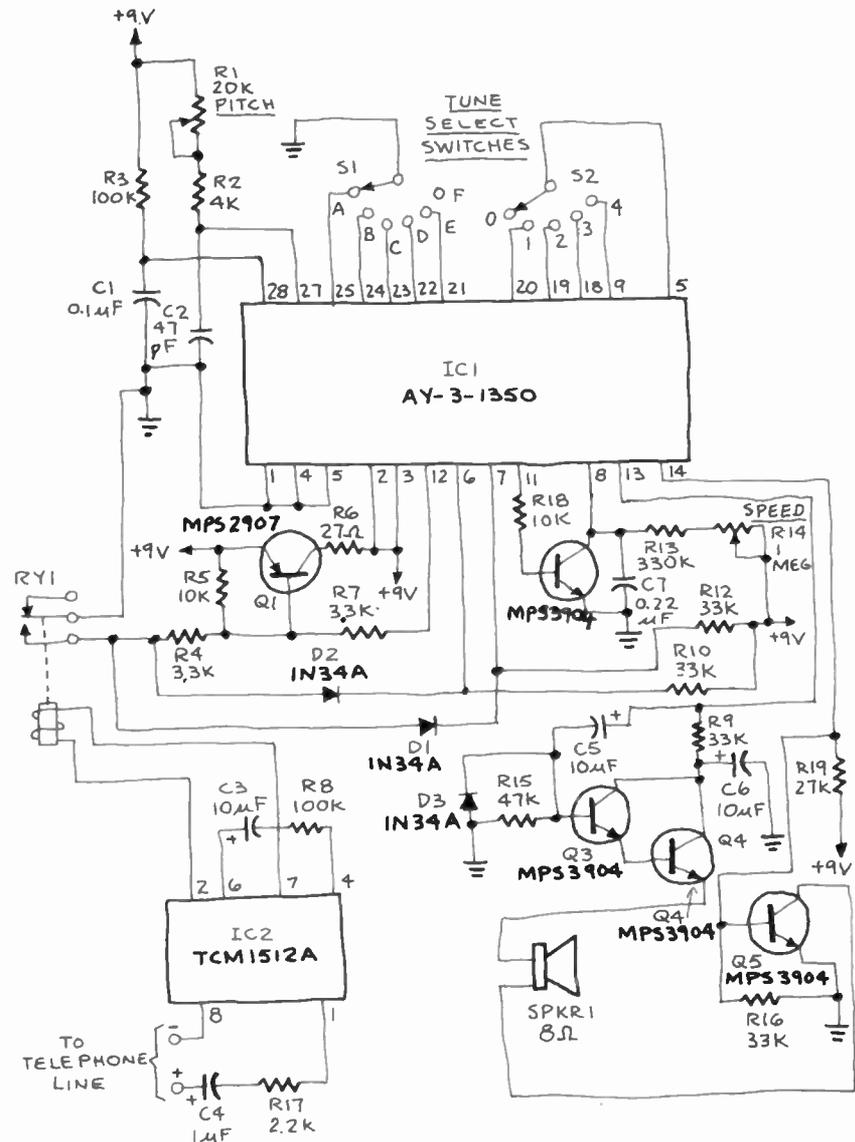
TUNE TABLE

- A0—Toreador
- B0—William Tell
- C0—Hallelujah Chorus
- D0—Star Spangled Banner
- E0—Yankee Doodle
- A1—John Brown's Body
- B1—Clementine
- C1—God Save the Queen
- D1—Colonel Bogey
- E1—Marseillaise
- A2—America, America
- B2—Deutschland Leid
- C2—Wedding March
- D2—Beethoven's 5th
- E2—Augustine
- A3—O Sol Mio
- B3—Santa Lucia
- C3—The End
- D3—Blue Danube
- E3—Brahms' Lullaby
- A4—Hell's Bells
- B4—Jingle Bells
- C4—La Vie en Rose
- D4—Star Wars
- E4—Beethoven's 9th
- F1—Westminster Chime
- F2—Simple Chime
- F3—Descending Octave Chime

When connecting the circuit to the telephone line, it's a good idea to use a meter to distinguish the positive side of the line from the negative. That's important for proper operation. Pin 1 is the positive (tip) input and pin 8 is the negative (ring) input, as shown in Fig. 1.

The desired tune is selected using two double-pole, 6-position switches, S1 and S2. Each tune is assigned a letter/number combination. To select a tune, dial the switches to the combination that corresponds to the tune desired as shown in Table 1. For instance, if the theme from Star Wars is desired, S1 is dialed to "D" and S2, to "4."

All components are available from a



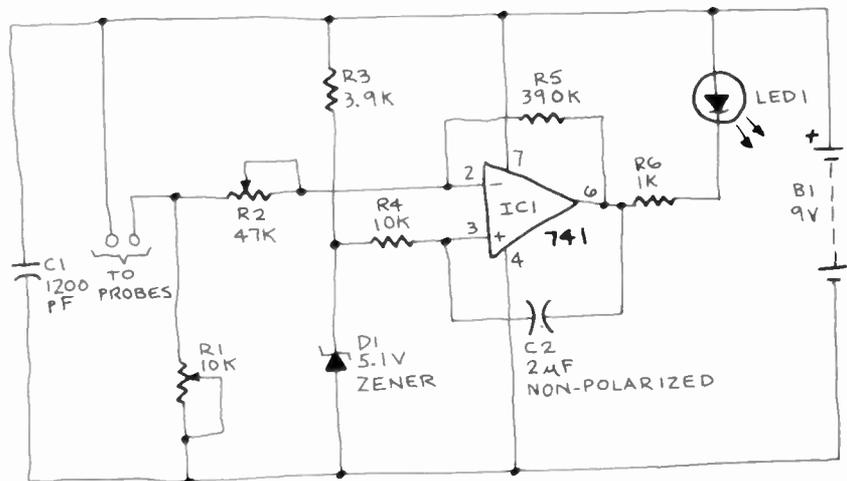
wide range of sources (including Radio Shack) Potentiometer R1 controls the pitch of each note, while R2 is used to set

the speed at which the tune is played. Therefore, each can be set to satisfy personal taste.
—John P. Keverleber

of perforated construction-board and housed in a small plastic case or experimenter's box. The probes are two slender metal rods. They should be tinned to prevent corrosion. For convenience, you can mount the probes on the case.

Calibrating the monitor is easy. Just connect the battery and insert the probe into a container of dry soil. Set R1 to its maximum value; then reduce that resistance until the LED begins to flash. The range over which the LED flashes before going out is adjusted using R2.

If you wish, you can reverse the operation of the circuit. That is, you can have the LED off when there is enough water, and on when more water is needed. That's done by simply switching the positions of R1 and the probes.
—Sreekumar, J.



Multiple-Outlet Control Circuit

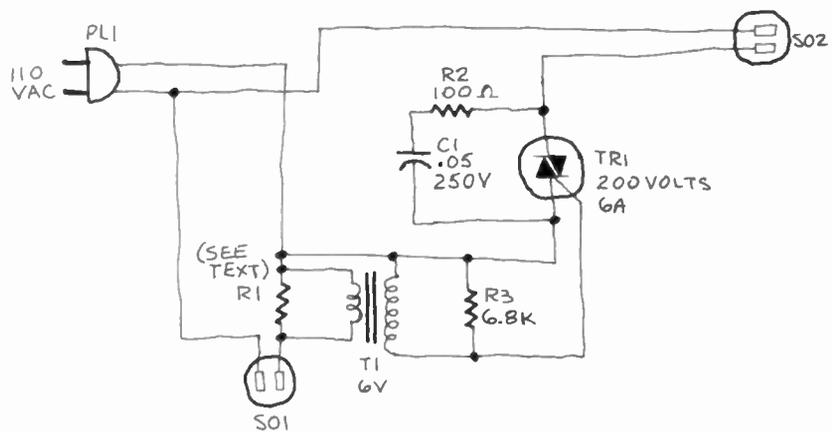
ALMOST EVERY ELECTRONIC DEVICE IS used with one or more different accessories. For example, an AM/FM receiver might have a tape deck, equalizer, and turntable connected to it. Or you may have a video system consisting of a TV set, VCR, video enhancer/stabilizer, and so on.

Each of those units has its own power-on switch, which means that if you want use one or more of those components in conjunction with the main unit (receiver or TV set), you'll have to turn on each component individually. That means that there is always the possibility that one or more components will be accidentally left on when you're finished.

There are many ways to get around that problem—for instance, you could use one of several commercially available switched outlet-strips, which can cost \$15 and up. Those products (often containing a surge suppressor) are fine for things like computers; but for other electronic devices, like stereos or TV's, they're simply not needed. There is, however, another way to go about it and save some bucks in the process.

The diagram shows a circuit that can be used to turn on several components of an audio or video system at the same time. The beauty of that scheme is that it can be built using a handful of easy-to-get parts. But that's not all; With a little imagination and some experimenting, it can be made to do the same things that the commercial products do, making it more than worth the parts cost and time spent building it.

First you should note that the circuit draws no standby current; in other words, when a device plugged into socket SO1 is turned off, no power is supplied to SO2. You may be wondering why no switch is



included in the 110-volt AC line. Well, the answer to that question will become clear as we discuss the circuit's operation.

One more point: T1 is a 6-volt transformer with its primary and secondary connected in reverse (i.e. the secondary in parallel with R1 and the primary feeding the Triac gate). Resistor R1 is chosen according to the load connected to SO1: If the SO1 load is 125–150 watts, R1 should be a 1-ohm, 10-watt unit. For loads of 250–300 watts, use a .5-ohm, 10-watt resistor or you can parallel two 1-ohm, 10-watt units if desired.

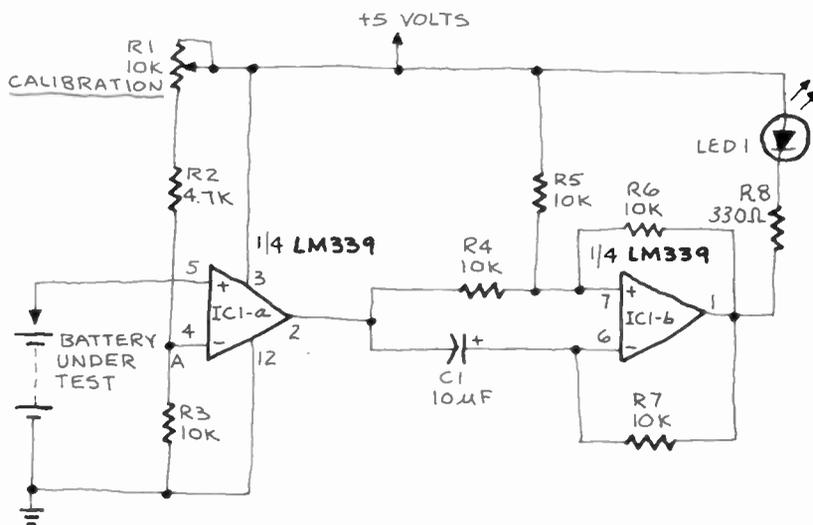
When the device connected to SO1 is turned off, no current will flow because that leg of the circuit is open; and therefore, there is no voltage developed across R1. (Remember the power switch on any device is used to complete a circuit.) Because there is no voltage drop across resistor R1, no voltage is fed to transformer T1. When the device plugged into SO1 is turned on, current flows to SO1 through resistor R1 causing a small voltage to be developed across the resistor.

The voltage across R1 is then applied to the secondary of T1 (which is used as a step-up transformer), resulting in a higher

output voltage at its primary. The output from T1 is fed to the gate of Triac TRI1. When TRI1 is turned on, power is supplied to the load at SO2. That means that the on-off function of any device connected to SO2 is controlled by the power switch of the SO1 load. Therefore, it is not necessary to include an on/off switch in the AC power line.

Additional sockets may be placed in parallel with SO2 so that any other device that you may want to use in conjunction with the main unit at SO1 may be powered up in the same manner. Just keep the 6-amp limitation of the Triac and the total current requirements of the load in mind when adding extra sockets. Also, the current rating of the Triac assumes proper heat-sinking. If the 6-amp limit is a problem, you may want to check into some of the higher rated Triacs, like those listed in the *ECG Replacement Guide*.

Although it is not necessary, you may want to add switches in series with the extra sockets, so that any device connected to those sockets may be turned off from a central location as needed. A final note: The circuit should be mounted in a case for safety's sake. —Theodore Stern



Low-Battery Warning

WHEN WORKING WITH LOW-POWER DEVICES, the use of a battery back-up becomes practical, and in some instances important. Nowhere is that more true than in the case of non-volatile RAM (Random Access Memory). But batteries have a limited life span and their failure, if not detected, could have catastrophic results in the event that the main power source is disconnected from a memory device. After all, without some source of power the contents of the memory will be lost.

The circuit discussed here was designed to help prevent such an occurrence. It constantly monitors the condition of the batteries, and signals if their voltage falls below a certain preset value. Use of a circuit such as this is

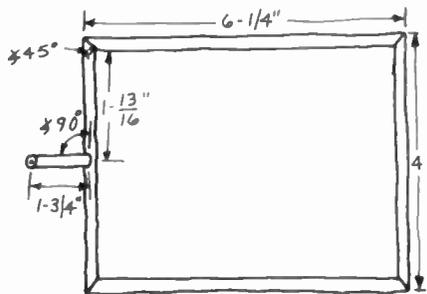
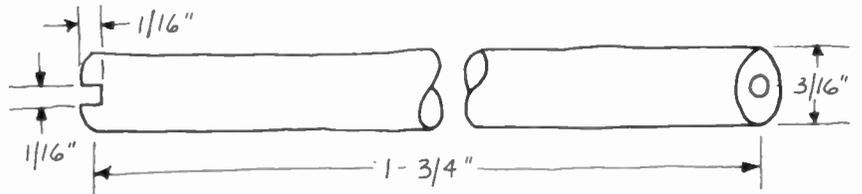
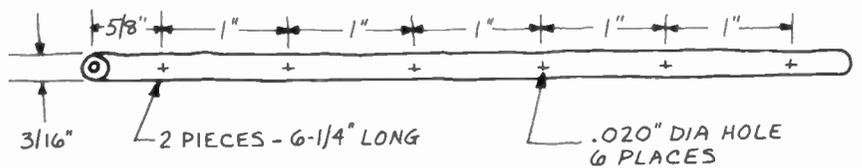
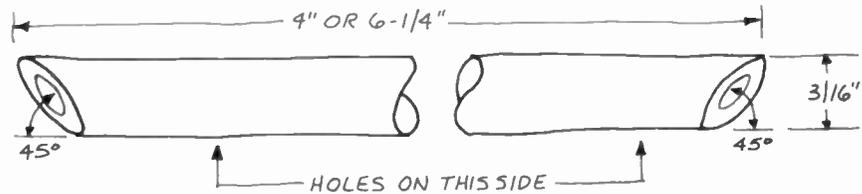
PC-Board Bubble Etcher

MY NEW IDEA INVOLVES CONSTRUCTION plans for an inexpensive (under \$10) bubble etcher that reduces the time to etch printed-circuit boards considerably. The materials required for the etcher consist of a phenolic instrument case, $\frac{1}{16}$ -inch OD rigid PVC tubing, instant-setting PVC cement, an aquarium air pump, a piece of $\frac{1}{8}$ -inch ID flexible plastic tubing, and a piece of plastic canvas of the type used for needlepoint. (The "canvas" has an open grid containing $\frac{1}{32}$ -in. square holes.) Any size etcher may be constructed simply by cutting the length of PVC tubing to fit the case size. The etcher described below uses a standard-size instrument case having inside dimensions of $6\frac{1}{2} \times 4\frac{3}{4} \times 2\frac{1}{2}$ inches. The PVC tubing, cement, flexible tubing, and plastic needlepoint canvas were purchased at a hobby and crafts store, the aquarium air pump at a pet store, and the case at an electronics parts supply house.

The heart of the etcher is a rectangular air tube constructed from two $6\frac{1}{4}$ -inch and two 4-inch lengths of the rigid PVC tubing (these dimensions fit the case I used.) The ends of each piece of tubing are cut at a 45° angle as illustrated in Fig. 1. Refer to Figs. 1 and 2 and mark the locations of the air holes in the $6\frac{1}{4}$ -inch pieces of tubing, use a No. 76 drill to drill a $.020$ -inch-diameter hole at each marked location.

Upon completion of the drilling, remove all loose fragments from inside the tubing, arrange the pieces into a $6\frac{1}{4}$ -inch \times 4-inch rectangle and cement the tubing ends together, being careful not to get cement inside the tubing. Let the cement dry before going to the next step.

At the top center of one of the 4-inch legs of the rectangle, drill a $\frac{1}{16}$ -inch-diameter hole through one wall of the tubing and remove any loose fragments from inside. Next cut a $1\frac{1}{4}$ -inch length of tubing and cut a notch in it about $\frac{1}{16}$ -in. wide by $\frac{1}{16}$ -inch deep, centered across one end as shown in Fig. 3. Align the notch parallel



To use the etcher, place the air pipe and board to be etched in the case, connect the air pump and air pipe with a piece of the $\frac{1}{8}$ -in. ID flexible tubing, and fill the case with enough etchant solution to cover the top of the board. Then, plug in the air pump and watch the resulting action.

—David L. Holmes

to the length of the drilled 4-inch tubing and cement the notched end of the tube into the hole, again being careful not to get cement inside the tubing. Allow sufficient time for the cement to dry before handling the air pipe further. The completed air pipe should look like the one illustrated in Fig. 4. Finally, cut a piece of plastic canvas to fit on top of the air-pipe assembly and cement it in place. The canvas provides a level resting surface for all PC-board sizes, and its open grid allows the air bubbles to flow to the surface.

especially important if carbon, alkaline, or nickel-cadmium batteries are used. Those devices have a relatively short shelf-life. What's more, they discharge relatively quickly.

Turning to the circuit itself, a voltage divider consisting of R1, R2, and R3 is used to set the input reference voltage below which the batteries are to be replaced. That reference voltage, at point A, is varied by R1. With the voltage divider shown in Fig. 1, a range of 2 to 3.5 volts is possible.

When the battery voltage drops below that at point A, the output of IC1-a, $\frac{1}{4}$ of a

LM339 quad comparator, switches from high to low. That triggers IC1-b, which is configured as an astable multivibrator.

Feedback resistors R6 and R7, coupled with capacitor C1, determine the time constant of the multivibrator. The output from IC1-b is connected to LED1 through dropping resistor R8. With the circuit values as shown, the flash rate is 3 Hz.

Although this circuit was designed specifically to monitor RAM back-up batteries, it can, of course, be modified for use in just about any application where the condition of a battery must be found.

—William T. Sargeson

Sliding-Tone Doorbell

HAVE YOU EVER BEEN STARTLED BY YOUR own doorbell? I have heard some doorbells that are so harsh and startling that they are sure to wreck anyone's nerves. But my doorbell is not of that type—at least not any more.

But if your bell is of that type, don't despair. I'll show you a way to prevent your quiet home from being disturbed. You can replace your harsh-sounding, nerve-wracking bell with what I'll call a "mild dose of sound stimulation." When the doorbell is pushed, you'll hear a low tone that will "slide up" to a higher frequency.

The sliding-tone doorbell circuit is made up of two main parts: an AF (Audio Frequency) oscillator and a variable resistance.

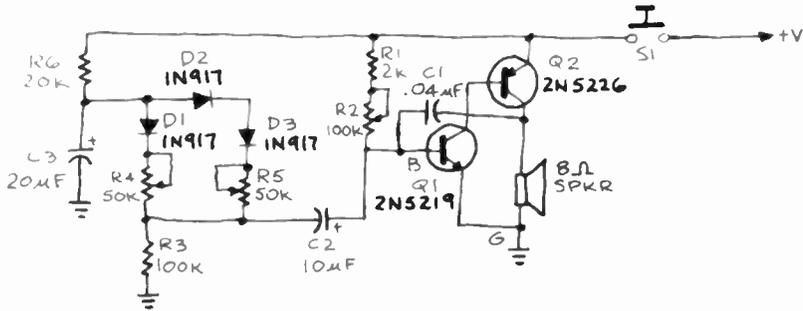
The frequency of the AF oscillator is determined by two factors. The first is the value of the coupling capacitor, C1. The second is the value of the resistance connected between the base of Q1 and ground. That resistance, which we'll call R_{BG} , is equal to $(R1 + R2) \parallel R3$.

When either of those two factors increases, the frequency of oscillation will decrease. Thus, whenever R_{BG} or C1 decreases, the frequency will increase.

First, assume that S1 is closed and R2

has been adjusted to produce a pleasant, low-frequency tone. Capacitor C3 will charge through R6 until it reaches such a voltage that will cause diode D1 to conduct. When that happens, the value of R_{BG} is paralleled by R4. Thus, because the total resistance R_{BG} decreases, the output tone slides up in frequency. Capacitor C3 will continue to charge until the voltage across D2 and D3 causes those diodes to conduct. Then R_{BG} is paralleled also by R5, the total resistance again decreases, and the oscillator's frequency again increases.

If you're not satisfied with how the "bell" sounds, there are several things you can do. First, if you want to change



the tone variation, feel free to try different values for R2, R4, and R5. And if you want to vary the sliding speed of the tone, then you can try different values of R6.

As with the rest of this easy-to-build circuit, the transistor types are not critical. Feel free to experiment!

—Tseng C. Liao

Liquid-Rosin Flux

AFTER I RETIRED, MY INTEREST IN ELECTRONICS grew tremendously. Partly because of that, I joined the RSVP (Retired Senior Volunteer Program) and volunteered to help high-school electronics students in their electronics laboratory courses. Recently, the students began to make their own printed-circuit boards for their projects, and the instructor decided that the boards should be tinned (solder plated). What the students would do was to load the board with solder and then sop it up with *Solder Wick*. There had to be a better way to tin a board than that!

One improvement would have been to use some liquid rosin solder flux. However, that was not readily available, and an order would have taken months to fill. A solution was found, though—we made our own liquid flux. It's not very hard to do, and everything you need is shown in the drawing.

I knew that the active ingredient in printed-circuit board cleaners—

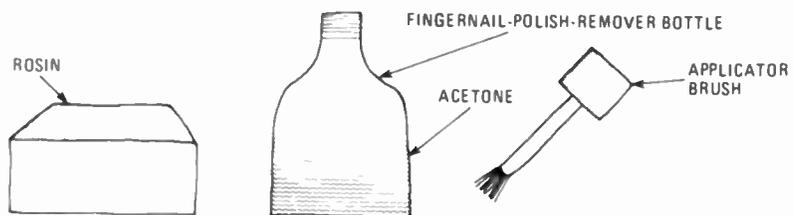
acetone—dissolves rosin like crazy. So I went to raid my wife's acetone-based fingernail-polish remover—but when I saw the price she paid for it I decided against it. However, I did manage to get my hands on an empty fingernail-polish remover bottle. That bottle was perfect for what I wanted to use because it came with a handy applicator brush. A little acetone was used to clean both the bottle and the brush.

The next problem was to find the rosin. A violin-repair shop was the source for that. I mashed up a bit of the rosin—a piece about as big as the end of my fin-

ger—and coaxed it into the bottle that was half-filled with acetone. It was easy to tell how much rosin to put in—it dissolves very quickly, but little chunks of rosin form at the bottom of the bottle, when you've reached the saturation point. Then, no more will dissolve.

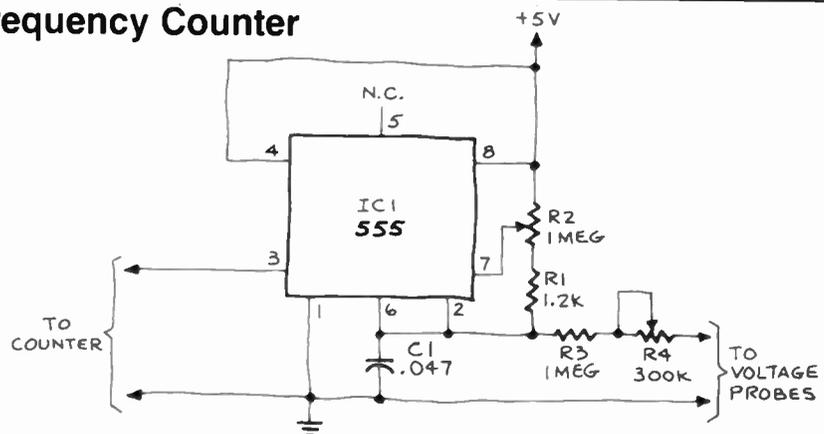
Now I had a little bottle of liquid rosin with its own applicator brush. It's a great way to put rosin flux on printed-circuit boards, to prime connectors, to tin stranded wires, and so on. You can probably get by without it; but, believe me, liquid rosin can make many jobs a lot easier.

—Roger F. Sheldon



Measuring Voltage with a Frequency Counter

AMONG THE REASONS FOR THE POPULARITY of the 555 IC are its capabilities for being used as an inexpensive free-running astable multivibrator, square-wave generator, or signal source. The frequency of the output from pin 3 of that IC is determined by the voltage input to pin 6. It can be shown experimentally that the relationship between the voltage input and the frequency of the output is linear, provided that the input resistance is large enough (at least 500,000 ohms). Because of those characteristics, it is possible to use a 555 IC to build a voltage-to-frequency converter. With that converter, a standard frequency counter can be used to measure voltages directly over a limited range of from 0 to 5 volts. (The range is limited by the 5-volt power supply to the oscillator.)



In the circuit, the 555 is wired as an astable multivibrator. Resistor R2 is used to determine the output frequency when the input to the circuit (the voltage mea-

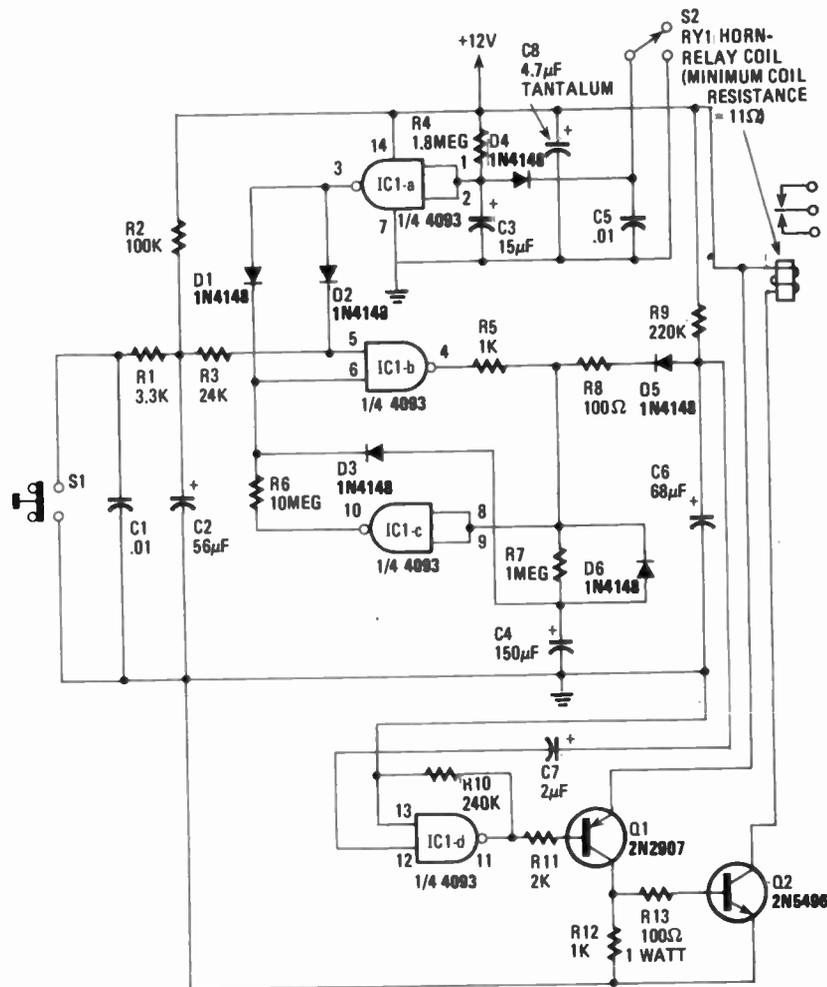
sured by the voltage probes) is zero. Resistor R4 is a scaling resistor and is used to adjust the output frequency so that a change in the input voltage of 1 volt will

Protecting Your Car

HERE IS AN ALARM CIRCUIT FOR YOUR CAR that uses only one IC and is rather easy to build. But it still has many desirable features, including entrance- and exit-delay times, an auto reset control, automatic shutoff, and low power consumption.

First we'll look at the two switches, S1 and S2. Opening switch S1, which is a normally-open door-mounted switch, activates the alarm after an 8-second delay. However, if S2—a hidden switch inside the car—is closed within that 8-second delay time, the alarm will not be activated. That switch always takes priority over S1. Whenever it is closed, the alarm is off. Even when S2 is opened again, it still inhibits the alarm activation—but only for an additional 20 seconds. (That delay is determined by the combination of R4 and C3.) That's enough time to get out of the car and close the doors. Switch S2 can be a momentary normally-open switch, but you may prefer using a toggle switch. That way you can disable the alarm if you have to keep your car open for more than 20 seconds, such as when you are loading it with luggage.

Integrated circuit IC1 is a quad 2-input NAND Schmitt trigger. The output of IC1-c latches IC1-b to a high output state once switch S1 is opened. After that, only S2 can stop the alarm oscillator, IC1-d, from being triggered after the 8-second delay (determined by R9 and C6). That drives transistor Q1 and Q2, which switch the load (the coil of the horn relay, RY1) to



result in a change in the output frequency of 10 Hz. That will happen when the combined resistance of R3 and R4 adds up to 1.2 megohms.

The circuit is fairly simple, and it can be built using any construction technique. For best stability, locate resistors R1-R4 and capacitor C1 as close to the 555 as possible. If stability is still a problem, bypass pin 5 to ground using a 0.1μF capacitor.

To calibrate the circuit, connect the output to a frequency counter, short the voltage probes together, and adjust R2 until the reading on the frequency counter just changes to 00 Hz. Then, use the voltage probes to measure an accurate 5-volt source and adjust R4 until the frequency counter reads 50 Hz. Repeat those adjustments until the frequency counter reads 00 with a 0-volt input and 50 with a 5-volt input. To read voltages greater than 5 volts, a voltage-divider network or attenuator will have to be used. When measuring very low voltages, remember that the circuit sources a few microamperes; that may throw off some readings slightly.

—Burjor T. Santoke

ground. Thus the horn sounds intermittently. The maximum current that transistor Q2 can sink safely is about one amp.

After about 2½ minutes (controlled by the R7-C4 combination), which is called the alarm cycle time, IC1-b is unlatched when pin 6 goes high via C4. If S1 at that time is not open, pin 4 of IC1-b goes low and the alarm stops and is once again ready to receive triggering signals from S1. If S1 is still open, the alarm will con-

tinue to sound. Remember though, that S2 inhibits both the detection and activation of the alarm at any point of the cycle.

I used RCA IC's when building my alarm. If you substitute those of another manufacturer, you may have to adjust the values of the timing resistors and capacitors. Some experimentation may be required before everything works as it should.

—Ronald Ham-Pong

Stereo Remote-Control Unit

THIS IDEA DESCRIBES A PASSIVE STEREO remote-control unit. Nothing is more aggravating than to relax for the evening in your favorite chair, intent on enjoying your stereo system—and then the telephone rings, or someone comes to the door. That requires you to get up, dash to the stereo to turn the volume down, and then dart to the phone or the door. The unit described here eliminates the problem. Merely turn the volume down on the control beside your armchair, then attend to the disturbance. The control also eliminates the constant getting up and down to raise the volume for your favorite pro-

grams. The remote balance control permits you to achieve perfect stereo sound, where you are in the listening area.

The remote-control unit takes advantage of the versatility of today's stereo components. It is connected between the preamplifier and power amplifier, or in the tape-monitor section—depending upon the configuration of your stereo system. The project can be built for about \$10.

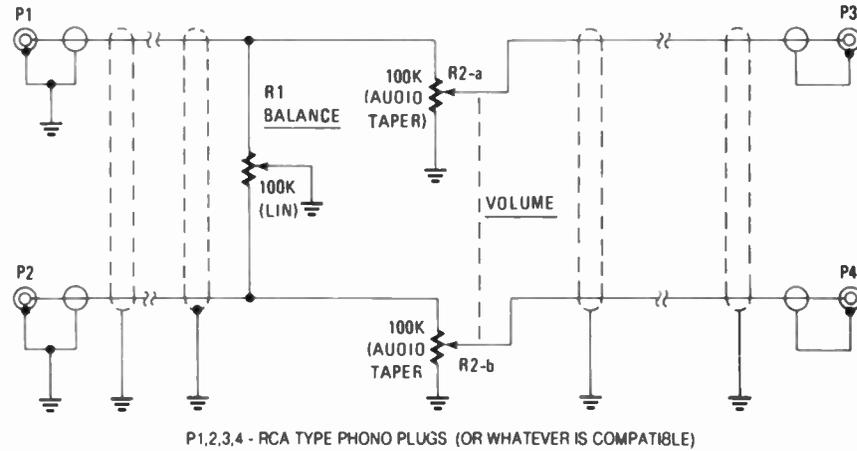
Both of the potentiometers used in the project were found in a potentiometer assortment obtained from a mail order outfit, although similar types can be purchased almost anywhere. An alternative

to the two potentiometers would be a joystick control wired with one side potentiometer used for each channel and the front or rear potentiometer to be used for the balance control.

The connecting cables used were two shielded two-conductor cables tied together. That turned out to be a quite flexible and compact bundle. The cables used were 15 feet long, but they could be up to 30 feet long without producing any drastic sound degradation. Be sure to terminate the stereo end of the cables in the proper connections.

The enclosure used for the project is a $2\frac{1}{4} \times 4 \times 1\frac{1}{8}$ inch plastic utility box. The aluminium cover was brushed and aluminium knobs were used to match the stereo system.

The performance of the remote control unit turned out to be quite good. The crosstalk is -62dB at 1 kHz and -55dB at 20 kHz. The frequency response was



P1,2,3,4 - RCA TYPE PHONO PLUGS (OR WHATEVER IS COMPATIBLE)

totally unaffected for all practical purposes. Some experts claim that it is less detrimental to the sound quality of the system to extend the lead length between the preamplifier and power amplifier than it is to extend the speaker leads of the

system.

That project has turned out to be an indispensable part of my stereo system and I am quite sure that it will be just as desirable for others, too, once they try it.

—Dennis Eichenberg

Simple Tesla Coil

I'M SURE THAT MANY READERS FOUND the article on the recreation of Tesla's original experiments by Robert Golka (see *Radio-Electronics*, February 1981 issue) very interesting. I know that I did, especially since I built a small version of a Tesla coil not too long ago (although I'm only age 14). I'd like to share the details with you.

There is one important thing to keep in mind before we even begin: The Tesla coil described here can generate 25,000 volts so, even though the output current is low, **be very careful!**

The main component of the Tesla-coil circuit is a flyback transformer. You can get one from a discarded TV.

The first thing you must do is to get rid of any excess wire or other debris that's on the transformer's core, as shown in Fig. 1. Leave the high-voltage winding alone; but if there is a capacitor at the end, it should be removed.

After that, you can start winding a new primary coil. Begin by winding 5 turns of No. 18 wire on the core. Then twist a loop in the wire and finish by winding five more turns. Wrap with electrical tape, but leave the loop exposed.

A four-turn winding has to be wound over the ten-turn winding that you've just finished. That is done the same way. First wind two turns of No. 18 wire, then make a loop, and finish up by winding two more turns. Again, wrap the new winding with electrical tape, leaving the loop exposed.

When the windings are finished, the two loops shouldn't be more than $\frac{1}{4}$ -inch apart (but take care that they do not touch). Connect a 240-ohm resistor be-

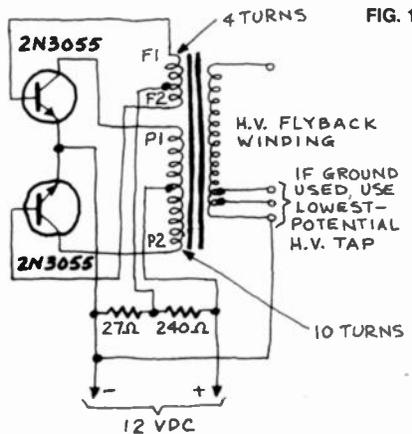


FIG. 1

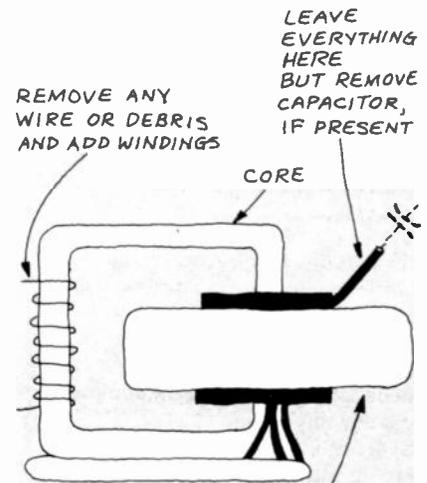
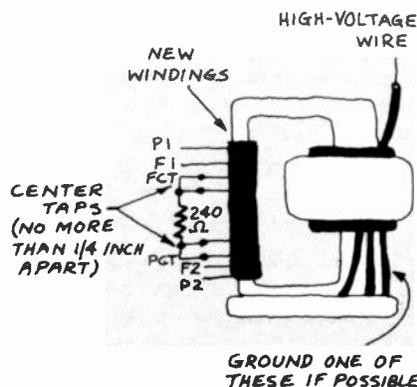


FIG. 2

FIG. 3

tween the two loops. The modified transformer now should look like the one shown in Fig. 2.

Connect the transformer as shown in Fig. 3. The 27-ohm resistor and the two transistors should be mounted on a heat sink and *must be insulated from it*.

The output of the high-voltage winding

should begin to oscillate as soon as the circuit is connected to a 12-volt DC power supply. If it does not, reverse the connections to the base leads of the transistors. In normal operation, you should be able to draw 1-inch sparks from the high-voltage lead using an *insulated* screwdriver.

—Eric Wold

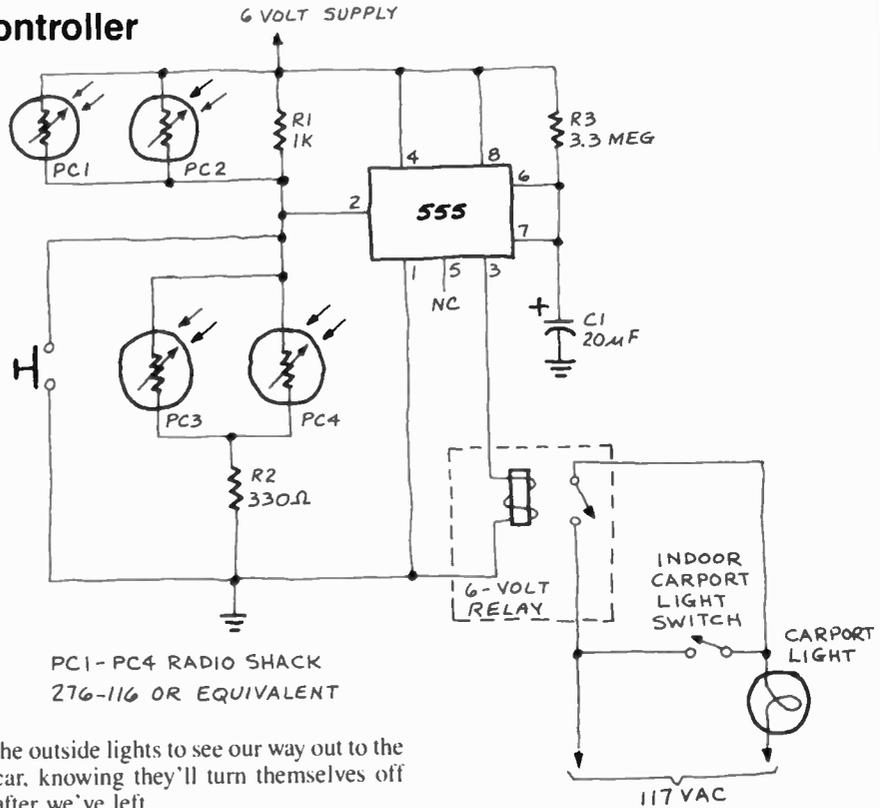
Carport Automatic Light Controller

MY WIFE WORKS EVENINGS AND GETS home well after dark. Because no one is at home to greet her upon her return, we used to leave the carport light on for many energy-wasting hours, just so she could avoid tripping over bicycles or stepping on the dog's tail when she returned in the evening.

To save my marriage—and conserve electricity—I devised the following circuit. It is simply a 555 timer IC, operating in the one-shot mode, that is triggered by light striking photoresistors. Those normally have a resistance of several megohms but, in the presence of light, that resistance drops to several hundred ohms, permitting current from the six-volt source to flow in the circuit. The R-C combination shown gives an on-time of about two minutes. Photoresistors PC3 and PC4 are mounted at headlight-height on the carport wall (one for each of our two cars).

Now, when my wife pulls into the carport at night, the headlights illuminate the photoresistor, and the timer starts. That actuates a relay, RY1, in parallel with the carport light switch, and the lights are turned on long enough for her to get safely into the house. The lights are automatically turned off when the timer's two minutes are up.

We also have a push-button switch mounted inside the house and, when we go out at night, that allows us to turn on



the outside lights to see our way out to the car, knowing they'll turn themselves off after we've left.

Photoresistors PC1 and PC2 are mounted on the outside of the house where they are in the sun much of the time. That keeps the timer from triggering during daylight hours. Resistors R1 and R2 establish the thresholds for proper on/off control.

My unit has been in service for over a year and has not given me any problems. I've also installed quite a few of them for friends, and they are pleased as can be.

All the components used are stock items.

—Ronald Picard

Meter Adaptor

MOST WORKBENCH-TYPE VOM'S HAVE A sensitivity of 20,000- to 30,000-ohms-per-volt and a reasonably high input-resistance on the higher voltage ranges. On the lower voltage ranges, however, the meter itself often loads the circuit heavily, and good accuracy on those ranges is a problem. The simple project described here can greatly reduce that problem. It increases the meter's input impedance considerably, and can be used with meters having sensitivities as low as 1000-ohms-per-volt.

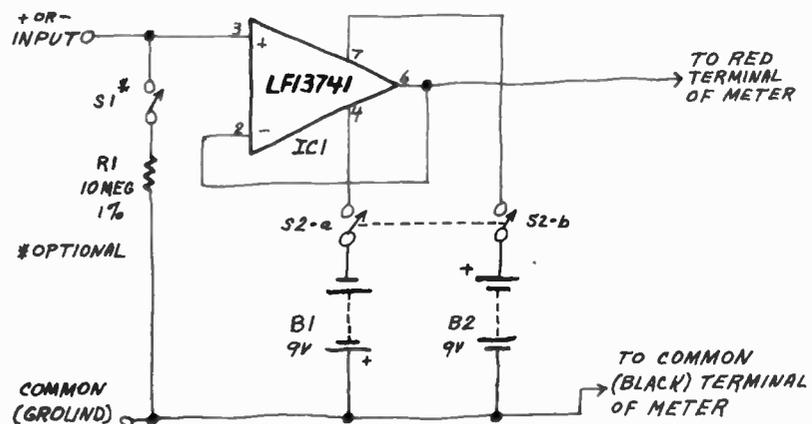
The heart of the unit is an LF13741 op-amp. That op-amp is a low-cost device (usually less than a dollar) that has a J-FET input circuit. When it is connected as a voltage follower, the gain of the op-amp is almost exactly one, but its input impedance at room temperature is nearly a million megohms and its output impedance is less than one ohm.

When two 9-volt batteries are used for the power supply, input voltages to ± 8 volts can be applied; the input-voltage range can be increased up to ± 18 volts,

the maximum rating of the op-amp, if four batteries (two batteries in series instead of one as shown) are used. Since the current drawn by the circuit is only about 2 milliamps, good battery life can be obtained using even standard-duty batteries.

As the offset voltage of the LF13741 is only about 5 millivolts, no offset trimmer is required; the offset terminals (pins 1 and 5) are left floating. Resistor R1 and switch

S1 are optional. If they are included, you will be able to switch from the op-amp's high-impedance input to a standard 10-megohm input simply by closing the switch; there is no need to disconnect the adapter from the meter. To keep things as simple as possible, the circuit has no input-over-voltage protection; be sure to keep the input voltage below the supply voltage of the op-amp. (more)



The adapter can be built by using any technique. The prototype was built on perforated construction-board; the op-amp was mounted in an 8-pin DIP socket. If you can't get (or don't want to use) the LF13741 op-amp, a standard 741 can be used.

In that case, the input impedance will typically be only 50 megohms, but that is still much better than the meter

itself. The 741 can be substituted directly for the LF13741, provided that the 8-pin DIP version of the device is used. Other J-FET input or standard op-amps can be used, but some changes in the circuit may be needed.

One thing that I did, that you may find interesting, was to build the adaptor so that it could be mounted directly onto the meter. To do that, use plugs that match the

input jacks on the meter as the adaptor's output terminals. Space them on the perforated board (or whatever else you used) so that they line up with the meter's input jacks. That will allow you to simply plug the adaptor into the meter, eliminating extra leads between the two for a much neater appearance. The test leads plug into the adaptor's input jacks.

—H.E. Fellhauer

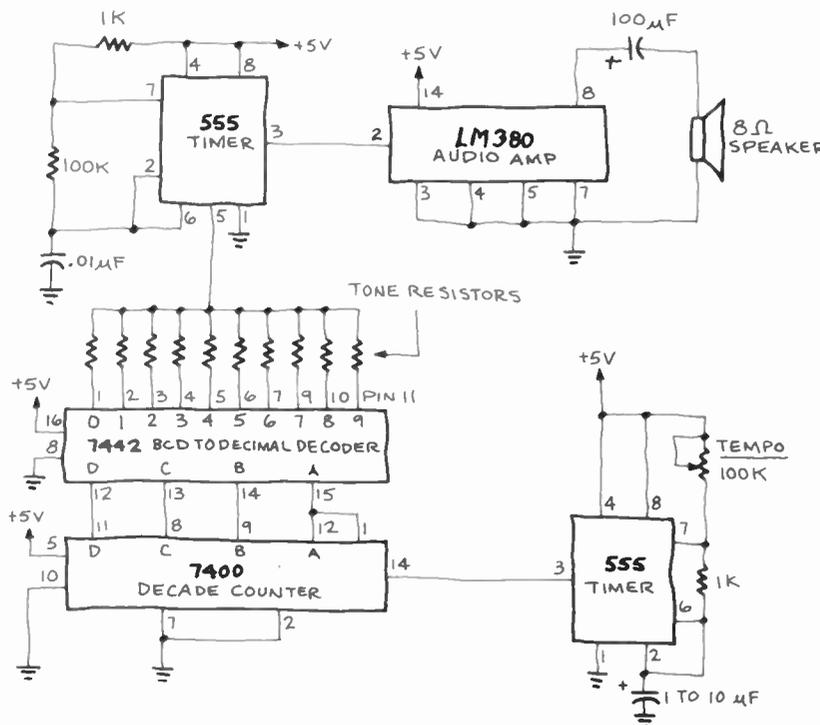
Music Maker

MY NEW IDEA IS A TONE SEQUENCER WITH a variable tempo. A 555 timer operated in an astable mode produces the tempo. The 555's output clocks a 7490 counter which then drives a 7442. The 7490 counts from 0 to 9 in binary and sequences the 7442 from 0 to 9. The 1 output of the 7442 goes low when its binary equivalent appears at the 7442's input. The 7442's output goes through some tone resistors to another 555, which is the tone generator. Its output goes to an LM380 amplifier IC and to the speaker.

Here is a way you can choose a set of fixed tone resistors for the circuit. Connect one outer terminal of a 1000-ohm potentiometer to ground. The center terminal of the pot is connected to pin 1 of the 7442. Turn the circuit on and as soon as a tone appears, deactivate the 555 clock by disconnecting pin 14 of the 7490. If you deactivate the clock circuit as soon as the tone burst is heard you can then start the programming procedure. When a fixed tone is heard from the speaker, rotate the pot's shaft until the desired tone is heard. Then disconnect the pot from the circuit and measure the resistance with an ohmmeter. You can then replace the pot with a fixed resistor. You then repeat the pro-

cedure for the rest of the outputs of the 7442 BCD to the decimal decoder chip. The original circuit was breadboarded

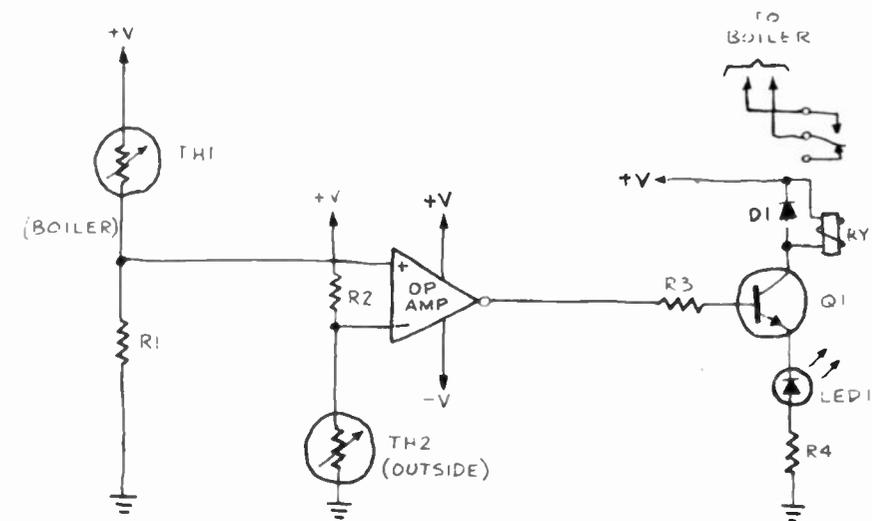
but any method of construction may be used to build a working device. —Mark Dittmar



Boiler Control

THE PURPOSE OF THIS CIRCUIT IS TO CONTROL the water temperature in a hot-water heating system. What it does is to lower the boiler temperature as the outside air temperature increases. For example, if the outside temperature is 0° (Fahrenheit), the boiler temperature would be 180°; if the outside temperature is 50°, the boiler temperature would be 140°, and so on. The result is a savings in fuel consumption.

The op-amp—almost any common type will do—is used as a comparator. Thermistor TH2 and R2 form a voltage divider that supplies a reference voltage to the op-amp's inverting input. Thermistor TH1 is placed outdoors, and the values of TH2 and R2 should be chosen so that when the outside temperature is 25° the resistance of the thermistor and resistor are equal.



Resistor R1 and thermistor TH1 make up a voltage divider that supplies a voltage

to the op-amp's non-inverting input. Thermistor TH1 is placed inside the boiler and

Frequency-Boundary Detector

I'M SURE THAT EVERY ELECTRONICS EXPERIMENTER or hobbyist, at one time or another, has needed a device that would indicate whether or not a signal was within a certain frequency range—I know I did when I was working with a switch-mode power supply. I got what I needed by building the frequency-boundary detector whose circuit is shown in Fig. 1. (The IC's supply and ground connections are shown in Fig. 2.)

The circuit can be used (with LED's or other indicators) to tell you whether or not an input signal is within a certain frequency range. Because you may be hard-pressed to come up with applications for the circuit, I should point out that voltage-to-frequency converters can be used to make the number of applications almost limitless.

The device itself is rather easy to build. It consists of three IC's—a dual monostable multivibrator and two dual D-type flip flops. The signal whose frequency is in question is fed to the clock input of one of the flip-flops. The \bar{Q} output of that flip-flop (IC-a) is cross-coupled to its data input so that it acts like a divide-by-two counter. (See the timing diagram in Fig. 3.) The trailing edge of the \bar{Q} output is used to trigger the one-shots formed by IC2.

The upper- and lower-frequency boundaries are determined by the two sections of IC2—the dual precision monostable multivibrator—and their external resistor-capacitor networks. The upper-frequency boundaries (f_1) is set by the output of IC2-a, and the lower-frequency boundary (f_2) is set by the output of IC2-b. The relationship that describes the periods of the outputs of IC2 is $T = \frac{1}{2}RC$, where T is

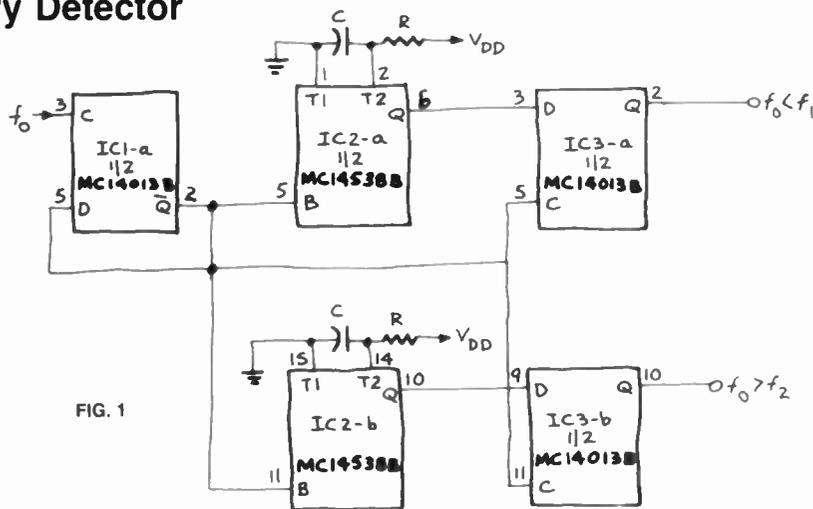


FIG. 1

measured in seconds, R in ohms, and C in farads. However, because IC1-a is used as a divide-by-two counter, the formula used to determine the period of the upper- and lower-frequency boundaries becomes: $T = RC$.

IC	PINS TIED TO V_{DD}	PINS TIED TO GROUND
IC1	14	4, 6, 7, 8, 9, 10, 11
IC2	3, 13, 16	1, 4, 8, 12, 15
IC3	14	4, 6, 7, 8, 10

FIG. 2

The frequency of the input to the circuit can be anywhere from DC to 100 kHz. However, you can use the "extra" half of IC1 as another divide-by-two counter and increase the circuit's range to 200 kHz.

Then the period of the outputs of IC2 would be represented by: $T = 2RC$.

The states of the outputs of IC2, which determine the upper- and lower-frequency boundaries, are latched by IC3-a and IC3-b respectively. As shown in the tim-

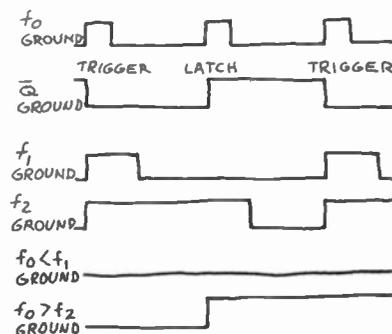


FIG. 3

ing diagram of Fig. 3, the output of IC3-a (which is clocked by the output of IC1-a) will be high only when the input frequency is less than that of the output of IC2-a (f_1). The output of IC3-b will be high only when the frequency of the input is greater than that of the output of IC2-b (f_2). You can use appropriate logic gates to give an "in-bounds" or an "out-of-bounds" indication.

—Jim N. Kitchen

the values of TH1 and R1 should be chosen so that when the boiler's temperature is 160°, their resistances are equal.

The output of the op-amp controls Q1, which is configured as a transistor switch. When the logic output of the op-amp is high, Q1 is turned on, energizing relay RY1. The relay's contacts should be wired so that the boiler's heat supply is turned on when the relay is *de-energized* and turned off when the relay is energized. An indicator, LED1, glows when the transistor conducts (Q1 is turned on), informing you that the boiler's heat supply is turned off (relay energized).

As the outside temperature increases, the resistance of TH2 increases. The higher the resistance of TH2, the higher the voltage applied to the inverting input of the op-amp. But as the temperature of the boiler increases, and the resistance of TH1

goes up, the voltage applied to the non-inverting input of the op-amp decreases.

Perhaps the best way to see how that works is with an example. If the temperature in the boiler is 160° and the outside temperature is 25°, the voltages at the non-inverting and inverting inputs of the op-amp are equal. As the boiler heats up, the voltage at the non-inverting input becomes higher than the voltage at the inverting input. That, of course, causes the op-amp's logic output to go high, energizing the relay. When the relay is energized, the boiler's heat supply is turned-off.

As the boiler cools off, and the temperature drops below 160°, the logic output of the op-amp goes low, de-energizing the relay, and turning on the boiler's heat supply. The boiler's on/off point is determined by the voltage at the op-amp's inverting input, which in turn is determined by the outside temperature. —Scott Buscy

Remote Telephone Ringer

HAVE YOU EVER MISSED AN IMPORTANT telephone call because you were in your basement or garage and didn't hear the phone ring? Or perhaps you heard it ring, but you heard it too late and, although you rushed as fast as you could, you couldn't get to the phone in time. And, even if the call is not important, missing it by a few seconds can be, to say the least, annoying.

Of course one solution to the problem

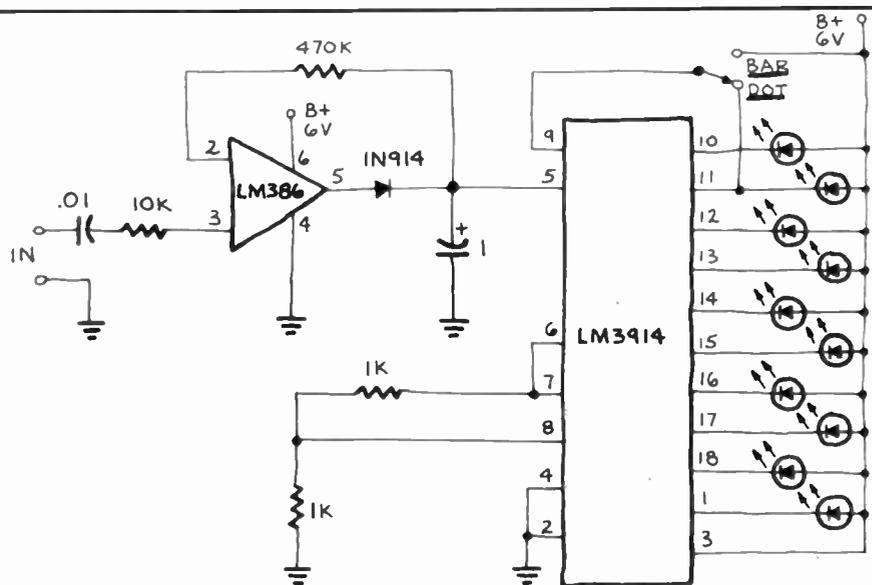
LED Peakmeter

I WOULD LIKE TO SUBMIT MY LATEST PROJECT to your New Ideas column. I call it the LED Peakmeter. It is a basic dot/bar readout built around the new national LM3914 display driver. The circuit also includes a peak detector that immediately drives the readout to any new higher signal level and slowly lowers it after the signal drops to zero. The readout is a moving dot or expanding bar display.

The diagram shows one channel of the stereo LED Peakmeter shown in the photograph. All parts are easily obtained and layout is not at all critical. Although not absolutely necessary, I suggest trying the circuit on a solderless breadboard before hand-wiring to check delay time and to match components in a stereo unit.

I used a spare piece of perforated board as a template to drill holes for the LED's in the project box's plastic front. A battery holder with four "C" cells is mounted on the back of the box.

The circuit has other possibilities. It can be expanded for a longer bar readout if desired. Tapping five or more LED Peakmeters into a frequency equalizer or series of audio filters should give a unique result. Physical layout of the LED's can also be changed to simulate the action of regular VU meters.



The bottom LED of each peakmeter thus providing a pilot light for the unit.

Wm. J. Cikas

the launch pad. Speaking of safety, that's the purpose of S2—it is there so that the launch circuit can be disconnected from the timer; disconnecting that circuit eliminates the possibility of an accidental launch.

Operating the launcher is very simple. Switch S3 is used to reset the countdown. Once that is done, pressing S1 starts the launch sequence; the rest is automatic. Switch S4 is used to latch RY1 manually if needed. That's all there is to it.

The circuit can be built on perforated construction board using point-to-point wiring. Assembly is very easy (incidentally, I'm only 13 and had very little trouble with it). As I said, with the values shown, the timing period is about 10 seconds; however, nothing in the circuit is very critical. Lead lengths should be kept as short as possible, however; if they get too long, oscillation may occur. To prevent that, C2 can be installed in the circuit as shown.

You can use any PNP transistor for Q1 and Q2, although the 2N404 seems to be a good choice. Switches S1 and S3 are normally open momentary pushbuttons. Switch S2 is DPDT, and S4 is SPST. The relays, RY1 and RY2, are SPDT. Radio Shack 275-004 or equivalent. The power source, B1, is 6 "C" cells wired in series.

—John Miles

VHF Tone Transmitter

I'D LIKE TO SHARE WITH YOU A SIMPLE, inexpensive and very useful circuit. Originally designed to generate horizontal bars on a TV screen to aid in vertical-linearity adjustments (test patterns are hard to find these days), the circuit is actually more useful as a RF signal generator that can be used for simple checks of TV and FM-radio RF, IF and AF stages. Its range is about 50 feet with a short whip antenna, but for most applications no antenna is required.

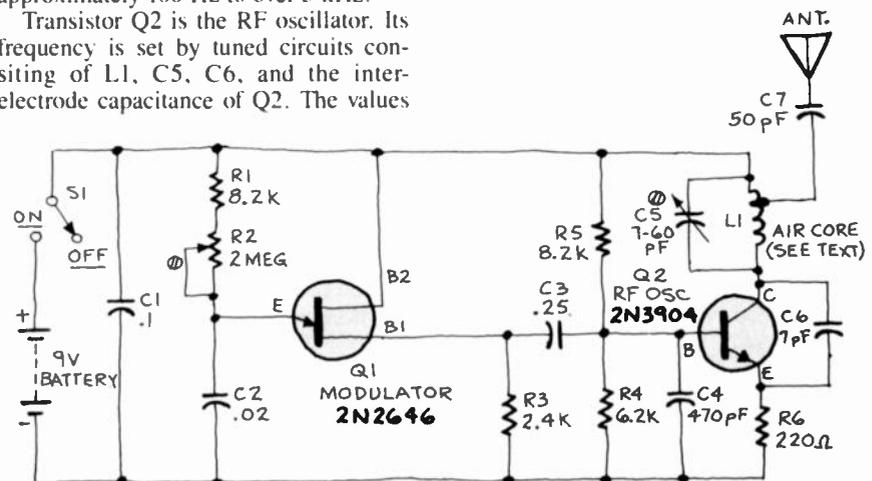
The first section, a tone generator, is made up of a unijunction transistor, Q1, and R1, R2, R3, and C2. Transistor Q1 pulses on and off at a rate determined by the time constant of R1 and R2, together with the capacitance of C2 and the B1-emitter junction of Q1. Trimmer potentiometer R2 determines the frequency of the tone generated and allows a range of approximately 100 Hz to over 5 kHz.

Transistor Q2 is the RF oscillator. Its frequency is set by tuned circuits consisting of L1, C5, C6, and the inter-electrode capacitance of Q2. The values

shown will give a tuning range of about 55 to 108 MHz. Capacitor C6 provides positive feedback from the emitter to the collector of Q2, for oscillation.

The audio tone generated by Q1 is applied to the base of Q2, causing the collector current to vary at the frequency of the tone, yielding an amplitude-modulated (AM) signal. This, in turn, varies Q2's collector-to-emitter capacitance (which makes up part of the tuned circuit) and causes the output frequency to vary similarly, producing a frequency-modulated (FM) signal, as well. The RF signal is coupled to the antenna through capacitor C7.

Most of the component values are non-critical. Q2 can be almost any silicon RF transistor, such as a 2N3904. (Note: depending on the transistor, the bias-resistor values may have to be changed to obtain



stable oscillation.) Capacitor C6 should be a silver mica type; all the others can be ceramic discs or paper. I used ½-watt resistors as a compromise between size and physical strength.

Tuning-capacitor C5 is a small trimmer. I used a mica trimmer in my prototype and soldered a short shaft (a machine screw with the head cut off) to its adjustment screw; doing that permitted me to attach a small knob for adjustment purposes.

Coil L1 consists of five turns of number-18 bare wire, close-wound on a piece of ¼-inch wooden dowel. The length of the winding is about ¼-inch. One end of capacitor C7 is soldered to the

coil one turn away from the nine-volt supply end (refer to Fig. 1) and the other end of the capacitor goes to the antenna. The circuit is easily built on a piece of perforated construction board that can be placed, along with the nine-volt transistor battery, in a small plastic box.

To adjust the vertical height and linearity of a TV set, place the tone transmitter near the set and use R2 to select the number of horizontal bars to be displayed. Once the picture is steady and the bars are sharp, adjust the set's vertical controls so that the bars are of the same height and are evenly spaced.

Be certain to tune the tone transmitter to an unused TV channel to avoid (illegal

interference with the reception of broadcast stations!

The fundamental tuning range of 55 to 108 MHz covers the lower TV channels and the FM broadcast band, but harmonics can still be detected—although more weakly—on the upper-VHF and UHF channels. The fact that both AM and FM signals are generated makes it possible to use this transmitter to check almost any receiver within its frequency range. A TV set's sound section (discriminator) will reject the AM portion of the signal, while its video section will respond to it. Similarly, the TV sound section, and FM receivers, will respond to the FM signal produced. —Robert M. Laskie

Sound-Activated Lamp Dimmer

MY NEW IDEA CONCERNS THE USE OF Motorola's MOC3011 opto-isolated triac driver. The triac driver consists of a LED and an optically coupled bilateral switch (better known as a DIAC). This device permits low-voltage control signals to control high-voltage, high-power loads. It essentially allows the user to create a solid-state relay for a fraction of the cost.

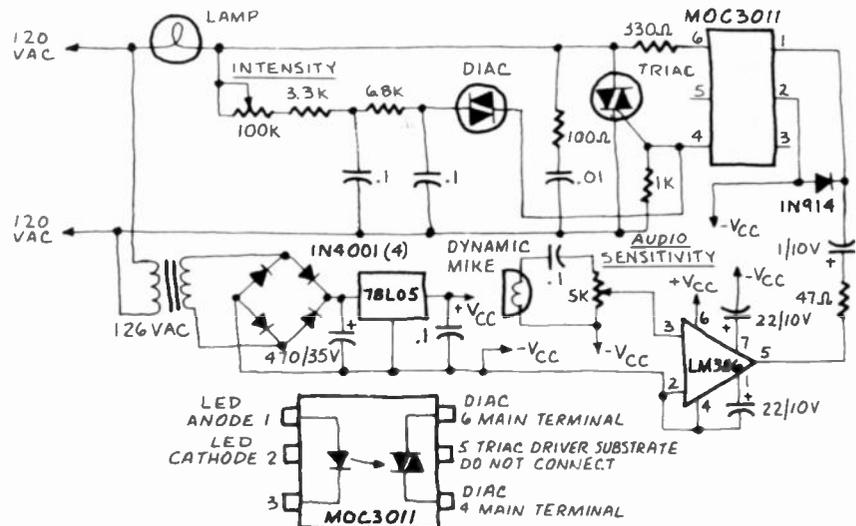
I wanted to make a simple and inexpensive device capable of sound modulating the intensity of a light source using a microphone built into the case. The device that I designed employs a conventional light dimmer circuit in addition to the sound activation circuit. The light dimmer may be used either independently of or in conjunction with the sound circuit. When used separately, the AUDIO SENSITIVITY control is set to minimum and the light dimmer is used in the conventional manner. When the light dimmer is activated by sound the 100K pot sets the minimum intensity that will remain in the absence of sound and return to after it has been triggered to full intensity by the sound section. This feature is made possible by the MOC3011. The signal that controls the triac in the light dimmer is so low that it does not harm the bilateral switch in the MOC3011. Furthermore, when the bilateral switch in the MOC3011 triac driver is triggered by the LED, it causes the triac to conduct fully and override the preset light dimmer setting.

The construction of the control unit is simple and straightforward, if circuit assembly is done using point-to-point wiring rather than a circuit board. Use **extreme caution** when wiring that portion of the circuit which is connected to the 120-volt power line. Be sure that during the wiring of the triac driver (MOC3011), no connection of any kind is made to pin 5. Set the microphone element into a hole drilled in the top of the case and secure it with a silicon rubber compound. The audio gain and light dimmer controls were placed near the microphone element to allow adequate

separation between the low-voltage section and the 120-volt power control section. A chassis-mounted power socket was used as a convenient way to make the device flexible in use. If a high-power load is anticipated, be sure that adequate heat sinking is provided for the triac.

In addition to using this unit to produce scary effects for Halloween and cause your Christmas tree lights to dance with the Christmas music, you can also use this device to produce unique DISCO lighting effects with just about any lamp in the house. Several units placed around the room create a wild effect and there is no required connection to a sound source.

—David L. Holmes



Sound-Activated AC Switch

WHILE LOOKING THROUGH SEVERAL REFERENCE books and periodicals for various switching methods, I not only found very little concerning sound-activated switches in general, but there was almost a complete absence of sound-activated switches that would directly switch an AC load. Switching on such a load is a fairly easy

problem that could be handled by a (mechanical) relay system. But I've found that it's just as easy to put together an inexpensive, reliable, non-mechanical sound-activated AC switch.

The circuit uses a 741 op-amp operating as an inverting amplifier. It amplifies the voltage produced by an 8-ohm speaker.

er. That speaker is used here to detect any sounds. The feedback resistor R3, a 1-megohm potentiometer can be used to vary the gain of the amplifier—it determines the sensitivity of the circuit.

When S1 is closed in the (SET position) and a sound is applied to the speaker, the silicon-controlled rectifier (SCR1) is turned on. It will remain in conduction until the anode voltage is removed by

Frequency-Counter Preamp

THIS EASY-TO-BUILD PREAMPLIFIER HAS made a great deal of difference with my frequency counter. Although my counter has a sensitivity of 25 mV, many signals from mixers, oscillators, and IF strips were too weak to get a stable readout on the counter. Some were so weak that I could not get any reading at all. By using the preamplifier with a short length of shielded cable and clip leads, signals that previously could not generate a readout at all generated precise and stable readouts on the counter.

With stronger signals, no direct connection is necessary—just placing the clip leads in the vicinity of the oscillator circuit results in a stable pickup!

The whole preamplifier is made with common junk-box parts and the physical layout is exactly as shown in the schematic (Fig. 1). The preamplifier and the battery fit inside a 2 × 2 × 4-inch aluminum box; the input and output cables enter from opposite sides of the box. The DPDT switch is used to bypass the circuit when amplification is not needed. And, of course, the LED reminds you to turn it off.

The preamplifier can also be used for many other purposes. For example, the unit was also tested as a receiver preamplifier and increased received signal strength about 6 "S" units at 30 MHz.

I also built a line tap so that I could measure the frequency directly at the output of a transmitter. The entire circuit for that consists of two diodes, one resistor

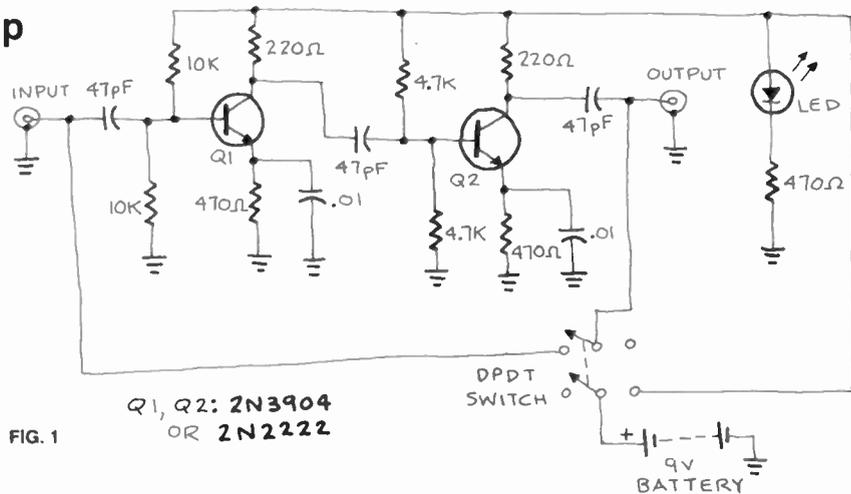


FIG. 1

Q1, Q2: 2N3904
OR 2N2222

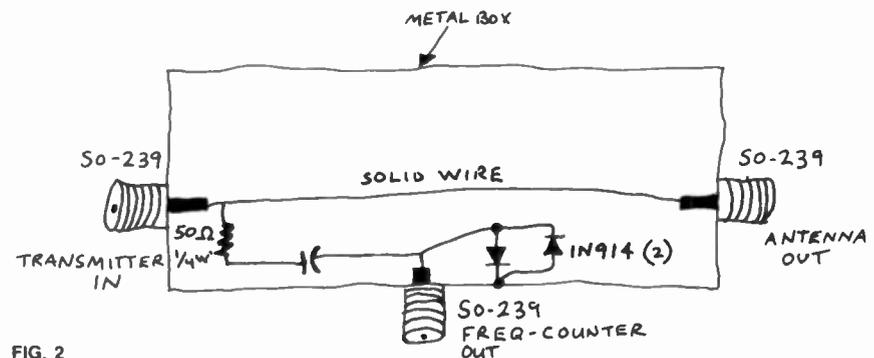


FIG. 2

and one capacitor, and is housed in a metal box as shown in Fig. 2. The line tap simply picks off a low-amplitude signal for measurement by the frequency counter. The antenna is still used as the load for

the transmitter.

The line tap can be connected to transmitters with an output power of between 1 watt and 250 watts. Connect the line tap as shown.

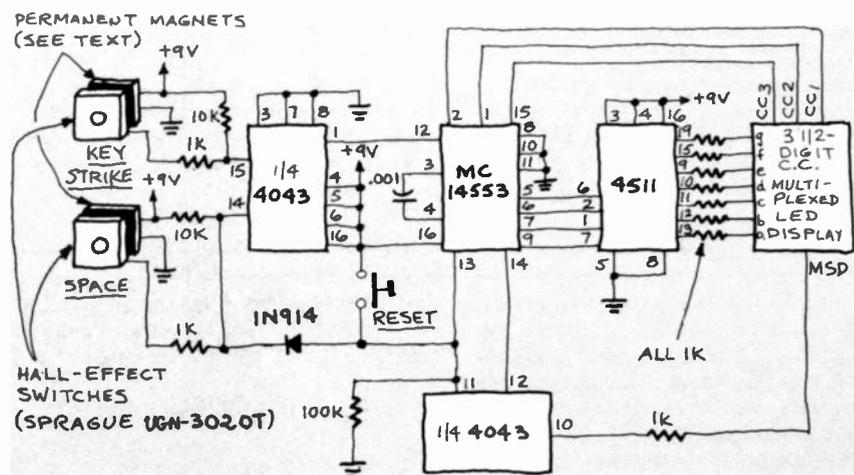
—John A. Crookshank

Typewriter Word Counter

HERE'S A PROJECT THAT CAN SAVE YOU some time when you need a manuscript of a specific length, such as for a school project, a classified advertisement, etc. It will keep track of how many words you've typed, and display the total. The circuit uses Hall-effect switches (Sprague UGN-3020T, or equivalent) to detect keystrokes and spaces.

The Hall-effect switches are sensitive to the presence of a magnetic field. In this project, permanent magnets are used to turn the switches on and off. When the magnet is near the switch, the output from the switch is logic 0; when the magnet moves away, the switch opens and, because of the 10,000-ohm pull-up resistor, the output goes to logic 1.

The switches are connected to 1/4 of a 4043 RS flip-flop. After the circuit has been reset, the output from that flip-flop is at logic 1. At the first keystroke, the output from the Hall-effect switch goes to logic 0, pulling the flip-flop's output to logic 0. The output from the flip-flop



drives the MC14553 three-decade counter. That counter is negative-edge triggered, so the transition of the flip-flop's output from logic 1 to logic 0 increments the counter. The counter's BCD output is then fed to the 4511, a BCD-to-7-segment display decoder/driver, which in turn con-

trols the 3 1/2-digit LED display.

Each subsequent key stroke is ignored until the space bar is hit. Hitting the space bar opens the space-bar Hall-effect switch, which in turn resets the RS flip-flop. Subsequent spaces are ignored until the next keystroke is entered, and the en-

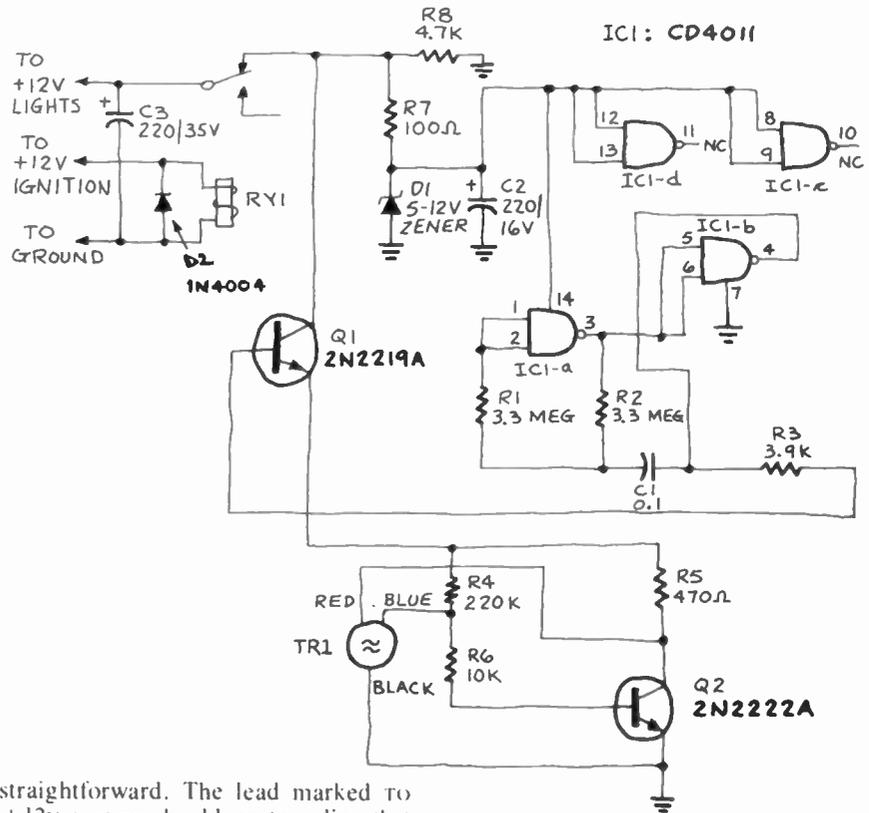
Headlight Alarm

HAVE YOU EVER FOUND YOUR CAR BATTERY dead because you had left your headlights on after shutting off the engine and walking away? Before long your battery is totally drained, and you have to start looking for a passing good samaritan or a service station. It is a frustrating experience, as you know if it has ever happened to you.

This circuit is designed to give off an alarm anytime that the lights are on but the engine off. The device is easy to build and almost any technique can be used. Installation is also simple and just two connections to your car's electrical system, and one to its chassis, are required for proper operation.

An SPDT relay, RY1 (Radio Shack 275-003 or equivalent), and diode D2 (1N4004 or equivalent) supply power to the rest of the circuit only when the headlights are on and the ignition switch is off. A circuit made up of R7 and D1 regulates the voltage to IC1. The IC is configured as an oscillator, and is used to supply pulses to Q1, which is used as a transistor switch. Each time a pulse from IC1 reaches it, Q1 supplies power to TR1's driver circuit (TR1 is a piezo-buzzer element, Radio Shack 273-064 or equivalent), sounding the alarm.

The connections to your car are fairly



straightforward. The lead marked TO +12V LIGHTS should go to a line that carries +12 volts whenever the headlights are on (the one for the dashboard lights is a good choice). The lead labeled TO +12V IGNITION should go to one of the lines that power the car's accessories (radio, cigarette lighter, etc.) Make those connections to any point that is easily accessible; typically that will be at your car's fuse box. The lead labeled TO GROUND can be made

to any convenient point that's connected to the car's chassis.

Of course there are times when you wish to use your headlights while the engine is off. All that needs to be done to silence the alarm in those instances is to turn the ignition switch to the ACCESSORY position.

—James Griggs

tire cycle is repeated. If the space bar and a key are struck at the same time, the flip-flop's output is logic 1, and the next keystroke increments the counter.

When the count reaches 999, the next negative transition will clear the counter but set its overflow high. That overflow output is latched by a second flip-flop, 1/4 of the 4043, driving the displays most significant digit (the 1 on the display) on. The procedure then repeats, for a maximum count of 1999 words.

For this circuit to work, the Hall-effect switches and the magnets must be mounted inside the typewriter itself. One switch and magnet should be mounted so that they are close together normally, but move apart when any key is struck. The second switch and magnet should be mounted so that they move apart when the space bar is hit. The switches and magnets are mounted using epoxy glue. Both sets of switches and magnets should be positioned so that the thick side of the switch (the side opposite the dot) is normally near the magnet's south pole.

You can power the circuit any way you wish. One good way would be to use a wall-plug transformer with a 9-volt battery. If you do that, you may want to devise a display blanking circuit to extend battery life.

—Larry Dighera

Battery Substituter Has Muscle

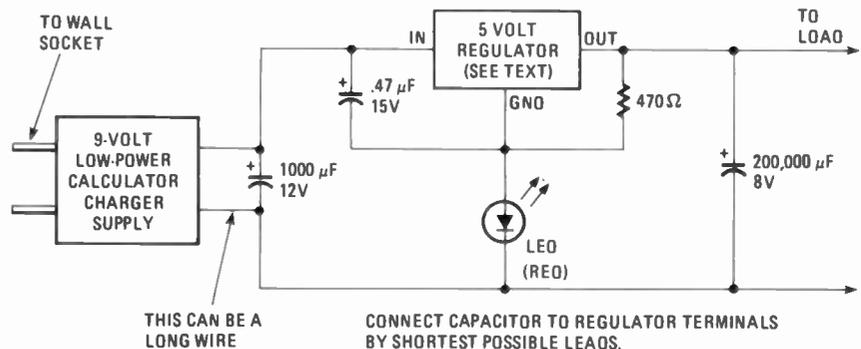
IT WOULD SEEM THAT BUILDING A LITTLE power supply to substitute for four flashlight (D cell) batteries would be a simple "handbook" job. Not so! The application in question is powering a widely-sold toy pinball machine.

The problem is that the bright bulb and electromagnetic counter draw an initial surge of about 4 amperes when the steel ball activates a scoring bumper. There are,

no doubt, other toys that suffer from the same problem. The pinball machine used up alkaline batteries at a rate that began to cost a significant part of the entire house electrical bill.

The problem *has* been solved, and I set up the following criteria for the design:

1. The supply should use a *safe* (U-L recognized) line-plug module as cal-



culators or small tape recorders using re-chargable batteries do. The idea was not to shock too many of our children, ages 4 through 14.

2. The supply should use an inexpensive and easily available regulator like the National LM340T-5.0 or the 7805-series voltage regulator available from several sources.

3. Despite using the commonly available 5-volt logic regulators, the supply should provide 6.3 to 6.5 volts.

To make the little, 100 mA-rated, calculator/charger supply provide 4-ampere surges required a minor reversal of design philosophy. Not only is the little charger-supply limited in power, but the plastic-packaged regulators that are easily available, are only rated for 1 to 1.5 amperes. Only three design tricks provide the solution.

1. Only moderate filtering on the regulator input (see the schematic) is needed, and fast recovery results.

2. Massive filtering on the output of the regulator is used (not the usual technique) to supply the surges. The three-terminal IC regulators are stable under these conditions.

3. A LED is inserted in the ground lead of the 5-volt IC regulator. This boosts its output voltage by about 1.5 volts, and provides a nice pilot-light as well.

Parts are not critical. The line-plug supply (transformer is part of plug) that I used had an open-circuit voltage of about 10 volts and could supply a little over 100 mA at 8 volts. [A power converter designed to supply 9 volts to small radios and calculators will do nicely.—*Editor*] The capacitors are also uncritical since none of the ripple currents are very high. I hap-

pened to use two 100,000-microfarad computer-type capacitors on the output because I could get them inexpensively. A number of smaller paralleled capacitors rated at 8 volts or more would certainly work well also. Surplus or junk-box devices would be quite suitable. The IC regulators must have current-limiting to avoid damaging the line-plug type supply with surges.

The battery-eliminator components can be placed wherever you can find the space. The location for the charger is obvious—in the wall receptable. I distributed the other parts around the pinball machine. The small capacitor and regulator are on a bracket on the back of the machine. The LED is glued into the front panel and the two 100,000- μ F capacitors are carefully insulated and then taped to the machine's back legs.—*Peter Lefferts*

Pool-Pump Timer

AS SUMMER TEMPERATURES GO UP, SO does the use of electricity. For those who own swimming pools, a large part of that increased electrical usage is caused by the swimming-pool pump. Although most pumps are set up to run continuously, that type of operation may be unnecessary.

The circuit described here is a pool-pump timer, or controller, that lets you run your pump for 15, 30, or 45 minutes out of an hour, rather than continuously. If you wish, the circuit can be disabled and the pump run continuously simply by turning the circuit's power switch to OFF.

The 555 timer IC is connected in the astable mode. Its output is adjusted by a potentiometer to give you a 2.27-Hz clock pulse. That clock pulse is applied to the input of the 4020, a 14-bit binary counter.

The differentiating circuit (C3, R3) resets the counter when the device is first turned on. After the 4096th clock pulse, pin 3 of the counter goes high and stays high until the 8192nd clock pulse. When that happens, pin 3 goes low again.

Using a clock frequency of 2.27 Hz, it will take about 30 minutes for pin 3 to go high and about 30 more minutes for it to go low again. The output of the counter is applied to one input of the 4011 NAND gate. To get the timing for the 30-minute "on" state, a logic "high" (12 volts) is applied to the other input of the NAND gate, and the gate's output is connected through R4 to the base of Q1.

To get the 15-minute "on" state, the logic "high" is removed from the input of the NAND gate and the output from pin 2 of the 4020 is connected in its place. When that is done, the output of the gate is high for 45 minutes and low for 15 minutes. To get the 45-minute "on" state, the output from the 15-minute "on" state is simply

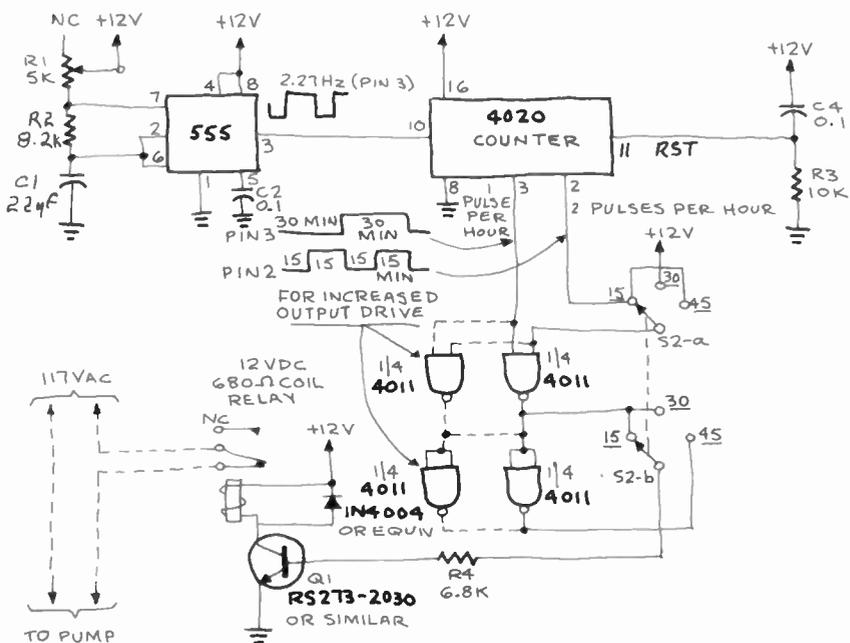


FIG. 1

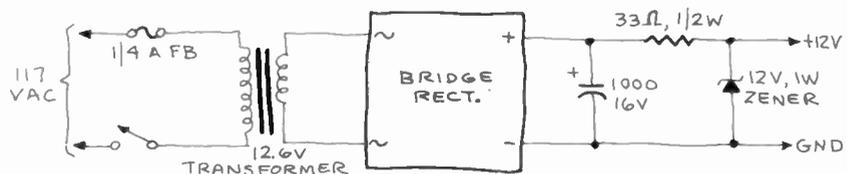


FIG. 2

inverted using a second NAND gate. Another pair of NAND gates may be used in parallel with the first if you find that more drive is needed.

The transistor switch, Q1, saturates when the input to its base is high. When that happens, current flows and energizes the relay. The pool pump is connected to the relay's normally closed contacts and is turned off when the relay is energized.

Construction is straightforward, and

any method can be used. Wire wrap was used to build the prototype. The only important point to remember is that the relay contacts must be capable of handling the current drawn by the pump. Any 12-volt power supply such as the one shown in Fig. 2 is advisable.

That's all there is to it. I'm sure that you'll find, as I did, that this circuit will make running your pool a lot less expensive this summer.

—*Tim Landreth*

Electronic Voice Substitute

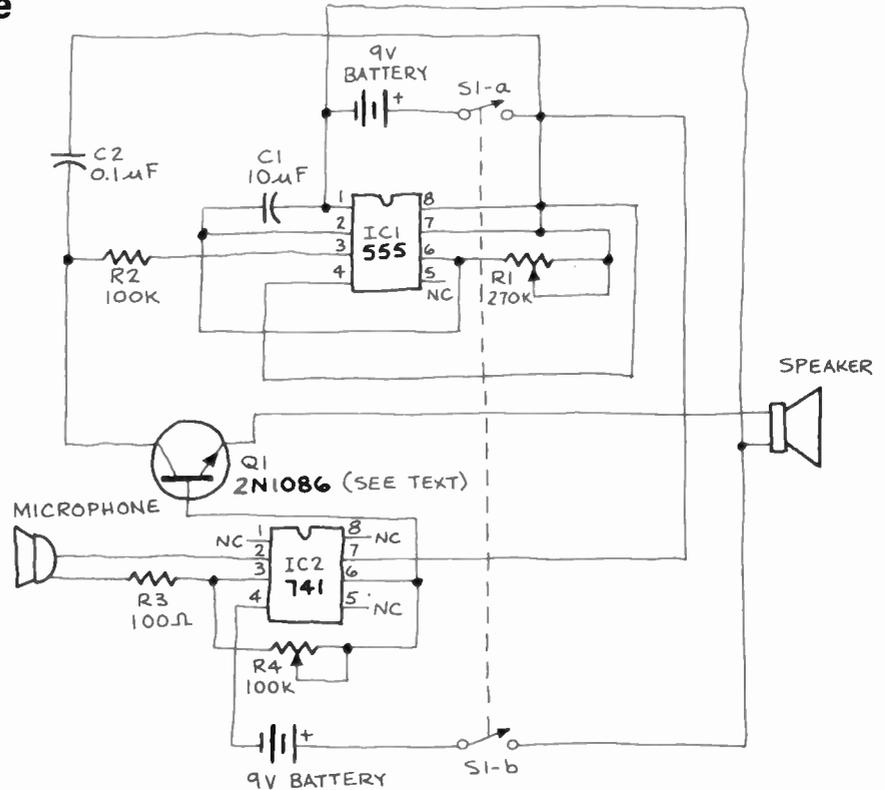
DID YOU EVER LOSE YOUR VOICE BECAUSE of laryngitis, or for some other reason? This device will give you a new "voice" of variable volume and pitch. It can also be used on Halloween, or other occasions, and it's a lot of fun just to play with, in order to see how many different voices you can create.

Your voice—or even a whisper—is amplified up to 1000 times by the 741 op-amp. That op-amp requires a dual-polarity power supply (positive and negative voltages of equal magnitude). Thus, it needs two 9-volt batteries. If you look carefully, you'll notice that two batteries are used for the 741 and that one of them is shared with the 555 IC.

If additional amplification is desired, as many op-amps as you feel are necessary can be added. Another option would be to use one of the many IC's that contain two or more op-amps.

The 555 acts as the tone generator, and it's configured in the astable mode. Its pin 3, square-wave output is transformed into a triangle wave by R1 and C2. The "voice's" pitch is controlled by R1.

Now we get to the heart of the circuit: Q1. Transistor Q1 can be a 2N1086, 2N1091, or any other equivalent NPN germanium-type such as a Radio Shack 276-2001. Sounds picked up by the microphone are amplified by the 741 and that IC's output drives the transistor to saturation. When the transistor is in the saturated state, the triangle wave is able to reach the speaker, and your new "voice"



is heard.

Unwanted noise may occasionally trigger your "voice" due to the high gain of the 741 op-amp. If this gets to be a problem there are several simple solutions you can try. One would be to use a higher-impedance microphone. Another would be to substitute a higher value for resistor

R3. A potentiometer may also be used so that the value can be adjusted to fit the ambient conditions. On-off switch S1 is a DPDT type.

Any technique can be used in building this circuit. I hope that the device will be useful or fun for you—or both!

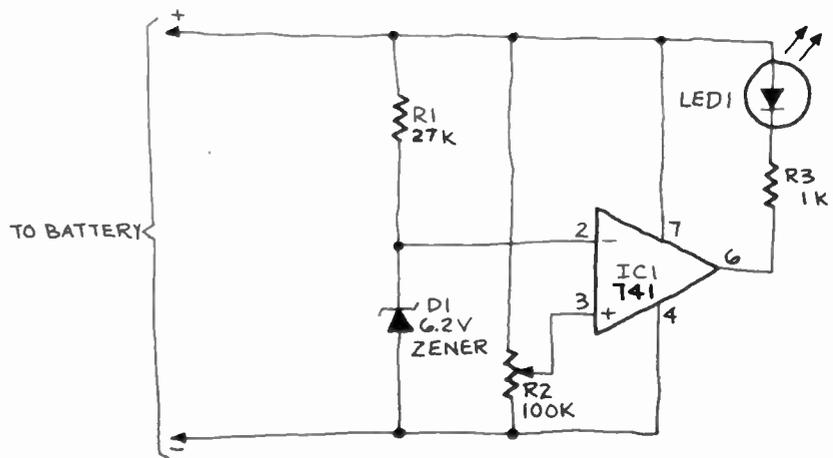
—J. Paul Sturgis

Low-Battery Voltage Indicator

TODAY MANY HOBBYISTS BUILD BATTERY-operated projects using highly efficient solid-state devices that ensure long battery-life. Even with those circuits, though, a need occasionally arises to make certain that the battery—which may have been in use for some time—is still in good condition. I use the low-battery voltage in several battery-powered special-effects devices for the theater, where it is crucial that everything operate when it's supposed to.

The low-battery voltage indicator uses an LED to signal when the battery voltage has dropped below a pre-selected level. It is easy to build, reliable, and inexpensive, and can be adapted for a wide range of voltages. The device shown is intended to operate in a 9-volt circuit.

The sensing circuit consists of a 741 op-amp set up as a voltage comparator, using a Zener diode as a voltage reference. The op-amp is inserted as a bridge between



two resistance ladders, one containing the Zener reference, and the other a high-value linear potentiometer. The Zener is connected to the inverting input of the op-amp, and the wiper of the potentiometer is connected to the non-inverting input. The top and bottom of the bridge are con-

nected to V_{CC} and ground, respectively.

When the voltage at the wiper of the potentiometer drops below the voltage set by the Zener, the output of the op-amp goes low; that turns on the LED connected between it and V_{CC} . The LED turn-on voltage is selected by the potentiometer;

the device can be adjusted most easily by applying to it the voltage at which you want the LED to turn on and adjusting the potentiometer until it just does so.

The indicator uses only six parts: R1 is 27K; R2 is a 100K linear potentiometer; R3 is 1K, and Zener diode D1 is rated at

6.2 volts; IC1 is a 741, and just about any LED will work. The device is easy to build and doesn't present much of a load to the battery it monitors—the version I use draws only about one milliamp when idling, and about 20 milliamps when the LED is lit.

The circuit can be adapted to work with battery-powered circuits requiring between 6 and 18 volts; the changes needed would be a lower-voltage Zener and smaller current-limiting resistor in the case of voltages below nine volts; larger, for higher voltages. —Donald F. Ricklies

Relay Multivibrator

AMONG THE EARLIER MULTIVIBRATORS, one of the simpler models was a device using two relays and one or more capacitors and resistors to control the timing cycle and operating frequency. When it comes to small size and speed, all is in favor of the solid-state electronic multivibrator.

However, from time to time we may need the simplicity of the relay multivibrator. Most circuits shown in literature use the charging of a capacitor to control the timing and one or more resistors to limit the discharge current so it won't damage the relay contacts. The circuit in Fig. 1 was developed around two relays and a single capacitor to perform the same tasks as the more elaborate circuits.

Circuit operation is as follows: When switch S1 is first closed, the C1 charging current activates relay RY1 and causes its normally closed contacts (RY1-1) to open.

When the C1 charging current falls below the hold-in rating of RY1, the relay releases and closes contact RY1-1. At that moment, the coil of RY2 is connected across C1. The capacitor starts to discharge and the discharge current energizes RY2 and causes contact RY2-1 to

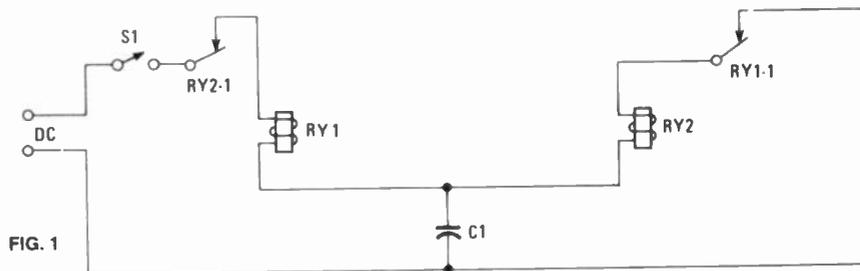


FIG. 1

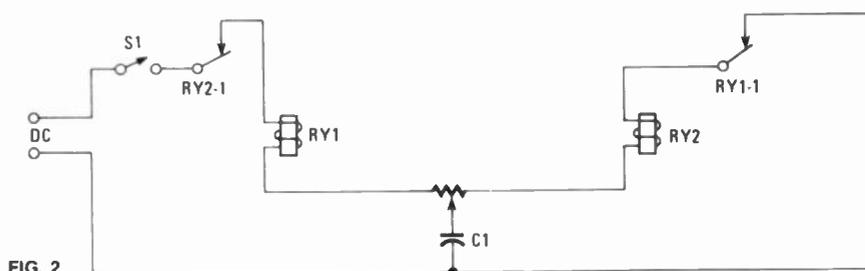


FIG. 2

open. When the discharge current drops below RY2's hold-in current rating, contact RY2-1 closes to start the cycle anew. The multivibrator will switch back and forth between the relays at a frequency governed by the capacitance of C1, the resistance of the relay coils, the applied

voltage, and the hold-in current of the relays. As the relays cycle, switching operations can be carried out as needed by auxiliary contacts on either or both relays.

A potentiometer can be inserted between the relays as in Fig. 2 so you can vary the cycling. —J. Ofer

Automobile Ignition Substitute

HERE'S A DEVICE THAT CAN HELP YOU find out what's wrong when suddenly one morning your car refuses to start. The ignition substitute described here can even be used to verify that repair work done to your engine by someone else has been done correctly.

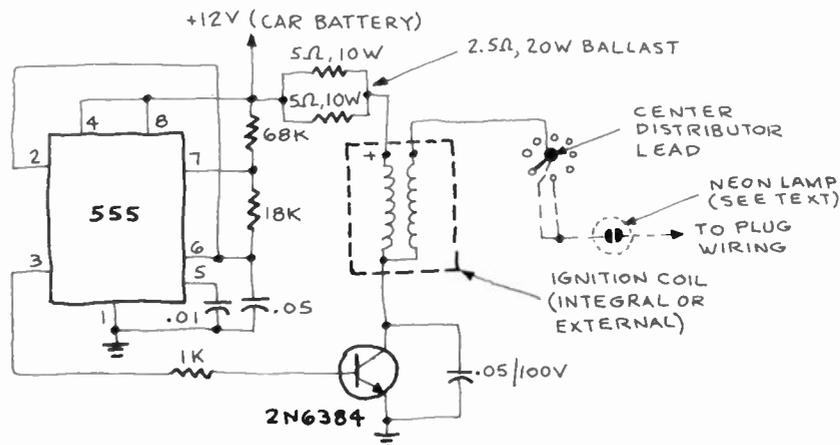
Basically, the ignition substitute provides a constant power-source for the ignition coil. Its frequency (0.5-1.0 kHz) is that used by an 8-cylinder engine with an idling speed of 650 RPM, and the unit provides a rapid spark at a 17% duty cycle, while nonetheless staying within the power-dissipation limits of the components.

Construction is straightforward, and any method can be used. The circuit consists of a 555 timer IC configured as an astable free-running multivibrator that is used to drive a high-current NPN transistor, such as a 2N6384. (That transistor should be heavily heat-sinked because it

may be drawing several amps over quite a long period of time.)

The coil ballast can be from 0.68 to 6.5 ohms, depending on what's available. The 2.5-ohm, 20-watt ballast shown in Fig. 1

works well. All the other resistors can be either 1/4- or 1/2-watt devices, and the capacitor between pins 1 and 5 of the 555 can range from 0.01 to 0.05 μ F. Do not omit the 100-volt, 0.05 μ F capacitor across the transistor; it prevents voltage spikes from damaging the device. Use 4-



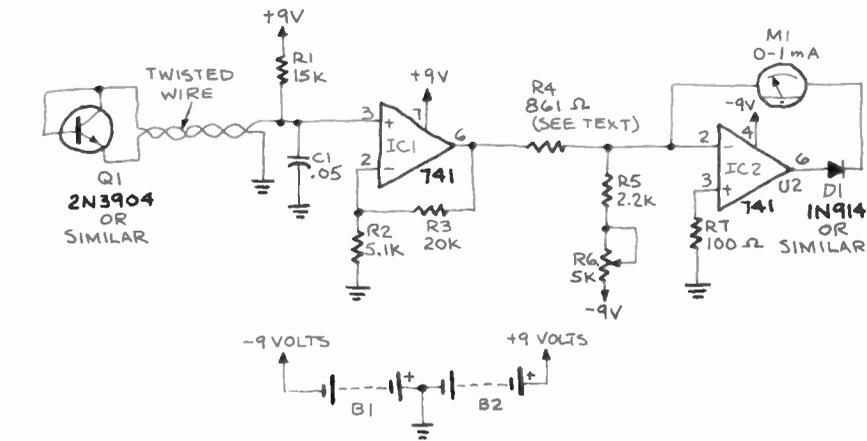
Electronic Thermometer

HERE IS AN INEXPENSIVE ELECTRONIC thermometer that can be built in just one evening. It is capable of measuring temperatures over a range of from -30°F to $+120^{\circ}\text{F}$.

The circuit operation is fairly straightforward. A diode-connected 2N3904 transistor forms a voltage divider with R1. The transistor is used as the temperature sensor and, for best results, should be connected to the rest of the circuit using twisted wire as shown. As temperature increases, the voltage drop across the transistor changes by approximately -1.166 millivolts-per- $^{\circ}\text{F}$. As a result, the current at pin 3 of IC1, a 741 op-amp with a gain of 5, decreases as the temperature measured by the sensor increases.

A second 741 op-amp, IC2, is configured as an inverting amplifier. Since pin 3 of that IC is grounded, pin 2 is at a virtual ground and the sum of all currents into that pin must be zero. Resistors R5 and R6 are used to calibrate the circuit. Once R6 is adjusted (more on that later), the current flow through those resistors will be constant. At a temperature of about -30°F , the current through R4 (that resistor is formed by connecting a 910- and a 1600-ohm resistor in parallel) should equal the current through R5 and R6.

At higher temperatures, the current through R4 will be less than the current through R5 and R6. Since the sum of the currents at pin 2 of IC2 should be zero, current will be drawn from the output (pin 6) of that IC to offset the difference. That current must pass through M1, and the amount of current drawn is, of course, measured by the meter. As the relationship between the amount of current drawn and the measured temperature is linear, it is relatively easy to calibrate the



meter to indicate measured temperature.

If the temperature goes below -30°F a reverse current will be generated. As that reverse current is undesirable, its flow is prevented by inserting D1 into the circuit as shown.

Calibration is also straightforward. When properly done, a temperature of -30°F will result in a meter reading of 0 milliamps, while a temperature of 120°F will result in a meter reading of 1 milliamp. Divide the scale between those points into equal segments and mark the divisions with the appropriate corresponding temperatures. Note that dividing the scale into more parts will result in greater accuracy; if you divide it into 150 equal segments, for instance, each division will equal one degree. The calibration is completed by placing the sensor in an environment with a known temperature, such as an ice-point bath. The ice point of water is approximately 32°F . That is the temperature at which water and ice can co-exist in the same container. To prepare the bath, place water and ice in a

large glass beaker or similar container, wait a few minutes for the temperature of the bath to stabilize, and verify that the temperature is indeed 32°F using another thermometer that is known to be accurate. Then, simply place the sensor in the bath and adjust R6 until you get the correct meter reading.
 —David McNeill

Use a Clock Radio as an Appliance Controller

DO YOU THINK THAT YOUR CLOCK RADIO should do more than just turn on its tiny internal radio (if its radio still works!)? Well, I have a solution. With this easy modification, you can use the clock to turn on any device of your choice automatically. If you are a heavy sleeper who doesn't usually wake up when the alarm rings, you can use this modification to "customize" your alarm to turn on lights, sirens, or anything else that may help you wake up more easily. As an added feature, a three-conductor cable allows you to remotely control one or two sets of devices.

I should point out right away that you do not have to cannibalize a clock radio that you are satisfied with. Many surplus outlets (many of which advertise in the back pages of **Radio-Electronics**) offer the clock "guts" from clock radios. However, if you have a clock radio without a working radio, then this sure beats throwing it out!

The circuit for the modification is fairly simple. We'll start with S1 and S2 which are the remote-control switches that are mounted at the end of the three-conductor cable. When one of those switches is closed, it will set its half of the flip-flop made up of IC1-a and IC1-b. That causes the output of IC2-b to go high, which, in turn, enables either IC1-c or IC1-d. That causes one of the relays to turn on, which drives one of the triacs that power the output sockets. (However, if you close

foot-long clip leads to obtain power directly from the automobile's battery; that length is suggested for convenience.

You can use either your car's own ignition coil, or a separate one. If you choose the latter, be sure to disconnect the one in the vehicle. A good coil will produce a spark between the high-tension lead and ground about $\frac{1}{4}$ - to $\frac{1}{2}$ -inch long, and a strong bright spark across a plug with a gap smaller than 0.040-inch. That, by the way, is the first test for ignition problems.

To determine whether there's a problem with the car's distributor, supply a spark derived from the ignition substitute to the center distributor lead leading to the rotor and slowly rotate the distributor cap. Crank the engine and, at some point, the engine should catch and run. If the engine cannot be started, but seems to be trying to, the problem is probably in the timing

chain, valves, camshaft, or elsewhere. If the engine doesn't even try to start, inspect the rotor, cap, wires, and plugs for damage. Once the ignition problem has been found and corrected, the normal procedure for setting the timing and dwell should be followed.

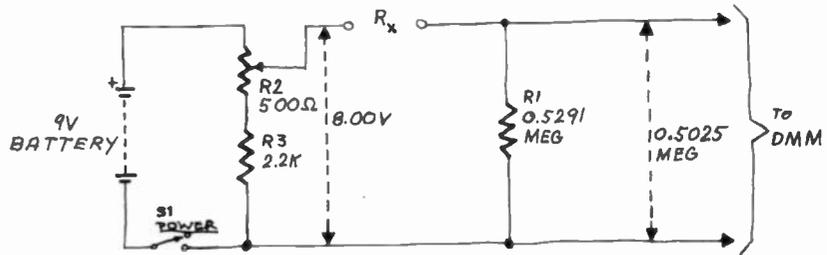
Do not attempt to adjust the distributor using the ignition substitute. That cannot be done because the spark the substitute produces is slightly different from that produced under normal conditions.

Although designed for an 8-cylinder engine, this device can be used with other types. In addition, a neon bulb can be added to the circuit to verify the presence of a spark, and, in fact, can be used as a timing light if placed close to timing marks that have been painted white with fingernail polish. —Stan K. Stephenson II

DMM Add-On

ON MOST DMM'S, THE HIGHEST RESISTANCE range is 20 megohms. But if you need to read higher resistances you are usually out of luck. Here, however, is a simple add-on for your DMM that can solve that problem. The meter readout will have to be converted to read the resistance, but that's relatively easy to do, especially if you have a calculator.

In the circuit, the voltage from a 9-volt battery is dropped across a voltage divider. Potentiometer R2 is adjusted so that the divider's output is exactly 8 volts. The odd value of R1, 0.5291 megohms, was chosen so that the parallel combination of it and the 10-megohm input impedance of the DMM equals 0.5025 megohms. If that is done, a 100-megohm resistance will result in a midscale reading on your meter (more on that later). As R1 is a non-standard value, it is formed by connecting either precision or selected 200K and 330K resistors in series. Note that the input impedance of some DMM's is not 10



megohms. If yours is one of those, R1 should be recalculated so that the parallel combination of it and the meter's input impedance is the same 0.5025 megohms.

In use, the R_x terminals are shorted, and R2 is adjusted so that the DMM reads 8 volts when the DMM is switched to the appropriate range. Then the short is removed, the unknown resistance is connected to those R_x terminals, and the DMM is switched to the 200-millivolt range. To find the resistance of the unknown, simply divide 4000 by the meter reading. The result is the resistance in

megohms, including proper placement of the decimal point. That's all there is to it.

Here are two notes that may come in handy:

When checking leakage resistance of large capacitors, be sure that the capacitors have charged up completely before switching to the 200-millivolt range. Otherwise, you'll be subjecting your meter to the rather high voltage caused by the charging current. Also, for best results, wait a few minutes after switching on the add-on before adjusting R2. That will allow the circuit to stabilize. —Don R. King

Low-Distortion Audio Limiter

SHORTWAVE LISTENING AND DXING IS without a doubt, an enjoyable hobby. However, it does pose a hazard to your ears—or to your peace of mind—because of the annoying loud-volume pops and

headphones not for your own benefit, but for the benefit of those around you.

I tried several ways to reduce the problem (for example, using FET's as attenuators) but I was unhappy because I was always trading one problem off for another: distortion. But I finally came up with a design that does what I want—it attenuates the blasts from my communications receiver while causing no noticeable distortion.

The level at which the audio limiter comes into action can be set with the LIMIT LEVEL trimmer potentiometer. When that level is exceeded, the output from the LIMITER-DETECTOR half of the op-amp (which is used as a comparator) causes the LED to light. The light from the LED causes the resistance of the photoresistor to decrease rapidly. That in turn causes the gain of the LIMITER half of the op-amp to decrease. When the signal drops below the desired limiting level the LED turns off, the resistance of the photoresistor increases, and the gain of the LIMITER op-

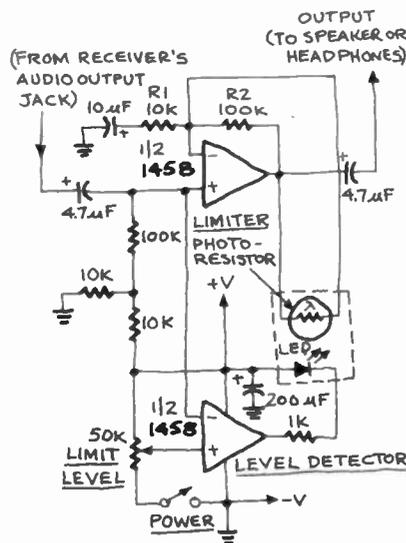
amp returns to its normal level—that set by the combination of resistors R1 and R2. A dual-polarity power supply (± 12 volts is desirable) is, of course, needed for the op-amp.

The circuit is very easy to build, and since the construction method is not critical, use the one you prefer. You might even want to mount the circuit inside your receiver. One important construction note, however, is that the photoresistor and LED should be encased facing each other in a light-tight enclosure.

The parts that you use are not critical either. One note here however is that the (cadmium sulfide, or CdS) photoresistive cell is most sensitive to light with a wavelength of about 5000 angstroms (or, approximately, green light). Therefore, you may want to use a green LED for best response.

Perhaps the best feature of the audio-limiter circuit is that it can be used with any receiver, whether it's a tube-type shortwave receiver or a new solid-state scanner. Your ears will thank you.

—Daniel Ulmer



blasts you're sure to hear from the communications receiver. Although the AGC (Automatic Gain-Control) circuits in communications receivers are supposed to take care of those sudden changes in volume, they never seem to do the job well enough. Those of you who wear headphones are especially vulnerable to the annoyance. What's especially annoying then is that you're probably wearing the

Plant Water Gauge

THIS PLANT WATER GAUGE CAN EASILY BE constructed on a small piece of perforated construction board. Its case is made from a piece of Styrofoam with a section carved out to hold the nine-volt battery, and a small recess is made into which the underside of the board is pressed. The probes are stuck right through the center of the

foam and glued in.

Assemble the gauge following the schematic in Fig. 1 and the drawing in Fig. 2. Be sure to tin the probes with solder to keep them from corroding.

To calibrate the gauge, connect the battery and press the probes gently into a pot containing a plant that is just on the verge of needing water (stick it in so that only an inch of the probe is left visible at the top).

Voltage Freezer

HAVE YOU EVER WANTED TO MEASURE THE voltage in a tight spot, only to find that before you could read the meter the test probe had slipped and you had to start all over? Having to hold the probe in place and read the meter at the same time is not only inconvenient, but if you slip, you can cause damage.

The circuit described here can solve that problem simply and easily. It reads and stores the voltage, thus freezing the meter reading even after the probes are removed.

The major component of the circuit is an 8-pin 741C op-amp. The op-amp is configured as a unity-gain voltage follower, with C1 at the input to store the voltage.

The circuit operates as follows: When a voltage is applied across C1, the capacitor charges to that value. When the voltage source is removed, the value is still stored in the capacitor, and can be read on the meter. While the capacitor *does* discharge, the process takes place very slowly due to the very low loading of the op-amp's high-impedance input. The meter is reset very simply: Just short the probes together; that discharges the capacitor.

Any type of construction can be used for the circuit, since nothing is critical.

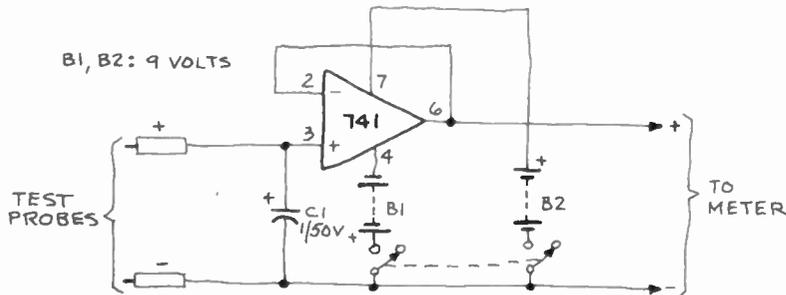
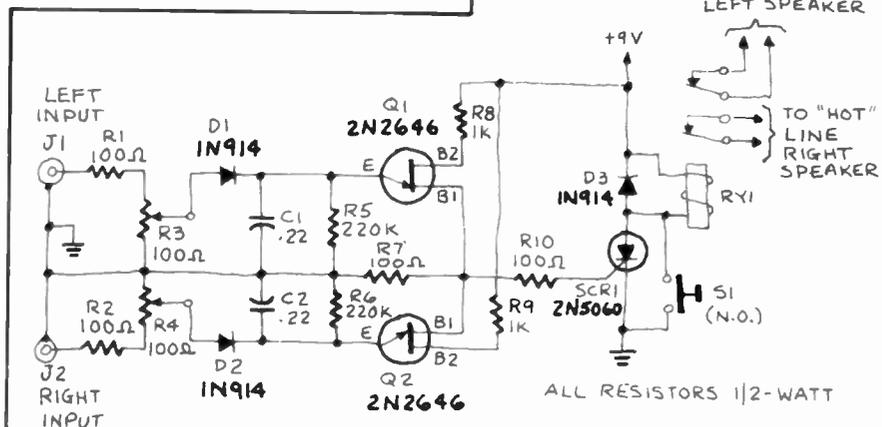


FIG. 1

Turn the potentiometer until the "OK" LED lights and then turn it back to the point where that LED goes out and the

The only thing you should bear in mind is to use a tantalum capacitor for C1, since it will hold a charge much longer than a relatively leaky aluminum electrolytic. Since no input protection is provided, keep the DC-voltage input below the supply voltage. A DPST switch turns the device on and off, and B1 and B2 are nine-volt transistor batteries. Finally, note that pins 1 and 5 of the 741 op-amp are fore offset null; as such those pins are not required for proper circuit operation and can be ignored. —Leonard Lee



in series with each speaker so that when the relay is *not* energized, the contacts are closed and the circuits between the speakers and the amp are complete.

The input to the circuit is taken from your amplifier's speaker-output terminals or jacks. If the right-channel signal is sufficiently large to charge C1 to a potential that is greater than the breakdown voltage of Q1's emitter, a voltage pulse will appear across R7. Similarly, if the left-channel signal is sufficiently large to charge C2 to a potential that is greater than the breakdown voltage of Q2's emitter, a pulse will appear across R7. The pulse across R7 triggers SCR1, a sensitive gate SCR ($I_{GT} < 15$ mA, where I_{GT} is the gate trigger current), that latches in a conducting state and energizes RY1. The action of the relay will interrupt both speaker circuits, and the resulting silence should alert you to the problem. Cut back the volume on your amplifier, then press and release S1 to reset the circuit and restore normal operation.

The circuit can be adjusted to trip at any level from 15 to 150-watts RMS. To calibrate, deliberately feed an excessive signal to the right input of the speaker protector and adjust R3 until RY1 energizes. Do the same with the left channel, this time adjusting R4. The circuit is now calibrated and ready for use.

—Willie Ward

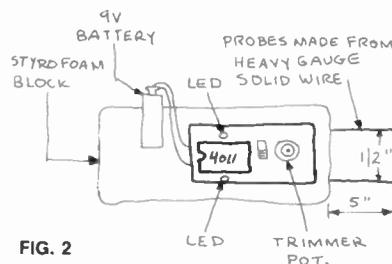


FIG. 2

"W." or "Water." LED just comes on. The device should now be properly adjusted.

Use this gauge anywhere for indoor plants and you will find it very useful in determining when to water and in preventing overwatering, since it reaches much farther down into the soil than you possibly can with your own fingers.

—Bob Mostafapour

Speaker Overload Protector

MANY OF THE LOWER-PRICED AMPLIFIERS available today do not provide any overload protection for your speakers. The purpose of the circuit shown in Fig. 1 is to remedy that shortcoming.

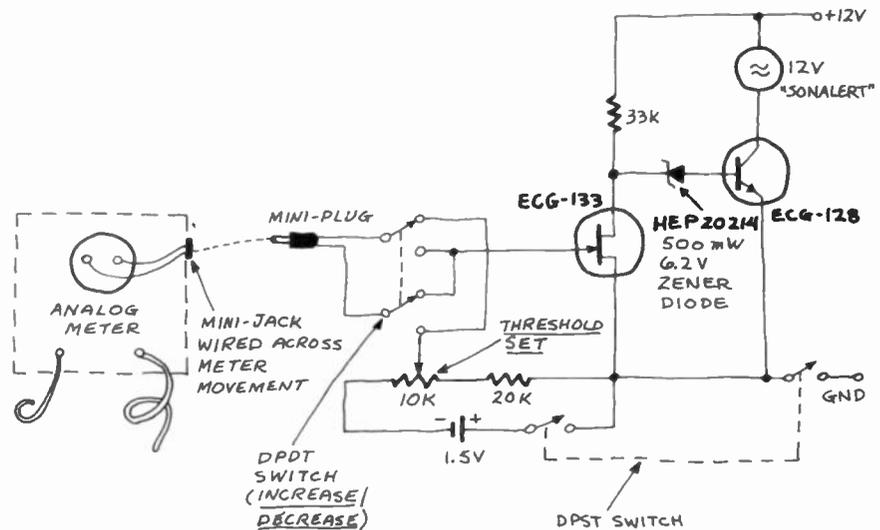
Relay RY1 is six-volt DPDT unit rated at 3-5 amps. One set of contacts is wired

Trouble Tone Alert

I DESIGNED THIS SYSTEM FIVE YEARS AGO for use in my service business, and it works great. I use it to look for intermittent problems on my bench. For example, if I had a color TV whose horizontal output current would go way up at unpredictable times, and I didn't want to sit by and wait for that to happen, I'd hook up the tone alert and let it tell me when the current increase took place.

The Trouble Tone Alert is intended for use with analog meters—just wire a "mini" earphone jack directly across the meter movement, plug it in, and you're all set. The high impedance of the alert keeps it from affecting the accuracy of the meter reading, because most meter movements are on the order of 1800 ohms and the input impedance of the alert is in the megohm range.

This device is as versatile as your meter, since all it reacts to is the meter-movement driving voltage. It will respond to a change in AC or DC voltage, current, or in resistance.



You tell the Trouble Tone Alert whether to look for an increase or decrease by means of the DPDT switch and adjust the threshold control until the tone from the Sonalert just disappears (with the meter in

the circuit being tested, of course). After that you can go about your business and wait for the alert to signal you when your intermittent problem has finally shown up.

—John J. Augustine

Automobile Locator

HAVE YOU EVER HAD TROUBLE FINDING your car in a crowded parking lot? If so, here's a device that will be of some help.

This automobile locator is made up of two parts. The first is an RF oscillator, whose circuit is shown in Fig. 1. The second is a sensitive receiver; that circuit is shown in Fig. 2.

The heart of the oscillator is a 555 timer IC. Its frequency—just below the AM broadcast-band—is determined by R1, R2, and C1. A tank circuit (C2 and L1) is used to tune the transmitter. The antenna is coupled to the transmitter through C3. Since efficiency is not very important here (output power should be kept under 100 mW), the length of the antenna can be kept short. A telescopic antenna or a length of hookup wire will work quite well. The only thing that is important is that the antenna be vertically polarized.

At the receiver, the income signal is tuned by C5 and L2 before being passed on to the 741 IC. That IC amplifies the signal up to 1000 times; the amount of amplification is controlled by adjusting R4, a linear-taper potentiometer (more on that later). The five LED's are used to indicate signal strength; they light up in order (1 to 5) as the signal gets stronger.

The 741 requires two 9-volt batteries for power. The positive terminal of one battery is connected to pin 7. The negative terminal of the other battery is connected to pin 4. The remaining terminals are connected together and grounded.

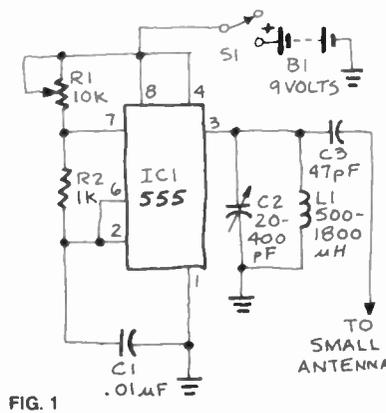


FIG. 1

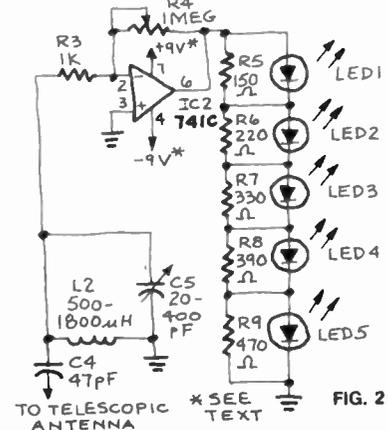


FIG. 2

After the devices are built, the receiver and transmitter will need to be tuned. Placing the transmitter and receiver next to each other, detune the receiver so that none of the LED's light. Then tune the transmitter until all of the receiver's LED's light, indicating maximum signal strength. Potentiometer R4 should be adjusted for the minimum amplification that will give you a usable signal. Too much amplification will give you a maximum-strength indication over too wide a range. Separate the receiver and the transmitter (the farther apart they are the better) and adjust R4 until you get a maximum strength reading only when the receiver's antenna is pointed directly at the transmitter. The RF locator is now ready for use.

Since the locator will not be able to work through the metal body of your car, you will need to set up the transmitter so

that the signal can radiate through a glassed-in area. That is really not much of a problem. If you are using a hook-up wire antenna, simply tape the free end to the top of either the front or rear windshield. If you're using a telescopic antenna, place the transmitter on the dashboard and extend the antenna so that it is as long as possible. In either case, remember to switch the transmitter on before you leave, and remember that the antenna should be aligned vertically for best results.

To find your car, just extend the telescope antenna to its full length and hold it parallel to the ground. Point the antenna to your far left, then swing it to your far right. Do that until you find in which direction the strongest signal lies, as indicated by the LED's. The antenna will be pointing at your car. —Doug Krause

Digital Combination Lock

THIS DIGITAL COMBINATION LOCK NOT only requires you to enter a specific seven-digit number, but to do it within a fixed period of time. Any mistake, and the lock automatically resets itself.

The sequence of numbers is entered either through a non-matrixed keypad (each key has its own set of contacts) or through a similarly arranged group of normally-open, momentary pushbutton switches.

A schematic of the circuit is shown in Fig. 1. To illustrate how the lock works, assume that the correct combination is "1234567." When the first digit is entered, via switch S1, IC1 is triggered and four things happen: The IC, wired as a one-shot, starts timing (duration is set by R1-C1) and is about five seconds as shown; the output of the IC goes high, the TIME LIMIT LED lights, and a pulse is output, through IC5-a, to IC2, a 7490 counter.

The counter, in turn, outputs the BCD (Binary Coded Decimal) equivalent of "1" to IC3, a 7441 BCD-to-decimal decoder/driver having ten outputs (see Fig. 2). When a BCD number appears at the inputs of the 7441, the appropriate output pin of that IC goes low.

"Coincidentally," the second switch in the sequence is connected across that output line, so when it is depressed, a negative-going pulse is applied to IC5-b, that inverts it. That "low" is NAND-ed with the "low" from IC1 by IC5-a, and a second pulse is sent to the counter. What happens after that is obvious.

Finally, when S7 is closed, the "6" pin on the 7441 goes low. That causes IC2 to reset and also triggers IC4, another 555 one-shot. Its duration is controlled by R2-C2 and during its "on" period, it lights the UNLOCK LED and activates a five- or six-volt relay. The contacts of the relay, in turn, can be used to control a solenoid-operated lock, a car's ignition circuits, an automatic garage-door opener, etc. when IC4 has "timed-out," (about 30 seconds,

using the values in the schematic) the relay opens.

The combination lock has several features intended to prevent its being opened by someone who does not know the proper combination. First, of course, is the time limit on entering the combination. Second, if any number is pressed out of sequence, the output line of IC3 will not go low, which means that even if the next key pressed is the correct one, no signal will be transmitted to IC5-b. Finally,

switches S8-S10 are connected so that if they are closed, they will reset the counter to 0.

Any seven-digit number, where no digit is used more than once, can serve as the combination. Just wire the switches so the first number corresponds to S1, the second to S2, etc.

In closing, a word to the wise—don't use your telephone number even if you have one without repeated digits! It's too easy for anyone to obtain and is probably one of the first things someone looking for a combination would think of trying.

—Tom Rezachek

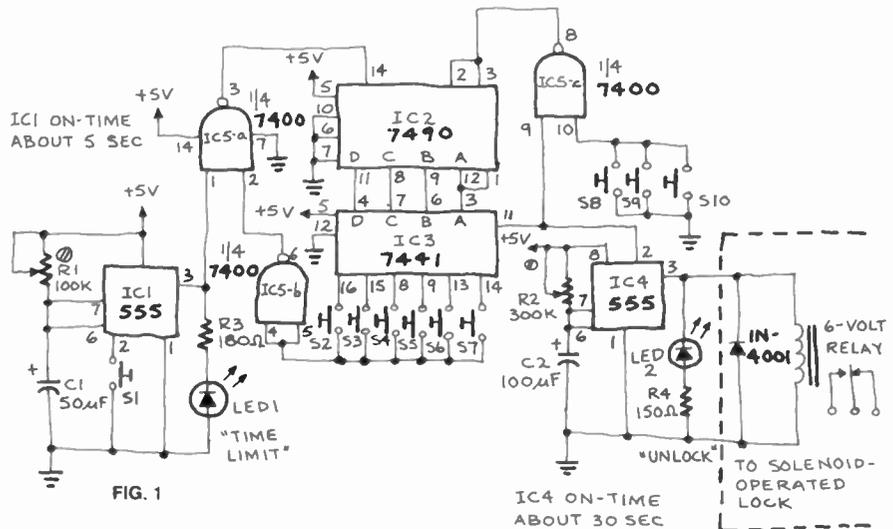


FIG. 1

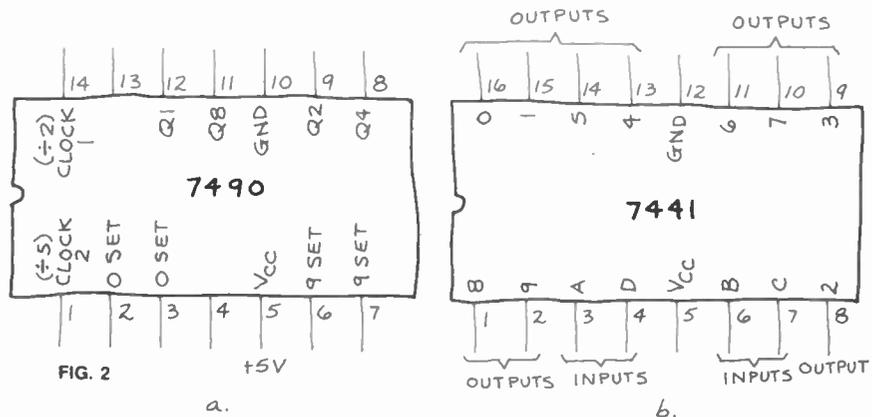


FIG. 2

Add-On Scope Multiplexer

HAVING A DUAL-TRACE SCOPE IS A LUXURY that many of us, unfortunately, must do without. However, with the simple circuit we'll describe, you can add dual-trace capability to your single-trace scope at a cost of less than \$5. Unfortunately, the device has one major drawback. It only monitors logic levels (TTL and CMOS); but at that price, who cares!

The multiplexing circuit that lets you view two traces simultaneously. The operation of the unit revolves around three IC's: a 4093 quad NAND Schmitt-trigger,

4066 quad analog-switch, and a 7555 timer (that is used to gate IC2-b and IC2-c on or off.)

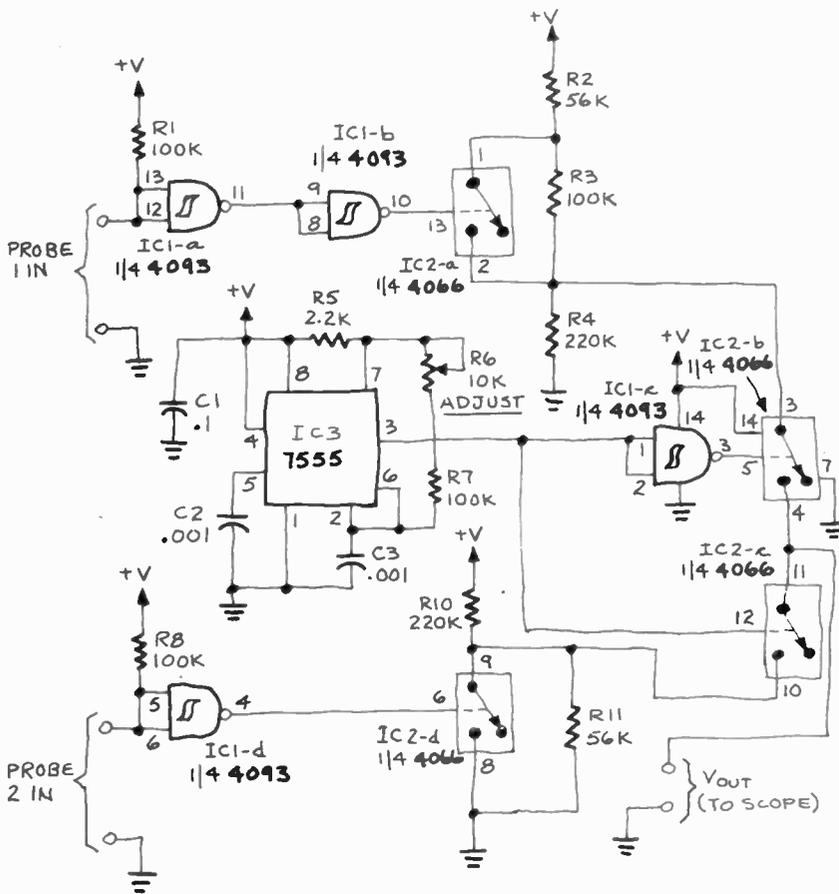
The device can be powered from a supply ranging of from 4.5 to 15 volts, and draws less than 2 mA. With a supply of 5 volts, the unit may be used to monitor TTL or CMOS logic-levels. At higher supply voltages (15 volts), it may be used to check only CMOS logic signals.

To make the operation of the unit a little easier to understand, we'll first look at the two input circuits separately and then see

how the switching action of the circuit is handled.

When a high is fed to PROBE 1 IN, it is inverted by IC1-a and once again by IC1-b, so that the input to IC2-a is high. That high causes the switch contacts in IC2-a to close. With the contacts closed, a high-level output is presented to the input of IC2-b.

Meanwhile, let's suppose that a high is fed to PROBE 2 IN. That signal is then inverted by IC1-d and routed to IC2-d, causing its contacts to open and the unit to output a logic-level high. The output of IC2-d is then fed to IC2-c. (more)



Unless a gating pulse is presented to both IC2-c and IC2-d, their contacts will remain open and no signal will appear at the output. We use the output from pin 3 of IC3 (a 7555 timer) to gate IC2-b and IC2-c. Note that the signal from IC3 is inverted before it is fed to IC2-b but not

before it is sent to IC2-c. Thus, the pulsing output from IC3 will alternately switch the display between probes.

Two voltage-divider networks determine the position that the trace is to be shown on the screen. Because we want to display both signals at the same time, the

high and low levels for one probe must be different from the high and low levels for the other probe. For INPUT 1, the divider is made up of resistors R2, R3, and R4, and for the other, R10 and R11.

The addition of R3 in the first voltage-divider circuit increases the voltage level of both the high-level and low-level inputs from probe 1. Thus, the probe-1 signals will be displayed at the top of the signals from probe 2. The probe-1 trace is displayed between the 3- and 4-volt mark, while the probe-2 trace is shown between zero and one-volt. That can be shown by the following formulas, which assume a high level of +5-volts.

Probe 1:

$$\text{High} \approx \frac{R4}{R2 + R4} (V) = \frac{220K}{56K + 220K} (5V) \approx 4V$$

$$\text{Low} \approx \frac{R4}{R2 + R3 + R4} (V) = \frac{220K}{56K + 100K + 220K} (5V) \approx 3V$$

Probe 2:

$$\text{High} \approx \frac{R11}{R10 + R11} (V) = \frac{56K}{220K + 56K} (5V) \approx 1V$$

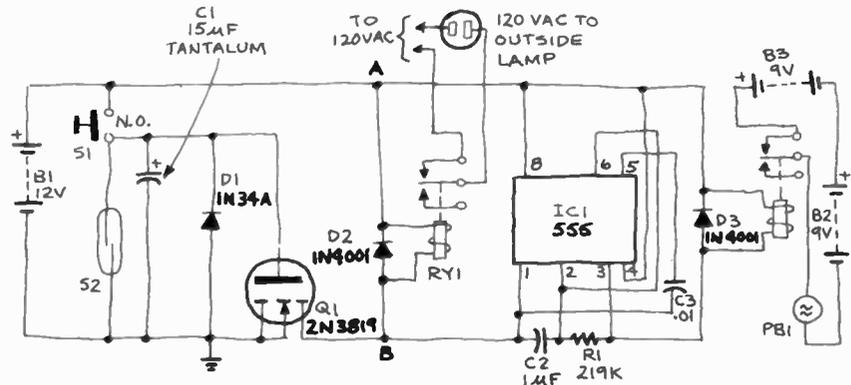
$$\text{Low} \approx 0V$$

With the scope set to trigger on one input, signals up to 50 kHz can be monitored. That makes the circuit ideal for low to medium speed logic-level inputs. Certain frequencies can cause garbage (harmonics of the sampling frequency) to be displayed; however, adjusting potentiometer R6 will correct that.

—Jeff Verive

Pulsating Doorbell

CONVENTIONAL DOORBELLS CAN OFTEN fail to get your attention. That can happen when you are in a remote part of your house, such as your basement or attic, or when there are other loud noises, such as when you are working with power tools. While it is possible to replace your doorbell with a loud, pulsating buzzer, such buzzers will pulsate only as long as the doorbell button is pressed. In addition, they can be rather expensive. However, as we'll see, there is a better solution by using a simple doorbell circuit that, when activated, will emit a loud, pulsating sound. The circuit is easy to build and uses readily available parts. Unlike other doorbells, this one will continue to sound for about 1½ minutes before it automatically turns off. An additional feature of the circuit is that it will automatically shut off if the door is opened before the 1½ minutes is up.



The operation of the circuit is centered around transistor Q1 (a 2N3819 general-purpose FET) and IC1 (a 555 timer configured as an astable multivibrator). The doorbell circuit is powered by two power supplies, 12- and 18-volts DC, made from several batteries. If you don't like the idea of using batteries, you can, of course, use

a DC power supply.

Capacitor C1 determines the on-time for the buzzer, while D1 provides a discharge path for that capacitor. When S1 (the doorbell button) is closed, C1 charges to the supply rail and a voltage is applied to the gate of transistor Q1, turning it on. Turning on Q1 provides a ground path for

Use Your Scope as a Capacitance Meter

THIS MONTH, WE'LL TAKE A LOOK AT A handy little circuit that allows your oscilloscope to be used as a precision capacitance meter. Basically, the device is an R-C oscillator and a wave shaper. The circuit consists of three IC's along with some resistors and capacitors.

The circuit shown is powered by a 7- to 15-volt DC supply. (A 9-volt transistor battery works just fine.) The supply consists of IC1 (a 78L05 voltage regulator) and two filter capacitors. Next, look at the oscillator/shaper circuit; that circuit consists of IC2 (a MC14541 oscillator/timer) and IC3 (a 74LS38 quad NAND buffer) along with some resistors and capacitors. There are several IC's that might have been used but those were chosen because of their availability.

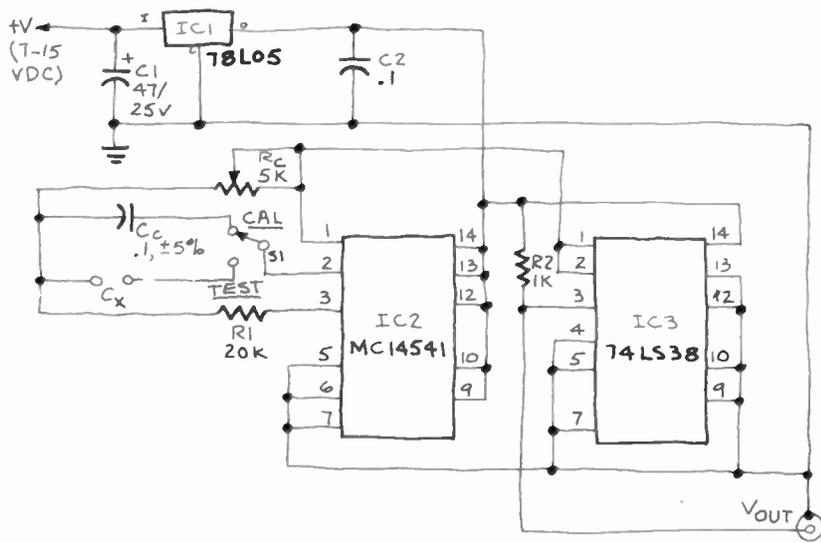
To calibrate the device, first connect your scope to V_{OUT} . Then put the CAL/TEST switch to the calibrate position and adjust the 5-kilohm potentiometer R_C until a 1-millisecond cycle is generated. That's it; easy, isn't it? The next step is to

try it out using a known-valued capacitor.

To find the value of the capacitor, simply connect the component leads to the points labeled C_X in the schematic. With the scope still connected to V_{OUT} , set the scope's attenuation to (typically) 2 volts. Now, adjust the sweep of the scope until you see 3 cycles or so on the screen. At that point, measure the time between two identical points on the trace (one complete cycle) and multiply that value by 100. That calculated value is the capacitance value in microfarads. It should be pretty close to the specified value of the capacitor. If so, you can now find the value of an unknown capacitor.

The precision of the device, as well as the value of the smallest capacitor it can measure, is limited by the scope and the calibration capacitor C_C . Typically, the device can be calibrated to 2% or better without difficulty by using a capacitor good to 1% or better. Those capacitors are generally more expensive, but we're sure you'll find that they're worth it.

—Jeff C. Verive



the rest of the circuit. With Q1 on, current flows and a trigger pulse is developed at the junction of C2 and R1. That trigger pulse is applied to pin 2 of IC1, causing it to begin the timing operation.

The output of IC1 (at pin 3) is used to turn relay RY2 on and off. Here, the output is used to sink current. When that output is low, current flows through the coil; when it is high, no current flows. As the output of the 555 is changing states rapidly, the relay contacts open and close repeatedly. The relay, of course, controls the sounding of the buzzer, so that it is continually being turned on and off, causing the pulsing effect.

When C1 has discharged (timed out), the gate voltage is removed and Q1 turns off, effectively opening the signal path and turning off the buzzer. But, as stated earlier, if the door is opened before that time, the buzzer automatically shuts off. That action is caused by S2. When the door is opened, S2 closes and shorts the charge on C1 to ground. That removes the Q1 gate-voltage and turns the transistor off, cutting off the path to ground. Switch S2 (Radio Shack 49-496, or equivalent) is a magnetic burglar-alarm type switch with normally open contacts (the type that's mounted recessed in the door frame).

Relay RY1 is optional; it's used to turn

Energy-Use Monitor

ENERGY CONSERVATION IS BECOMING increasingly more important, particularly when you're trying to save a couple of bucks—and who isn't? In fact, it is often with thoughts of energy conservation that we decide to get rid of an appliance and replace it with a new one. But replacing old appliances is not always worth the expense. The circuit described this month will allow you to monitor the time that an appliance—such as an old refrigerator with worn out insulation—runs. Then, with some simple arithmetic you can figure the kilowatt-hours used.

Multiplying the run-time in hours by the appliance load in watts (as printed on the appliance) will let you know the kilowatt-hours used. Armed with that information, it is a simple matter to figure your total cost (by multiplying the kilowatt-hours by the cost of electricity in your area. Now, let's take a look at the energy monitor circuit.

Besides having a low parts count, most of the components in the circuit are commonly available. Power for the circuit is provided by T1 (a 33-volt transformer) and diodes D4-D7 (1N4004), which form a full-wave bridge rectifier. The rectified AC voltage is filtered by capacitor C3. The LOAD and CLOCK sockets (SO1 and SO2 respectively) are connected to the primary of the transformer. One side of the line cord to socket SO1 is passed through the center of (handwound) coil L1 so that they are inductively coupled. (More about that coil in a moment.)

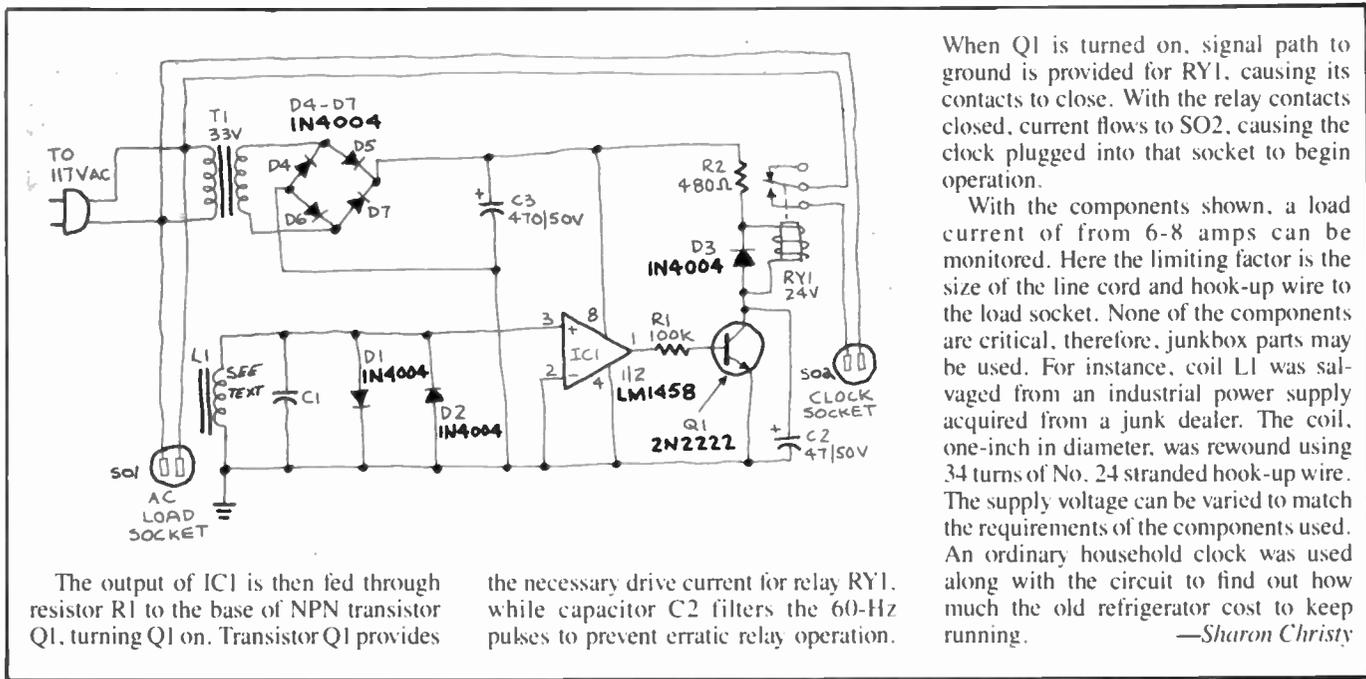
When an appliance is plugged into socket SO1 and power is turned on, a current is induced in L1. That creates a potential difference that is then applied to the input of the op-amp, IC1, causing its output to saturate. Because of the high open-loop gain of the op-amp, a few millivolts is all that is needed. Capacitor C1 and diodes D1 and D2 are used to protect the input of IC1.

(more)

on an outside lamp so that you can see the person that's at the door.

Relay RY1 is a SPDT 12-volt coil relay with 125-volt, 3-amp contacts (if you wish. Radio Shack sells a DPDT relay, 275-206, that is rated appropriately and can be used here; with that relay, one set of contacts is simply not used) and RY2 is a mini SPDT relay with a 6—9-volt coil and contacts rated at 1-amp at 125 volts (Radio Shack 275-004). To make RY2 operate properly, it is necessary to strip off 4 or 5 turns of wire from the coil tension spring to increase its tension. Transistor Q1 and diode D1 are general-purpose devices.

—Fred Jellison, Jr.



When Q1 is turned on, signal path to ground is provided for RY1, causing its contacts to close. With the relay contacts closed, current flows to SO2, causing the clock plugged into that socket to begin operation.

With the components shown, a load current of from 6-8 amps can be monitored. Here the limiting factor is the size of the line cord and hook-up wire to the load socket. None of the components are critical, therefore, junkbox parts may be used. For instance, coil L1 was salvaged from an industrial power supply acquired from a junk dealer. The coil, one-inch in diameter, was rewound using 34 turns of No. 24 stranded hook-up wire. The supply voltage can be varied to match the requirements of the components used. An ordinary household clock was used along with the circuit to find out how much the old refrigerator cost to keep running.

—Sharon Christy

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Farmingdale, NY 11735