9 IC PROJECTS

# 99 IC PROJECTS

by the Editors of Science & Electronics

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- Computer Accessories
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- Security Devices
- Original Games
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15

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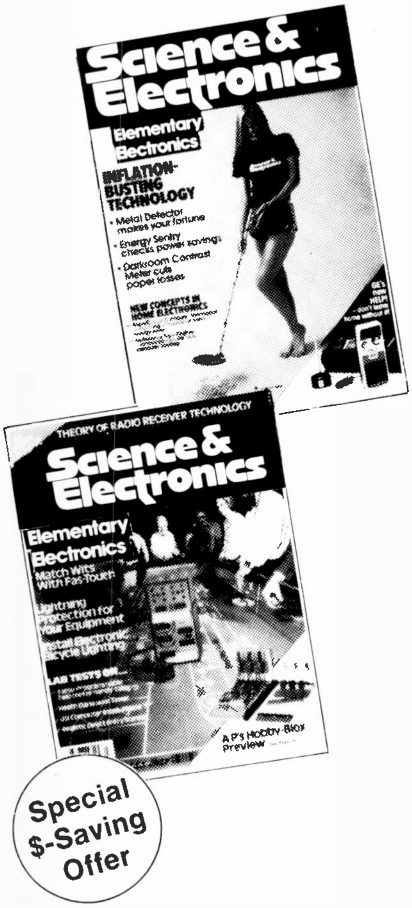
# SCIENCE & ELECTRONICS

## The Magazine of Science and Electronics




**Half a million readers know it, and enjoy it, as ELEMENTARY ELECTRONICS.**

Because it's the magazine that helps half a million electronics enthusiasts "do their thing"—whether it's radio, hi-fi, CB, the new electronic games, or projects for the home.

If you're turned on by the wires and the gadgets and the switches, knobs, cords and meters—and by the adventure of fixing and building with all these things—then you probably already know you can turn to ELEMENTARY ELECTRONICS for

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and so much more to give you hours of personal satisfaction in your electronics pursuits!

**And now it's growing . . .**

Because of the growing interest in science throughout the country—and because science is affecting electronics in such exciting new ways—we've decided to grow with it.

Nothing's being lost or even toned down—we're just *adding* a new element—SCIENCE. And changing our name to reflect the new mix. We're becoming

SCIENCE & ELECTRONICS

**What kind of science? (And what does it have to do with my favorite pastime?)**

Any science with wires in it! Because, whether you're aware of it or not, science is *already* affecting your efforts in electronics. For instance—just look at what a vital force the computer is becoming in our lives! (Hi-fi buffs—are you keeping up with the latest in digital recording? And those of you with Home Box Office—what about the way satellites are affecting TV viewing!)

You won't want to miss a thing that's happening! Keep up with new developments in science that will affect the technology in your electronics projects. Not to mention new developments in *electronics* that will affect *scientific* advances!

Some people are already calling the 80's "The Science Decade." We want you to be a part of it—and take advantage of all it has to offer you!

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When we plug in the Science, we're increasing the voltage to cover subjects like

- the new consumer computer information networks
- AM stereo
- computer voice synthesis
- music synthesis
- energy-saving electronics
- communications innovations
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SEE PAGE 7 FOR EXTRA COUPON

CHRIS HERRERA





CIRCLE 12 ON READER SERVICE COUPON

# New Products

### Record Care

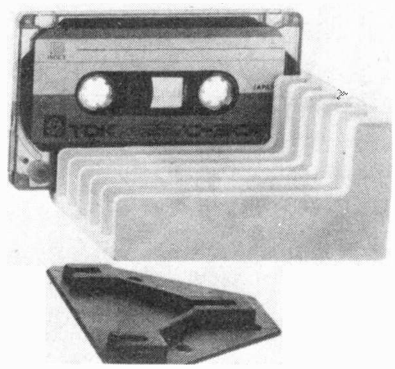
A three-piece Record and Stylus Care Kit from Cecil Watts record care line, is now being offered by Empire Scientific Corporation. Designed to introduce the record collector to this basic non-liquid system for record care, the kit includes the best-selling Parostatik®


CIRCLE 2 ON READER SERVICE COUPON

Disc Cleaner. Experts recommend a humid system for record cleaning because the free use of liquid cleaners can interfere with tracking. The Watts record cleaning devices are used in a semi-dry or slightly moist state and do not leave a film or residue on the record. The new three-piece Cecil Watts Record and Stylus Care Kit is the perfect record care starter kit. It is popularly priced at about $13.95 in audio shops nationwide. For more information, write to Empire Scientific Corp., 1055 Stewart Avenue, Garden City, NY 11530.

### Car Cassette Holder

Car accidents could occur when the driver fumbles for a music cassette. S & K Enterprises has a better idea with its Swan cassette holder that costs only $6.95 suggested retail. The holder's back plate bracket may be secured to the car dash—or anywhere in the home. The other part is the cassette holder that accommodates six cassettes. It can be locked into the bracket and then secured to the dashboard or elsewhere in the car or van within driver reach. The cassettes don't fall out. When

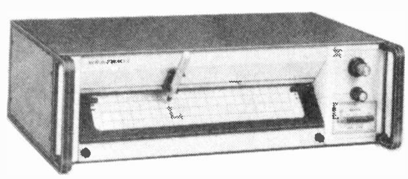


CIRCLE 3 ON READER SERVICE COUPON

the driver wants to take the cassettes into the house, he merely lifts the cassette holder off the bracket. S & K Enterprises offers a 14 day money back guarantee. Write to them at 4417 Red Maple Court, Concord, CA 94521.

### Strip Chart Recorder Kit

The Heathkit IR-5204 is the kit version of the popular Heath SR-204 Strip Chart Recorder, a boon to budget conscious hobbyists, experimenters, and small shops. Digital chart drive in the IR-5204



CIRCLE 1 ON READER SERVICE COUPON

is provided by a precision stepper motor that is synchronized to highly-precise internal oscillator or external TTL-level signal. The stepper motor provides 10 chart speeds, either in inches or centimeters per minute. All speeds are instantly selectable with a front panel switch, and are accurate to better than 0.5 percent. Other standard features of the IR-5204 include a rear panel for total recorder operation from a remote location, metric conversion, pushbutton chart advance, electric pen lift and rack mounting hardware. The unit is mail order priced at

*(Continued on page 4)*



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# 99 IC PROJECTS

## 1981 EDITION



## 25 TRANSISTOR PROJECTS



## FEATURES



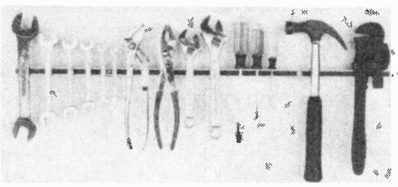
## REGULAR DEPARTMENTS

# New Products

$339.95 (F.O.B. Benton Harbor, MI). For more information on the IR-5204 Strip Chart Recorder kit, write for a free catalog to Heath Company, Dept. 350-320, Benton Harbor, MI 49022.

### Magnetic Tool Holder

Super Power magnetic tool holder for workshops, tool rooms, maintenance departments, and

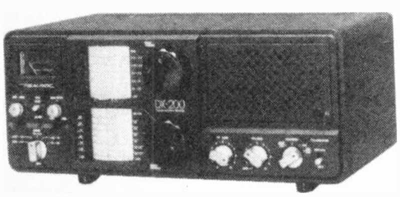


CIRCLE 4 ON READER SERVICE COUPON

home use holds heavy tools and helps keep work areas organized. Features heavy-duty ferrite permanent magnets, rust-resistant galvanized finish, and choice of lengths: 12, 18 and 32-inches. Price prepaid is $10.95, $14.95, and $21.95, respectively. Write to Dowling Miner Magnetics Corp., 372-D Bel Marin Keys Blvd., Novato, CA 94947.

### 5-Bander for SWLs

A five-band receiver from Radio Shack, the Realistic DX-200 Communications Receiver, tunes long-

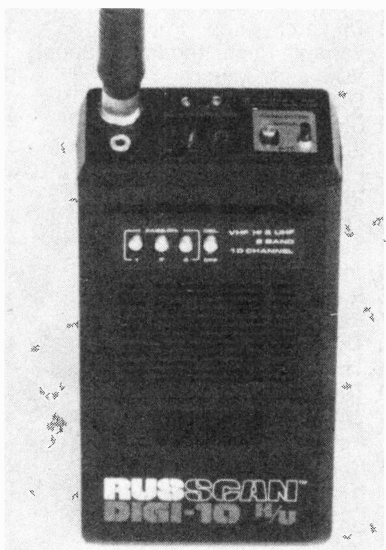


CIRCLE 32 ON READER SERVICE COUPON

wave from 150 to 400 kHz, 520 kHz to 1600 kHz AM broadcast band, and 1600 kHz through 30 MHz for international shortwave, Amateur Radio, WWV time signals and more. The DX-200 has illuminated drum-type dials for both main tuning and bandspread tuning. Bandspread covers both Amateur Radio and shortwave bands. A built-in 500 kHz quartz-referenced calibrator and an adjustable cursor on the main dial assure frequency accuracy. Other features include LED band indicators, an antenna trimmer for best reception with any antenna, an RF gain control that adjusts for signal sensitivity, five-element ceramic filter for selectivity, lighted signal strength meter and a built-in speaker. An adjustable BFO pitch control permits reception of CW (code) and SSB (single sideband) signals. The receiver also has a standby switch and rear panel "mute" terminal for use in two-way "Ham" installations. The receiver is single conversion with a 455 kHz IF. Sensitivity is given as 1 $\mu$V for 10 dB S/N ratio, and selectivity, $\pm$4 kHz, $-6$ dB; $\pm$8 kHz, $-40$ dB. Operates on 120 VAC, 60 Hz. The Realistic DX-200 Communications Receiver is priced at $229.95. Available exclusively from participating Radio Shack stores and dealers.

### Pocket Scanner

The Russell Industries Digi-10 H/U channel hand-held pocket scanner gives instant access to police, fire, weather and other

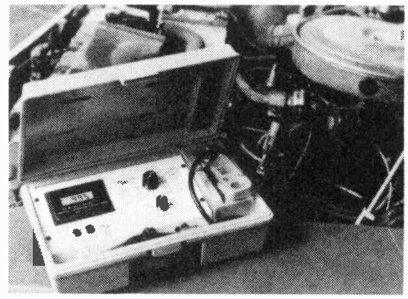



CIRCLE 5 ON READER SERVICE COUPON

special interest broadcasts on high VHF and UHF bands. Digi-10 H/U features 10 channels with a scan rate of 15 channels per second and LED display readout. The Digi-10 H/U has manual/automatic pushbutton stepping from channel to channel plus overpassing switches to lock out unwarranted monitoring. One second delay switch holds desired channel position. Comes with rechargeable Ni/Cad batteries and an AC battery charger. Unit weight is 8.8 ounces. For more information, contact Russell Industries, Inc., 3069 Lawson Blvd., Oceanside, NY 11572.

### Digital Engine Analyzer

The Heathkit Portable Digital Engine Analyzer kit, CM-1550, handles several tune-up measurements, including dwell for 4 through 8-cylinder engines, RPMs to 10,000 in two ranges, DC voltage to 200 volts in two ranges, resistance to 2 megohms in three

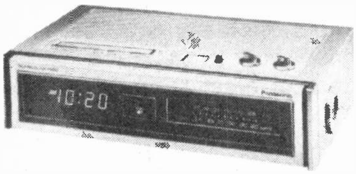


CIRCLE 1 ON READER SERVICE COUPON

ranges and direct current to 20 amperes. With the optional CMA-1550-1 Shunt Accessory, the CM-1550 will also measure starting current and battery charging/discharging current, up to 400 amperes. The CM-1550's large liquid crystal display shows all measurements. Power is supplied by a 9-volt battery (not included). The inductive pick-up for the RPM readings is attached to any spark plug wire. Thermal insulation on attachment leads resists melting or burning under high heat conditions. The CM-1550 can be assembled in two or three evenings, with just one circuit board to wire. It is mail order priced at $94.95, while the optional CMA-1550-1 400-Amp Shunt Accessory sells for $14.95, mail order—both F.O.B. For more information on the CM-1550 Engine Analyzer, send for a free catalog to Heath Company, Dept. 350-180, Benton Harbor, MI 49022.

### Talking Clock Radio

Panasonic has introduced an FM/AM electronic digital talking clock radio. Model RC-6800 features an electronic "voice" that calls out the time automatically at 1, 15, 30 or 60-minute intervals. "Voice" call can be operated manually for current or alarm time check. The "voice" alarm announces the time, and continues every minute until turned off. The digital talking clock radio also offers a "voice" volume control, "Sure Time" battery back-up sys-

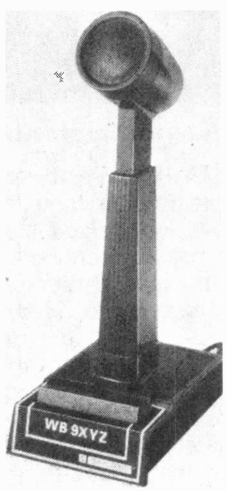


CIRCLE 6 ON READER SERVICE COUPON

tem that stores current time and alarm time, even during power failure, and a 4-in. PM dynamic speaker. Model RC-6800 also offers a terminal for a remote control voice-activator button. Sells for about $169.95 or less. For more information, write to Panasonic, One Panasonic Way, Secaucus, NJ 07094.

### Fixed-Station Microphone

The new Shure Model 444D, which retains all the performance characteristics that made the Model 444 popular, but also offers added features Radio Amateurs will find especially appealing. The

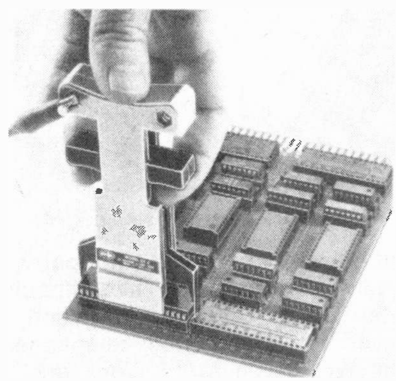



CIRCLE 7 ON READER SERVICE COUPON

Model 444D has a new high/low impedance selector switch located on the bottom of the base, increasing compatibility with fixed-station equipment. A second slide switch provides switching between normal or VOX operation. Also, an easy-to-use, momentary or locking, push-to-talk switch bar actuates the microphone and an external relay or control circuit with fingertip action. Other added features of the Model 444D are a coiled cable, the availability of a free, personalized nameplate imprinted with an amateur's station call letters, and a new wiring guide with instructions for wiring the microphone to major brands of ham equipment. User net price of the Model 444D is $55.50. For more information, write to Shure Brothers Inc., 222 Hartrey Avenue, Evanston, IL 60204.

### Safe 28-40 Pin DIP Puller

A new 28-40 pin IC extractor, Model EX-2, from O.K. Machine and Tool extracts ICs having standard .600-in. body widths, including MOS and CMOS devices. Unique mechanism is self-adjusting, and gently lifts the IC from its socket or board using uniform



CIRCLE 40 ON READER SERVICE COUPON

pressure applied simultaneously at both ends of the IC. Designed for easy one-hand operation, the EX-2 features heavy chrome plating for reliable static dissipation, as well as a terminal lug for attaching a ground strip. The EX-2 is priced at only $7.95, and is available through local electronics retailers or directly from O.K. Machine and Tool Corporation, 3455 Conner Street, Bronx, New York 10475.

### Number, Please

An all-in-one telephone, the Radio Shack DuoFone-16, provides pushbutton dialing, a built-in two-way amplifier and an autodialer that can store up to 16 telephone numbers for instant, one-button dialing. A universal dial system is said to give you the convenience of pushbutton calling almost anywhere in the U.S. without paying extra charges and regardless of whether your local telephone system is for pushbutton or rotary dialing. Another feature provides one-button redialing of the last number called if the line was busy or did not answer. The built-in two-way amplifier allows "hands-free" con-

# New Products

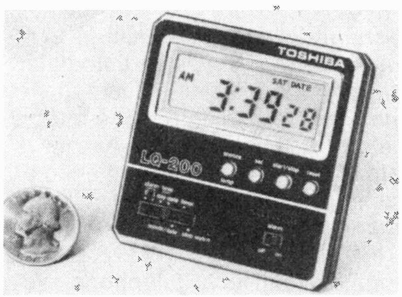
versation and features on-hook dialing so that you need not lift the telephane receiver to make a call. A privacy button cuts off the microphone so that you can confer with-

CIRCLE 32 ON READER SERVICE COUPON

out being heard by the other party, or monitor conference calls without interrupting. Up to 16 frequently called or emergency telephone numbers of up to 15 digits each can be stored in the auto-dialer. The Radio Shack Duo-Fone-16 Telephone with built-in auto-dialer and amplifier is priced at $129.95 at participating Radio Shack stores and dealers.

## Tick-Free Clock

Super-long battery life, multi-alarms, and tick-free functioning are the major features of an attractive, compact travel clock, Model LQ-200, introduced by Toshiba. The battery life of 7,000 hours protects the traveller against battery failure during a trip. Three alarms, including a timer and a five-minute





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snooze feature make it easy to stay on schedule. A large LCD display shows six digits with day, alarm, AM/PM indicators, and there is an added automatic calendar. Measuring only 2½-in. wide x 2½-in. length x ½-in. thick, and weighing 1.76 oz., this travel clock fits easily into a briefcase or purse. The unit has a built-in stand for use on the desk or night table, and comes in an attractive pouch. Suggested retail price: $29.95. For more information, write to Business Equipment Division, Toshiba America, Inc., 82 Totowa Road, Wayne, NJ 07470.

## Battery-Powered Turntable Light

Now you can read the record label and keep the romantic mode. Just add a battery-powered phono turntable light that turns on automatically when the dust cover is

CIRCLE 9 ON READER SERVICE COUPON

raised. The battery-powered RoboLite from Robins Industries operates from two D-size cells in a container that is connected to the turntable light through a 3-foot cable; there is no need to use a spare AC outlet as the power source. The turntable light simply snaps onto the bottom edge of the dust cover; no tools are needed for the installation. Suggested list price of the RoboLite is approximately $21, not including batteries. For further details on the Robins battery-powered RoboLite, contact Robins Industries Corp., 75 Austin Blvd., Commack, NY 11725.

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## Space Destroyer Program

APF Electronics Space Destroyer is a video space game designed for it's personal computer, The Imagination Machine. The game will put you in the commander's seat as you maneuver your field. The excitement of the action is heightened with sound. The suggested retail price for Space Destroyer is $19.95. Write to APF Electronics, Inc., 444 Madison Avenue, New York, NY 10022. ■


**Got a question or a problem with a project—ask Hank! Please remember that Hank's column is limited to answering specific electronic project questions that you send to him. Personal replies cannot be made. Sorry, he isn't offering a circuit design service. Write to:**

**Hank Scott, Workshop Editor**
**99 IC PROJECTS**
**380 Lexington Avenue**
**New York, NY 10017**

### It Adds Up

*Using an op amp, give me a simple signal mixing circuit. I've tried it using input at 2 and 3 of a 741, but with no success.*
*—L.Y., Richardson, TX*

You are effectively inserting a signal before mixing which is not what you want to do when summing. The diagram shows you how to put this together.

### White's is Complete

*Why doesn't White's Radio Log which appears in* COMMUNICATIONS WORLD *once a year list FM stations by call letters?*
*—J.N., Long Beach, CA*

DXing FM stations is just not practical. Very seldom does one need such a listing. If you don't find the call letters in the FM listing for your state, then examine adjacent states along the axis of the FM antenna. Some signals may skip in, but don't bet on it. Also, a few may sneak in from behind, so always examine the state behind you. The original Mr. White didn't list FM stations by frequency, nor do we see any reason to do so. As for errors in White's Radio Log—it happens because we are human (we're not blaming it on the computer). However, most errors are traceable to inaccurate data and changes that occur during the year. Did you know there are over 1000 listing changes in White's Radio Log each year? You can help. Should you spot an error, jot down the old (incorrect) data and the new data. We'll update the list.

### Computer Power

*Should I run a special AC line to my PET computer as is done with commercial computers?*
*—C. H., Loyalton, CA*

Why? If the power fails, start all over. Should you be working on a very long program, constantly LOAD it into your cassette or disk drive. Should the switch be pulled or the power fail, you will only lose the last 10 minutes of work. The magnetic memory never fails. But, it is wise to take power from an outlet that does not share a circuit breaker with kitchen appliances that blow breakers more often than any other reason. Also, the outlet should not be controlled by a wall switch which could accidently be flipped to the "off" position.

### Bond It

*My serviceman suggested I "bond my chassis." He meant that the engine compartment leaked RF which interfered with my radio reception. How do I do it?*
*—W.N., Oceanside, NY*

Check your auto supply outlet for bonding straps. If you can't get any, use the wire braid in an RG-8/U cable. Take off the outer jacket, the inner insulation and center wire. It's easy to do because you'll need strips of about one foot each. Now, connect the hood to the firewall with one strap. Connect each fender to the firewall. (The firewall is the metal between the engine compartment and the passenger section.) Check to see that the cable from the battery ground to the engine makes good connection and is not damaged. That should do it.

### Long Line Ground

*My car stereo works fine on the workbench when I power it with a battery eliminator, but reception is poor in the car. I know the antenna system is O.K. What's wrong?*
*—E.J., Rapid City, SD*

Take a good look at your DC ground return. Considering the amount of plastic used in a car today, the radio may be floating in non-metalic space with several feet of ground wire seeking the car's frame or body. Keep that DC return short! Connect the case of the radio to the metal on the car with one foot or less of braided copper wire rated at #14 or #12. I once fixed a radio in a car that had no ground return in its plastic mounting slot. The ground strap, a piece of cheap steel, broke when the radio was pulled out. When I connected the hot line and slid the radio in place, no grounding occured. This could be very upsetting the first time it happens to you.

### It's a Cannon

*What is an XL-type connector?*
*—D.M., Boston, MA*

It's any of several varieties of audio connectors having 3 or more conductors plus an outer metal shell which shields the mating pieces and locks them in place. The most common type is the 3-pin XL-type connector used to make balanced mic and line level connections on professional audio systems. It is not uncommon for XL-type connectors to be connected to unbalanced lines. Very often the XL-type connector is called a "Cannon connector," so named for the original manufacturer.

# ASK HANK

Presently, many companies now manufacture compatible 3-pin connectors.

## Sound Off

*Hank, I am writing in response to the letter from "T.H., Great Fall, MT" in the July-August issue of* Elementary Electronics. *Is your mind operating gigo, or what? The boy didn't ask for your opinion on what the use of home computers should be, he asked if you knew how to interface one to a BSR X-10 remote control! I am not usually one to criticize the opinions of others, but I had to speak up about your reply to his letter. If you can't, or won't, answer his question, then give him my name and address, and I'll be glad to help him. A computer isn't "too valuable for anything. In any application where they can help people, that is where they belong. I hope you have enough intestinal fortitude to publish this letter, and send my name and address to the boy who wrote you, so I can give him some help. By the way, this letter was written on my TRS-80 using a text-editing system I wrote, called "MAX"!*

*—W.M., No. Platte, NE*

Yep, we have "guts," so we printed your letter. In fact, although you disagree with us, your views are worthy of consideration. You'll note that we dropped your middle paragraph where you qualify your background to justify your position. I'm impressed, but I'll stick to my guns. Please write to us again, and everyone else who disagrees with me. I'm not too old to learn, or so they tell me.

## Draw!

*Hank, how good are you at computer language?*

*—D.R., Grafton, VT*

At BASIC I'm about as good as Larry Friedman, our young editor of the Simply BASIC column. However, he's much faster than me. That's what youth and practice has over us old timers.

## Nice Note

*I am a new subscriber to* Elementary Electronics, *and just wanted to tell you that I am enjoying this publication very much. I really did enjoy the article "Solar Alchemy," by T.J. Beyers. Mr. Beyers proves he has an excellent understanding of his material and presents it in a very readable manner.*

*—D.A., Alpine, Tx*

I received several complementary notes on Author Beyers article on Solar Alchemy. It's good to know the Editors are giving you what you want to read. Those who sent story ideas and specific requests had their letters forwarded to the Editor. Thanks for writing.

## Spend to Save

*I like to build the projects in* Elementary Electronics, *but the prices charged for parts are just too much! How can I break the price barrier?*

*—B.F., Ellwood, PA*

Buy in quantity and reuse parts. For example, never buy a resistor off the peg board rack, buy a large assortment of resistors that include the resistor you need. This way you will build up your parts supply, and somewhere down the road you may build a project with all resistors coming from spare parts. Also, the unit costs for bulk resistors are anywheres from one-quarter to one-tenth the peg board price. Do the same with other parts. Next, a switch to solderless breadboards. They may seem costly, but you will be able to salvage 100 percent of the parts used. Think of the many 741s and 555s you can use over and over.

## Lend a Hand

Here are a few readers who need your help, so lend a hand, boys!

Δ General Electric oscilloscope Model CRO-3A; needs schematic diagram and operational manual; Gary L. Smith, 10956 S.W. 63rd, Portland, OR 97219.

Δ Archer (Radio Shack) Model 28-4004, needs schematic diagram; Joseph Greco, 9905 W. Montana Ave., Milwaukee, WI 53227.

Δ National NC-57M receiver; would like to get manual and know when unit was first made; Kevin Kaff, 3803 Hilltop, Hutchinson, KS 67501.

Δ Hallicrafters Model S-85 receiver; needs schematic diagram, operational manual and alignment data; John Wilson, P.O. Box 512, Farmerville, LA 71241.

Δ Fisher Stericorder open reel tape recorder; needs manual and/or schematic diagram; Herbert W. Klumpe III, Box 32, Meredith, NY 13805.

## Saving Watts

*The great job you did on attic ventilation can be helped a great deal by better fan control and the kind that is right up your alley. I used two thermistors in a bridge circuit tripping an SCR. One thermistor is outside in the shade. The other is in the attic. The outside thermistor continually biases, or resets, the attic thermistor so that its setting, where the SCR is tripped, is always about 5 degrees above the outdoor temperature. This is perfect from a heat gain point of view. It keeps the house heat pick-up from the attic to the bare practical minimum. My SCR sometimes short cycles on shut down, I have to work on this.*

*—G.K.M., Kettering, OH*

Good to hear you're keeping down the watts and saving bucks. To prevent short cycling, I suggest you use a lockout feature that prevents the fan from coming on for a few minutes. Use a 555 IC with a variable time control. I believe a 5-degree temperature differential is too small. A well insulated attic could stand 20 to 30°F easily before the fan comes on.

## Good Application

*Hank, I'd like to know if the Digital Voltmeter project in the 1980 March-April issue of ELEMENTARY ELECTRONICS can be used in a variable (5-16 VDC) power supply.*

*—C.A., Las Vegas, NV*

You bet. In fact, that's what your car's battery supply is when it's not charged properly.

## Mike Tip

*Hank, can you give me some tips on recording a vocalist.*

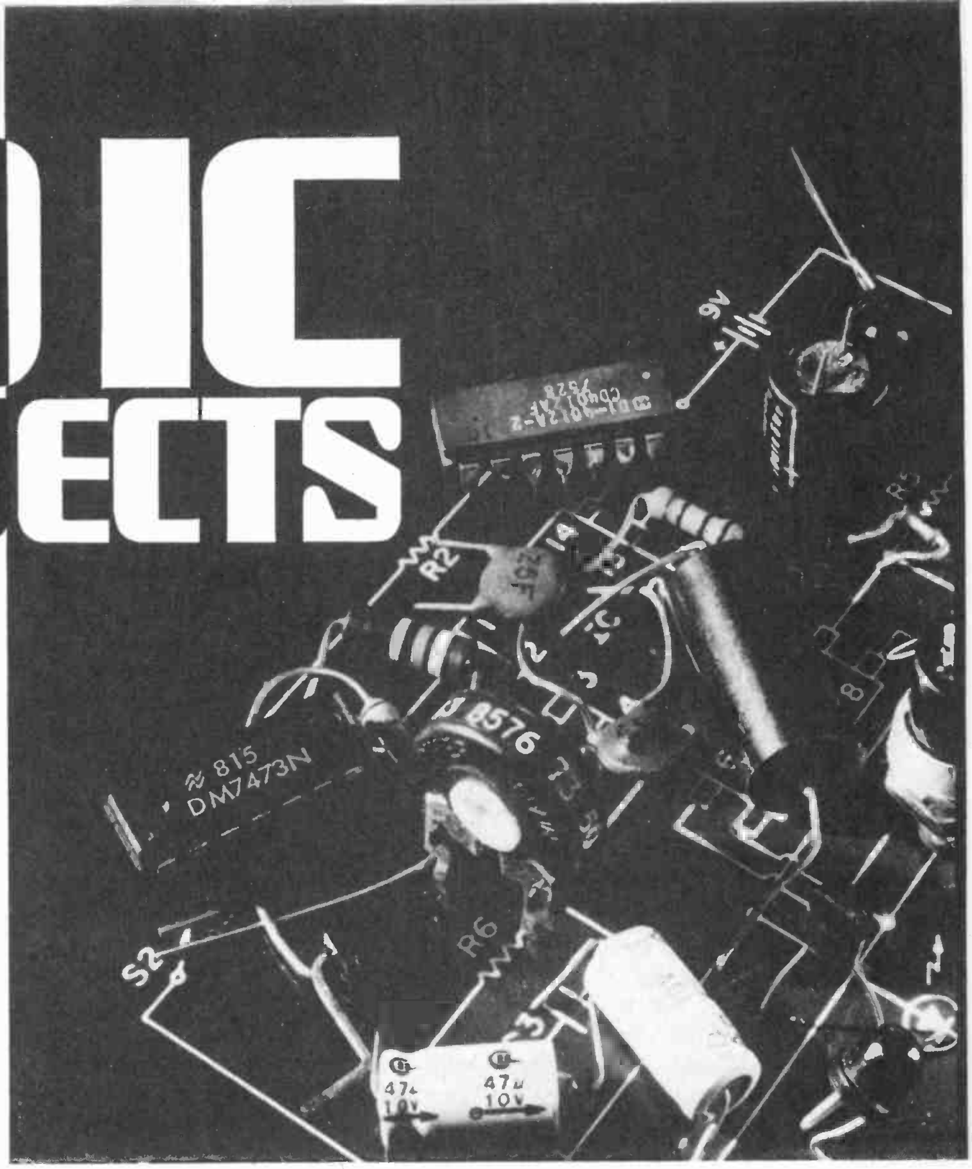
*—J.N., Walnut Creek, CA*

Here are some simple rules for recording a soloist: The mike should generally be positioned 8-in. to 12-in. from the face and slightly to the side (to avoid "popping Ps"). If the recording is being done outside, a windscreen is a must. Recording a medium to large size vocal group represents more of a problem. A little "juggling" of the performers might be in order. The best idea is to position the strongest voices a little farther away so they won't overpower the weaker voices. In general, the best position for the mikes is slightly above head level. ■

# 99 IC PROJECTS

## 1981 EDITION

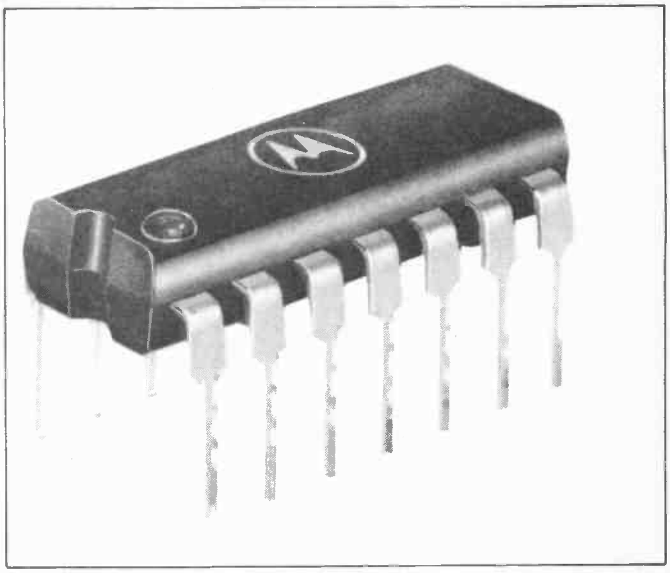
Enter the fascinating world of miniature electronics today and join the IC generation!




YOU'VE BEEN PUTTING OFF YOUR INTRODUCTION into the fascinating world of integrated circuit construction for too long, and the time to get your feet wet is now. The electroncs field is moving ahead so rapidly that you really cannot afford to sit back and let it happen around you. That in itself is the primary reason for the existence of 99 Integrated Circuit Projects magazine. Contained on the following pages is the necessary information, both theory and construction, which will allow you to begin utilizing the miniature marvels available right now at your local hobbyist outlets.

***No Excuses!*** Too expensive, you say? Wrong! Many of the ICs used in the construction projects on the following pages can be had for $1.00 or less with some sharp shopping techniques.

Too complicated, you say? Sorry, wrong again. If you've had any experience in following schematic diagrams to build transistor projects, or, for that matter vacuum tube projects, you'll have very little trouble in adapting to the use of ICs. Again, we'll show you what you need to know, both in circuit theory and in construction theory. And to help build your confidence, we've included 25 Transistor Projects which are not only useful in themselves, but will help you come to grips with

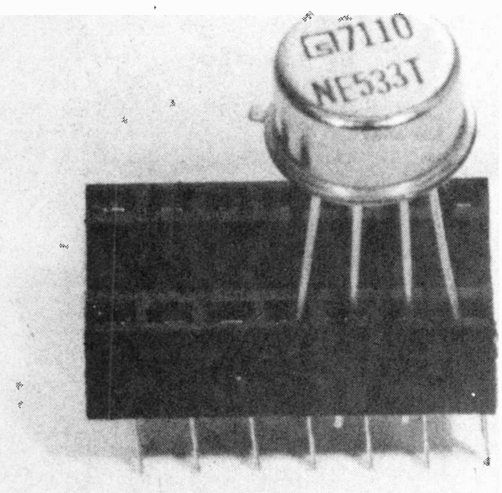


Here's what it is all about, a typical DIP (dual in-line package) integrated circuit. This is a 14-pin package, the most commonly used in our projects, but 16-pin units are also used. Note indentation at the left end—(facing towards you), the first pin to the right is #1. Pin numbers ascend in counter-clockwise order.

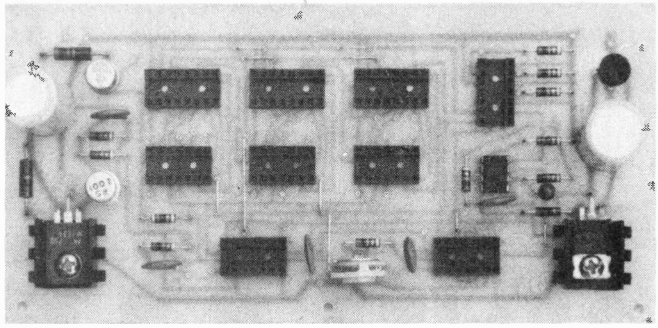
# 99 IC

solid state construction and circuitry techniques before you get involved with the more complex IC projects. In fact, you can actually "build" your own chip just to see how the digital logic actually functions inside an IC.

***Heart of the Matter.*** Right now, let's get to the heart of the book, the 99 IC construction projects. Even if electronics is your number one hobby, as it is for us, most likely you have other pastimes as well. With this thought in mind, we have tried to bring you a selection of project ideas that will allow you to experience the satisfaction of building a working project that will also be useful to you in other areas. A glance at the Contents page will indicate that the 99 integrated circuit projects in this issue are grouped in categories for your convenience. Those of you who play musical instruments or know someone who does will enjoy building projects such as the Slide Trombone, Touch Sensitive Keyboard, Organ-Plus Tone Generator and Multi-Input Music Synthesizer. Computer operators will find the Simple 6-Bit D/A Converter a useful, low-cost addition to their system and security conscious builders will find a variety of electronic burglar alarms, locks, robot "eyes" and "ears" to strike terror into the hearts of the uninvited. Hobbyists will delight in Automatic Train Sound Effects and both photographers and experimenters will find the Thermostatic Bath very useful. Inveterate gamblers and others who wish to test their skills are sure to find enjoyment among several original electronic games such as LED Blackjack and Mini-Digital Roulette. You can use the money saved to build more projects.




**One of the most important (and least costly) expenditures you'll make for building the IC projects is for IC sockets. They are available in all sizes (8, 14, and 16-pin, etc.) and have terminals for solderless and wire-wrap boards, as well as for PC types.**



**A neat, clean professional-style printed circuit board made from a template. Nine of the ICs are not in their sockets. With the right materials, all of your projects can be this neat and compact. Take sufficient time to plan ahead for tight parts layouts.**

The list goes on and on, and we're sure that you can find many alternative uses for these projects other than the ones which we've suggested. Additionally, you will soon see that many of the projects are compatible with each other. For instance, many of the burglar alarm circuits for both home and car require some sort of alarm device, such as a bell, buzzer, etc. You can combine them with the Two-Tone Siren to create a really formidable protection system.

Perhaps the major reason for taking the time to inform you of these possibilities is that the actual text accompanying the projects is very brief—there's just enough there to let you know how to build the project, and in some cases how to operate it as well. This was done not because we're lazy, but because we wanted to leave as much as possible to your imagination. The schematics and parts lists have been checked, rechecked, and then checked again to provide you with trouble-free construction. We've also tried our hardest to limit the amounts of different parts you will require to assemble the projects. You will find that both the NPN and PNP transistors used throughout the magazine are of the "general replacement" variety, which means that you can pretty much substitute freely from the junk box. The same goes for the resistors and capacitors. You'll find that we've adhered to the most common values and tolerances—the ones which are easily found either around the shop or any electronic and/or TV repair supply.

***Pay Attention!*** We would undoubtedly be remiss if we didn't pass along some of the do's and don'ts which pertain to the care and handling of integrated circuits during construction. No matter what construction format you choose—solderless breadboarding, wire-wrap breadboarding (see the articles on these at the rear of the magazine) or even printed circuit construction, if you're so inclined, the followng tips apply throughout, and we suggest that you read them carefully before you begin any work.

While integrated circuits are basically composed of groups of transistors and other standard electronics components, some types do require special handling on your part. CMOS types in particular are susceptible to damage in the most innocuous ways. For instance, even though many of these chips are designed with resistor/diode protection circuits on the input leads, it is possible for the slight static electrical charge which is normally built up in your body (your body, by the way, happens to be an excellent natural capacitor) to ruin part or all of a chip's circuitry just by touching the pins when removing it from the packing. A good idea here is to ground yourself by wrapping a few turns of wire (be sure to strip off the insulator if you use insulated wire here—otherwise bare wire will work fine) around your metal wristwatch band, and connect the other end of the wire to a good electrical ground. Alternatively, you can purchase a pair of non-conductive tweezers with which to handle the ICs. There are also IC installers/removers made to handle the ICs when using sockets.

***If You Must Solder.*** If you plan on soldering the IC leads directly into the circuit, something which we do not recommend, there are several precautions which you'll have to take to avoid ruining your precious ICs. To begin with, put your heavy duty soldering gun on the shelf. Use no more than a 15-watt straight iron. If the iron you have, or the one you contemplate purchasing, does not have a grounded tip, then you'll have to attach a ground lead to the coolest point on the tip, much as you did for personal grounding, as we mentioned earlier. Stray AC in the tip can kill a chip just as surely as stray static charges can. The reason we specify a low power iron, is for the simple reason that the ICs are rather sensitive to heat as well, and you stand a much less chance of doing damage with a smaller iron than with a larger one.

Our strong recommendation is that you invest in IC sockets which can be soldered into the circuit directly, and which allow you to insert the IC at such a time as you have checked all the wiring connections and all the voltages to assure safe operating conditions for the IC. The first time you find a potentially damaging wiring error in checking out a socket setup, the price you paid for the socket will have been refunded to you by saving a more expensive chip from destruction.

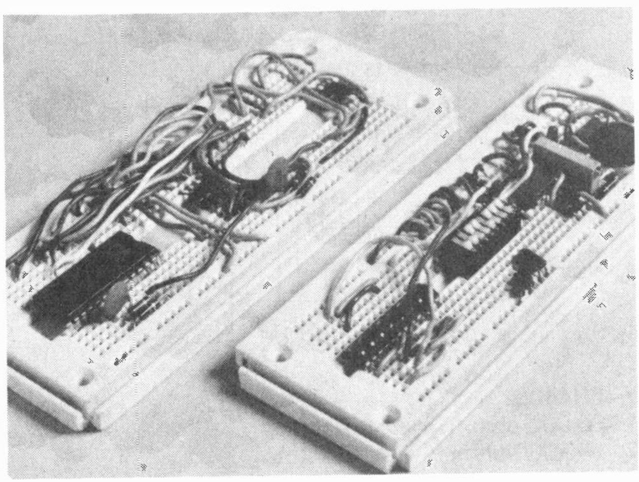
Again, refer to the articles on solderless breadboarding and wire-wrap breadboarding for easy, convenient methods of wiring up your projects. The added feature of both these methods is that they both allow for easier troubleshooting when de-bugging a circuit that doesn't work quite right the first time out.

***Troubleshooting.*** When de-bugging a circuit, or testing for signal levels or voltages prior to firing up your project for the first time, it is important that you remember to NEVER apply an input signal to a chip unless the entire circuit is powered up. It is almost a certainty that you will cause an overload potential within the chip that cannot be safely dissipated without the power switch being closed, thereby completing the circuit. The damage will usually be irrevocable. For those projects which require a separate input signal, such as a clock source, it's a good idea to power the clock source off the main circuit's power supply if at all possible. This will minimize the possibility of applying the signal to an unpowered chip. Alternatively, if it is impossible to utilize the same power supply for both the signal source and the main project, use a DPST switch which will allow you to control the power feed to both circuits simultaneously.

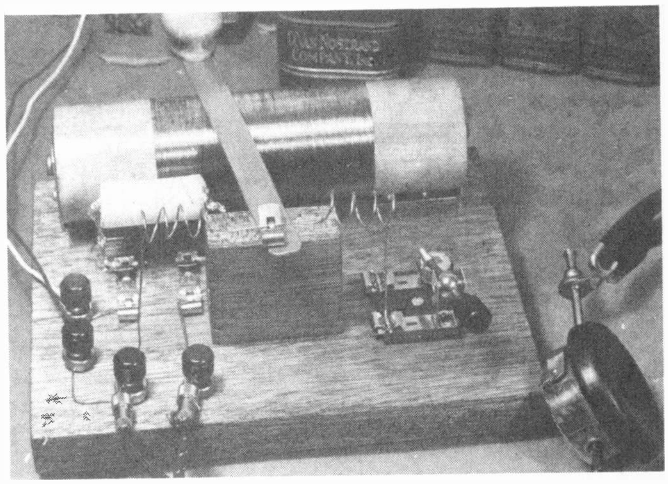
Of course, the same procedure should be used when disconnecting a circuit as well. If you do not use simultaneous switching or a common power supply, make sure that you remove the external signal source from the chip before shutting down the circuit. Just try to reverse the steps you took in hooking up the circuit in the first place, and follow them in reverse order when shutting down. It's simple, but also easy to forget.

***In Conclusion.*** We've tried to make this issue of 99 Integrated Circuit Projects as self-contained as possible, with as much construction technique and circuit theory as is necessary for you to get the uptmost out of the projects we've outlined. Please do take the time to read the articles on wirewrapping techniques and breadboarding. Then, try your hand with some of the 25 Transistor Projects to develop and perfect your skills in wiring and layout. After that, it's full speed ahead with the IC projects.

When you're done and it works, you'll probably wonder why it took you so long to get into IC electronics. Don't worry though, you're not alone. You'll also no doubt be glad you did join the IC generation. We are certain you won't be alone in that thought either! ■



**Solderless breadboarding is a convenient method for circuit building, as components and jumpers can be repositioned at will. The only drawback with this medium (and it's a minor one) is that it's not really a permanent setup and care in handling is needed.**



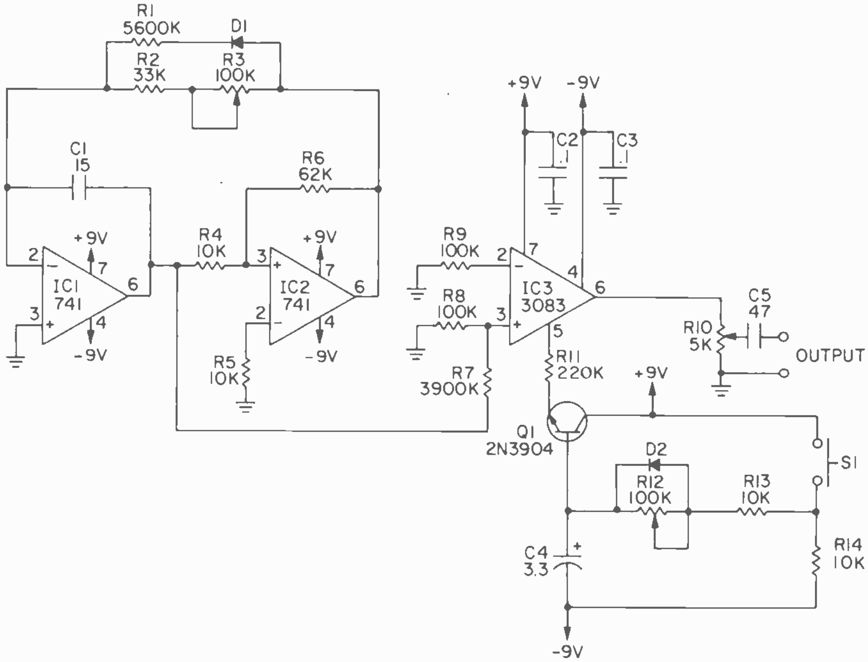
**The most rudimentary (and least expensive) method which you can use to breadboard a circuit is to use, well, a breadboard. Obviously this is where the name came from. You can use Fahnestock clips (left, center) to secure components on the board.**

# 1 Slide Trombone

□ This is a novel little instrument that can be played through your stereo system. IC1 and IC2 comprise a ramp generator, the frequency of which is adjusted by R3. The range of adjustment spans two octaves from 150 to 600 Hz. The ramp signal is fed to modulator IC3, which imparts a natural-sounding attack and decay to the note the sounds when S1 is pressed. R12 allows adjustment of the note's decay interval, and R10 controls the volume. Maximum signal amplitude at the output is 500 mV peak to-peak (sufficient to drive an amp's high-level input). To play, adjust R3 for a particular note; press S1; slide R3; then release S1. You can make things easy by calibrating R3 in terms of musical notes. Either a slide or rotating pot can be used for R3, depending on your playing preferences.

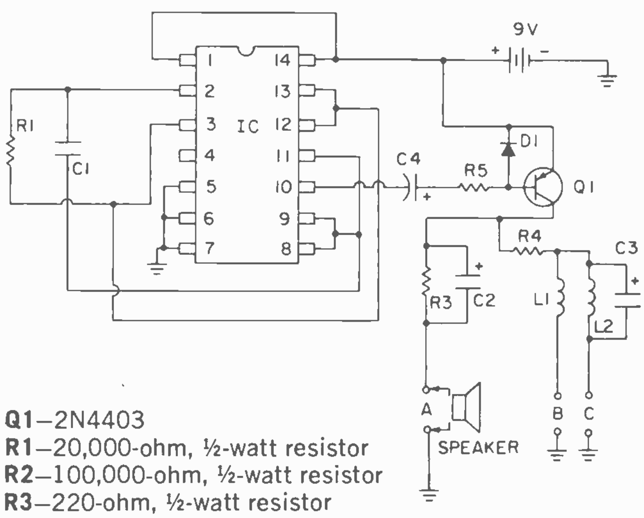
**PARTS LIST FOR SLIDE TROMBONE**

**C1**—0.15-uF mylar capacitor
**C2, C3**—0.1-uF ceramic disc capacitor
**C4**—3.3-uF, 25VDC electrolytic capacitor
**C5**—0.47-uF mylar capacitor
**D1, D2**—1N914 diode
**IC1, IC2**—741 op amp integrated circuit
**IC3**—3080 transconductance amp integrated circuit (RCA)
**Q1**—2N3904 NPN transistor
**R1**—5,600-ohm, ½-watt resistor (all resistors 10%)
**R2**—33,000-ohm, ½-watt resistor
**R3, R12**—100,000-ohm linear-taper potentiometer
**R4, R5, R13, R14**—10,000-ohm, ½-watt resistor
**R6**—62,000-ohm, ½-watt resistor
**R7**—3,900-ohm, ½-watt resistor
**R8, R9**—100-ohm, ½-watt resistor
**R10**—5,000-ohm audio-taper potentiometer
**R11**—220,000-ohm, ½-watt resistor
**S1**—pushbutton switch, normally open




# 2 Organ-Plus Tone Generator

□ Musical organ-like sounds can be generated with this CMOS circuit. The IC generates a nearly square-wave output from pin 11 and the spacings on that output stream of pulses can be varied by changing R1 and R2. If you change them smoothly, you can get a slide-trombone effect. Outputs A, B, and C are different from the pin 4 output in that the square wave now becomes a sawtooth, a spike and a complex combination of both. Rich overtones result that you can hear with the 8-ohm speaker.

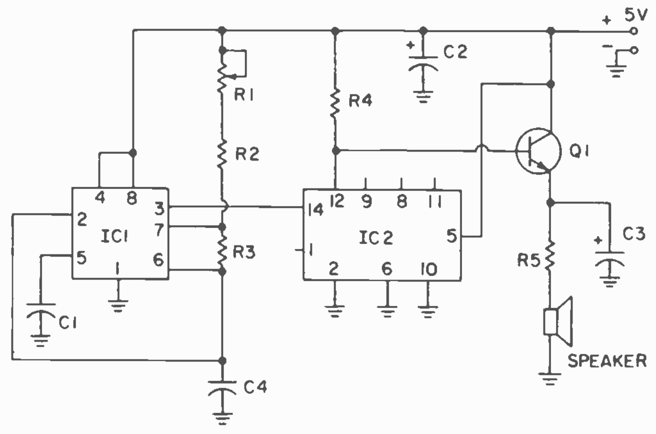



**PARTS LIST FOR ORGAN—PLUS TONE GENERATOR**

**C1**—0.2-uF disc capacitor, 15 VDC
**C2**—4.7-uF electrolytic capacitor, 15 VDC
**C3**—6.8-uF electrolytic capacitor, 15 VDC
**C4**—2-uF electrolytic capacitor, 15 VDC
**D1**—1N4001 diode
**IC1**—4011 quad NAND gate
**L1**—2.5-millihenry RF choke
**L2**—2.5-millihenry RF choke
**Q1**—2N4403
**R1**—20,000-ohm, ½-watt resistor
**R2**—100,000-ohm, ½-watt resistor
**R3**—220-ohm, ½-watt resistor
**R4**—220-ohm, ½-watt resistor
**R5**—1,000-ohm, ½-watt resistor
**SPKR.**—8-ohm PM type

# 3 Guitar Tuning Aid

☐ By taking advantage of the frequency stability of the 555 timer IC operating in an astable mode, an oscillator can be constructed which can be used as a tuning aid for the guitar. The first string of the guitar, E, produces a note with a frequency of 82.4 Hertz. The frequency of the oscillator is set to twice this value, 164.8 Hertz, and then followed by a divide-by-two stage to produce the desired frequency. The purpose of the divide-by-two stage is to guarantee that the waveform produced has a duty cycle of exactly 50%. This produces a note with no second harmonic distortion. The frequency of oscillation of the circuit is set by adjustment of R1, R2, and C2 also determine the frequency of oscillation but these components are fixed values and need no adjustment. The output of IC2 is fed to an emitter follower to provide current gain to drive a loudspeaker. C3 acts as a low-pass filter to attenuate harmonics and produce a more natural sounding note. The circuit is powered by a 5 volt supply, and this voltage *must* fall within the range of 4.75 to 5.25 volts for IC2 to operate properly.

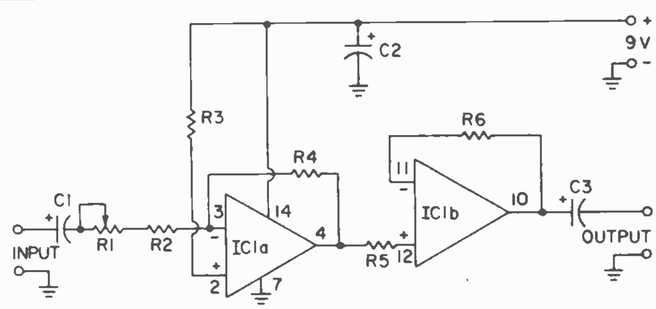



**PARTS LIST FOR GUITAR TUNER**

**C1, C4**—0.1-uF ceramic capacitor, 15 VDC
**C2**—15-uF electrolytic capacitor, 15 VDC
**C3**—100-uF electrolytic capacitor, 15 VDC
**IC1**—555 timer
**IC2**—7490 decade counter
**Q1**—2N4401
**R1**—50,000-ohm linear-taper potentiometer
**R2, R4**—4,700-ohm, ½-watt resistor
**R3**—33,000-ohm, ½-watt resistor
**R5**—33-ohm, ½-watt resistor
**SPKR**—8-ohm PM type speaker

# 4 Power Mike Amplifier

☐ A popular accessory to a CB radio is a power microphone. This circuit provides an adjustable gain of 1 to 10 which will increase the output of a dynamic microphone for higher modulation levels without shouting. The circuit has very low output impedance and will drive the microphone input circuit of any CB radio. IC1A provides voltage amplification and is adjustable by potentiometer R1. IC1B is a buffer amplifier which provides isolation between the amplifier and output terminal. The circuit draws about 7 milliamperes from a 9 volt supply and can be powered by an ordinary 9 volt transistor battery.




**PARTS LIST FOR POWER MIKE AMPLIFIER**

**C1, C2, C3**—10-uF electrolytic capacitor, 10 VDC
**IC1**—3900 quad amplifier
**R1**—100,000-ohm audio taper potentiometer
**R2**—10,000-ohm, ½-watt resistor
**R3**—220,000-ohm, ½-watt resistor
**R4**—100,000-ohm, ½-watt resistor
**R5, R6**—1,000,000-ohm, ½-watt resistor

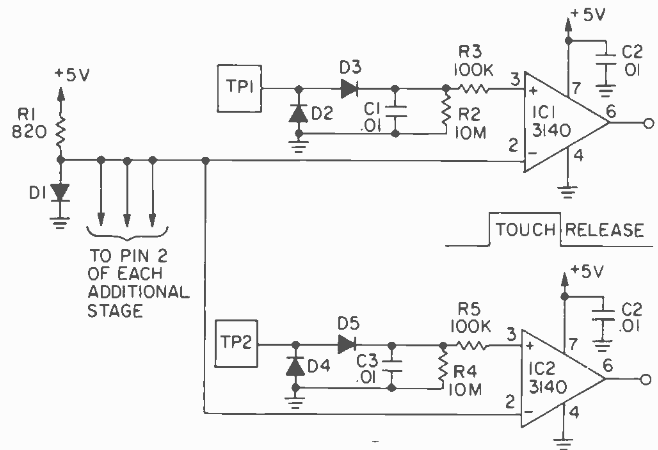
# 5 Touch-Sensitive Keyboard

☐ There's no better way to add an exotic touch to a piece of electronic equipment than by employing touch-sensitive switching. The set-up diagrammed here will enable you to employ one, two or however many touch-sensitive switches you need. Electronic musicians, for example, may wish to use 37 units in a 3-octave keyboard.

Each separate unit consists of a touch plate, a silicon-diode detector system, and a 3140 op amp that functions as a voltage comparator. Finger contact with a touch plate feeds 60-Hz power-line radiation from your body, which acts as an antenna, to the detector system. If the rectified AC exceeds 1.2 volts, the 3140's output swings high and remains there for as long as you touch the plate. All stages use the .6-volt drop across D1 as a reference voltage. NOTE: If you're running a battery-operated device in Dogpatch, this touch-switching arrangement may not work. Most homes, however, have sufficient 60-Hz radiation to trigger these sensitive switches.

**PARTS LIST FOR TOUCH-SENSITIVE KEYBOARD**

**C1-C4**—.01-uF ceramic disc capacitor
**D1-D5**—1N914 diode
**IC1, IC2**—3140 FET-input op amp (RCA or equivalent)
**R1**—820-ohm, ½-watt resistor (all resistors 10%)
**R2, R4**—10,000,000-ohm, ½-watt resistor
**R3, R5**—100,000-ohm, ½-watt resistor
**TP1, TP2**—touch plates (small, aluminum or copper)

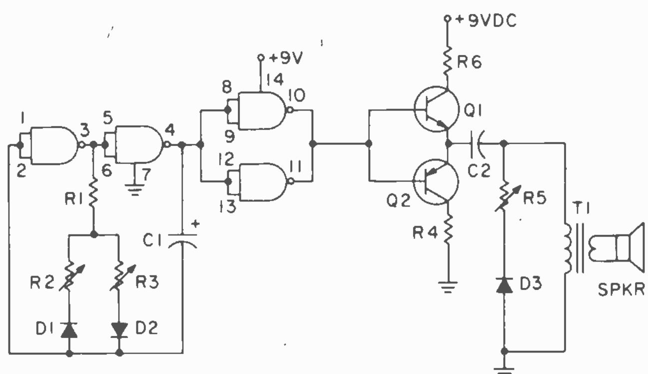



# 6 Mini Micro Metronome

☐ Transforming IC pulses into sound, this tiny ticker goes both tick *and* tock, at a rate of about 2 seconds per tic to 6 tocks per second. The timing capacitor, C1, should be a low leakage mylar type of about 2-uF or else a quality tantalum of about 4.7-uF. Although the reversed flow of current through the transformer's primary winding causes a different sound in the speaker from the positive-going inrush, diode D3 and potentiometer R5 can be added to make the "tock" more definitive in its sound quality.

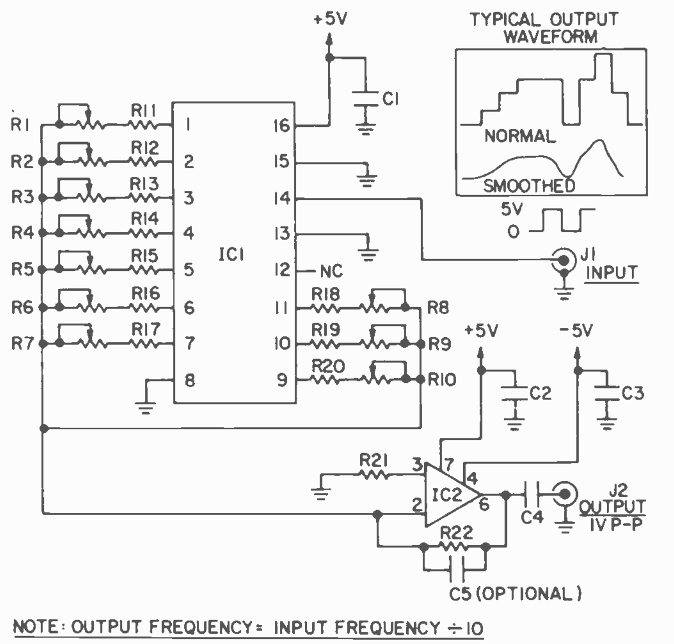
**PARTS LIST FOR MINI-MICRO METRONOME**

**C1**—2 to 5-uF low-leakage mylar or tantalum capacitor, 15 VDC
**C2**—2.2 to 10-uF electrolytic capacitor, 15 VDC
**D1, D2, D3**—1N4148 diode
**IC1**—4011A quad NAND gate
**Q1**—2N4401 transistor
**Q2**—2N4403 transistor
**R1**—47,000-ohm, ½-watt resistor
**R2, R3**—500,000-ohm linear-taper potentiometer
**R4, R6**—10-ohm,½-watt resistor
**R5**—1,000-ohm linear-taper potentiometer
**T1**—audio output transformer 500-ohm primary/8-ohm secondary




# 7 The Waveshaper

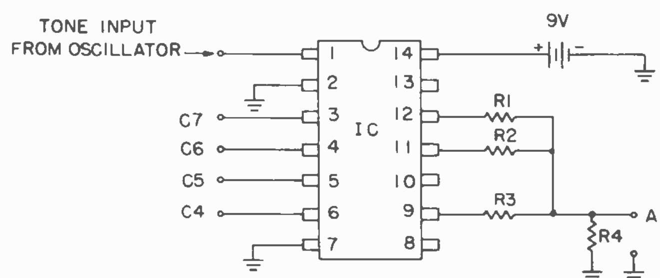
☐ This little circuit illustrates the principle behind multi-kilobuck laboratory-style waveform synthesizers as well as some of the more advanced music synthesizers. Into J1 you should feed a square-wave signal swinging from ground to almost 5-volts. The input signal's frequency should be ten times that of the desired output. Adjusting potentiometers R1 through R10 will enable you to literally design the shape of the output waveform. If you can get hold of an oscilloscope, use it to observe the effect of R1 through R10 on the output. At the same time, feed the output to an audio amp so that you can hear the changes in timbre that occur as the waveshape is altered. Capacitor C5 can be used to smooth out the chunky shape of the output. With a 10 kHz input, start with a value of 0.1 μF for C5 and experiment. Make sure at least one potentiometer is set to maximum resistance and that at least one is set to minimum. This guarantees a full 1-volt peak-to-peak output. You might also try feeding some interesting waveforms into the Musical Modulator (elsewhere in this issue) and listening to the notes formed.




**PARTS LIST FOR THE WAVESHAPER**
**C1, C2, C3**—0.01-uF ceramic disc capacitor, 35 VDC
**C4**—0.5-uF mylar capacitor, 35 VDC
**C5**—see text
**IC1**—4017 CMOS decade counter
**IC2**—741 op amp
**J1, J2**—phono jack
**R1 through R10**—2-megohm linear-taper potentiometer
**R11 through R20**—68K-ohm ½-watt resistor, 10%
**R21, R22**—15K-ohm ½-watt resistor, 10%

# 8 Octave Music Maker

☐ This circuit will provide you with musical octaves that are very well reproduced from the top octave that you feed as an input. Putting in any tone, like the tone from an electric guitar, or from an organ, or from a CMOS oscillator, will cause C4 to be four octaves lower, C5 to be five octaves lower, and so on. Output A is a special waveform that is a saw-tooth made up of octaves that are one, two, and three times lower than the input. The sounds of these outputs can be changed with resistor and capacitor circuits before feeding into your hi-fi.




**PARTS LIST FOR OCTAVE MUSIC MAKER**
**IC1**—4024 binary counter
**R1**—12,000-ohm, ½-watt resistor
**R2**—22,000-ohm, ½-watt resistor
**R3**—47,000-ohm, ½-watt resistor
**R4**—1,000-ohm, ½-watt resistor

# 9 Computer-Controlled Note Generator

☐ Computer music can be created in many different ways. One method is to specify all of a note's parameters—frequency, harmonic structure, amplitude, and attack/sustain/decay times—as well as special effects by means of software. Naturally, this gobbles up a lot of memory, thus making such an approach impossible for the owner of a very small computer. All is not lost, however. By augmenting your system with some inexpensive hardware, the software burden is diminished.

This computer-controlled note generator produces 5 octaves of the equally tempered chromatic scale under the control of one of your computer's 8-bit parallel ports (only 7 bits of which are used). Lines D6 through D4 select the octave, while lines D3 through D0 select one of the twelve notes within that octave.

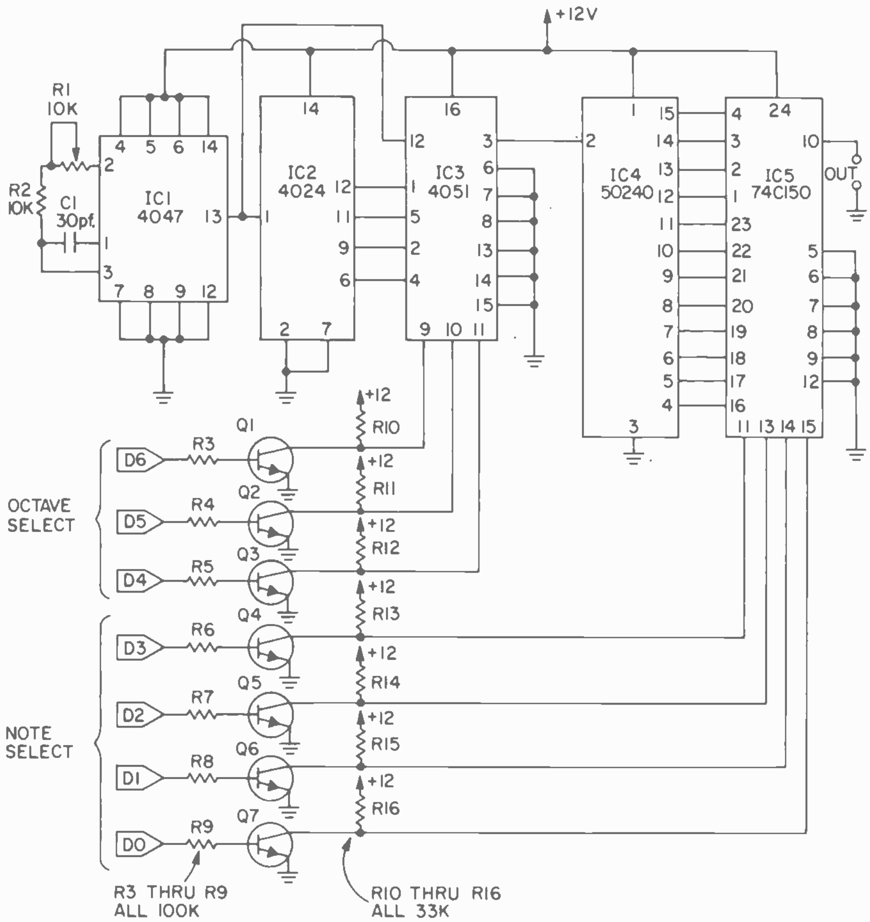
The lowest octave is selected by a binary 0 on lines D6 through D4. A binary 1 selects the next higher octave, and so on until you reach the highest octave, coded by a binary 4 (100). (Note: D6 is the most significant bit; D4 is the least significant.) Codes higher than 4 yield no output.

The note-selection lines behave similarly, except that 12 codes are used. (Here D3 is the most significant bit, and D0 is the least significant.) Binary 0 gives you a C#. D is produced by a binary 1, and binary 2 yields D#. This continues on up the scale until you reach binary 11, which gives the twelfth note, C. Codes above binary 11 give no output.

Tuning can be accomplished by adjusting R1 to produce a 1,000,120 Hz signal at pin 13 of IC1, or you can tune by ear against some pitch reference. The output at pin 12 of IC5 is a square wave that can be filtered and/or shaped (see the computer-controlled keyer circuit). The software we'll leave to you. In general, your programming burden has been reduced to the generation of a rhythmic sequence of 7-bit binary codes.

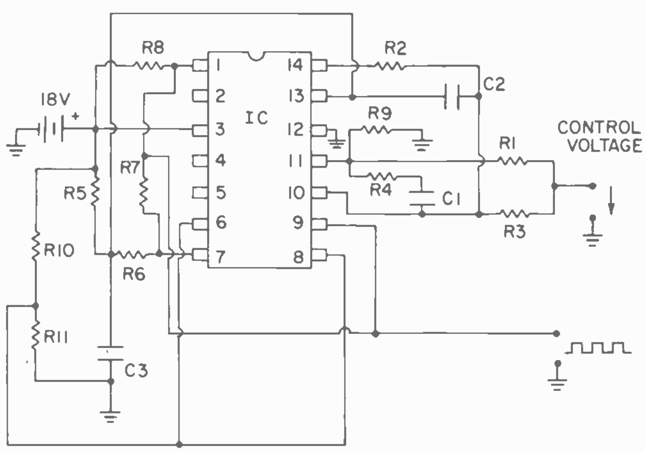
**PARTS LIST FOR COMPUTER-CONTROLLED NOTE GENERATOR**

**C1**—30-pF polystyrene capacitor
**IC1**—4047 CMOS multivibrator integrated circuit
**IC2**—4024 CMOS binary divider integrated circuit
**IC3**—4051 CMOS 8:1 multiplexer integrated circuit
**IC4**—50240 Mostek top-octave generator integrated circuit
**IC5**—74C150 16:1 CMOS multiplexer integrated circuit (National)
**Q1-Q7**—2N3904 NPN transistor
**R1**—10,000-ohm trim potentiometer (all resistors 10% unless otherwise noted.)
**R2**—10,000-ohm, ½-watt resistor
**R3-R9**—100,000-ohm, ½-watt resistor
**R10-R16**—33,000-ohm, ½-watt resistor




# 10 High Frequency VCO

☐ By varying the control voltage (a separate battery) between 1 and 25 volts, the output frequency of this oscillator will vary between about 500 Hz and 50,000 Hz. There are a host of experimental applications, such as putting a microphone in series with the control voltage and having the output frequency go into an amplifier and speaker. Voice-like singing sounds can be made. Or run the output of an electric guitar into the control voltage input and listen to the music!




**PARTS LIST FOR HIGH-FREQUENCY VOLTAGE CONTROLLED OSCILLATOR**

**C1**—0.1-pF ceramic disc capacitor, 15 VDC
**C2**—500-pF mica capacitor, 15 VDC
**C3**—0.01-uF ceramic disc capacitor, 15 VDC
**IC1**—LM339 quad comparator
**R1, R7**—100,000-ohm, ½-watt resistor
**R2**—50,000-ohm, ½-watt resistor
**R3**—20,000-ohm, ½-watt resistor
**R4**—10,000-ohm, ½-watt resistor
**R5, R8**—3,000-ohm, ½-watt resistor
**R6**—5,100-ohm, ½-watt resistor
**R9, R10, R11**—30,000-ohm, ½-watt resistor

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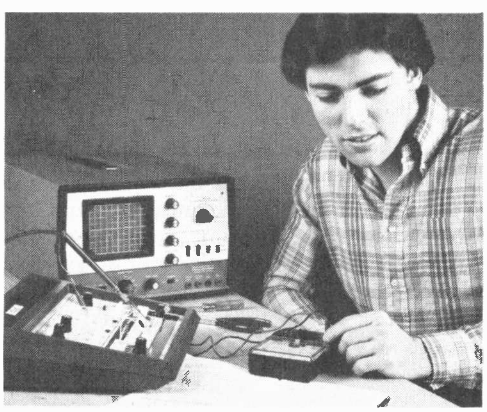

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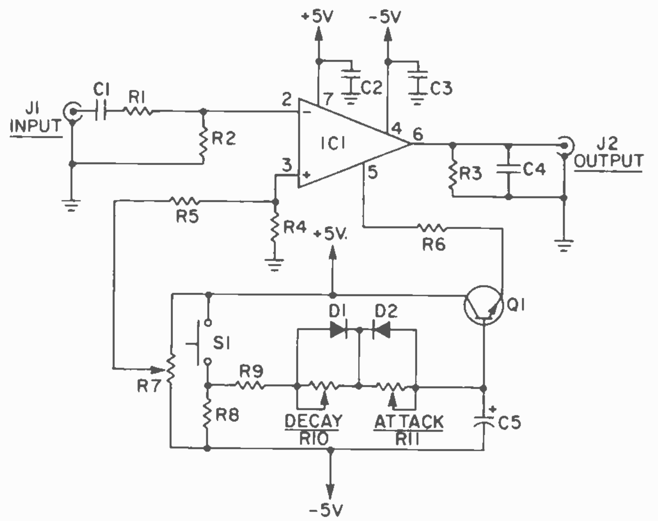
# 11 Musical Modulator

☐ Feed this circuit a simple audio tone, and it gives you back a musical note with selectable attack, sustain and decay. Input impedance is 10,000-ohms, output impedance is 1000-ohms, and the gain is unity. Best results will be obtained with signal inputs having amplitudes of 1-volt peak-to-peak or less. When S1 is pressed, the output volume rises at a rate determined by attack control R11. As long as S1 is pressed, the sound will be sustained. Releasing S1 causes the note to decay at a rate determined by decay control R10. Try sine, square or triangular wave inputs for musical notes. With a noise input you can imitate such things as gunshots and explosions. Trimmer R7 can be adjusted to cancel out any audible "thumping" (noticeable with very rapid attack or decay).

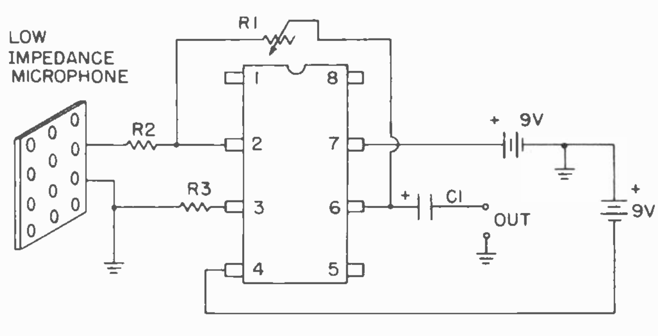



**PARTS LIST FOR MUSICAL MODULATOR**

**C1**—0.33-uF mylar capacitor, 35 VDC
**C2, C3**—0.1-uF ceramic disc capacitor, 35 VDC
**C4**—0.005-uF mylar capacitor, 35 VDC
**C5**—2.2-uF electrolytic capacitor, 16 VDC
**D1, D2**—1N914 diode
**IC1**—RCA CA3080 transconductance amp
**J1, J2**—phono jack
**Q1**—2N3904 NPN transistor
**R1**—9100-ohm ½-watt resistor, 10%
**R2, R3, R4**—1000-ohm ½-watt resistor, 10%
**R5**—2.2 Megohm ½-watt resistor, 10%
**R6**—15K-ohm ½-watt resistor, 10%
**R7**—1 Megohm trimmer potentiometer
**R8, R9**—5600-ohm ½-watt resistor, 10%
**R10, R11**—250K linear-taper potentiometer
**S1**—normally open SPST pushbutton switch

# 12 Low Impedance Mike Booster

☐ A low-impedance microphone has the property of being able to pass sufficient current to be directly in the feedback path of this 741 amplifier. The gain is controlled by changing R1. This circuit can feed into your hi-fi unit to give greater power output.




**PARTS LIST FOR LOW Z MIKE BOOSTER AMP**

**C1**—68-uF electrolytic capacitor, 25 VDC
**IC1**—741 op amp
**R1**—500,000-ohm linear-taper potentiometer
**R2, R3**—1,000-ohm, ½-watt resistor

# 13 Computer-Controlled Keyer

☐ This is a good companion to the computer-controlled note generator. Your computer should have available an 8-bit parallel port with which to control the keyer's gain. Feed the desired audio tone to the keyer's input, and hook an amplifier to its output.

A binary zero on the 8 lines from your computer yields zero output, while a binary 255 (11111111) provides maximum output. (D7 is the most-sinificant bit, and D0 is the least significant.) During a note's attack interval, count upwards from 0 to 255. Conversely, count down from 255 to 0 to make the note decay. Take tiny steps for best results. Large steps generate thumping sounds in the output.

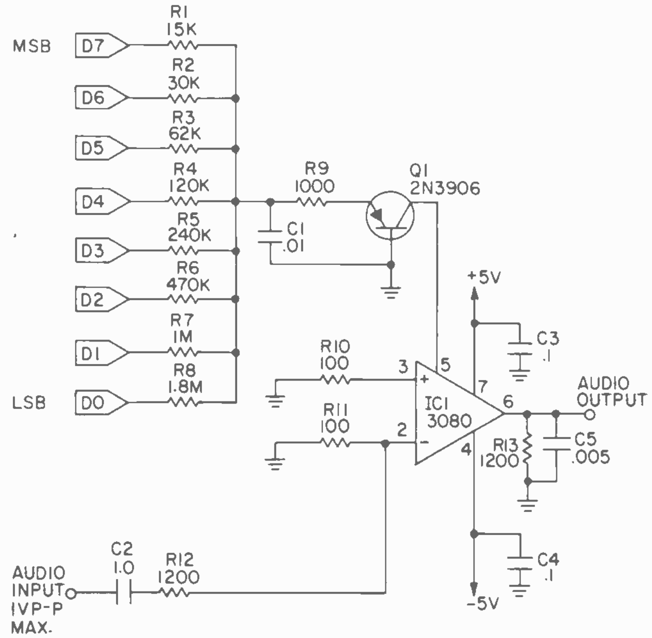
Let's say we want a fast attack time of 10 milliseconds. Using all available codes, it will take 255 steps to climb from zero to full output. For simplicity's sake, we'll let the note's amplitude rise linearly during attack, which means that the code will be incremented at regular, fixed time intervals. Since we wish to take 255 steps in 10 milliseconds (10,000 microseconds), it will be necessary to increment the code by 1 every 40 microseconds or so.

Linear attacks and decays are easy to figure, but not very realistic—especially for decay. The notes from most musical instruments attack and decay exponentially. This circuit gives you unlimited potential in the specification of a note's envelope, and it lets you change the envelope from note to note.

The audio input should be in the neighborhood of 1 volt peak-to-peak. When using the 12-volt signal from the computer-controlled note generaor, raise R12 to 15K ohms to accommodate the increased input amplitude.

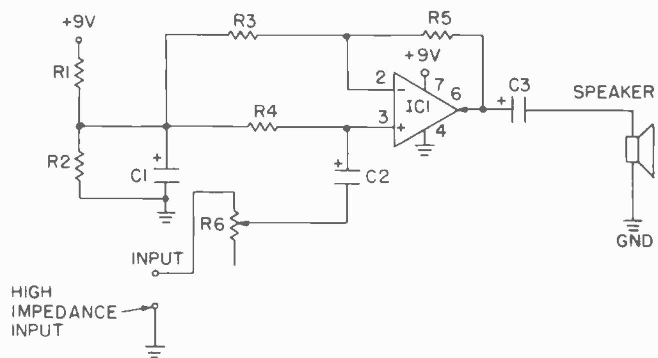
**PARTS LIST FOR COMPUTER-CONTROLLED KEYER**

**C1**—.01-uF ceramic disc capacitor
**C2**—1.0-uF mylar capacitor
**C3, C4**—0.1-uF ceramic disc capacitor
**C5**—.005-uF mylar capacitor
**IC1**—3080 transconductance integrated circuit amplifier (RCA)
**Q1**—2N3906 PNP transistor
**R1**—15,000-ohm, ½-watt resistor (all resistors 5%)
**R2**—30,000-ohm, ½-watt resistor
**R3**—62,000-ohm, ½-watt resistor
**R4**—120,000-ohm, ½-watt resistor
**R5**—240,000-ohm, ½-watt resistor
**R6**—470,000-ohm, ½-watt resistor
**R7**—1,000,000-ohm, ½-watt resistor
**R8**—1,800,000-ohm, ½-watt resistor
**R9**—1,000-ohm, ½-watt resistor
**R10, R11**—100-ohm, ½-watt resistor
**R12, R13**—1,200-ohm, ½-watt resistor




# 14 Micro-Mini PA

☐ Designed for *very* private listening, this little amplifier sports a tiny loudspeaker of 1½ to 2 inches diameter. The gain may be varied through the feedback resistor from about 1 to 100. Only a single power supply, which may be a nine volt transistor radio battery, is required.

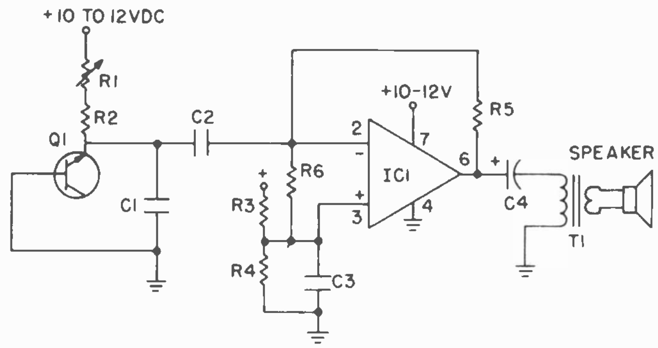



**PARTS LIST FOR MICRO-MINI PA**

**C1**—100-uF electrolytic capacitor, 100 VDC
**C2**—100-uF electrolytic capacitor, 6 VDC
**C3**—100-uF electrolytic capacitor, 10 VDC
**IC1**—741 op amp
**R1, R2**—5,600-ohm ½-watt resistor
**R3**—1,000-ohm ½-watt resistor
**R4**—50,000-ohm ½-watt resistor
**R5**—100,000-ohm ½-watt resistor
**R6**—100,000-ohm audio taper potentiometer
**SPKR**—8 ohm, 2-in. PM type

# 15 Useful Noise

☐ Noise, more or less "pure white" from some source of uncertainty, can be filtered and shaped for various purposes, ranging from radio alignment, to music, or the simulated sounds of rain on the roof. There are various naturally random impulse sources available to the experimenter, including the plasma from gaseous discharges occurring in neon lamps. On the semi-conductor level, there are diodes and transistors purposely configured and biased into noisiness. But under certain conditions, many semiconductor junctions develop wide band RF noise. When amplified by a type 741 op amp, which has internal frequency roll-off elements, the result is a continuous hiss in the output speaker, simulating rain. The signal can also be used in the development of "electronic music" and the testing of hi-fi filters and systems.




**PARTS LIST FOR USEFUL NOISE**

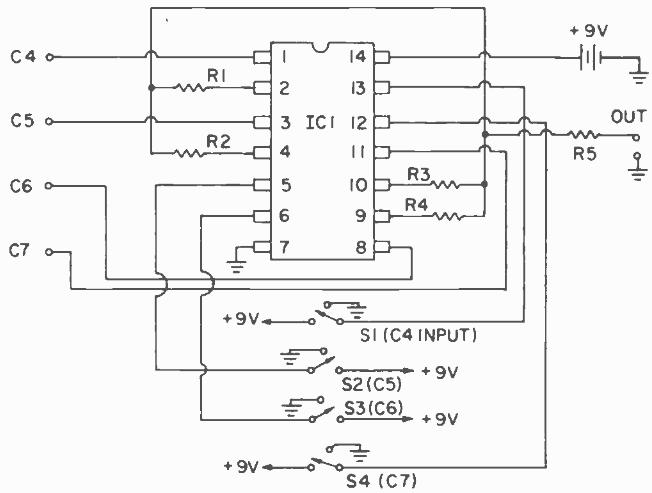
**C1**—.005-uF ceramic capacitor, 15 VDC
**C2, C3**—10-uF electrolytic capacitor, 15 VDC
**C4**—75-uF electrolytic capacitor, 25 VDC
**IC1**—741 op amp
**Q1**—2N4401
**R1**—100,000-ohm linear-taper potentiometer
**R2, R6**—10,000-ohm, ½-watt resistor
**R3, R4**—4,700-ohm, ½-watt resistor
**R5**—1,000,000-ohm, ½-watt resistor
**SPKR**—8-ohm PM type speaker
**T1**—audio output transformer with 500-ohm primary/8-ohm secondary

# 16 Multi-Input Music Synthesizer

**PARTS LIST FOR MULTI-INPUT MUSIC SYNTHESIZER**

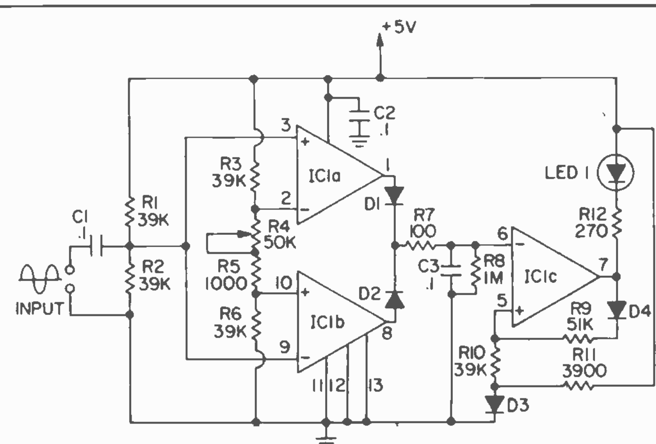
**IC1**—4016 quad bilateral switch
**R1 through R5**—1,000-ohm, ½-watt resistor
**S1 through S4**—SPDT slide switch

☐ The inputs to this synthesizer can be from any musical instruments. C4 can be from an electric guitar, C5 from an electronic organ, etc. Or the inputs can be from the outputs of the "Octave Music Maker" project. The voltage should not exceed 9 volts at these inputs. The output will be a combination of the inputs, where you control the combining via the switches. The switch marked "S1" will put the C4 input through to the output when it is switched to the down position.




# 17 Peak-Level Detector

☐ In many situations, particularly in recording, it is more important to know a signal's peak level than its average level. While VU meters are customarily employed for such




**PARTS LIST FOR PEAK-LEVEL DETECTOR**

**C1, C2, C3**—0.1-uF ceramic disc capacitor
**D1-D4**—1N914 diode
**IC1**—LM324 quad op amp integrated circuit
**LED1**—light emitting diode
**R1, R2, R3, R6, R10**—39,000-ohm, ½-watt resistor (all resistors 5%)
**R4**—50,000-ohm, ½-watt trim-potentiometer
**R5**—1,000-ohm, ½-watt resistor
**R7**—100-ohm, ½-watt resistor
**R8**—1,000,000-ohm, ½-watt resistor
**R9**—51,000-ohm, ½-watt resistor
**R11**—3,900-ohm, ½-watt resistor
**R12**—270-ohm, ½-watt resistor

purposes, you'll find this circuit's LED output easier to interpret and, as a result, more accurate. IC1a gauges the positive peaks, while IC1b does the same for the negative peaks. Both the positive and negative signal thresholds are determined by pot R4's setting. You can choose any threshold from ±20 mV to ±1 V. Whenever the input exceeds either the positive or negative threshold, LED1 flashes on for approximately one-tenth of a second. That's long enough to attract your attention and warn you to cut back on the volume.

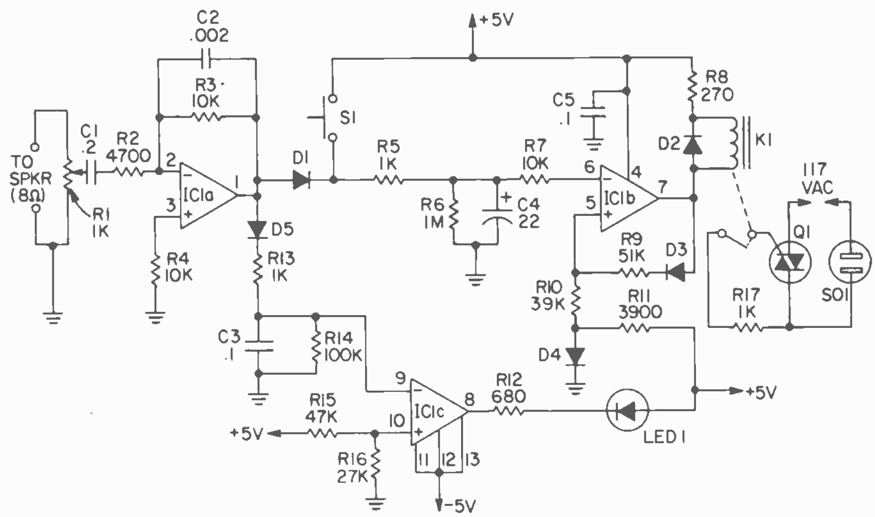
# 18 Automatic Stereo Shut-Off

☐ It's ironic, isn't it? Almost every cheap stereo system shuts itself off after the last record has been played, but just try to find a sophisticated, multi-component system that can do the same. Well, here's a circuit that may solve the problem for you. Plug all of your equipment into SO1. Touch S1 and K1 closes, thereby energizing your system. If no audio is fed from your amp's output (4-16 ohms) to R1, the system shuts down in approximately thirty seconds. However, if music is being fed into the shut-off circuit's input, C4 is consantly re-charged, and the power remains on until 30 seconds after the last record goes silent.

To set the circuit up, select the quietest passage to which you expect to listen. Press S1; put the tonearm in the groove, and adjust R1 until LED1 begins to flicker on and off with the music. Now relax, knowing that you finally have all the advantages of a cheap stereo.

**PARTS LIST FOR AUTOMATIC STEREO SHUT-OFF**

- **C1**—0.2-uF mylar capacitor
- **C2**—.002-uF mylar capacitor
- **C3**—0.1-uF mylar capacitor
- **C4**—22-uF, 10-VDC tantalum capacitor
- **C5**—0.1-uF ceramic disc capacitor
- **D1-D5**—1N914 diode
- **IC1**—LM324 quad op amp integrated circuit
- **K1**—6-VDC, 500-ohm relay
- **LED1**—light emitting diode
- **Q1**—200-VDC, 10A triac
- **R1**—1,000-ohm linear taper potentiometer
- **R2**—4.700-ohm, ½-watt resistor (all resistors 5% unless otherwise noted.)
- **R3, R4, R7**—10,000-ohm, ½-watt resistor
- **R5, R13**—1,000-ohm, ½-watt resistor
- **R6**—1,000,000-ohm, ½-watt resistor
- **R8**—270-ohm, ½-watt resistor
- **R9**—51,000-ohm, ½-watt resistor
- **R10**—39,000-ohm, ½-watt resistor




- **R11**—3,900-ohm, ½-watt resistor
- **R12**—680-ohm, ½-watt resistor
- **R14**—100,000-ohm, ½-watt resistor
- **R15**—47,000-ohm, ½-watt resistor
- **R16**—27,000-ohm, ½-watt resistor
- **R17**—1,000-ohm, 1-watt resistor
- **S1**—pushbutton switch, normally open
- **SO1**—AC power socket

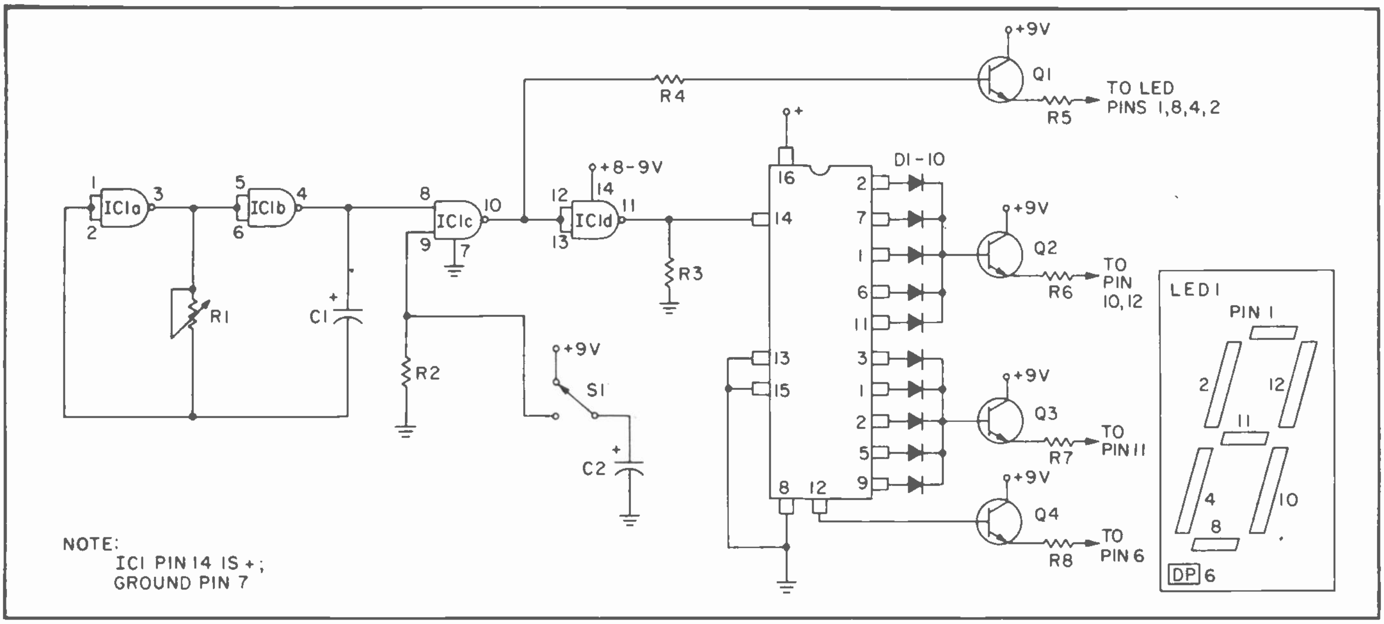
# 19 Coin Toss

**GAMES**

☐ The continued versatility of the 4017 counter and DL-750 digital display is demonstrated in this Odd-Even or Coin Toss simulator. As an added feature, the decimal point of the display is illuminated for an Odd or Even "Low Count," 0, 1, 2, 3, or 4 count from the counter. Even numbered counts (0 is considered even, for the sake of symmetry) cause the display to present an E, while odd-numbered counts result in a 0. Segments A, D, E and F are common to both 0 and E, but they are driven by the clock along with B, C, and G to stimulate all the segments into "random" motion. Holding down the pushbutton, causes C to discharge through R, giving an uncertainty period of five or seven seconds, depending upon the size of the capacitor chosen. Good Luck!

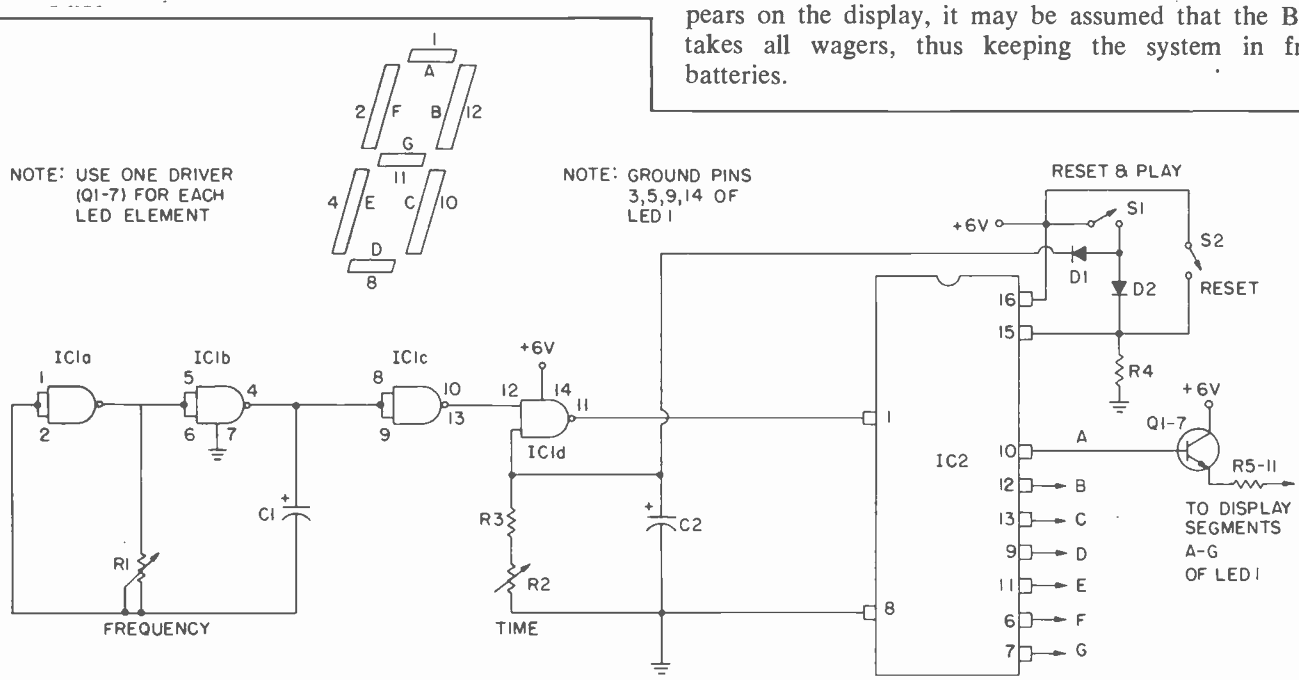
**PARTS LIST FOR COIN TOSS**

- **C1**—0.47 to 2.2-uF electrolytic capacitor, 15 VDC
- **C2**—50 to 100-uF electrolytic capacitor, 15 VDC
- **D1 through D10**—1N4148 diode
- **IC1**—4017 decade counter
- **Q1 through Q4**—2N4401 transistor
- **LED 1**—DL-750 7-segment display
- **R1**—500,000-ohm, linear-taper potentiometer
- **R2**—100,000-ohm, ½-watt resistor
- **R3**—1,000-ohm, ½-watt resistor
- **R4**—560-ohm, ½-watt resistor
- **R5, R6, R7, R8**—1,000-ohm, ½-watt resistor
- **S1**—SPDT momentary-contact pushbutton switch




# 20 Mini-Digital Roulette

☐ A more adult form of entertainment can be obtained from the 4026 counter and display previously described. The clock input terminal is connected via a pushbutton switch to the "Basic Pulse Maker" and two to nine players select a number. Then, press the button. The input frequency should be 10-Hz or higher and the Reset may zero the display first, although there is statistically little or no effect upon subsequent outcomes. When the switch is released, the counter holds on one number, which is displayed until reset or new counts arrive. If a Zero appears on the display, it may be assumed that the Bank takes all wagers, thus keeping the system in fresh batteries.

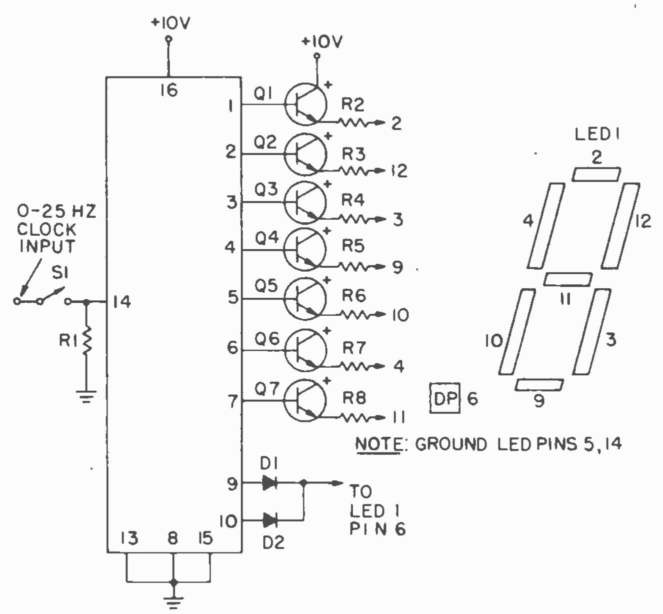



**PARTS LIST FOR MINI-DIGITAL ROULETTE**

**C1**—0.47 to 2.2-uF electrolytic capacitor, 15 VDC
**C2**—100-uF electrolytic capacitor, 15 VDC
**D1, D2**—1N4148 or 1N914 diode
**IC1**—4011 quad NAND gate
**IC2**—4026 decade counter
**LED 1**—DL-750 7-segment display
**Q1 through Q7**—2N4401 transistor
**R1**—500-000-ohm linear-taper potentiometer
**R2**—100,000-ohm linear-taper potentiometer
**R3**—10,000-ohm, ½-watt resistor
**R4 through R11**—1,000-ohm, ½-watt resistor
**S1, S2**—SPST momentary-contact switch

# 21 Common Cathode Casino

☐ The counter-display circuit of the "Quicker Than the Eye" project can be adapted to a game of chance for up to seven players, with a built-in provision to insure that "The House Never Loses." Note that all seven display segments, like the previous circuitry, have only one connection. Three outputs (pins 8, 9, 10) now go to the decimal point, via isolating diodes D1, D2, and D3. This gives "The House" a 3 out of 10 chance to take all bets. The clock should be set to provide a rapidly flickering display when the push-button switch is depressed. When the player holds down the switch for a few seconds and releases it, one of the segments, or the decimal point will remain lighted . . . and the odds are on the Point!



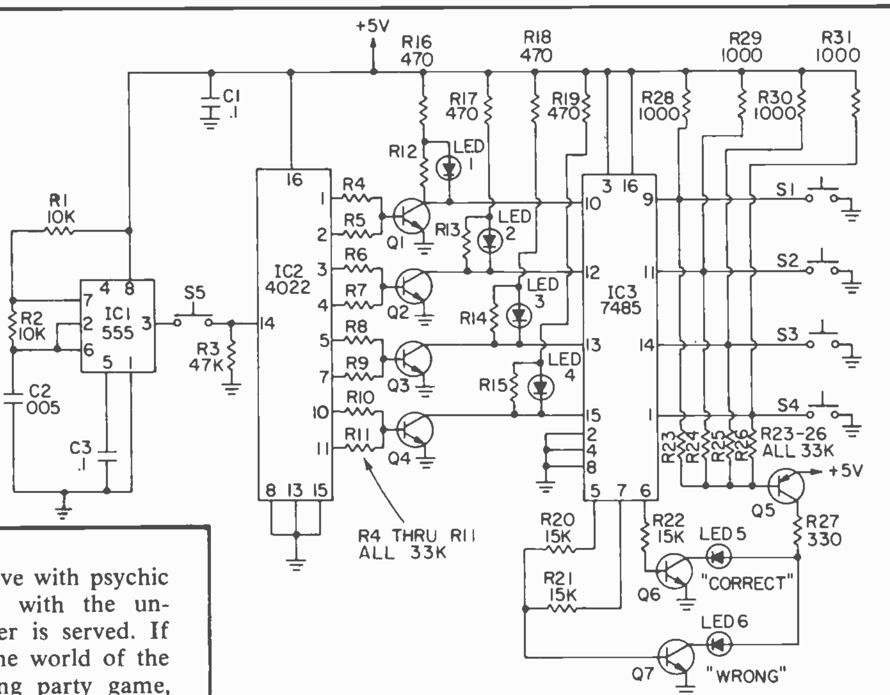

**PARTS LIST FOR COMMON CATHODE CASINO**

**D1,D2**—1N4148 diode
**IC1**—4017 CMOS decade counter
**LED1**—DL-750, 7-segment display
**Q1 through Q7**—2N4401
**R1 through R8**—1,000-ohm, ½-watt resistor
**S1**—SPST momentary-contact switch

# 22 ESP Tester

**PARTS LIST FOR ESP TESTER**

**C1, C3**—0.1-uF ceramic disc capacitor
**C2**—.005-uF mylar capacitor
**IC1**—555 timer integrated circuit
**IC2**—4022 CMOS octal counter integrated circuit
**IC3**—7485 4-bit magnitude comparator
**LED1-LED6**—light emitting diodes
**Q1-Q4, Q6, Q7**—2N3904 NPN transistor
**Q5**—2N3906 PNP transistor
**R1, R2**—10,000-ohm, ½-watt resistor (all resistors 10%)
**R3**—47,000-ohm, ½-watt resistor
**R4-R11, R23-R26**—33,000-ohm, ½-watt resistor
**R12-R15**—4,700-ohm, ½-watt resistor
**R16-R19**—470-ohm, ½-watt resistor
**R20-R22**—15,000-ohm, ½-watt resistor
**R27**—330-ohm, ½-watt resistor
**R28-R31**—1,000-ohm, ½-watt resistor



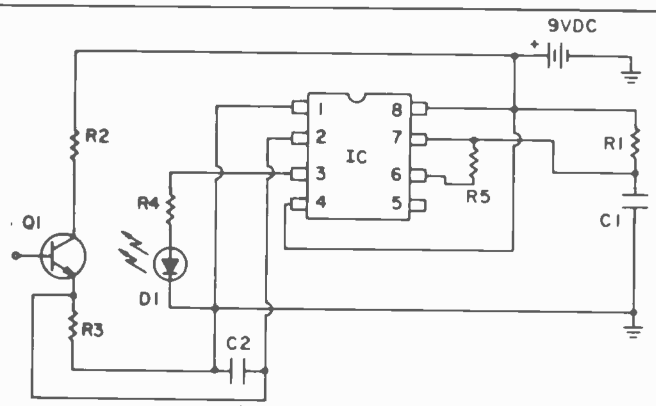

☐ The closest encounter most of us ever have with psychic phenomena probably comes from in-laws with the uncanny knack for dropping by just as dinner is served. If you'd like to delve somewhat deeper into the world of the unknown, or if you just want an intriguing party game, give this ESP tester a try.

Testing requires three persons—a Tester, a Sender and a Receiver—each one of whom has access only to a part of the circuitry. The Tester has S5, LED5 and LED6. By pressing and releasing S5, he causes the random lighting of one LED out of the set consisting of LEDs 1, 2, 3, and 4. Each LED of this set is identified in some way—usually by a geometric symbol like a star or triangle alongside it. The Sender, who views only these four LEDs, seeks to telepathically transmit the identity of the lit LED by mentally "broadcasting" a picture of the symbol linked with the LED.

The Receiver, whom we hope is monitoring the correct channel, indicates his response by pushing one of the four switches (S1 through S4) at his displosal. S1 corresponds to LED1 and is marked with the same geometric symbol. Likewise, S2 corresponds to LED2, and so forth. If the Receiver makes the correct choice, the Tester sees LED5 light up. On the other hand, if the Receiver's choice is wrong, or if he gets cute and pushes several buttons simultaneously, the Tester is notified of an error by the lighting of LED6.

# 23 Optical Confusion

☐ "As anyone can plainly see, the LED (D1) flashes rather rapidly," you say to an unsuspecting guest. "But in fact, the flashes are an optical illusion. Just hold this white paper in front of the LED and look at the light through the paper. You will see that in fact the LED is not flashing, at least not until you remove the paper." Your guest will be the victim of optical confusion. The trick lies in the fact that the LED flashes only as long as its light shines on Q1. Put the paper between D1 and Q1 and the LED shines continuously.

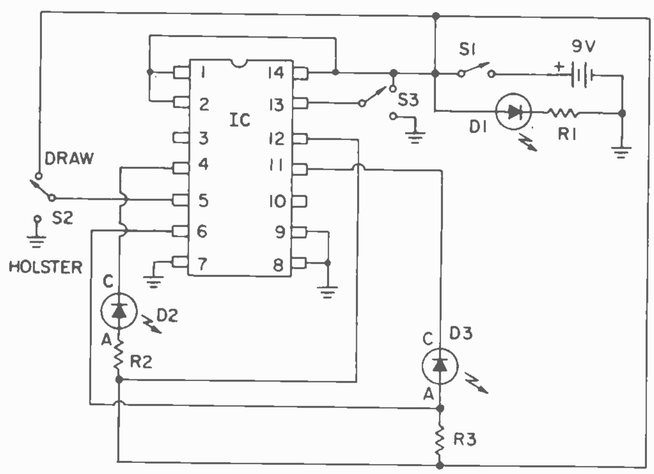



**PARTS LIST FOR OPTICAL CONFUSION**

**C1**—0.01-uF ceramic capacitor, 15 VDC
**C2**—0.1-uF ceramic capacitor, 15 VDC
**D1**—large LED
**IC1**—555 timer
**Q1**—FPT100 phototransistor
**R1**—10,000,000-ohm, ½-watt resistor
**R2, R3**—1,000,000-ohm, ½-watt resistor
**R4**—220-ohm, ½-watt resistor
**R5**—2,000,000-ohm, ½-watt resistor

# 24 Quick Draw

☐ The object of "Quick Draw" is to test your reaction time against your opponent's. A third person acts as referee and begins the duel by pressing S1, which lights LED D1. Upon seeing D1 lit, you try to outdraw your opponent by moving S2 (or S3) from "holster" to "draw" before he does. If you do, D2 (or D3 if you use S3) will light first and will automatically prevent the other LED from lighting. A clear winner every time.



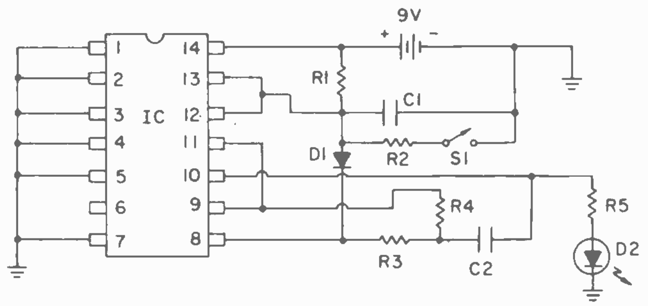

**PARTS LIST FOR QUICK-DRAW**

**D1, D2, D3**—large LED
**IC1**—4011 NAND gate
**R1**—2,000-ohm, ½-watt resistor
**R2, R3**—1,000-ohm, ½-watt resistor
**S1**—pushbutton (doorbell) SPST switch
**S2**—toggle-type SPDT switch
**S3**—toggle-type SPDT switch

# 25 LED Black Jack

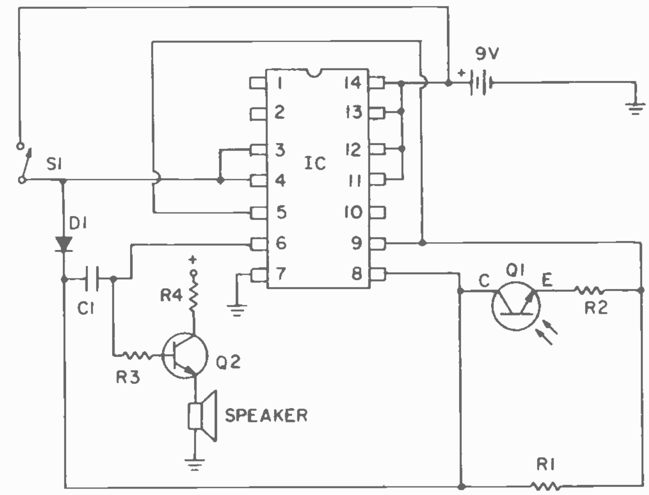
☐ The object is to see who can get closest to 21 LED flashes without going over. Any number of people can play. Press S1 until D2 starts flashing (1 second on, 1 second off). Then count the number of pulses *after* S1 is released. You may get 5 the first time. That is like being dealt a 5 in Black Jack. Do it again and add the second count to the first, etcetera, until you are as close as you can get to 21 without going over. If you go over, you are out of the game. A fun game and easy to build. The 9 volt battery will last for months.

**PARTS LIST FOR LED BLACKJACK**
**C1**—4.7-uF tantalum capacitor, 15 VDC
**C2**—0.1-uF ceramic disc capacitor, 15 VDC
**D1**—1N4001 diode
**D2**—small LED
**IC1**—4000 NOR gate
**R1**—5,000,000-ohm, ½-watt resistor
**R2**—30,000-ohm, ½-watt resistor
**R3, R4**—10,000,000-ohm, ½-watt resistor
**R5**—1,000-ohm, ½-watt resistor
**S1**—SPST pushbutton (doorbell) switch




# 26 Haunted House

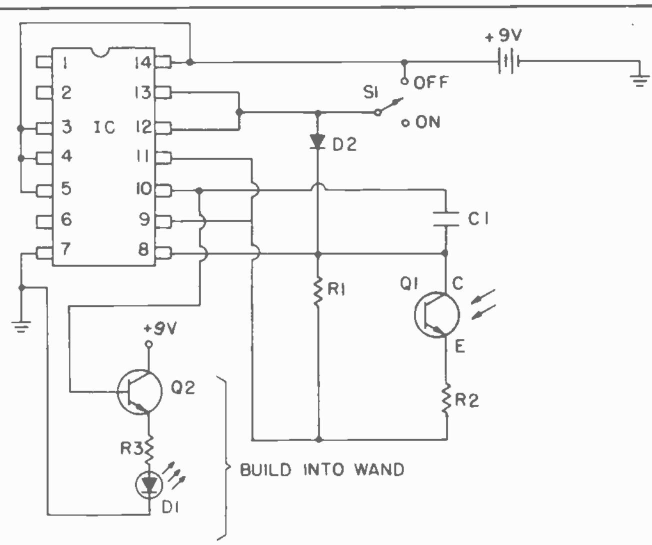
☐ An eerie sound comes from a small box in a dark room. As your friends shine a light toward the sound, it whines with a higher pitch, but falls again as they drop the light and run. The output at A can also be run into your hi-fi system to cause a very loud witch's squeal. The principle is a NOR-gate oscillator with a pitch controllable via the light-sensitive transistor Q1. Changing R1 to a higher value will give a lower-pitched wail.




**PARTS LIST FOR HAUNTED HOUSE**
**C1**—0.01-uF ceramic capacitor, 15 VDC
**D1**—1N4001 diode
**IC1**—4000 dual NOR gate w/inverter
**Q1**—FPT-100 phototransistor
**Q2**—2N4401
**R1**—30,000-ohm, ½-watt resistor
**R2**—1,000,000-ohm, ½-watt resistor
**R3**—2,000-ohm, ½-watt resistor
**R4**—500-ohm, ½-watt resistor
**S1**—SPDT toggle switch

# 27 Magic Blinker

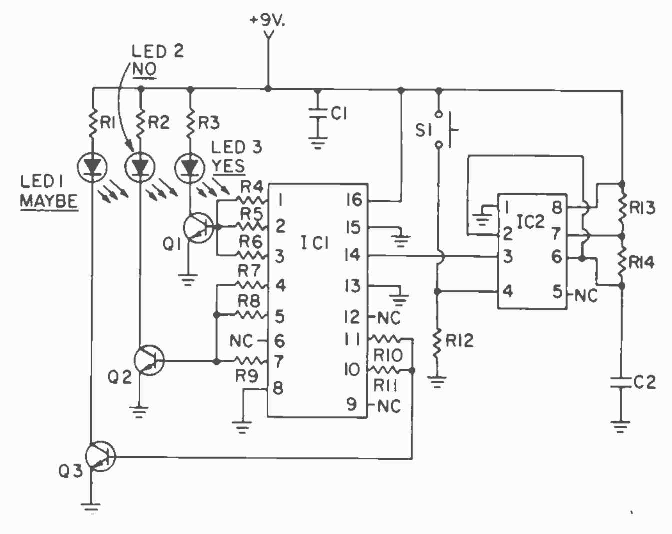
☐ Imagine a small black box that you place on a table in front of your friends. Connected to the box with a thin wire is a wand with a small red light (LED) on the end. The light flashes about twice a second, but at your command, it flashes faster and faster. You hand it to your friends, but they cannot do it. The secret? In the box is a small hole with photo transistor Q1 showing through. As D1 gets closer to Q1, it flashes faster and faster but it will take your friends a long while to catch on. It's especially effective when all the room lights are out. Have fun.




**PARTS LIST FOR MAGIC BLINKER**
**C1**—0.01-uF ceramic capacitor, 15 VDC
**D1**—small LED
**D2**—1N4001 diode
**IC1**—4000 dual NOR gate w/inverter
**Q1**—FPT100 phototransistor
**Q2**—2N4401 transistor
**R1**—5,000,000-ohm, ½-watt resistor
**R2**—1,000,000-ohm, ½-watt resistor
**R3**—680-ohm, ½-watt resistor

# 28 Mystic Fortune Teller

☐ In ancient times, if you needed help with a tough decision you went to the neighborhood oracle who, for a small fee, supplied you with advice straight from the gods. Those days are gone, unfortunately, but if you're really desperate for advice, maybe this circuit will help. Ask the Optical Aracle a question, press and release S1, and read your answer—YES, NO or MAYBE—on the lit LED. You'll get a MAYBE 25% of the time and a definitive YES or NO the rest of the time. If your horse comes in a winner, simply send 10% of the purse to us.

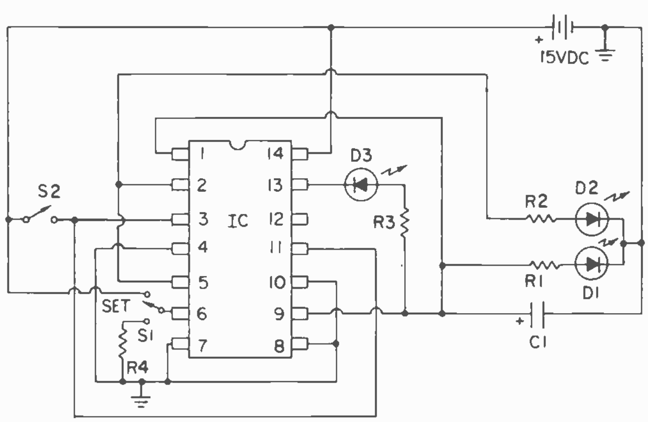



**PARTS LIST FOR MYSTIC FORTUNE TELLER**

**C1**—0.1-uF ceramic disc capacitor, 35 VDC
**C2**—330-pF polystyrene capacitor, 35 VDC
**IC1**—4022 CMOS octal counter
**IC2**—555 timer
**LED 1, 2, 3**—light-emitting diode
**Q1, Q2, Q3**—2N3904 NPN transistor
**R1, R2, R3**—680-ohm ½-watt resistor, 10%
**R4 through R11**—47K-ohm ½-watt resistor, 10%
**R12**—2200-ohm ½-watt resistor, 10%
**R13, R14**—18K-ohm ½-watt resistor, 10%
**S1**—normally open SPST pushbutton switch

# 29 Lightning Speed Reaction Tester

☐ This circuit uses the two flip-flops of the CD 4013 integrated circuit to test your eyesight. Start by moving S1 from ground to "set" and back to ground. This will light D1 and D3. Now press S2. D1 and D3 will go off and D2 will go on, but D3 must go off slightly later than D3 due to built-in delays in the circuit. Can you see the difference in the two LED's? This makes a great experiment for kids to take to school.




**PARTS LIST FOR LIGHTNING REACTION TESTER**

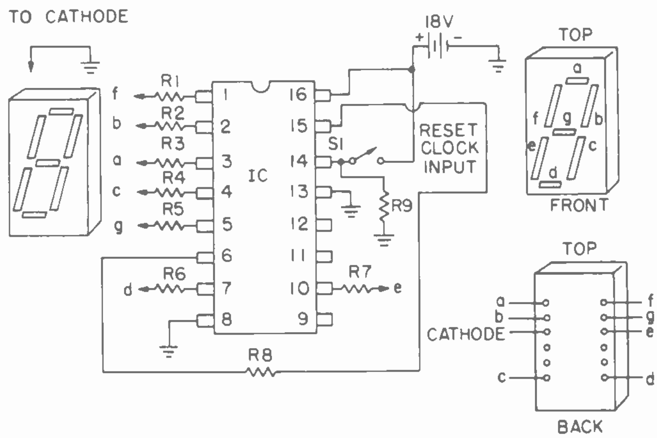
**C1**—1-uF electrolytic capacitor, 15 VDC
**D1, D2, D3**—small LED
**IC1**—4013 dual flip-flop
**R1, R2, R3**—2,000-ohm, ½-watt resistor
**R4**—500,000-ohm, ½-watt resistor
**S1**—SPDT slide switch
**S2**—SPST momentary contact pushbutton switch

# 30 Quicker Than The Eye

☐ The faster you can repeatedly press S1, the faster the segments of the digit "8" will fly around the LED display. The fun of this quicker than the eye game is to see if you can make the 8 look like a solid number. We have here the basic multiplex principle used in calculator displays. In calculators only one segment of a digit is on at a time, but the rapid change makes it appear that all are on. Pin 6 above is used to reset to zero.

**PARTS LIST FOR QUICKER THAN THE EYE**

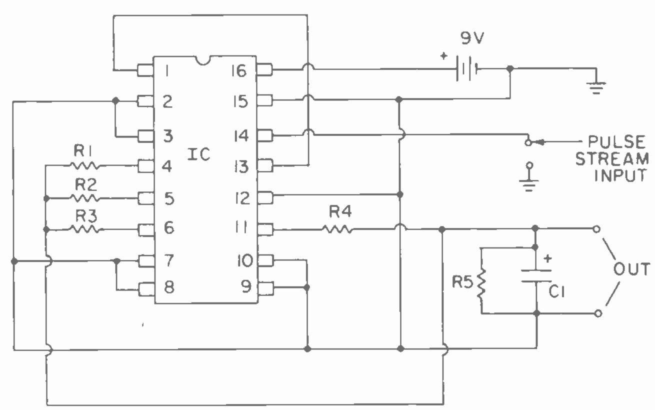
**IC1**—4017 decade counter
**LED1**—DL-750 7-segment display
**R1 through R7**—680-ohm, ½watt resistor
**R8**—1,200-ohm, ½-watt resistor
**R9**—100,000-ohm, ½-watt resistor
**S1**—SPST momentary-contact pushbutton switch






# 31 Sine Wave Generator

☐ Think it is possible to have a pulse stream turned into a nice smooth sine-wave? This circuit will do it! In fact, you can have the lowest sine-wave frequency you can imagine by slowly pressing a button to generate your own manual pulse stream, if you like. The IC is a counter that has been made to divide the input pulse rate by ten. The outputs feed through resistors R1, R2, R3, and R4 to build up a sine wave.

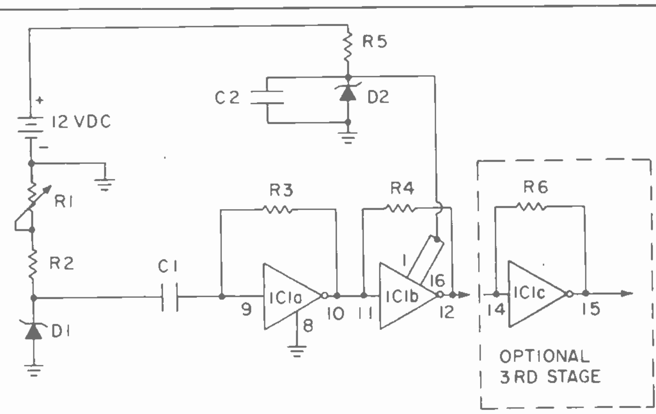



**PARTS LIST FOR SINE WAVE GENERATOR**

**C1**—10-uF electrolytic capacitor, 15 VDC
**IC1**—4018 dividing counter
**R1, R2, R3, R4**—20,000-ohm, ½-watt resistor
**R5**—47,000-ohm, ½-watt resistor

# 32 RF Noise Generator

☐ The diode-generated radio-frequency noise has such a wide spectrum of energy that it can be detected by both long and short-wave receivers. Bringing a transistor radio near the circuit shown below will demonstrate the power and limitations of the generator. The noise generator may be used in checking out a defective receiver through RF and IF stages by injecting it at various points. In the circuit, RF amplification was provided by running CMOS inverters in a linear mode. To reduce heating, an operating potential of about five volts was established through the use of a 1N751 zener diode, functioning normally, and not a noise generator in its own right, we hope!

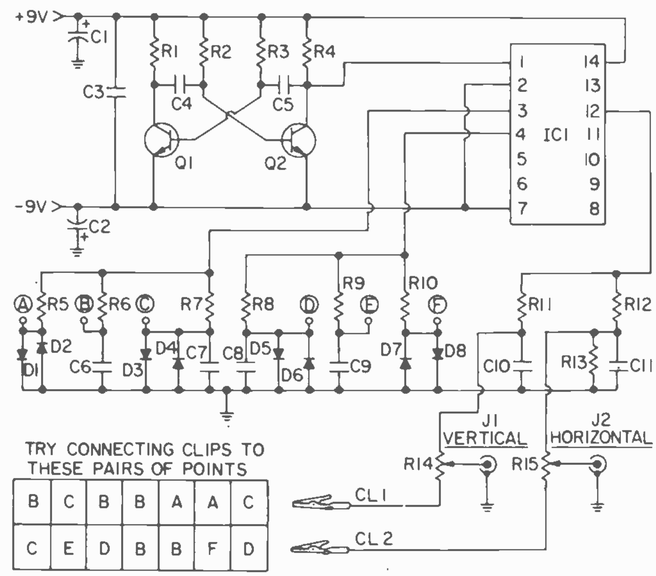



**PARTS LIST FOR RF NOISE GENERATOR**

**C1, C2**—0.1-uF ceramic disc capacitor, 15 VDC
**D1**—1N758 or 1N759 diode
**D2**—1N751 diode
**IC1**—4009A hex buffer
**R1**—500,000-ohm linear-taper potentiometer
**R2**—10,000-ohm, ½-watt resistor
**R3 R4**—1,000,000-ohm, ½-watt resistor
**R5**—300-ohm, 1-watt resistor
**R6**—1,000,000-ohm, ½-watt resistor

# 33 Video Pattern Generator

☐ Those of you with oscilloscopes might enjoy breadboarding this pattern generator. Feed the signal at J1 to your scope's vertical input, and connect the horizontal input to J2. Attach the clips to the selected pairs of test points, then adjust potentiometers R14 and R15 to create complex images. Output signals are about 1-volt, peak-to-peak.

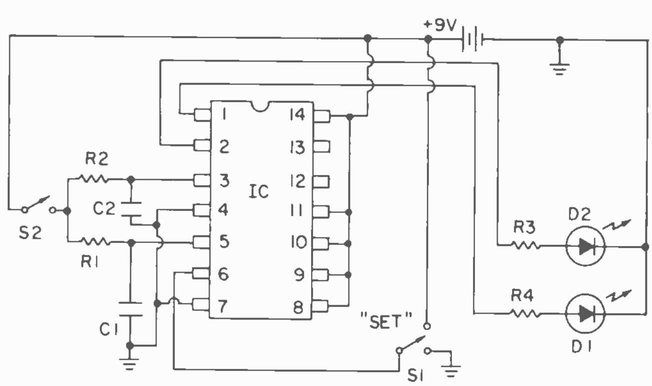



**PARTS LIST FOR VIDEO PATTERN GENERATOR**

**C1, C2**—250-uF electrolytic capacitor, 25 VDC
**C3**—0.1-uF ceramic disc capacitor, 35 VDC
**C4, C5**—100-pF polystyrene capacitor, 35 VDC
**C6, C7**—1.0-uF mylar capacitor (non-polarized), 35 VDC
**C8, C9**—0.5-uF mylar capacitor, 35 VDC
**C10**—0.022-uF mylar capacitor, 35 VDC
**C11**—0.001-uF mylar capacitor, 35 VDC
**CL1, CL2**—alligator clip
**D1 through D8**—1N914 diode
**IC1**—4024BE CMOS ripple divider
**J1, J2**—phono jack
**Q1, Q2**—2N3904 NPN transistor
**R1, R4, R5, R10**—100K-ohm ½-watt resistor, 10%
**R2, R3**—1.5-Megohm ½-watt resistor, 10%
**R6, R9**—68K-ohm ½-watt resistor, 10%
**R7, R8**—33K-ohm ½-watt resistor, 10%
**R11, R12**—47K-ohm ½-watt resistor, 10%
**R13**—3300-ohm ½-watt resistor, 10%
**R14, R15**—250K linear-taper potentiometer

# 34 Capacitor Match Maker

☐ This useful, but simple circuit will allow you to match two capacitors or to tell if one has greater capacitance than the other. Suppose you have one capacitor of known value, say 1 uF. Put it where C1 is in the circuit. Suppose you have another capacity of some unknown value. Put it where C2 is in the circuit. Now flip S1 from "set" back to ground. Then press S2. If D1 goes off and D2 goes on, it means C2 is less than C1, like 0.5 uF. If D1 stays on and D2 off, it means C2 is equal or greater than C1. You can use this circuit to help you quickly sort through a pile of old capacitors.




**PARTS LIST FOR CAPACITOR MATCH-MAKER**

**C1, C2**—see text
**D1, D2**—small LED
**IC1**—4013 dual flip-flop
**R1, R2**—30,000-ohm, ½-watt resistor
**R3, R4**—1,000-ohm, ½-watt resistor
**S1**—SPDT slide switch
**S2**—SPST momentary-contact pushbutton switch

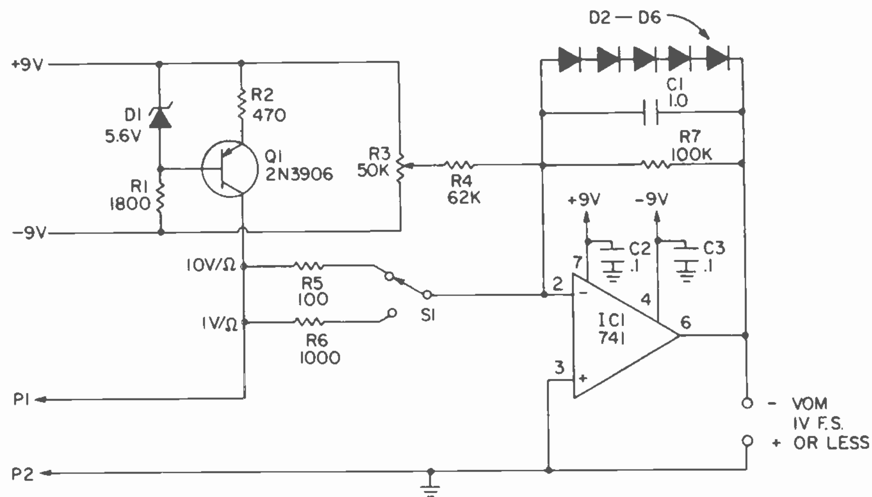
# 35 Milliohms Adapter

☐ Few experimenters have the equipment to measure resistances of less than one ohm, and even fewer of them could care to do so. But the ability to measure resistance in the milliohm range can be very handy. For insance, motor manufacturers routinely check their coils with milliohmmeter. Since the net resistance is proportional to the length of wire on the coil form, measuring the resistance provides a simple, non-destructive method for checking the number of turns on a coil. With a milliohmmeter you can even check the relative quality of switch contacts and solder joints.

Current source Q1 drives a constant 10-milliamp current through whatever resistance lies between probes P1 and P2. U1 amplifies the voltage generated across the resistance by the current flowing through it. You read the voltage at U1's output on your VOM and multiply by the appropriate scale factor—10V/ohm with S1 up, 1V/ohm with S1 down—to get the resistance. Before reading, short the probes together, and adjust R4 for zero output. Use needle-type probes, since they easily pierce surface oxide films (which can introduce significant resistance of their own). Keep the output voltage below one volt; in other words, the *maximum* resistance you can measure is one ohm.

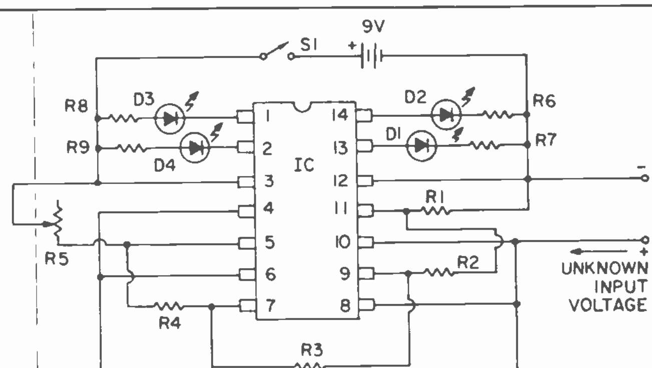
**PARTS LIST FOR MILLIOHMS ADAPTER**

**C1**—1.0-uF mylar capacitor
**C2, C3**—0.1-uF ceramic disc capacitor
**D1**—5.6-VDC, ½-watt zener diode
**D2-D6**—1N914 silicon diode
**IC1**—741 op amp
**P1, P2**—test probes
**Q1**—2N3906 PNP transistor
**R1**—1,800-ohm, ¼-watt resistor (all resistors 5%, unless otherwise noted.)
**R2**—470-ohm, ¼-watt resistor
**R3**—50,000-ohm linear taper potentiometer
**R4**—62,000-ohm, ¼-watt resistor
**R5**—100-ohm, ¼-watt resistor
**R6**—1,000-ohm, ¼-watt resistor
**R7**—100,000-ohm, ¼-watt resistor
**S1**—SPDT toggle switch




# 36 Meter Eliminator

☐ This circuit introduces the principle of a digital voltmeter and actually provides a very sensitive, high impedance meter for your workbench. The LM-339 is an IC containing four separate operational amplifiers of a special type. These op amps compare the reference voltage set on one input pin with an unknown voltage on the other. If the unknown voltage exceeds the reference, the output goes high and lights an LED. D1 lights first. With a slightly higher input voltage, D2 will light, etc. Variable resistor R5 allows you to set the voltage steps between D1, D2, D3 and D4 from about .02 volts per step to about 0.5 volts per step.




**PARTS LIST FOR METER ELIMINATOR**

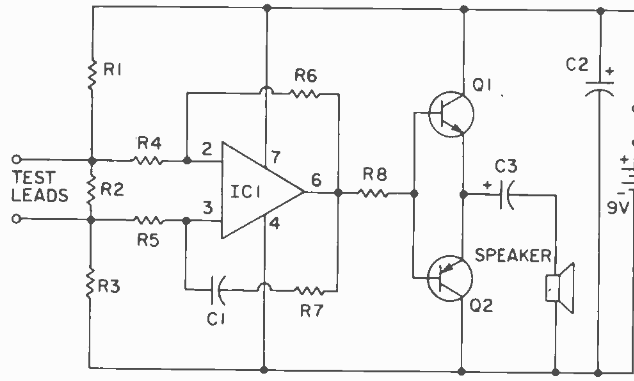
**D1, D2, D3, D4**—large LED
**IC1**—LM339 quad comparator
**R1, R2, R3, R4**—1,200-ohm, ½-watt resistor
**R5**—1,000,000-ohm linear-taper potentiometer
**R6, R7, R8, R9**—470-ohm, ½-watt resistor
**S1**—SPST toggle switch

# 37 Continuity Checker

☐ After wiring a new electronic project or troubleshooting an old one, it is often good practice to make several continuity checks to be sure that certain connections in the circuit are correct. In the days of vacuum tubes this was accomplished with an ohmmeter, but for today's solid state circuitry you can't use most ohmmeters for several reasons. Some ohmmeters have far too much battery voltage and deliver as much as hundreds of milliamperes into a short circuit. This can easily damage expensive solid state devices. Also, the ohmmeter is an unreliable method to measure circuit continuity, since it will read through an emitter-base or diode junction. This continuity checker is a handy accessory for troubleshooting circuits, and is safe to use on any solid state device or circuit. The maximum voltage at the input terminals is about 40 millivolts, and negligible current is passed through the circuit when continuity is indicated. The circuit will not indicate continuity for resistance values of about 35 ohms or greater, and will not register through an emitter-base junction or diode. The circuit is powered by a standard 9 volt transistor battery and draws about 1 milliampere when the input leads are open. Shorting the lead causes an audio tone to be generated and draws about 15 milliamperes of battery current.

**PARTS LIST FOR CONTINUITY CHECKER**

**C1**—.001-uF ceramic disc capacitor, 15 VDC
**C2**—10-uF electrolytic capacitor, 15 VDC
**C3**—15-uF electrolytic capacitor, 15 VDC
**IC1**—741 op amp
**Q1**—2N4401
**Q2**—2N4403
**R1, R3, R4, R5, R8**—10,000-ohm, ½-watt resistor
**R2**—100-ohm, ½-watt resistor
**R6**—4,600,000-ohm, ½-watt resistor
**R7**—100,000-ohm, ½-watt resistor
**R9, R10**—10-ohm, ½-watt resistor
**SPKR**—8-ohm PM type speaker




# 38 Penny Pincher Frequency Meter

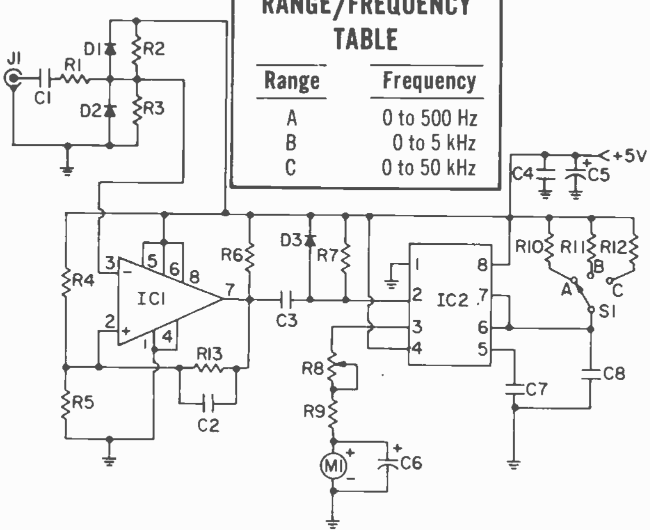
☐ One of the handiest instruments you can own is the digital frequency counter, but unless you do an awful lot of experimenting, the expense is usually hard to justify. However, if you can spare $15, consider building this *analog* frequency meter. Input impedance is 100,000-ohms, and frequencies up to 50 kHz can be measured, which makes the instrument ideal for the audio experimenter. After construction, calibrate the instrument by first selecting the middle range (Range B, 0-5 kHz) with S1. Feed a 5-kHz signal of known accuracy to J1, and adjust potentiometer R8 for a full-scale deflection on meter M1. That's it.

**PARTS LIST FOR PENNY PINCHER FREQUENCY METER**

**C1, C4, C7**—0.1-uF ceramic disc capacitor, 35 VDC
**C2**—5-pF polystyrene capacitor, 35 VDC
**C3**—100-pF polystyrene capacitor, 35 VDC
**C5, C6**—100-uF electrolytic capacitor, 10 VDC
**C8**—3000-pF polystyrene capacitor, 35 VDC
**D1, D2, D3**—1N4001 diode
**IC1**—LM311 comparator
**IC2**—555 timer
**J1**—phono jack
**M1**—0-50 microAmp DC meter
**R1**—4700-ohm ½-watt resistor, 10%
**R2, R3, R4, R5**—18K-ohm ½-watt resistor, 5%
**R6**—1000-ohm ½-watt resistor, 10%
**R7**—10K-ohm ½-watt resistor, 10%
**R8**—10K trimmer potentiometer
**R9, R11**—30K-ohm ½-watt resistor, 5%
**R10**—300K-ohm ½-watt resistor, 5%
**R12**—3000-ohm ½-watt resistor, 5%
**R13**—10 Megohm ½-watt resistor, 10%
**S1**—single pole, 3-position rotary switch

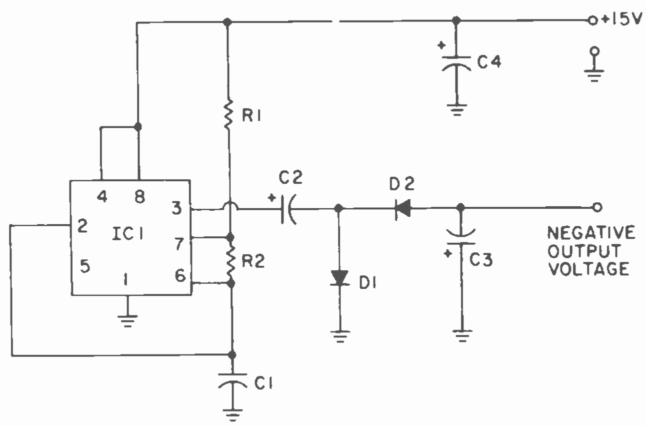
**RANGE/FREQUENCY TABLE**

| Range | Frequency |
|---|---|
| A | 0 to 500 Hz |
| B | 0 to 5 kHz |
| C | 0 to 50 kHz |




# 39 Negative Power Supply

☐ Many operational amplifiers operate from a dual-polarity power supply. For low current applications, it may be easier to construct this negative power supply using one IC, rather than rectifying from the power line or transformer. IC1 operates in an astable mode with essentially square wave output at pin 3. C2, C3, D1 and D2 form a full-wave voltage doubler circuit which produces approximately minus 14 volts with no load at the negative output terminal. The circuit will deliver 12 volts into a load of 1000 ohms.

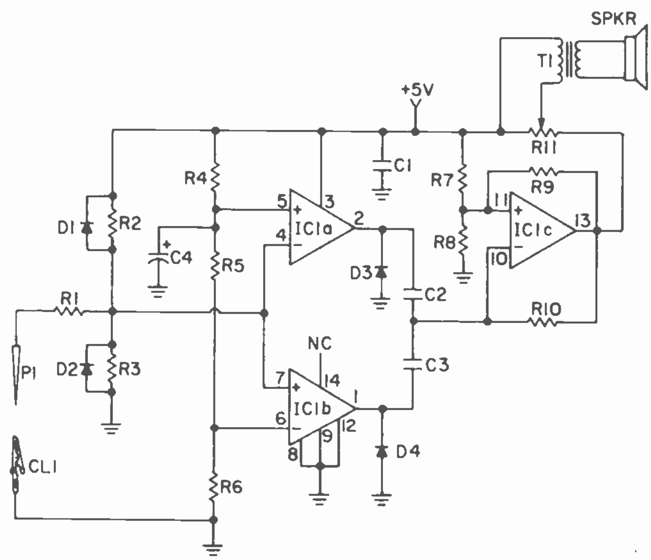



**PARTS LIST FOR NEGATIVE POWER SUPPLY**

**C1**—.01-uF ceramic capacitor, 15 VDC
**C2, C3, C4**—15-uF electrolytic capacitor, 25 VDC
**D1, D2**—1N4148 diode
**IC1**—555 timer
**R1**—1,000-ohm, ½-watt resistor
**R2**—10,000-ohm, ½-watt resistor

# 40 IC Audible Logic Probe

☐ Here is the old familiar logic probe but with a new twist. Instead of displaying logic status with LEDs, it does the job aurally. The logic-1 state, 2-volts or greater, is signalled by a high tone. On the other hand, a low tone sounds to indicate the logic-0 state, 0.8-volt or less. Inputs between 0.8 and 2-volts produce no output. (Note that this probe is designed especially for TTL and cannot be used for any other logic family.) The circuit requires a regulated 5-volt supply, which means that it can be powered by the same supply used by the TTL circuitry under test. Output can be taken from a miniature speaker, as shown in the schematic, or you may use a miniature earphone. Potentiometer R11 sets the output volume level.




**PARTS LIST FOR IC AUDIBLE LOGIC PROBE**

**C1**—0.1-uF ceramic disc capacitor, 35 VDC
**C2**—0.005-uF mylar capacitor, 35 VDC
**C3**—0.1-uF mylar capacitor, 35 VDC
**C4**—1.0-uF tantalum capacitor, 10 VDC
**CL1**—alligator clip
**D1, D2**—1N4001 diode
**D3, D4**—1N914 diode
**IC1**—LM339 quad comparator
**P1**—metal probe tip
**R1**—10K-ohm ½-watt resistor, 10%
**R2, R3**—220K-ohm ½-watt resistor, 10%
**R4**—30K-ohm ½-watt resistor, 5%
**R5**—12K-ohm ½-watt resistor, 5%
**R6**—8200-ohm ½-watt resistor, 5%
**R7, R8, R10**—56K-ohm ½-watt resistor, 10%
**R9**—120K-ohm ½-watt resistor, 10%
**R11**—1000-ohm audio-taper potentiometer
**SPKR**—8-ohm miniature speaker
**T1**—miniature audio output transformer—1,000-ohm primary/8-ohm secondary

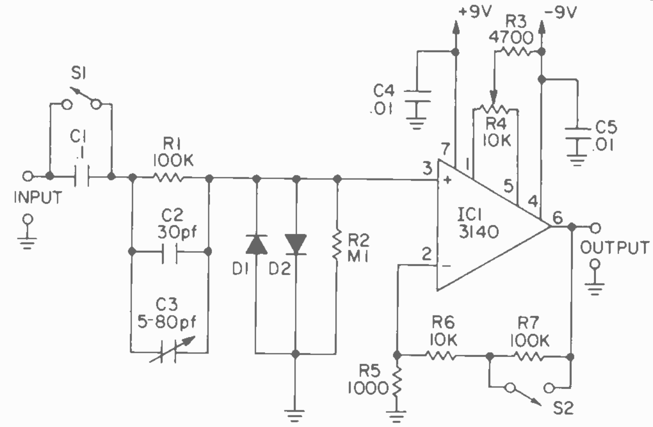
# 41 Instrument Sensitivity Booster

☐ This tiny, high-impedance amplifier will boost the sensitivity of your oscilloscope or voltmeter by a factor of 10 or 100. So, if your oscilloscope's maximum sensitivity at present is 10mV/div, you can boost it to 1mV/div or .1mV/div. Signals you previously could not measure, such as the output of your magnetic phono cartridge, will now be visible. Note also that if all you own is a 20K-ohms-per-volt VOM, the sensitivity booster will not only let you measure smaller voltages, it will give you a 1-megohm input impedance besides.

Switch S2 selects the gain—10 if closed and 100 is open. When you need direct coupling to measure DC voltages, close S1. Otherwise, leave it open for AC coupling. If the booster is to be used with a scope, feed a 20-kHz square wave to its input, and adjust C3 for the best-looking square wave at the output. For use with just a VOM, C2 and C3 will have little effect; therefore, you can leave them out. The amp can be nulled by grounding its input and adjusting R4 for zero output. Sinewave response extends to 400 kHz at a gain of 10, and 40 kHz at a gain of 100. Limit input signals to less than ± 100 mV.

**PARTS LIST FOR INSTRUMENT SENSITIVITY BOOSTER**

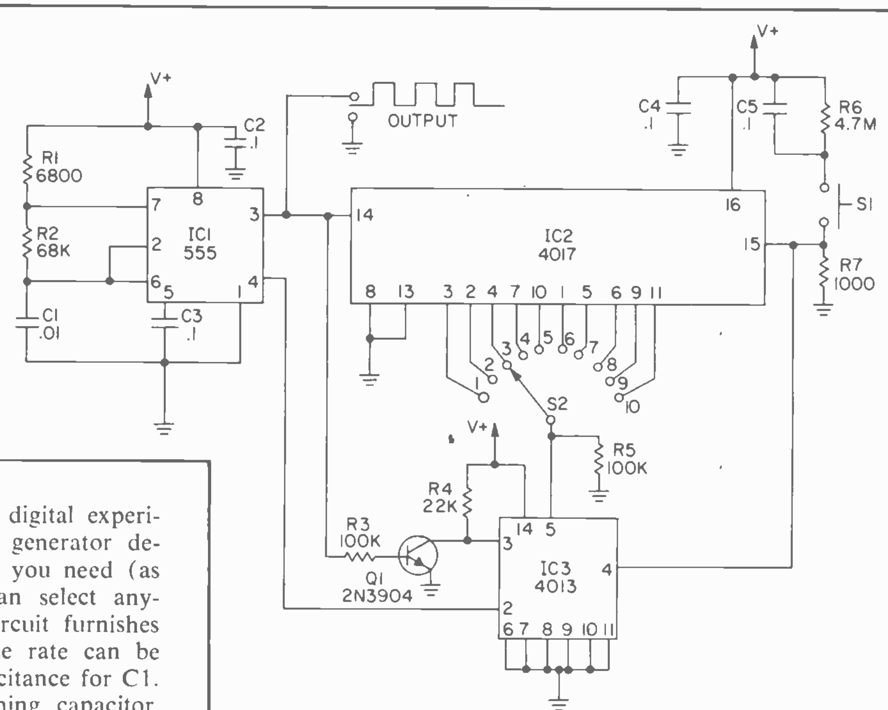
**C1**—0.1-uF mylar capacitor
**C2**—30-pF polystyrene capacitor
**C3**—5-80-pF trimmer capacitor (Arco 462 or equivalent)
**C4, C5**—0.01-uF ceramic disc capacitor
**D1, D2**—1N914 diode
**IC1**—3140 FET-input op amp (RCA or equivalent)
**R1, R7**—100,000-ohm, ½-watt resistor (all resistors 5% unless noted.)
**R2**—1,000,000-ohm, ½-watt resistor
**R3**—4,700-ohm, ½-watt resistor
**R4**—10,000-ohm, linear-taper potentiometer
**R5**—1,000-ohm, ½-watt resistor
**R6**—10,000-ohm, ½-watt resistor
**S1, S2**—SPST switch




# 42 Pulse-Burst Generator

**PARTS LIST FOR PULSE-BURST GENERATOR**

**C1**—.01 uF-mylar capacitor
**C2, C3, C4, C5**—0.1-uF ceramic disc capacitor
**IC1**—555 timer integrated circuit
**IC2**—4017 CMOS decade counter integrated circuit
**IC3**—4013 flip-flop integrated circuit
**Q1**—2N3904 NPN transistor
**R1**—6,800-ohm, ½-watt resistor (all resistors 10% unless otherwise noted.)
**R2**—68,000-ohm, ½-watt resistor
**R3, R5**—100,000-ohm, ½-watt resistor
**R4**—22,000-ohm, ½-watt resistor
**R6**—4,700,000-ohm, ½-watt resistor



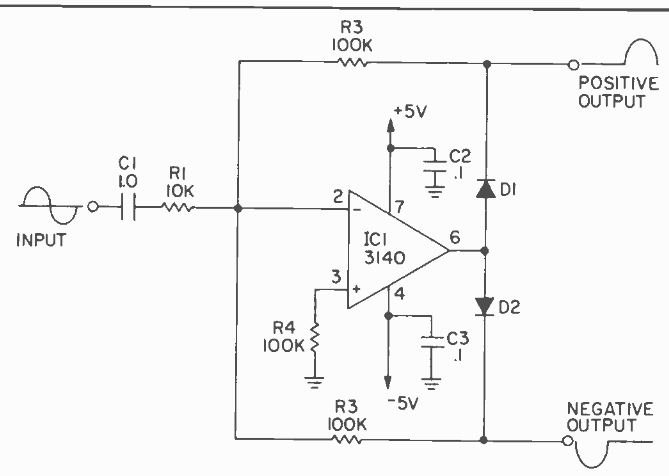

☐ This is a fiendishly clever circuit for the digital experimenter. Just press S1, and this pulse-burst generator delivers the exact number of glitch-free pulses you need (as determined by the setting of S2). You can select anywhere from one to ten pulses, which the circuit furnishes at a rate of 1 kHz. If necessary, the pulse rate can be slowed down by using a larger value of capacitance for C1. With a 10 mf electrolytic unit as the timing capacitor, pulses arrive at a one-per-second rate, which is slow enough for visual observation (on an LED display, for instance). Any potential (V+) between +5 and +15 volts can be used, depending on the requirements of the circuitry you intend to drive.

# 43 Precision Rectifier

☐ One of the problems with the conventional silicon rectifier diode is its .6-volt forward drop. Rectification cannot occur until an input signal exceeds this voltage. So it is impossible to rectify a signal with a 250-millivolt peak-to-peak amplitude because it never exceeds the diode's conduction threshold. The precision rectifier circuit diagrammed here gets around the whole problem by tucking the rectifier into an op amp's feedback loop. Signals on the millivolt level can now be rectified with ease.

In addition, the circuit has a gain of −10. The minus

sign means that this is an inverting circuit: positive peaks come out negative, and vice versa. Half-wave-rectified positive-going signals are available through D1, while D2 provides the negative rectified output. Remember, positive input cycles are multiplied by 10 and inverted; hence, they show up at the negative output. To keep things from going awry, use both loops (D1-R2 and D2-R3) even if you want output of just one polarity.

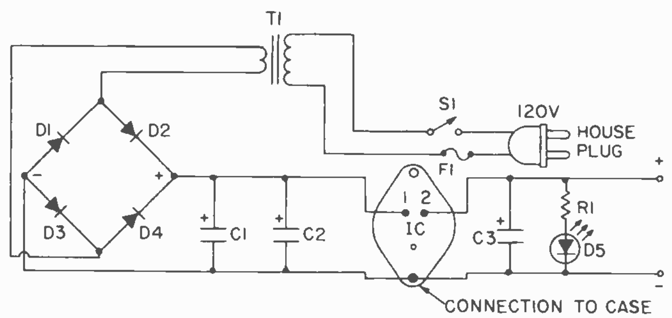



**PARTS LIST FOR PRECISION RECTIFIER**

**C1**—1.0-mylar capacitor
**C2, C3**—0.1-ceramic capacitor
**D1, D2**—1N914 silicon diode
**IC1**—3140 op amp integrated circuit (RCA)
**R1**—10,000-ohm, ½-watt resistor
**R2, R3, R4**—100,000-ohm, ½-watt resistor

# 44 TTL Power Supply

☐ This IC project will provide you with a flat, ripple-free, and locked-on 5 volts for any use around the house or on your work bench. It will prove to be very handy for the TTL projects in this magazine, i.e., those projects using any IC that starts with the two numbers 74. The LM309 is a remarkable IC containing over a dozen transistors and several diodes. It can handle up to about 1 amp without a heat sink. If you mount it on a heat sink, a 4 by 4 inch piece of aluminum will do, it can supply up to 4 amps without dropping its 5 volt output.




**PARTS LIST FOR TTL POWER SUPPLY**

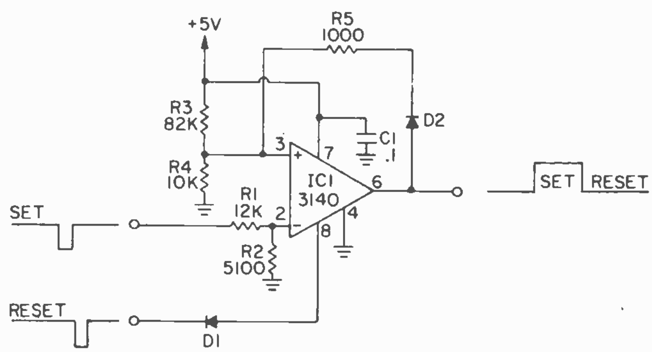
**C1, C2, C3**—1,000-uF electrolytic capacitor, 25 VDC
**D1, D2, D3, D4**—1N4003 diode
**D5**—large LED
**F1**—120 VAC ½ amp fuse, fast acting type
**IC1**—LM309
**R1**—500-ohm, 2-watt resistor
**S1**—SPST toggle switch rated at 120 VAC/15 amps
**T1**—120 VAC to 12.6 VAC transformer

# 45 Op-Latch

☐ The perfect op amp has yet to be invented, but if you're looking for the next-best thing, try the 3140. It is fast, operates with supplies as low as 4 volts, has internal frequency compensation, and is happy even in very-high-impedance circuits (thanks to its FET inputs). Here is an offbeat application using the 3140 as a digital latch that's

**PARTS LIST FOR OP-LATCH**

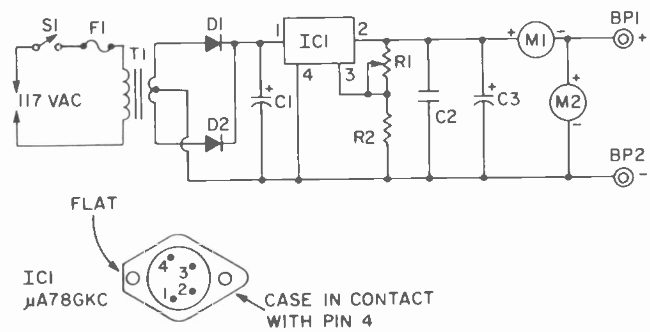
**C1**—0.1-uF ceramic disc capacitor
**D1, D2**—1N914 diode
**IC1**—3140 op amp (RCA or equivalent)
**R1**—12,000-ohm, ½-watt resistor (all resistors 5%)
**R2**—5,100-ohm, ½-watt resistor
**R3**—82,000-ohm, ½-watt resistor
**R4**—10,000-ohm, ½-watt resistor
**R5**—1,000-ohm, ½-watt resistor



CMOS- or TTL-compatible. Driving the SET input momentarily low latches the output in a high state, while a low pulse to the RESET input sends the output low once again. When both inputs are high, the circuit rests. Don't send both inputs low at the same time.

# 46 Variable Regulated Power Supply

☐ These are lots of good power supplies on the market, but why not build your own and save a bundle? This circuit can provide voltages between 5 and 15-volts DC at currents up to one ampere. Be sure to heat-sink the μA78GKC regulator by bolting it to either a commercial aluminum heat sink or to your supply's cabinet (if it's made of aluminum). Mount C2 and C3 as close as possible to pins 2 and 4 of IC1. If you cannot locate a 28VCT transformer, go to something slightly higher, say 32 VCT. The same goes for the transformer's current rating; for example, you could use a 2-amp device.



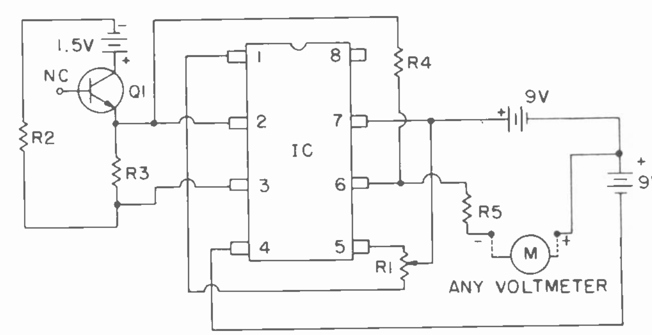

**PARTS LIST FOR VARIABLE REGULATED POWER SUPPLY**

**BP1, BP2**—binding post
**C1**—2200-uF electrolytic capacitor, 40 VDC
**C2**—0.1-uF ceramic disc capacitor, 35 VDC
**C3**—100-uF electrolytic capacitor, 25 VDC
**D1, D2**—1N4003 (1A, 200 PIV) rectifier diode
**F1**—0.5-Ampere slow-blow fuse
**IC1**—μA78GKC adjustable voltage regulator
**M1**—0-to-1 Amp DC meter
**M2**—0-to-15-Volt DC meter
**R1**—10K-ohm linear-taper potentiometer
**R2**—4700-ohm, ½-watt resistor, 5%
**S1**—SPST toggle switch
**T1**—28VCT, 1.2-Amp power transformer (see text)

# 47 VOM Light Meter

HOBBY

☐ The beauty of this light meter is that it is almost perfectly linear over a wide range of light inputs. It provides you with the basic operation of a camera light meter and can be made to read directly in f-stops and shutter speed. Phototransistor Q1 senses the light level and passes that on to the 741 op amp where the small voltage is amplified. Meter M is any you currently have around the house, or any inexpensive meter you can buy. If you do not have a meter, see the meter eliminator circuit in this book. R1 provides a zero adjustment for the meter.




**PARTS LIST FOR VOM LIGHT METER**

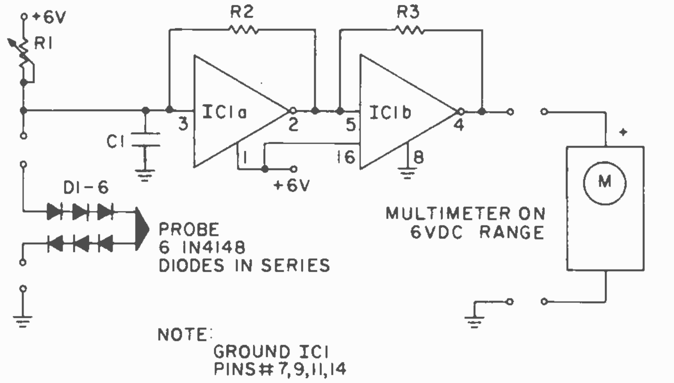
**IC1**—741 op amp
**Q1**—FPT100 phototransistor
**R1**—10,000-ohm, linear-taper potentiometer
**R2**—10,000-ohm, ½-watt resistor
**R3**—30,000-ohm, ½-watt resistor
**R4**—100,000-ohm, ½-watt resistor
**R5**—2,000-ohm, ½-watt resistor

# 48 Diode Thermometer

☐ In another project, it was shown how a package of silicon diodes could be developed into a solid-state thermostat. Here is an analog version, which can be interfaced with a voltage-to-frequency converter for use with a frequency counter, or can be directly read by a 10 to 20 thousand-ohms-per-volt multimeter. The circuit utilizes a pair of 4009 inverter sections, biased into the linear region to amplify the temperature effects upon the diode probe. In this application, the adjustment potentiometer, R1, is set to give a mid-scale reading at room temperature on a typical multimeter set on the 6 volts DC scale. If a separate 0-1 DC miliampere meter is available, it could be calibrated directly in degrees F or C, with a suitable resistance in series with the amplifier output.

**PARTS LIST FOR DIODE THERMOMETER**

**C1**—0.1-uF ceramic capacitor, 15 VDC
**D1 through D6**—1N4148 diode
**IC1**—4009A hex buffer
**R1**—100,000-ohm linear-taper potentiometer
**R2, R3**—1,000,000-ohm, ½-watt resistor

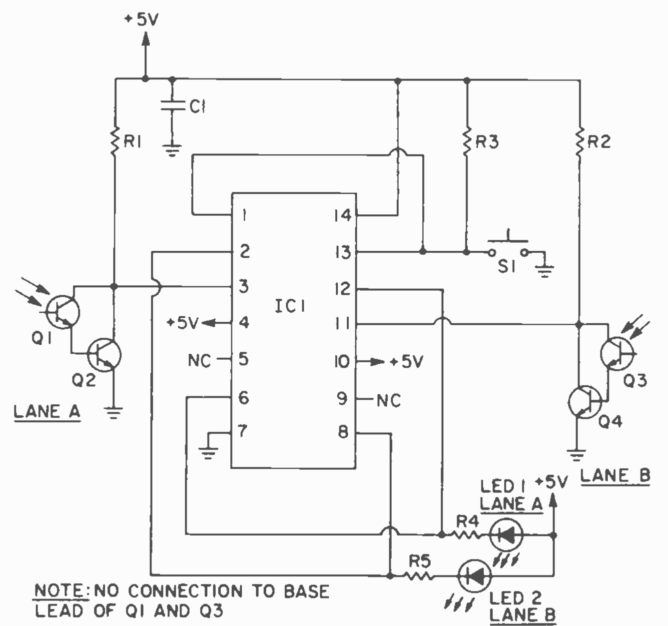



# 49 Slot Car Race Referee

☐ Build this optoelectronic judge and end forever those quarrels over who really won the race. Install phototransistors Q1 and Q3 at the finish line, but in separate lanes of your slot-car track so that the light-sensitive face of each device is facing upwards. The best method would be to cut a small hole into the track for each phototransistor, and mount each unit flush with the track's surface. Arrange for light to fall on both Q1 and Q3; a small desklamp will work well, but ambient room light will usually suffice. Press S1 and both LEDs will go off. The first car to cross the finish line interrupts the light beam and causes the appropriate LED to light up.

**PARTS LIST FOR SLOT CAR RACE REFEREE**

**C1**—0.1-uF ceramic disc capacitor, 35 VDC
**IC1**—7474 dual D-type flip-flop
**LED1, LED2**—light-emitting diode
**Q1, Q3**—FPT-100 NPN phototransistor
**Q2, Q4**—2N3904 NPN tranistor
**R1, R2**—18K-ohm ½-watt resistor, 10%
**R3**—3900-ohm ½-watt resistor, 10%
**R4, R5**—330-ohm ½-watt resistor, 10%
**S1**—normally open SPST pushbutton switch

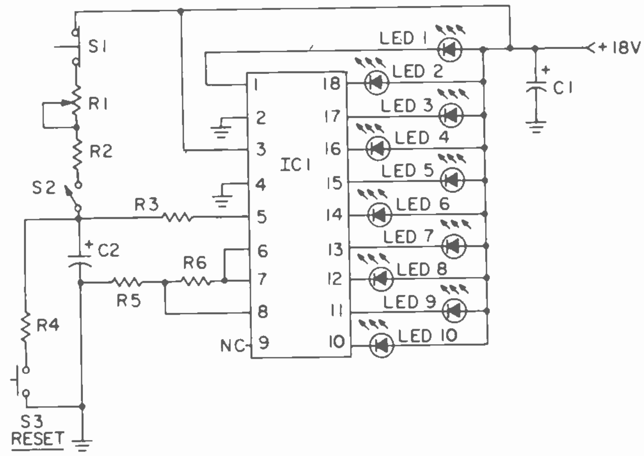



# 50 Sobriety Tester

☐ It's a curious and unfortunate fact, but many people feel that a drink or two will improve their reflexes. Here's your chance to prove them wrong. Imagine for the moment that S1 is depressed (open circuited), S2 is closed, and C2 has been completely discharged. On command from someone acting as the tester, the person depressing S1 must remove his hand from that switch and use the same hand to open toggle switch S2. When S1 is released, charging current begins to flow into capacitor C2 through R1 and R2. This current is interrupted, however, as soon as S2 has been opened. C2 will have accummulated a voltage directly proportional to the reaction time, which is the interval between S1's release and the opening of S2. Longer times create higher voltages and cause higher-numbred LEDs to light. For example, a sober person might react quickly enough to light LED 2 or LED 3, while someone truly sloshed will light up LED 10. To run another test, discharge C2 with S3, then press S1 and, finally, close S2 once more. R1 should be adjusted so that a sober person lights one of the low-numbered LEDs.

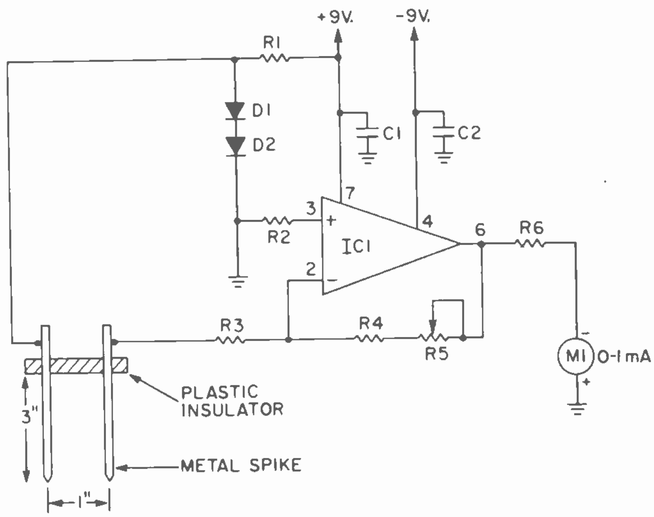
**PARTS LIST FOR SOBRIETY TESTER**

- **C1**—250-uF electrolytic capacitor, 35 VDC
- **C2**—50-uF electrolytic capacitor, 35 VDC
- **IC1**—LM3914 LED display driver
- **LED1 through LED10**—light-emitting diode
- **R1**—50K trimmer potentiometer
- **R2**—5600-ohm ½-watt resistor, 10%
- **R3**—33K-ohm ½-watt resistor, 10%
- **R4**—47-ohm ½-watt resistor, 10%
- **R5**—1800-ohm ½-watt resistor, 10%
- **R6**—1000-ohm ½-watt resistor, 10%
- **S1**—normally closed SPST pushbutton switch
- **S2**—SPST toggle switch
- **S3**—normally open SPST pushbutton switch




# 51 Plant Moisture Meter

☐ Talked to your houseplants recently? Well, if they could talk back, you'd hear plenty of complaints—most of them about water. Too much of the wet stuff is just as bad as too little. To assist you with the watering, try this little moisture meter. Note that you will need to construct a probe assembly consisting of two metal spikes mounted in a wooden or plastic block. For the sake of uniformity, use the dimensions supplied. The spike can be nails or pieces of heavy wire (#8). Stick the probe assembly into the soil surrounding a just-watered plant and adjust R5 for a deflection around mid-scale on M1. Thereafter you can use the meter to tell whether your plants are too wet or too dry. Note that different plants are apt to prefer different degrees of wetness.




**PARTS LIST FOR PLANT MOISTURE METER**

- **C1, C2**—0.01-uF ceramic disc capacitor, 35 VDC
- **D1, D2**—1N914 diode
- **IC1**—741 op amp
- **M1**—0-1 mA DC meter
- **R1**—6800-ohm ½-watt resistor, 10%
- **R2**—15K-ohm ½-watt resistor, 10%
- **R3**—1000-ohm ½-watt resistor, 10%
- **R4**—10K-ohm ½-watt resistor, 10%
- **R5**—100K trimmer potentiometer
- **R6**—3300-ohms ½-watt resistor, 10%

# 52 Random Sequence Generator

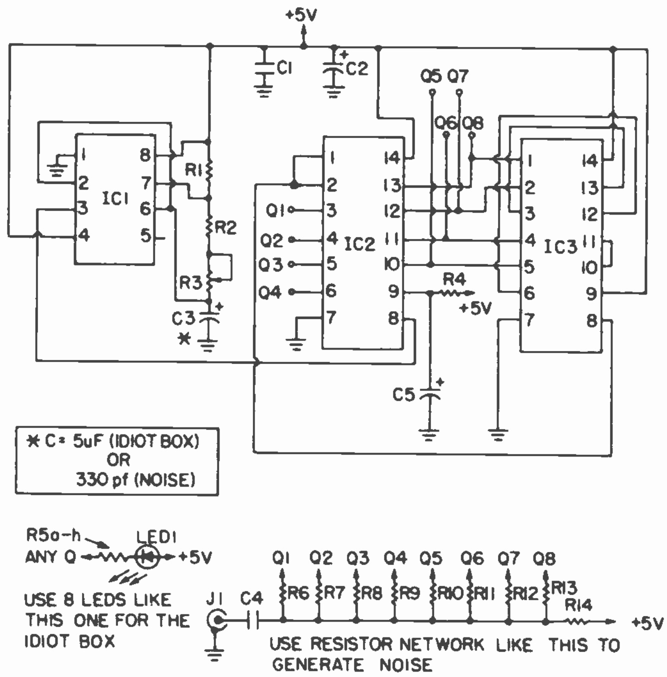
☐ A pseudo-random sequence generator is like a scrambled counter. Instead of counting 1,2,3,4,..., the PRSG might yield an output of 2,9,7,1... The PRSG shown here supplies a sequence of 255 scrambled numbers, available in binary form at the eight outputs (Q1 through Q8). Some applications:

First, you might hook up an LED and a 330-ohm resistor to each output as illustrated. Use a 5-μF electrolytic capacitor for C3, and you'll have a dandy idiot box, which will blink impressively on your desk, but do nothing.

Or, you could hook up the resistor network diagrammed, and use a 330 pF polystyrene capacitor for C3. You'll get a 1-volt peak-to-peak noise voltage at J1 which can be used to generate interesting percussive sounds in conjunction with the Musical Modulator presented elsewhere in this issue.

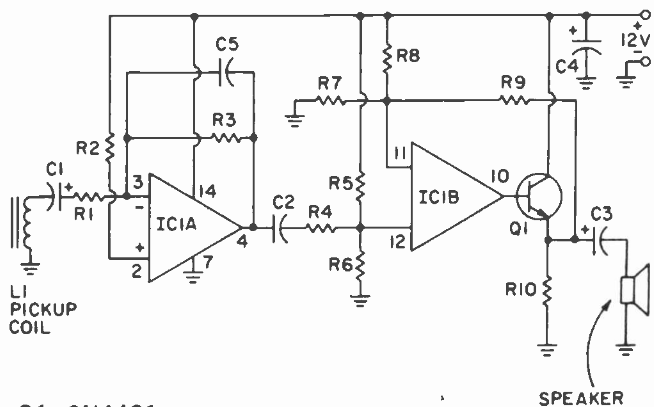
**PARTS LIST FOR PSEUDO-RANDOM SEQUENCE GENERATOR**

**C1**—0.1-uF ceramic disc capacitor, 35 VDC
**C2, C5**—100-uF electrolytic capacitor, 10 VDC
**C3**—5-uF, 10V electrolytic or 330-pF polystyrene capacitor (see text)
**C4**—1.0-uF mylar capacitor (non-polarized), 35 VDC
**IC1**—555 timer
**IC2**—74164 shift register
**IC3**—7486 quad EX-OR gate
**J1**—phono jack
**LED1 through LED8**—light-emitting diode
**R1, R2**—6800-ohms
**R3**—100K linear-taper potentiometer
**R4, R6**—1000-ohms
**R5a through R5h**—330-ohm ½-watt resistor, 10%
**R7**—2200-ohm ½-watt resistor, 10%
**R8**—3900-ohm ½-watt resistor, 10%
**R9**—8200-ohm ½-watt resistor, 10%
**R10**—15K-ohm ½-watt resistor, 10%
**R11**—33K-ohm ½-watt resistor, 10%
**R12**—62K-ohm ½-watt resistor, 10%
**R13**—120K-ohm ½-watt resistor, 10%
**R14**—120-ohm ½-watt resistor, 10%




# 53 Telephone Pickup

☐ You can pick up and amplify the voice signals from your telephone by using this simple IC circuit and a small pickup coil. The circuit has sufficient output to drive a loudspeaker. One section of a quad op amp is used as a high-gain voltage amplifier. This increases the relatively low output of the pickup coil (a few millivolts) to a sufficient level to drive the loudspeaker. The circuit draws about 60 milliamperes from a 12 volt power source. You can purchase a ready made pickup coil or construct one yourself using about 200 turns of fine enamel wire wound around an iron core. Place the pickup coil near the telephone receiver for best results.



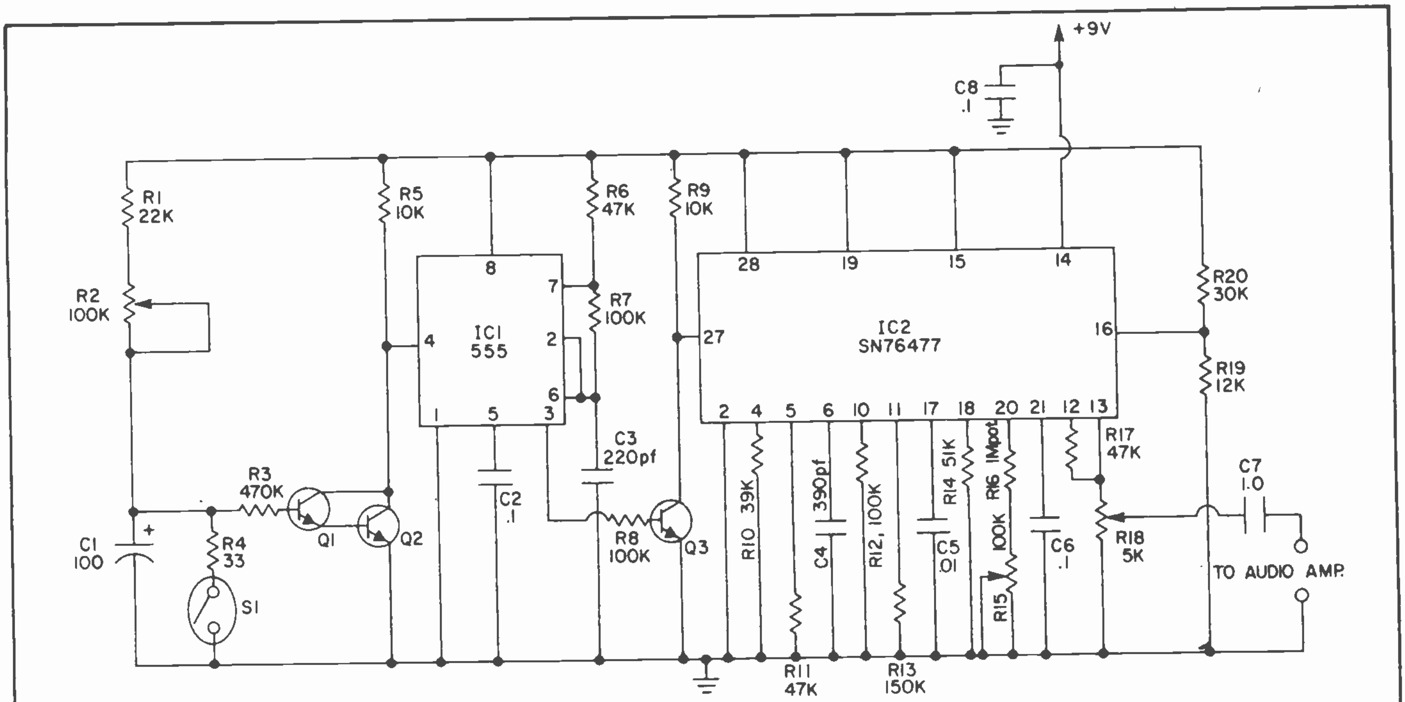

**PARTS LIST FOR TELEPHONE PICKUP**

**C1**—10-uF electrolytic capacitor, 25 VDC
**C2**—.01-uF ceramic disc capacitor, 15 VDC
**C3, C4**—15-uF electrolytic capacitor, 15 VDC
**C5**—.001-uF ceramic disc capacitor, 15 VDC
**IC1**—3900 quad amplifier
**L1**—inductance pickup coil (see text)
**Q1**—2N4401
**R1**—1,000-ohm, ½-watt resistor
**R2, R4**—1,000,000-ohm, ½-watt resistor
**R3**—470,000-ohm, ½-watt resistor
**R5, R6, R7, R8, R9**—10,000,00-ohm, ½-watt resistor
**R10**—100-ohm, ½-watt resistor
**SPKR**—8-ohm PM type speaker

# 54 Automatic Train Sound Effects

☐ Anyone with a model railroad layout will appreciate this circuit. Normal output consists of the characteristic "chuff-chuff" of a steam locomotive. Pot R16 can be used to adjust the chuffing rate to simulate faster or slower train speeds, while R18 sets the volume. Feed the unit's 1-volt peak-to-peak output signal to an amp rated at 10 watts and a 12-inch PA speaker for the utmost realism. (Note: This may not be feasible for apartment dwellers unless, of course, you're looking for a way to break the lease.)

Mount a small, powerful Alnico magnet on your train so that upon reaching a certain track position, the train triggers reed switch S1 with its magnet. This causes the circuit to produce a whistle blast that lasts between .5 and 2.5 seconds, depending on the setting of R2. If you wish to sound the whistle at several points on the track, or if you want to sound it manually, other switches may be wired in parallel with S1 and located at the appropriate positions.




**PARTS LIST FOR AUTOMATIC TRAIN SOUND EFFECTS**

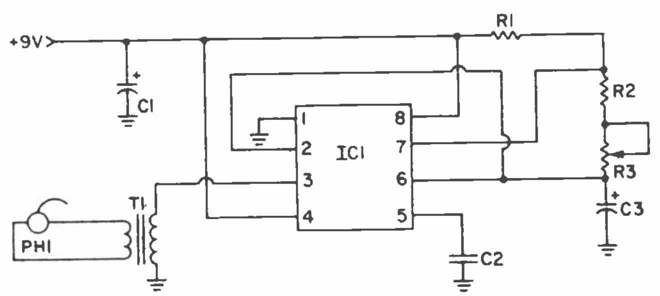
**C1**—100-uF, 16-VDC electrolytic capacitor
**C2, C6, C8**—0.1-uF ceramic disc capacitor
**C3**—200-pF polystyrene capacitor
**C4**—390-pF polystyrene capacitor
**C5**—.01-uF mylar capacitor
**C7**—1.0-uF mylar capacitor
**IC1**—555 timer integrated circuit
**IC2**—SN76477 sound generator integrated circuit
**Q1-Q3**—2N3904 NPN transistor (all resistor 10% unless otherwise noted.)
**R1**—22,000-ohm, (½-watt resistor (all resistors 10% unless otherwise noted)
**R2**—100,000-ohm linear-taper potentiometer
**R3**—470,000-ohm, ½-watt resistor
**R4**—33-ohm, ½-watt resistor
**R5, R9**—10,000-ohm, ½-watt resistor
**R6, R11, R17**—47,000-ohm, ½-watt resistor
**R7, R8, R12, R16**—100,000, ½-watt resistor
**R10**—39,000-ohm, ½-watt resistor
**R13**—150,000-ohm, ½-watt resistor
**R14**—51,000-ohm, ½-watt resistor
**R16**—1,000,000-ohm, linear-taper potentiometer
**R18**—5,000-ohm, audio-taper potentiometer
**R19**—12,000-ohm, ½-watt resistor
**R20**—30,000-ohm, ½-watt resistor
**S1**—magnetic reed switch

# 55 Jogging Pacesetter

☐ One of the problems faced by the beginning jogger, especially on city streets, is that of maintaining a constant pace. Tractor-trailer trucks, careening cars, and ill-mannered dogs can all interrupt your concentration. While there is little that can be done about these nuisances, this little pacesetter may make them less severe. A miniature

**PARTS LIST FOR JOGGING PACESETTER**

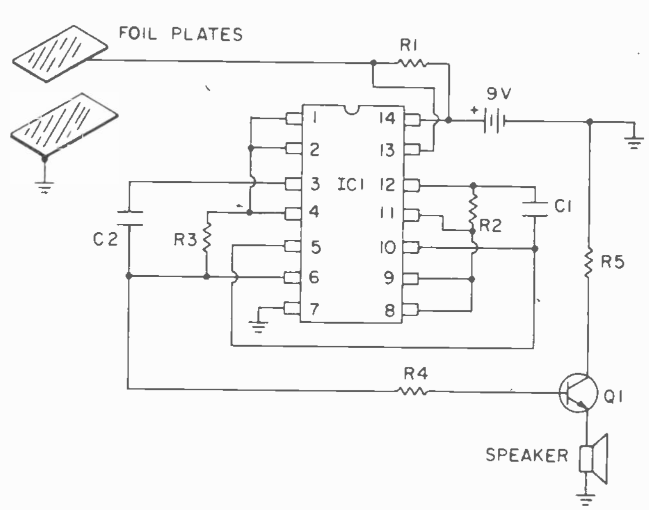
**C1**—100-uF electrolytic capacitor, 16 VDC
**C2**—0.1-uF ceramic disc capacitor, 35 VDC
**C3**—1.0-uF tantalum electrolytic capacitor, 20 VDC
**IC1**—555 timer
**PH1**—8-ohm miniature earphone
**R1**—10K, ½-watt resistor, 5%
**R2**—220K, ½-watt resistor, 5%
**R3**—1-Megohm trimmer potentiometer
**T1**—miniature audio output transformer—1,000-ohm primary/8-ohm secondary



earphone in your ear driven by a 555 timer produces regularly spaced "ticks" just like a metronome. The pace can be adjusted via R3 from a leisurely one stride per second to a sole-blistering six paces per second. The whole circuit complete with a 9-volt transistor radio battery weighs only a few ounces.

# 56 Rain Detective

☐ Have some problem with water now and then? Trying to keep rain from ruining your top-down convertible? This circuit will sound an alarm when rain gets between the aluminum foil strips to keep you high and dry.




**PARTS LIST FOR RAIN DETECTIVE**

**C1**—0.47-uF ceramic disc capacitor, 15 VDC
**C2**—0.01-uF ceramic disc capacitor, 15 VDC
**IC1**—4001 quad NOR gate
**Q1**—2N4401
**R1**—5,000,000-ohm, ½-watt resistor
**R2**—1,500,000-ohm, ½-watt resistor
**R3**—100,000-ohm, ½-watt resistor
**R4**—2,000-ohm, ½-watt resistor
**R5**—100-ohm, ½-watt resistor
**SPKR.**—8-ohm PM type speaker

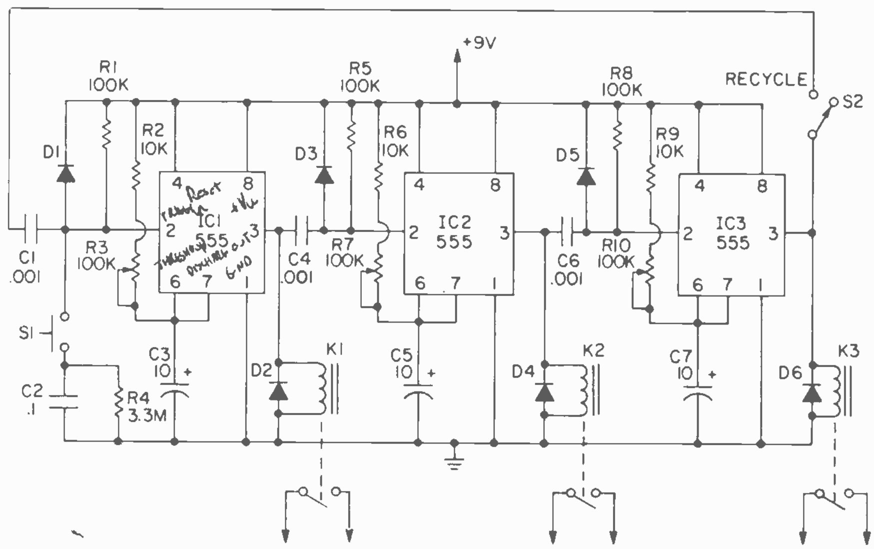
# 57 Re-Cycling Sequential Timer

☐ Press S1, and relay K1 pulls in for a time interval determined by the setting of R3. When IC1 times out and K1 opens once again, IC2 gets triggered. This causes K2 to pull in for an interval determined by R7's setting. Finally IC2 will time out and trigger IC3, thereby causing K3 now to pull in. Once IC3 times out and K3's contacts open, action ceases if S2 is flipped to the right. However, if S2 had been flipped to the left, IC1 would have once again been triggered as IC3 timed out, thus starting the whole cycle over again.

With the values shown, each timer can be adjusted for times from .1 to 1 second. If your application demands longer timing intervals, simply increase the size of the timing capacitors (C3, C5 and C7) and/or the timing resistors (R2-R3, R6-R7, and R9-R10). One application of the circuit that comes to mind is in flash photography. Let each relay fire a separate, cheap flash unit. With the timers adjusted for rapid fire, you'll be able to take stroboscope-like pictures that you couldn't take with a single conventional flash unit because re-cycle times (.3-.5

**PARTS LIST FOR RE-CYCLING SEQUENTIAL TIMER**

**C1, C4, C6**—.001-uF mylar capacitor
**C2**—0.1-uF ceramic disc capacitor
**C3, C5, C7**—10-uF, 25-VDC electrolytic capacitor
**D1-D6**—1N914 diode
**IC1, IC2, IC3**—555 timer integrated circuit
**K1, K2, K3**—6-VDC, 500-ohm relay
**R1, R5, R8**—100,000-ohm, ½-watt resistor (all resistors 10% unless otherwise noted.)
**R2, R6, R9**—10,000-ohm, ½-watt resistor
**R3, R7, R10**—100,000-ohm, linear-taper potentiometer
**R4**—3,300,000-ohm, ½-watt resistor
**S1**—pushbutton switch, normally open
**S2**—SPDT switch



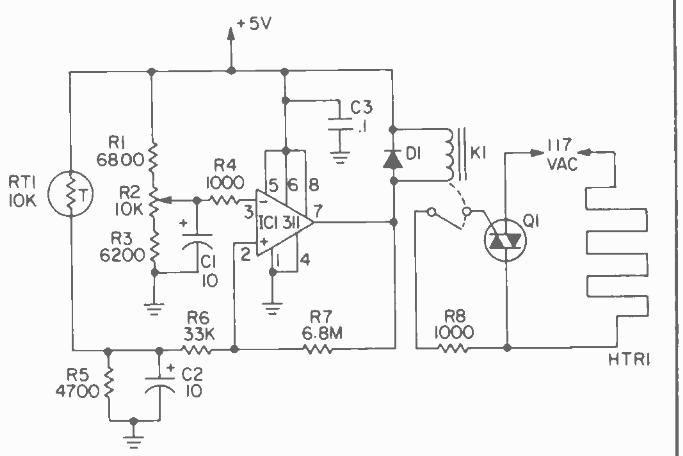
second) are too long. With three units, each flash has ample time to re-cycle while the others are firing. You might also try using color film and putting a separate colored filter over each flash tube.

# 58 Thermostatic Bath

☐ Maintaining a volume of solution at constant temperature is easy if you do it electronically. Photographic processing is the obvious application for a thermostatic bath, but if you etch your own printed circuits, you can also use it to keep your etchant hot. Thermistor RT1 comes packaged as a small glass probe. Waterproof it with several coats of epoxy, and mount it below the surface of the fluid in your tank. The heating element, HTR1, must also be submerged—preferably close to the bottom of the tank and away from RT1. (CAUTION: Do not operate an immersion heater in open air.) Heater wattage depends upon the volume of solution you wish to heat. A 500-watt heater will raise two gallons of water from 70° to 120° F. in half an hour or so. Conventional brass or stainless steel heaters are perfect for a simple water bath, but if you plan to heat an etchant like ferric chloride, get a quartz immersion heater. Pot R2 sets the bath temperature at any point between 70° and 160° F. A temperature of 115° gives safe and fast etching with ferric chloride. Do not use this bath with flammable liquids, and always wear goggles.

**PARTS LIST FOR THERMOSTATIC BATH**

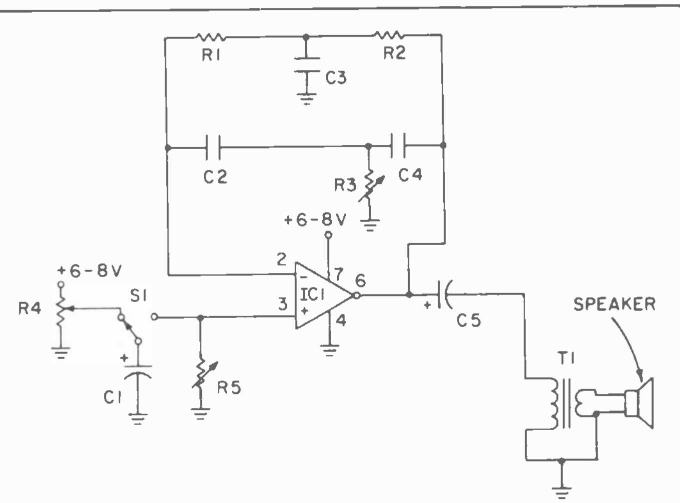
**C1, C2**—10-uF, 10-VDC tantalum capacitor
**C3**—0.1-uF ceramic disc capacitor
**D1**—1N914 diode
**HTR1**—200 to 500-Watt immersion heater (see text)
**IC1**—LM311 comparator
**K1**—6-VDC, 500-ohm relay
**Q1**—200-VDC, 10-A triac
**R1**—6,800-ohm ½-watt resistor (all resistors 5% unless otherwise noted.)
**R2**—10,000-ohm linear-taper potentiometer
**R3**—6,200-ohm, ½-watt resistor
**R4**—1,000-ohm, ½-watt resistor
**R5**—4,700-ohm, ½-watt resistor
**R6**—33,000-ohm, ½-watt resistor
**R7**—6,800,000-ohm, ½-watt resistor
**R8**—1,000-ohm, 1-watt resistor
**RT1**—10,000-ohm, @ 25° Thermistor (Fenwal 6B41P12 or equivalent)




# 59 The Whistler

SECURITY

☐ At the push of a button, this circuit lets forth with an attention-getting whistle, which can be tailored to meet a variety of formats. The circuitry is built around a Twin-T oscillator, which is triggered into action by a varying positive potential placed on the non-inverting op amp input. Resistors R1, R2, and R3, together with capacitors C1, C2, and C3, determine the fundamental pitch, with R3 providing a useful variation. When S1 is pushed, the potential stored in C4 is placed on the non-inverting input, causing the oscillator to function. The duration is determined by R5. The format of the whistle is modified by the setting of R4. At full potential, the effect is a sharply rising tone, followed by a more gradual decline. At about half setting, the effect is more bell-like.

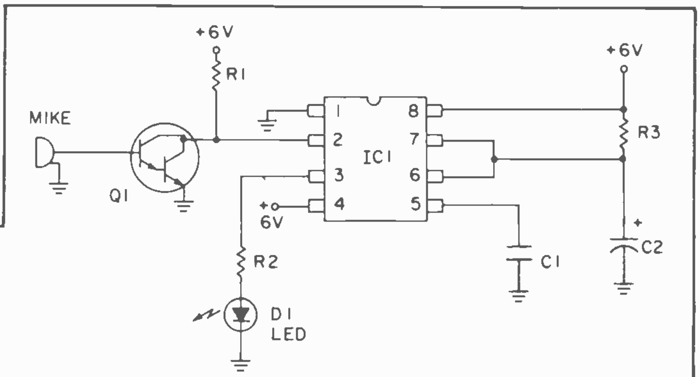



**PARTS LIST FOR THE WHISTLER**

**C1**—100 to 200-uF electrolytic capacitor, 15 VDC
**C2, C4**—0.001-uF ceramic capacitor, 1 VDC
**C3**—0.002-uF ceramic capacitor, 15 VDC
**C5**—100-uF electrolytic capacitor, 15 VDC
**IC1**—741 op amp
**R1, R2**—100,000-ohm, ½-watt resistor
**R3, R4, R5**—10,000-ohm linear-taper potentiometer
**SPKR**—8-ohm PM type speaker
**T1**—audio output transformer 500-ohm primary/8-ohm secondary

# 60 The Robot Ear, TTL

☐ The type 555 timer can not only see, but hear, as this sound pick-up circuit shows. It is most apt in picking up sudden sharp sounds. A type MPS A13 Darlington transistor provides gain to cause triggering action. With RC time constants of 4.7 or 5-uF and 220,000 ohms, the warning indicator LED will remain on for about two seconds.

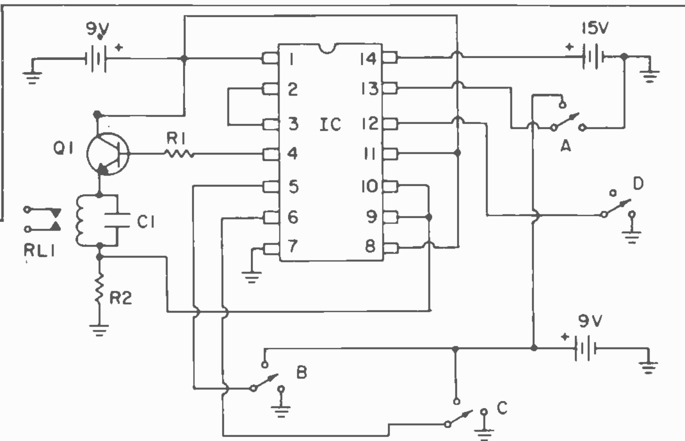



**PARTS LIST FOR THE ROBOT EAR TTL**

**C1**—0.1-uF ceramic capacitor, 15 VDC
**C2**—5-uF electrolytic capacitor, 15 VDC
**D1**—small LED
**IC1**—555 timer
**Q1**—Motorola MPS-A13 transistor
**R1**—47,000 to 100,000-ohm, ½-watt resistor
**R2**—470-ohm, ½-watt resistor
**R3**—220,000-ohm, ½-watt resistor

# 61 Electronic Combination Rock

☐ The CD4016 contains four electronic switches that can be operated with control current. The relay in this circuit will operate only if A and B switches are on (switched to the +9V side) and if C and D are off. You can experiment with different connections to make your own combination, or substitute rotary switches with additional contacts.

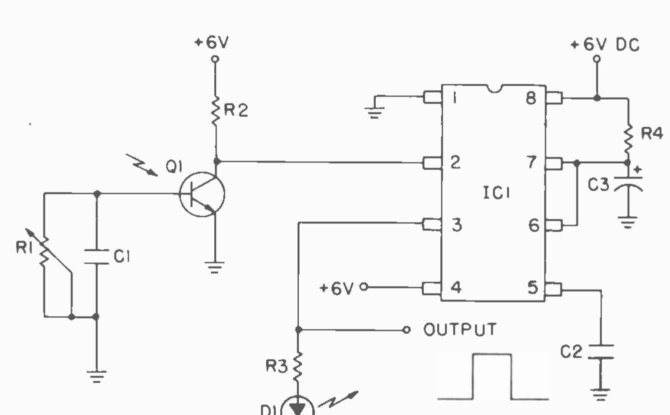



**PARTS LIST FOR ELECTRONIC COMBINATION LOCK**

**C1**—0.1-uF ceramic capacitor, 15 VDC
**IC1**—4016 quad bilateral switch
**Q1**—2N4401 transistor
**R1**—10,000-ohm, ½-watt resistor
**R2**—100-ohm, ½-watt resistor
**RL1**—any relay w/9 VDC coil to suit application
**SWITCHES (A, B, C, D)**—SPDT slide type

# 62 Robot Eye, TTL

☐ A useful chip, at home with both TTL and CMOS logic, is the type 555 timer, which can be used both in the mono-stable and astable or free-running modes. In the mono-stable mode shown here, timing RC can run from 1000 ohms to over 1 megohm, and 0.001-uF to over 100-uF. A combination of 2.2-uF and 220K ohms gave a delay interval of about one second. The Robot Eye can thus extend from a tiny wink to an intent gaze!

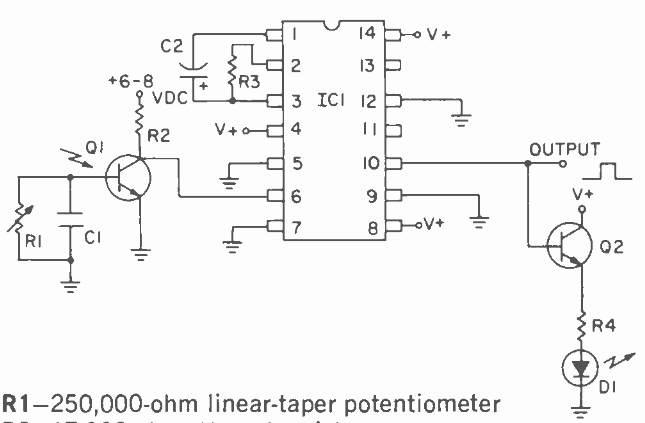



**PARTS LIST FOR THE ROBOT EYE, TTL**

**C1, C2**—0.1-uF ceramic capacitor, 15 VDC
**C3**—2.2-uF electrolytic capacitor, 15 VDC
**D1**—small LED
**IC1**—555 timer
**Q1**—FPT100 phototransistor
**R1**—250,000-ohm linear-taper potentiometer
**R2**—47,000-ohm, ½-watt resistor
**R3**—470-ohm, ½-watt resistor
**R4**—220,000-ohm, ½-watt resistor

# 63 Robot Eye, CMOS

☐ The Robot Ear described elsewhere can be given visual capability through a type FPT-100 phototransistor. In this application, use is made of the negative trigger input. Sensitivity control can be a 100K or 250K potentiometer to the base connection. By-pass the base connection to avoid false triggering by pick-up of electrical noise. With the components shown, a delay interval of about 4 seconds was obtained. The Robot Eye is always alert to unexpected light sources and never falls asleep, as may a watchdog or watch-person.

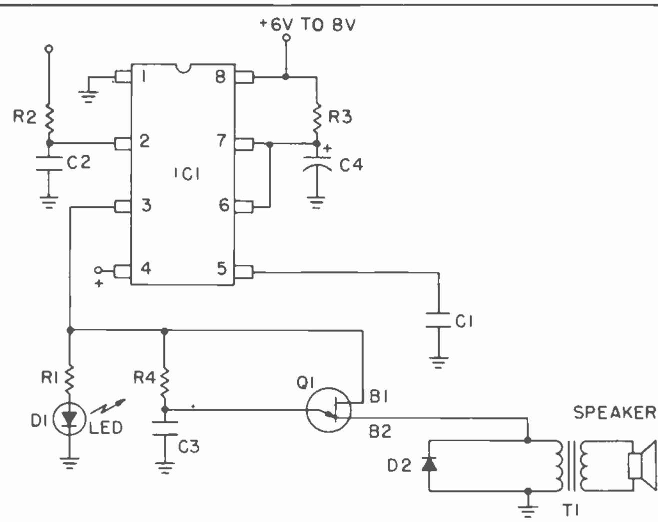



**PARTS LIST FOR THE ROBOT EYE, CMOS**

**C1**—0.1-uF ceramic capacitor, 15 VDC
**C2**—4.7-uF electrolytic capacitor, 25 VDC
**IC1**—4047 multivibrator
**Q1**—FPT100 phototransistor
**Q2**—2N4401
**R1**—250,000-ohm linear-taper potentiometer
**R2**—47,000-ohm, ½-watt resistor
**R3**—220,000-ohm, ½-watt resistor
**R4**—1,000-ohm, ½-watt resistor

# 64 Hands Off!

☐ This circuit finds the 555 timer as a watchdog ready to cry out if an inquisitive finger comes too close. The trigger input is terminated with a one megohm resistor, attached to a coin or some other small metallic object. Hand capacity is sufficient to initiate the timer for about five seconds. The output is fed not only to a warning LED, but to a unijunction type oscillator, whose tiny two-inch speaker can make itself heard throughout the room.




**PARTS LIST FOR HANDS OFF**

**C1**—0.1-uF ceramic capacitor, 15 VDC
**C2**—0.01-uF ceramic capacitor, 15 VDC
**C3**—0.1-uF ceramic capacitor, 15 VDC
**C4**—1-uF electrolytic capacitor, 15 VDC
**D1**—small LED
**D2**—1N4148 diode
**IC1**—555 timer
**Q1**—2N2646
**R1**—470-ohm, ½-watt resistor
**R2**—1,000,000-ohm, ½-watt resistor
**R3**—220,000-ohm, ½-watt resistor
**R4**—15,000-ohm, ½-watt resistor
**SPKR**—8-ohm PM type speaker
**T1**—audio output transformer 500-ohm primary/8-ohm secondary

# 65 Cassette-Based Control System

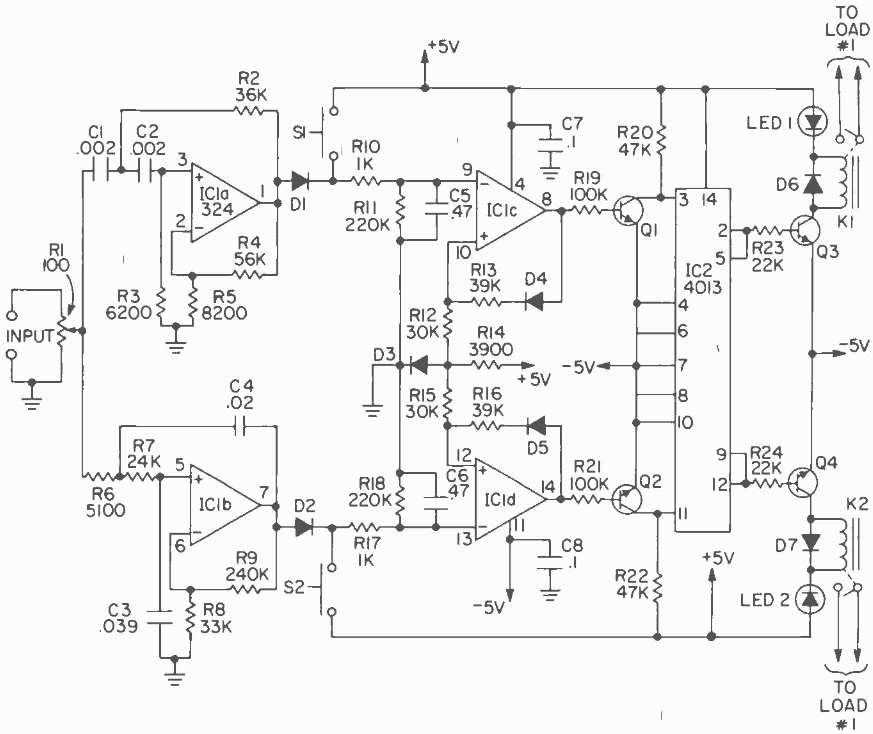
☐ Let's say that you need a programmable control system that can perform a timed sequence of operations. This sounds like a job for a high-priced computer, doesn't it? In many instances, however, just a cheap cassette recorder can do a respectable job—provided, of course, that you build this 2-channel controller.

High-frequency signals (above 5000 Hz) at the controller's input are amplified by high-pass filter U1a, then detected and used to clock one half of a dual flip-flop (U2). Each tone burst toggles the flip-flop, causing relay K1 to alternately open and close. These high-frequency audio signals have no effect on low-pass filter U1b, but frequencies below 500 Hz will produce the same effect in the lower channel as high frequencies in the upper channel, with the result that K2 alternately opens and closes on successive bursts of low frequency audio.

Feed the signal from your recorder's speaker output jack to the controller's input. Record a short sequence of tones—about 300 Hz for the low channel, and 7500 Hz for the high channel. Play back the tape-recorded sequence, and adjust R1 somewhat past the point where toggling of the relays starts. The LED go on and off with the relays and serve as convenient indicators of channel activity. Pushbuttons S1 and S2 can be used to change the status of a channel independently of the audio input. Whistles, tuning forks and electronic oscillators can all be used as tone sources. Whichever you use, strive to keep the level of the recorded signal constant.

**PARTS LIST FOR CASSETTE-BASED CONTROL SYSTEM**

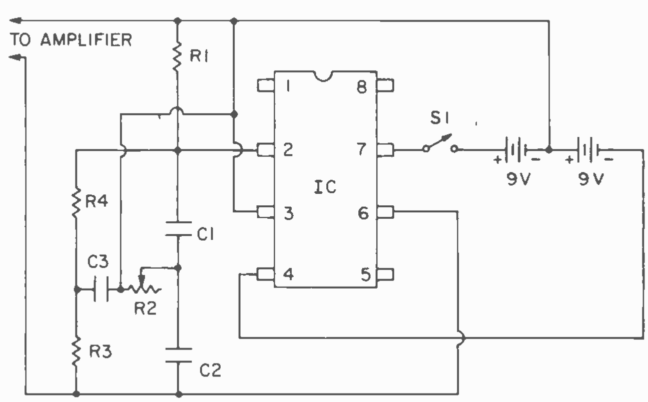
**C1, C2**—.002-uF polystyrene capacitor
**C3**—.039-uF polystyrene capacitor
**C4**—.02-uF polystyrene capacitor
**C5, C6**—0.47-uF mylar capacitor
**C7, C8**—0.1-uF ceramic disc capacitor
**D1-D7**—1N914 diode
**IC1**—LM324 quad op amp integrated circuit
**IC2**—4013 CMOS dual flip-flop integrated circuit
**K1, K2**—6-VDC, 500-ohm relay
**LED1, LED2**—light-emitting diode
**Q1-Q4**—2N3904 NPN transistor
**R1**—100-ohm trimpot (all resistors 10% unless otherwise noted.)
**R2**—36,000-ohm, ½-watt resistor 5%
**R3**—6,800-ohm, ½-watt resistor, 5%
**R4**—56,000-ohm, ½-watt resistor 5%
**R5**—8,200-ohm, ½-watt resistor 5%
**R6**—5,100-ohm, ½-watt resistor 5%
**R7**—24,000-ohm, ½-watt resistor 5%
**R8**—33,000-ohm, ½-watt resistor, 5%
**R9**—240,000-ohm, ½-watt resistor, 5%
**R10, R17**—1,000-ohm, ½-watt resistor
**R11, R18**—220,000-ohm ½-watt resistor
**R12, R15**—30,000-ohm, ½-watt resistor
**R13, R16**—39,000-ohm, ½-watt resistor
**R14**—3,900-ohm, ½-watt resistor
**R19, R21**—100,000-ohm, ½-watt resistor




**R20, R22**—47,000-ohm, ½-watt resistor
**R23, R24**—22,000-ohm, ½-watt resistor
**S1, S2**—pushbutton switch, normally open

# 66 The Howler

☐ This howler will produce a loud dog-like howl that starts strong and slowly grows weaker and weaker until it stops. To start it again, just press S1. Useful for alarms, bicycle horns, a different type doorbell, or as a Halloween trick. Changing R4 will change the frequency, or pitch of the howl, but the main purpose of R4 is to set the filter circuit into oscillation with the op amp. Adjust R4 until oscillations begin. The output should go to an amplifier rather than just to a speaker directly because the effect is better.




**PARTS LIST FOR THE HOWLER**

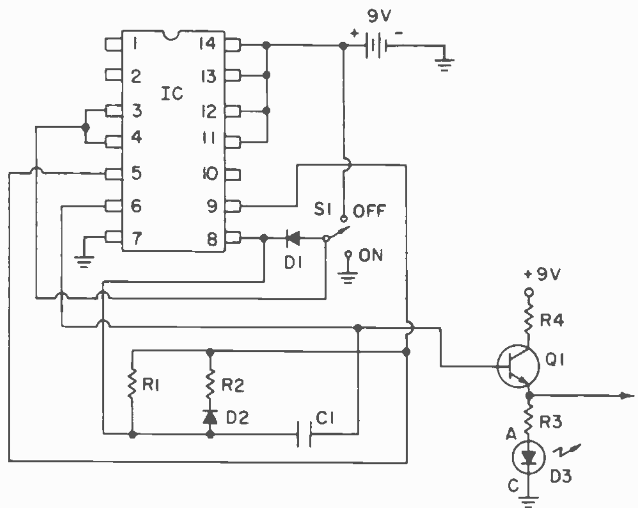
**C1, C2**—.001-uF ceramic disc capacitor, 15 VDC
**C3**—.005-uF ceramic disc capacitor, 15 VDC
**IC1**—741 op amp
**R1**—10,000-ohm, ½-watt resistor
**R2**—1,000,000-ohm, linear-taper potentiometer
**R3, R4**—220,000-ohm, ½-watt resistor
**S1**—SPST momentary-contact switch

# 67 Pulsed Alarm

☐ This circuit is great for driving alarms because it pulses the bell or buzzer with a frequency you can select via R1 and R2. The pulsing action not only gets attention faster, but saves battery power as well, because the alarm can run longer. And the beauty of this circuit is its low power consumption. In the off state, before the panic switch S1 is thrown, the circuit uses microwatts of power, so it can sit ready for months. That's one of the beauties of CMOS.

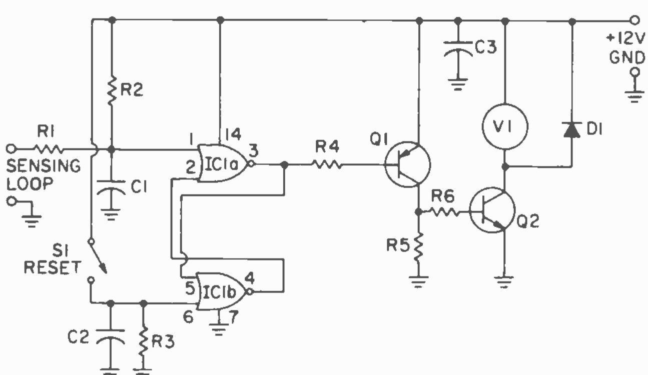
**PARTS LIST FOR PULSED ALARM**

**C1**—0.68-uF tantalum capacitor, 15 VDC
**D1, D2**—1N4001 diode
**D3**—small LED
**IC1**—4000 NOR gate
**Q1**—2N4401
**R1**—10,000,000-ohm, ½-watt resistor
**R2**—1,000,000-ohm, ½-watt resistor
**R3**—1,000-ohm, ½-watt resistor
**R4**—10-ohm, ½-watt resistor
**S1**—SPDT toggle switch




# 68 Burglar Alarm

☐ This burglar alarm circuit uses one integrated circuit and operates from a 6 volt battery. It is activated upon the breaking of a circuit. Since the sensing loop operates in a high impedance circuit, there is virtually no limit to the length of wire you can use. You can protect every window and door in your house. Practical operation by using four D cells for power is accomplished through the use of a four-section CMOS integrated circuit which draws only a few microamperes from the battery. Thus, battery life will be equivalent to its shelf life unless the alarm is activated. The heart of the circuit is a pair of NOR gates connected in a bistable configuration called a flip-flop or latch circuit. When the circuit is in standby, pin 1 of IC1 is held to almost zero volts by the continuous loop of sensing wire. This causes pin 3 to assume a voltage of 6 volts, cutting off Q1 and Q2. When the sensing circuit is broken, C1 charges to battery voltage through R2. This causes the latch circuit to change state and pin 3 goes to zero volts. B1 becomes forward-biased through R4 and turns on Q2 which operates the buzzer. The circuit will remain in an activated state once the alarm is set off, even though the broken circuit is restored. A reset switch has been provided to return the latch circuit to its original state and shut off the alarm.




**PARTS LIST FOR HOME BURGLAR ALARM**

**C1**—0.1-uF ceramic capacitor, 15 VDC
**C2**—0.1-uF ceramic capacitor, 15 VDC
**C3**—0.47-uF ceramic capacitor, 15 VDC
**D1**—1N4148 diode
**IC1**—4001 quad NOR gate
**Q1**—2N4403
**Q2**—2N4401
**R1, R3**—100,000-ohm, ½-watt resistor
**R2**—4,700,000-ohm, ½-watt resistor
**R4, R5**—10,000-ohm, ½-watt resistor
**R6**—100-ohm, ½-watt resistor
**S1**—SPST momentary-contact pushbutton switch
**V1**—6 VDC buzzer

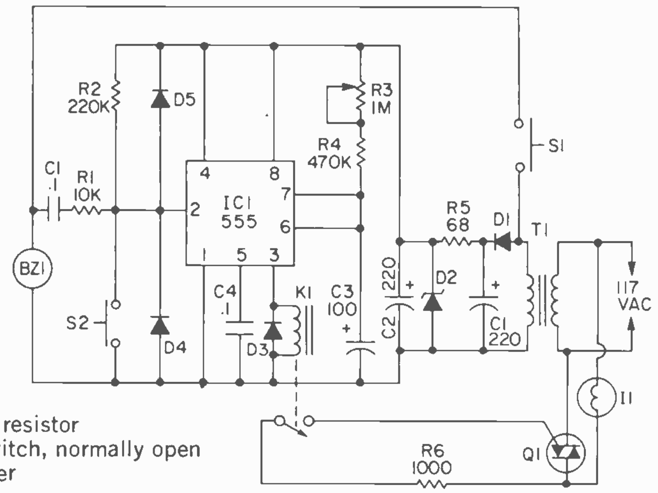
# 69 Smart Porch Light

☐ For convenience and security, you can't beat this smart porch light. Whenever someone rings your door buzzer with S1, on comes the front porch light. One to three minutes later, depending on the setting of R3, it goes off. If a burglar rings the doorbell while you're away (trying to ascertain whether or not the house is empty), the light will fool him. But even if he's smart enough not to be fooled, he'll think twice about breaking in. After all, there are likely to be more electronic booby traps and alarms waiting for him inside.

You can activate the light timer without ringing the buzzer by pressing S2. Do this as you leave the house at night, and you'll never stumble over a skateboard again.

**PARTS LIST FOR SMART PORCH LIGHT**

**BZ1**—6-VAC buzzer
**C1, C2**—220-uF, 25-VDC electrolytic capacitor
**C3**—100-uF 25-VDC electrolytic capacitor
**C4, C5**—0.1-uF ceramic disc capacitor
**D1**—1N4003 rectifier diode
**D2**—15-VDC, ½-watt Zener diode
**D3-D5**—1N914 diode
**IC1**—555 timer integrated circuit
**I1**—incandescent porch light
**K1**—6-VDC, 500-ohm relay
**Q1**—200-VDC, 6-A triac
**R1**—10,000-ohm, ½-watt resistor (all resistors 10% unless otherwise noted.)
**R2**—220,000-ohm, ½-watt resistor
**R3**—1,000,000-ohm trim potentiometer
**R4**—470,000-ohm, ½-watt resistor
**R5**—68-ohn, 1-watt resistor
**R6**—1,000-ohm, 1-watt resistor
**S1, S2**—pushbutton switch, normally open
**T1**—6.3-VAC transformer

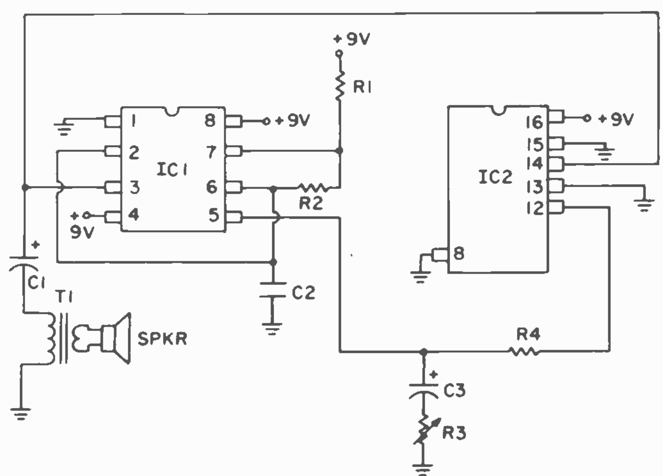



# 70 Two-Tone Alarm

☐ When this circuit is triggered into action, it is hard to ignore for very long! A 555 timer is operated in the astable free-running mode, with its output powering both a loudspeaker and clocking a 4017 counter. Pin 12 of the counter provides a high-low output which changes with every five input pulses counted. This output is applied via a resistor of from 2.2K to 10K ohms to pin 5, the modulated input of the timer. This produces a strident warble that calls immediate attention. More mellow, but interesting, tones can be obtained with the addition of the RC filter shown.

**PARTS LIST FOR TWO TONE ALARM**

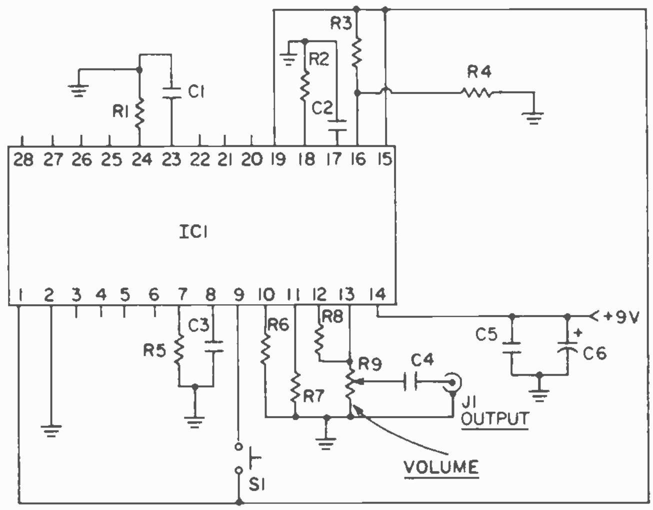
**C1**—100-uF electrolytic capacitor, 25 VDC
**C2**—0.1-uF ceramic capacitor, 15 VDC
**C3**—1-uF electrolytic capacitor, 25 VDC
**IC1**—555 timer
**IC2**—4017 decade counter
**R1, R2**—4,700-ohm, ½-watt resistor
**R3**—10,000-ohm linear-taper potentiometer
**R4**—2,200 to 10,000-ohm, ½-watt resistor (see text)
**SPKR**—8-ohm PM type speaker
**T1**—audio output transformer 500-ohm primary/8-ohm secondary




# 71 Featherweight Foghorn

☐ Despite its small size, this circuit generates an authentic-sounding foghorn blast. Couple the output signal to a good amp and loudspeaker, press switch S1, and you'll unleash a blast that will untie the shoelaces of anyone within hearing distance. The output signal has a 1-volt peak-to-peak maximum amplitude, which is just right for driving the AUX or TUNER inputs of most hi-fi or PA amplifiers. You can change the pitch to suit your own taste by substituting a different value of resistance for R2; larger resistances lower the pitch while smaller ones raise it. Be sure to use a socket with the IC.

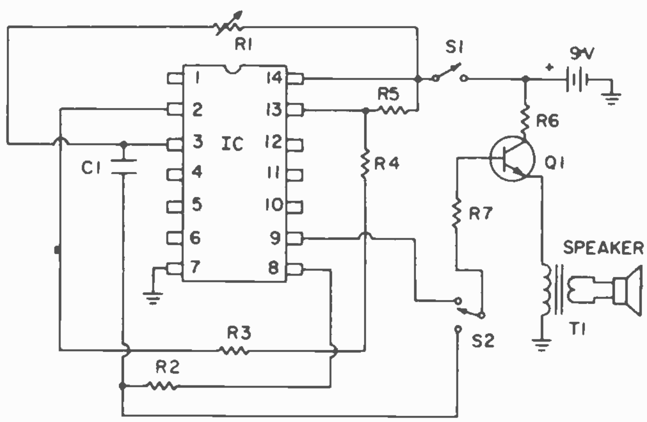
**PARTS LIST FOR FEATHERWEIGHT FOGHORN**
C1, C3—0.47-uF mylar capacitor, 35 VDC
C2—0.01-uF mylar capacitor, 35 VDC
C4—1.0-uF mylar capacitor, 35 VDC
C5—0.1-uF ceramic disc capacitor, 35 VDC
C6—100-uF electrolytic capacitor, 16 VDC
IC1—SN76477 sound generator
J1—phono jack
R1—1-Megohm ½-watt resistor, 10%
R2—470K-ohm ½-watt resistor, 10%
R3—15K-ohm ½-watt resistor, 10%
R4—10K-ohm ½-watt resistor, 10%
R5—1.5-Megohm ½-watt resistor, 10%
R6—180K-ohm ½-watt resistor, 10%
R7—150K-ohm ½-watt resistor, 10%
R8—47K-ohm ½-watt resistor, 10%
R9—5K audio-taper potentiometer
S1—SPST normally open pushbutton switch




# 72 Two-Tone Siren

☐ This circuit lets you generate an up-and-down siren sound by varying R1, and lets you change the type of sound by flipping S2. The output from pin 4 is a sawtooth waveform which causes one type of sound by flipping S2. The output from pin 4 is a sawtooth waveform which causes one type of sound through the speaker. The other type of sound, sharper and higher than the first, comes from the square wave output of pin 9. Flipping between the two types of sounds while varying R1 produces the sound of a French Police siren.

**PARTS LIST FOR TWO-TONE SIREN**
C1—0.01-uF ceramic capacitor, 15 VDC
IC1—3900 quad op amp
Q1—2N4401 transistor
R1—1,000,000-ohm linear-taper potentiometer
R2—100,000-ohm, ½-watt resistor
R3—510,000-ohm, ½-watt resistor
R4—120,000-ohm, ½-watt resistor
R5—1,200,000-ohm, ½-watt resistor
R6—1,000-ohm, ½-watt resistor
R7—2,000-ohm, ½-watt resistor
S1—SPST toggle switch
S2—SPDT slide switch
T1—audio output transformer 500-ohm primary/8-ohm secondary

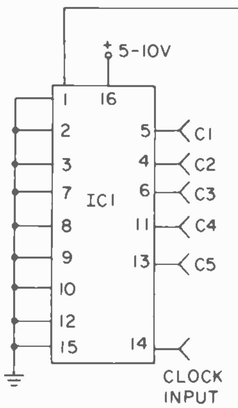


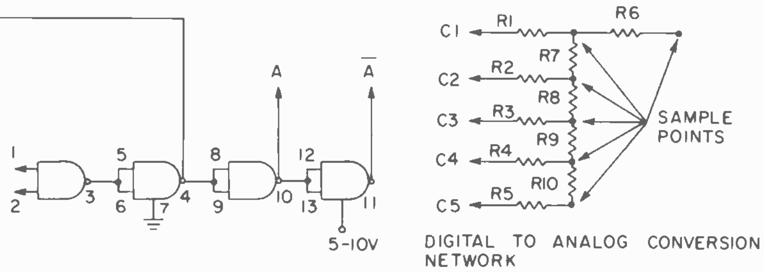

# 73 Dividing It All Up

**EXPERIMENTER**

☐ The type 4018 programmable counter is a useful digital tool, especially where a basic clock frequency must be divided down for various timing operations. With proper connections, divisors of from 2 through 10 may be configured. The table shown below gives the connections. The odd divisors do not give symmetrical outputs, but close ratios, such as four-high, three-low for a divide-by-seven setup. Digital-to-Analog Conversion may also be studied by connecting the outputs as shown. Interesting waveforms may be obtained by trying out the various dividing connections, while tying an oscilloscope into the different resistor network junctions. With the circuit set for a divide-by-ten function, a *digital sine wave* may be discovered at certain points along the network. With clock frequencies above 1 KHz, this output may be heard on an audio amplifier. Computer Music, anyone?

| To Divide By | Connect Pins 1&2 of IC2 To Pin 1 | Pin 2 |
|---|---|---|
| 2 | C1 | C1 |
| 3 | C2 | C1 |
| 4 | C2 | C2 |
| 5 | C2 | C3 |
| 6 | C3 | C3 |
| 7 | C3 | C4 |
| 8 | C4 | C4 |
| 9 | C4 | C5 |
| 10 | C5 | C5 |



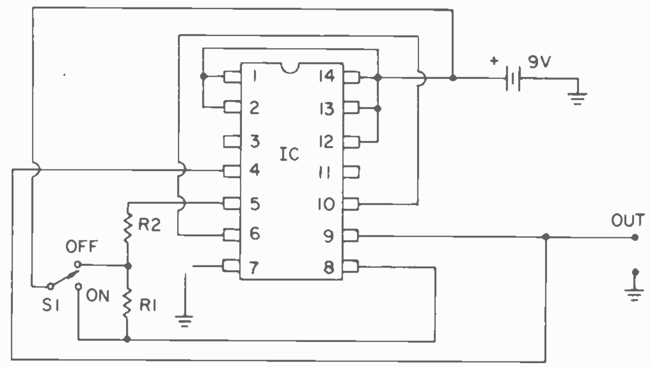




**PARTS LIST FOR DIVIDING IT ALL UP**

**IC1**—4018 dividing counter
**IC2**—4011A quad NAND gate
**R1 through R6**—100,000-ohm, ½-watt resistor
**R7 through R10**—47,000-ohm, ½-watt resistor

# 74 Clean Switch

☐ There is nothing worse in a circuit than a noisy switch. Even the slightest bounce will cause a double "on" and lead to double digits on your calculator display, or extra pulses into a million dollar computer system. So what to do? This circuit shows the basic idea used throughout the computer indusrty. The CD 4001 NOR gates are hooked up in flip-flop fashion so that once they flip, they stay that way. Double bounces still lead to a single, solid "on" pulse at the output.

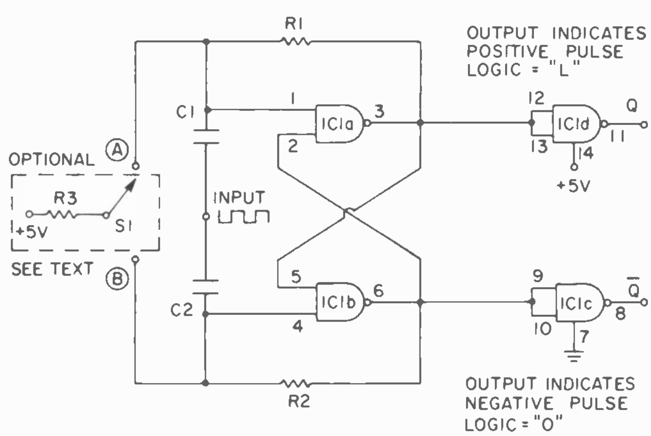



**PARTS LIST FOR CLEAN SWITCH**

**IC1**—4001 quad NOR gate
**R1, R2**—870,000-ohm, ½-watt resistor
**S1**—SPDT slide switch

# 75 Do-It-Yourself Logic

☐ Sometimes the integrated circuits taken for granted are not always available, and one must fall back on more basic components. We do not go quite as far as discrete transistors here, but show how a frequency divider flip-flop can be improvised from simple gates. The following divide-by-two circuit was used for dividing a 60 Hz square wave, but should work well at other frequencies. A 7400 or 74LS00 quad NAND gate was selected, with the two extra gates employed as buffers to keep the input toggle clock from appearing when the flip-flop was biased off. If the cut-off resistor R3 is the same value as R1 and R2, a lock-out will be obtained. If it is about doubled, then the circuit will function, but will hold one output high (or low) when the clock signal drops out.

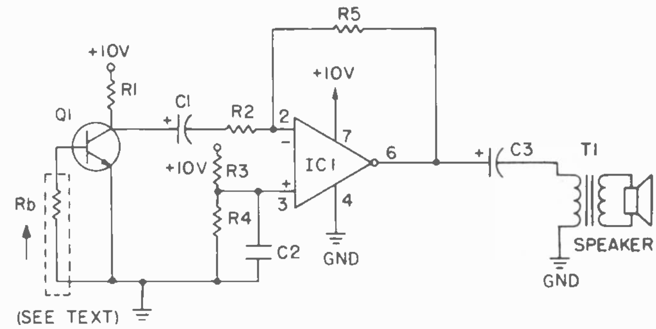



**PARTS LIST FOR DO-IT-YOURSELF LOGIC**

**C1, C2**—0.01 to 0.1-uF ceramic capacitor, 15 VDC
**IC1**—7400 quad NAND gate
**R1, R2**—50,000 to 100,000-ohm, ½-watt resistor (see text)
**R3**—50,000 to 200,000-ohm, ½-watt resistor (see text)
**S1**—SPDT toggle switch

# 76 Light Into Sound

☐ While another project in this book illustrates how sound impulses could be converted into light signals, via an LED indicator, here, a type FPT-100 phototransistor turns light into sound. When connected, the system may be quick-checked with a flashlight, while listening to the speaker and/or observing the op amp output on a scope. Modulating the light source mechanically with a pocket comb produces a buzzing tone, as the teeth of the comb alternately gate the light source. A modulated LED can be used, with proper optical interfacing, as a communication source. The phototransistor is at its greatest sensitivity with the base lead open, though this may introduce unwanted hum. A 100K to 1 Meg resistor (R6) may be run to ground to check the best compromise.

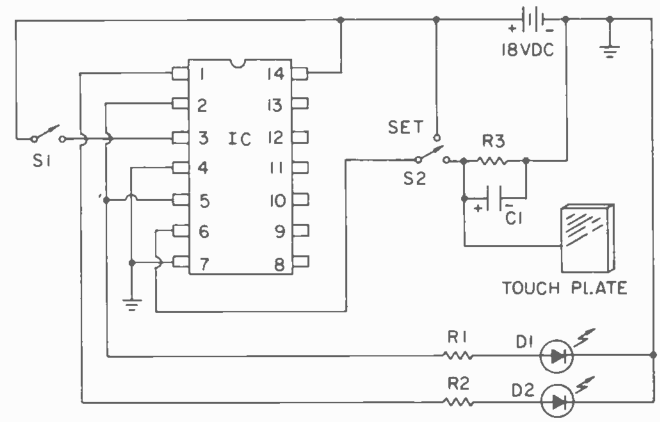



**PARTS LIST FOR LIGHT INTO SOUND**

**C1 C2**—10-uF electrolytic capacitor, 15 VDC
**C3**—50-uF electrolytic capacitor, 25 VDC
**IC1**—741 op amp
**Q1**—FPT100 phototransistor
**Rb**—100,000 to 1,000,00-ohm, ½-watt resistor (see text)
**R1**—47,000-ohm, ½-watt resistor
**R2**—1,000 to 10,000-ohm, ½-watt resistor
**R3 R4**—4,700-ohm, ½-watt resistor
**R5**—500,000-ohm, ½-watt resistor
**SPKR**—8-ohm PM type speaker
**T1**—audio output transformer 500-ohm primary/8-ohm secondary

# 77 Touch 'N Flip

☐ Ever wonder how a touch plate, like the kind you see on some elevator buttons, works? This circuit will give you a good feel for how the touch plate works in a circuit and lets you experiment further. The plate can be just a small piece of metal or aluminum foil. Start by sliding S2 to "set" then back to R3. Now press S1. LED's D1 and D2 will flip. Now touch the plate to flip them back. The sensitivity of the touch plate will depend on humidity in the room and on R3 and C1. You can experiment with those in various ways.




**PARTS LIST FOR TOUCH 'N FLIP**

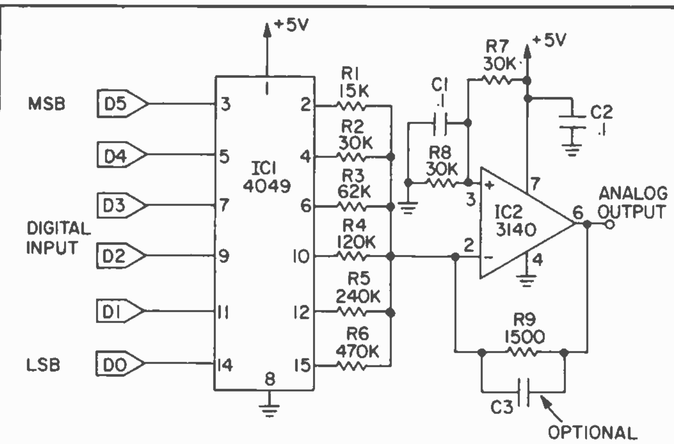
**C1**—4.7-uF electrolytic capacitor, 15 VDC
**D1, D2**—large LED
**IC1**—4011 quad NAND gate
**R1, R2, R3**—2,000-ohm, ½-watt resistor
**S1**—SPST momentary contact pushbutton switch
**S2**—SPDT slide switch

# 78 Simple 6-Bit-D/A Converter

☐ Here is a simple way to convert a digital code into an analog equivalent. This circuit accepts a 6-bit binary-coded digital input. D5 is the most significant bit, and D0 is the least significant. Each one of the 64 possible digital input codes produces a unique analog level at the output. This analog output varies between +2 volts (input = 111111) and +3 volts (input = 000000), with 62 discrete levels in between.

For applications such as music generation, where you'd like to smooth out some of the steps in the analog output, capacitor C3 can be added. The size of C3 can be determined experimentally by feeding in a digital sequence at the desired rate, and trying capacitors until the right effect is obtained. This is most easily done while observing the output on a 'scope.

If the converter is to be driven by TTL circuitry rather than CMOS, tie a 4700-ohm resistor between each digital input and the positive supply. This will raise the TTL levels high enough to drive CMOS.

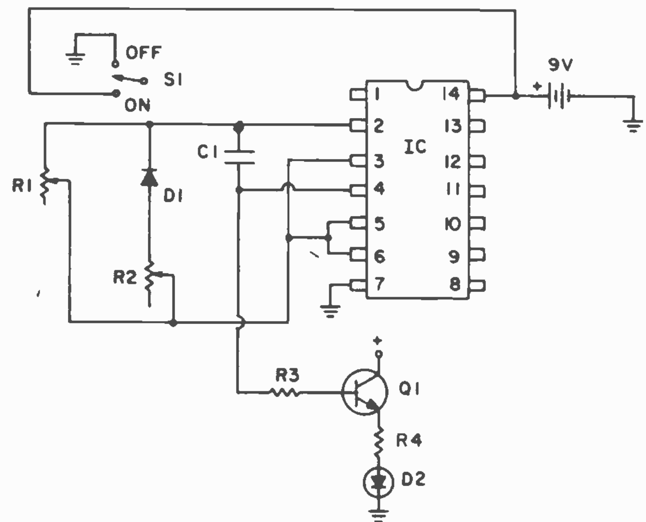



**PARTS LIST FOR SIMPLE 6-BIT DA CONVERTER**

- **C1, C2**—0.1-uF ceramic disc capacitor
- **IC1**—4049 hex CMOS buffer integrated circuit
- **IC2**—3140 FET-input op amp integrated circuit (RCA)
- **R1**—15,000-ohm, ½-watt resistor (all resistors 5%)
- **R2, R7, R8**—30,000-ohm, ½-watt resistor
- **R3**—62,000-ohm, ½-watt resistor
- **R4**—120,000-ohm, ½-watt resistor
- **R5**—240,000-ohm, ½-watt resistor
- **R6**—470,000-ohm, ½-watt resistor
- **R9**—1,500-ohm, ½-watt resistor

# 79 Basic CMOS NAND Oscillator

☐ Closing S1 causes this CMOS NAND oscillator to flash the LED. The "ON" time is controlled by R1 and the "OFF" time is controlled by R2. This oscillator can sit for months with S1 open because, being CMOS, it draws very little power. It is a basic oscillator useful for driving buzzers, computer clocks, counters, various alarm circuits, windshield wipers and uncountable other applications. The output from pin 4 can drive small loads, even small relays, directly, or you can drive a transistor or SCR to handle bigger loads.



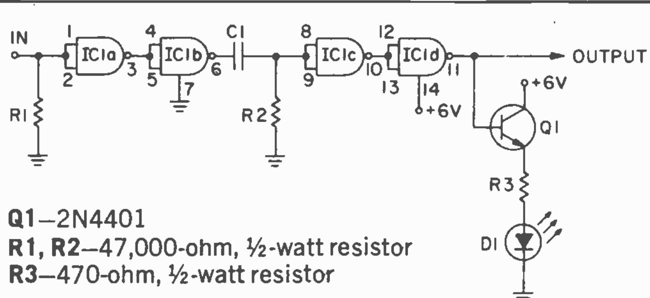

**PARTS LIST FOR BASIC CMOS NAND OSCILLATOR**

- **C1**—0.1-uF ceramic capacitor, 15 VDC
- **D1**—1N4001 diode
- **D2**—small LED
- **IC1**—4011 quad NAND gate
- **Q1**—2N4401 transistor
- **R1**—10,000,000-ohm linear-taper potentiometer
- **R2**—100,000-ohm linear-taper potentiometer
- **R3**—1,000-ohm, ½-watt resistor
- **R4**—10,000-ohm ½-watt resistor
- **S1**—SPDT slide switch

# 80 Improvised Monostable

☐ Like the preceeding projects, this one is also dedicated to the art of improvisation. While TTL and CMOS prepackaged monostable multivibrators are available, one may not be at hand when such a useful device is called for. Once again, two very common gates, the 4001 quad NOR and the 4011 quad NAND will equally fill the bill.

In operation, when the input is made high, the output of the first inverter goes low, forcing the output of the



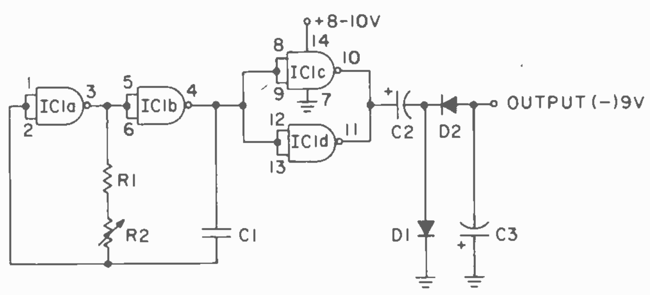

**PARTS LIST FOR IMPROVISED MONOSTABLE**

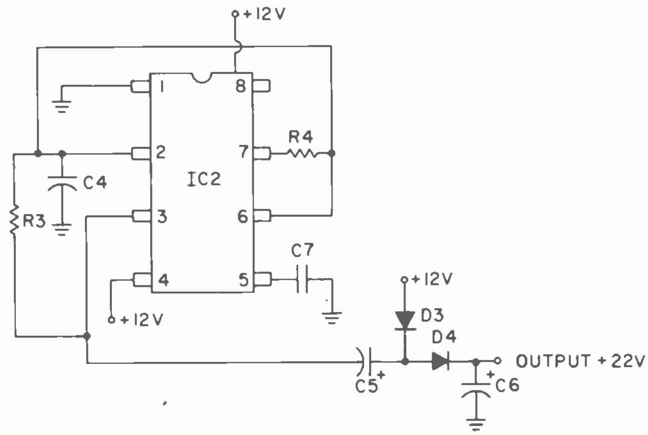
- **C1**—0.1-uF ceramic capacitor, 15 VDC
- **D1**—small LED
- **IC1**—4001A or 4011A quad NAND gate
- **Q1**—2N4401
- **R1, R2**—47,000-ohm, ½-watt resistor
- **R3**—470-ohm, ½-watt resistor

second high, charging the capacitor C through resistor R2. For a while, the output of the third gate is driven low, causing the output stage to go high, activating the LED indicator. In this elementary circuit, it is only necessary that the turn-on signal remain high for at least the duration of the timed interval.

# 81 Positive Into Negative

☐ Certain IC chips and other circuit elements often require small negative potentials of small current drain, necessitating the construction of bulky transformer-operated supplies. Operating at 1 KHz or higher frequency, the pulse generator shown below drives a voltage-doubler circuit furnishing a negative potential approaching that of the positive input supply. With a 10 volt input, an output of about −9 VDC was measured into a 20,000 ohm load. A voltage tripler or quadrupler circuit may also be employed for higher potentials (positive or negative) as well. For loads requiring up to 50 ma, the type 555 timer in astable mode is an ideal choice.

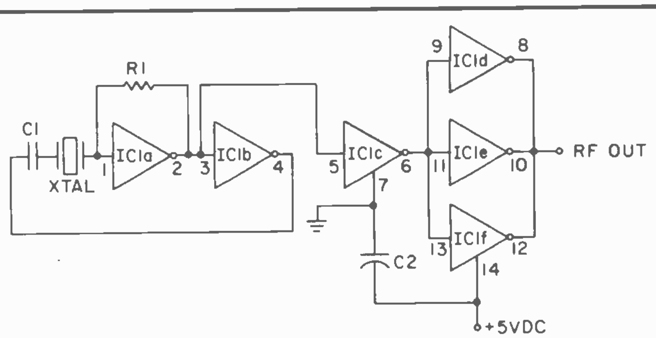



**PARTS LIST FOR POSITIVE INTO NEGATIVE**
**C1**—0.01 to 0.1-uF ceramic capacitor, 15 VDC
**C2, C5**—10-uF electrolytic capacitor, 25 VDC
**C3**—10 to 100-uF electrolytic capacitor, 25 VDC
**C4**—0.001-uF ceramic capacitor, 15 VDC
**C6**—25-uF electrolytic capacitor, 25 VDC
**C7**—0.01-uF ceramic capacitor, 15 VDC
**D1 through D4**—1N4001 diode
**IC1**—4011 quad NAND gate
**IC2**—555 timer
**R1**—500-ohm, ½-watt resistor
**R2**—50,000-ohm linear-taper potentiometer
**R3**—33,000-ohm, ½-watt resistor
**R4**—4,700-ohm, ½-watt resistor

# 82 Crystal Controlled TTL

☐ This inexpensive color-TV crystal of approximately 3.58 MHz can readily be persuaded to oscillate in the following 7404 circuit. The resultant waveform can be divided down, via other popular IC chips, such as the 4017 CMOS type.



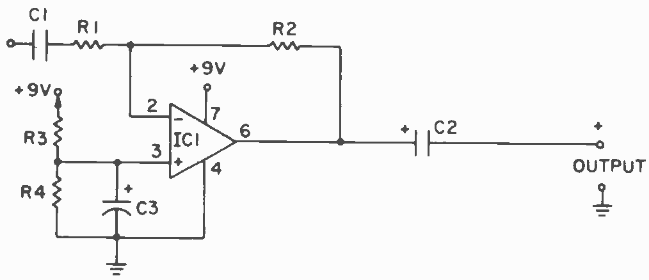

**PARTS LIST FOR CRYSTAL-CONTROLLED TTL**
**C1**—75-pF mica capacitor, 15 VDC
**C2**—0.01-uF ceramic capacitor, 15 VDC
**IC1**—7404 hex inverter
**R1**—1,000-ohm, ½-watt resistor
**XTAL**—3.58 MHz crystal (color TV carrier type)

# 83 Single Supply Signal Shifter

☐ Op amps, like the popular 741, are usually operated with matching plus and minus power supplies. However, for simple signal amplification applications, the single positive supply shown below has been found to work quite nicely. Resistors R3 and R4 may be fixed at about 5000 ohms each, or replaced with a 5K or 10K potentiometer, if it is desired to adjust the no-signal output level so that high-amplitude signals will not be clipped. Sometimes, intentional clipping is desired, so this feature may be retained for general experimental applications. Note: If a potentiometer is used for R3, R4, connect center terminals of pots to pin #3 of IC1.

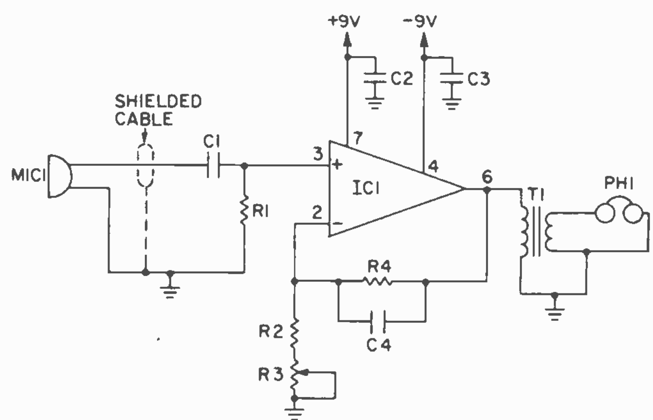
**PARTS LIST FOR SINGLE SUPPLY SIGNAL SHIFTER**

**C1**—0.01-uF ceramic capacitor, 15 VDC (gain=10)
—0.10-uF ceramic capacitor, 15 VDC (gain=100)
**C2**—1 to 100-uF electrolytic capacitor, 15 VDC (increase value with frequency)
**C3**—100-uF electrolytic capacitor, 15 VDC
**IC1**—741 op amp
**R1**—10,000-ohm, ½ watt resistor
**R2**—100,000-ohm, ½ watt resistor (gain=10)
—1,000,000-ohm, ½ watt resistor (gain=100)
**R3, R4**—5,000-ohm, ½ watt resistor or 5,000-10,000 ohm linear taper potentiometer




# 84 Super Stethoscope

☐ Auscultation is the medical term for the procedure. In simple language, it means having your ribs ticked with an icy cold stethoscope. Should you ever get the urge to play doctor, we prescribe the simple electronic stethoscope diagrammed here. Best results will be obtained using hi-fi or communications-type low-impedance headphones designed to isolate the listener from ambient sounds. Be sure to connect the microphone cartridge to the rest of the circuit using shielded audio cable to keep noise pickup to a minimum. Potentiometer R3 adjusts the gain. Use a socket when mounting IC1 since it has delicate FET inputs.



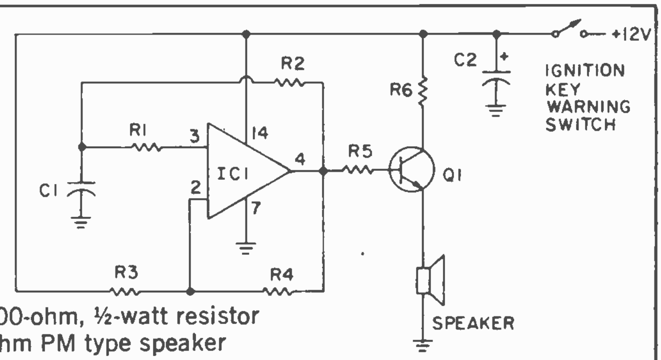

**PARTS LIST FOR SUPER STETHOSCOPE**

**C1**—0.01-uF mylar capacitor, 35 VDC
**C2, C3**—0.1-uF ceramic disc capacitor, 35 VDC
**C4**—10-pF polystyrene capacitor, 35 VDC
**IC1**—RCA CA3140 op amp
**MIC1**—crystal microphone cartridge
**PH1**—low-impedance headphones, hi-fi or communications type
**R1, R4**—1-Megohm, ½-watt resistor, 10%
**R2**—1000-ohm, ½-watt resistor, 10%
**R3**—10K linear-taper potentiometer
**T1**—miniature audio output transformer—1,00-ohm primary/8-ohm secondary

# 85 Ignition Key Tone Generator

**AUTO**

☐ This ignition key tone generator replaces the loud, annoying buzzer in your car with a pleasing tone of




**PARTS LIST FOR KEY TONE GENERATOR**

**C1**—0.01-uF ceramic capacitor, 15 VDC
**C2**—10-uF electrolytic capacitor, 20 VDC
**IC1**—LM 3900 quad amplifier
**Q1**—2N4401
**R1**—2,700,000-ohm, ½-watt resistor
**R2**—33,000-ohm, ½-watt resistor
**R3, R4**—10,000,000-ohm, ½-watt resistor
**R5**—10,000-ohm, ½-watt resistor
**R6**—100,000-ohm, ½-watt resistor
**SPKR**—8-ohm PM type speaker

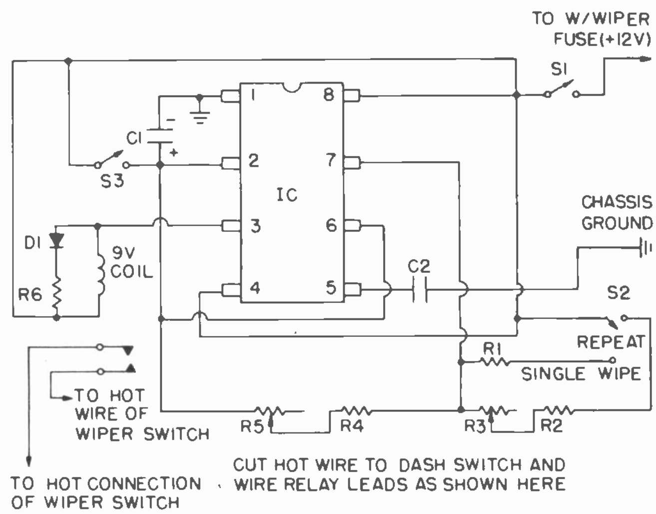
about 2000 Hertz. One section of an LM3900 quad operational amplifier is connected as a square wave generator, which is rich in harmonics and produces a pleasant sound. Current amplification to drive the speaker is provided by Q1. The frequency of oscillation is determined by C1 and R2. Total current drawn by the circuit is about 75 milliamperes at 12 volts.

# 86 Go-Slo Wiper Control

☐ Ever have the problem of not being able to make your car wipers go slow enough? And sometimes, would you like to just press a button to make wipers flip one time? This circuit does both. Set S2 to the mode you want. If you pick "repeat", then R3 will determine the time between wipes (up to several minutes), so put R3 on a knob you can turn while sitting in the driver's seat. R5 will control the length of the wipe; you just set it once for your car. If S2 is set to "single wipe", then pressing S3 will kick the wipers up once. A very handy circuit.

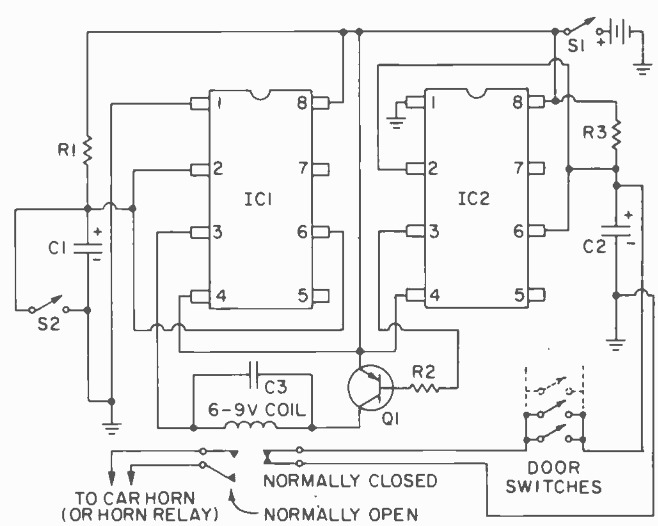
**PARTS LIST FOR SELECT-DELAY WINDSHIELD WIPER CONTROL**

- **C1**—100-uF electrolytic capacitor, 15 VDC
- **C2**—0.1-uF ceramic disc capacitor, 15 VDC
- **D1**—1N4001 diode
- **IC1**—555 timer
- **R1**—10,000,000-ohm, ½-watt resistor
- **R2**—20,000-ohm, ½-watt resistor
- **R3**—500,000-ohm linear-taper potentiometer
- **R4**—18,000-ohm, ½-watt resistor
- **R5**—50,000-ohm linear-taper potentiometer
- **R6**—100-ohm, ½-watt resistor
- **S1**—SPST toggle switch
- **S2**—SPDT toggle switch
- **S3**—SPST momentary-contact (pusbutton) switch
- **RELAY**—9 VDC coil with normally open SPST switch contacts rated at 15 VDC/25 amps




# 87 Auto Burglar Alarm

☐ This burglar alarm will sound your car horn if anyone opens your car door. The timers allow you to leave and enter the car without the horn sounding. To set, or arm, the alarm circuit, open S2. This will give you five seconds (R1, C1) to get out and shut the door behind you. If anyone opens a door for two seconds (R3, C2), the horn will sound and will stay locked on until S1 is opened. If you open the door to enter, you have two seconds to close S2, which is plenty of time if S2 is conveniently located.




**PARTS LIST FOR AUTO BURGLAR ALARM**

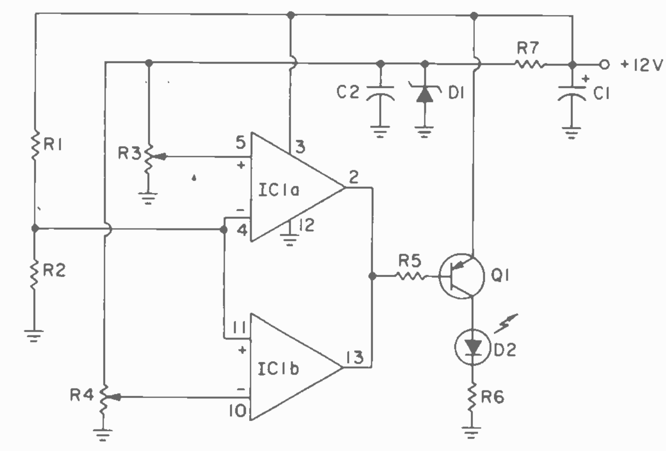
- **C1**—10-uF electrolytic capacitor, 15 VDC
- **C2**—1-uF electrolytic capacitor, 15 VDC
- **C3**—0.1-uF ceramic disc capacitor, 15 VDC
- **IC1, IC2**—555 timer
- **Q1**—2N4403
- **R1**—500,000-ohm, ½-watt resistor
- **R2**—270-ohm, ½-watt resistor
- **R3**—2,000,000-ohm, ½-watt resistor
- **RELAY**—6 to 9 VDC coil with switch contacts rated at 15 VDC/30 amps; 1 set SPST normally open, 1 set SPST normally closed

# 88 Alternate Monitor

☐ This circuit will monitor the output of the alternator of any car with a 12 volt electrical system and indicate if the charging system is either undercharging or overcharging. This is accomplished by using 2 sections of a quad voltage comparator IC and connecting the outputs in an "OR" configuration so that the LED will become lit if section A or section B of the comparator detects an improper voltage level. The circuit is connected into any circuit which is active when the car is in operation, such as the ignition or radio circuit. This prevents drain on the battery when the car is not in use. To calibrate the circuit, connect an adjustable DC power supply to the + and – inputs of the circuit. Set the power supply to 13.4 volts and adjust R3 so that the voltage at pin 5 of IC1A is maximum. Then adjust R4 so that the LED just goes out. Set the power supply to 15.1 volts and adjust R3 so that the LED just goes out. The LED will now become lit if the voltage is outside the permissable range of 13.5 to 15.0 volts when the engine is running.

**PARTS LIST FOR ALTERNATOR MONITOR**

- **C1**—10-uF electrolytic capacitor, 15 VDC
- **C2**—0.1-uF ceramic capacitor, 15 VDC
- **D1**—9 VDC zener diode
- **D2**—large LED
- **IC1**—339 quad comparator
- **Q1**—2N4403
- **R1, R2, R5**—10,000-ohm, ½-watt resistor
- **R3, R4**—50,000-ohm linear-taper potentiometer
- **R6**—470-ohm, ½-watt resistor
- **R7**—220-ohm, ½-watt resistor



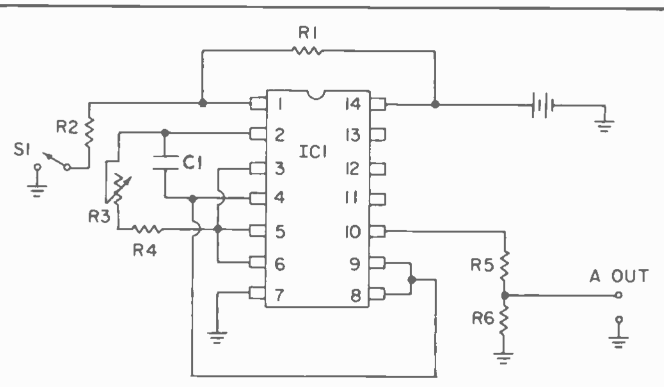

# 89 Code Practice Oscillator

COMMUNICATIONS

☐ Boning up for your Amateur code exam? Pushbutton S1 makes a very inexpensive Morse code key. The tone out of the circuit, at point A, can drive an amplifier or a pair of high-impedance headphones.

**PARTS LIST FOR CODE PRACTICE OSCILLATOR**

- **C1**—0 1-uF ceramic capacitor, 15 VDC
- **IC1**—4001 quad NOR gate
- **R1**—91,000-ohm, ½-watt resistor
- **R2**—220-ohm, ½-watt resistor
- **R3**—500,000-ohm, linear-taper potentiometer
- **R4**—50,000-ohm, ½-watt resistor
- **R5, R6**—2,200-ohm, ½-watt resistor
- **S1**—SPST momentary-contact pushbutton switch



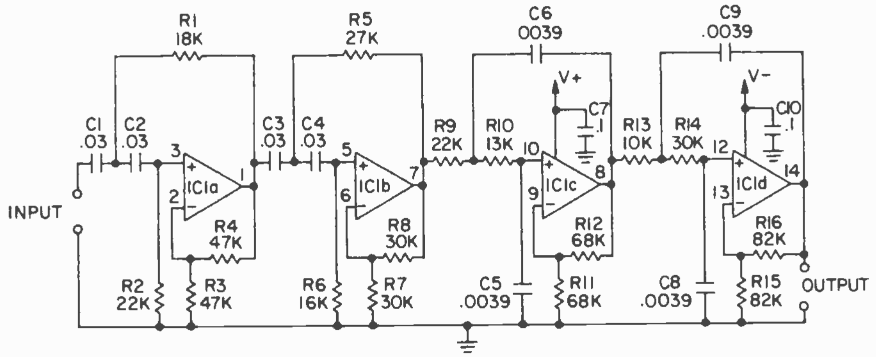

# 90 Audio Bandpass Filter

☐ There are two different approaches to bandpass-filter design. The first involves use of a high-Q resonant network. You'll find this type of device sold as a CW filter, an application in which it excels. However, the selectivity of a resonant bandpass filter is such as to favor a very few frequencies to the exclusion of all others, and this makes it useless in voice reception. To filter the garbage out of an SSB transmission, you need a filter that freely passes the band of frequencies between about 300 and 2500 Hz but drastically attenuates frequencies outside the passband. An audio filter of this type is constructed by cascading (i.e., hooking in series) very sharp high- and low-pass filters.

That's what we've done here. U1a and U1b comprise a sharp, 4-pole Butterworth high-pass filter with a 300-Hz cut-off. The two remaining stages function as a low-pass 4-pole Butterworth filter having a 2500-Hz cut-off frequency. Overall circuit gain is 16. Insert the filter into your receiver's audio chain at a point where the input signal level will be less than 100mV peak-to-peak. If the filter's extra gain causes problems, chop its output down with a resistive divider. A dual supply furnishing anywhere between ± 2.5V and ±15V can be used to power the circut.

**PARTS LIST FOR AUDIO BANDPASS FILTER**

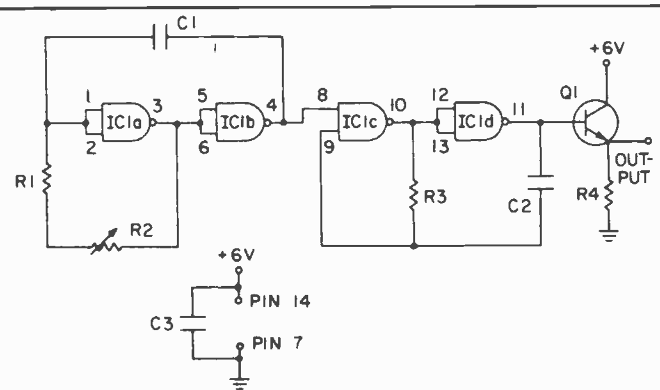
**C1-C4**—0.03-uF polystyrene capacitor
**C5, C6, C8, C9**—.0039-uF polystyrene capacitor
**C7, C10**—0.1-uF ceramic disc capacitor
**IC1**—LM324 quad op amp integrated circuit
**R1**—18,000-ohm, ½-watt resistor (all resistors 5% unless otherwise noted.)
**R2, R9**—22,000-ohm, ½-watt resistor
**R3, R4**—47,000-ohm, ½-watt resistor
**R5**—27,000-ohm, ½-watt resistor
**R6**—16,000-ohm, ½-watt resistor
**R7, R8, R14**—30,000-ohm, ½-watt resistor




**R10**—13,000-ohm, ½-watt resistor
**R11, R12**—68,000-ohm, ½-watt resistor
**R13**—10,000-ohm, ½-watt resistor
**R15, R16**—82,000-ohm, ½-watt resistor

# 91 Digital Modulator

☐ When a high-frequency oscillator is gated by a much lower frequency, modulation is accomplished. The following circuit provides a 1 MHz oscillator modulated or gated by a variable frequency in the audio range. A transistor-buffer is used for the output. The resulting signal can be employed for a variety of AM radio testing and each signal may be individually be taken off, increasing the versatility of this little circuit. *Note*: Do not use an antenna longer than 3 ft., or RF emission may exceed allowable FCC standards and cause illegal RF interference.




**PARTS LIST FOR DIGITAL MODULATOR**

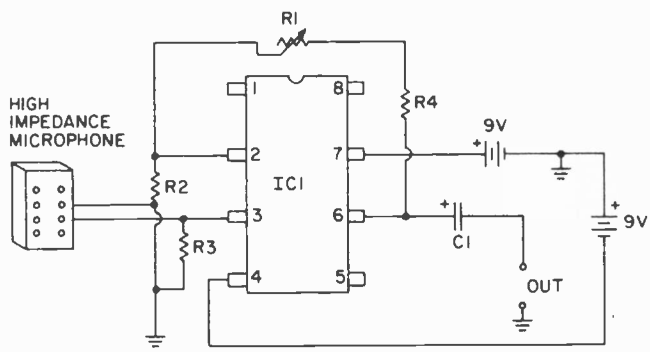
**C1**—0.01-uF ceramic capacitor, 15 VDC
**C2**—100-pF mica capacitor, 15 VDC
**C3**—0.1-uF to 0.22-uF ceramic capacitor, 15 VDC
**IC1**—4011A quad NAND gate
**Q1**—2N4401 transistor
**R1**—10,000-ohm, ½-watt resistor
**R2**—100,000-ohm, ½-watt resistor
**R3**—2,200-ohm, ½-watt resistor
**R4**—150-ohm, ½-watt resistor

# 92 High Impedance Mike Amplifier

☐ A high impedance microphone will drive this circuit nicely. The output can drive a 1000 ohm earphone directly, or it can drive a transistor to, in turn, run a speaker. The gain is determined by the ratio of R1 to R2 and, in practice, can get up to about 50 dB.

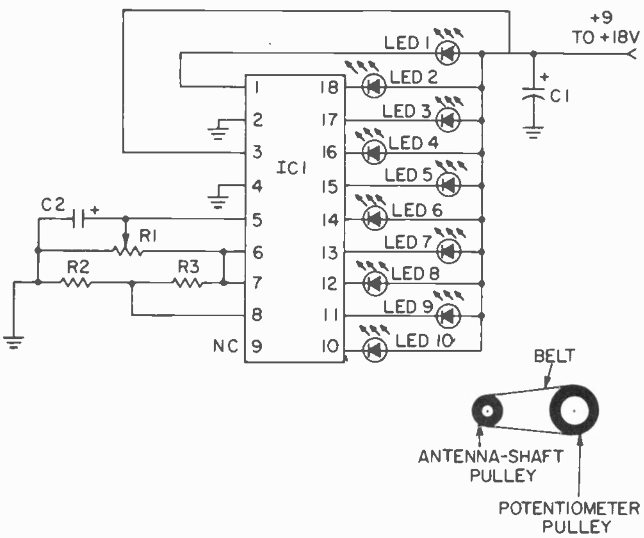
**PARTS LIST FOR HI-IMPEDANCE MIKE AMP**

**C1**—68-uF electrolytic capacitor, 25 VDC
**IC1**—741 op amp
**R1**—500,000-ohm linear-taper potentiometer
**R2, R4**—1,000-ohm, ½-watt resistor
**R3**—910,000-ohm, ½-watt resistor



# 93 Antenna-Bearing Indicator

☐ Using an economy-type rotator with your TV, FM or ham beam-type antenna? Then you probably have a direction indicator that's hard-to-read, inaccurate, or in the case of homebrew rotators, probably non-existent. However, it's easy to add on a direction indicator using LEDs for readout. Referring to the schematic, note direction-sensing potentiometer R1. As its wiper moves away from ground potential, first LED 1 will light, then LED 2 will come on as LED 1 extinguishes; this process continues in numerical succession until finally LED 10 is the only lit LED. Coupling the pot to your rotating antenna's shaft with pulleys and a belt allows the display of LEDs to respond to antenna position. The potentiometer's pulley should have a larger diameter than that of the antenna shaft because most potentiometers cannot rotate through a full 360°.

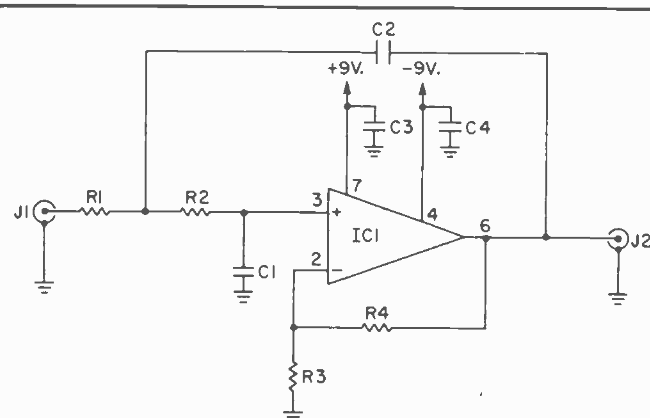



**PARTS LIST FOR ANTENNA-BEARING INDICATOR**

**C1**—100-uF electrolytic capacitor, 35 VDC
**C2**—5-uF electrolytic capacitor, 10 VDC
**IC1**—LM3914 LED display driver
**LED1 through LED10**—light-emitting diode
**R1**—25K linear-taper potentiometer
**R2**—3900-ohm, ½-watt resistor, 5%
**R3**—1200-ohm, ½-watt resistor, 5%

# 94 Active Low Pass Filter

☐ As its name suggests, a low-pass filter passes signals with frequencies lower than some specific value, called the *cut-off frequency*, but blocks passage of frequencies above the cut-off. Illustrated here is an active low-pass filter having a 1000 Hz cut-off frequency. You can shift the cut-off by changing C1 and C2 together. To multiply the cut-off by a factor of N, multiply the capacitances of C1 and C2 by a factor of 1/N. For example, a 2000 Hz cut-off would require 0.005 μF capacitors, while a 500 Hz cut-off calls for 0.02 μF capacitors for C1 and C2. Drive the filter directly from the output of a preceding op-amp stage for best results.

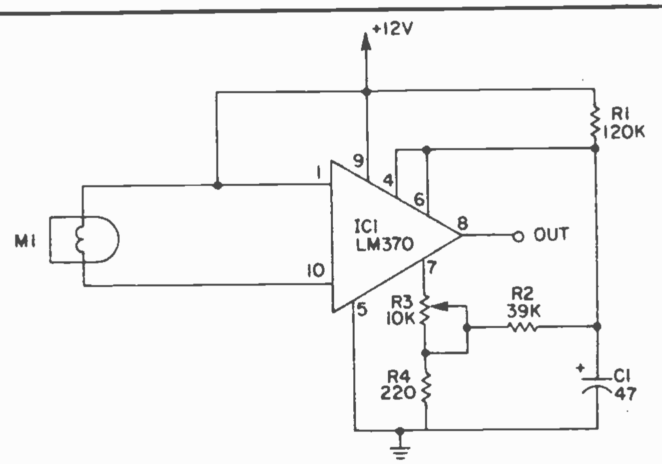



**PARTS LIST FOR ACTIVE LOW PASS FILTER**

**C1, C2**—0.01-uF polystyrene or mylar capacitor, 35 VDC
**C3, C4**—0.1-uF ceramic disc capacitor, 35 VDC
**IC1**—741 op amp
**J1, J2**—phono jack
**R1**—12K-ohm ½-watt resistor, 5%
**R2**—22K-ohm ½-watt resistor, 5%
**R3, R4**—68K-ohm ½-watt resistor, 5%

# 95 Squelched Microphone

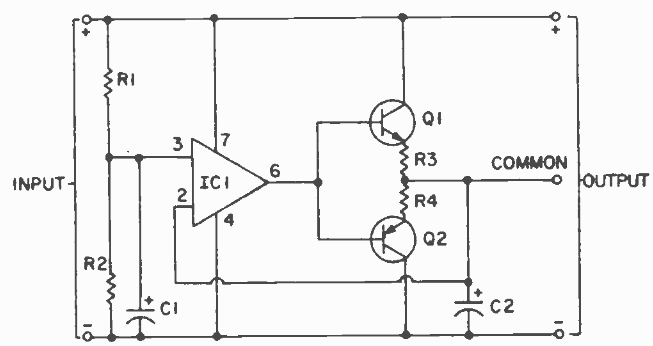
☐ Here is a way to eliminate unwanted background noise and conversation when using a microphone for communications or recording purposes. IC1, an LM370, is a preamplifier with squelch capability. This means that amplification does not begin until the input signal exceeds a preset threshold level. Since background noise is, in most instances, not as loud as the voice of the person speaking into the microphone, all ouput is squelched whenever speech stops. So, instead of noise, you get silence. The squelch threshold can be set by adjustment of R3.




**PARTS LIST FOR SQUELCHED MICROPHONE**
C1—47-uF, 25-VDC electrolytic capacitor
IC1—LM370 AGC amplifier integrated circuit
M1—dynamic microphone cartridge
R1—120,000-ohm, ½-watt resistor (all resistors 10%)
R2—39,000-ohm, ½-watt resistor
R3—10,000-ohm, trim-potentiometer
R4—220-ohm, ½-watt resistor

# 96 Dual Polarity Power Supply

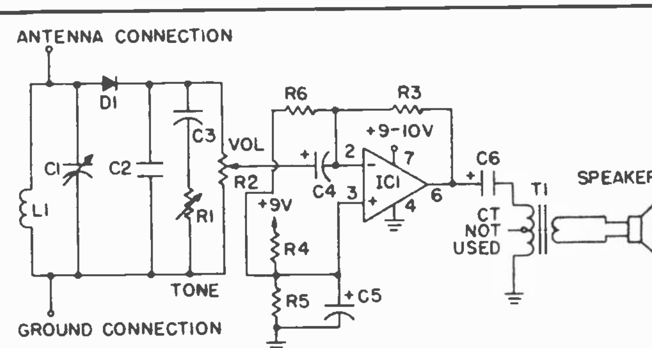
☐ Many operational amplifiers require both positive and negative supplies for proper operation. With this simple circuit you can take a floating power supply and convert it into a dual polarity supply. To provide ±15 volts as most op amps require, you will need a 30 volt supply to drive the circuit. The output voltages of this circuit are set by the voltage divider action of R1 and R2 and are well regulated. Current output is limited only by the unbalance between the loads on the positive and negative outputs, and should not exceed the rating of the transistors, 200 milliamperes.




**PARTS LIST FOR DUAL POLARITY POWER SUPPLY**
C1, C2—15-uF electrolytic capacitor, 30 VDC
IC1—741 op amp
Q1—2N4401
Q2—2N4403
R1, R2—100,000-ohm, ½-watt resistor
R3, R4—10-ohm, ½-watt resistor

# 97 Mini-Modern Crystal Receiver

☐ A 741 mini-power-amplifier can update those 1N34 "cat's whiskers" crystal receivers right into the Space Age. Depending on antenna and ground facilities, good reception is possible with clear volume from the tiny speaker. A 9-volt transistor battery provides portable radio convenience for escaping the frustrations of the IC experimental test bench. *(Continued on page 98)*




**PARTS LIST FOR MINI-MODERN CRYSTAL SET**
C1—365-pF variable capacitor
C2—0.01-uF ceramic capacitor, 15 VDC
C3—0.1-uF ceramic capacitor, 15 VDC
C4, C5—100-uF electrolytic capacitor, 15 VDC
C6—50-100-uF electrolytic capacitor, 15 VDC
D1—1N34 diode
IC1—741 op amp
L1—loopstick coil
R1—25,000-ohm linear-taper potentiometer
R2—25K to 50,000-ohm audio taper potentiometer
R3—1,000,000-ohm, ½-watt resistor
R4, R5—4,700-ohm, ½-watt resistor
R6—10,000-ohm, ½-watt resistor
T1—500/8-ohm audio output transformer
MISC.—8-ohm 2 in. PM type speaker; snap type 9 V battery clip

# 25 Easy-to-Build Transistor Projects

ONE OF THE BEST WAYS to begin your mastery of electronic circuitry construction is to work with discrete components before diving headlong into integrated circuit construction. After all, integrated circuits are nothing more than these individual components and circuits in a more compact package. The only problem is that they don't come in see-through packages to help you identify the individual working areas.

A project such as the "Penny Pincher's Utility Amplifier," which requires 6 individual electronic components, could be purchased as a single integrated circuit, such as a GE IC-77, for less than the cost of the individual components. Not only that, but it would require only one-tenth the physical space of the discrete components setup.

We don't feel that it's of much value to simply "plug in" black boxes without the understanding of what actually goes on inside them. This then is the purpose of the 25 Transistor Projects section. If you can learn what the circuitry of an integrated circuit is supposed to do, then it frees you to come up with your *own* innovations, and to accurately troubleshoot your creations when you run into the inevitable bugs or "glitches."

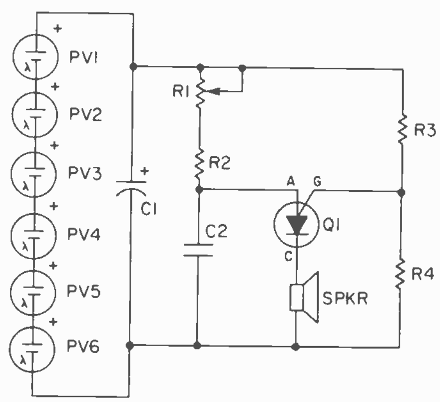
This brings up another point. While some ICs are relatively sensitive to miswiring and are easily destroyed, these discrete components, as a rule, are not. It's a lot better to make your mistakes here than on an integrated circuit project, where ruining an IC due to a reversed diode polarity might set you back two or three dollars. So have fun, but learn!

## 1 Solar-Powered Metronome

☐ You'll never miss a beat because of dead batteries with this metronome. As long as there is a little sunlight or lamplight to illuminate the silicon solar cells, the circuit will keep ticking away merrily. The six series-connected solar cells provide a supply potential of 3-volts for the PUT relaxation oscillator. Potentiometer R1 can be adjusted to yield the desired pulse rate. Should you wish to lower the output volume, a small resistor on the order of 10-ohms may be installed in series with the speaker.

**PARTS LIST FOR SOLAR-POWERED METRONOME**

**C1**—220-uF, 25-VDC electrolytic capacitor
**C2**—0.39-uF, 25-VDC mylar capacitor
**PV1 thru PV6**—0.5-VDC silicon solar cells (Radio Shack #276-120 or equiv.)
**Q1**—2N6027 programmable unijunction transistor
**R1**—2,000,000-ohm linear-taper potentiometer
**R2**—470,000-ohm, ½-watt resistor, 5%
**R3**—1,500,000-ohm, ½-watt resistor, 5%
**R4**—2,400,000-ohm, ½-watt resistor, 5%
**SPKR**—8-ohm PM miniature speaker




## 2 Hi-Temp Alarm

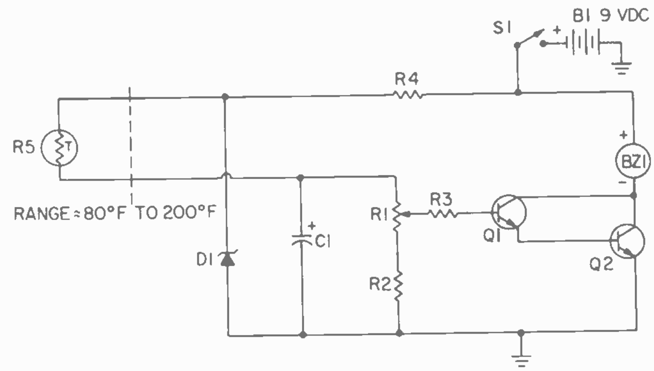
☐ Has a temperature-control problem got you hot under the collar? Well, this little temperature alarm/thermostat may be just the thing to cool you down. Temperature-sensing is done by thermistor RR5, a negative-temperature-coefficient device whose resistance varies between 10K-ohms at 77° F, and about 1000-ohms at 200° F. Potentiometer R1 sets the exact temperature at which the Q1-Q2 Darlington pair gets turned on by the thermistor's signal. Whenever ambient temperature rises above the alarm setting, the transistors conduct current through the buzzer, which then emits an attention-getting shriek.

Note that the thermistor must be

located away from the control circuitry—as indicated by the dashed line in the schematic—so that the operation of the control circuit is not adversely affected by temperature extremes. If a 6-volt, 500-ohm relay is substited for the buzzer, you get a thermostat capable of turning on a fan or turning off a small electric heater.

**PARTS LIST FOR HI-TEMP ALARM**

- **B1**—9-volt transistor battery
- **BZ1**—9-VDC buzzer (Radio Shack #273-052)
- **C1**—220-uF, 10-VDC electrolytic capacitor
- **D1**—1N752A, 5.6-volt, ½-watt zener diode
- **Q1, Q2**—2N3904 NPN transistor
- **R1**—2,000-ohm trimmer potentiometer
- **R2, R3**—1,000-ohm, ½-watt, 5% resistor
- **R4**—820-ohm, ½-watt, 5% resistor
- **R5**—thermistor rated 10,000-ohms @ 25°C (Fenwal part #RB41L1)
- **S1**—SPST toggle switch

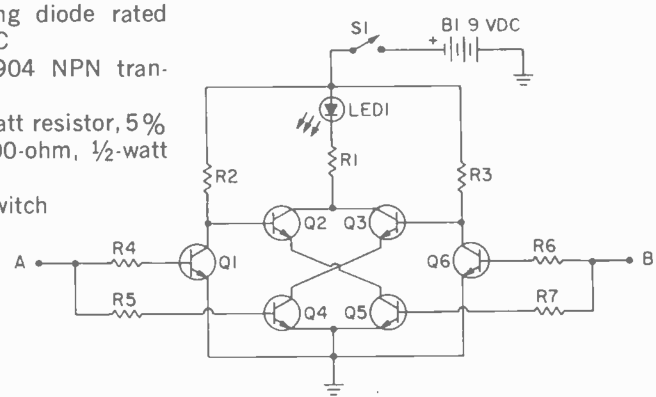



# 3 The Brain Teaser

☐ Ordinarily, we tell you how the circuit works, but this time the tables are turned. Your job is to figure how to make LED1 light by applying the correct combination (or combinations) of input signals to points A and B. Signals must be either +9-VDC or 0-VDC (gnd). Check your answer by breadboarding the circuit; then, present this quiz to a friend. (HINT: You must consider *four* possible combinations.)

**PARTS LIST FOR THE BRAIN TEASER**

- **B1**—9-volt transistor battery
- **LED1**—light emitting diode rated 20mA @ 1.7-VDC
- **Q1 thru Q6**—2N3904 NPN transistor
- **R1**—330-ohm, ½-watt resistor, 5%
- **R2 thru R7**—22,000-ohm, ½-watt resistor, 5%
- **S1**—SPST toggle switch

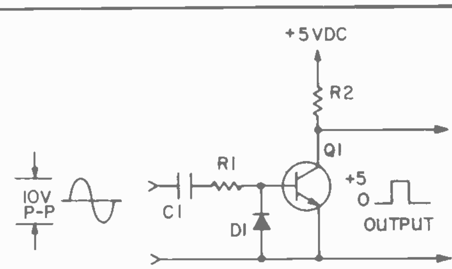



# 4 Square Wave Converter

☐ Got a yen to go digital but few bucks to spend? Well, if you happen to have an old audio signal generator at hand, you can convert its sinewave output to a squarewave and save yourself the expense of a squarewave generator. The converter consists of an ordinary saturating transistor switch which, when driven by a large amplitude (about 10-VDC peak-to-peak or greater) sinewave, yields squarewaves with reasonably fast rise and fall times. Be certain to use as large an input amplitude as possible. Certain edge-triggered ICs, TTL flip-flops in particular, may fail to clock on a waveform whose rise and fall times are too long; however, the majority of ICs will clock readily when driven by this converter.

**PARTS LIST FOR SINE-TO-SQUARE WAVE CONVERTER**

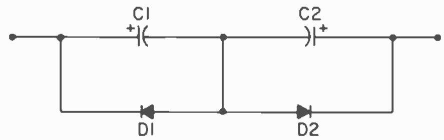
- **C1**—1.0-uF, 25-VDC non-polarized mylar capacitor
- **Q1**—2N3904 NPN transistor
- **R1**—4,700-ohm, ½-watt resistor, 5%
- **R2**—1,000-ohm, ½-watt resistor, 5%



# 5 Home Made NPO Capacitor

☐ From time to time, all of us encounter circuits that require large, *non-polarized* capacitors. Unfortunately, these are scarcer than the proverbial hen's teeth. Looking through some catalogs, you'll soon discover that capacitors larger than 10-$\mu$f are usually electrolytics, which are polarized devices. Electrolytic capacitors cannot be used in AC circuits, where the voltage undergoes periodic reversals in polarity. Such reversals destroy the insulating layer between the plates of an electrolytic capacitor, and the device soon fails.

So what can be done when you need a non-polarized capacitor for a hi-fi crossover or a motor-starting circuit, and all that you can find are electrolytics? One alternative is to get some aluminum foil and roll your own, but there's an easier way. Just hook two electrolytics back-to-back as we've diagrammed here, then add two current-steering diodes. These diodes ensure that each capacitor sees only voltage of the correct polarity. C1 and C2 should be identical, and each one should have a capacitance equal to the value needed for proper circuit operation. Make sure that the capacitors have working voltages equal to about three times the RMS value of the AC voltage in the circuit. Also, choose diodes having a PIV rating greater than or equal to the capacitor's rating.




**PARTS LIST FOR HOME MADE NPO CAPACITOR**

**C1, C2**—identical electrolytic capacitors
**D1, D2**—identical silicon rectifiers

**Note:** Be sure to match voltage ratings of rectifiers and capacitors.

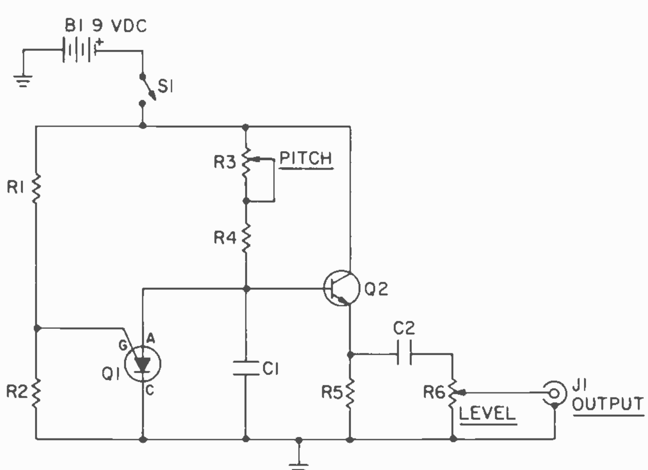
# 6 Moose Call

☐ If "Hey, Bullwinkle" is your idea of a moose call, you're in for a surprise. The little circuit diagrammed here produces deep, resonant grunts and bellows when used in conjunction with a PA or stereo amp. Q1, a programmable unijunction transistor (PUT) functions as a relaxation oscillator. The sawtooth voltage produced across capacitor C1 is buffered by Q2 and fed through level control R6 to the output jack. The signal at J1 has a peak-to-peak amplitude of about 1.5-volts, which can be fed into the TUNER or AUX inputs of your amp.

To use the device, manipulate pitch control R3 and level control R6 in unison. During the sound's attack period, rotate R3 to boost the pitch as the level increases. During decay, let the pitch drop. The circuit is also capable of realistic imitations of horns of all kinds; just remember that a horn's attack is usually much more abrupt than its decay. Finally, apartment dwellers should note that this circuit attracts police as well as moose.

**PARTS LIST FOR MOOSE CALL**

**B1**—9-volt transistor battery
**C1**—0.39-uF, 25-VDC mylar capacitor
**C2**—1.0-uF, 25-VDC non-polarized mylar capacitor
**J1**—RCA-type phono jack
**Q1**—2N6027 programmable unijunction transistor
**Q2**—2N3904 NPN transistor
**Note:** All resistors rated ½-watt, 10% tolerance unless noted otherwise.
**R1**—3,000-ohms
**R2**—1,200-ohms
**R3**-100,000-ohm linear-taper potentiometer
**R4**—33,000-ohms
**R5**—10,000-ohms
**R6**—10,000-ohm linear-taper potentiometer
**S1**—SPST toggle switch

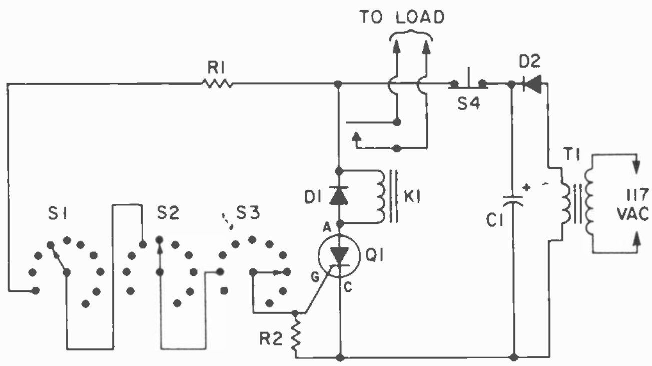


# 7 Three-Dial Combination Lock

☐ Here's an effective little combination lock that you can put together in one evening's time. To open the lock, simply dial in the correct combination on the three rotary or thumbwheel switches. With the correct combination entered, curent flows through R1 into Q1's gate terminal, causing the SCR to latch in a conductive state. This sends a current through relay K1, which responds by closing its contacts and actuating whatever load is attached. After opening the lock, twirl the dials of S1 through S3 away from the correct combination so that nobody gets a look at it. The lock will remain open and your load will remain on because the SCR is latched on. To lock things up, it's only necessary to interrupt the flow of anode current through the SCR by pressing pushbutton S4.

**PARTS LIST FOR THREE-DIAL COMBINATION LOCK**

**C1**—500-uF, 25-VDC electrolytic capacitor
**D1, D2**—1N4002 diode
**K1**—relay with 6-volt coil rated @ 250-ohms, with SPST contacts
**Q1**—2N5050 SCR
**R1, R2**—4,700-ohm, ½-watt resistor, 5%
**S1, S2, S3**—single pole, 10-position rotary or thumbwheel switches
**S4**—normally closed SPST pushbutton switch
**T1**—120-VAC to 6.3-VAC @ 300mA power transformer

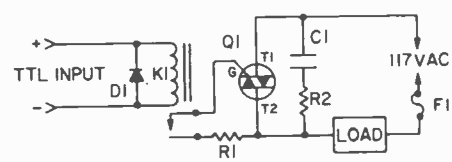



# 8 Microcomputer/AC Interface

☐ Here's one of the simplest and best ways to harness your microcomputer for the purpose of appliance control. Let an output line drive relay K1, a small, 5-volt device designed expressly for TTL. The relay's contacts supply gate drive to Triac Q1 which, in turn, does the hard job of controlling the relatively large load current. Besides controlling the Triac, relay K1 also isolates the logic circuitry from the AC line. C1 and R2 prevent false turn on of the Triac with inductive loads, and F1 protects the Triac should the load short out. Of course, this circuit can be used to interface any type of logic circuit—not just a microcomputer—to the AC line.

**PARTS LIST FOR MICROCOMPUTER/AC INTERFACE**

**C1**—0.1-uF, 50-VDC ceramic capacitor
**D1**—1N4002 diode
**F1**—3AG 10-amp fuse (fast-acting type only)
**K1**—relay with coil rated 5-VDC @ 50-ohms, with SPST contacts (use ½ of Radio Shack part #275-215). **Note:** For very high speed switching applications, use a reed relay with similar specifications.




**Q1**—Triac rated 200-volts @ 10-Amps (Motorola part #MAC11-4, Sylvania part #ECG5624)
**R1**—1,000-ohm, 1-watt, 5% resistor
**R2**—10-ohm, 1-watt, 5% resistor

# 9 General Purpose Pulser

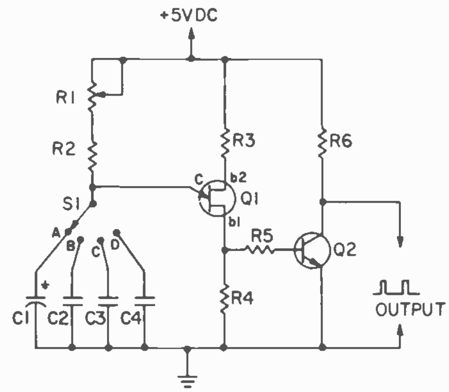
☐ Here is a simple pulse generator that can be useful in a variety of applications, from audio to logic. The heart of the circuit is the familiar UJT (unijunction transistor) relaxation oscillator, Q1. Potentiometer R1 adjusts the repetition rate over a range of one decade, while range switch S1 allows selection of one of four decade ranges. The total range of adjustment goes from 0.5 ppS (pulses per second) to 5000 ppS, which is more than enough for most purposes. Voltage spikes across resistor R4 are amplified and "squared up" by transistor Q2. The output consists of 5-volt-high pulses that may be used to drive TTL, CMOS (if a 5-volt supply is used) or an audio circuit (in which case, you can couple the pulses through a 1.0-μF capacitor).

Range "A" is slow enough to be useful when breadboarding logic circuitry, since slow clocking allows you to observe circuit operation easily. If you attach a wire lead to the output and set S1 to range "D", you can generate harmonics up to several MHz.

**PARTS LIST FOR GENERAL PURPOSE PULSER**

**C1**—15-uF, 10-VDC tantalum capacitor
**C2**—1.5-uF, 25-VDC non-polarized mylar capacitor
**C3**—0.15-uF, 25-VDC mylar capacitor
**C4**—0.015-uF, 25-VDC mylar capacitor
**Q1**—2N2646 unijunction transistor
**Q2**—2N3904 NPN transistor
**Note:** All resistors rated ½-watt, 5% tolerance unless otherwise noted.
**R1**—25,000-ohm linear-taper potentiometer
**R2**—2,700-ohms
**R3**—470-ohms
**R4**—47-ohms
**R5**—100-ohms
**R6**—1,000-ohms
**S1**—single pole, 4-position rotary switch

| RANGE | FREQUENCY |
|---|---|
| A | 0.5 to 5 Hz |
| B | 5 to 50 Hz |
| C | 50 to 500 Hz |
| D | 500 to 5,000 Hz |



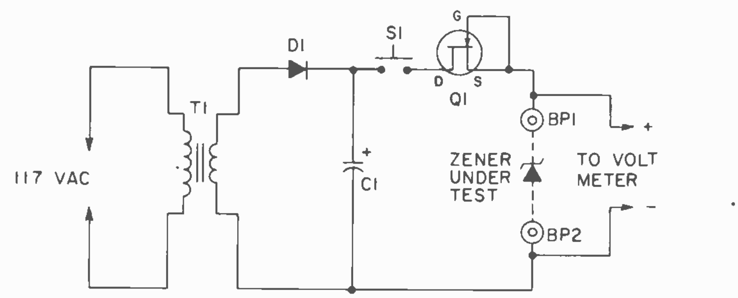

# 10 Zener Diode Tester

☐ If you're at all familiar with the surplus market, you know that zener diodes presently abound in surplus—at tremendous discounts, too. The problem with buying surplus, however, is that many diodes are unmarked or incorrectly marked. Consequently, these must be tested to verify their working voltages. Another problem crops up when you buy so-called "grab bags" of components. The zeners you find may be legibly marked, but unless you happen to have a data sheet for those particular diodes, they will require testing to identify the zener voltages. You can do your testing quickly and easily with the circuit presented here.

T1, D1 and C1 comprise a simple half-wave rectifier system. Pressing S1 sends a DC current through current limiter Q1 and the diode under test. Q1 regulates the current to a value of about 10 mA regardless of the zener voltage. You can use your VOM or voltmeter to monitor the voltage drop across the zener; values as high as 25-volts can be reliably tested in this circuit. If you get a very low reading, say 0.8-volts, you have the diode in reverse. Interchange the zener's connections.

**PARTS LIST FOR ZENER DIODE TESTER**

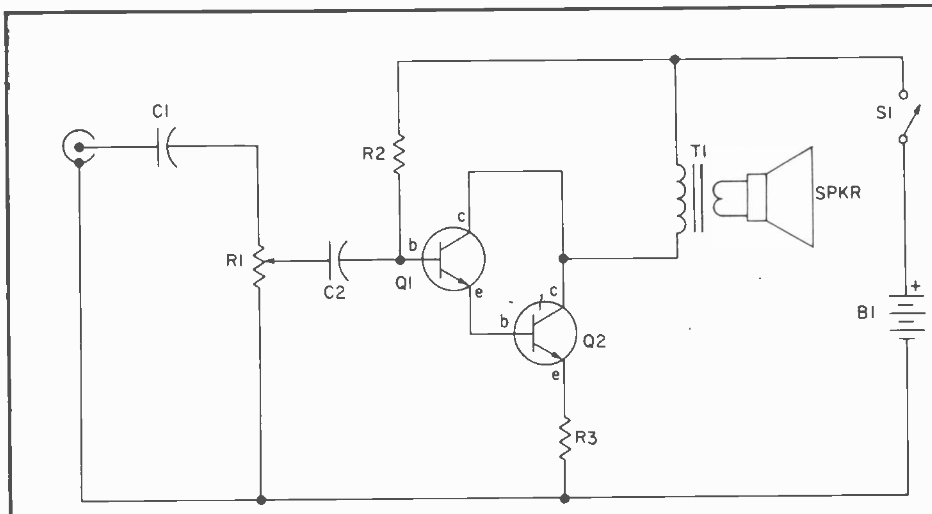
**BP1, BP2**—binding posts
**C1**—500-uF, 50-VDC electrolytic capacitor
**D1**—1N4002 diode
**Q1**—2N5363 n-channel JFET (junction field effect transistor)
**S1**—normally open SPST push-button switch
**T1**—120-VAC to 24-VAC @ 300-mA power transformer




# 11 Penny Pinchers Utility Amplifier

☐ Here's high gain with just a handful of parts for a zillion audio applications. Q1 and Q2 are Darlington connected to deliver a lot of gain and make this a really hot circuit. Transformer T1 reduces the loading on the transistors to help assure a strong, clean output. This amplifier has many test bench applications, from signal tracing to loudness boosting to checking out new sound effects.

Add it to an inexpensive record or tape player for a quick and easy checkout. Or tie a high output crystal mike to the input and use it as an electronic stethoscope.




**PARTS LIST FOR PENNY PINCHER'S UTILITY AMPLIFIER**

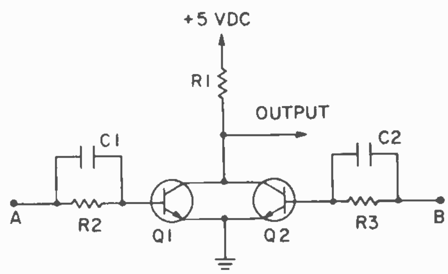
**B1**—9VDC battery
**C1, C2**—.1-uF capacitor
**Q1**—PNP transistor, 2N3904 or equiv.
**Q2**—PNP transistor, 2N2222 or equiv.
**R1** — 1-Megohm potentiometer, audio taper
**R2**—1.8-Megohm resistor, ½-watt
**S1**—SPST switch
**SPKR**—8-ohm speaker
**T1**—500:8-ohm transformer
**J1**—RCA phono jack (or any two-conductor jack)
**R3**—2,700-ohm, ½-watt resistor

# 12 Basic NOR Gate

☐ Integrated logic is certainly a wonderful thing, but we often lose sight of how logical operations are performed when dealing with integrated devices. The circuit diagrammed here is a throwback to pre-IC days when all logic was implemented with discrete devices (resistors, transistors and diodes for the most part). This NOR gate is typical of the circuitry used. Whenever base drive is applied to either input A or input B, the output drops to a low potential. If desired, extra inputs could be added simply by adding more transistors and tying their collector terminals to R1. In high-speed applications, capacitors C1 and C2 could be added to speed up switching of the transistors, but for clock rates of less than 1 MHz or so, you can forget about the capacitors. Generally, if speed-up capacitors were to be used, their values would have to be determined experimentally with a 'scope.

**PARTS LIST FOR BASIC NOR GATE**

**C1, C2**—optional (see text)
**Q1, Q2**—2N3904 NPN transistor
**R1**—1,000-ohm, ½-watt resistor, 5%
**R2, R3**—10,000-ohm, ½-watt resistor, 5%




Is this circuitry just a museum piece? Definitely not. Try it the next time you need something strange like a 6-input NOR or when there are no ICs at hand. With the values shown, this NOR gate interfaces directly with TTL circuitry.

# 13 Constant Current Ohms Adapter

☐ Ever notice how confusing it is to read the OHMS scales on your multimeter? The numbers are so crowded together at the high end that meaningful readings are almost impossible to make. Top-of-the-line meters get around the problem by employing a constant-current source, and so can you with this adapter. You'll be able to read resistances accurately and unambiguously on the *linear* voltage scales of your meter.

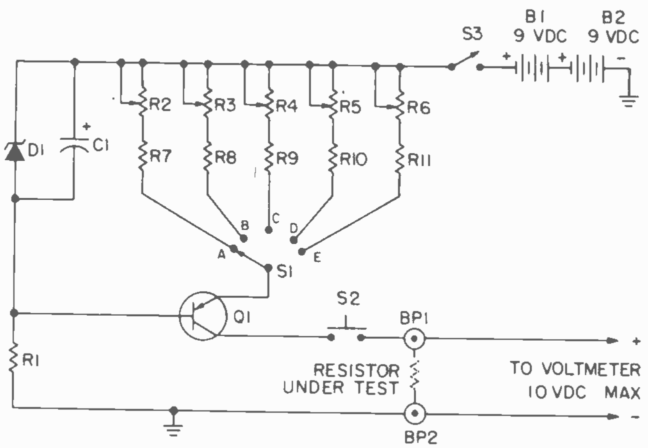
In the schematic, note that the resistor under test is tied between BP1 and BP2. Whenever S2 is pressed, a regulated current flows out of Q1's collector and through the resistor. By Ohm's Law, this current generates a voltage across the resistor that's directly proportional to its resistance. Any one of five test currents—from 10-mA to 0.001-mA—can be selected via S1.

To calibrate the test currents, hitch a multimeter to the adapter's output terminals; make sure the meter is set to measure current. Press S2 and adjust the trimmers one at a time to obtain the five required currents. No resistor should be connected to BP1 and BP2 during calibration.

When measuring resistance, use the following conversion formula:

$$\text{RESISTANCE (kilOhms)} = \frac{\text{VOLTAGE}}{\text{CURRENT (mA)}}$$

For example, a resistor that produces a 7.56-volt reading when fed a current of 0.01-mA must have a resistance of 756-kilOhms (756K). Use smaller currents with larger resistances, and don't exceed a level of 10-volts during testing. If you do, switch S1 to the next smaller current. Finally, for best accuracy, make sure that the input resistance of your meter is much greater than that of the resistor under test. With a 10-megOhm meter, the resistor under test should be no larger than 1-megOhm to keep errors under 10%.




**PARTS LIST FOR CONSTANT CURRENT OHMS ADAPTER**

**B1, B2**—9-volt transistor battery
**BP1, BP2**—binding posts
**C1**—10-uF, 20-VDC tantalum capacitor
**D1**—1N748A, 3.9-volt, ½-watt zener diode
**Q1**—2N3676 PNP transistor
**Note:** All resistors rated ½-watt, 5% tolerance unless otherwise noted.
**R1**—2,200-ohms
**R2**—100-ohm trimmer potentiometer
**R3**—1,000-ohm trimmer potentiometer
**R4**—10,000-ohm trimmer potentiometer
**R5**—100,000-ohm trimmer potentiometer
**R6**—1,000,000-ohm trimmer potentiometer
**R7**—270-ohms
**R8**—2,700-ohms
**R9**—27,000-ohms
**R10**—270,000-ohms
**R11**—2,700,000-ohms
**S1**—single pole, 5-position rotary switch
**S2**—normally open SPST pushbutton switch
**S3**—SPST toggle switch

| RANGE | CURRENT |
|---|---|
| A | 10 mA |
| B | 1 mA |
| C | 0.1 mA |
| D | 0.01 mA |
| E | 0.001 mA |

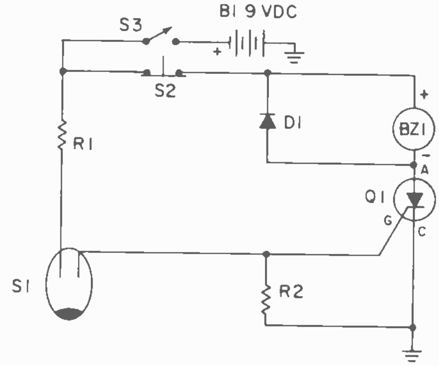
# 14 Equipment Theft Alarm

☐ As an electronics hobbyist, you very likely own one or more pieces of expensive equipment, and these can be very tempting targets for thieves or vandals. To protect your investment, why not install the simple alarm pictured here in some of your more valuable possessions? Things like Amateur or CB transceivers, computers, oscilloscopes and stereo equipment are all excellent candidates.

In the schematic, mercury switch S1 is normally open. However, should the equipment in which the alarm has been installed be picked up and tilted, S1 closes and thereby supplies gate current to the SCR. Q1 then latches in a conducting state, causing current to flow through buzzer BZ1. The buzzer will sound until pushbutton S2 is pushed to reset the circuit. For best results, use an electromechanical, rather than piezoelectronic buzzer, since it will emit more noise.

**PARTS LIST FOR EQUIPMENT THEFT ALARM**

**B1**—6, 9, or 12-volt battery
**BZ1**—6, 9, or 12-volt buzzer
**D1**—1N4002 diode
**Q1**—2N5060 SCR
**R1, R2**—4,700-ohm, ½-watt resistor
**S1**—normally open SPST mercury switch
**S2**—normally closed pushbutton switch
**S3**—SPST toggle switch

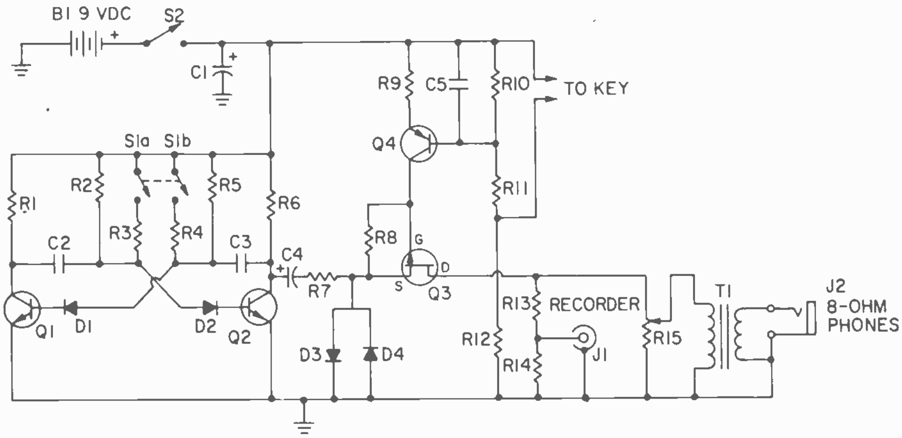



# 15 Shaped Output Code Oscillator

☐ Most code-practice oscillators are keyed by switching the oscillator transistor's supply voltage on and off or by driving the transistor into and out of saturation. This has the advantage of being simple, and it provides tolerable results if a speaker is to be driven. However, the sound of a CPO is like Chinese water torture to the uninitiated, so public opinion usually dictates that you practice with headphones. What you hear then is the "kerchunk" that occurs each time the key is opened or closed. If you want a nice, pure tone signal devoid of "kerchunks," you have to shape the rise and decay of the tone. Here's a circuit that does just that.

The basic tone is generated by a multivibrator (Q1 & Q2) at a pitch determined by S1; low pitch with S1 open, high with S1 closed. This tone is fed through C4 to a clipper (D1, D2) and FET Q3, which functions as a signal attenuator. How much of a signal passes through the FET is determined by its gate potential, controlled by current source Q4 together with capacitor C5, the associated resistors, and your key. With the key down, the signal from Q3's drain is available for recording (J1) and for headphone listening (J2). R15 controls the volume.

Smaller values of C5 will yield a more abrupt attack and decay, while larger values can be used to produce mellower results. If you cannot find a 2N3994 FET for Q3, substitute a 2N5461. The great majority of these will work fine, but if you still hear a tone with the key up, try a different 2N5461.




**PARTS LIST FOR CODE OSCILLATOR**

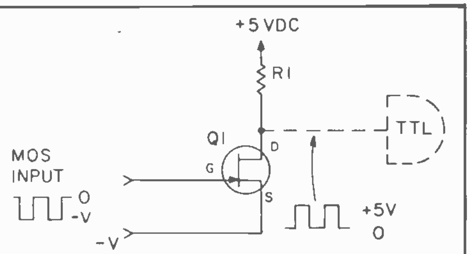
**B1**—9-volt transistor battery
**C1**—220-uF, 25-VDC electrolytic
**C2, C3**—0.22-uF, 25-VDC mylar capacitor
**C4**—2.2-uF, 10-VDC tantalum capacitor
**C5**—0.22-uF, 25-VDC mylar capacitor
**D1, D2, D3, D4**—1N914 diode
**J1**—RCA-type phono jack
**J2**—standard 2-conductor phone jack
**Q1, Q2, Q4**—2N3904 NPN transistor
**Q3**—2N3994 or 2N5461 p-channel JFET (junction field-effect transistor)
**Note:** All resistors rated ½-watt, 5% tolerance unless otherwise noted.
**R1, R6**—1,000-ohms
**R2, R3, R4, R5, R8, R10**—56,000-ohms
**R7**—4.700-ohms
**R9**—22,000-ohms
**R11**—33,000-ohms
**R12**—82,000-ohms
**R13**—51,000-ohms
**R14**—22-ohms
**R15**—1,000-ohm audio-taper potentiometer
**S1**—DPST slide switch
**S2**—SPST toggle switch
**T1**—1,000-ohm to 8-ohm audio transformer

# 16 MOS-to-TTL Logic Interface

☐ Here is a problem encountered from time to time by the advanced computer hobbyist: How do you mate the signals from MOS logic (the foundation of many microprocessor and peripheral ICs) to TTL logic (the most convenient and readily available logic form from which to construct add-on circuitry)? The problem stems from the fact that MOS signals swing between ground and some negative voltage (−V in the diagram), while signals for TTL should swing from ground to something greater than +2.8-VDC (+3.5-VDC usually). One of the easiest solutions requires just one resistor and one n-channel field effect transistor. Note that Q1's source (S) lead goes to the negative supply potential of the MOS circuitry, and its gate (G) gets driven by the MOS input signal. TTL loads can be driven directly by the output signal available at Q1's drain (D). Finally, note that R1 is tied to the +5-VDC TTL supply and that the level-shifted output signals have been inverted: negative-going input pulses swing positive at the output, and vice versa. The circuit works well at data transmission rates less than 1 or 2 MHz. To interface faster clock signals or very abrupt pulses, use one of the commercially available level-shifter ICs.

**PARTS LIST FOR MOS-TO-TTL LOGIC INTERFACE**

**Q1**—2N3971 n-channel JFET (junction field effect transistor)
**R1**—2,200-ohm, ½-watt resistor, 5%



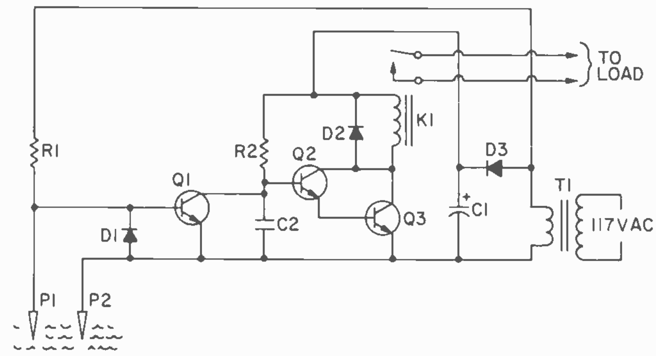

# 17 Fluid Detector

☐ For those of you anticipating the melting of the polar ice caps, we present a handy device to warn you of the deluge. Many other useful, though less dramatic, applications should be obvious as well. Basically, this a circuit capable of detecting the presence of any ionic fluid, that is, any fluid that can conduct an electrical current. Ultra-pure water will not be detected because so few ions exist that scarcely any current can flow. However, the water that seeps into your cellar, the water that overflows from your washing machine and most aqueous solutions are all readily detectable.

With no fluid between the probes, AC current flows through R1 into Q1's base, turning the transistor on at a 60 Hz rate. C2 filters the signal at Q1's collector to a low DC potential. Should the probes be immersed, base current is shunted away from Q1 by the fluid's resistance. Consequently, Q1's collector potential rises, thereby turning on the Q2-Q3 Darlington pair. This causes K1 to pull in and turn on a pump or whatever load you attach. Because only a small AC voltage exists between the probes, no troublesome plating occurs

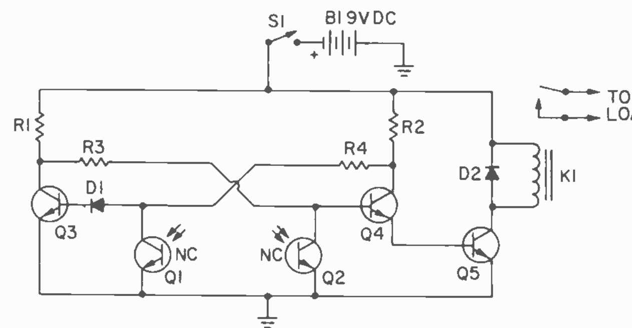
**PARTS LIST FOR FLUID DETECTOR**

**C1**—500-uF, 25-VDC electrolytic capacitor
**C2**—0.5-uF, 25-VDC mylar capacitor
**D1, D2, D3**—1N4002 diode
**K1**—relay with coil rated 6-VDC @ 250 to 500-ohms, with SPST contacts
**P1, P2**—stainless steel or aluminum probes
**Q1, Q2, Q3**—2N3904 NPN transistor
**R1**—300,000-ohm, ½-watt, 5% resistor
**R2**—470,000-ohm, ½-watt, 5% resistor
**T1**—120-VAC to 6.3-VAC @ 300-mA power transformer




# 18 The Light Latch

☐ Looking for a novel way to control electrical apparatus or appliances? Here's a bright idea: Why not use a beam of light? This little light latch can be readily actuated by a flashlight beam and is capable of controlling as much current as your relay's contacts will allow (1 to 3-Amps, typically). When phototransistor Q1 is momentarily illuminated, relay K1 is latched in its closed position and your appliance is ON. To turn your load OFF, shine a beam of light briefly on Q2's light-sensitive face. Feedback between Q3 and Q4 via R3 and R4 is responsible for the latching action. Be sure to mount phototransistors Q1 and Q2 so that room light does not fall on them. Recessing the phototransistors within small-diameter pieces of tubing is a good way to exclude extraneous light.




**PARTS LIST FOR LIGHT LATCH**

**B1**—6 or 9-volt battery
**D1, D2**—1N914 diode
**K1**—relay with 6-volt coil rated @ 500-ohms, with SPST contacts
**Q1, Q2**—FPT-100 phototransistor
**Q3, Q4, Q5**—2N3904 NPN transistor
**R1, R2**—10,000-ohm, ½-watt resistor, 5%
**R3, R4**—100,000-ohm, ½-watt resistor, 5%
**S1**—SPST toggle switch

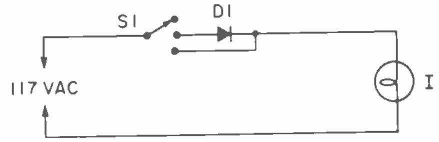
# 19 Photoflood Dimmer #1

☐ If you dabble in photography, you know that in addition to natural light, there are two other light sources available: flash or photoflood. Flash units are very popular because of their speed, which allows action to be captured, and their portability. However, it's extremely difficult to visualize a shot with flash because the light appears only at the instant of exposure. High-intensity photofloods, on the other hand, are on continuously; therefore, the photographer can readily compose a shot, paying attention to details such as evenness of illumination across the field and shadow placement.

As the photofloods burn, however, they generate a great deal of heat, which can be discomforting both to the photographer and the subject. In addition, it's wasteful of the photoflood lamp's already limited lifetime (about 8 hours for an EBV No. 2) to have it on any longer than absolutely necessary. You can use this simple dimmer to cut down the lamp's intensity during composition, thereby reducing the heat generated and extending the lamp's useful life. With S1 in its middle position, power to the lamp is cut in half because of rectifier D1. When you're ready to expose, flip S1 to full power. NOTE: On half-power, the lamp's color balance is shifted toward the red, so be careful not to make exposures at half-power with color film.

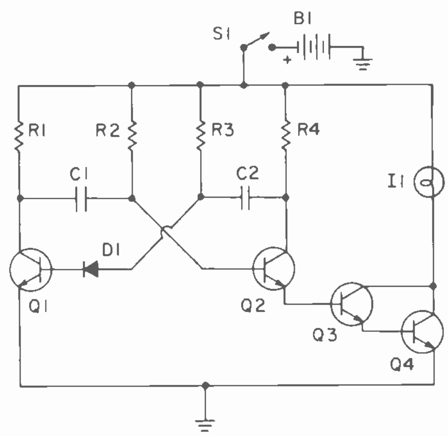
**PARTS LIST FOR PHOTOFLOOD DIMMER**

**D1**—1N5404 rectifier rated 400 PIV @ 3-amps
**I1**—EBV No. 2 500-watt photoflood lamp
**S1**—single pole, 3-position switch with contacts rated 10-Amps @ 120 VAC




# 20 Portable Emergency Flasher

☐ For camping or highway emergencies, here is a solid-state light flasher that's compact and reliable. Q1, Q2 and the associated resistors and capacitors comprise a conventional 2-transistor multivibrator. Q2's emitter signal drives the Q3-Q4 Darlington pair, which turns on high-current lamp I1. The light flashes on for about 0.4-second, then darkens for about the same period of time before turning on again. Power for the circuit comes from a standard 6-volt lantern battery. You could probably build the entire flasher circuit inside the housing of your lantern, and actuate it only when necessary. If longer battery life is desired, and decreased illumination is acceptable, you could substitute a less power-hungry 6-volt lamp for I1.




**PARTS LIST FOR PORTABLE EMERGENCY FLASHER**

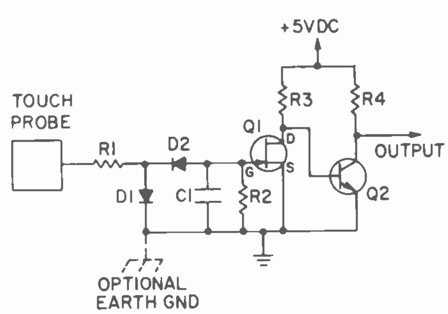
**B1**—6-volt lantern (heavy-duty) battery
**C1, C2**—1.0-uF, 25-VDC non-polarized mylar capacitor
**D1**—1N4002 diode
**I1**—#82 lamp rated 6.5-VDC @ 1-amp
**Q1, Q2, Q3**—2N3904 NPN transistor
**Q4**—2N3724A NPN transistor
**R1, R4**—10,000-ohm, ½-watt resistor, 5%
**R2, R3**—390,000-ohm, ½-watt resistor, 5%
**S1**—SPST toggle switch

# 21 Simple Touch Switch

☐ Looking for a way to add a touch of class to your digital projects? Try this touch switch. Not only does it add a note of distinction to a project, but it's bounce-free as well. Whenever a finger touches the contact plate, stray 60 Hz powerline interference is coupled into the circuit due to the antenna effect of your body. The 60 Hz pickup is rectified and filtered to provide a negative bias on Q1's gate, thus causing Q1 to turn off and Q2 to turn on. As a result, Q2's collector drops to ground potential. When the touch plate is released, the potential at Q2's collector terminal once again jumps high. You can use the output to drive either

**PARTS LIST FOR SIMPLE TOUCH SWITCH**

**C1**—0.1-uF, 50-VDC ceramic capacitor
**D1, D2**—1N914 diode
**Q1**—2N5953 n-channel JFET (junction field effect transistor)
**Q2**—2N3904 NPN transistor
**Note:** All resistors rated ½-watt, 5% tolerance unless otherwise noted.
**R1**—100,000-ohms
**R2**—22,000,000-ohms
**R3**—27,000-ohms
**R4**—1,000-ohms




**TP**—copper or aluminum touch plate

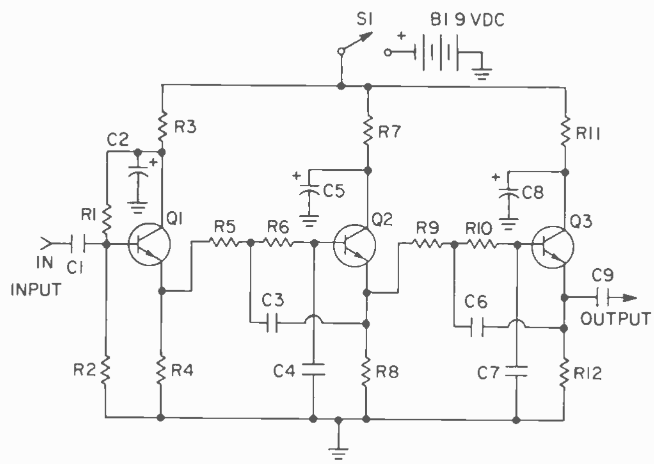
CMOS or TTL with ease.

Note that if you do your experimenting in a place devoid of 60 Hz powerline radiation—in the middle of a field of wheat, for example—the circuit will not work. The average home is full of 60 Hz radiation, however, so the switch should function well. If you have some difficulty, connect your system's electrical ground to an earth ground (the screw on your AC outlet's cover plate). This will boost the signal pickup.

# 22 Low Pass Audio Filter

☐ If you own an old inexpensive receiver, chances are it could use a little extra selectivity. In that case, you should consider adding a filter. You could add an IF filter, but it's probably easier, and certainly less expensive, to tack on the simple low-pass audio filter diagrammed here. With the constants shown, it has a corner frequency of 1000 Hz—perfect for CW (code) reception. For voice, reduce the values of R5, R6, R9 and R10 to 1200-ohms. The filter's voltage gain is unity (1) so it won't upset things no matter where you insert it. Input impedance is about 30K-ohms—high enough to cause negligible loading.

To install the filter, break into the receiver's audio chain at some convenient point—preferably at a point where the audio voltage is small, say, 1-volt peak-to-peak or less. You may wish to include a bypass switch, too. This will allow you to shunt the signal around the filter and restore the original performance of the receiver.




**PARTS LIST FOR LOW PASS AUDIO FILTER**

- **B1**—6 to 12-volt battery
- **C1, C3, C6**—0.1-uF, 25-VDC mylar capacitor
- **C2, C5, C8**—22-uF, 20-VDC tantalum capacitor
- **C4, C7**—0.02-uF, 25-VDC mylar capacitor
- **C9**—1.0-uF, 25-VDC non-polarized mylar capacitor
- **Q1, Q2, Q3**—2N3391 NPN transistor

**Note:** All resistors rated ½-watt, 5% tolerance unless otherwise noted.

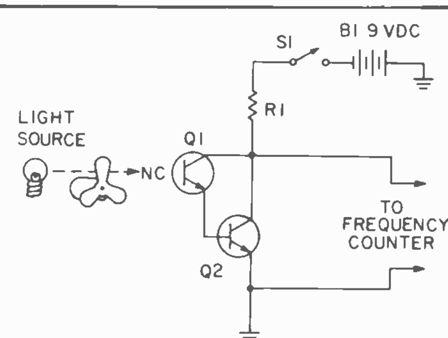
- **R1**—56,000-ohms
- **R2**—100,000-ohms
- **R3, R7, R11**—100-ohms
- **R4, R8, R12**—1,800-ohms
- **R5, R6, R9, R10**—3,000-ohms
- **S1**—SPST toggle switch

# 23 Phototachometer Adapter

☐ If you own a frequency counter, you can use this nifty little circuit to measure the rate of rotation of motors, fans and anything else that revolves and can break a beam of light. In the accompanying schematic, you can see that light from the bulb is chopped by the rotating fan blades. This chopped light beam then falls on the light-sensitive face of phototransistor Q1. Transistor Q2 amplifies the photo-current from Q1's emitter to yield a rectangular waveform approximately 9-volt in amplitude at the output. Naturally, the frequency of the output is related to the fan's speed of rotation.

**PARTS LIST FOR PHOTOTACHOMETER ADAPTER**

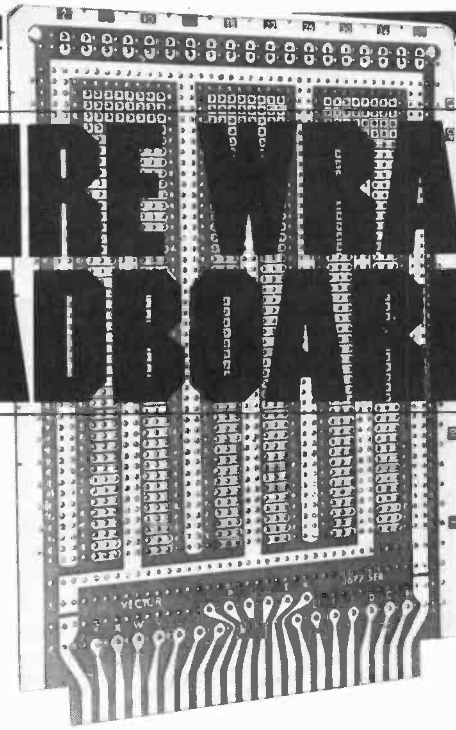
- **B1**—9-volt transistor battery
- **Q1**—FPT-100 phototransistor (or equiv.)
- **Q2**—2N3904 NPN transistor
- **R1**—10,000-ohm, ½-watt resistor, 5%
- **S1**—SPST toggle switch




$$\text{RPM} = \frac{\text{Freq. (Hz)} \times 60}{\text{\# of beam interruptions per second}}$$

Suppose we obtain a frequncy reading of 100 Hz with the 3-bladed fan illustrated here. Obviously, there are 3 interruptions per revolution. The actual speed is therefore 2000 RPM. For best results, mount Q1 in a small, hollow tube (an old pen barrel, for example) with its light-sensitive face recessed with respect to one end. This will ensure that only the chopped beam strikes the phototransistor.

*(Continued on page 98)*



# WIRE WRAP BREADBOARDING

A survey of this method and its special tools

**F**OR THE LAST FEW YEARS, there have been two major methods of circuit board construction dominating the hobbyist field: etched printed circuit boards, and solderless breadboards. Both have their respective advantages and disadvantages. The printed circuit offers compactness and ease of actual assembly of components onto the board. However, the initial startup cost for the hobbyist can be expensive, when the cost of materials necessary for the production of a printed circuit board is added up. Additionally, there is the time involved in the design of a printed circuit, where component shapes and sizes often dictate departures from simply transferring the flow of the schematic onto the board.

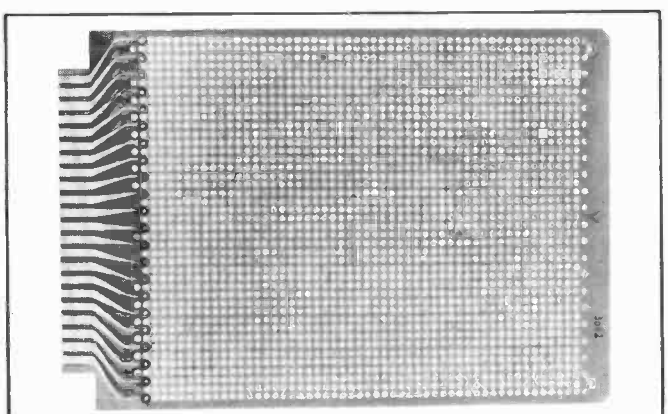
However, the finished product is rugged and, if designed with care, usually compact in size.

***To Solder or Not.*** Solderless breadboards, on the other hand, offer the hobbyist the opportunity to literally transfer a schematic on paper to a physical working circuit by utilizing point-to-point construction. Spring-loaded terminals allow the insertion of component leads without trimming, thereby extending their value in that they remain completely reuseable in other circuits at a later time. However, the drawback with solderless breadboards is that they lack permanency in the sense that components can become dislodged from their terminals due to careless handling and through exposure to the elements, if not used in a controlled environmental setting (meaning that you'll require a heavy degree of weather-proofing if the circuit is to be used anywhere outside the home).

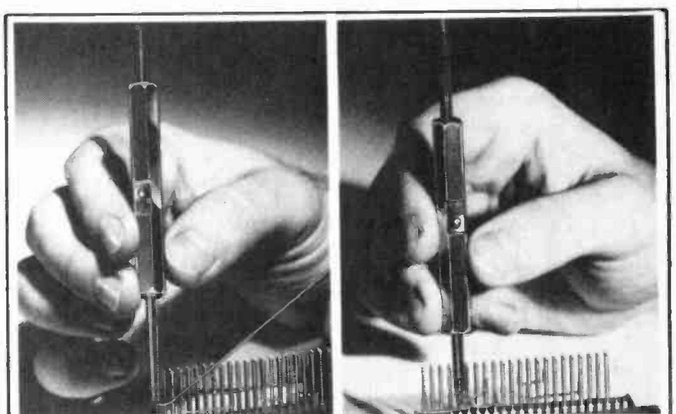
***The Best of Both.*** This brings us to the relative newcomer in the hobbyist construction field, the wire-wrapped breadboard. We use the term "relative newcomer," because in fact wire-wrapping as a method of connecting components together on a circuit board has been around for close to twenty years, but was mainly used only in industrial applications before printed circuitry came into widespread acceptance, bringing with it miniaturized components. Many of you will recall the advertisements of the Zenith Television Corporation in the early 1960's, extolling the virtues of their completely hand-wired television receivers. If you still have one about the house, a quick gander at the chassis will reveal the presence of wire-wrapped connections, running from point to point between tube sockets and tie points for such components as capacitors and larger resistors. And those sets really did last.

Through the good offices of the OK Machine and Tool Company, and Vector Electronics, we've illustrated a fair cross section of the tools and accessories necessary and available to the hobbyist for wire-wrap construction.

***Made for You.*** Perhaps the primary reason for the emergence of wire wrapping on the hobbyist level has been the increase in complexity of the pro-



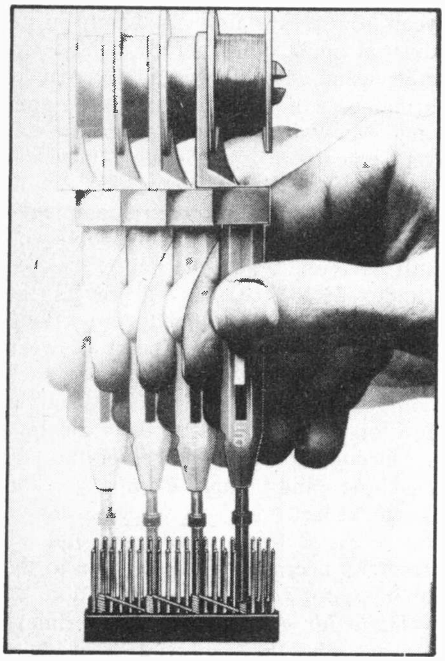
**An excellent example of a "basic" matrix board is this model 3662 Plugboard™ from Vector. In addition to the edge-pin terminals, this model has hole spacing which accomodates that of DIP ICs.**



**A basic wrap tool, such as OK's WSU-30 allows the user to wrap and unwrap connections with ease. The built-in wire stripper is seen in the middle of the tool in both photographs above.**

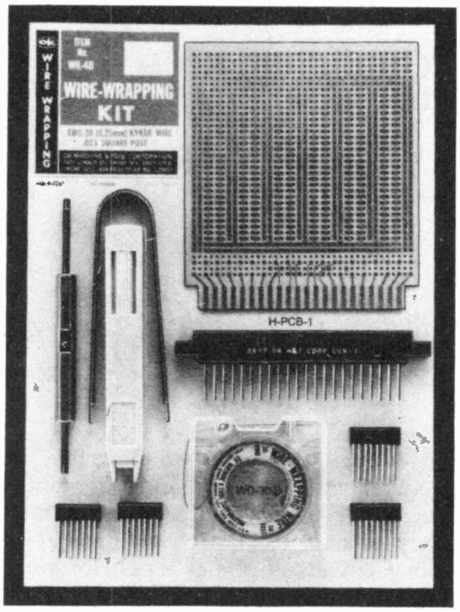
# WIRE-WRAP

jects available for the hobbyist to build. One can literally build her or his own microcomputer from scratch these days, and the complexity of the circuitry involved dictates that the medium upon which the circuit is constructed be flexible enough to allow rearrangement of components and connections as modifications (and yes, sometimes mistakes) are made, yet it must be rigid enough to allow the circuit to be put to practical use. Let's face it—the days of the electronics project as a conversation piece are almost gone. Today's hobbyist builds for more pragmatic reasons, and it has become necessary to apply the latest technology to keep up with the demands of the hobbyist builder. Therein lie the advantages of wire-wrapping.



**If you're willing to spend a few more dollars for convenience, OK's "Just Wrap" tool has a built-in wire dispenser, allowing for one-handed operation. Circle number 40 on the reader service coupon for more info.**

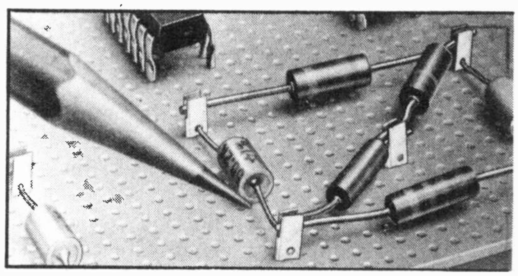
***What You'll Need.*** The basics you'll require for wire-wrapping are: the wrapping tool, wire (usually the wrapping tools can accommodate anything from #22 to #30 gauge insulated wire), a perforated matrix board, and the terminal posts upon which to wrap both component leads and interconnecting leads (meaning jumpers).




**A good starter kit is OK's WK-4B, which contains all you'll need to begin to execute your projects in wire-wrapped formats. Make sure the terminals you buy are the correct diameter for your boards' holes.**

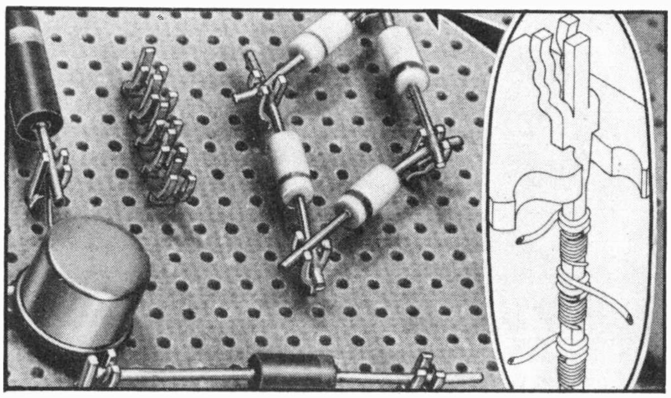
A basic wrapping tool, such as OK's WSU-30, allows the user to strip insulation from the wire, wrap connections with one end, and unwrap connections (just as quickly) with the other end. As you can see from the photos, connections between terminals are made by stopping the wrap on one terminal, stretching the unbroken wire to another terminal, and then wrapping again. As your proficiency increases, you'll find that this process can take less than a second, and that you'll be producing the kind of tight mechanical connection that can stand by itself or take solder just as easily. (Everyone who has ever read about or been instructed on proper solder techniques has heard about the necessity for a "good mechanical connection" underlying the solder joint. There is no better example of that connection than a wire-wrapped junction.)

The base for your wire-wrapped circuitry can be as simple as a regular, perforated phenolic board, or something as esoteric as an epoxy/glass copper-clad board. The simpler perforated boards require that you merely insert wire-wrap terminals at the points where component leads meet on the board, and then simply wire up the junctions. Some of the more expensive boards available (and there are none in the hobbyist category that would be considered prohibitively expensive even for the most budget-minded builder) have staggered hole spacing which can accommodate the DIP (dual in-line package) pin spacing required for integrated circuits (or IC sockets) at certain areas on the boards.



**Vector offers push-in flea clips which are extremely suitable for pre-wrap circuit testing. They can be crimped and soldered for permanent use as well. Circle number 79 on the reader service coupon for more info.**

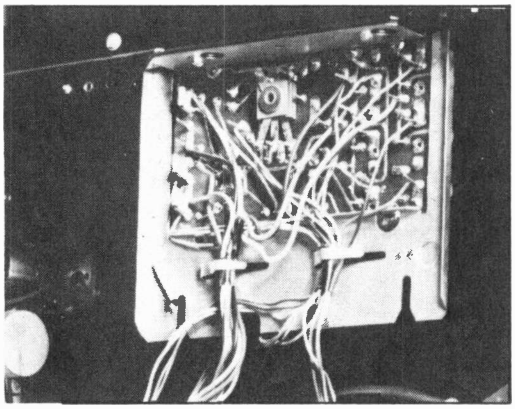
***Some Nice Touches.*** Additionally, there are many specialized board designs available for computer-type circuitry, with special end terminal accessories for mating with standard ribbon connectors and/or PC card 44-pin edge connectors. For breadboarding peripheral circuitry for home computers, wire-wrap construction offers the unique advantage of having all junctions exposed and accessible for signal tracing and logic testing with probes. Any of you who have ever attempted to force a



**A further improvement upon the basic terminal is the "Klip-wrap"™ type, which can accommodate up to three component leads on top of the board, the wrapped wire connection underneath the board. These are used on the larger, unetched perforated matrix boards.**

probe tip into a standard solderless breadboard hole in order to trace a pulse will no doubt appreciate this.

The more complex copper-clad boards which we referred to earlier also allow the builder to create "hybrid" circuit boards, utilizing the copper traces for standard printed circuit assembly of some components, while still being able to insert terminals through

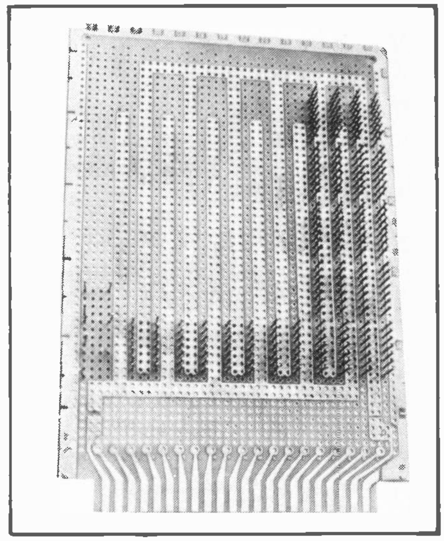


The high-voltage circuit board of this mid-1960's TV shows the use of wire-wrapped terminals combined with printed circuits. This type of hybrid can be built using the type of matrix boards seen on this page.

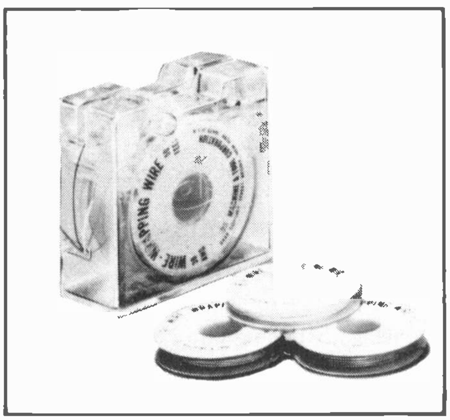
the same holes or busses for the flexibility of rapid changeover of certain other components. This allows for much experimentation with differing component values without having to rip up an entire board, (something of a nuisance if the circuit is a functional, in-use item already installed in a cabinet or another piece equipment) while still maintaining the physical integrity of the circuit's other connections.

***Where to Get Them.*** If the possibilities we've presented here appeal to you, then by all means do some further investigating on your own, either at your local electronics supplier, or by contacting the manufacturers directly. OK Machine and Tool Company, one of the largest hobby supplier of wire-wrapping tools and accessories, has a free catalog available, which can be had by writing them at: 3455 Conner St., Brooklyn, NY 10475, or by circling number 40 on the reader service coupon. A listing of one of the widest assortments of matrix boards available to the hobbyist can be obtained by writing to: Vector Electronics Company, 12460 Gladstone Avenue, Sylmar, CA 91342, or by circling number 79 on the reader service card. ■

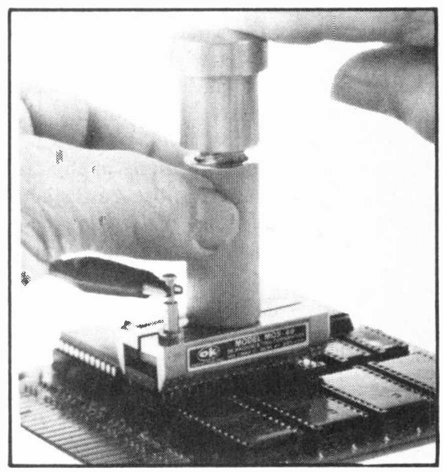
If you decide to go into wire-wrapping in a big way, a battery-operated wrapping tool can be a real time and work-saver. Interchangeable bits accommodate all wire sizes commonly used for wire-wrap construction.



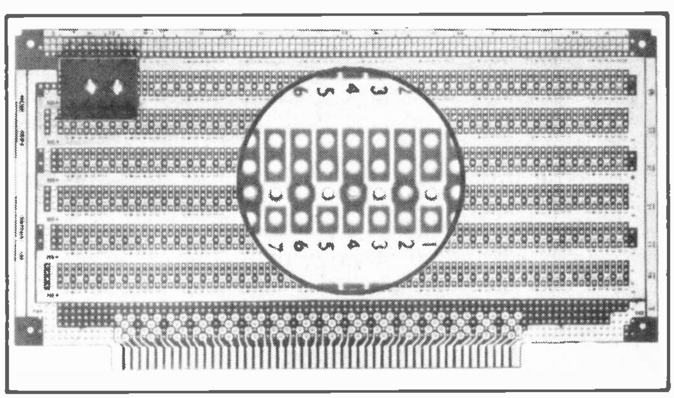
This Plugboard™ (model 3682-4) has etched copper bus strips for soldering as well as holes for wire-wrap terminals. This allows you to build rugged, yet flexible circuitry for virtually any electronic application.



Buying your wire in a dispenser will keep it handy and always ready for use. Some dispensers have built-in cut/strip mechanisms, which make them all the more useful. Most types of dispensers are refillable.



For safe and sure removal of delicate CMOS (as well as other types) ICs, an insertion tool is recommended. OK's MOS-40 has a lug for grounding the tool, this prevents damage caused by static electrical charges.

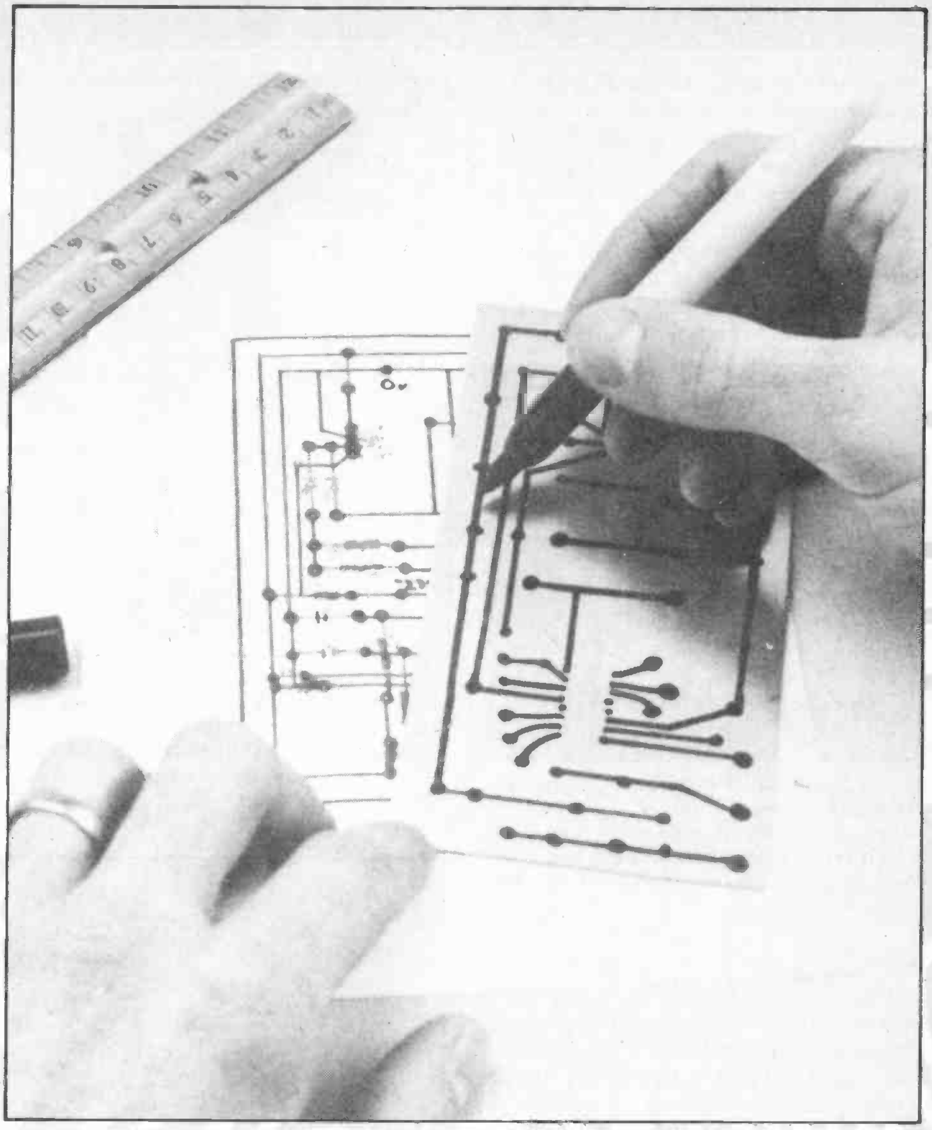


Vector's "Any DIP"™ Plugboard is designed specifically for S-100 microcomputer accessory circuitry. It comes complete with a built-on heatsink for power supply voltage regulator chips.

# CIRCUIT BOARD ETCHING

A step-by-step guide to making project boards

BY M. W. HOUSER



WHILE PERFORATED PROJECT BOARDS, or perf boards, are relatively cheap and easily obtained, a circuit board etched for its particular usage will provide neater, more professional results. Projects with the circuitry foundation of an etched board will be less prone to vibration damages as well as have greater impact resistance–in all, an etched board provides sturdier construction and greater safeguards.

In addition to the quality of construction, in contrast to perf boards, etching lessens the chances of undesirable oscillations caused by crossed or jumpered output signal wires producing feedback in sensitive component elements. Also, electrical noise interference caused by spurious radiations in the circuit's environment are more easily suppressed as a result of the close proximity of ground and voltage supply leads. Decoupling capacitors can easily span supply and ground distribution lines with correct board layout.

Only the etching process will be discussed in this article. The actual circuit board layout should be considered carefully and fully in advance.

*Materials.* The materials required for board etching can be found in nearby electronic retail stores, and the supplies, once purchased, should last through a number of etchings. A list of the materials needed includes:

1. Copper Clad Board.
2. Etchant Solution.
3. Resist Pen.
4. Shallow Pan.
5. Heat Source.
6. Template.
7. Drill Bits.

1. Copper-Clad Board. For good results on initial etchings, use boards with copper coating on one side only. A little experience is best before attempting double-sided boards. As for board dimensions, any convenient thickness or size will do depending upon the individual project. Copper-clad boards can easily be cut to fit exact measurements with a fine-toothed saw such as a hacksaw.

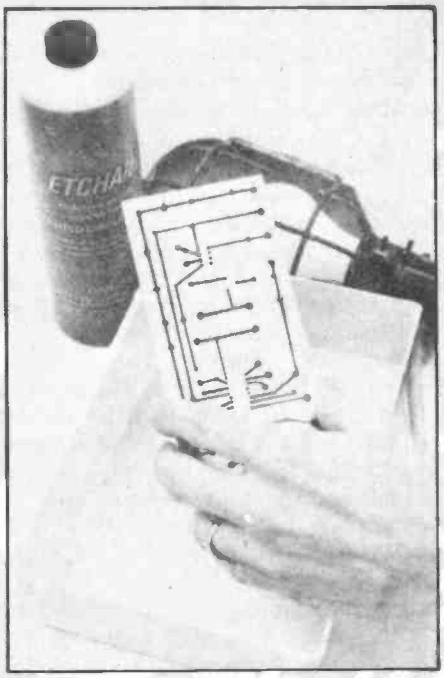
2. Etchant Solution. There is a variety of etchant solutions currently on the market, both in crystal form and already mixed. An inexpensive, pre-mixed solution of ferric chloride is good for a starter; it conveniently provides a uniform end product. Although the solution used during an etching (several boards may be etched at once) cannot be reused, the bottles of solution commercially available contain enough fluid for a number of board projects.

3. Resist Pen. Most electronic retail outlets have on stock pens specially designed for circuit board etching. However, most discount or five-and-dime stores sell the Sanfords Sharpie pen, or one like it, guaranteed to write on metal, plastic, etc. for one-quarter to one-half the price of the special resist pens. Both types give good service.

4. Shallow Pan. Do not use metal pans to etch in, because the etchant will act on the pan metal. Instead, use a glass or plastic pan close to board size to conserve the etchant solution. An inexpensive set of plastic photographic developing trays would be a good investment for etching projects. Photographic trays are available in a variety of sizes.

5. Heat Source. A thermostatically controlled heat lamp would be the ideal heat source to be used during the etching process. However, an ordinary 60-watt light bulb suspended near the solution pan will accomplish the same thing for less expense. A droplight with a 60-watt bulb works well. Use a plastic photographic darkroom thermometer for temperature checking. In fact, with warm (60°F or above) air temperature, simply placing the plastic tray in warm water will provide the needed heat during the etching process.

6. Template. A template, or exact board layout, can be hand drawn. Often



This photo shows all of the vital items needed to etch custom-made circuit boards.

it is provided in electronic project plans.

7. Drill Bits. For board projects, get drill bits size 1/16-inch and 1/32-inch. Bits in these sizes can be found in most hardware or hobby stores.

***Marking The Board.*** A board layout, or template, provided with an electronic project may already be drawn in reverse. This is necessary, since circuit designs are drawn from the component side of the board, leaving the copper clad rear of the board an exact reverse.

If the design to be etched onto the circuit board is an original hand drawn layout, though, a reversed drawing can be easily accomplished by placing a carbon ink side up beneath the drawing and retracing the lines of the layout topside. When the carbon is removed, an exact reverse remains on the back of the original drawing. This carbon reverse is the template for etching. Before transferring the template drawing to the copper clad board, *lightly* rub the copper with a steel wool pad, then rinse and dry. Cleaning the board in this way permits the resist ink to adhere better.

Taking the template, punch small holes in the paper at each connection point. Place the template over the copper and use the resist pen to mark each connection point through the holes. Remove the template. If the circuit is simple, draw the rest of the template drawing onto the board. If lines are complicated, use a ruler as straightedge.

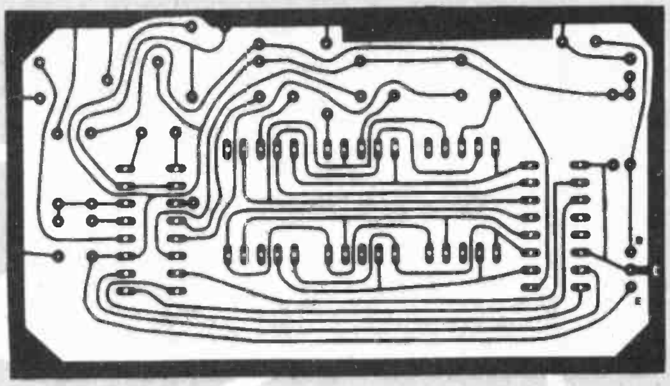
To get the most accurate results using the resist pen, store the pen with its tip down for several hours prior to use. When drawing on the copper, use long smooth lines and stop marking only at connecting points, otherwise there will be fine lines in the resist ink that will cause hairline cracks in the finished product. Do not back-up while marking or retrace lines for best results. Wide lines can be drawn by using the side of the pen point. Two lines drawn side by side can produce a wide area, but generally the end product is better using one mark. When mistakes occur, erase with a pencil eraser. Store the resist pen point down to prevent the point from drying between usages.

***Etching.*** The etchant itself is an acid and therefore handle the solution with care. Take the same precautions necessary when handling any acid. Do not store the fluid where it is accessible to children. If during the etching process the solution splashes into the eyes, flush the affected area with water immediately and see a physician. Avoid body contact with the fluid and wash well if the etchant touches skin.

Pour only enough etchant needed to cover the resist marked board to a depth of ⅛-inch or slightly greater into the shallow tray. Use the etchant solution in a well ventilated room, and avoid breathing the fumes. Place the heatlamp or light bulb near the solution to raise the fluid temperature to approximately 100°F—the exact degree of temperature is not critical. Carefully slide the board into the etchant, copper side up. Gently agitate the solution every few minutes. By using the proper temperature of near 100°F, the etching should be completed within 15 minutes or so. Keep a close eye on the board and remove immediately upon completion of the etching. Tilt the pan carefully to one side to determine if all unwanted copper is gone.

The etching process can be undertaken with success using no heat source if the etchant solution temperature is above 60°F. The process takes approximately one hour with no applied heat, but the results are not as certain.

Some practice is needed to etch involved circuit boards like this one, but even a board of this complexity is within reach of hobbyist who is willing to learn etching.

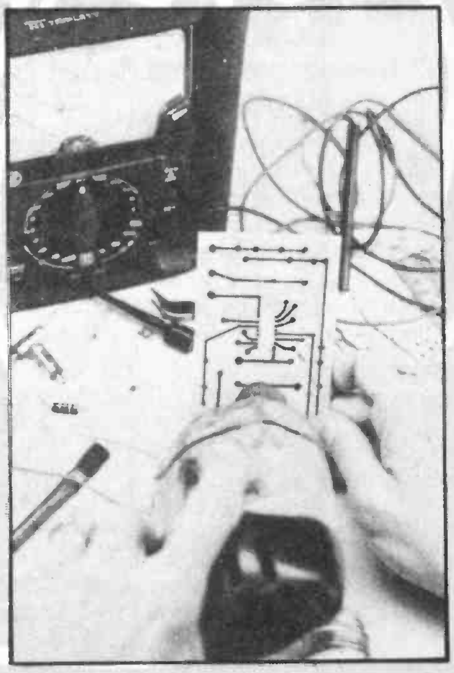


***Finishing The Board.*** After the etching process has been completed, pour off the solution and rinse the board well under running water. Do not pour the used solution back into the solution bottle with unused etchant—this contaminates the entire contents of the bottle. To remove the resist ink, *gently* rub with a steel wool pad. Rinse, then dry the etched board.

Drill holes for connection wires with a 1/16-inch drill bit. For transistor or other component leads, use a bit size of 1/32-inch. To use these tiny bits in an ordinary hand drill, wrap the bit shank with masking tape before inserting it into the drill.

During etching, hairline cracks may form in critical paths on the board. Repair these cracks with solder before attaching components to the board.

The etched circuit board is now ready for whatever project you have in mind. ■



The final step is drilling holes to mount components. Use a 1/16- or 1/32-inch bit.

# HOUNDOG

This electronic metal detector is a thoroughbred

ONE OF THE PROBLEMS with the hobby of treasure-hunting is that much more money has been spent on looking for it than the value of what might and has been found gives. One of the best ways to balance the books is to start out as inexpensively as possible, and that opportunity is provided by *Houndog*, a relatively simple and inexpensive metal detection device. *Houndog* can sniff out metal objects as small as a penny buried as deep as 3 to 5-inches, and will operate reliably for up to a year on one 9-volt transistor battery.

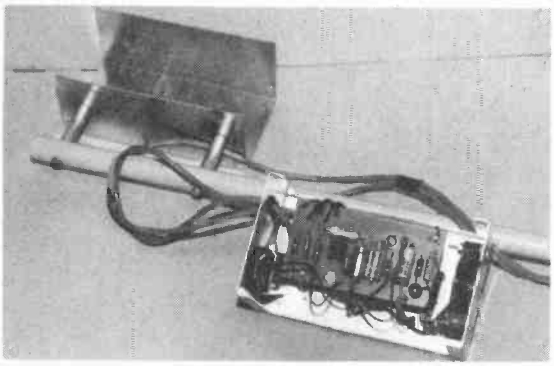
**Operational Principle.** *Houndog's* "nose" consists of three large inductance coils which, when placed in proximity with a conductive metal will exhibit a change in their total inductance value, the change being read by the circuitry and translated into an audible signal. In short, when *Houndog* "barks," it's time to start digging.

**The Circuit.** The heart of the circuit is U1, an audio amplifier, whose differential inputs are fed by a bridge circuit consisting of L1, L2, and R7, fed through R6A and R6B. U1's output is coupled to L3 by either C1 or C1 and C2, depending upon the setting of sensitivity switch S1. The placement of L1, L2 and L3 is such that the total field set up in L1 and L2 by current flowing in L3 is effectively zero. Therefore, the inputs to the amplifier are equal and opposite (zero), and it's output will be zero.

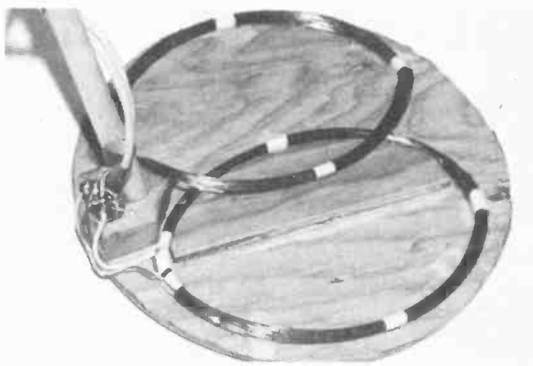
When a conductive metal enters the field, it changes the distribution to the effect that the field across L1 and L2 is no longer zero, and a voltage appears across the amplifier's inputs. The coil connections are such that when this condition exists, the positive input voltage is in phase with that of the output, and the circuit oscillates. The signal is fed to Q1, causing it to turn on, allowing current to flow to buzzer BZ1, creating *Houndog's* "bark."

Because the coils used in *Houndog* are designed to be hand-wound, and also due to the effects of stray capacitance and noise generated internally in the circuit itself, a feedback loop has been included (through R7) which will allow the user to keep *Houndog* from sounding off due to false signals caused by variations from the theoretically perfect zero field.

**Construction.** There are actually two steps involved in the assembly of the *Houndog;* wiring the PC board for the control circuitry, and the construction of the coils for the search head (which we'll discuss later). With the exception of C7, the potentiometers, the switches and BZ1, all components mount directly on the PC board, as indicated in the PC component layout guide. C7 is soldered directly to the terminals of S1, and the potentiometers and switches and the buzzer are mounted to the



**This photo shows the circuit board mounted in the cabinet, and the method used for attaching the cabinet cover to the handle.**



**Closeup of the search head shows the position of coils L1/L2 and L3, and their respective overlaps as described in the text.**

aluminum or plastic chassis. As always. pay careful attention to the polarities of the electrolytic capacitors during installation. Although not completely necessary, use of an IC socket for U1 is recommended.

The circled numbers appearing on the schematic and parts layout guide are for keying up the connections to the off-board components. It is not necessary for you to etch the numbers onto the PC board, so long as you refer to them during the final wiring stages.

To assist you in construction of the coils (L1, L2 and L3), we have provided a diagram of a coil form which may be cut from plywood. This, at the carefully mark the position of the two coils, and prepare to attach them per- very least, will allow you to wind L1/L2 and L3 to the same basic dimension, which is about the only critical factor (outside of getting the number of turns of wire correct) in the construction of the search head.

When winding L1/L2, rather than winding two sets of 30 turns each, we suggest that at turn 30 of L1, you scrape away a bit of the insulation and solder the ground tap in, wrap the solder junction with a small bit of tape, and then begin the next 30 turns for L2. This provides a stronger final assembly, and less of an alignment problem (you now need deal only with aligning two coils instead of three).

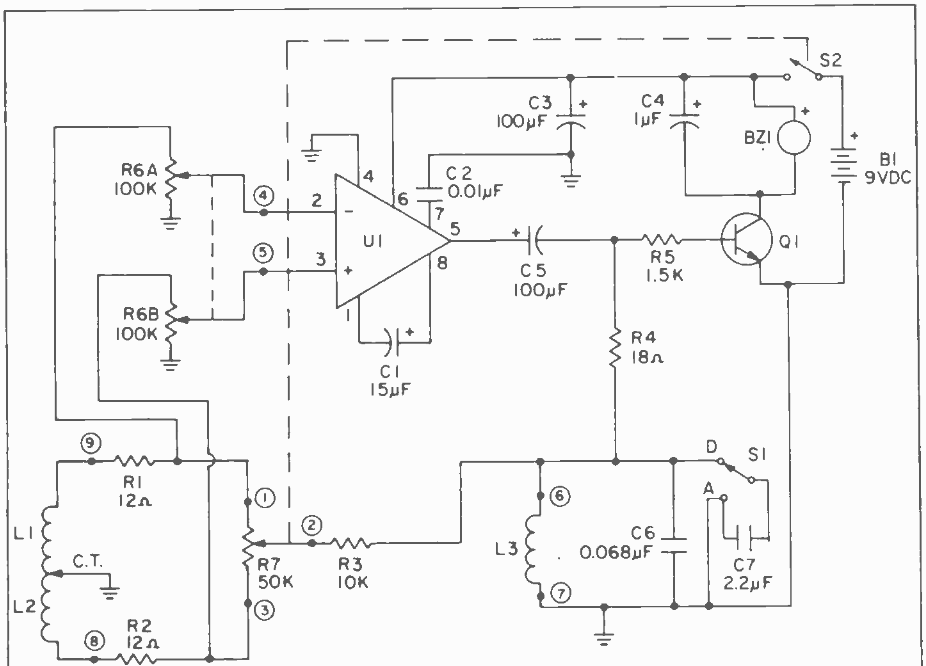
When the coils are completely wound, bind them with tape before removing them from the form. This will help to hold their shape until they are installed on the search head.

***Final Assembly/Calibration.*** Before permanently attaching the coils to the plywood head, it is best to tack them down temporarily with either tape or rubber cement (for obvious reasons, no metal fasteners can be used now or during the final attachment).

Connect L1/L2 to the PC board with 2-conductor shielded wire, attaching the inner conductors to the outside ends of L1 and L2 (points 8 and 9), and using the braided shield for the center tap ground connection. The shield should be grounded to circuit ground on the PC board. Single conductor shielded wire is used for the connection of L3 to the circuit, with the braided shield used for the grounded side of the coil. Solder the braid to circuit ground on the PC board as you did for L1/L2.

Set R6A/R6B to a two-thirds clockwise position, and set R7 to its midpoint. When you throw power switch S2 on, the buzzer should *not* sound. If it does, reverse the L3 connections at the coil end and try again. Slowly reduce the amount of overlap between the two coils until the buzzer sounds. At this point, backing off counter-clockwise on R6A/R6B should cause the buzzer to silence. If this is the case. manently to the search head.

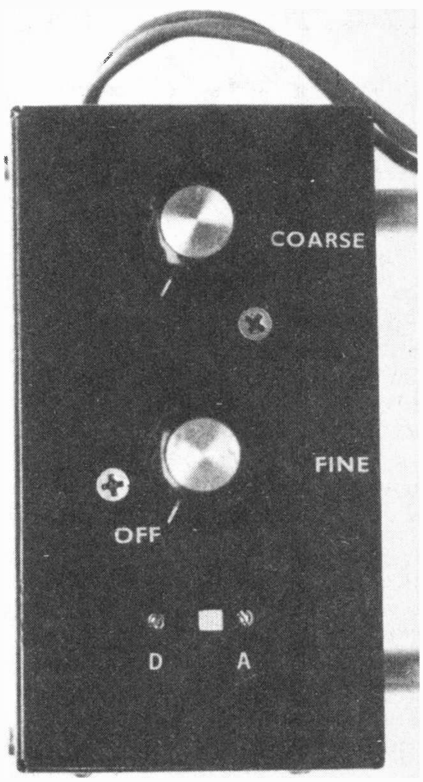
As a final test, return R6A/R6B to the two-thirds position, set R7 just below the point where the buzzer sounds,




**PARTS LIST FOR HOUNDOG**

**B1**—9-VDC transistor battery
**BZ1**—piezoelectric buzzer (Radio Shack #273-060)
**C1**—15-uF, 15-VDC electrolytic capacitor
**C2**—0.01-uF, 50-VDC ceramic capacitor
**C3, C5**—100-uF, 35-VDC electrolytic capacitor
**C4**—1-uF, 35-VDC electrolytic capacitor
**C6**—0.068-uF, 25-VDC mylar capacitor
**C7**—2.2-uF, 35-VDC non-polarized electrolytic capacitor
**L1, L2**—30 turns of #20 enameled copper wire see text
**L3**—60 turns of #20 enameled copper wire
**Q1**—2N5210 NPN low-level transistor
**R1, R2**—12-ohm, ½-watt resistor, 10%
**R3**—10,000-ohm, ½-watt resistor, 10%
**R4**—18-ohm, ½-watt resistor, 10%
**R5**—1,500-ohm, ½-watt resistor, 10%
**R6A/R6B**—dual-section 100,000-ohm linear-taper potentiometer
**R7**—50,000-ohm linear- taper potentiometer with SPST switch (S2)
**S1**—SPDT slide switch
**S2**—SPST rotary switch (part of R7)
**U1**—LM386 audio amp integrated circuit
**Misc.**—battery clip, aluminum chassis, hookup wire, solder, spacers, knobs, 100-foot roll of #20 enameled copper wire, weatherproofing finisher (varnish, shellac, polyurethane, etc.), non-metallic support rod, 10-feet of 2-conductor shielded wire, 10-feet of 1-conductor shielded wire, ¼-inch plywood stock, etc.

A complete parts kit for Houndog including pre-etched PC board and all components (but less case) is available from Niccum Electronics, Rte. 3, Box 271B, Stroud, OK 74079. Price for the complete kit is $24.50; a pre-etched and labeled PC board only is $5.50. No CODs, Please.




**Houndog's control head is laid out simply; there's an SPDT switch and two adjustments.**

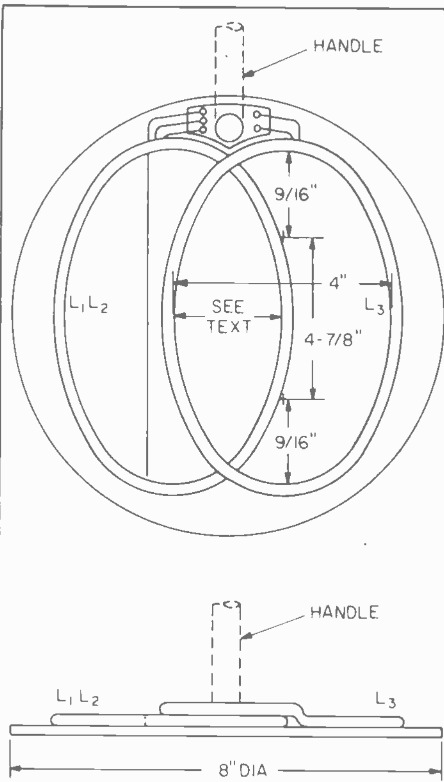
# HOUNDOG

and S1 to the "discriminate" position. Bring a penny directly above the coils' overlap, and lower it to a height of about 3-inches above the coils. If the buzzer does not sound, try re-peaking R6A/R6B and R7 for a lower threshold (increase R6A/R6B more clockwise, while backing off more on R7 to stop oscillation) and repeat the procedure. Three inches should be the minimum distance at which *Houndog* detects the presence of the penny.

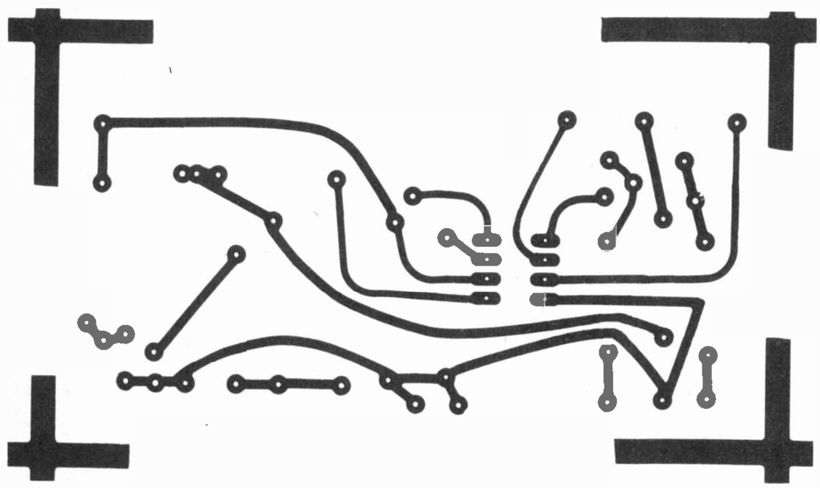
Remember that when conducting these tests, you should be in an area free from the presence of large metallic objects, such as radiators, pipes and ducts, etc. Their presence may cause you to set the sensitivity of R6A/R6B too low, making actual measurements against coins ineffective to the point of believing that the unit is not working.

You may now attach the coils to the head in a permanent manner with epoxy or several coats of polyurethane or shellac, in order to affix the coils firmly.

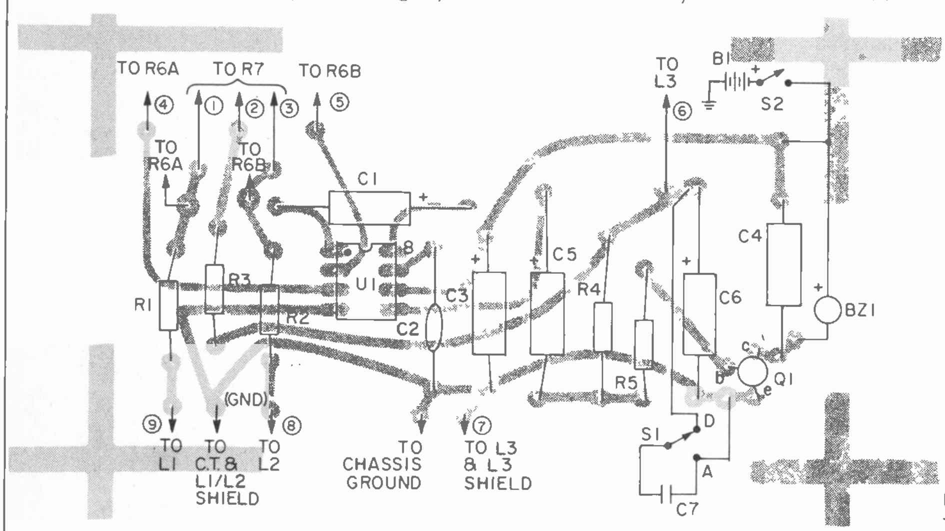
***Conclusion.*** Once you get out of doors with *Houndog*, it might be wise to bury some treasure of your own, and adjust the controls for maximum sensitivity depending upon the type of soil found in your locality. These adjustments will vary from area to area, depending upon soil composition, which is why we haven't used a calibrated dial for the potentiometers. Don't be discouraged if your first few hours of searching with S1 set to the "discriminate" (coins) position don't unearth Captain Kidd's treasure chest. With S1 set in the "all" position, you'll get a lot more "barks," but you might find a lot of tin cans and beer can pull-tops for your efforts. Patience is a virtue in this hobby. ■



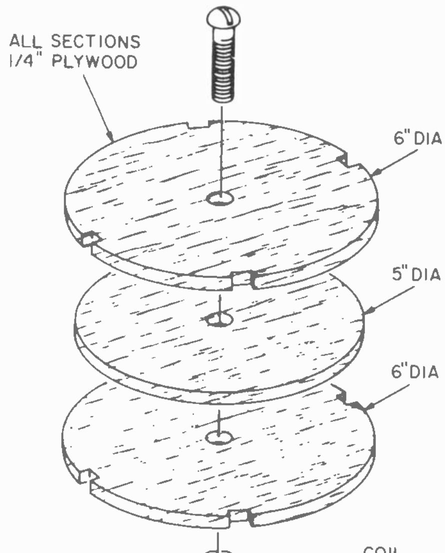

The dimensioning guide for the search head shows you how to bend round coils into the elliptical shape necessary for installation on the search head plywood base.

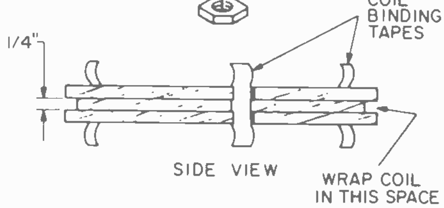


Here is the full scale etching guide for Houndog's PC board. If you purchase a Niccum PC board, the layout may differ slightly. Follow their assembly instructions for it.



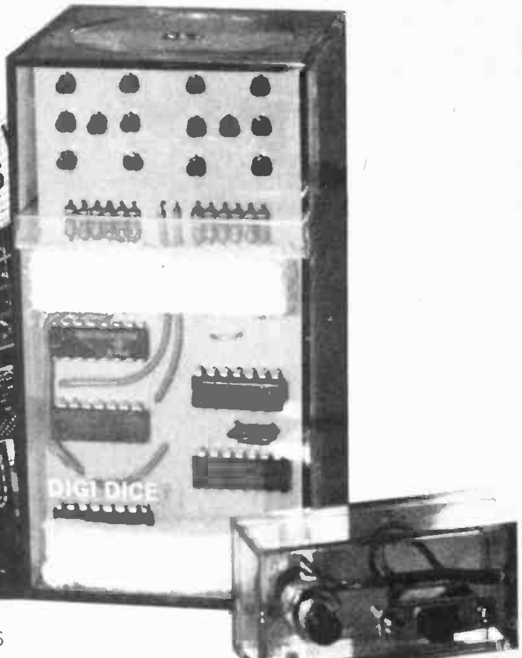

The component layout guide gives you the connections for the off-board components. If you use another method of assembly, rest assured that parts layout isn't critical.




Use this template for winding the coils. The finished coils will be circular, and you will have to bend them into an oval, as seen in the diagram above, to fit them.

# DIGI DICE


An electronic dice game with infinite possibilities

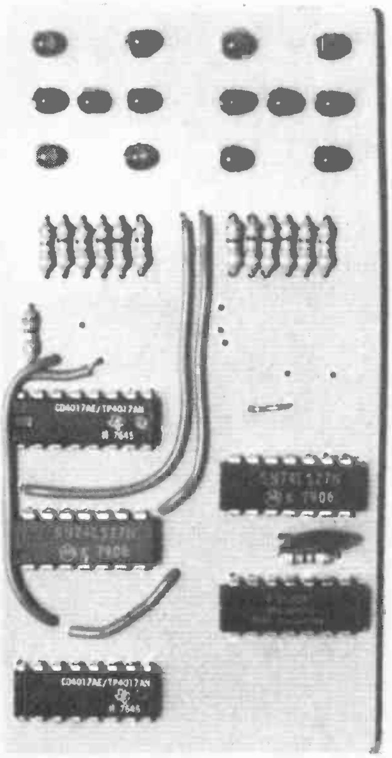
HERE IS A PROJECT for those of you tired of rolling old fashioned mechanical dice. *Digi Dice* can be used anywhere normal dice are used, and has been designed to be cheap, portable, and fun. And, since it is an electronic device, it is probably more random than any regular dice with their inherent mechanical imperfections. Construction time will vary, of course, but we built our dice in an afternoon and by evening were "rolling" in a game of craps. Total cost should run about $12 to $15, depending on how much spare junk you have lying about and where you buy the needed parts.

***The Circuit***. Refering to the block diagram, you can see that *Digi Dice* is composed of three main blocks. Block A, the oscillator, is made of two 74LS inverters connected as an oscillator, using a resistor and capacitor to regulate the frequency. The output of this oscillator is sent to block B, the counter. This consists of two CD 4017 decimal decoded counters, each wired to reset at a count of six, such that its sequence is 0, 1, 2, 3, 4, 5, 0, 1, etc. The first IC (U1) gets its input directly from the block A oscillator, while the second (U2) receives its pulses every time its partner resets itself to zero. Obviously, the second 4017 only counts one sixth as fast as the first.

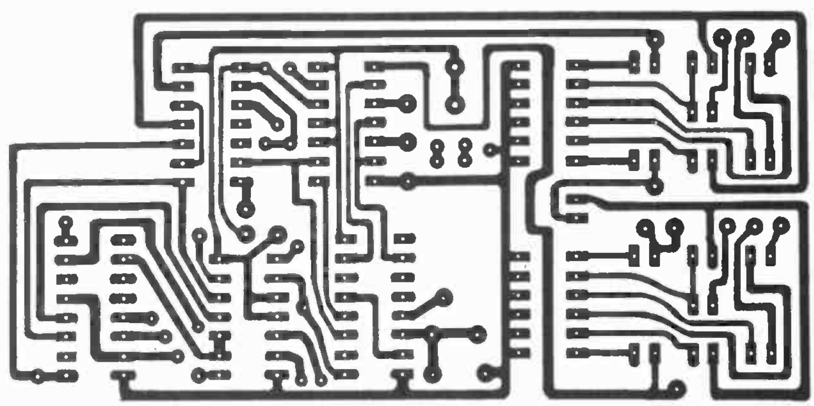
The net result of all this is a two-place base six (modulo six) counter. If we now interrupt the count at some point, each 4017 will contain a value of 0 through 5. If then, and this is the heart of the circuit, we run the counters so fast that we don't know where they are when we halt them, we have devised two independent and "random" six counters. But that is exactly what mechanical dice are, so now all that must be done is to display our results in some suitable way.

Block C, decoding and driving, does this by interpreting the values present in the CD 4017s and displaying them using red LEDs arranged to give the appearance of a pair of dice.

Now, look at the schematic diagram for a more complete idea of how the circuit operates. Switch S1 is power on-off. S2 is a normally closed momentary-contact pushbutton which inhibits



**This front view of the PC board shows the arrangement of ICs and the LEDs that read out the score. "Snake eyes" lights up first.**



**This is the exact size of the PC board for Digi Dice, shown here with foil side up. If you do not care to etch the board yourself, order a pre-etched and labeled Niccum kit.**

# DIGI DICE

counting in both U1 and U2 by holding pin 14 at ground. Opening (pushing) S2 allows R14 to pull pin 14 to a high level, thereby allowing the counters to run. When this happens, the decoder/drivers will be displaying the contents of the U1 and U2 using the LEDs, but so quickly that the eye cannot follow. Releasing the pushbutton switch (closing S2) will freeze the count in each 4017, which can now be seen displayed by the LEDs.

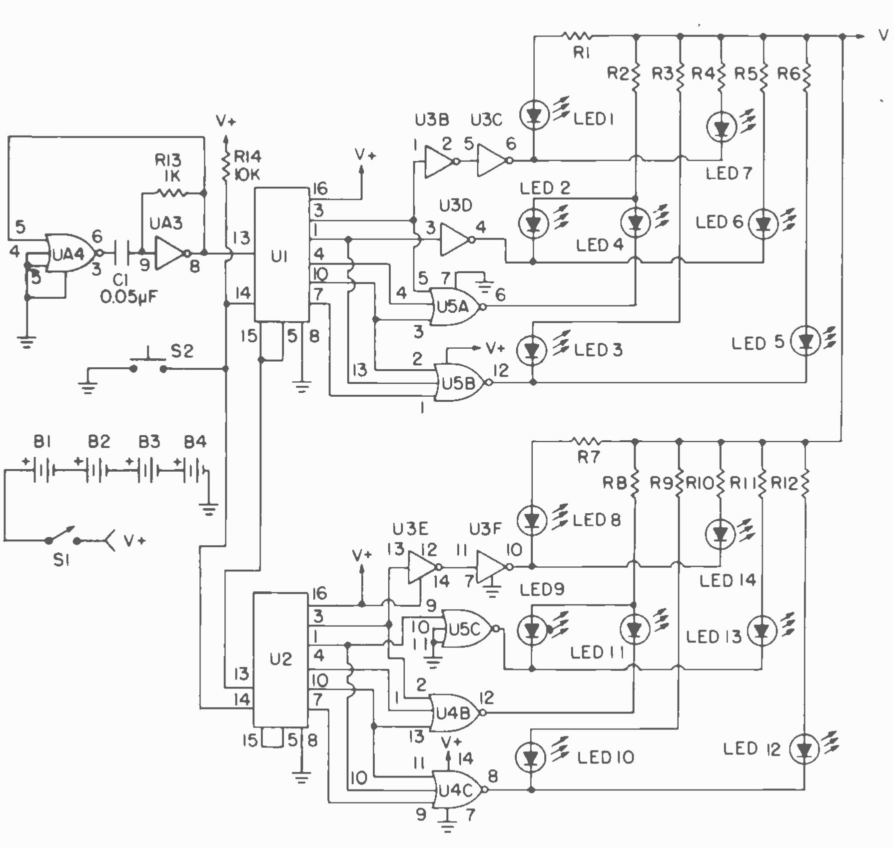
***Construction.*** A full size PC board layout is shown for your use. As the pattern is very tight, we recommend that only advanced hobbyists attempt a reproduction. Wire wrapping is a bit more tedious and time consuming, but easier to correct. Anyway, if you do choose the PC route, carefully check for breaks and shorts in the foil with an ohmmeter, since they are easy to miss by visual inspection.

Follow the parts layout guide when assembling the PC board, and be sure you have the correct orientation of the chips; a small notch is preesnt at pin #1 of each chip. Also, don't arrange the LEDs backwards. The anode lead (+), which is usually longer than the cathode lead is always nearest to the ICs on the board. Reversing this won't hurt the LED but it won't light either.

The entire project fits neatly into a 2¼-inch by 2¼-inch by 4¹⁄₁₆-inch plastic box available in art supply stores. We ran four wires out of the main box to a smaller matching unit in which we mounted switches S1 and S2. Ribbon cable is perfect for this. The battery and circuit board are stabilized by styrofoam strips and blocks cut to the necessary shapes and either glued or press-fit into the large box. When the time comes to change batteries, the holder is easily unclipped and slid out of the case. Incidently, any 5-volt to 6-volt source can be used in place of the dry cells. The absolute maximum voltage the 74LS chips will tolerate is 7 VDC, so be careful.

***Operation.*** Closing switch S1 activates the circuit. Don't be surprised if an unusual combination of lights appears when the unit is first turned on. Now press pushbutton switch S2. All of the LEDs will illuminate, some more brightly than others. Releasing the pushbutton will force *Digi Dice* to display two random values. Repeat the sequence for further play.

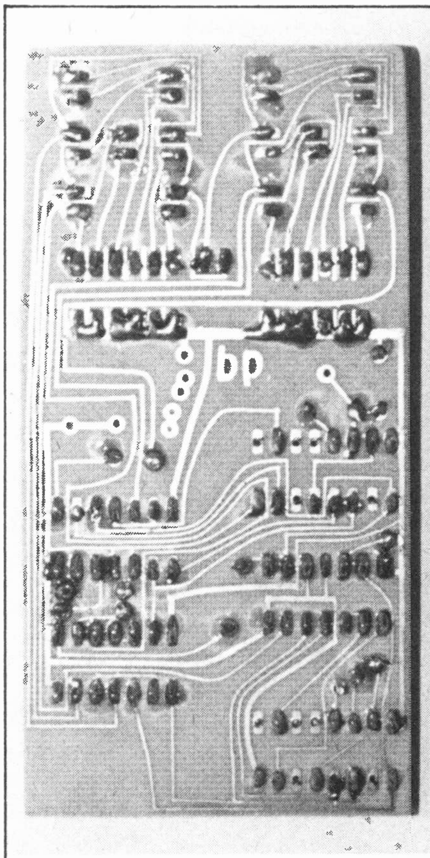
To test the theory of randomness, we "rolled" Digi Dice one hundred times. A summary of the results is shown. Although the tabulation was not checked using statistical analysis, you can see




**PARTS LIST FOR DIGI DICE**

**B1 thru B4**—1.5 VDC battery
**C1**—0.05-uF, 50 VDC ceramic disc capacitor
**LED1 thru LED 14**—light emitting diode rated 20 mA @ 1.7 VDC
**R1 thru R12**—470-ohm, ¼-watt resistor, 10%
**R13**—1,000-ohm, ¼-watt resistor, 10%
**R14**—10,000-ohm, ¼-watt resistor, 10%
**S1**—SPST subminiature slide switch
**S2**—SPST normally closed pushbutton switch
**U1, U2**—CD4017 decade counter integrated circuit
**U3**—74LS04 hex inverter integrated circuit
**U4, U5**—74LS27 three section, triple input NOR gate integrated circuit
**Misc.**—battery holder/clip, suitable enclosure, IC sockets, hookup wire, solder etc.

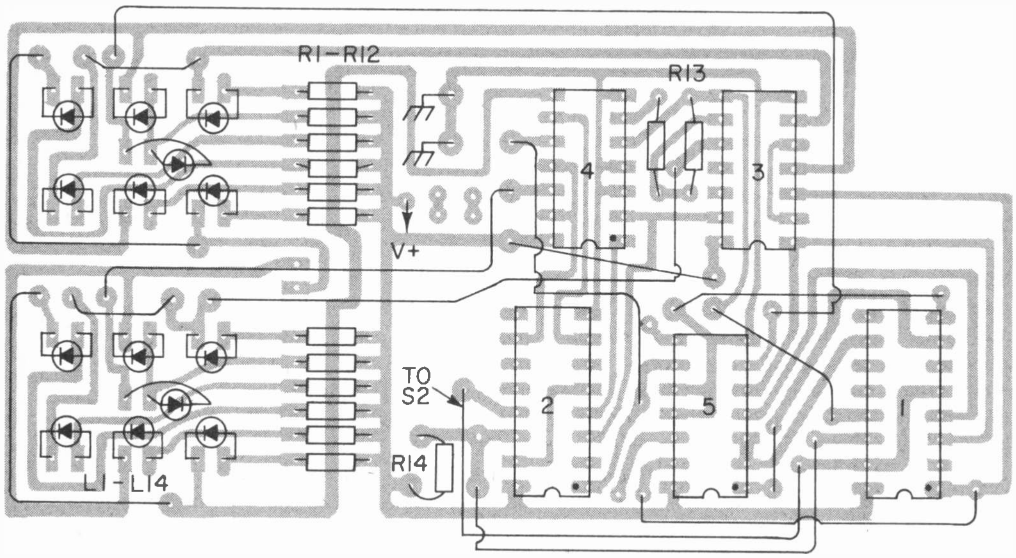
A complete parts kit including PC board and all components is available from Niccum Electronics, Rte. 3, Box 271B, Stroud, OK 74079. Price for the complete kit is $24.50; a pre-etched and labeled PC board only is $5.50. No CODs, please.



**The foil side of the completed PC board is a gem of neat solder connections. The unit fits into a variety of handy plastic cases.**

that the theoretical 16⅔ frequency for each level is closely approached—the small variations are just random fluctuations in this relatively few number of trials. *Digi Dice* draws about 20 to 60 mA from the supply, depending on how many LEDs are lit. Alkaline cells are best for long life, but regular carbon-zinc batteries will provide several hours of "rolling." Be sure to try this circuit in a game of backgammon. It runs much more quickly and a third person can get into the game as a dice roller.

***Conclusion.*** We'll add the usual caution at this point about getting involved with "money" games. While *Digi Dice* has been designed to be as "random" as is possible for a project of this nature, we certainly do not wish to become referees in arguments between you and your friends (or your victims). *Digi Dice* is intended for entertainment only, and any other use of this project (either with a modified circuit or not), especially for gambling, is done against our strongest recommendation. If you're all that hot to *really* gamble, the Chamber of Commerce of Atlantic City would no doubt like you to visit the town's casinos instead! ■

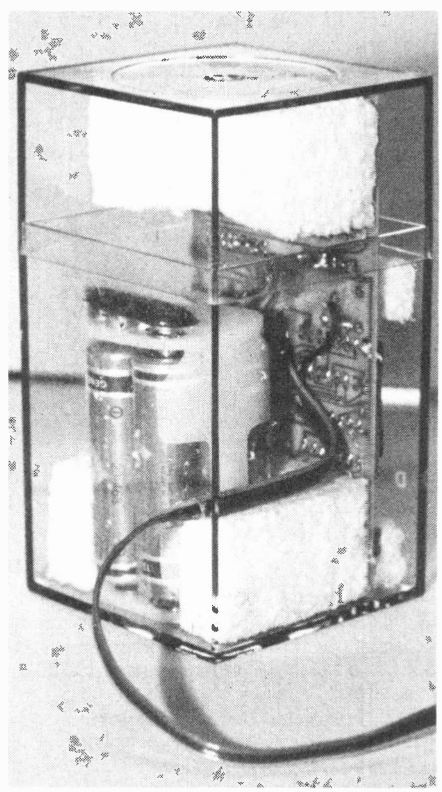



**The parts overlay diagram shows the placement of components on the PC board. As in all projects using a number of delicate ICs care must be taken with the pins and with the use of soldering irons too near to the chips. Digi Dice is a project to gladden a gambler.**

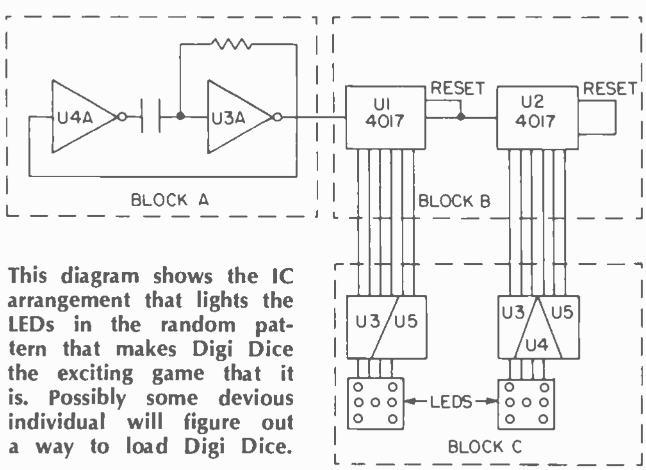
**STATISTICAL BREAKDOWN OF 100 ROLLS**

| Face Value | Die #1/100 Rolls | Die #2/100 Rolls |
|---|---|---|
| 1 | 18 | 16 |
| 2 | 14 | 18 |
| 3 | 18 | 14 |
| 4 | 15 | 17 |
| 5 | 18 | 16 |
| 6 | 17 | 19 |
| Total | 100 | 100 |

**This chart shows how truly random Digi Dice is, much more so than old-fashioned "bones." While it may be possible, we know of no way to rig Digi Dice.**



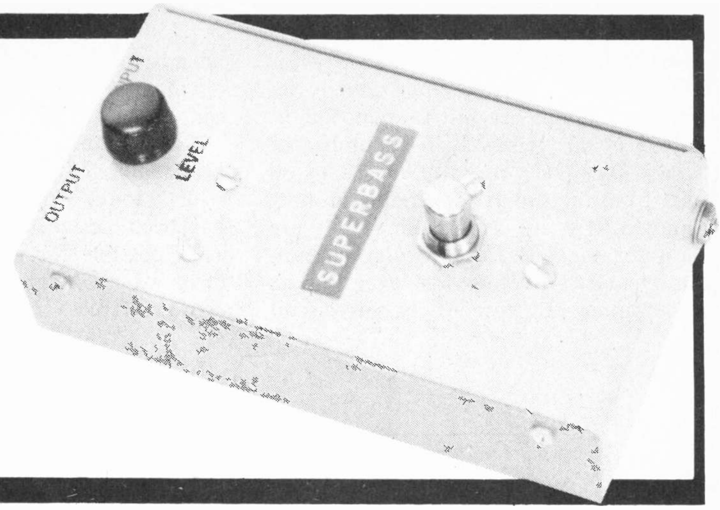
**The battery pack holding the four 1.5 volt cells that power Digi Dice fits neatly into one of the common rectangular plastic boxes which can be found in a variety of shops. Styrofoam or a similar material can be used to take up room in the box, since the PC board and battery pack aren't likely to fill the entire box.**




**This diagram shows the IC arrangement that lights the LEDs in the random pattern that makes Digi Dice the exciting game that it is. Possibly some devious individual will figure out a way to load Digi Dice.**

# SUPERBASS AMPLIFIER

Increase the bass output of your present instrument at modest cost!

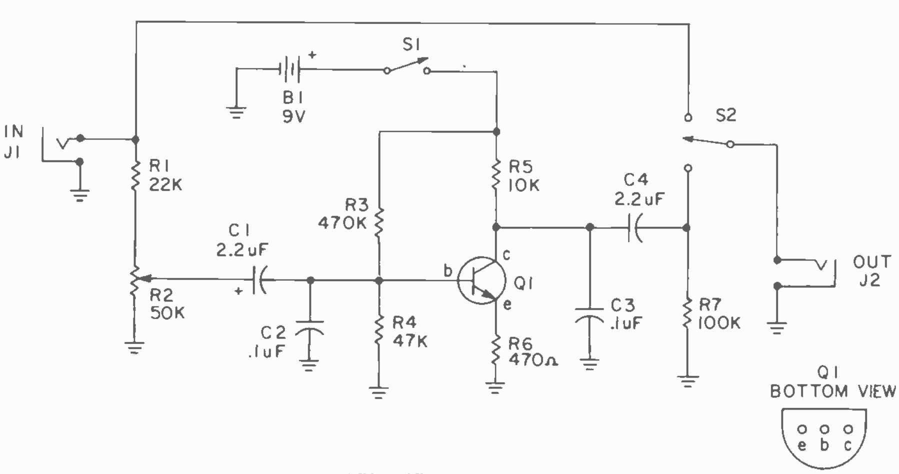



Superbass is today's sound . . . whether it's the driving, gut-vibrating pulsations of disco, or the solid bass line of soft, hard, or laid-back rock. One way to get the modern superbass sound without running out and buying an all-new expensive piece of equipment is to use a Superbass amplifier between your guitar, electronic organ or what-have-you, and the instrument amplifier.

A Superbass strips the highs from the instrument's output signal and amplifies low frequencies, feeding on "all-bass" sound to the instrument amplifier. Naturally, the bigger the speakers used with the amp, the more powerful the bass: use 15-inchers with a Superbass and you can rattle the windows.

The Superbass is powered by an ordinary 9-volt transistor radio battery. It is keyed in and out—switching from superbass to standard instrument output—by a foot operated switch. A level control allows you to equalize the superbass sound level with that of the musical instrument, so your volume level remains relatively constant as you key the superbass sound in and out. Of course, if you want the superbass to be louder or softer than the unequalized sound, you can adjust the level control accordingly.

The superbass connects between your instrument and its amplifier through two standard phone jacks—you can use your regular "patch cords"




**PARTS LIST FOR SUPERBASS**

**B1**—9-volt battery, Burgess 2U6 or equivalent
**C1, C4**—2.2-4.7-uF, 10-VDC electrolytic capacitor (see text)
**C2, C3**—0.1-uF Mylar capacitor, rated 10-VDC or higher
**J1, J2**—3-conductor, ¼-inch phone jack
**Q1**—NPN transistor (Radio Shack RS-2010, or equiv.)
All resistors 1/10 or 1/4-watt, 10%
**R1**—22,000-ohm resistor
**R2**—100,000-ohm audio taper potentionmeter (see text)
**R3**—470,000-ohm resistor
**R4**—47,000-ohm resistor
**R5**—10,000-ohm resistor
**R6**—470-ohm resistor
**R7**—100,000-ohm resistor
**S1**—SPST switch (see text)
**S2**—SPDT push On-push Off switch

**Misc.**—9-volt battery clip, aluminum cabinet, screws and other hardware.

***Construction.*** Since you're going to stomp down on a footswitch to key the superbass in and out, the project should be assembled in a sturdy metal cabinet. We suggest one of the flat "instrument-type" cabinets which are available from time to time. The project fits nicely into a 1¼-inch x 3-inch x 5½-inch cabinet such as the one shown in the photographs. The "instrument" cabinets are not always available; as a substitute we suggest an aluminum "handy" or "Minibox." Do not use a plastic cabinet with a metal cover because it will probably fall apart after a few stomps.

***Plug-in Circuitry.*** The amplifier itself can be assembled on a small printed circuit board, or on a perf-board using point-to-point wiring. Perhaps the easiest construction is the one used for the model shown: it uses a combination of printed circuit and perf-board. The board is an "Op-Amp IC Experimental Breadboard," available from Radio Shack stores. It has factory-etched copper strips, ground loops and buses that are pre-drilled in a perf-board pattern. You simply plug the parts into the board so the leads stick out on the foil side and solder. When finished, you have a printed circuit without the bother of making the PC board itself. (Use a 1½-inch x 1⅞-inch piece for this project.)

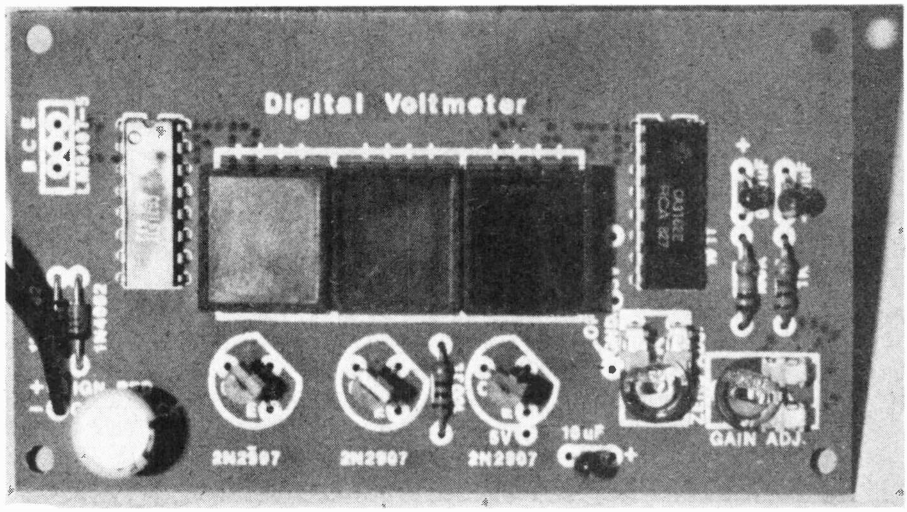
While the overall layout isn't critical, try to follow the layout shown because it keeps cables and the level control away from the footswitch. To conserve space, level control R2 can be any type of miniature audio taper potentiometer.

The battery is held in place by a small L-bracket. To prevent the battery from sliding around, two small strips of cork or rubber are cemented to the bracket. The bracket should be positioned so the battery must be lightly forced into position—in this way the

*(Continued on page 99)*

# Dashboard Digital Voltmeter

Keep an electronic eye on the voltage leve' of your vehicle's electrical system and save on expensive repair bills later




YOU'RE MAKING TIME down the interstate at three in the morning, and all of a sudden you become aware that the lights on the dash seem kind of dim, and that the headlights don't seem to be reaching out as far ahead to warn you of darkened semis parked on the shoulder. Are your eyes just playing tricks on you, or is there something the matter with your car's electrical system? A quick glance down at the three glowing LED numerals on the dash gives you the instant answer. Either you pull into a rest area and grab a few hours of shuteye, or you pull into a service area and have the battery, alternator and voltage regulator given a good scrutinizing by the mechanic.

In either case, your car's digital voltmeter has given you the information sought about the state of the electrical system, and maybe saved you either a headache, a smashup, or a king-sized repair and towing bill. Maybe all three.

Recent advances in the design and availability of industrial integrated circuits have opened up many doors to the electronics hobbyists. Analog-to-digital devices have become more complex internally, thus making the portions of the circuitry which have to be assembled by the hobbyist that much more simple. The Dashboard Digital Voltmeter takes advantage of these advances, utilizing three ICs and a small handful of discrete components to give you an instrument capable of better than ± 1% accuracy in reading the voltage level delivered by your car's (or boat's) electrical system.

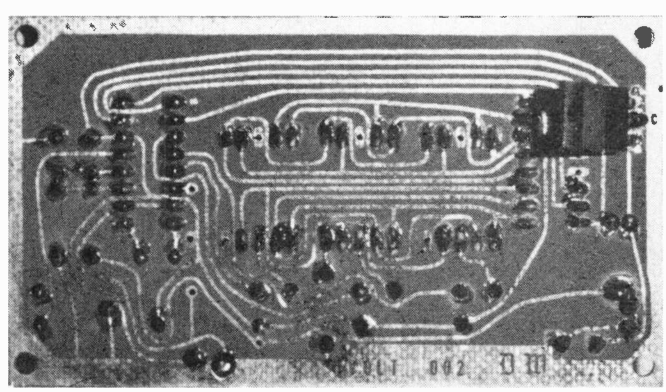
***Two New ICs.*** The system is built about three ICs: the LM340T-5 (a 5-volt regulator now available for several years); a CA3162E; a CA3161E; and a support combination of diodes, resistors, and capacitors. It is the CA3161E and CA3162E that now open the door to new horizons in possible applications not only because of their unique capabilities, but also because they reduce substantially the numbers and types of formerly required support components. The heart of this system is the CA-3162E, a dual-slope, dual-speed, A/D converter industrial chip. Its almost equally important companion, the CA-3161E, is a BCD, 7-segment, decoder/driver chip. It is also unique in that it has a current-limiting feature. This eliminates the necessity of resistors in series with the 7-segment displays that were required in earlier designs.

The above feature not only reduces circuit board space requirements, but reduces the probability of component failure. Power required to operate this voltmeter is minimal (160 mA or less), a result of the multiplexing feature of the CA3162E. With that as a background, let's consider some of the more important operations of this simple, but very accurate digital instrument.

***Circuit Function.*** Analog voltage from 000 mV to 999 mV can be applied between pins 11 (+) and 10 (−) of the CA3162E (U2). That IC converts the voltage into a Binary Coded Decimal (BCD) equivalent. The BCD leaves pins 2, 1, 15, and 16 (the group represents the 1's, 2's, 4's, and 8's) and enters pins 7, 1, 2, and 6 respectively of the CA3161E (U3). The latter IC takes the BCD code, converts the output, then uses it (in conjunction with the 7-segment display) to generate (form) the number that correlates to the BCD input of the CA3161E. The multiplexing driver pins 5, 3, and 4 (5 being the least significant and 4 the most significant) turn on that display by means of the PNP switching transistors. Concurrently, the CA3162E is providing the BCD information to the CA3161E driver/decoder.

As indicated earlier, the system includes a combination of diodes and capacitors. These are required to control or minimize the voltage spikes (positive and negative) that result from turning inductive devices on and off; e.g. windshield wiper, air conditioner, and electric windows, etc.

The maximum input differential between pins 11 and 10 of CA3162E is 999 mV. A resistor network (R1, R2) is used to attenuate the applied 13.8-volts to .138 mV. An Ohm's Law cal-



**This view of the assembled PC board shows the voltage regulator, (U1) mounted on the underside of the PC board. This was done in order to accommodate a flush-mount installation in a smaller car. Let your space needs dictate placement of this component.**

# Digital Voltmeter

culation would give a result of 136.6 mV. The gain-adjust potentiometer compensates for the slight drop. The FND 507s display this as 13.8-volts.

Note the point marked OPTION on the schematic. With Pin 6 of the CA-3162E grounded or disconnected, there are four conversions or comparisons made each second. Tying pin 6 to the 5-volt line will result in 96 conversions or comparisons per second. The 96/second rate moves with excessive rapidity, is not appealing to the eye, and usually results in the least significant digit appearing to be blurred. Of the two rates, the 4/second conversion (4 Hz) is by far the more pleasing to the eye, is easier for the eye to focus on quickly, and is the recommended rate. These rates could vary slightly because of capacitor difference and manufacturer variance from stated values.

***Assembling the Voltmeter.*** The unit may be assembled quickly and relatively easily using a predrilled and etched circuit board. If a Digital World circuit board is being used, the four corner holes will have been drilled. If a blank board is being used, drill the corner holes *before* starting to "stuff" the board. It is easy at this point to scribe the plexiglass panel and mark the corner holes on it for later drilling and perfect alignment. Additionally, examine the recess or place where the completed unit will be mounted. Determine how it will be secured (bolted, clamped, or glued), doing any additional drilling that may be required.

Get the workbench ready for soldering. Use a low wattage, electrically-isolated, fine-tipped soldering tool and fine solder. A blunt-nosed tool could damage or destroy the ICs and create foil bridges between pins. This is both expensive and frustrating. If you have had limited experience in soldering in small areas, it may be wise to practice on something else before you start.

Now, locate all resistors and potentiometers on the circuit board placement diagram and install them in their respective holes. Next, do the same for all capacitors, observing polarity. Install the CA3161E and CA3162E. *Caution!* When inserting the ICs, be careful *not* to fold the pins under or bend them in any way.

IC *orientation* is critical. Be sure these chips (CA3162E and CA3161E) are aligned as shown on the diagram. Note the notch mark on the chips and the corresponding notch mark on the schematic, or the "1" on pin 1 on top of the plastic case. All manufacturers use one or both of these base reference directional indicators.

If you have doubts about your soldering ability or the type of solder tool you have (grounded or not grounded), place two 16-pin sockets in the chip holes. The ICs may then be placed (not soldered) in the sockets. Next, insert the three LEDs, noting the notch marks on the LEDs and the notch marks indicated on the diagram. For the final action on this side of the board, insert both diodes in their respective holes (observing cathode markings).

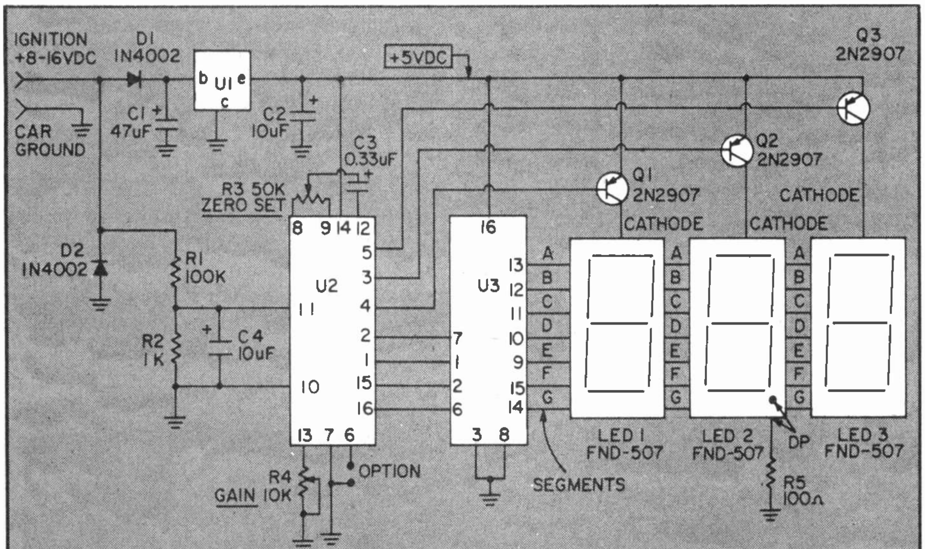
Reverse the circuit board and install the LM340T-5 regulator. *Caution!* This must be correctly placed or it will destroy your unit when power is applied. The *metal side* of the regulator must be facing the FND 507 pins. Recheck it to make sure.

Now, turn the board over again. Use a red wire for the ignition line and a black wire for the chassis ground. Determine the lengths required (usually three-feet is sufficient). Solder the red wire to the point marked IGNITION on the diagram and the black wire to the GROUND.

***Calibration Procedure.*** Correct calibration determines the accuracy of your voltmeter. Follow these steps carefully and sequentially. Apply a *known* voltage source (above 10 and below 16-volts) to the IGNITION point. We recommend a 13.8-volt source. Next, for zero adjustment, ground pins 11 and 10 to the circuit board ground momentarily. Using a small screwdriver, slowly rotate the wiper arm on R3 until there is a reading of 000. Remove the ground from pins 10 and 11. Set the *gain control* (R4) by rotating the wiper arm until the displays are displaying the same voltage as is being applied.

***Installation.*** One final action is necessary before your unit is ready to be mounted in the dash location of your choice. Secure the black wire to the metal chassis ground and the red wire to any accessory line that is active only when the motor is running. Secure and mount the voltmeter in the location of your choice.

A colored plexiglass facing (cover) is required and we recommend red for most display contrast. A location which is not usually exposed to the sunlight will make the displays easier to read during the brighter periods of the day. If the unit is going into an existing recess, the present glass cover may be




**PARTS LIST FOR DIGITAL VOLTMETER**

- **C1**—47-uF electrolytic capacitor, 25 VDC
- **C2, C4**—10-uF tantalum electrolytic capacitor, 16 VDC
- **C3**—0.33-uF tantalum capacitor, 35 VDC
- **D1, D2**—1N4002 diode
- **F1**—1-amp fuse
- **LED1, 2, 3**—FND-507 7-segment LED display
- **Q1, 2, 3**—2N2907 PNP transistor
- **R1**—100,000-ohm, ¼-watt resistor, 5%
- **R2**—1,000-ohm, ¼-watt resistor, 5%
- **R3**—50,000-ohm PC trimmer potentiometer
- **R4**—10,000-ohm PC trimmer potentiometer
- **R5**—100-ohm, ¼-watt resistor, 5%
- **U1**—LM340T-5 5-volt voltage regulator
- **U2**—CA3162E Analog-to-Digital converter
- **U3**—CA3161E BCD display driver
- **Misc.**—solder, hookup wire, red plexiglass (for display filter), IC sockets, transistor sockets, suitable enclosure, etc.

Note: An etched and drilled circuit board for the Digital Voltmeter is available for $6.50 (postpaid in U.S. and Canada), and a complete parts kit, including PC board but not including plexiglass, is available for $27.50 from: Digital World, P.O. Box 5508, Augusta, GA 30906. Please allow 4 to 6 weeks for delivery. No C.O.D.s or foreign orders, please.

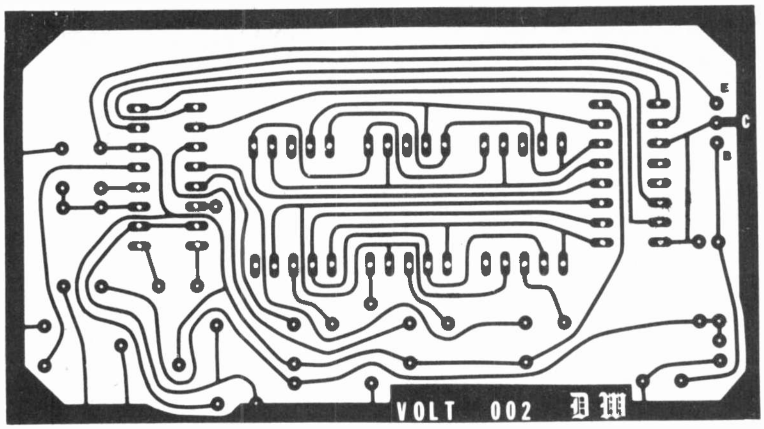
used as a template for the plexiglass cover dimensions. One-eighth or 1⁄16-inch thickness plexiglass works well and is relatively easy to cut using a roofer's shingle cutter knife. Place two clamps on a straight line along the template edge, then cut one side at a time. Scribe it deeply with a dozen or more strokes, then break off the excess with a pliers. When drilling screw holes, use a small starter bit first, then the larger bit. This should prevent the larger bit from wandering across the plexiglass.

The plexiglass must be "spaced" away from the board by approximately 5⁄8-inch, using either spacers or the bolt/nut method. The latter method is to insert a bolt through the plexiglass corner hole and put a nut on the reverse side. Put a second nut on the bolt, allowing a 1⁄2-inch inside space between the two nuts. Do this on all corners. Next, insert the bolts into the board corner holes and put on the final nuts. We recommend securing all four corners, rather than just two.

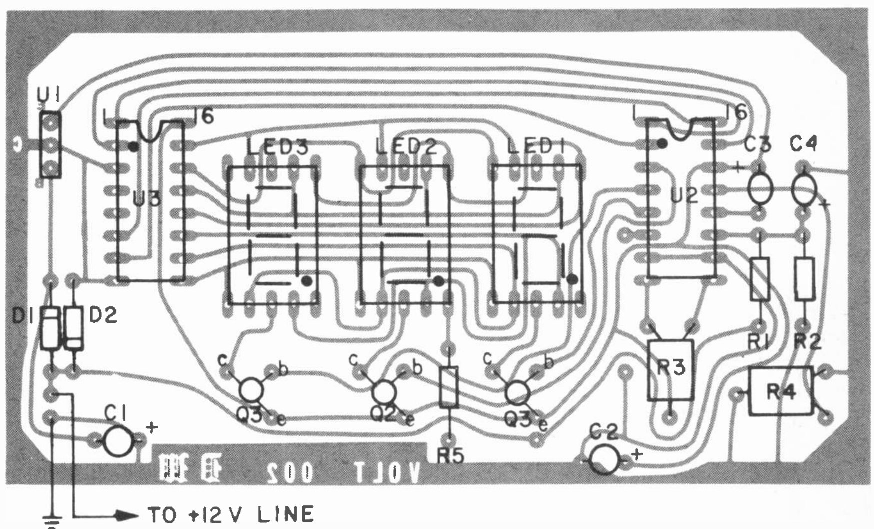
***Troubleshooting.*** If the unit does not light up for the calibration procedure, first check that the wiper of R3 is centered. If it still does not light up, recheck your work. Carefully inspect for possible solder bridges and loose connections. If a solder bridge is discovered, remove it carefully. It is easy to destroy a chip during the removal process. If it still fails to light up, start a systematic test check to isolate possible faulty component(s).

If the unit does not function after installation, recheck for a good electrical connection on the line that supplies power from the car. Did you break or loosen the solder connections of the source wires during installation? If so, this will require removal and resoldering, plus a bit more care during installation the second time.

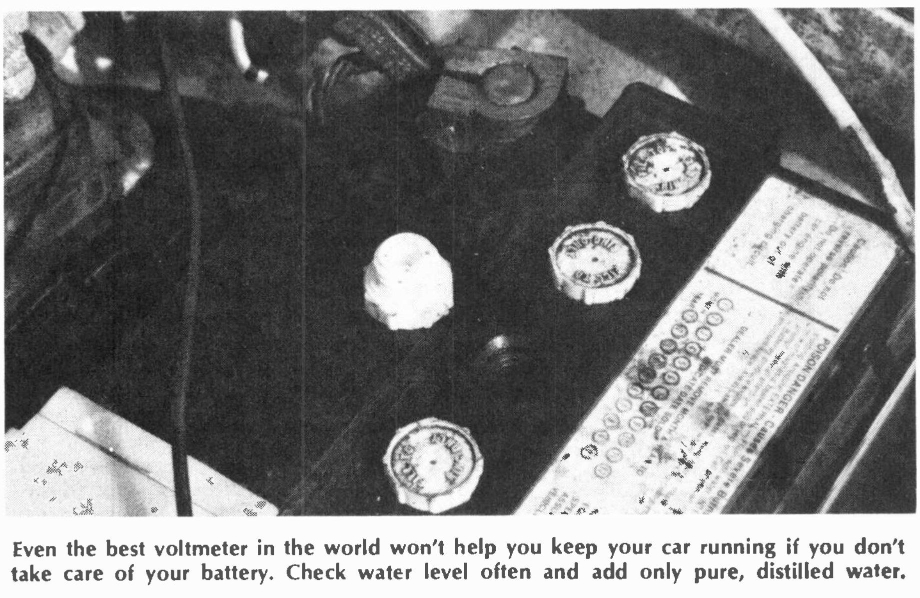
***One Final Note.*** Some ICs, and quite possibly the ones used in this project, generate high frequency harmonics which might find their way into your car's radio. Try holding your LED readout pocket calculator next to the radio antenna with the radio tuned to a blank spot on the AM dial to see what we mean. If you experience any interference from the voltmeter circuit, try rerouting the antenna coax away from the voltmeter itself. A metal case around the voltmeter's PC board will also aid in the reduction of RFI. We suggest that you avoid using the radio's power lead as the voltage source for your voltmeter. The power lead to the horn (or horn relay) or the hot lead of the windshield wiper switch (find it at the fuse box) is probably the best place to attach the voltmeter. ■




This full-scale etching guide for the voltmeter's PC board is one of the trickiest we've offered. Unless you know your stuff, we suggest you use a Digital World board.




The component placement diagram for the PC board shows all IC and capacitor polarities. Take special care to observe them during assembly phases of project.

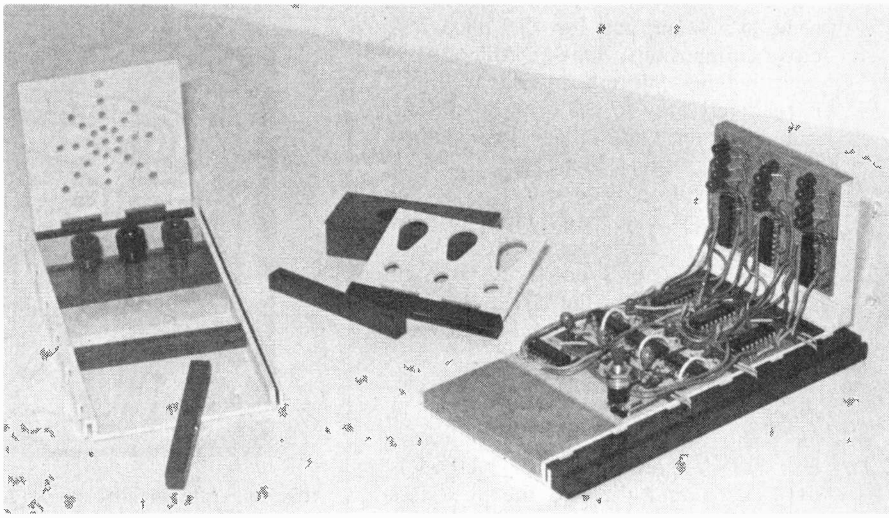


Even the best voltmeter in the world won't help you keep your car running if you don't take care of your battery. Check water level often and add only pure, distilled water.

Project Builder's Budget Tip

# AP Products Hobby Blox

Prefitted color-coded building blocks make for easy perf-board project assembly



CIRCLE 70 ON READER SERVICE COUPON

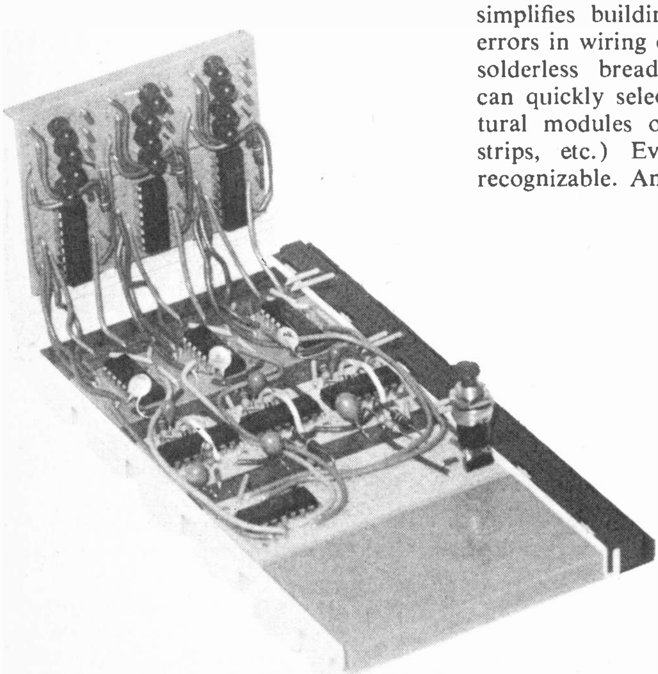
INFLATION BUSTING begins at home, and electronics hobbyists can help by saving cash on the price of their solderless breadboards. Until now, electronics hobbyists had to buy pro-type solderless breadboards and pay "professional" prices to build those projects. Hobbyists have long dreamed of a total breadboard system which would allow the user to customize the board to fit his projects while being both economical and flexible. Well, it looks like the hobbyists have what they want with help from A P Products. Recently, our technical editors had a sneak preview of their HOBBY-BLOX, a new modular circuit-building system designed and produced by A P Products.

At the core of the HOBBY-BLOX system are two starter packs; one for discrete component projects, the other for integrated circuit projects. Each system comes with a number of modules which fit into a tray and an accompanying project booklet that describes step-by-step how to build ten projects with the existing packaged parts. For a suggested retail price of under $7.00, the hobbyist has everything he needs in breadboards at his fingertips.

***The Benefits!*** Every hobbyist (from beginner to more advanced) who gets his hands on the HOBBY-BLOX system will probably make his own list of benefits for this system. Just to give you an idea of the positive features you'll discover, the HOBBY-BLOX system is modular. It doesn't matter what pack you start with, all the modules are interchangeable. A color keyed system is very helpful to the hobbyist because each module is grouped in a different color as it relates to its function. This simplifies building and eliminates two errors in wiring common to uni-colored solderless breadboards. The hobbyist can quickly select the light gray structural modules or the yellow terminal strips, etc.) Every module is easily recognizable. Another feature which is a big plus to the new system is the benefit of being expandable by allowing the hobbyist to add modular parts to design new projects or expand on existing ones. The HOBBY-BLOX system includes 14 separate modules which can be purchased individually.

Two features, compatibility and affordability, are probably the most important to the hobbyists. This system is compatible with DIPs of all sizes and a wide variety of discrete components with wire lead diameters from diode size to ½-watt resistor size (.015" to .032" diameter). In terms of affordability, it would seem like A P Products has thought of everything, even down to the important aspect of costs. Here again, the hobbyist doesn't have to be a Rockefeller to enjoy his pastime. The HOBBY-BLOX system costs less than professional systems with individual modules available to choose only what the hobbyist needs.

***The Way We See It!*** By offering a variety of modules, A P's HOBBY-BLOX system allows the electronics hobbyist to use his imagination to build and expand on a multitude of projects. Our editorial staff saw this concept in its developmental stages and even at that time, the system met the primary objectives of expandability and affordability. The idea of color coding and indexing as well as offering a modular system allows the hobbyist to progress and learn with each project completed. For the experienced hobbyist, here's a fast way to modify projects, and troubleshoot them when circuit design failures occur. To find out where you can buy HOBBY-BLOX system call this toll free number (800) 321-9668; or write A P Products, Inc., 1359 W. Jackson Street, Painesville, Ohio 44077. For more information, circle number 70 on the reader service coupon. ■



**The Hobby Blox system gives the project building hobbyist an easy vehicles for assembling circuits to a professional level without having to resort to expensive and often complicated solderless breadboards.**

# SEMICONDUCTOR ANALYSIS

## THE EXAR XR-2207: A FOUR-FREQUENCY VCO

BY ED NOLL

THE EXAR XR-2207 is a voltage-controlled oscillator (VCO) that can provide simultaneous triangle and square wave outputs or simultaneous pulse and ramp outputs. Frequency range extends from 0.01 Hz to 1 MHz. Four separate output frequencies can be selected by a two-terminal binary logic input.

The internal arrangement, shown in Fig. 1, consists of the VCO and individual buffer amplifiers for both triangular and square wave outputs. There are four internal current switches to which four external timing resistors can be connected. These resistors, in conjunction with the timing capacitor connected between pins 2 and 3, determine the operating frequency. Four individual frequencies can be selected, as set by the logic levels applied to the binary keying input terminals 8 and 9.

A simplified schematic of the frequency control arrangement is given in Fig. 2. The frequency-determining capacitor is connected between pins 2 and 3, while the four frequency-determining resistors are connected to pins 4 through 7. It is these resistors that are keyed in and out of the circuit by the binary information applied to terminals 8 and 9.

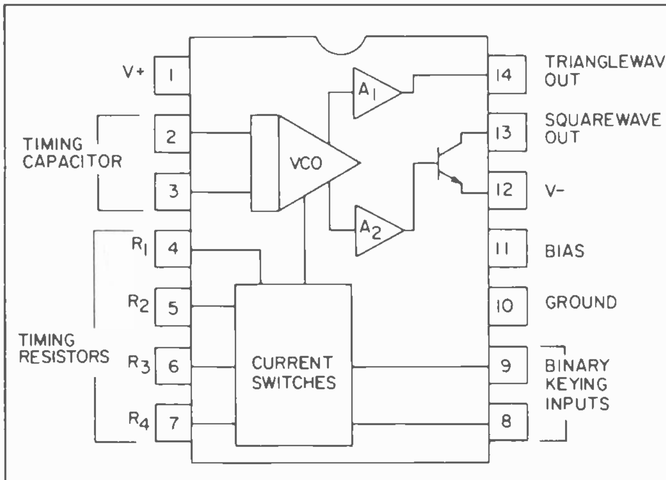



**Figure 1. Block plan of the Exar XR-2207 voltage-controlled oscillator. Note the four internal switches to which external timing resistors can be added.**

***Frequency of Operation.*** The frequency of operation is determined by the resistor-capacitor time constants as selected by the binary logic levels of A and B as applied to pins 8 and 9 respectively. These relations are shown in the table.

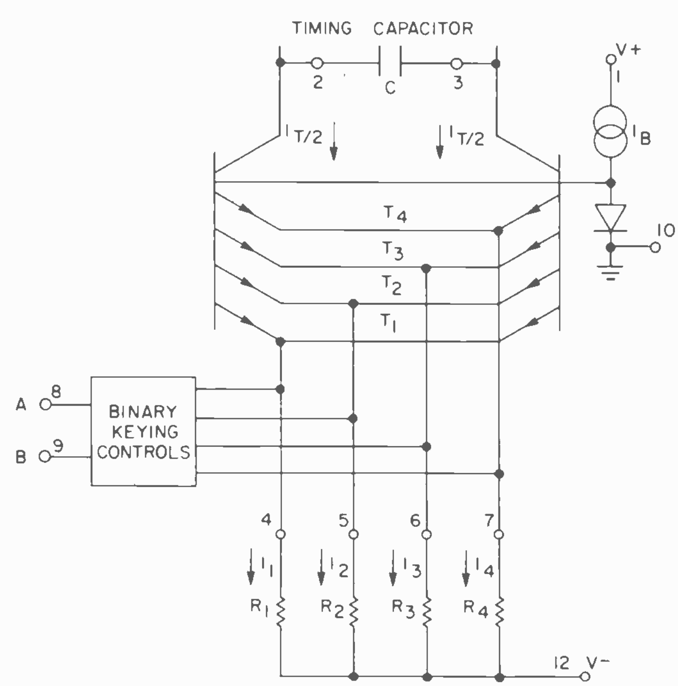
Individual equations for $f_1$, $\Delta f_1$, $f_2$ and $\Delta f_2$ are:

$f_1 = 1/R3C$ $\quad \Delta f_1 = 1/R4C$

$f_2 = 1/R2C$ $\quad \Delta f_2 = 1/R1C$

For example, when terminals 8 and 9 (A and B) are at logic 0, the resistor connected to pin 6 is selected. Thus the frequency of operation is 1/R3C. If the logic level at A is zero and at B is 1, both resistors R3 and R4 are selected. Therefore, the frequency of operation is 1/R3C + 1/R4C. If resistors R3 and R4 were of exactly the same value, the latter logic condition would produce an output frequency that is twice the frequency obtained with the first logic condition.

***Four-Frequency Oscillator.*** The practical four-frequency oscillator circuit of Fig. 3 was set-up by the author on a solderless breadboard. The logic switching is shown at the lower right. When



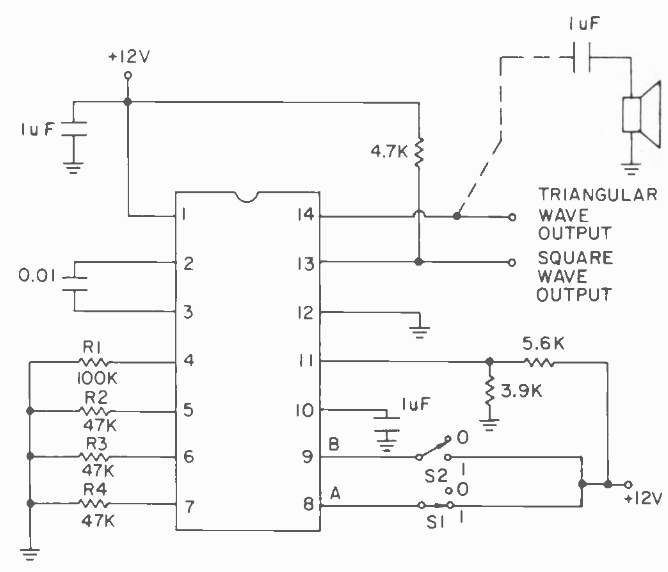




**Figure 2. Schematic of frequency control arrangement is at left. The frequency-determining capacitor is connected as shown.**

**Figure 3. Above is a practical four-frequency oscillator circuit employing the XR-2207. Logic switching is shown at lower right.**

# ANALYSIS

switch S1 is connected to the supply voltage, point A is at logic 1. When switch S1 is open there is a logic 0 at point A. The same applies for the logics at input B using switch S2.

In the schematic diagram, switch S1 is set to logic 1 and switch S2 is set to logic 0. Therefore, A is logic 1 and B is logic 0. From the chart note that this pair of connections selects the resistor connected to timing pin 5. Thus, the frequency of operation is:

$$f_2 = 1/R2C = 1000 \text{ hertz}$$

If switches S1 and S2 are both set to logic 1, the resistors at both pins 4 and 5 are selected. The frequency of operation would be $f_2 + \Delta f_2$. Since resistors R1 and R2 are of the same value, the output frequency would now be 2000 Hz. The value of capacitor C1 and resistors R1 through R4 can be selected according to the desired frequencies of operation.

***Precautions.*** Several precautions must be observed. Terminals 2, 3, 4, 5, 6 and 7 have very low internal impedance and should, under no circumstances be shorted to ground or connected to the supply voltage. In fact, the total current drawn from pins 4, 5, 6 and 7 should be limited to 6 milliamperes or less.

| LOGIC A | B | SELECETED PINS | FREQUENCY |
|---|---|---|---|
| 1 | 1 | 4 & 5 | $f_2 + \Delta f_2$ |
| 1 | 0 | 5 | $f_2$ |
| 0 | 1 | 6 & 7 | $f_1 + \Delta f_1$ |
| 0 | 0 | 6 | $f_1$ |

**This chart shows the pin connections of the various logic configurations possible with the XR-2207. Equations give the frequency.**

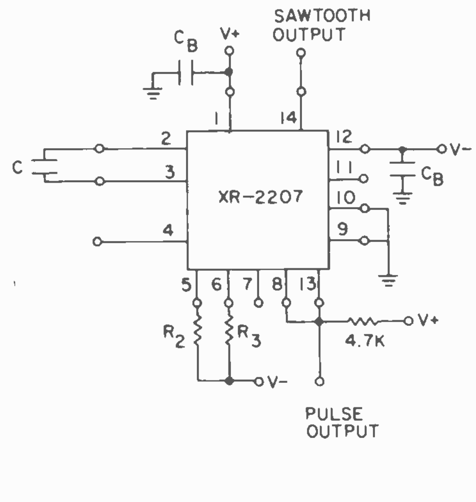



**Figure 4. The XR-2207 set up in a pulse and sawtooth generating arrangement is shown in the schematic above. As the text describes, you'll need either a split-voltage 6-volt supply, or 2 6-volt batteries.**

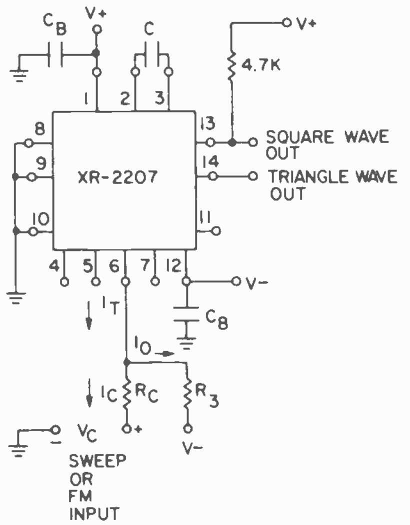



**Figure 4b. The chip set up in a frequency sweep configuration is shown above. Outputs vary with changes in input voltage.**

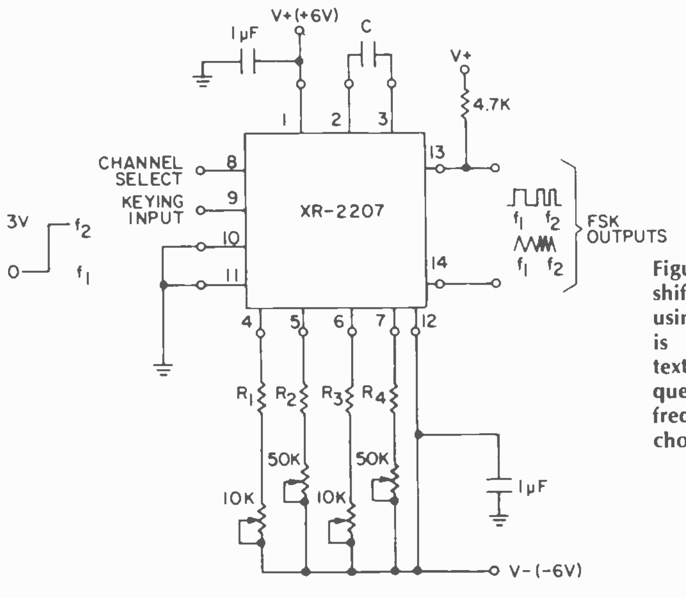



**Figure 5. A frequency shift keying circuit using the XR-2207. As is discussed in the text, two pairs of frequency shift keying frequencies can be chosen as you wish.**

***Output Characteristics.*** The square wave output is an open-collector stage, and a pull-up load resistor is used. Recommended values range from 1K to 100K. The stage is capable of sinking as much as 20 mA of load current. The triangle wave output has a peak swing of about one-half of the supply voltage. It has a very low 10-ohm output impedance. Output can be monitored on a small loudspeaker using the optional circuit connected to pin 14, as shown in Fig. 3.

***Applications.*** In addition to its operation as a voltage-controlled oscillator and waveform generator, the XR-2207 can be used in a phase-locked loop circuit, as an FM or sweep generator or as a frequency-shift keying generator. EXAR suggests several circuit arrangements. The circuit of Fig. 4A shows its application as a pulse and sawtooth generator. In this mode of operation the operating frequency is:

$$f = 2/C(R2 + R3)$$

$$\text{Duty Cycle} = R2(R2 + R3)$$

A split supply connection is used. Two 6-volt batteries or a +6V, −6V split-voltage power supply would do.

The second example shows how the chip can be used for frequency sweep operation. In this application, the square and triangular wave outputs vary in frequency in accordance with the DC voltage change or waveform change applied at the Vc input.

A versatile frequency-shift keying circuit is given in Fig. 5. The keying signal is applied to pin 9. When the keying signal is a 0 level, the output frequency is $f_1$; at the 3-volt level, the output frequency is $f_2$. Thus, as the input keying signal changes between space and mark, the appropriate space and mark audio output frequencies are made available. These frequencies can be set precisely with the potentiometers connected to timing pin connections 4, 5, 6 and 7.

In this versatile arrangement, two pairs of FSK frequencies can be chosen, using the channel select pin 8. For a logic 1 level at pin 8 the mark and space frequencies are determined by resistors R1 and R2. Conversely a logic 0 setting at pin 8 sets up mark and space frequencies determined by resistors R3 and R4. ■

# OCTAVIZER

## Add a third dimension to the sound of music


CONNECT ANY ELECTRIFIED or electronic musical instrument to OctaVizer and your instrument's single frequency output is expanded threefold. In addition to the single frequency input signal, square waves at fifty-percent of the frequency and one at twenty-five-percent of the frequency are available at OctaVizer's output. All three signals can be mixed in any proportion desired, using the *blend* and *prime* controls. The composite output signal can be used immediately, or further processed using filters or other such devices.

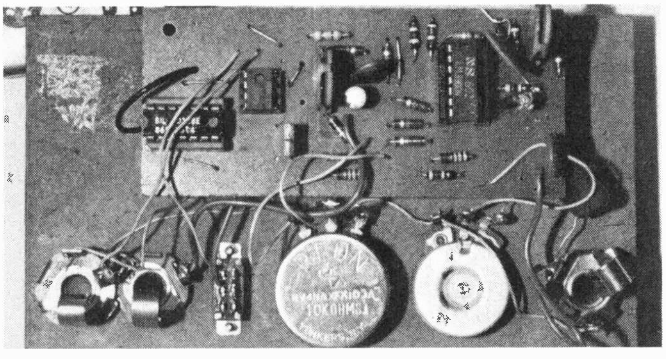
The *blend* control adjusts the relative magnitude of the two square wave signals, while the *prime* control adjusts the amount of input signal which is fed through to the output. The footswitch-operated cancel function disables the square wave outputs when activated.

OctaVizer uses readily available linear and CMOS digital integrated circuits, is powered by a single 9-volt battery, and can be built for less than $15.00.

***How It Works.*** As shown in the schematic diagram, the input signal is AC coupled through C1 and C6 to a low-pass filter and a level control (R23) respectively. R4 and C2 form the low pass filter with a −3 dB point of about 350 Hz, which filters higher order harmonics that might otherwise be detected in later stages and cause false triggering. The filtered signal is amplified in IC1D along with the DC level set by R2. The output of IC1D is further processed in IC1A where it is squared up and clipped. The output of IC1A is AC coupled through C3 and added to the variable DC level set by R12 in the R11, R12, R13 voltage divider. This composite signal is used to trigger a monostable multivibrator (one shot) formed from IC2, R14, R15 and C4. If pin 4 of IC2 is held low by grounding J2, the output remains low regardless of the input. If J2 is not grounded, pin 4 of IC2 is held high by R16 and the pin 3 output is a pulse train of the same frequency as the input signal. This pulse train is used to clock two divide-by-2 flip-flops (IC3B and IC3A) which produce square waves at one-half and one-quarter the frequency of the input pulse train. The two flip-flop outputs are attenuated in the two variable voltage dividers formed by R17, R18 and R19. With R19 set at midrange, two equal voltage dividers are formed which attenuate the 9-volt square wave outputs to about 95-millivolts each (a level similar to that of the input signal). As the wiper is moved toward one side, that divider's signal level is decreased while the other's is increased. Therefore, *blend* control R19 can select either signal alone, or any ratio of the two. The level of the input signal provided to IC1B is selected by the *prime* control (R23). This signal, along with the output of the two voltage dividers, is added in unity gain summer IC1B. Since the output of IC1B has a DC component, it is coupled by C5 to output jack J3.

***Construction.*** OctaVizer can be constructed using any standard technique. Standard CMOS handling precautions should be observed when handling IC3. IC sockets may be used if desired. Assemble all components onto the board, being sure to observe polarity for the ICs, D1, and C5. Note that C6 is not mounted on the PC board, but is wired directly between J1 and R23. Interconnect the completed PC board with all jacks and controls. Any suitable case may be used to house the project.

***Alignment.*** If the input to OctaVizer was always a pure, mono-frequency signal, no alignment would be necessary. However, many electrified musical instruments' outputs are generated by a non-linear electromagnetic device (such as a magnetic pickup) and, as such, contain non-sinusoidal and/or harmonically related components. These



**As you can see from this almost full-scale photograph, the circuit board is rather compact. It would be a relatively easy matter to build it into an existing pre-amp. Any suitable case can be used to house this board, but a "woodgrain" type will match the instrument's finish.**

# OCTAVIZER

components can be detected and cause false triggering. The alignment procedure outlined below will minimize the effects of these components while maximizing the overall response of the unit.

Begin by setting the wiper of R2 to ground, and the wipers of R12 and R15 to midposition. Connect the input device you will be using, and patch the output to an amplifier. Turn the unit on and rotate the wiper of R12 towards ground until you hear oscillation begin. Now turn the wiper of R12 slightly past the point where the oscillations stop (If a VOM is handy, set the voltage on the wiper to about 3¼-volts). Set R23 (*prime*) to minimum and R19 (*blend*) to high. As you play the instrument, rotate the wiper of R2 until an output is obtained. If the output is not half the frequency of the input (as determined aurally), back off R12 very slightly. You will notice that when the proper frequency output is obtained, its duration may be short. To increase the duration, adjust R2 slightly in the direction that produces oscillation. Next, play the highest note you will intend to play. The output will either be correct, very static sounding, or much lower in frequency than anticipated. If the output is correct, no adjustment is required. If the output is static sounding or lower than anticipated, rotate R15 until the proper output is obtained.

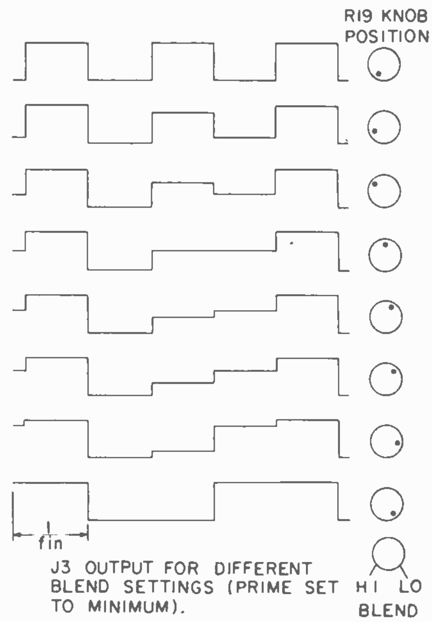
The final step is a fine adjustment which will maximize how long the signal lasts while minimizing false triggering. This adjustment consists of alternately adjusting R12 and R2 until you are satisfied you have obtained maximum duration and minimum (if any) false triggering.

**Use.** OctaVizer can be used over a 3-octave range. As with any new device, it is best to experiment with all controls to determine the effects that can be obtained. A standard guitar can be used with OctaVizer to create a raspy bass guitar effect by setting *blend* to "Hi" and *prime* to "Min." An interesting effect is created with *blend* to midvalue and *prime* set so both output components are of equal loudness. By striking the strings forcefully, you can create high amplitude harmonics that will false trigger the unit and raise the square wave outputs in frequency by an octave. Thus, by varying your striking force, you can play in different octaves.

When viewed on an oscilloscope, the output signal changes shape as shown in the diagram when the *blend* control is rotated. As you can see, at midsetting of the *blend* control, a step approximation to a ramp wave is generated. This signal can be fitted to produce a realistic reed-type sound.

A standard foot switch can be used for the *cancel control*. If not available, one can be made using a push on-push off SPST switch and a length of audio cable.

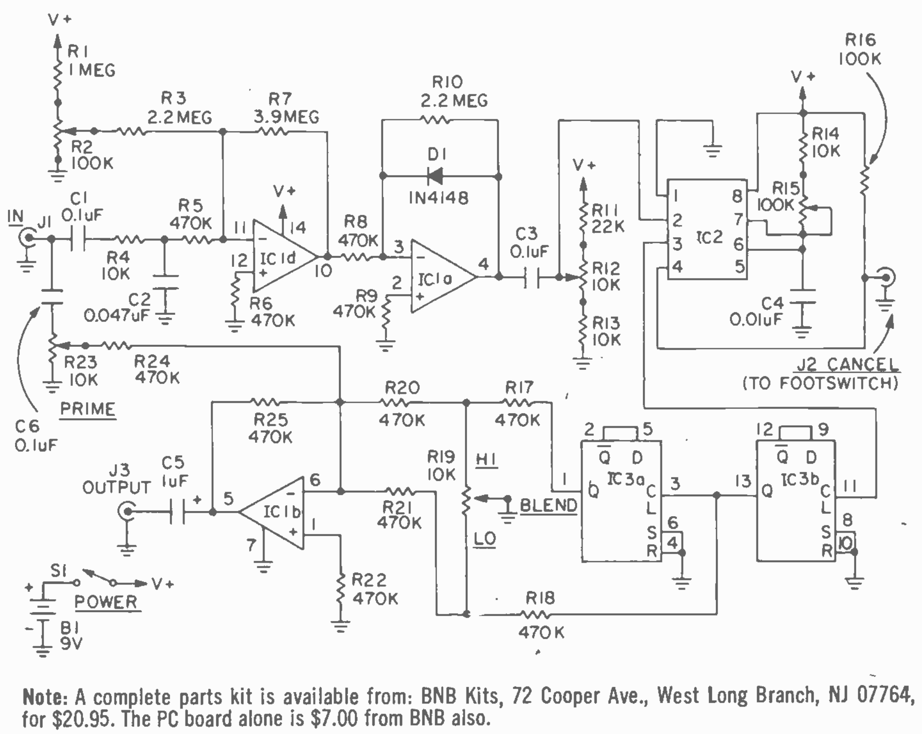
As you familiarize yourself with this new tool, you will find it an interesting and useful special effects device. ■



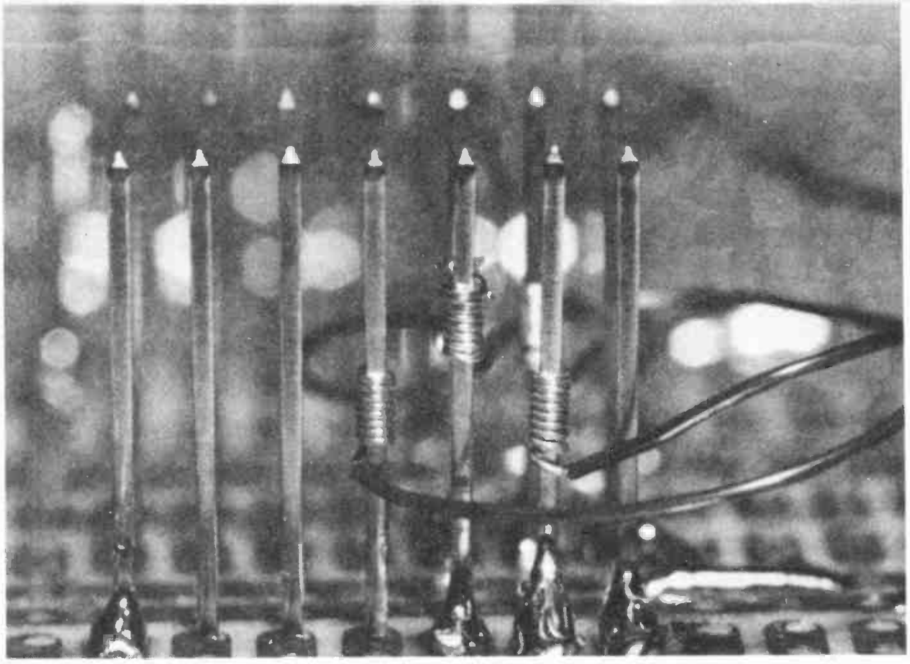

**Here is the chart of the various waveform configurations made possible by varying settings on the "blend" and "prime" controls. Although designed for use through a three-octave range, if used with an electric guitar, false harmonics can be generated by forceful strumming, thus raising the outputs by one full octave automatically.**

**PARTS LIST FOR OCTAVIZER**

**B1**—9-volt transistor battery
**C1, C3, C6**—0.1-µF, 25-VDC disc capacitor
**C2**—0.047-µF, 25-VDC disc capacitor
**C4**—0.01-µF, 25-VDC disc capacitor
**C5**—1.0-µF, 16-VDC electrolytic capacitor
**D1**—1N4148 diode
**IC1**—LM3900 quad op amp
**IC2**—555 timer
**IC3**—CD4013 dual flip-flop
**J1, J2, J3**—standard 2-conductor phone jack
**R1**—1,000,000-ohm, ¼-watt resistor
**R2, R15**—100,000-ohm, ¼-watt vertical-mount trimmer potentiometer
**R3, R10**—2,200,000-ohm, ¼-watt resistor
**R4, R13, R14**—10,000-ohm, ¼-watt resistor
**R5, R6, R8, R9, R17, R18, R20, R21, R22, R24, R25**—470,000-ohm, ¼-watt resistor
**R7**—3,900,000-ohm, ¼-watt resistor
**R11**—22,000-ohm, ¼-watt resistor
**R12**—10,000-ohm, ¼-watt vertical-mount trimmer potentiometer
**R19, R23**—10,000-ohm, ¼-watt linear-taper potentiometer
**S1**—SPST slide switch
**Misc.**—cabinet, hookup wire, knobs, etc.




**Note:** A complete parts kit is available from: BNB Kits, 72 Cooper Ave., West Long Branch, NJ 07764, for $20.95. The PC board alone is $7.00 from BNB also.



# WIRE-WRAPPING TECHNIQUES

Streamline electronic circuit construction with this new method.

BY WALTER SIKONOWIZ

WHAT'S THE BEST METHOD for construction of an electronic circuit? There is no easy answer to this question, since the most suitable method varies from project to project (as well as from builder to builder). In this article we are going to take a look at wire-wrap construction; in particular, we'll focus on the OK Machine & Tool's new WK-4B wire-wrap kit.

***The OK WK-4B Kit.*** Each WK-4B comes with one circuit board, a dispenser loaded with AWG No. 30 Kynar wrapping wire, four wrappable IC sockets, a tool for wrapping and unwrapping, an IC insertion tool, an IC extraction tool, and a 22-pin double row edge connector that mates with the kit's circuit board. The clear plastic wire dispenser is an ingenious little device with a built-in wire cutter and wire stripper. It produces cleanly stripped and cut wire in a matter of seconds with a minimum of fuss. Equally ingenious is OK's IC insertion tool. Not only does it do a perfect job of getting an IC into its socket, but it straightens bent IC pins as well.

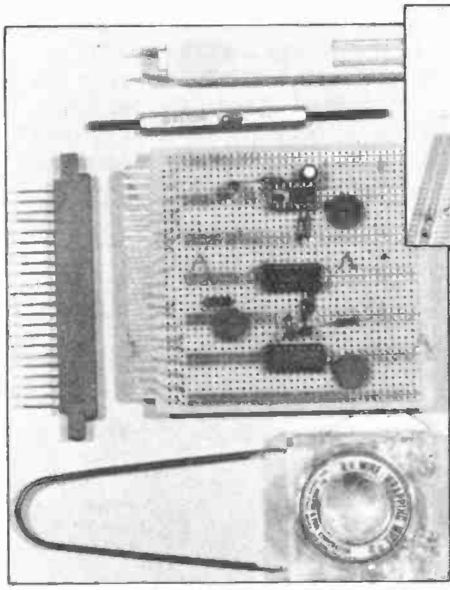
The circuit board is made of heavy duty epoxy composition, which doesn't bend the way paper laminates sometimes do. Each board has etched upon it a pattern of solder-plated copper pads and buses. During construction, which we'll cover later, the builder uses these pads and conductors to satisfy as many of his circuit's connection requirements as possible. Whatever connections that remain are made by wire wrapping. The board's edge has a double-sided pattern of 22 plated fingers that mate with the kit's edgeboard connector. This is handy if the circuit you're building is to be one module of a larger system. Simple projects, however, will not require edgeboard connections, and you can ignore them.

Also included is a double-ended, rod-shaped tool, one end of which does the wrapping. The other end can be used to unwrap an incorrect connection, if necessary. Wrapping is a quick and simple operation that involves threading one end of a stripped wire into the wrapping tool, placing the tool over a wrapping post, and wrapping about ten turns of wire into place. Since the wrapping wire is of light gauge, very little force is required to make an electrically secure connection.

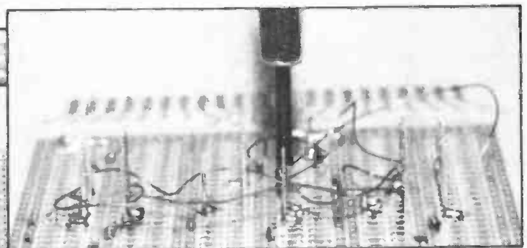
At least part of the credit for a secure wrap must go to the wrapping post. These posts have a square cross section, the corners of which bite into the soft wire as it is wrapped into place. The resulting connection is mechanically tight and of low electrical resistance. Four IC sockets are supplied with the kit, and all of them have wire-wrappable square posts. When you run out, you can buy extra sockets from any electronics dealer. The last kit component, an IC extraction tool, is a U-shaped pincer that lets you pluck an IC from its socket in much the same way as a dentist yanks a tooth.

***A Typical Application.*** Now let's review the construction of a typical project—in this case, the simple pulse burst generator illustrated here. Begin by putting the required IC sockets into convenient positions on the board, and tack-soldering two diagonally opposed pins of each socket to the circuit pads. This serves to anchor the sockets in

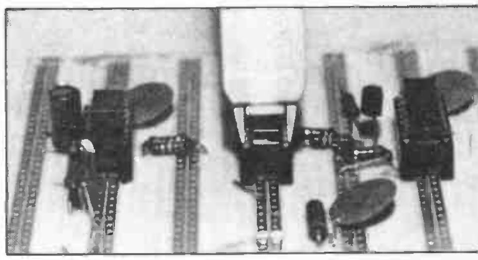
*(Continued on page 101)*



**All elements of the OK wire-wrapping kit come conveniently packaged in plastic.**



**The wire-wrapping tool fits over the posts on the circuit board for fastening on wires.**



**OK's IC insertion tool aids in assembling projects that use ICs in the circuit design.**

# Solid State Multivibrators

**By any other name there are still three basic types**

☐ When the conversation turns from the Mets to multivibrators, you may hear all manner of strange words bandied about. Flip-flop, one-shot, astable, and bistable roll off the tongue of the all-knowing. And don't be too surprised if you hear the words free-running, single-step, and monostable—to name just a few—at your next electrified cocktail party. What do all these terms mean? Are there really so many different kinds of multivibrators? And, for that matter, of what use is a multivibrator for the experimenter?

The main job of a multivibrator is to generate square waves and pulses. Period. That's all!

A square wave is often used as a test signal for audio amplifiers to reveal frequency-response problems. In other applications, multivibrators generate short time constant pulses—only a few microseconds in duration. These mini pulses synchronize, or steady, the picture on our TV screens.

Longer pulses—those which are several seconds in duration—control the exposure time of photographic enlargers. Slow multivibrators can also drive the flashing warning lights seen by motorists as they approach roadside hazards. And, in the radio amateur's shack, faster multivibrators running at audio rates train the ham's eye and ear as he works with his code practice oscillator. Or, the same MV, as the multivibrator is also called, doubles duty as an audio signal source. The list could go on and on.

The uses of multivibrators grow daily, limited only by the ingenuity of those who understand their working principles.

The imposing list of names in the first paragraph creates the impression that there must be almost a dozen different types of multivibrators. Fortunately, this is not so! There are only three basic types. The long list of names merely shows the existence of more than one name for the same type of multivibrator.

***The Circuit With an Alias.*** The three basic types of multivibrators are the *free-running* multivibrator, the *one-shot* multivibrator, and the *flip-flop*. With these three basic circuit types under your belt, you can whip up any of the jobs a multivibrator is capable of doing.

The free-running multivibrator is probably the type most familiar to the experimenter. It is very likely that the square wave generator or oscilloscope on his workbench has a free-running multivibrator buried somewhere in the instrument's circuit. The outstanding characteristic of the free-running multivibrator—and the one from which it earns its name—is that it runs freely. As long as a power supply is connected to it, the free-running MV enthusiastically pumps out a never-ending stream of square waves. This feature consistently earns the title of the Most Popular Circuit whenever John Q. Electronicsbuff needs square waves. See Fig. 1.

In contrast to the free-running MV, the one-shot multivibrator is a very reluctant beast. If fed DC from a power supply, it does not react by joyously bubbling forth a stream of square waves like its enthusiastic free-running cousin. Instead, it sits there, doing nothing.

And, it will continue to sit there unless kicked in the right place by an externally generated pulse, called a trigger pulse.

Under this urging, it reluctantly makes one and only one pulse, and then lapses back into its former sullen condition. Until, of course, it's kicked by another trigger. It derives its name—one shot—from the fact that it gives only one pulse in response to a trigger. See Fig. 2.

***Flip Out Forget-me-not.*** The third type of multivibrator, the flip-flop, is a forgetful fellow. It, like the one-shot, gives no output pulse unless urged by a trigger pulse. But its response to a trigger is quite different. It starts out to produce a pulse, but forgets to end it, unless told to do so by another trigger pulse. Strangely enough, this forgetfulness can be turned into a memory. The flip-flop is the heart of the register system of large computers. See Fig. 3.

How can this be? Because, as Fig. 4 shows, the flip-flop can remember forever (or, at least, until the power is turned off) that a trigger pulse has been applied to it. Using this single basic capability, the registers of giant computers can be constructed.

***Some Basic Building Blocks.*** Circuit diagrams for these three basic multivibrators are surprisingly similar. They're all built from the same basic building blocks. These building blocks are shown in Fig. 5.

The free-running multivibrator combines these basic building blocks. The

Fig. 1

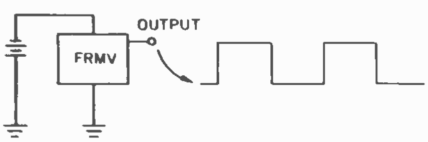



Fig. 2

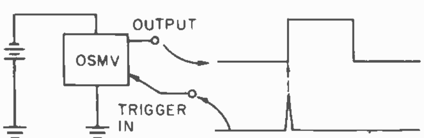



Fig. 3

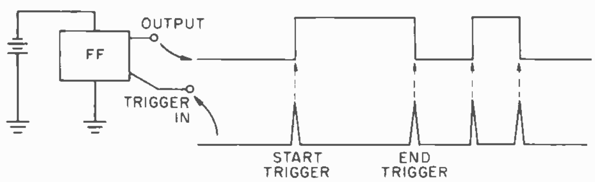
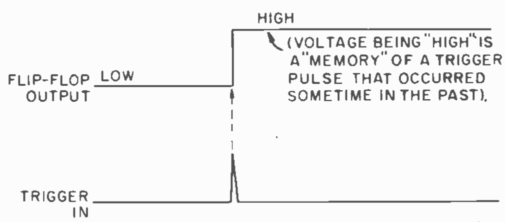



Fig. 4



component values shown in Fig. 6 will make a free-running multivibrator which runs at 440 Hz. Musicologists know that frequency as A above middle C on the piano.

To double that frequency, cut the values of both coupling capacitors in half; to triple it, cut them to one third the value shown, and so on. To hear the square wave, place an ordinary 2,000-ohm headset across either 1,500-ohm collector load resistor. To see the square wave, connect an oscilloscope to the point marked "output."

The one-shot multivibrator is very similar. It is built from pieces stolen from the free-running multivibrator as shown in Fig. 7 by replacing one of the coupling capacitors with a coupling resistor, and one of the "on" amplifiers with an "off" amplifier.

The values shown produce a pulse two seconds long. To double the pulse length, double the capacitor's value; to triple it, triple the capacitor's value, and so on. To hear the pulse, place an ordinary 2,000-ohm headset across either 1,500-ohm resistor.

Momentarily touch the point marked "trigger in" to the the power supply. A click will be heard in the headphones as the one-shot begins its solitary pulse. Two seconds later, a second click will be heard as the one-shot ends its pulse. (The actual time may be longer, because large-value capacitors sometimes have twice the capacity on their case.)

To see the pulse, connect a voltmeter to the point marked "output." It will indicate –9 volts. Trigger the one-shot as above, by touching "trigger in" to the power supply. The voltmeter's needle will drop to zero volts, remain there for two seconds, and then pop up to 9 volts again.

To change the one-shot schematic to a flip-flop schematic; both pulse amplifiers must be of the biased-off type, and both coupling elements must be resistors. See Fig. 8. To see the action of this circuit, connect a voltmeter to output #1 or output #2—whichever of the two causes the voltmeter to register –9 volts. Leaving the voltmeter connected, short the output to ground. The voltmeter reading will drop to zero, of course, because there is a dead short right across its terminals. But, the surprising thing is that the reading will stay at zero after the short is removed.

Next, short the other output to ground. The voltmeter reading will rise to –9 volts, and stay there after the short is removed, showing that the flip-flop can remember an occurrence (like shorting one output) even after the occurrence is ended.

***Kicked by a Trigger Pulse.*** Of course, shorting an output to stimulate the flip-flop into action is not the same as running it from a trigger. Triggering circuitry can be added to the basic flip-flop as shown in Fig. 9.

So, in spite of the abundance of names, there are only three basic types of multivibrators. Call the MV what you will, but the application of these three types reach through to almost every project the electronics hobbyist is likely to conjure up on his workbench. ■

**Fig. 5**

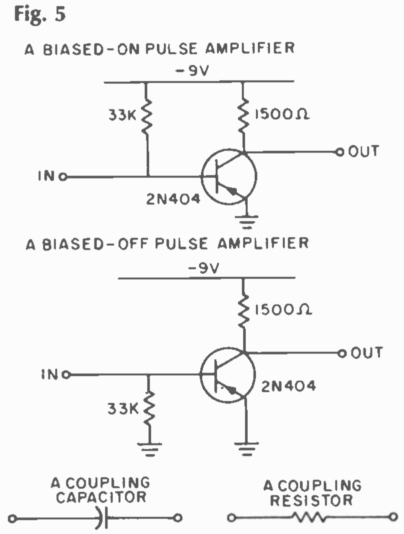



**Fig. 6**

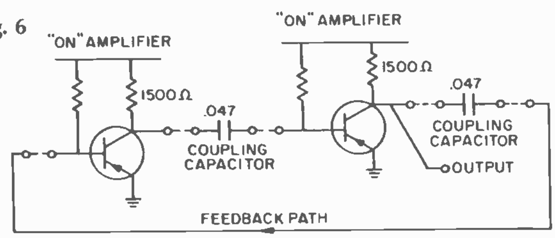



**Fig. 7**

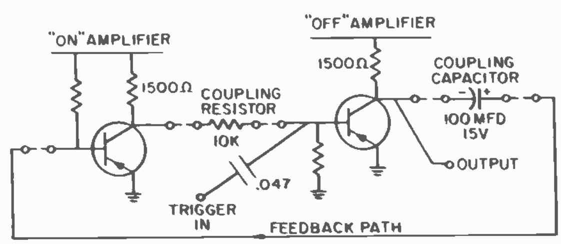



**Fig. 8**

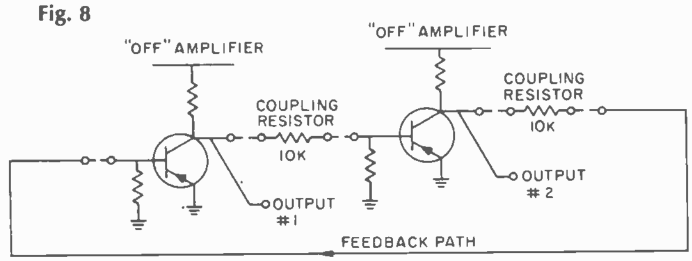
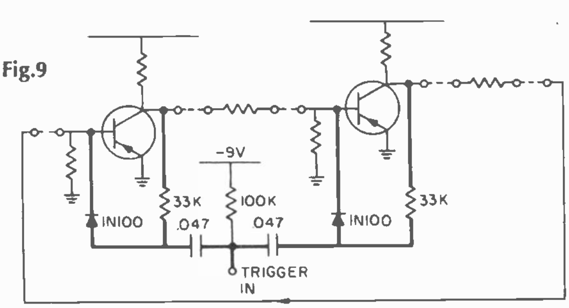


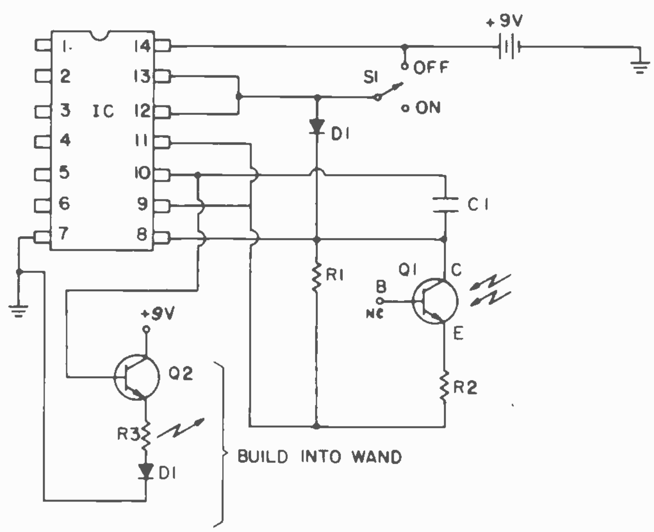

**Fig.9**



# 98 Magic Blinker

99 IC PROJECTS (Continued from page 61)

☐ Imagine a small black box that you place on a table in front of your friends. Connected to the box with a thin wire is a wand with a small red light (LED) on the end. The light flashes about twice a second, but at your command, it flashes faster and faster. You hand it to your friends, but they cannot do it. The secret? In the box is a small hole with photo transistor Q1 showing through. As D1 gets closer to Q1, it flashes faster and faster but it will take your friends a long while to catch on. It's especially effective when all the room lights are out. Have fun.

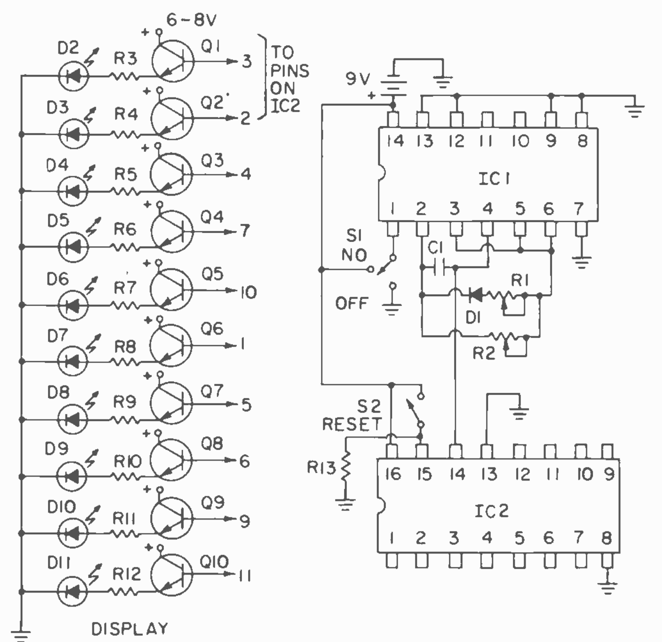



**PARTS LIST FOR MAGIC BLINKER**

**C1**—0.01-uF ceramic capacitor, 15 VDC
**D1**—small LED
**D2**—1N4001 diode
**IC1**—4000 dual NOR gate w/inverter
**Q1**—FPT100 phototransistor
**Q2**—2N4401 transistor
**R1**—5,000,000-ohm, ½-watt resistor
**R2**—1,000,000-ohm, ½-watt resistor
**R3**—680-ohm, ½-watt resistor

# 99 Rippling Wave

☐ The rippling effect on the ten LEDs is a beautiful and interesting sight, especially if they are mounted atop a nice wooden case and placed in the living room. A nice conversation piece. The speed of the ripple is controllable via R1 and R2, where a smaller R1 and R2 makes the ripple go faster. The "on" of each LED overlaps perfectly with no momentary "off," so the ripple travels very smothly.




**PARTS LIST FOR RIPPLING WAVE**

**C1**—0.01-uF ceramic capacitor, 15 VDC
**D1**—1N4401 diode
**D2 through D11**—small LED
**IC1**—4011 quad NAND gate
**IC2**—4017 decade counter
**Q1–Q10**—2N4401
**R1**—10,000,000-ohm linear-taper potentiometer
**R2**—500,000-ohm linear-taper potentiometer
**R3 through R12**—1,000-ohm, ½-watt resistor
**S1**—SPDT slide switch
**S2**—SPST momentary-contact pushbutton switch
**R13**—100,000-ohm, ½-watt resistor

# 24 Battery Monitor

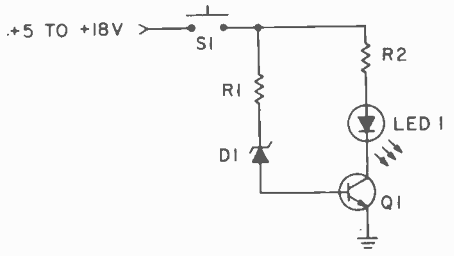
Transistor Projects (Continued from page 74)

☐ Tired of playing guessing games with your batteries? With this battery-voltage monitor you'll know at a glance whether or not batteries need replacement. The circuit's compact size, which comes about because it's a meterless voltage monitor, makes it easy to build into an existing piece of equipment. To use the device, press S1 and, if LED1 lights up, your batteries are still good. If not, throw them away.

Transistor Q1's gain makes the monitor very sensitive to changes in voltage. Consequently, LED1 is either ON or OFF with little ambiguity most of the time. The voltage level being sensed is determined by zener diode D1's rating and the base-emitter voltage drop of Q1. Specifically, the switching point is equal to the zener voltage plus 0.75-volts. For example, a 5.6-volt zener diode will set the trip level at approximately 6.35-volts. The voltage level you choose should be less than the battery's nominal voltage when fresh. A 9-volt battery, for example, might be useless when its voltage drops to 7.5-volts; however, the exact point at which a battery becomes useless depends both on the battery and on the application. Finally, it's best to test the battery with a normal load current being drawn.

**PARTS LIST FOR BATTERY MONITOR**

**D1**—zener diode (see text)
**LED1**—light emitting diode rated 20-mA @ 1.7-VDC
**Q1**—2N3904 NPN transistor
**R1**—1,500-ohm, ½-watt resistor, 5%
**R2**—680-ohm, ½-watt resistor, 5%
**S1**—normally open SPST push-button switch



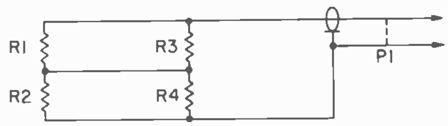

# 25 Low-Power Dummy Load

☐ For transmitter tune-up and testing, you need some sort of dummy load. As far as your transmitter is concerned, the dummy load looks just like a normal 50-ohm antenna. However, with a dummy load, almost all of the transmitter's output power is dissipated as heat rather than being radiated as RF. This makes little difference to the transmitter itself, but it makes a world of difference to nearby Amateurs or CB-ers because they don't have to contend with the interference generated as you fiddle with your transmitter.

Dummy loads are available commercially, but the Amateur QRP (low-power) enthusiast or CB'er can easily and inexpensively build his own. All you need are four 50-ohm, 2-watt, carbon-composition resistors, a coax plug and a minibox. (You must *not* use wire-wound resistors, even though they are capable of handling more power than carbon resistors, because wirewounds exhibit too much inductance.) Keep the interconnecting wires as short as possible to minimize stray inductance and capacitance. Used on an intermittent basis, this dummy can safely handle about 15-watts.

**PARTS LIST FOR LOW-POWER DUMMY LOAD**

**P1**—PL-259 coaxial plug
**R1 thru R4**—5-ohm, 2-watt carbon composition resistors




## Superbass

*(Continued from page 86)*

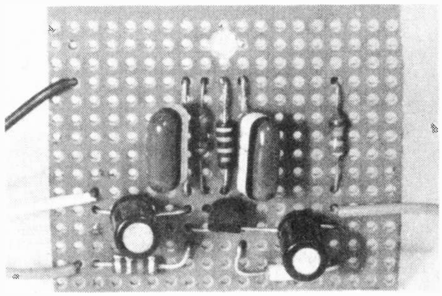
cork or rubber will retain the battery. You can use small cork "feet" such as sold in hardware stores for use on the bottom of bric-a-brac to prevent scratching of furniture. The cost is usually well under fifty cents and you can cut the "feet" to the needed size.

Take extra care to get S2's wiring right the first time. Note that S2 is SPDT, switching only the output connection. The input is permanently connected to the amplifier and switch S2.

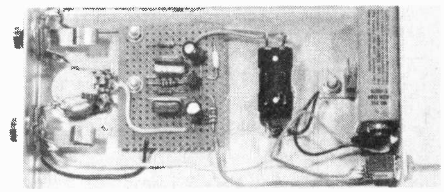
Nothing about the entire project is really critical other than the values of C2 and C3. Resistors need be no better than 10% tolerance—why spend money for better tolerance when the project won't work any better?—and electrolytic capacitors C1 and C4 can be any value from 2.2-uF to 4.7-uF. Use whatever you can get at lowest cost. The same "lowest cost" rule applies to C2 and C3; they don't have to be precision tolerance as long as their rated value is 0.1-uF.

***Using Superbass.*** Connect your electric guitar or other electronic instrument to input jack J1; connect output jack J2 to your instrument amplifier's normally-used input. With power switch S1 *off*, key S2 so the instrument feeds directly to the instrument amplifier. With R2 set full counter-clockwise (Off), turn power switch S1 on, key S2 once, and advance R2 for the desired superbass sound level. To cut back to natural sound just stomp down on S2 and key the superbass out.

Don't worry about leaving power switch S1 on for the several hours of a gig. The circuit pulls less than 1-mA from the battery, so the battery will last many, many months. ■



**Bread board amplifier component mounting eliminates the need for etching your own PC board.**



**Inside the completed Superbass. Secure the amplifier board well to withstand the stress and pressure.**

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## Wire-Wrapping

*(Continued from page 95)*

place. Next, wire the power connection pins of each socket to the power buses using conventional wire jumpers and soldering them in.

Now insert the rest of your components, and interconnect them with a hybrid technique: solder those connections which can be made using the board's copper pad pattern. For instance, the junction of two resistors is easily established by inserting the wire leads of the resistors into two adjacent holes in a copper pad, and soldering both leads to the pad.

***Wire-Wrap Tight Spots.*** The great advantage of the wire-wrapping technique is that it allows connections to be made in tight places. There is no danger of shorts from solder bridges, and no nicking of insulation by a hot iron. However, a good wire-wrap joint requires a square post to wrap over. Wrapping on the round lead from a resistor is all right as a temporary technique, but not recommended for more permanent construction.

Digital projects, where the ICs usually outnumber the passive components, will require lots of wrapping. On the other hand, projects containing more passive components than integrated circuits will demand a greater amount of soldering. (Note: Passive components have widely spaced leads; hence they are easy to solder. Integrated circuits, with their tightly spaced pins, are much easier to wire-wrap.)

***The Results.*** How did the WK-4B kit work? Just fine, as you can see from the neat looking pulse burst generator illustrated here. The technique is relatively fast and convenient—much easier than perfboard. While wire-wrap may not be as compact (nor as quick to assemble) as a pre-fab printed circuit, it is much faster to assemble than a homemade PC board. Furthermore, the wire-wrapped connections are every bit as reliable as a solder joint, provided that you make them properly. As testimony to that fact, it should be noted that even commercial equipment is being wire-wrapped today—often by computer-controlled wire-wrapping tools.

So, whether you're building a prototype of your own design, or assembling a project for which no prefab PC board is available, why not give wire-wrapping a try? For more information on the WK-4B Kit, write OK Machine and Tool Corp., 3455 Conner St., Bronx, NY 10475. Circle No. *40* on the Reader Service Coupon. ■

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396. *Creative Computing's* first software catalog of various education and recreation simulation programs as well as sophisticated technical application packages is available now.

395. *OK Machine and Tool* explains the technology of wire-wrapping, complete with illustrations, in its catalog of industrial and hobby products. The 60-page book (80-36N) is available now.

394. *KEF Electronics Ltd.* is offering two speaker systems in kit form at a significant cost-savings. The Model 104aB and the Cantata can be easily assembled and may be auditioned before purchasing.

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408. *PanaVise Products, Inc.*, a manufacturer of precision vises for holding electronics projects, circuit boards and other devices requiring precise, steady support is offering their new eight-page color catalog. The PanaVise system uses a series of interchangeable base mounts and accessories to accommodate a variety of applications.

404. *Spectronics, Inc.* offers a complete line of equipment for the shortwave listener. Their catalog lists receivers, a complete SWL library and numerous other accessories, all at discount prices.

405. The *Kester Solder Company* is offering a book on soldering techniques and a handy guide to the various types of solders and their applications. Both are valuable items for the electronics hobbyist working with conductive metals.

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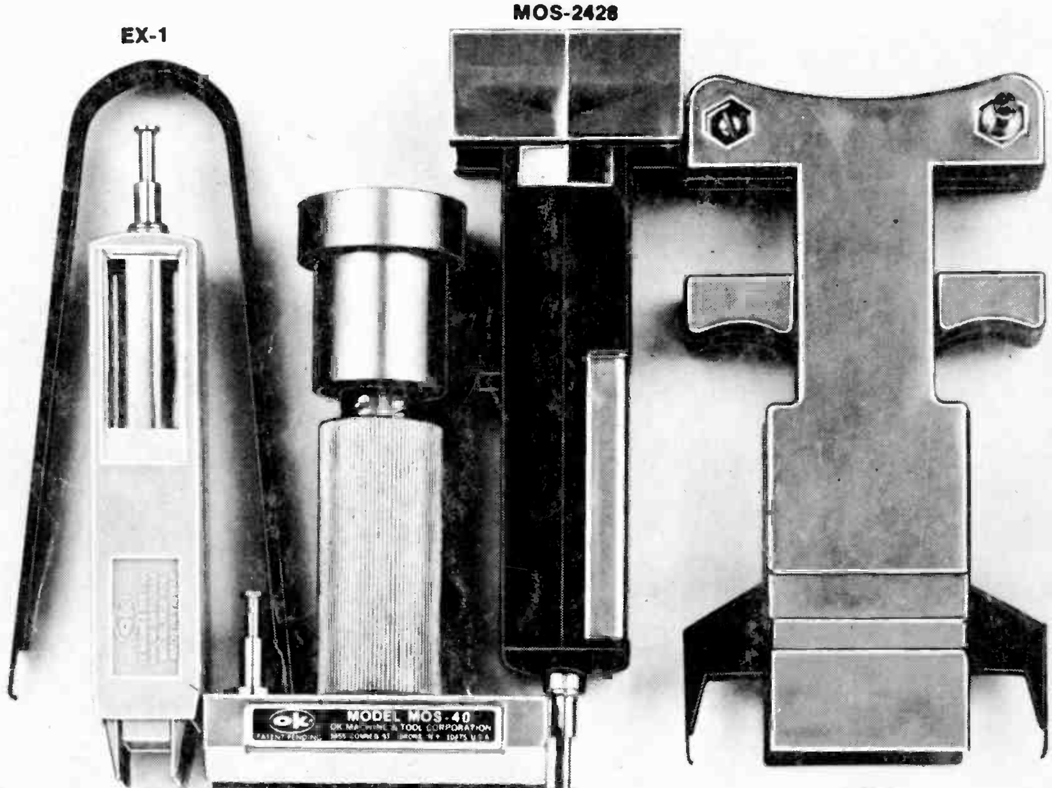


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