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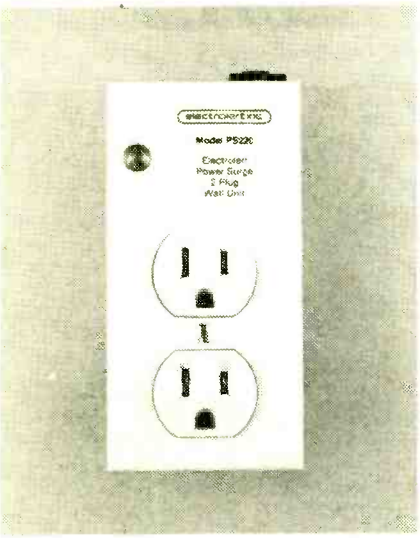
OUTLET EXTENDER/PROTECTOR



Electrolert Model PS220 Power Surge 2-Plug Wall Unit

Electrolert is offering a new line of power supply products, which includes three new surge/spike protectors, that put an end to harmful power surges/spikes before they put an end to your electrical equipment. Voltage surges (also known as transients, spikes, and glitches) are capable of causing extreme damage or even total destruction to systems that are left unprotected. Electrolert has also introduced two new multiple outlet extenders, ideal for organizing and providing electrical power for electrical equipment such as: home computers, TV's, stereos, microwave ovens, etc. These products convert one electrical outlet into many.

One such unit, the Model PS220 Power-Surge Extender is a 2-plug wall unit with surge protection. It plugs into any 120-VAC outlet and protects equipment connected to it from the harmful effects of voltage surges. The PS220 also contains a circuit breaker with reset and indicator light. The suggested retail of the Model PS220 is $34.95.

For further information on Model PS220 and other extended units, contact Robert McDougall, Electrolert, Inc. 4949 South 25A, Tipp City, OH 45371.

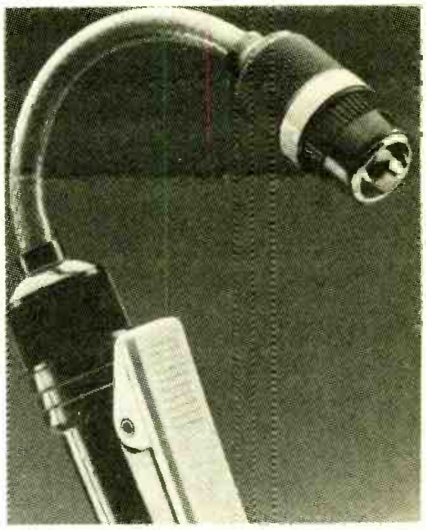
SOFTWARE INTERFACE

A new concept in Amateur Radio and computer interfacing, COMP-CODE 1.0, a software-only Morse Code Interface is especially written for the Radio Shack Model 1, III, and IV microcomputers. This unique program uses the standard TRS-80 cassette I/O parts for input and output connections to a communications receiver and transmitter, or transceiver. The results obtained from this software-only interface has been found to equal that of combined hardware/software interface packages offered by others costing many times more money.

This 12K machine-language program has special routines that check the incoming signal to make sure it is valid Morse code signal and not noise. Bursts of noise are disregarded and only valid Morse code is processed and displayed on the video screen. There is also a routine that allows the monitor viewing of the incoming signal to aid in the optimizing of the receiver control settings. The program samples receive code bits and automatically adjusts to the proper speed. The transmitter mode features five programmable buffers (200 character total), a type-ahead working buffer, and user selectable sending speeds up to 70 words-per-minute.

Before spending $150 and $499 dollars on other hardware/software systems, you owe it to yourself to try this new software-only interface for only $24.95 plus $2.00 for shipping and handling. Please specify Model I or Model III TRS (Model III version also works on a TRS-80 Model IV). Send check or money order for $26.95 to Gary Woodall, Box 284, Plainfield, IN 46168. Questions can be answered by calling (317) 271-2565 after 5PM weekdays or all day Saturday.

NEW FLEXIBLE LIGHT



The FL-100 flexible light illuminates those hard-to-reach work areas, putting the light where you need it. Its high-intensity prefocussed bulb and reflector system measures only ½" in diameter. The tool's 4" long flexible shaft positions light in any direction. Additional features are a convenient rotary switch and a spring clip on the handle which allows it to be clipped to any handy surface, thereby freeing both hands. Ideal for checking and repairing electronic and mechanical equipment of all types, the FL-100 is essential for workshop and field service use. Requires two "AA" batteries (not included).

The FL-100 is available from stock at local electronics distributors nationwide or directly from O.K. Industries, 3455 Conner Street, Bronx, New York 10475.

PHONES THAT REMEMBER

ATT Touch-a-Matic 6000 Automatic-Dialing Telephone

The latest in automatic dialing telephones, is ATT's Touch-a-Matic 6000 telephone that can be programmed to Dial 59 frequently used numbers including three that are color-coded—red, green and blue—so that even a child can learn how to dial for help in an emergency. One location is reserved for automatic redialing of the last number called. All numbers, up to 16 digits, are permanently stored in memory for instant one-touch dialing.

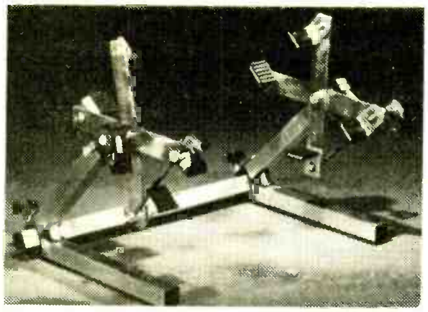
The Touch-a-Matic 600 phone stores that last number called in memory for one-touch redialing. If a number is busy the first time it is dialed, just a touch will recall that number automatically. As the number is dialed, or after one of the automatic dialing locations is touched, the called number appears on a liquid-crystal display screen.

The digital display on the Touch-a-Matic 6000 phone shows both time and date continuously when the phone is not in use. When dialing or programming a phone number, the display shows those numbers for checking accuracy. The last number dialed or any one of the repertory numbers is instantly called up for display by pressing the appropriate location.

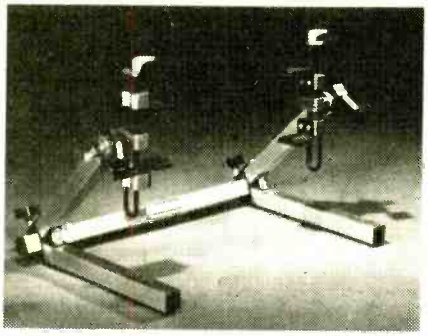
The phone also has an automatic timer so that users can time their telephone calls—or anything else they may want to time—up to 99 minutes and 59 seconds.

The Touch-a-Matic 6000 phone comes in an almond colored desk model whose modern styling would accent any home or office decor. It installs easily by plugging into a modular telephone outlet. The Touch-a-Matic 6000 is available nationally at company-owned ATT Phone Centers and retailers. The suggested retail price for the Touch-a-Matic 6000 phone is $229.95.

CHASSIS MOUNT



Panavise Model 601 Chassis Mount with Scissor Clamps



Panavise Model 602 Chassis Mount with Centering Heads

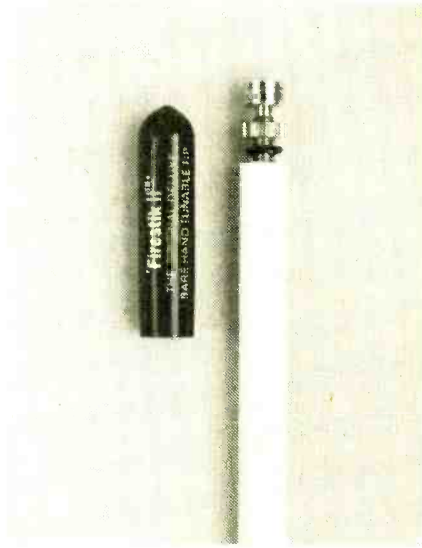
Panavise unveiled their new chassis mount product. This lightweight and portable Chassis Mount was designed to provide industry and hobbyists with a holding device loaded with features and advantages never before available. Available with either self-centering heads (Model 602) or with scissors clamp (Model 601), the Chassis Mount offers a load capacity of a full 100 pounds, and width capacity of up to 18 inches.

The upright arms, legs and crossbars are made of sturdy, thick 1/8-in. wall by 1 1/4-in. square tubing. The arms provide a pivot center height of 9-in. from work surface.

For safety, a positive lock detent is visible while rotating the chassis, and a visual indicator shows when the safety latch is engaged or disengaged. An all metal friction brake design allows for either right or left hand operation and is conveniently located at a natural angle for a seated operator. Quick width adjustments of the side frames can be made by sliding them along the cross beam and then tightening the locking knob.

Because of Panavise's unique design, more than one head operation is available. The scissors clamp has 360 degree swivel jaws thus allowing for odd-shaped chassis to be mounted and the quick opening self-centering head offers a full 9 inches of opening. The Chassis Mount retails for only $199.95. For more information and details, contact: Panavise Products, Inc., 2850 E. 29th St., Long Beach, CA 90906; or telephone (213) 595-7621.

NEW ANTENNA TWIST



Firestik II Tunable Tip

Firestik Antenna Company has been awarded a patent for their newest innovation, the Firestik II antenna. The highlighted feature of the fiber glass wire-wound Firestik II antenna is at the top of the stick. In the past, antenna installers had to labor through a tedious and time consuming process to match their antennas to the transmitter; often times requiring wire clippers and other hand tools as well. The Firestik II Bare Hands Tunable Tip tunes without the need for any tools. It's quick! It's easy! It's the installer's dream!

The unique Firestik II antenna, aside from its simplicity of tuning for 1.5 to 1, or better, VSWR on CB, doubles as an excellent AM/FM auto radio antenna. The heavy duty, multi-purpose Firestik II antennas are backed up by a 5-year no hassle warranty. For further information on the Firestik II antenna and other Firestik products, write to: Firestik Antenna Company, 2614 E. Adams, Phoenix, AZ, 85034.

LETTER'S TO THE EDITOR

Big, Big Magnet
I hear much about EMP—electromagnetic pulse. I'm talking about the enormous magnet field created when an atomic nuclear bomb goes off. What is it all about?
Bob D., Laurel, MD

I can tell you only what I read in the press. So much of EMP is classified and beyond my comprehension. It seems that a large amount of electrons are released by an atomic reaction. Their sudden movement results in an enormous magnetic field that rises in less than a nanosecond and collapses in a few microseconds. Hundreds of miles away communications circuits and power circuits are upset by large currents induced into them causing circuits to be blown open and delicate communications equipment to be destroyed. One U.S. hydrogen bomb test event is suspected of disrupting power circuits on islands 800 miles away and more. Full details are not known about the effect of EMP, because there were not enough land masses in the Pacific ocean on which to obtain a complete, meaningful experience. On the other hand, the Russians test their bombs in Siberia, and the land masses in between had effects which they experienced the full effect of EMP. To fully discover what the Russians have learned, tear off the top of your local Commissar and mail it to Moscow with ten Rubles—and see what that gets you for your time. We have a lot to learn. For example, will a jet aircraft, which is so dependent on electronics not only to seek out the enemy, but just fly, be put out of operation for days, if not weeks? As for those in the air when the bomb goes off—will they crash? Who really knows.

Flash in the Pan
I don't like the idea of companies coming out with products and then dumping them on us poor, helpless consumers. I'd like to buy an IBM Personal Computer, but I'm going to wait till IBM is sure it wants to stay in this market. Do you agree with me, Hank?
Paul C., Morris Plains, NJ
IBM has been selling their PC for almost two years as I write this answer, and they have captured over one fifth of the market. Their Junior Model is now out, and you can expect IBM to set new sales records. What are you waiting for?

Junkman
I salvaged a bunch of high-current TTL power supplies, enough to take care of me until I hit the rocking chair. They work great, but my friend and a school teacher tell me that they're no good because most circuits are CMOS. Should I junk all but a few for my immediate needs?
Dom B., Greenville, NC

I'm sure that should you dump the excess power supplies on the lawns of your friend and school teacher, they would be all smiles. CMOS circuits work on TTL power supplies, and most of the circuits with which you would be experimenting need only the +5-volts DC. Higher voltages are required in few circuits, so these power supplies are ideal for the experimenter. Also, I'm sure they can be modified to voltages higher than 5-volts for a minimum expense. If you must throw them away, mail a few to me!

Cable Booster
I want to provide unity gain into a 75-ohm coax line. I'm piping much of my satellite TV signal from the back year (30 yards away) to the house, and then for distribution throughout the house to at least six color sets and a few black white jobs. There's nothing in the way of a circuit I like to use in the half-dozen cookbooks I've looked in. Any suggestions?
Milt. S., Piqua, OH

The last time I heard of Piqua, Ohio was in a mail-order advertisement for a full-size balloon doll, but that's another story! Milt, I suggest you try the LH0033 or LH0063 operational amps made by National Semiconductor. They are expensive. Get a copy of the spec sheet, and decide if they are suitable for your needs.

Starting Up
Why must I turn off my lights, A/C and radio when I start my car's motor? My battery is kept in good shape by long drives, and it can take the load.
Frank F., Waco, TX

Your car's battery has enough to do starting your engine, why add more current to the battery drain than necessary. Your A/C is automatically disconnected from the battery, then it snaps back in when the starter catches and you release the key. The switched inductive loads can cause high currents and voltages swinging as negative as 50 volts in a positive 12 volt system. Think what this may do to your car's electrical circuit breakers and fused wires. Also, it is not too good for the car's radio and tape system. I've seen courtesy lights blow under these conditions, so keep your doors closed when you start. Listen to what is said in the car's driver manual—they never had to recall a manual yet!

Wants to Think It Out

Don't tell me where the diagram can be found, just give me a tip on how I can store the output of a meter reading that lasts for an instant.

Paul M., Brooklyn, NY

Fire off a flash bulb or strobe. A light-sensitive diode senses the duration and intensity of the flash and charges a capacitor through a diode. The capacitor is tied to the gate input of a FET circuit. That's enough—you take it from here.

Wants the Truth

What's the BIG DEAL about wire-wrapping?

Carl G., Denver, CO

You never have to buy solder!

Tie the End

When a trimmer potentiometer is used as an adjustable series resistance in a circuit, sometimes the unused end of the resistance is tied to the wiper, and sometimes it is not. I've seen it both ways in a circuit. Does it matter?

Ralph S., Santa Barbara, CA

Imagine that one end of the resistance in a potentiometer is not tied to the wiper and some dirt gets between the wiper and the resistance—there would be an open circuit. Now, most circuits are designed so that the potentiometer resistance swing of full resistance to zero resistance will not cause damage to a circuit. However, should a resistance element open, causing an infinite resistance, there is the possibility of damage to the circuit. You experimenters at home are better off tieing the end of the resistive string to the wiper so that should the wiper open, the circuit would see the full resistance of the potentiometer, and not an open circuit.

BUILD, BUILD, BUILD

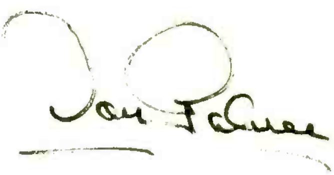
Do we really expect you to build all 99 IC projects? Well, I'm sure you'll build one, maybe ten, maybe twenty — who knows, some of you will build all 99 IC projects. But that is not the purpose of this magazine. What we had in mind was that you would thumb through the pages, reading and absorbing knowledge useful to your hobby, and then, you'd spot a circuit or two that'll be the root of some project that will make your hobby experience more enjoyable, more educational.

No, we are not school teachers — we are realists. Not every circuit in this magazine will be of importance to you; in fact, some circuits may have been known to you for some time. Nevertheless, one good idea inspired by this magazine must truly be worth more than the cover price.

We urge each reader to get the most from this publication by building several projects based on the circuit ideas herein. Then, build upon those ideas. Make the projects better, larger, add additional functions, and, as they say, do your thing.

We'd like to hear from you about your success with the projects you assembled. In particular, we'd like to know about those projects which are basically new, and hardly, or do not, reflect on one of the original 99 circuits. For, if your imagination is inspired, the circuit you come up with may be considered for publication in the next edition of 99 IC Projects. Think of it — your ideas are the next generation of 99 IC Projects!

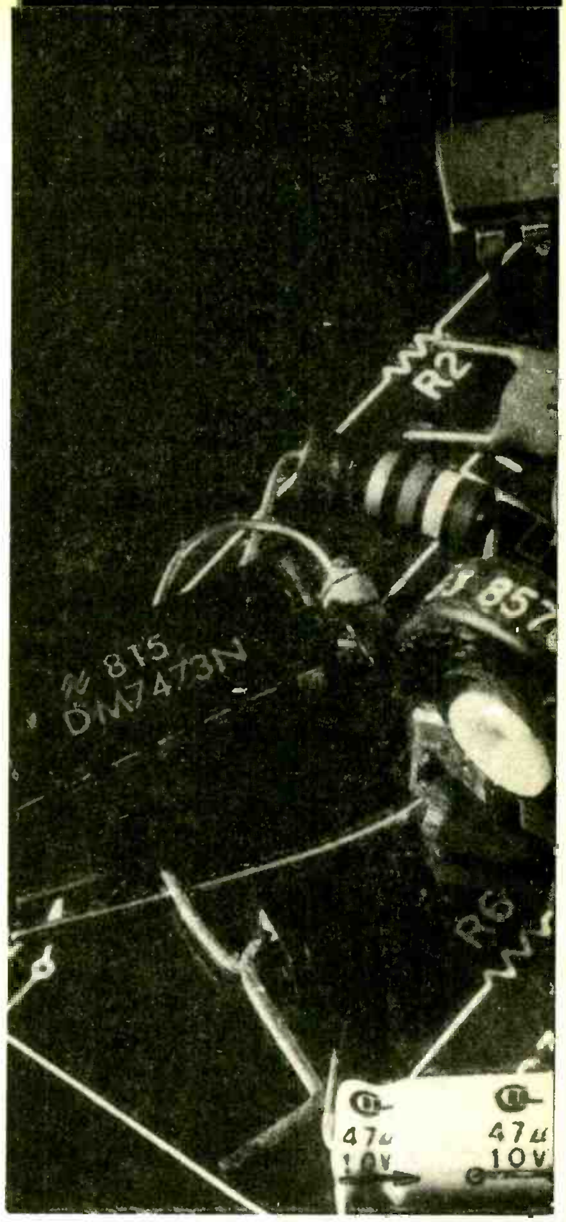
Let us hear from you about your projects. Your successes make our labors fruitful.



DON GABREE

Publisher

99 IC PROJECTS



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

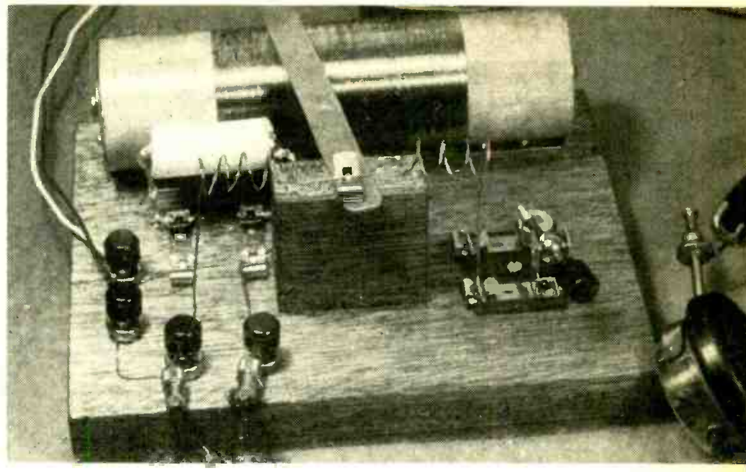
YOU'VE BEEN PUTTING OFF YOUR INTRODUCTION into the fascinating world of integrated circuit construction for too long, and the time to get your feet wet is now. The electroncs field is moving ahead so rapidly that you really cannot afford to sit back and let it happen around you. That in itself is the 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 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.

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

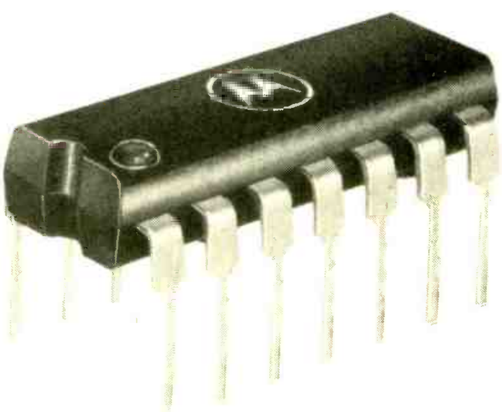


The most rudimentary (and least expensive) method which you can use to breadboard a circuit is to use, well, a breadboard. Obviously this is where the name came from. You can use Fahnestock clips (left, center) to secure components on the board.

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.

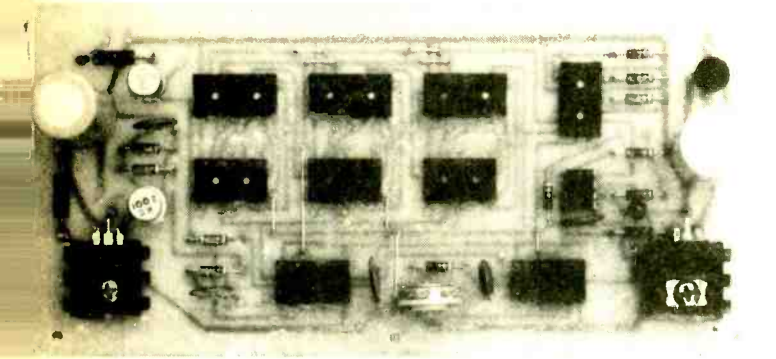
Perhaps the major reason for taking the time to inform you of these possibilities is that the actual text accompanying the projects is very brief—there's just enough there to let you know how to build the project, and in some cases how to operate it as well. This was done not because we're lazy, but 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.



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



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.

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.

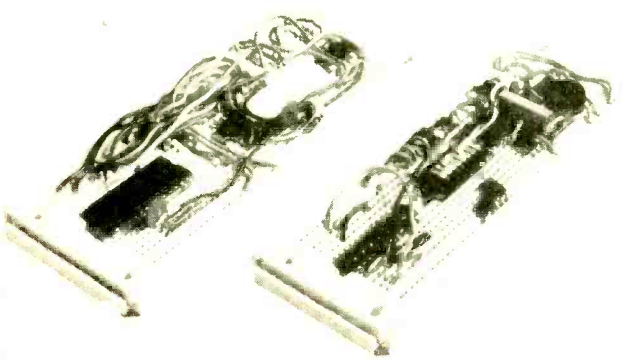
If You Must Solder. If you plan on soldering the IC leads directly into the circuit, something which we do not recommend, there are several precautions which you'll have to take to avoid ruining your precious ICs. To begin with, put your heavy duty soldering gun on the shelf. Use no more than a 15-watt 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 when shutting down. ■



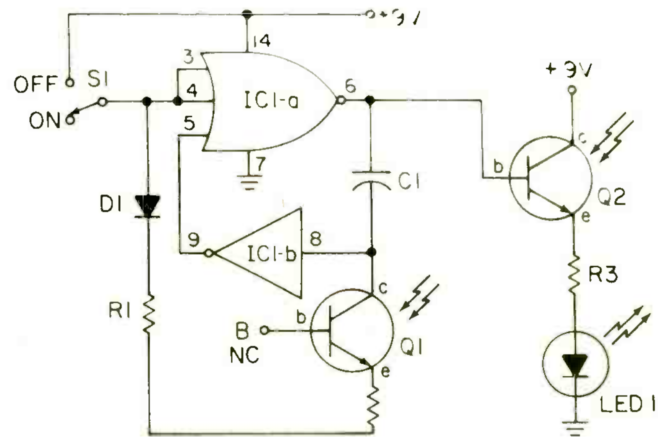
Solderless breadboarding is a convenient method for circuit building, as components and jumpers can be repositioned at will. The only drawback with this medium (and it's a minor one) is that it's not really a permanent setup and care in handling is needed.

1 Tinkerer's Blinker

□ We call it "Tinker's Blinker," but what's in a name, if you don't know how the circuit works. Tinkerer's Blinker is 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 (LED1) 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 phototransistor Q1 showing through. As LED1 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 TINKERER'S BLINKER

C1—0.01-uF ceramic capacitor, 15 VDC
D1—IN4001 diode
IC1—4000 dual NOR gate w/inverter
LED1—Light-emitting diode
Q1—FPT100 phototransistor
Q2—2N4401 trransistor
R1—5,000,000-ohm, 1/2-watt resistor
R2—1,000,000-ohm, 1/2-watt resistor
R3—680-ohm, 1/2-watt resistor



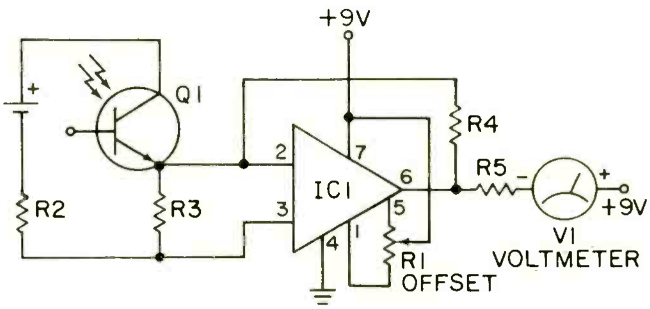
NOTE: BUILD LED1, Q2 AND R3 IN WAND

2 Cheapie Light Meter

□ The beauty of this Cheapie 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 M1 is any instrument you currently have around the house, or any inexpensive meter you can buy. R1 provides a zero adjustment for the meter.

PARTS LIST FOR CHEAPIE LIGHT METER

B1—1.5-VDC dry cell
M1—See text
IC1—741 op amp
Q1—FPT100 phototransistor
R1—10,000-ohm, linear-taper potentiometer
R2—10,000-ohm, 1/2-watt resistor
R3—30,000-ohm, 1/2-watt resistor
R4—100,000-ohm, 1/2-watt resistor
R5—2,000-ohm, 1/2-watt resistor



3 Rodent Repeller

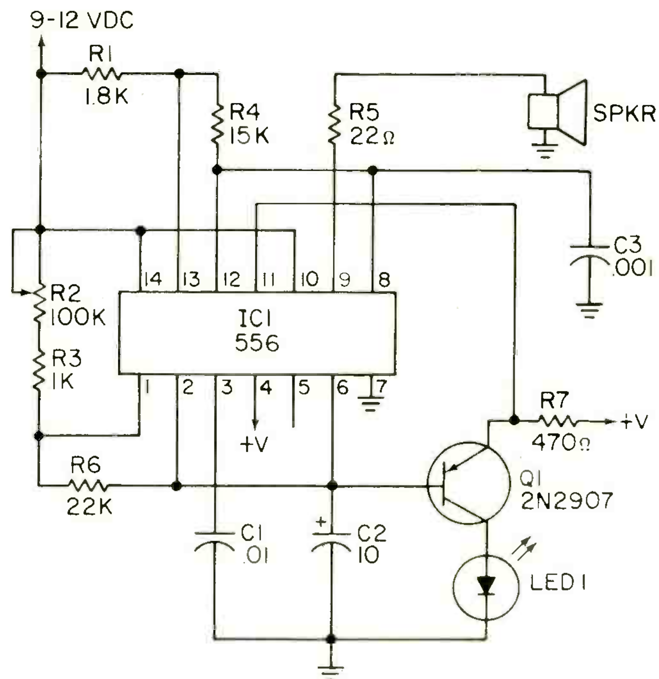
☐ One way to get the unwelcomed squeaks out of your house and the yard area is to squeak back with the Rodent Repeller. This circuit produces freq-squeaks in the ultrasonic range sweeping from 25,000 to 50,000 Hertz. IC1, a 556 dual timer functions as a combined stable multivibrator and a voltage sweeper that varies the oscilator output. The second timer stage effect on capacitor C2 provides the frequency's sweeping effect—enough to drive a rodent nuts. Transistor Q1 isolates the two sections of the timers in IC1. When Q1 conducts, it lowers the control voltage at pin 11 of IC1, which in turn increases the frequency output. The cycle will be about one second or less depending upon the setting of the potentiometer.

You can't hear the output of the Rodent Repeller, so it is suggested that for testing purposes a .01 disc capacitor be connected across C3. You may want to leave it in the circuit if humanoids are your problem.

The speaker is a piezoelectric tweeter out of Radio Shack, that sells for $10, depending on the model you buy. The circuit can be powered by batteries, but fix up an AC-powered supply that will keep costs down. The output from the chip is sufficient to drive the speaker. Do not attempt to put more power into the speaker by adding a stage of amplification unless you know for sure that the speaker is not being overdriven. Heat will destroy it. The 556 provides just enough oomph to do the job.

PARTS LIST FOR RODENT REPELLER

C1—.01-uF, disc capacitor
C2—.10-uF, 16-VDC electrolytic capacitor
C3—.001-uF, disc capacitor
IC1—556 dual timer
LED1—Light-emitting diode, any lens, any color
Q1—2N2907 PNP transistor
(All resistors are 10%, 1/2-ohm)
R1—1800-ohm
R2—100,000-ohm potentiometer (taper not important)
R3—1000-ohm
R4—1500-ohm
R5—22-ohm
R6—22,000-ohm
R7—470-ohm
SPKR—Piezoelectric tweeter speaker from Radio Shack



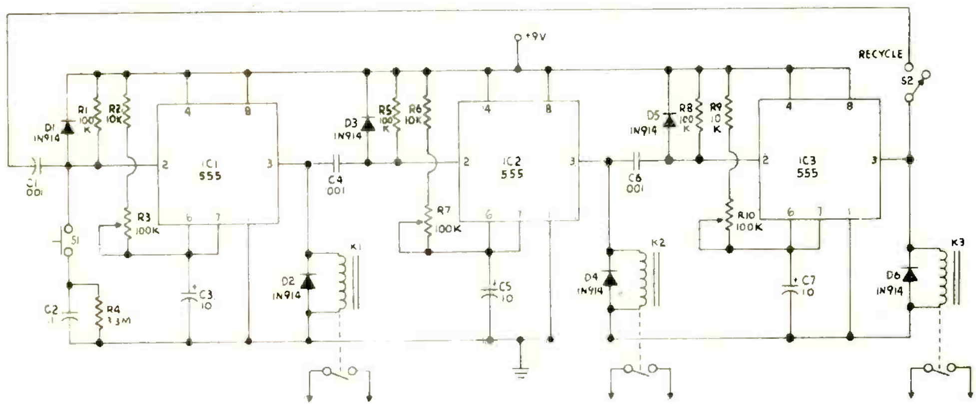
4 Sequential Timer

☐ 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 capacitors resistors (R1-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 recycle times (.3-.5 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.

PARTS LIST FOR SEQUENTIAL TIMER

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

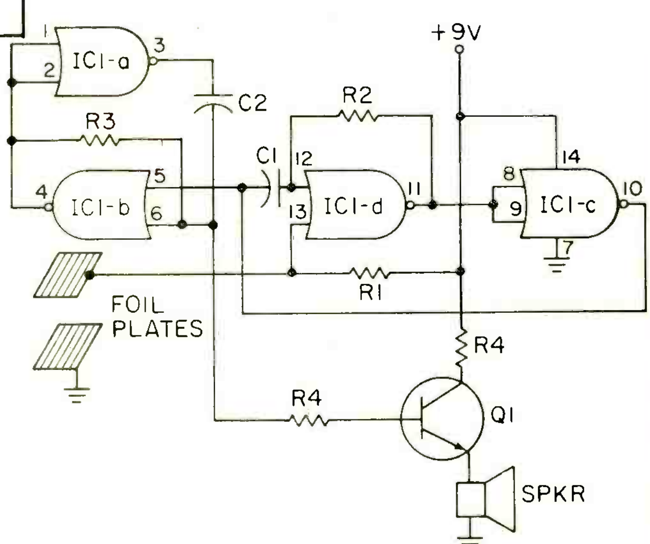


5 Rain Detector

☐ 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 aluminum foil strips to keep you high and dry.

PARTS LIST FOR RAIN DETECTOR

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



6 10-Minute Power-On Switch

□ There are projects and devices that operate off batteries that are used infrequently. When you switch them on, the battery is dead because the switch was on for the last few days. This happens all too often. So what do you do?

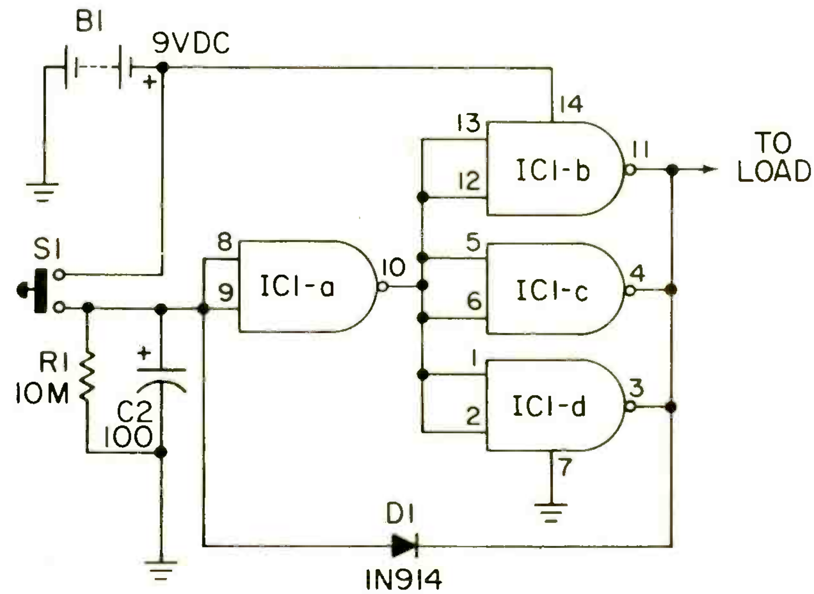
The 10-minute power-on switch delivers up to 10-12 milliamperes from a 9-volt source for ten minutes, then turns off automatically. This is a great feature for most devices, especially test gear, that is used for a few moments, at best—a few minutes, then remains unused for hours, days or longer.

The circuit consists of quad AND gates contained in a single 4011 chip. When S1 is depressed, and released, capacitor C1 charges up to the battery potential of 9 volts. A positive input is supplied to IC1-a for about 10 minutes as C1 slowly discharges through R1—a 10-megohm resistor. A 6.8-megohm resistor provides about 5 minutes of power. Experiment with different values for R1 to obtain different periods. The output of IC1-a goes low driving the combined outputs of IC1-b, -c, and -d to 9-volts DC. The output of these three paralled AND gates provide the power to drive the low-current stages that follow.

The battery, B1, is tied to the quad AND gate chip drawing almost no current when the circuit is at rest resulting in almost shelf life for the battery. Diode D1 completely discharges C1 when the power supply shuts off. Should the circuit you wish to automatically turn off require much more than 10 milliamperes of DC current, let the load be a sensitive relay that can control higher voltages and currents.

PARTS LIST FOR 10-MINUTE POWER-ON SWITCH

B1—9-volt transistor battery
C1—100-uF, 16-VDC, electrolytic capacitor
D1—1N914 diode
IC1—4011 quad AND gate chip
R1—10,000,000-ohm resistor
S1—Normally-open pushbutton switch

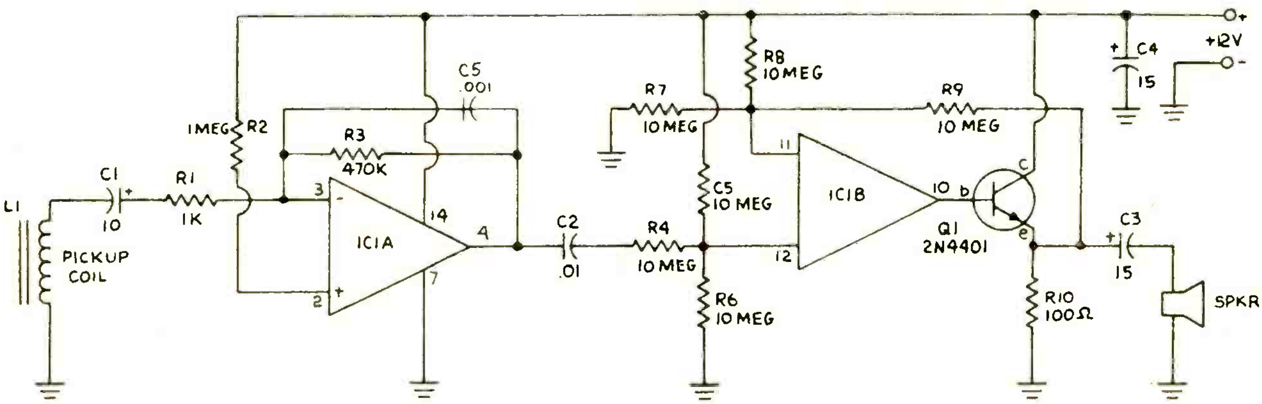


7 Telephone Voice Pickup

□ 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 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 near the telephone receiver for best results.

PARTS LIST FOR TELEPHONE VOICE PICKUP

C1—10-uF, 25-WVDC electrolytic capacitor
C2—.01-uF, 15-WVDC ceramic disc capacitor
C3, C4—15-uF, 15-WVDC electrolytic capacitor
C5—.001-uF, 15-WVDC ceramic disc capacitor
IC1—3900 quad amplifier
L1—inductance pickup coil (see text)
Q1—2N4401
R1—1000-ohm, ½-watt 10% resistor
R2, R4—1,000,000-ohm, ½-watt 10% resistor
R3—470,000-ohm, ½-watt 10% resistor
R5, R6, R7, R8, R9—10,000,00-ohm, ½-watt 10% resistor
R10—100-ohm, ½-watt 10% resistor
SPKR—8-ohm PM type speaker



8 Cassette Control System

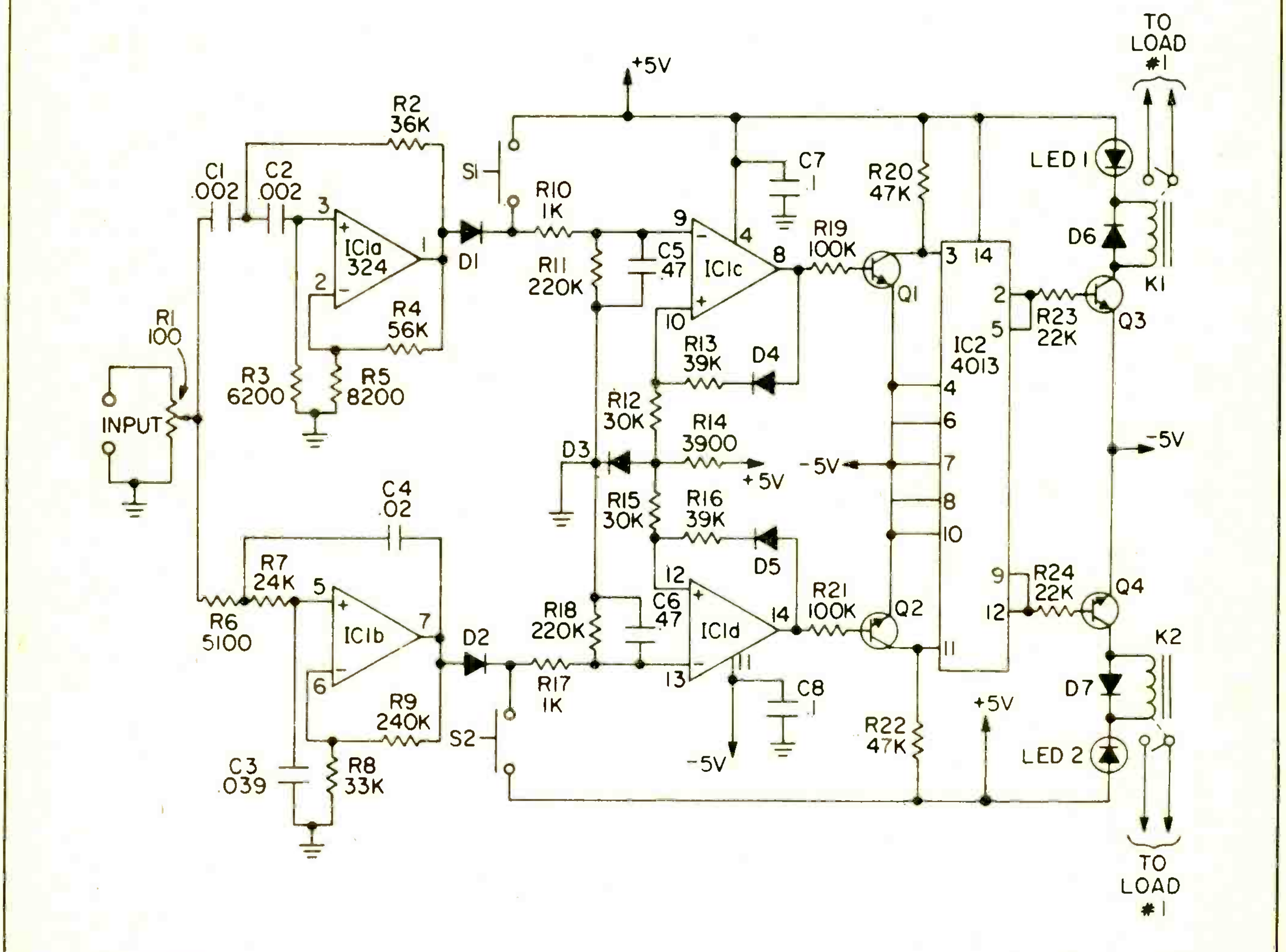
☐ Let's say that you need a programmable control system that can perform a timed sequence of operations. This sounds like a job for a high-priced computer, doesn't it? In many instances, however, just a cheap cassette recorder can do a respectable job—provided, of course, that you build this 2-channel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

High-frequency signals (above 5000 Hz) at the controller's input are amplified by high-pass filter IC1-a; 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 a burst 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 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—6,900-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-oh, ½-watt resistor
S1, S2—pushbutton switch, normally open



9 Pseudo-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:

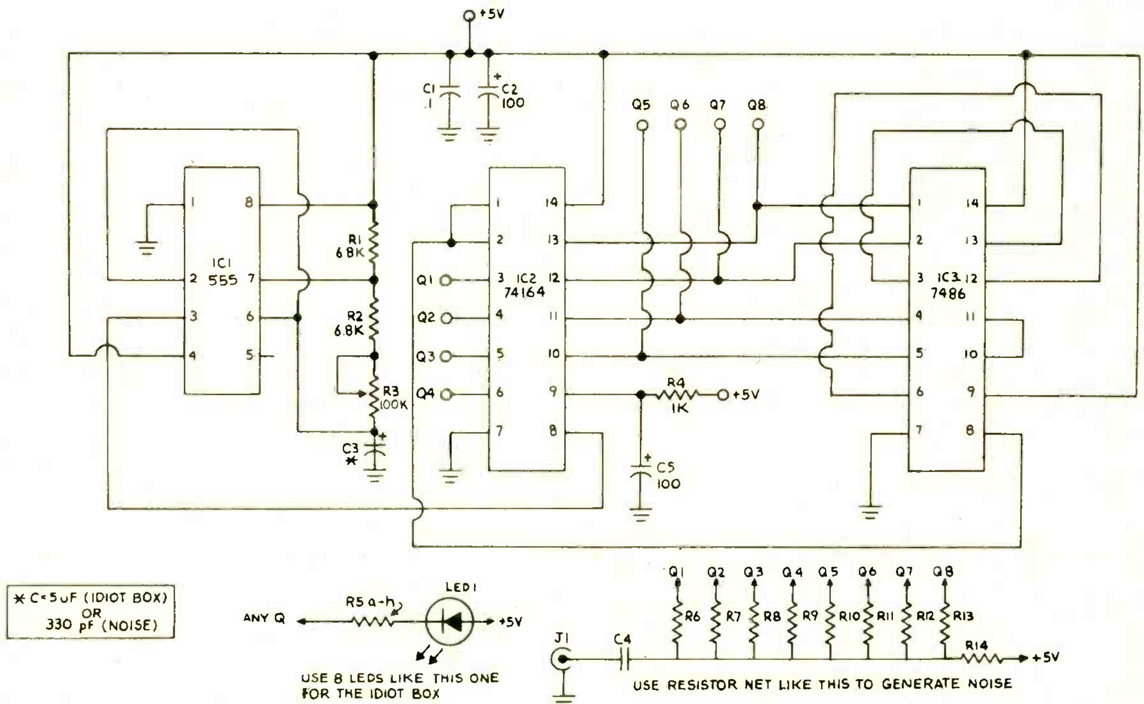
First, you might hook up an LED and a 330-

ohm resistor to each output as illustrated. Use a 5-uF 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 polysyrene 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 GENERATOR

C1—0.1-uF ceramic disc capacitor, 35-WVDC
C2, C5—100-uF electrolytic capacitor, 10-WVDC
C3—5-uF 10-WVDC electrolytic or 330-pF polystyrene capacitor (see text)
C4—1.0-uF mylar capacitor (non-polarized), 35-WVDC
IC1—555 timer integrated circuit
IC2—74164 shift register integrated circuit
IC3—7486 quad EX-OR gate integrated circuit
J1—phono jack
LED1 thru LED8—Light-emitting diode
R1, R2—6800-ohms-ohm, ¼-watt 10% resistor
R3—100,000-ohm linear-taper potentiometer
R4-R6—1000-ohm, ¼-watt 10% resistor
R5a thru R5h—330-ohm, ½-watt 10% resistor
R7—2200-ohm, ½-watt 10% resistor
R8—3900-ohm, ½-watt 10% resistor
R9—8200-ohm, ½-watt 10% resistor
R10—15,000-ohm, ½-watt 10% resistor
R11—33,000-ohm, ½-watt 10% resistor
R12—62,000-ohm, ½-watt 10% resistor
R13—120,000-ohm, ½-watt 10% resistor
R14—120-ohm, ½-watt 10% resistor



10 Thermal Latch

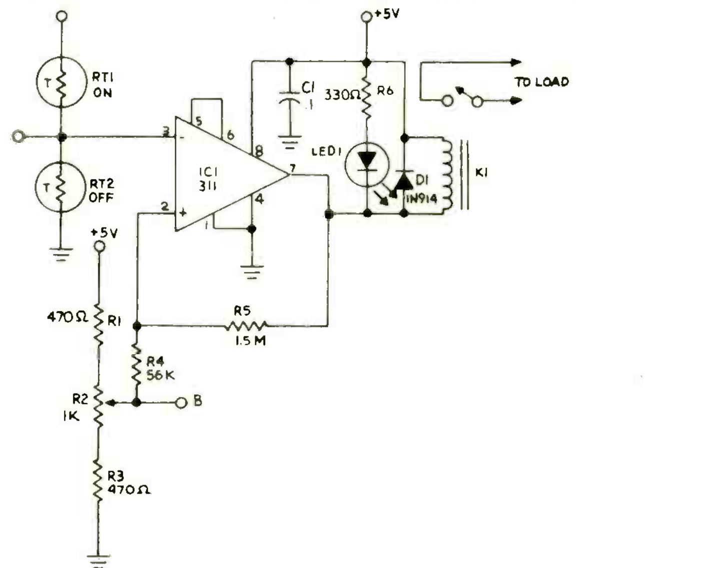
☐ This is a tricky control circuit based on temperature. Touch thermistor RT1, and a moment or two later both LED1 and K1 will be energized. They will stay in that condition after you release RT1. Later, if you decide to turn things off, just touch RT2 until LED1 extinguishes. After you release RT2, the circuit will remain in the off condition.

One preliminary adjustment must be made before you can use the circuit. Connect a voltmeter (20,000 ohms/volt or greater) between points A and B. If the meter deflects backwards, reverse its leads. Adjust R2 for exactly zero voltage on your voltmeter's most sensitive scale. That's it.

For those who care about such things, what we have here is a thermistor voltage divider driving a Schmitt trigger built around an LM311 comparator. As a thermistor heats, its resistance decreases. Hence, the voltage at the junction of RT1 and RT2 is a function of the heat supplied by your finger or hand. This circuit is intended for use at normal room temperatures, that is, 70°-80°F. If the ambient temperature is in the vicinity of human body temperature, clearly you will not have much effect on the circuit by touching it.

PARTS LIST FOR THERMAL LATCH

C1—.1uF ceramic disc capacitor
D1—1N914 silicon diode
IC1—311 comparator
K1—6-volt, 500-ohm relay or 5-volt TTL-logic relay
LED1—Light-emitting diode, any color
R1, R3—470-ohm, ½-watt 5% resistor
R2—1,000-ohm trimpot
R4—56,000-ohm, ½-watt 10% resistor
R5—1.5 Meg-ohm, ½-watt 10% resistor
R6—330-ohm, ½-watt 10% resistor
RT1, RT2—Negative-temperature-coefficient thermistors, 10K ohms or greater at 25°C. For example, Fenwal #GB41P12 or equiv.



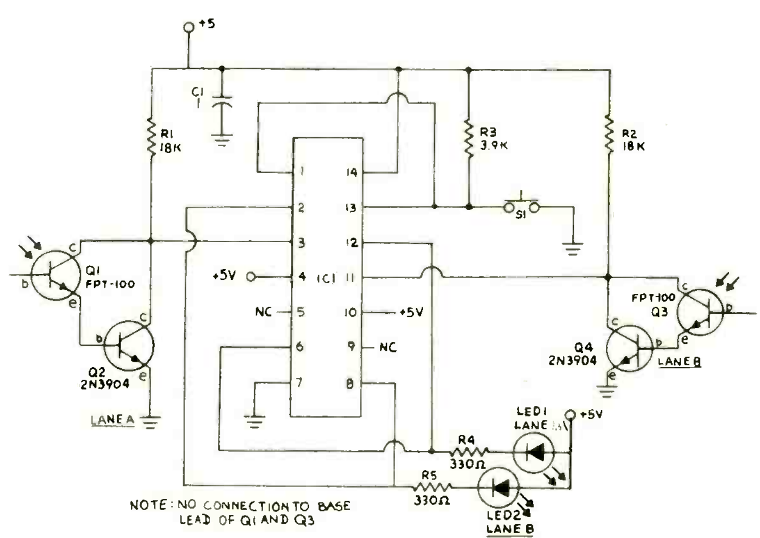
11 Slot Car Race Referee

☐ 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

PARTS LIST FOR SLOT CAR RACE REFEREE

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



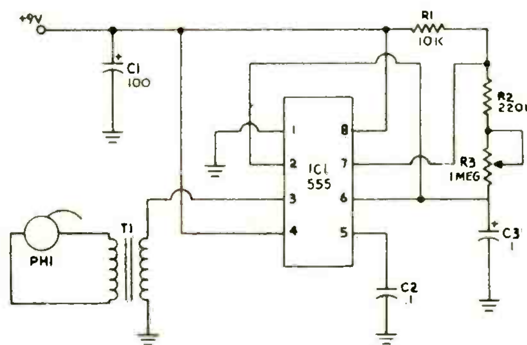
so that the light-sensitive face of each device is facing upwards. The best method would be to cut a small hole into the track for each phototransistor, and mount each unit flush with the track's surface. Arrange for light to fall on both Q1 and Q3; a small desklamp will work well, but ambient room light 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.

12 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 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.

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 5% resistor
R2—220K, ½-watt 5% resistor
R3—1-Megohm trimmer potentiometer
T1—Miniature audio output transformer —1,000-ohm primary/8-ohm secondary

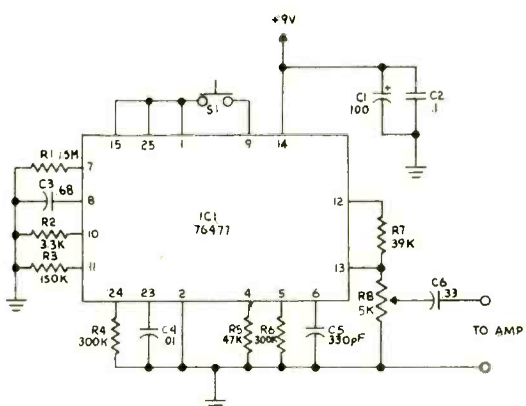


13 Kaboom Chip

□ No, IC1 does not disintegrate in a fiery blast when S1 is pressed, but it does feed a mighty impressive burst of explosion-like noise to your amplifier. The more powerful your amplifier is, the

PARTS LIST FOR KABOOM CHIP

C1—100-uF, 25-WVDC electrolytic capacitor
C2—.1uF ceramic disc capacitor
C3—.68-uF mylar capacitor
C4—.01 uF mylar capacitor
C5—330-pF polystyrene capacitor
C6—.33 uF mylar capacitor
IC1—SN76577 sound-effect generator
R1—1.5 Megohm-ohm, ½-watt 10% resistor
R2—3,300-ohm, ½-watt 10% resistor
R3—150,000-ohm, ½-watt 10% resistor
R4, R6—300,000-ohm, ½-watt 10% resistor
R5—47,000-ohm, ½-watt 10% resistor
R7—39,000-ohm, ½-watt 10% resistor
R8—5,000-ohm audio-taper potentiometer
S1—SPST normally open pushbutton switch



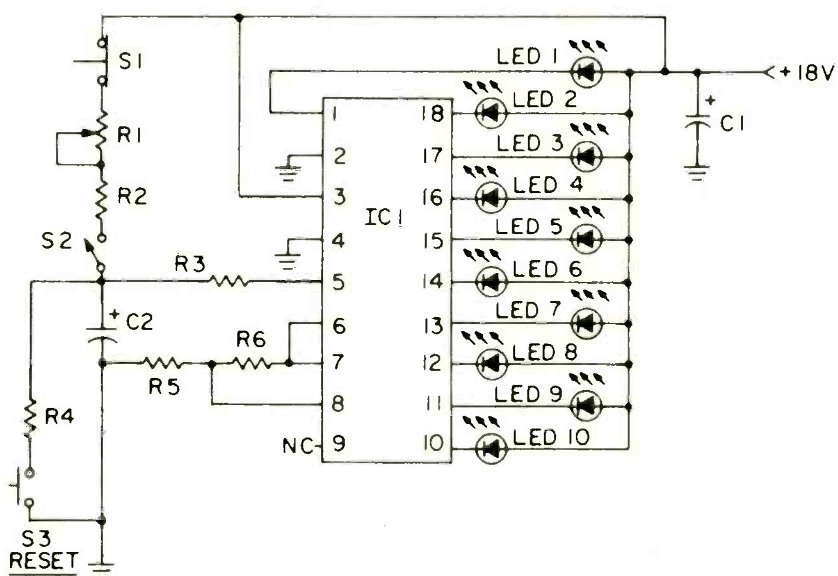
more realistic the effect becomes. Just be sure that your speaker can handle the power safely. Maximum output from this circuit is about one volt peak-to-peak, which you can feed to the high-level input of any amp. One final note of caution: Don't overdo it, or you may find your home surrounded by the local SWAT team.

14 Alcohol 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 realease, 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 accumulated a voltage directly proportional to the reaction time, which is the interval between S1's release and the opening of S2. Longer times create high voltages and cause higher-numbered LEDs to light. For example, a sober person might react quickly enough to light LED2 or LED3, while someone truly sloshed will light up LED10. 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 ALCOHOL 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—50,000-ohm trimmer potentiometer
R2—5600-ohm ½-watt resistor, 10%
R3—33,000-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 closed SPSt pushbutton switch

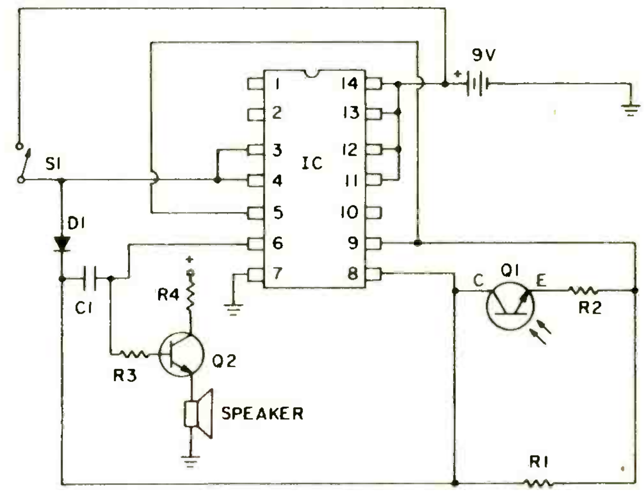


15 Haunted House

□ 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.

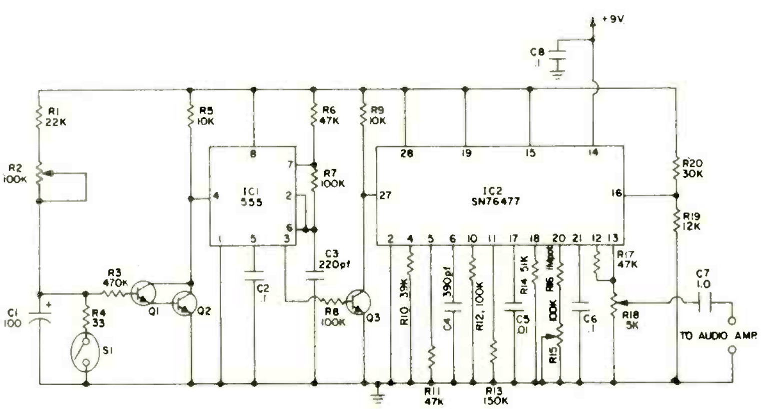
PARTS LIST FOR HAUNTED HOUSE

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



16 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



PARTS LIST FOR TRAIN SOUND EFFECTS

C1—100-uF, 16-BDC electrolytic capacitor
C2, C6, C8—0.1-uF ceramic disc capacitor
C3—200-pF polystyrene capacitor
C4—390-pF polystyrene capacitor
C5—.01-uF myular capacitor
C7—1.0-uF mylar capacitor
IC1—555 timer integrated circuit
IC2—SN76477 sound generator integrated circuit
Q1-Q3—2N3904 NPN transistor (all resistors 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, ½-2att resistor
R6, R11, R17—47,000-ohm, ½-watt resistor
R7, R8, R12, R16—100,000-ohm, 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, linear-taper potentiometer
R19—12,000-ohm, ½-watt resistor
R20—30,000-ohm, ½-watt resistor
S1—magnetic reed switch

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, or course, you're looking for a way to break the lease.)

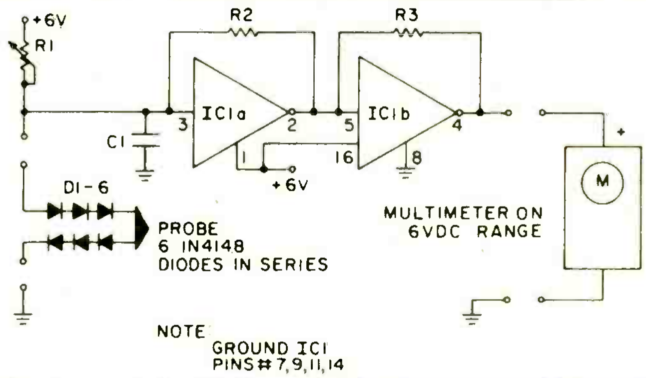
Mount a small, powerful Alnico magnet on your train so that upon reaching a certain track position, the train triggers reed switch S1 with its magnet. This causes the circuit to produce a whistle blast that lasts between .5 and 2.5 seconds, depending on the setting of R2. If you wish to sound the whistle 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.

17 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-volt 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

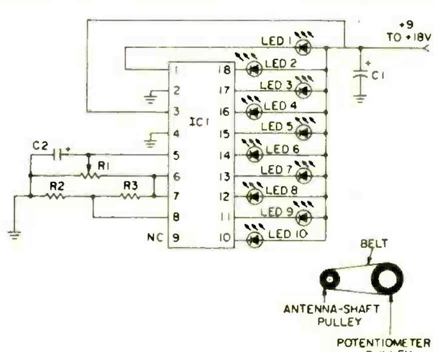
C1—0.1-uF ceramic capacitor, 15 VDC
D1 through D6—1N4148 diode
IC1—4009A hex buffer
R1—100,000-ohm linear-taper potentiometer
R2, R3—1,000,000-ohm, ½-watt resistor



18 Direction 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

PARTS LIST FOR DIRECTION 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—25,000-ophm linear-taper potentiometer
R2—3900-ohm, ½-watt resistor, 5%
R3—1200-ohm, ½-watt resistor, 5%

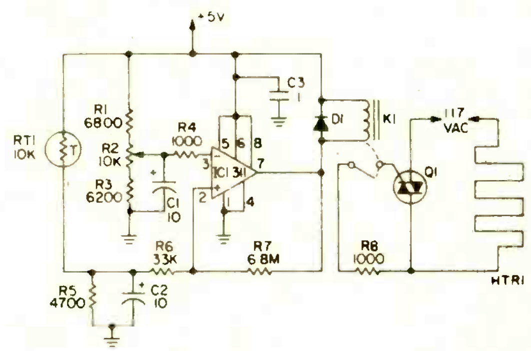


rotators, probably non-existent. However, it's easy to add on a direction indicator using LEDs for readout. Referring to the schematic, note direction-sensing potentiometer R1. As its wiper moves away from ground potential, first LED 1 will light, then LED 2 will come on as LED 1 extinguishes; this process 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°.

19 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.

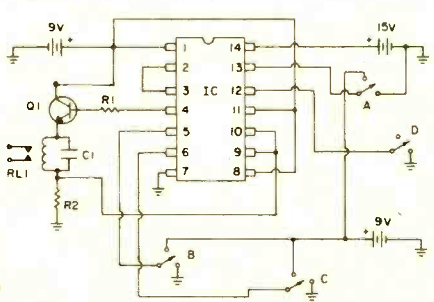
PARTS LIST FOR THERMOSTATIC BATH
C1, C2—10-uF, 10-VCD tantalum capacitor
C3—0.1-uF ceramic disc capacitor
D1—1N914 diode
HTR1—200 to 500-Watt immersion heater (see text)
IC1—LM311 comparator
K1—6-VDC, 500-ohm relay
Q1—200-VDC, 10-A triac
R1—6,800-ohm ½-watt resistor (all resistors 5% unless otherwise 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)



20 Combination Lock

□ 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

PARTS LIST FOR 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



C and D are off. You can experiment with different connections to make your own combination, or substitute rotary switches with additional contacts.

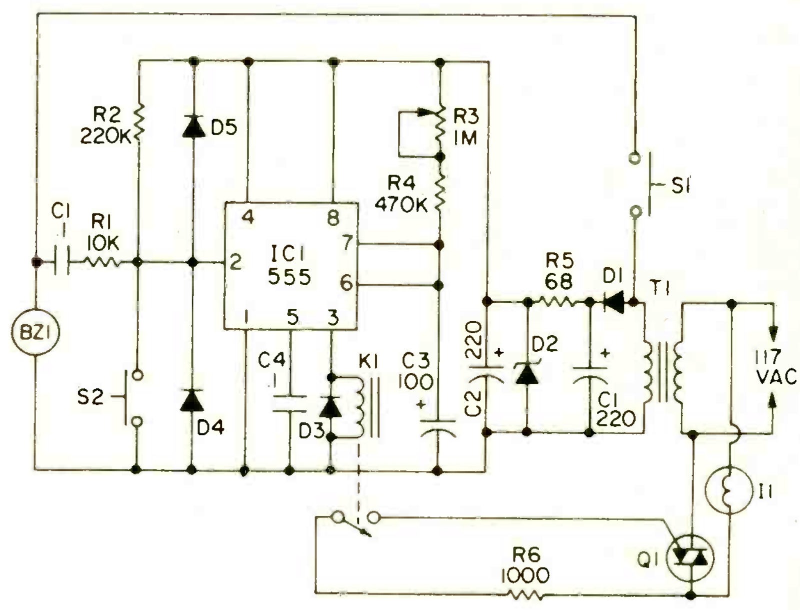
21 Smart Porch Light

☐ 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-ohm, 1-watt resistor
R6—1,000-ohm, 1-watt resistor
S1, S2—pushbutton switch, normally open
T1—6.3-VAC transformer

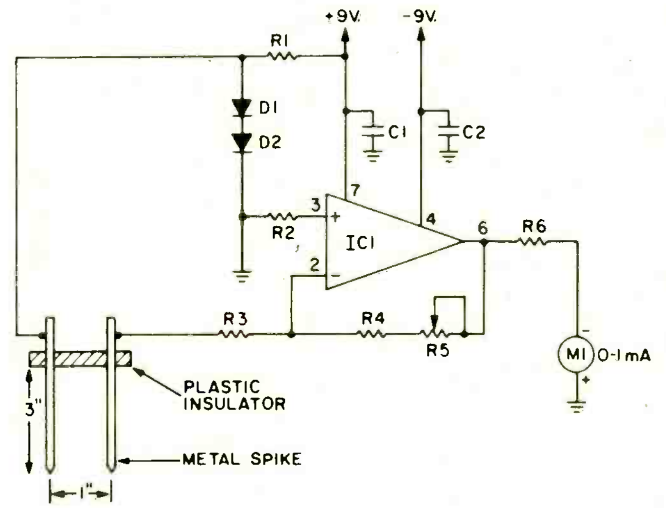


22 Soil Moisture Meter

☐ 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 soil 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 SOIL MOISTURE METER

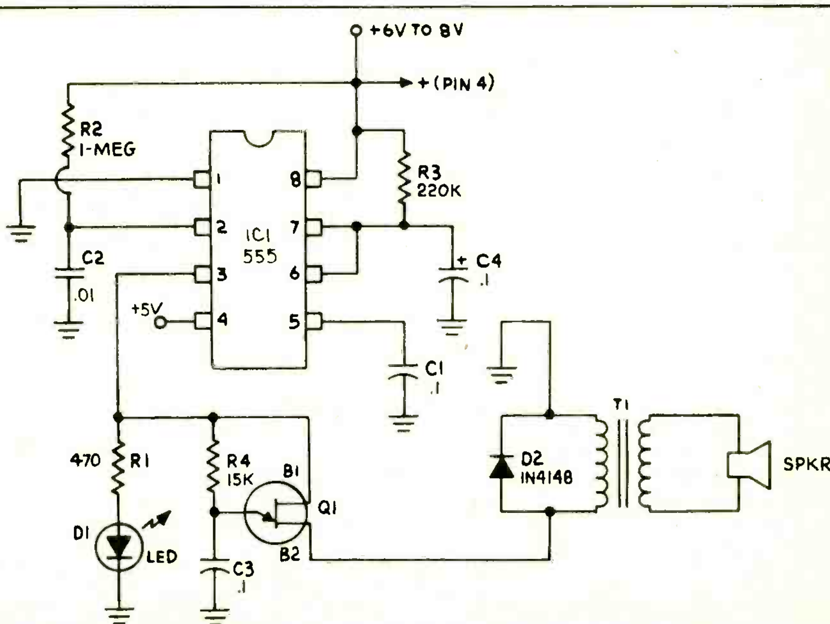
C1, C2—0.01-uF ceramic disc capacitor, 35 VDC
D1, D2—1N914 diode
OC1—741 op amp
M1—0-1 mA DC meter
R1—6800-ohm ½-watt resistor, 10%
R2—15,000-ohm ½-watt resistor, 10%
R3—1000-ohm ½-watt resistor, 10%
R4—10,000-ohm ½-watt resistor, 10%
R5—100,000-ohm trimmer potentiometer
R6—3300-ohms ½-watt resistor, 10%



23 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 time 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, C3—0.1-uF ceramic capacitor, 15-WVDC
C2—0.01-uF ceramic capacitor, 15-WVDC
C4—1-uF electrolytic capacitor, 15-WVDC
D1—Light-emitting diode, any color
D2—1N4148 diode
IC1—555 timer integrated circuit
Q1—2N2646 field-effect transitor
R1—470-ohm, ½-watt 10% resistor
R2—1,000,000-ohm, ½-watt 10% resistor
R3—220,000-ohm, ½-watt 10% resistor
R4—15,000-ohm, ½-watt 10% resistor
SPKR—8-ohm PM type speaker
T1—audio output transformer 500-ohm primary/8-ohm secondary

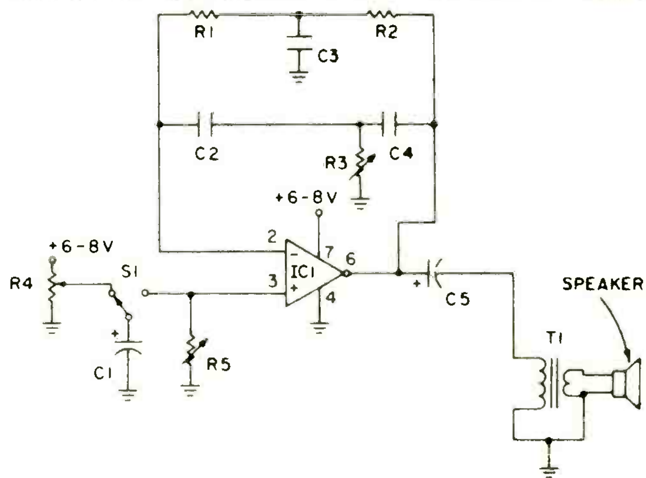


24 Whistler

☐ 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 imput. 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 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

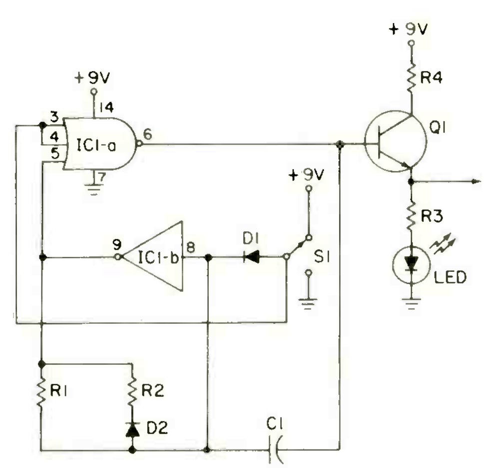


25 Pulsed Alarm

☐ 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

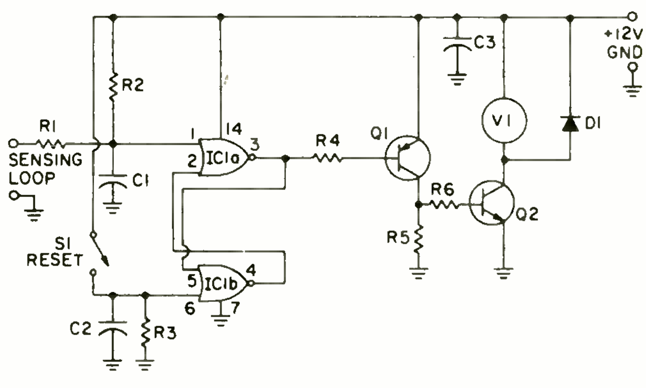
C1—0.68-uF tantalum capacitor, 15 VDC
D1, D2—1N4001 diode
D3—small LED
IC1—4000 dual 3-input NOR gate
Q1—2N4401
R1—10,000,000-ohm, ½-watt resistor
R2—1,000,000-ohm, ½-watt resistor
R3—1,000-ohm, ½-watt resistor
R4—10-ohm, ½-watt resistor
S1—SPDT toggle switch



26 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, 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.

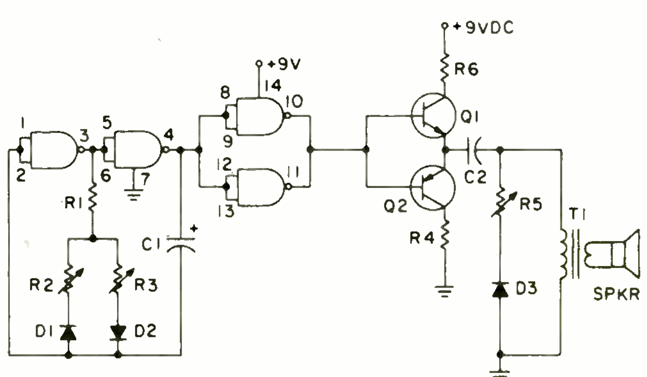
PARTS LIST FOR BURGLAR ALARM
C1—0.1-uF ceramic capacitor, 15 VDC
C2—0.1-uF ceramic capacitor, 15 VDC
C3—0.47-uF ceramic capacitor, 15 VDC
D1—1N4148 diode
IC1—4001 quad NOR gate
Q1—2N4403
Q2—2N4401
R1, R3—100,000-ohm, ½-watt resistor
R2—4,700,000-ohm, ½-watt resistor
R4, R5—10,000-ohm, ½-watt resistor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



27 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

PARTS LIST FOR 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



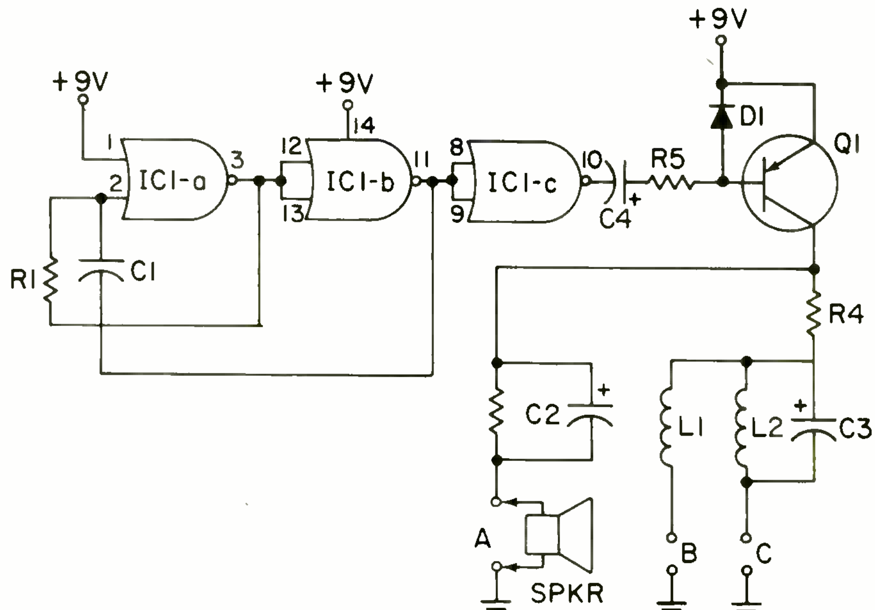
of about 2-uF or else a quality tantalum of about 4.7-uF. Although the reversed flow of current through the transformer's primary winding causes a different sound in the speaker from the positive-going inrush, diode D3 and potentiometer R5 can be added to make the "tock" more definitive in its sound quality.

28 Organ 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 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 transistor
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

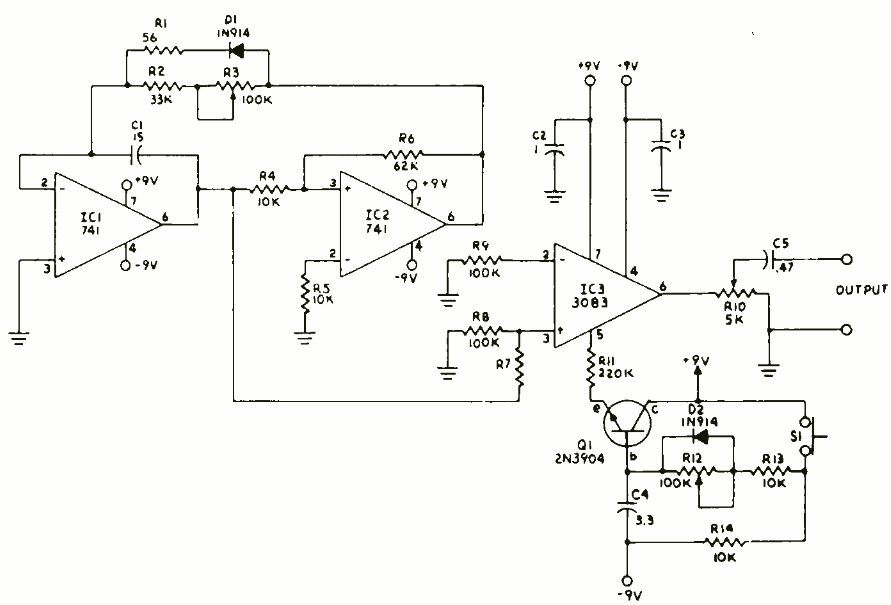


29 Slide Trombone

☐ 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, just 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, 25-WVDC 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 10% resistor
R2—33,000-ohm, ½-watt 10% resistor
R3, R12—100,000-ohm, ½-watt 10% resistor
R4, R5, R13, R14—10,000-ohm, ½-watt 10% resistor
R6—62,000-ohm, ½-watt 10% resistor
R8, R9—100-ohm, ½-watt 10% resistor
R10—5,000-ohm audio-taper potentiometer
R11—220,000-ohm, ½-watt 10% resistor
S1—Pushbutton switch, normally open



30 Telephone Turkey Caller

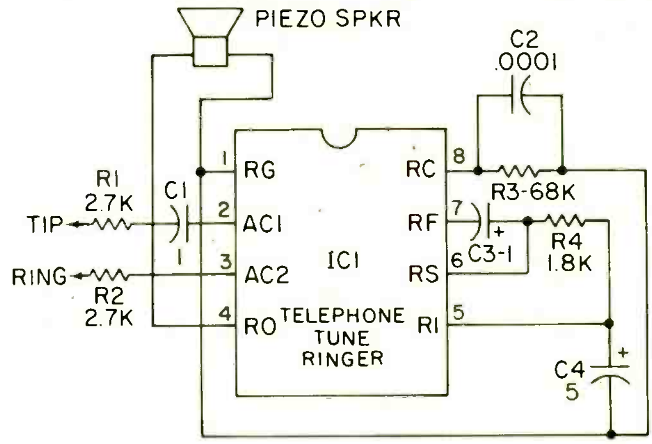
☐ No, this project will not put the white and dark meat on the diningroom table comes Thanksgiving day! We call it the Telephone Turkey Caller because it produces sounds like a turkey to some people. It's pleasent two-tone warbling sound is welcome in place of the harsh bell ringer used in most telephones. Also, since it does not need a phone to operate, it can be placed anywhere in the telephone line in the house, or outside the house, where the telephone normal ringer cannot be heard informing the household that the telephone is ringing.

The chip, a Motorola MC34012, uses the telephone's ringing power to provide the DC to operate the chip. A relaxation oscillator within the chip develops an Fo signal, and from this basic frequency, the chip selects frequencies Fo/4 and Fo/5 (fourth and fifth note in the octive beginning with the frequency Fo), amplifies them and buffers the signal out to a piezo speaker that produces the turkey sound. C2 and R3 determine the Fo frequency. Small changes in the component values will vary the output sound frequencies. Resistor R4 controls the ringing threshold voltage. Its value may be varied between 800 to 2000 ohms. Capacitor C3 can be used to eliminate dial transcients—experiment with values from .5 to 5-uF.

For those who must report the ringer to their telephone company, the ringer equivalent is approximately .7A. Should you own your in-home or office telephone system, you need not report its use to the telephone company.

PARTS LIST FOR TELEPHONE TURKEY CALLER

C1—1-uF, non-polarized capacitor, 200-WVDC
C2—.001 disk capacitor
C3—1-uF, 16-WVDC
IC1—MC43012-1 telephone tone ringer chip
R1, R2—2700-ohm, ½-watt resistor
R3—68,000-ohm, ½-watt resistor
R4—1800-ohm, ½-watt resistor
SPKR—piezoelectric speaker (inexpensive tweeter may be used)

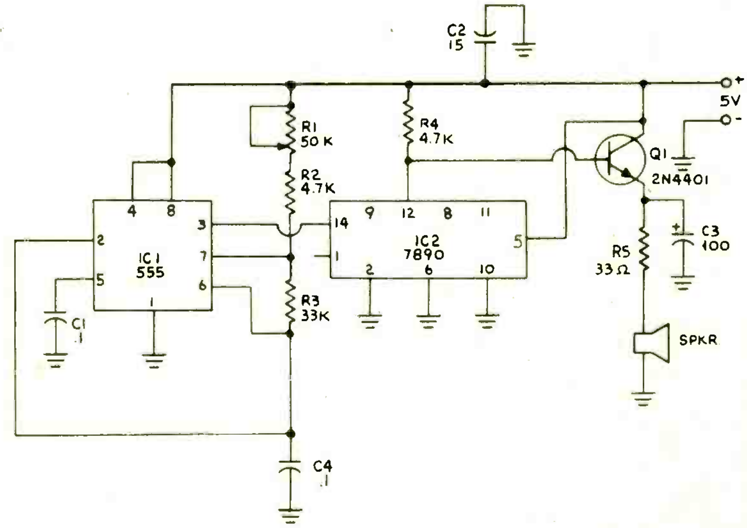


31 Guitar Tuner

□ 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. That 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 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-WVDC
C2—15-uF electrolytic capacitor, 15-WVDC
C3—100-uF electrolytic capacitor, 15-WVDC
IC1—555 timer
IC2—7490 decade counter
Q1—2N4401
R1—50,000-ohm linear-taper potentiometer
R2, R4—4,700-ohm, ½-watt 10% resistor
R3—33,000-ohm, ½-watt 10% resistor
R5—33-ohm, ½-watt 10% resistor
SPKR—8-ohm PM type speaker



32 Note Generator

□ 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-significant 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.

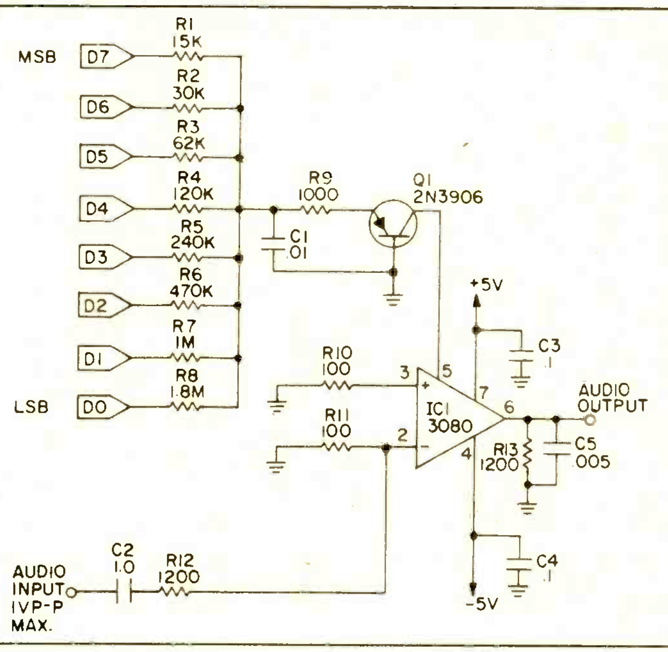
Let's say we want a fast attack time of 10 milliseconds. Using all available codes, it will take 255 steps to climb from zero to full output. For simplicity's sake, we'll let the note's amplitude rise linearly during attack, which means that the code will be incremented at regular, fixed time intervals. 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 generator, raise R12 to 15K ohms to accommodate the increased input amplitude.

PARTS LIST FOR NOTE GENERATOR

C1—0.1-uF ceramic 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



33 Melodious Sequencer

□ Press pushbutton S1, and this circuit will play you a short melody up to nine notes long. The immediate effect of pressing the button is to reset counter IC2 and set pin 3 of the counter HIGH. A voltage, determined by the setting of the pot attached to pin 3 of IC2, gets fed to the input of voltage-controlled oscillator IC3.

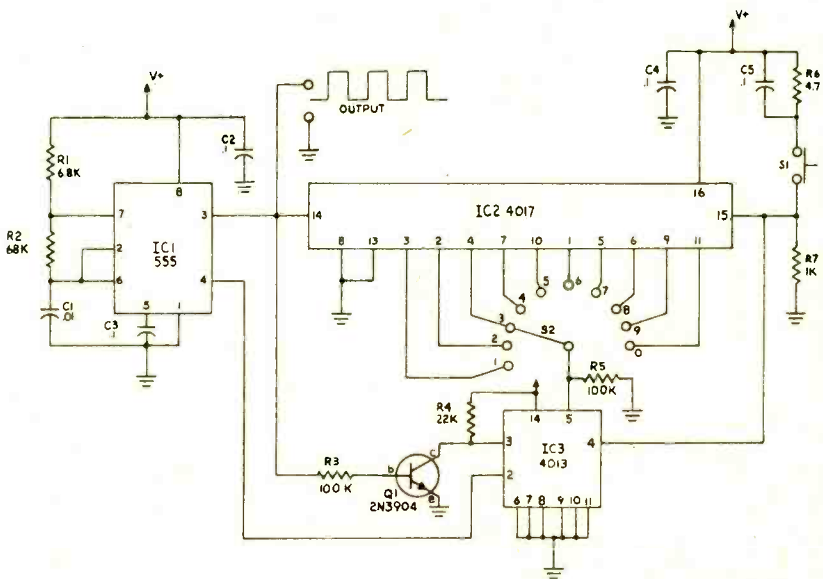
IC3's output consists of either a squarewave or a triangular wave, one of which can be selected by S2. The frequency of both these waveforms is identical and is determined by the voltage fed to the VCO. Potentiometer, R21 is the circuit's volume control.

Meanwhile, back at counter IC2, a pulse has just arrived from oscillator IC1. This increments the counter by one, causing pin 2 of the counter to go HIGH, and pin 3 to return to a LOW state. Successive pulses from IC1 cause the HIGH signal to advance along IC2's output (3, 2, 4...9). The ninth pulse send pin 11 high, thereby turning Q1 on and halting the oscillation of IC1. Pressing S1 sends pin 11 LOW and allows normal sequencing to resume.

Potentiometer R3 controls the tempo, which can be varied from 5 notes per second to one note every two seconds. Trimmers R6 through R14 are used to set the pitch of individual notes over the range from 200 to 2000Hz. If you desire a shorter sequence of notes, omit pots and diodes from end of the sequence starting with pin 9 of IC2 and working backwards.

PARTS LIST FOR MELODIOUS SEQUENCER

R1—6,800-ohm, ½-watt 10% resistor
R2,—47,000-ohm, ½-watt 10% resistor
R3—500,000 trimpot resistor
R4—3,900-ohm, ½-watt 10% resistor
R5—33,000-ohm, ½-watt 10% resistor
R14—20,000 trimpot resistor
R15—4,700,000-ohm, ½-watt 10% resistor
R16—1,000-ohm, ½-watt 10% resistor
R17—68,000-ohm, ½-watt 10% resistor
R18—10,000-ohm, ½-watt 10% resistor
R19—18,000-ohm, ½-watt 10% resistor
C1—100 uF, 25-WVDC electrolytic capacitor
C2, C4, C5—.1 uF, ceramic disc capacitor
C3—3.3 uF, 25-WVDC electrolytic capacitor
C6—.001 uF polystyrene capacitor
C7—.02 uF, mylar capacitor
C8—.47 uF, mylar capacitor
D1-D9—1N914 silicon diode
IC1—555 timer
IC2—4017B CMOS decade counter
IC3—LM566 voltage-controlled oscillator
Q1—2N3904 PNP transistor
R20—4,700-ohm, ½-watt 10% resistor
R21—5,000-ohm, audio-taper potentiometer
S1—SPST normally open pushbutton switch
S2—SPDT switch

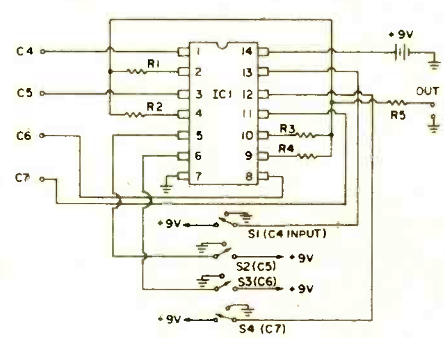


34 Multi-Input Music Synthesizer

☐ 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

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



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.

35 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.

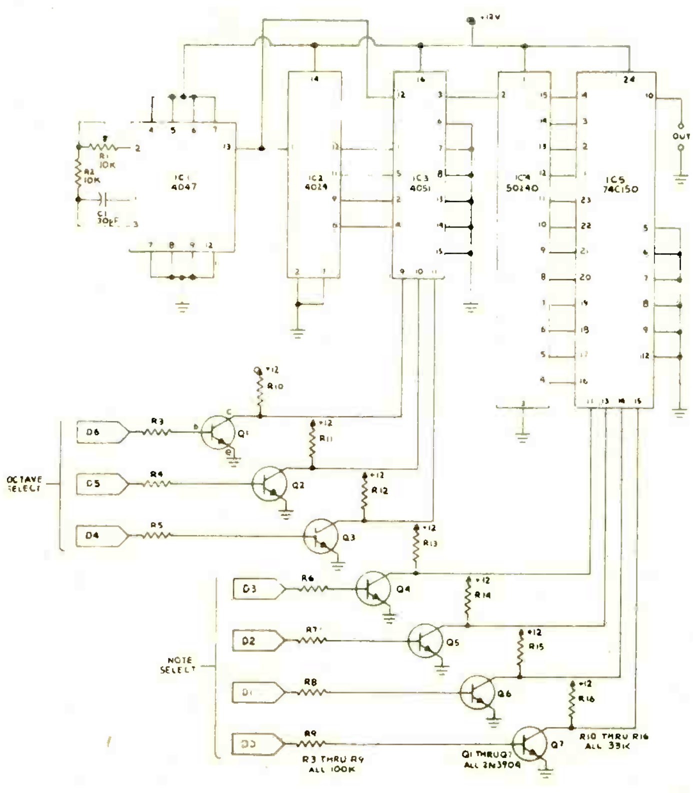
The lowest octave is selected by a binary 0 on lines D6 through D4. A binary 1 selects the next higher octave, and so on until you reach the highest octave, coded by a binary 4 (100). (Note: D6 is the most significant bit; D4 is the least significant.) Codes higher than 4 yeild no output.

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.

Turning 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

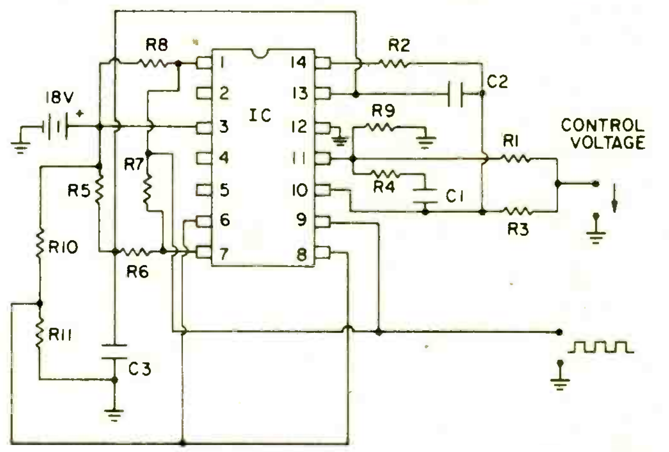


36 Voltage-Controlled Oscillator

☐ 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 VOLTAGE-CONTROLLED OSCILLATOR

C1—0.1-pF ceramic disc capacitor, 15 VKC
C2—500 pF mica capacitor, 15 VDC
C3—0.01-uF ceramic 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

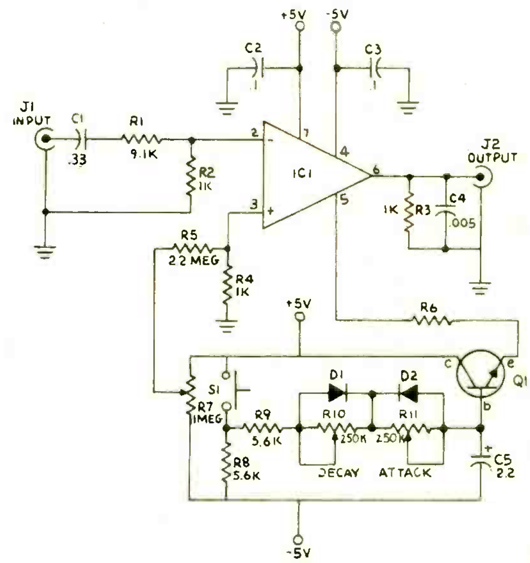


37 Musical Modulator

☐ Feed this circuit a sample audio tone, and it gives you back a musical note with selectable

PARTS LIST FOR MUSICAL MODULATOR

C1—0.33-uF capacitor, 35-WVDC
C2, C3—0.1-uF mylar capacitor, 35-WVDC
C4—0.005-uF electrolytic capacitor, 16-WVDC
C5—2.2-uF electrolytic capacitor, 16-WVDC
D1, D2—1N914 diode
IC1—RCA CA3080 transconductance amp
J1, J2—phone jack
Q1—2N3904 NPN transistor
R1—9100-ohm, ½-watt 10% resistor
R2, R3, R4—1000-ohm, ½-watt 10% resistor
R5—2.2 Megohm-ohm, ½-watt 10% resistor
R6—15,000-ohm, ½-watt 10% resistor
R7—1 Megohm trimmer potentiometer
R8 R9—5600-ohm, ½-watt 10% resistor
R10, R11—250,000 linear-taper potentiometer
S1—normally open SPST pushbutton switch



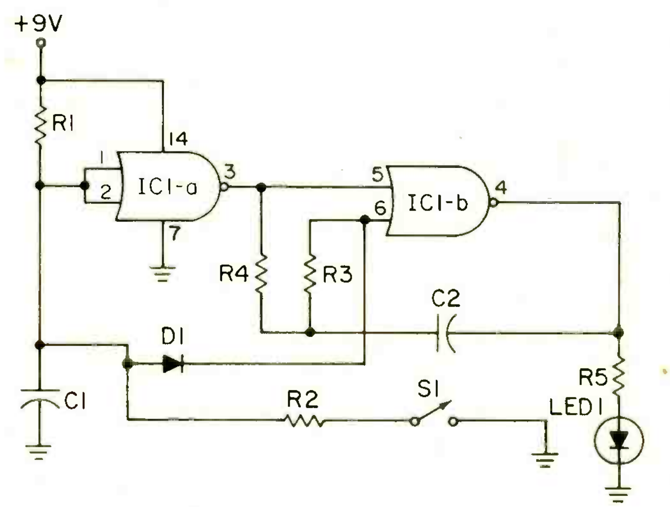
attack, sustain and decay. Input impedance is 10,000-ohms, output impedance is 1000-ohms, and the gain is unity. Best results will be obtained with signal imputs having amplitudes of 1-volt peak-to-peak or less. When S1 is pressed, the output volume rises at a rate determined by attack control R11. As 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).

38 Black Jack Foot Stomper

☐ 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 LED1 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, etc., 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. Ground all unusual terminals on IC1. If you have a horse who can count to 11 by stomping its hoof, you'll keep that hours for many hours.

PARTS LIST FOR BLACK JACK FOOT STOMPER

C1—4.7-uF tantalum capacitor, 15 VDC
C2—0.1-uF ceramic disc capacitor, 15 VDC
D1—1N4001 diode
IC1—4000 NOR gate
LED1—Light-emitting diode
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)



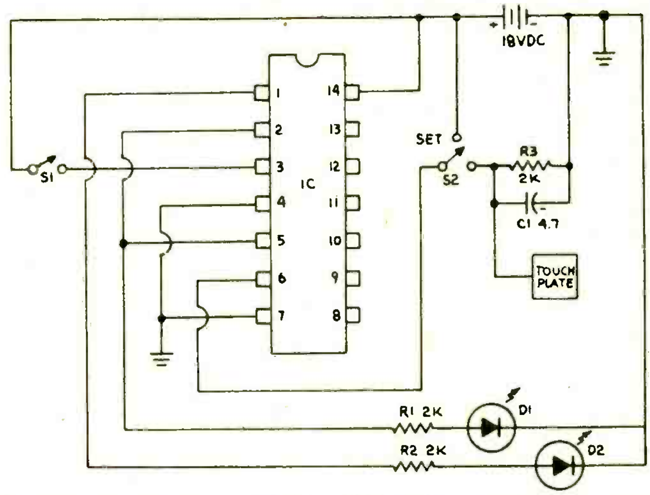
39 Touch 'N Flip

☐ Ever wonder how a touch plate, like the kind you see on some elevator buttons, work? 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.

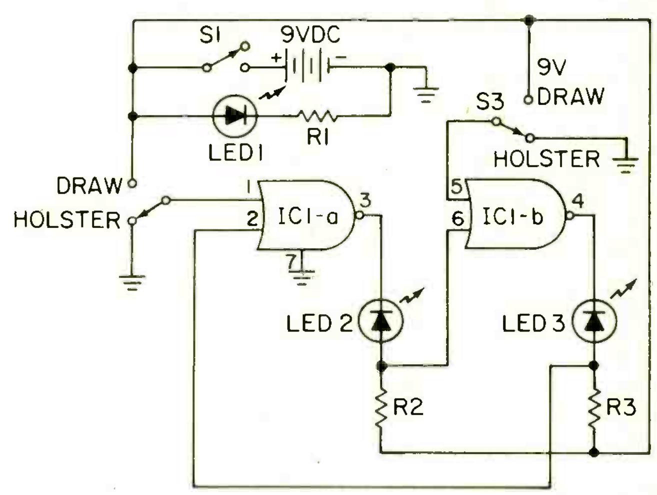
PARTS LIST FOR TOUCH 'N FLIP

C1—4.7-uF 15-WVDC
D1, D2—large LED
IC1—4011 quad NAND gate
R1, R2, R3—2,000-ohm, ½-watt 10% resistor
S1—SPST momentary contact pushbutton switch
S2—SPDT slide switch



40 SHOOT-OUT

☐ The object of "Shoot-Out" 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 LED1. Upon seeing LED1 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. This is a great party game for children.



PARTS LIST FOR SHOOT-OUT

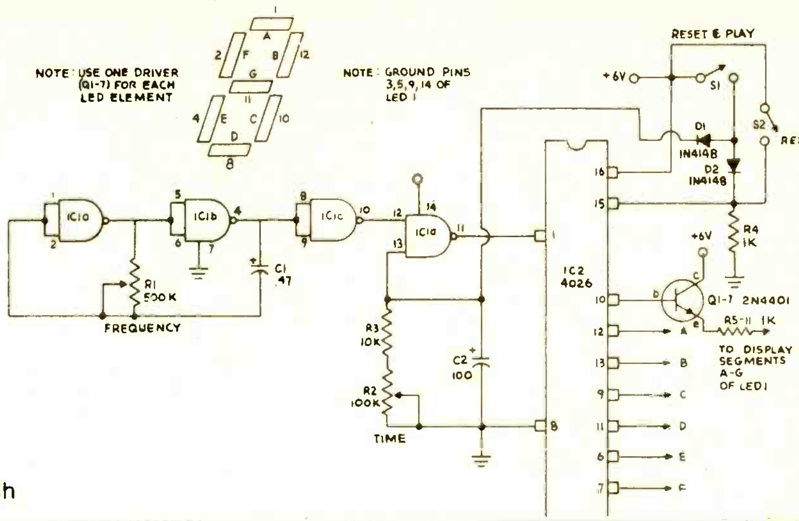
IC1—4011 NAND gate
LED1-LED3—Light-emitting diode
R1—2,000-ohm, ½-watt resistor
R2, R3—1,000-ohm, ½-watt resistor
S1—Pushbutton (doorbell) SPST switch
S2—Toggle-type SPDT switch
S3—Toggle-type SPDT switch

41 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, 14-VDC
D1, D2—1N4148 or 1N914 diode
IC1—4011 quad NAND gate
IC2—4026 decade counter
LED1—DL-750 7-segment display
Q1-Q7—2N4401 transistor
R1—500,000-ohm linear-taper potentiometer
R2—100,000-ohm linear-taper potentiometer
R3—10,000-ohm, ½-watt 10% resistor
R4-R11—1,000-ohm, ½-watt 10% resistor
S1, S2—SPST momentary-contact switch

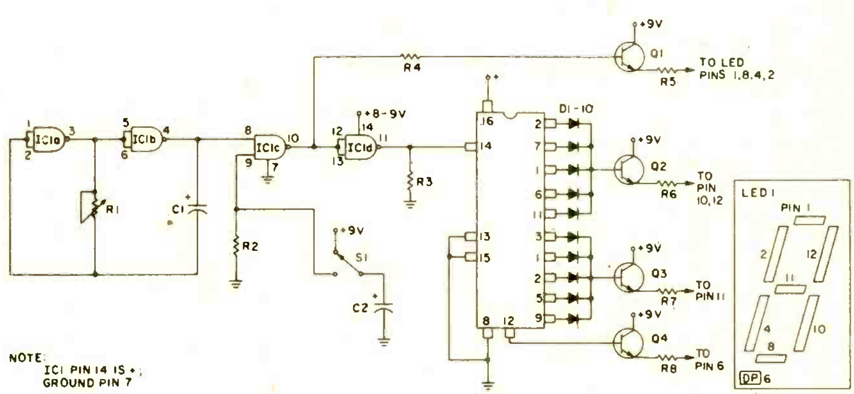


42 Flip It

☐ The continued versatility of the 4017 counter and DL-750 digital display is demonstrated in this flip-it 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 O. Segments A, D, E and F are common to both O 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 FLIP IT

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



43 Theremin Junior

☐ Let's return now to prehistoric times, at least as far as electronic music is concerned. Way back then, nearly forty years ago, an odd-looking and equally odd-sounding instrument known as the Theremin was born. Playing the Theremin entailed waving one's arms spastically between two sets of antennas. The purpose of all this was to modulate the RF fields in the vicinity of these antennas, thereby producing accompanying changes in the frequency and volume of the sound emitted by the instrument.

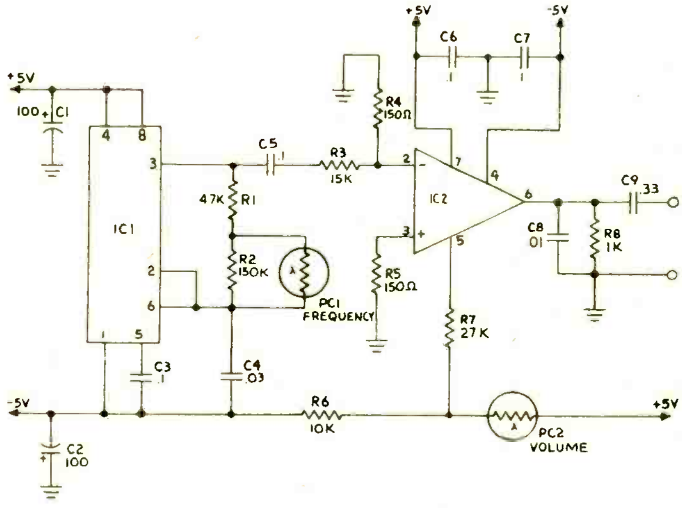
Controlling the sound was both difficult and inexact. As a result, the Theremin never gained widespread popularity, but was instead relegated to the domain of avant-garde composers and science-fiction-movie soundtracks.

Despite the shortcomings, the Theremin is great fun to play, so we decided to create a simple solid-state circuit. Theremin Junior, for those of you too young to have experienced the real thing. In this instance, photocells replace the Theremin's antennas. To play, you move your hands to cast shadows on two photocells, one of which controlls pitch—the other, volume. PC1, the pitch-control photocell, varies in resistance as the intensity of the light shining on its surface varies. This causes a change in the frequency of square-wave oscillator IC1.

Similarly, modulating PC2's resistance with light changes the voltage at pin 5 of IC2, which controls the gain of the circuit. High light intensity results in high frequency and high volume. Frequencies between 150 and 4800 Hz, approximately, can be produced at a maximum amplitude of about 0.5 volt peak-to-peak.

PARTS LIST FOR THEREMIN JUNIOR

C1, C2—100-uF, 16-WVDC electrolytic capacitor
C3, C5, C6, C7—.1-uF ceramic disc capacitor
C4—.03-uF mylar capacitor
C8—.01-uF mylar capacitor
C9—.33-uF mylar capacitor
IC1—555 timer
IC2—RCA 3080 transconductance op-amp
PC1, PC2—cadmium sulfide photocell (Radio Shack 276-116 or equiv.)
R1—4,700-ohm, ½-watt 10% resistor
R2—150,000-ohm, ½-watt 10% resistor
R3—15,000-ohm, ½-watt 10% resistor
R4, R5—150-ohm, ½-watt 10% resistor
R6—10,000-ohm, ½-watt 10% resistor
R7-27,000-ohm, ½-watt 10% resistor
R8-1,000-ohm, ½-watt 10% resistor

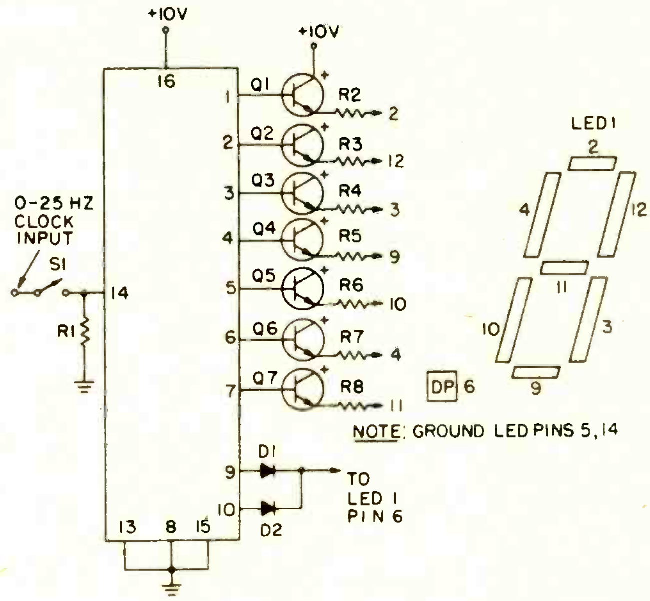


44 Casino Royal

☐ A simple counter-display circuit 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 CASINO ROYAL

D1, D2—IN4148 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.

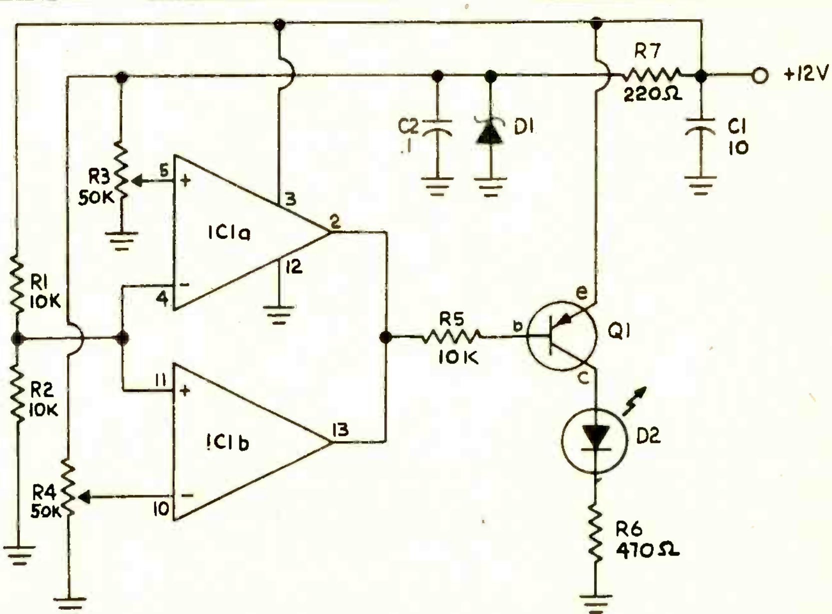


45 Alternator Monitor

□ 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

PARTS LIST FOR ALTERNATOR MONITOR

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



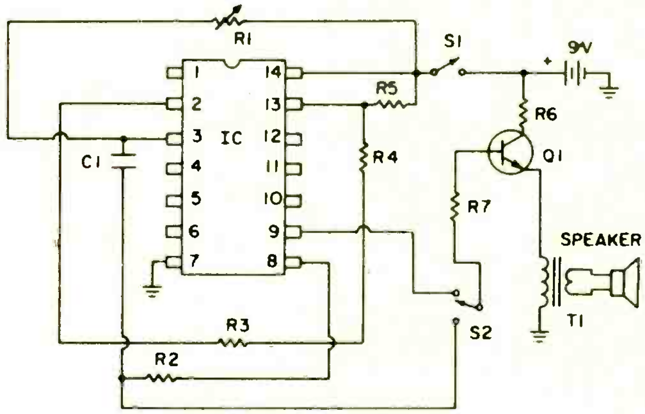
the battery when the car is not in use. To calibrate the circuit, connect an adjustable DC power supply to the + and — inputs of the circuit. Set the power supply to 13.4 volts and adjust R3 so that the voltage at pin 5 of IC1A is maximum. Then adjust R4 so that the LED just goes out. Se tthe power supply 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 permissible range of 13.5 to 15.0 volts when the engine is running.

46 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-WVDC
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

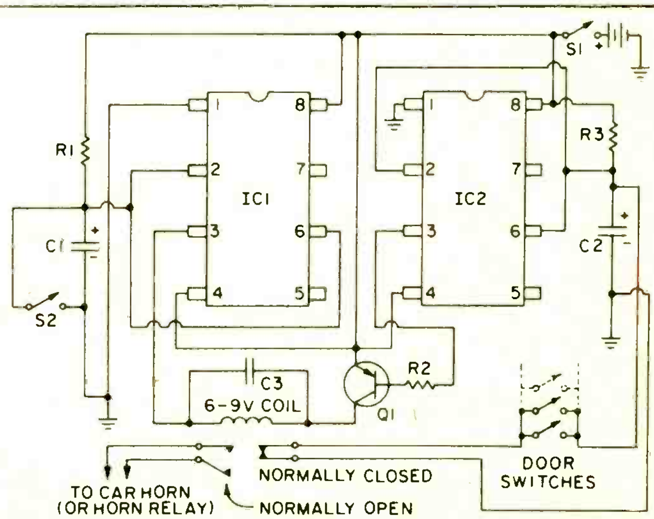


47 Auto Theft Alarm

□ This Auto Theft Alarm aill sound your car horn if anyone opens your car door. The timers allow

PARTS LIST FOR AUTO THEFT ALARM

C1—10-uF electrolytic capacitor, 15-WVDC
C2—1-uF electrolytic capacitor, 15-WVDC
C3—0.1-uF ceramic disc capacitor, 15-WVDC
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



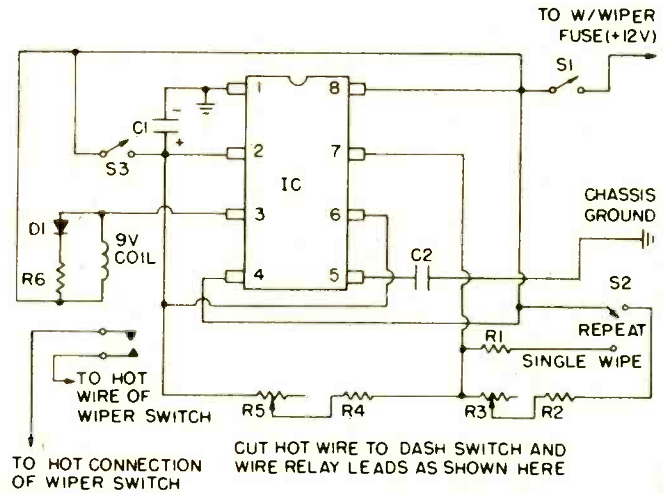
you to leave and enter the car without the horn sounding. To set, or arm, the alarm circuit, open S2. This will give you five seconds (R1, C1) to get out and shut the door behind you. If anyone opens a door for two seconds (R3, C2), the horn will sound and will stay locked on until S1 is opened. If you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

48 Delay 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 DELAY WIPER CONTROL

C1—100-uF electrolytic capacitor, 15 VDC
C2—0.1-uF ceramic 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 (pushbutton) switch
RELAY—9 VDC coil with normally open SPST switch contacts rated at 15 VDC/25 amps

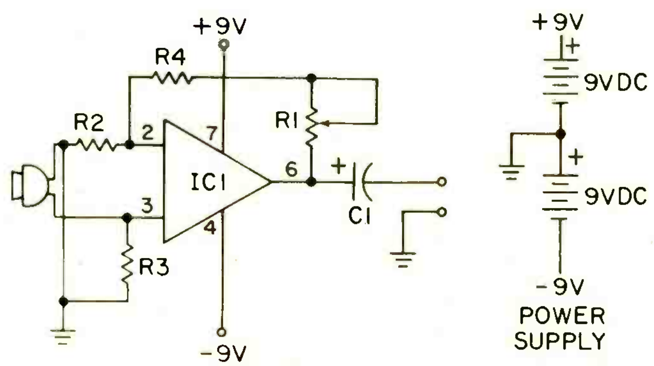


49 Hi-Z Mike Amp

☐ A high-impedance microphone will drive this circuit nicely. The output can drive a 1000 ohm

PARTS LIST FOR HI-Z 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



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.

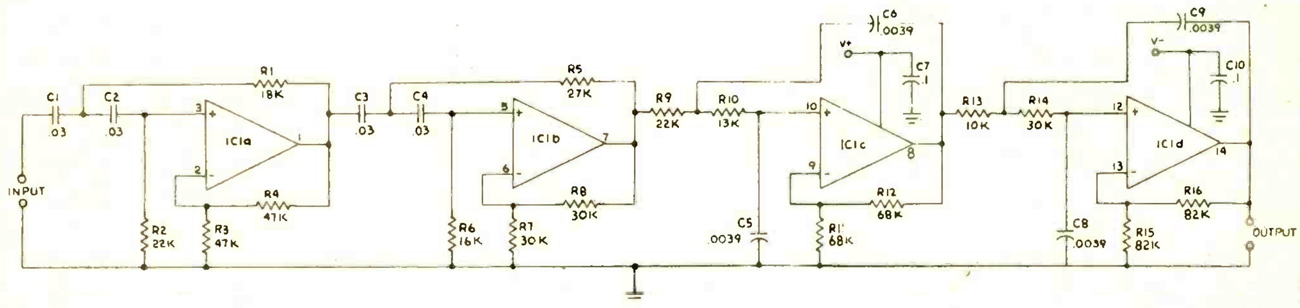
50 Audio Bandpass Filter

□ 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 100m V 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 circuit.

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 5% resistor
R2, R9—22,000-ohm, ½-watt 5% resistor
R3, R4—47,000-ohm, ½-watt 5% resistor
R5—27,000-ohm, ½-watt 5% resistor
R6—16,000-ohm, ½-watt 5% resistor
R7, R8, R14—30,000-ohm, ½-watt 5% resistor
R10—13,000-ohm, ½-watt 5% resistor
R11, R12—68,000-ohm, ½-watt 5% resistor
R13—10,000-ohm, ½-watt 5% resistor
R15, R16—82,000-ohm, ½-watt 5% resistor

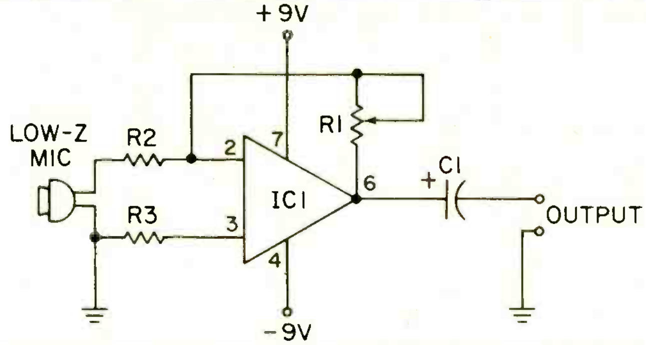


51 Low-Z Mike Booster

□ 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 the setting of R1. This circuit can feed into your hi-fi unit to give greater power output. You can use two nine-volt DC batteries for the power supplies. The returns for the supplies must be grounded.

PARTS LIST FOR LOW-Z MIKE BOOSTER

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

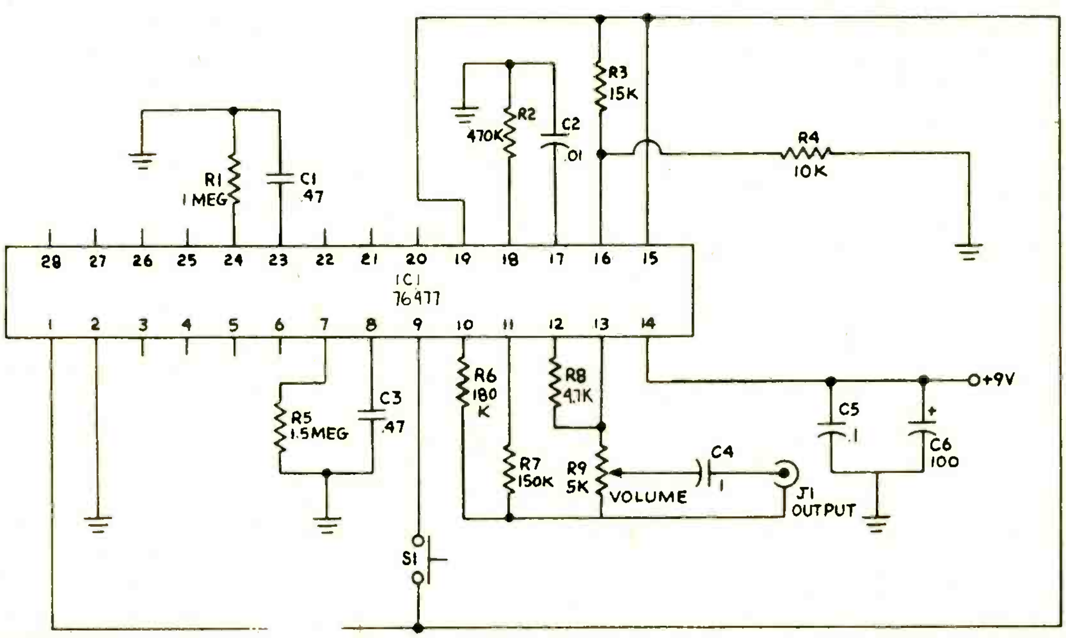


52 Featherweight Foghorn

☐ Despite its small size, the 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

PARTS LIST FOR FEATHERWEIGHT FOGHORN

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

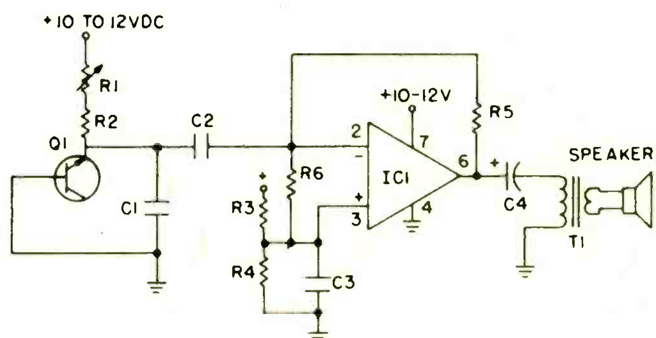


will untie the shoelaces of anyone within hearing distance. The output signal has a 1-volt peak-to-peak maximum amplitude, which is just right for driving the AUX or TUNER inputs of most hi-fi or PA amplifiers. You can change the pitch to suit your own taste by substituting a different value of resistance for R2; larger resistances lower the pitch while smaller ones raise it. Be sure to use a socket with the IC.

53 White 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 semiconductor 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.

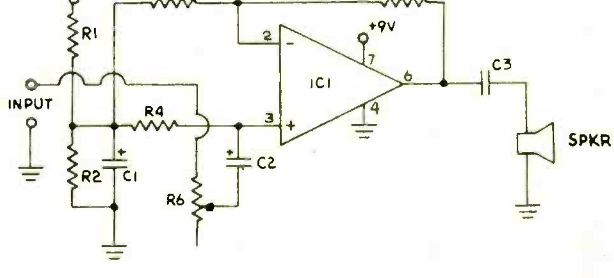
PARTS LIST FOR WHITE NOISE
C1—.005-uF ceramic capacitor, 15 VDC
C2, C3—10-uF electrolytic capacitor, 15 VDC
C4—75-ukF electrolytic capacitor, 25 VDC
IC1—741 op amp
Q1—2N4401
R1—100,000-ohm linear-taper potentiometer
R2, R6—10,000-ohm, ½-watt resistor
R3, R4—4,700-ohm, ½-watt resistor
R5—1,000,000-ohm,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



54 Micro-Mini PA

☐ Designed for **very** private listening, this little amplifier sports a tiny loudspeaker of 1½ to 2

PARTS LIST FOR MICRO-MINI PA
C1—100-uF electrolytic capacitor, 100-WVDC
C2—100-uF electrolytic capacitor, 6-WVDC
C3—100-uF electrolytic capacitor, 10-WVDC
IC1—741 op amp
R1, R2—5,600-ohm, ½-watt 10% resistor
R3—1,000-ohm, ½-watt 10% resistor
R4—50,000-ohm, ½-watt 10% resistor
R5—100,000-ohm, ½-watt 10% resistor
R6—100,000-ohm audio tape potentiometer
SPKR—8 ohm, 2-in PM type



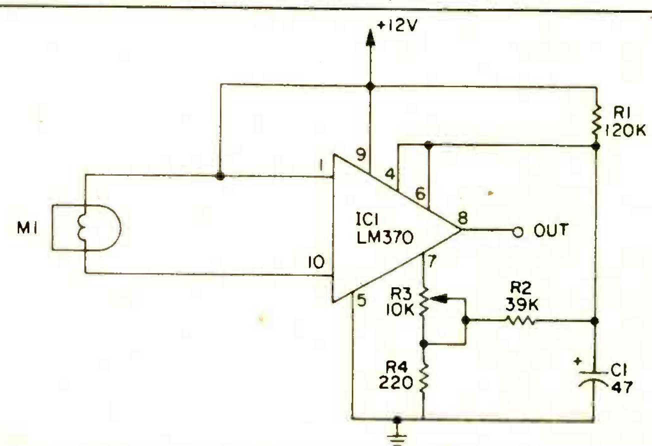
inches diameter. The gain may be varied through a feedback resistor from about 1 to 100. Only a single power supply, which may be a nine volt transistor radio battery, is required.

55 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 output 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

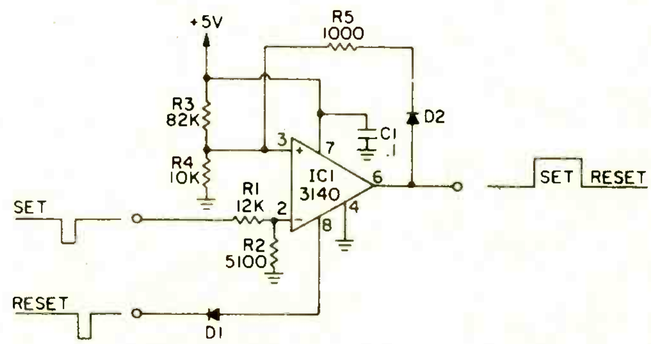


56 Super Op Amp

☐ 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 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.

PARTS LIST FOR SUPER OP AMP

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

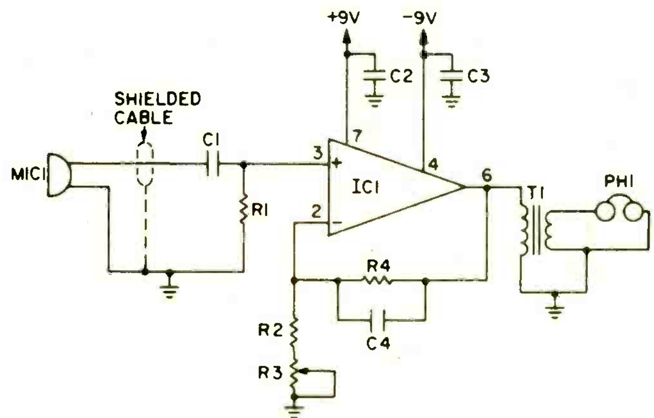


57 Super Stethoscope

□ Ausculation 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 resutls 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—10,000-ohm linear-taper potentiometer
T1—miniature audio output transformer—1,00-ohm primary/8-ohm secondary

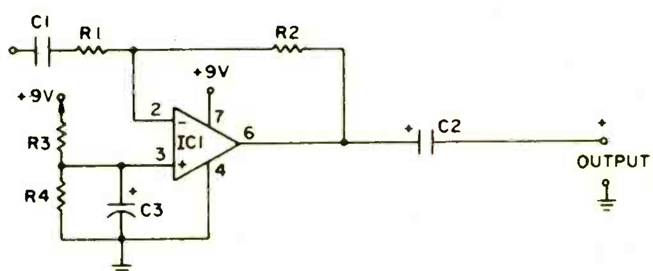


58 Op Amp Variation

□ 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 OP AMP VARIATION

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

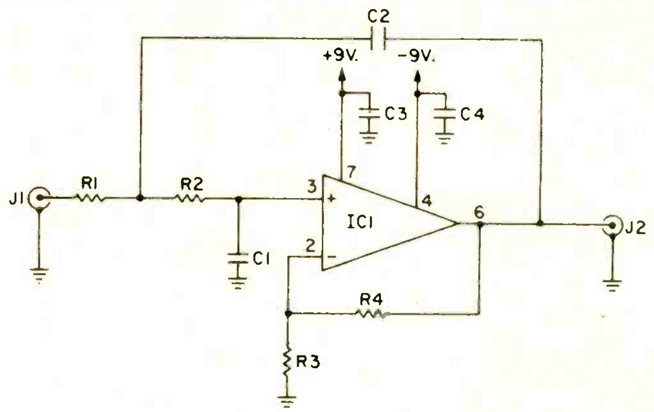


59 Active Low-Pass Filter

☐ 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—12,000-ohm ½-watt resistor, 5%
R2—22,000-ohm ½-watt resistor, 5%
R3, R4—68K-ohm ½-watt resistor, 5%

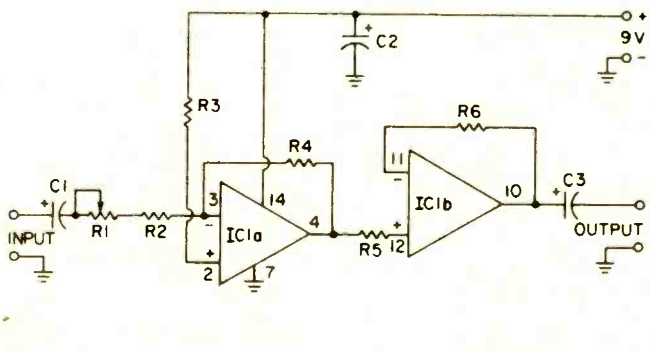


60 Power Mike Amplifier

☐ 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—339 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



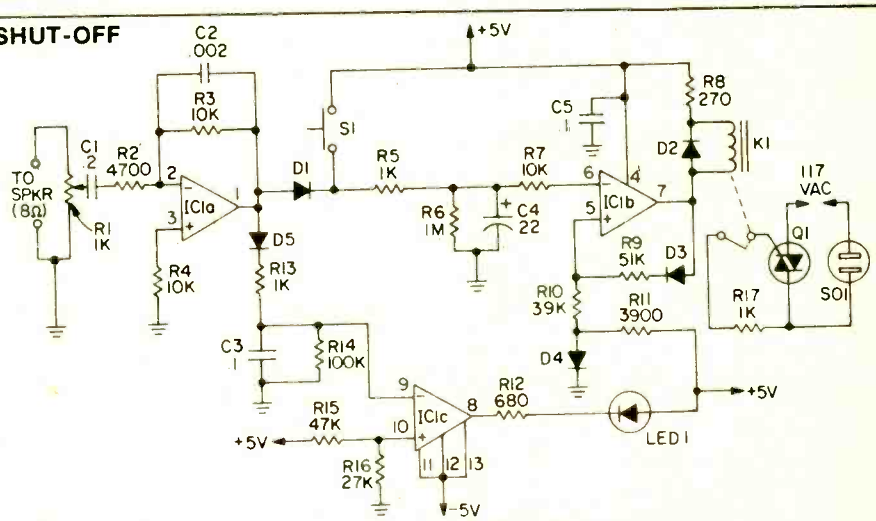
61 Stereo Auto Shut-Off

☐ 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 constantly 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 STEREO AUTO 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, 500-ohm relay
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



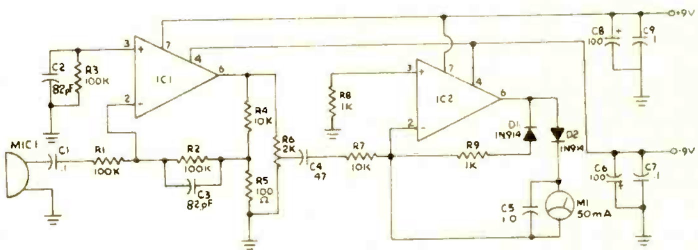
R10—39,000-ohm, ½-watt resistor
R11—3,900-ohm, ½-watt resistor
R12—680-ohm, ½-watt resistor
R14—100,000-ohm, ½-watt resistor
R15—47,000-ohm, ½-watt resistor
R16—27,000-ohm, ½-watt resistor
R17—1,000-ohm, 1-watt resistor
S1—pushbutton switch, normally open
SO1—AC power socket

62 Sound-Level Meter

☐ With this sound-level meter you can easily measure the relative loudness of sounds in the

PARTS LIST FOR SOUND-LEVEL METER

C1, C7, C9—.1-uF ceramic disc capacitor
C2, C3—82 pF polystyrene capacitor
C4—.47 uF mylar capacitor
C5—1.0 uF mylar capacitor
C6, C8—100 uF 25V electrolytic capacitor
D1, D2—1N914 silicon diode
IC1—RCA 3140 FET-input op amp
IC2—741 op amp
M1—0-50 microamp DC meter
MIC1—crystal microphone cartridge
R1, R2, R3—100,000-ohm, ½-watt 10% resistor



R4, R7—10,000-ohm, ½-watt 10% resistor
R5—100-ohm, ½-watt 10% resistor
R6—2,000-ohm linear taper potentiometer
R8, R9—1,000-ohm, ½-watt 10% resistor

range from 20 to 20,000 Hz. Although your readings will not be calibrated in terms of—or even be linearly proportional to—true sound power, this circuit should very adequately fill the bill.

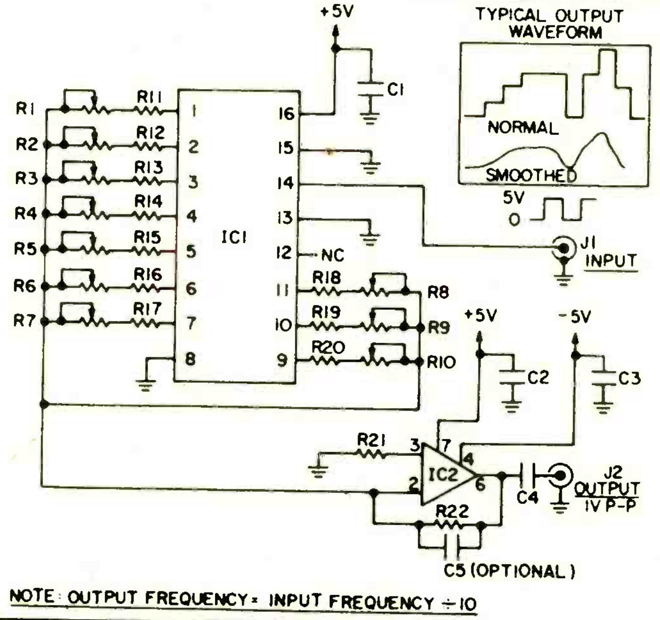
Amplifier IC1 multiples the signals from microphone MIC1 by a factor of 100. This amplied signal is then applied to IC2, which functions here as a precision rectifier. Meter MI is tucked into one of IC2's feedback loops, where it measures a rectified and filtered direct current proportional to the sound level. Potentiometer R6 allows you to adjust the instrument's sensitivity to match the application—anything from audience-applause measurement to sound-system installation.

63 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 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—68,000-ohm ½-watt resistor, 10%
R21, R22—15,000-ohm ½-watt resistor, 10%



64 Precision VOM Calibrator

☐ Until now, most of the calibrator circuits appearing in hobby magazines could not be considered as primary reference standards. Instead, they were **transfer standards,** since the builder would be instructed to align his calibrator using a voltage reference of known accuracy. The obvious reaction of most readers was: "If I had access to an accurate voltage reference to begin with, why would I want to build this calibrator?"

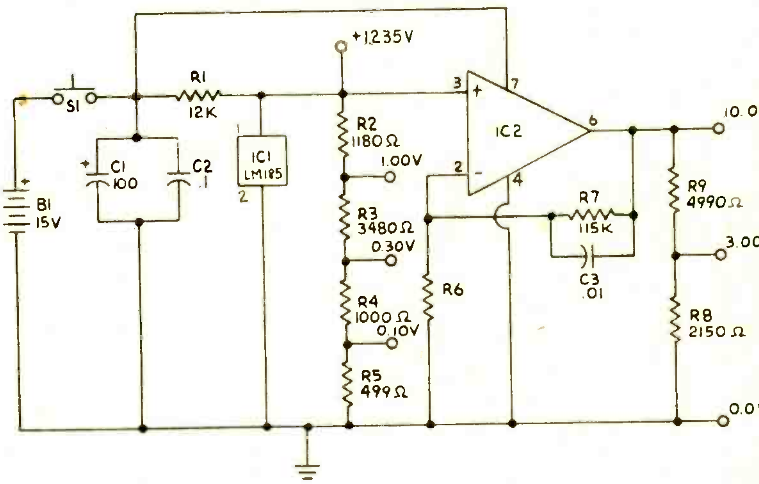
Our sentiments exactly. Now National Semiconductor comes to the rescue with a voltage reference IC, the LM185, having an output of 1.235 bolts 1%. What's more, this voltage remains stable in the face of changing ambient temperature and supply current.

The circuit diagrammed here produces six useful reference voltages from .100 V to 10.0 V. As noted above, the 1.235-volt output is accurate to within 1%. All of the other outputs are accurate to within 2% except for the 3-volt output, which has a tolerance of 4%. Reduced accuracy on all derived outputs is the result of errors introduced by the 1% resistor tolerances. Bear in mind, however, that worst-case accuracies are quoted here.

Be certain that the input resistance of the instrument being calibrated greatly exceeds the resistance at the circuit node being read. Most of you who worry about calibration have high-impedance (10-megohm) FET voltmeters, the loading effects of which are negligible here.

PARTS LIST FOR PRECISION VOM CALIBRATOR

B1—ten AA cells in series to yield 15 volts
C1—100 uF, 25 electrolytic capacitor
C2—.1 uF ceramic disc capacitor
C3—.01 uF polystyrene or mylar capacitor
IC1—LM185 1.235-volt reference IC (National Semiconductor)
IC2—3140A FET-input op amp (RCA) All Resistors ½w, 1% precision unless noted otherwise
R1—12,000-ohm, ½-watt 10% resistor
R2—1,180-ohm, ½-watt resistor
R3—3,480-ohm, ½-watt resistor
R4—1,000-ohm, ½-watt resistor
R5—499-ohm, ½-watt resistor
R6—162,000-ohm, ½-watt resistor
R7—115,000-ohm, ½-watt resistor
R8—2,150-ohm, ½-watt resistor
R9—4,990-ohm, ½-watt resistor
S1—SPST normally open pushbutton switch

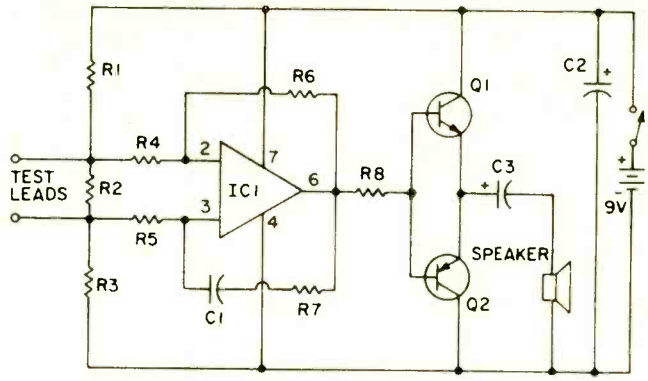


65 Continuity Tester

□ 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 TESTER

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 transistor
Q2—2N4403 transistor
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

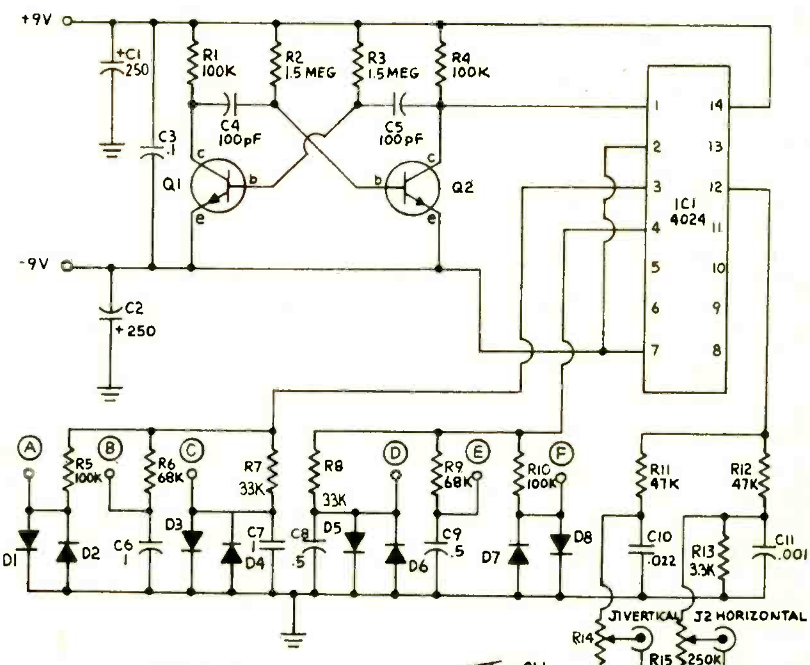


66 Video Pattern Generator

☐ Those of you with oscilloscopes might enjoy bread boarding 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, 34 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-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 10% resistor
R2, R3—1.5-Megohm, ½-watt 10% resistor
R6, R9—68,000-ohm, ½-watt 10% resistor
R7, R8—33,000-ohm, ½-watt 10% resistor
R11, R12—47,000-ohm, ½-watt 10% resistor
R13—3300-ohm, ½-watt 10% resistor
R14, R15—250,000 linear-taper potentiometer



B	C	B	B	A	A	C
C	E	D	B	B	F	D

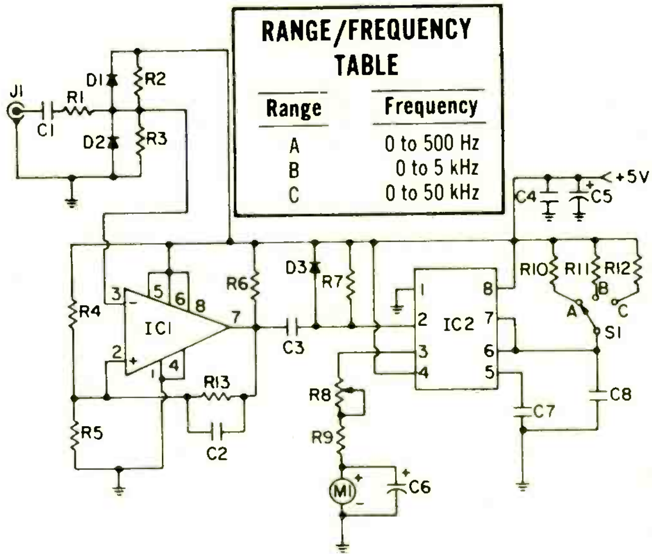
TRY CONNECTING CLIPS TO THESE PAIR OF POINTS

67 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 FREQUENCY METER

C1, C4, C7—0.1-uF ceramic disc capacitor, 34 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—18,000-ohm ½-watt resistor, 5%
R6—1000-ohm ½-watt resistor, 10%
R7—10,000-ohm ½-watt resistor, 10%
R8—10,000-ohm trimmer potentiometer
R9, R11—30,000-ohm ½-watt resistor, 5%
R10—3000-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

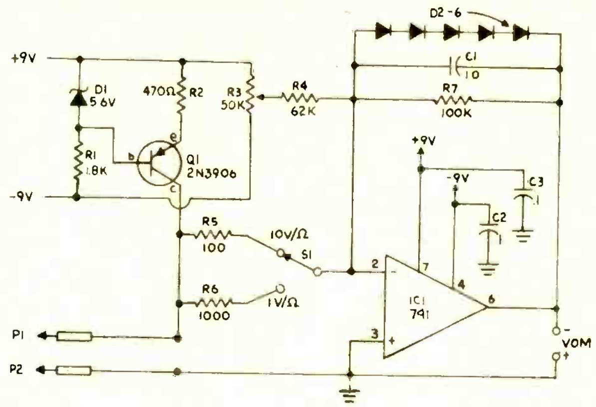
68 Milliohms Adapter

☐ 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 instance, motor manufacturers routinely check their coils with milliohmmeter. Since the next 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 IC1'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, so set the VOM to the 1-volt scale.

PARTS LIST FOR MILLIOHMS ADAPTER

C1—1.0-uF mylar capacitor
C2, C3—0.1-uF ceramic disc capacitor
D1—6.6-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 fixed resistors 5%, unless otherwise noted.)
R2—470-ohm, ¼-watt resistor
R3—66,000-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



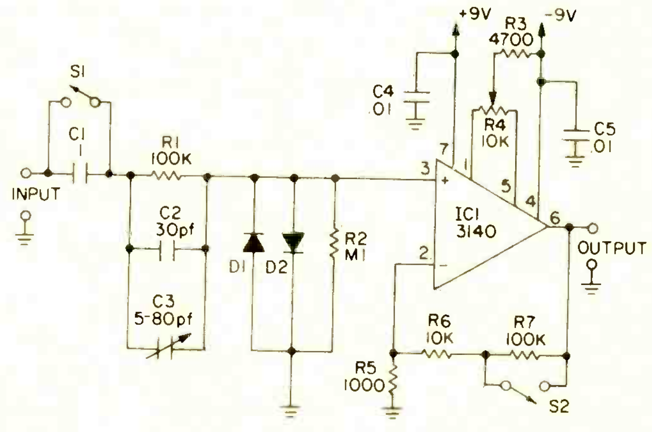
69 Instrument Sensitivity Booster

☐ 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
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



70 Meterless Voltmeter

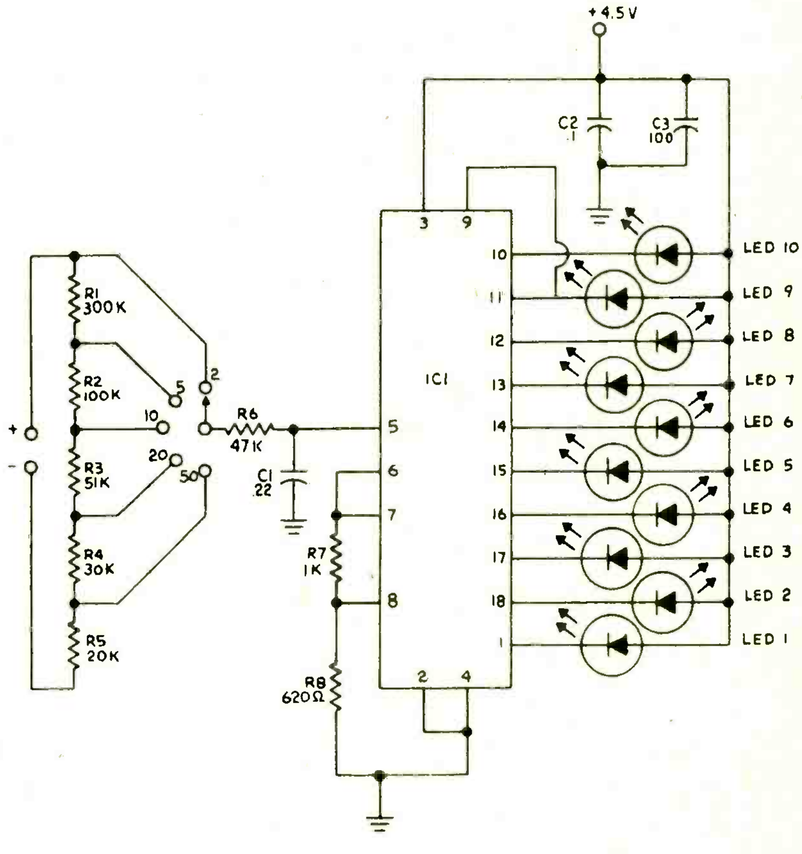
□ Here is a DC voltmeter that is light, rugged and, best of all, **cheap.** Instead of a meter, it uses the National Semiconductor LM3914 display driver and ten light-emitting diodes to measure voltage in five ranges. As the voltage present at the instrument's input rises above ground level, first LED1 lights, followed by LED2 and so on until, finally, LED10 comes on.

We have chosen the dot-display mode, so only one LED is on at a time. This is more energy-efficient than a bargraph display (which this chip is also capable of producing). Capacitor C1 filters out any extraneous AC components of the input signal, thus eliminating display jitter.

Should you be inclined to absent-mindedness, take heart because you will have a tough time clobbering this meter regardless of how careless you are. Inputs as high as 100 portionately higher overloads can be tolerated on the higher voltage ranges. Full-scale sensitivities of 2, 5, 10, 20 or 50 bolts DC may be selected with S1. Each LED represents a voltage increment one-tenth of full scale. Three AA cells in series can supply power for this circuit.

PARTS LIST FOR METERLESS VOLTMETER

C1—.22 uF mylar capacitor
C2—.1 uF ceramic disc capacitor
C3—100 uF, 10V electrolytic capacitor
IC1—LM3914 dot/bar display driver (National Semiconductor)
LED1 thru LED10—light emitting diodes
R1—300,000-ohm, ½-watt 5% resistor
R2—100,000-ohm, ½-watt 5% resistor
R3—51,000-ohm, ½-watt 5% resistor
R4—30,000-ohm, ½-watt 5% resistor
R5—20,000-ohm, ½-watt 5% resistor
R6—47,000-ohm, ½-watt 5% resistor
R7—1,000-ohm, ½-watt 5% resistor
R8—620-ohm, ½-watt 10% resistor
S1—SP5 ps. rotary switch

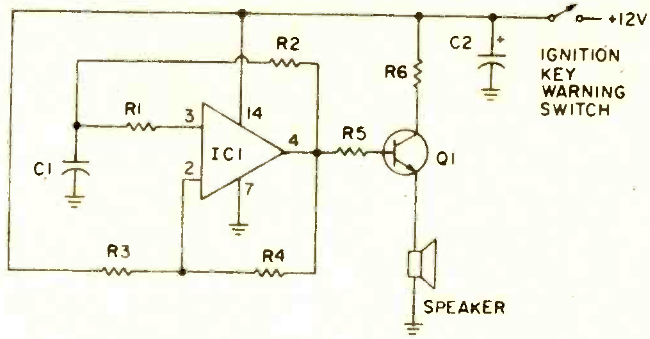


71 Ignition Key Alarm

□ This ignition key alarm replaces the loud, annoying buzzer in your car with a pleasing tone of about 2000 Hertz. One section of an LM3900 quad operational amplifier is connected as a square wave generator, which is rich in harmonies 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.

PARTS LIST FOR IGNITION KEY ALARM

C1—0.01-uF ceramic capacitor, 15 VDC
C2—10-uF electrolytic capacitor, 20 VDC
IC1—LM 3900 quad amplifier
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

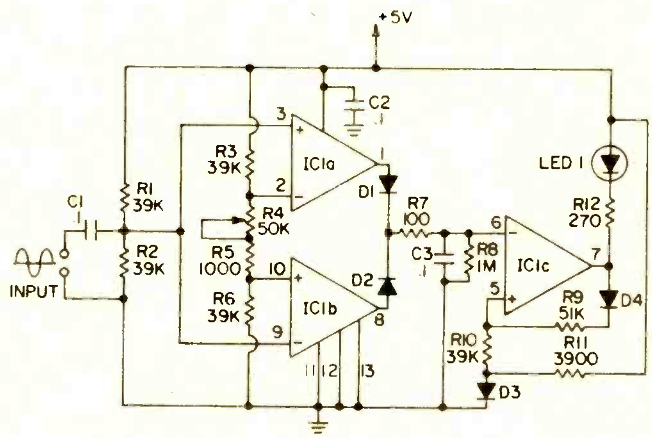


72 Peak-Level Detector

□ 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 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.

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

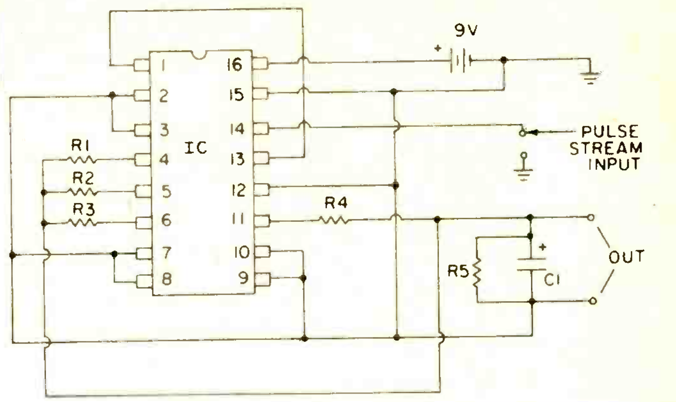


73 Sinewave Generator

□ Think it is possible to have a pulse stream turned into a nice smooth sinewave? This circuit will do it! In fact, you can have the lowest sinewave 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 sinewave.

PARTS LIST FOR SINEWAVE 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

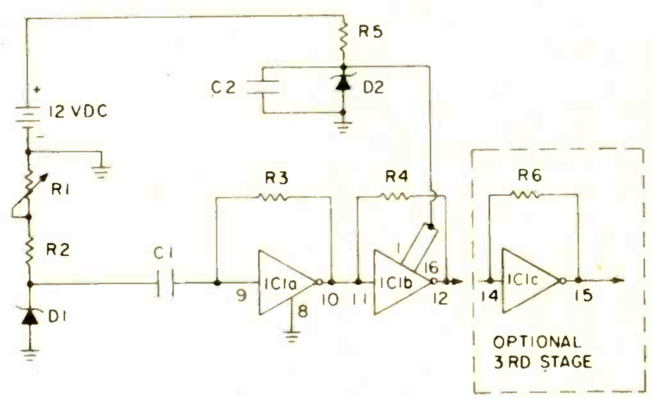


74 RF Noise Generator

□ 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

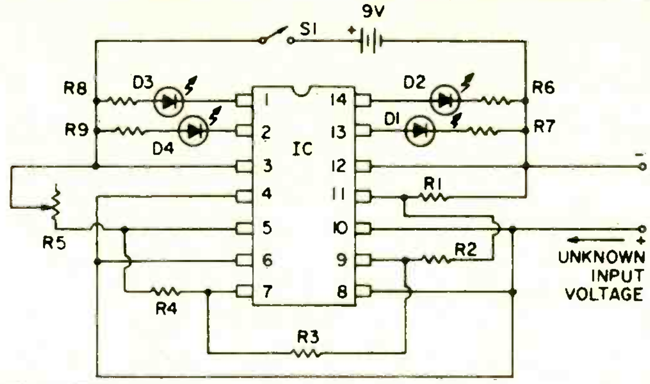


75 Meter Eliminator

□ 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

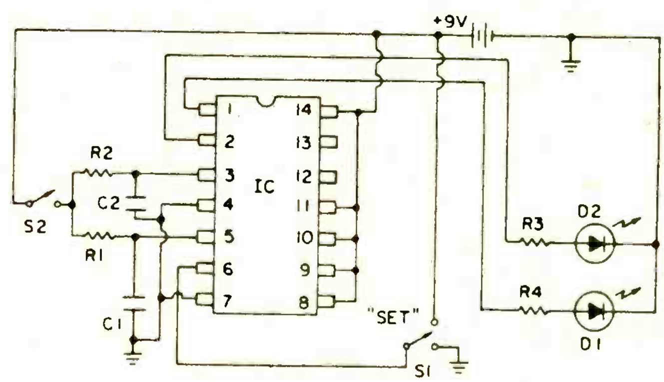


76 Capacitor Match-Maker

☐ 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



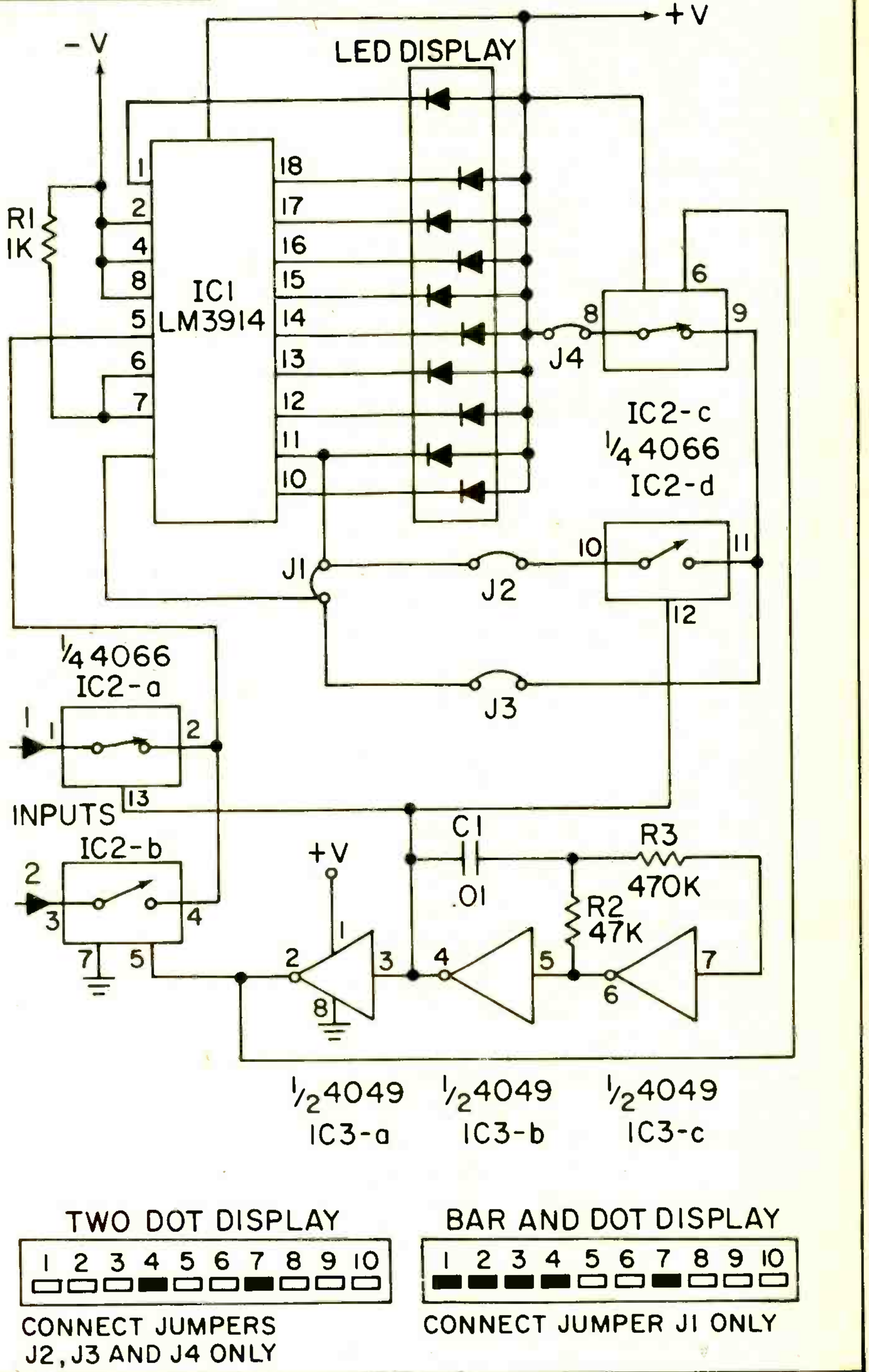
77 Doubled-Up Bargraph Display

☐ What could be simpler than comparing two bargraph displays? If you said that one bargraph display is simpler for two signals—you guessed right. This unique circuit switches the inputs of two analog signals and provides a LED bargraph displayed by one driver such as the LM3914 for a linear readout (LM3915 offers a logarithmic display; LM3915, VU display). The circuit may be set to display two dots (see jumper connection data in diagram), so that when they coincide and only one dot is seen, the amplitudes of inputs 1 and 2 are about equal. This unusual setup makes for a very interesting and accurate VU display. The clock section is composed of IC3 (4049 chip) that triggers the switch action of IC2 (analog switch).

Should you want to use a format where the bargraph is used with a dot graph, remove jumper 1 and install jumpers 2, 3, and 4. This setup is ideal for watching the rms value of an audio signal on the bargraph and the peak voltage at that time appears as a dot that will either fall in the bargraph or bounce somewhere above it. This makes for a very unusual display. Remember, with jumper 1 in the circuit, the other jumpers are out; with jumper 1 out of the circuit, the other three are in.

PARTS LIST FOR DOUBLED-UP BARGRAPH DISPLAY

C1—.01-uF disc capacitor
DIS1—Bargraph display with 10 LED elements
IC1—LM3914 bar graph driver
IC2—4066 quad switch
IC3—4049 hex inverting amplifiers
J1-J3—copper wire used as jumpers to avoid expensive switching
R1—1000-ohm, ½-watt resistor
R2—47,000-ohm, ½-watt resistor
R3—470,000-ohm, ½-watt resistor

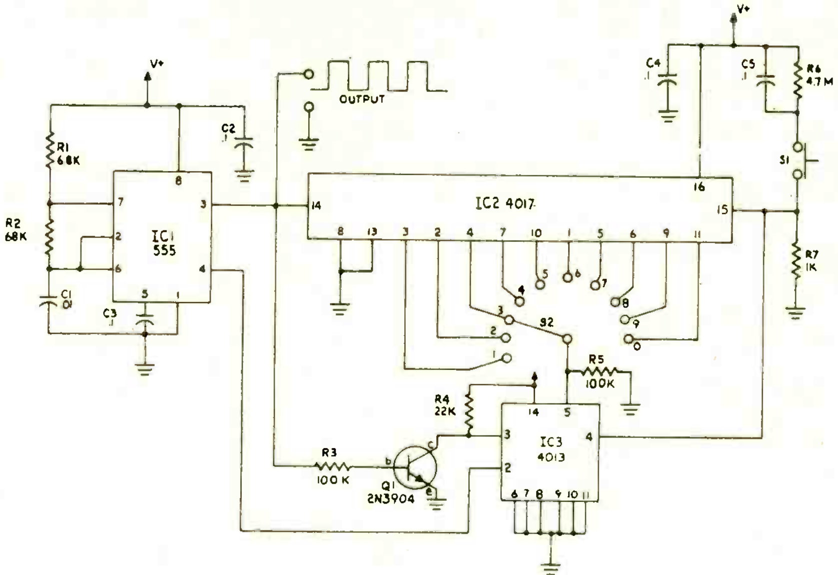


78 Pulse-Burst Generator

☐ 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 1kHz. 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.

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 10% resistor
R2—68,000-ohm, ½-watt 10% resistor
R3, R5—100,000-ohm, ½-watt 10% resistor
R4—22,000-ohm, ½-watt 10% resistor
R6—4,700,000-ohm, ½-watt 10% resistor

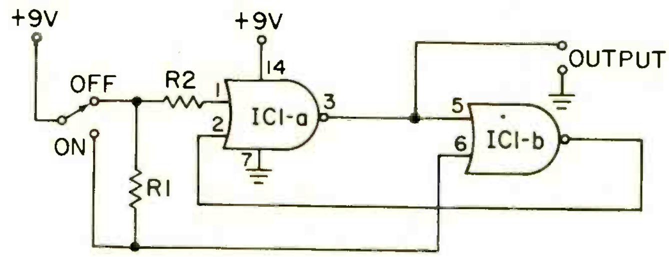


79 Clean Switch

☐ 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 industry. 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

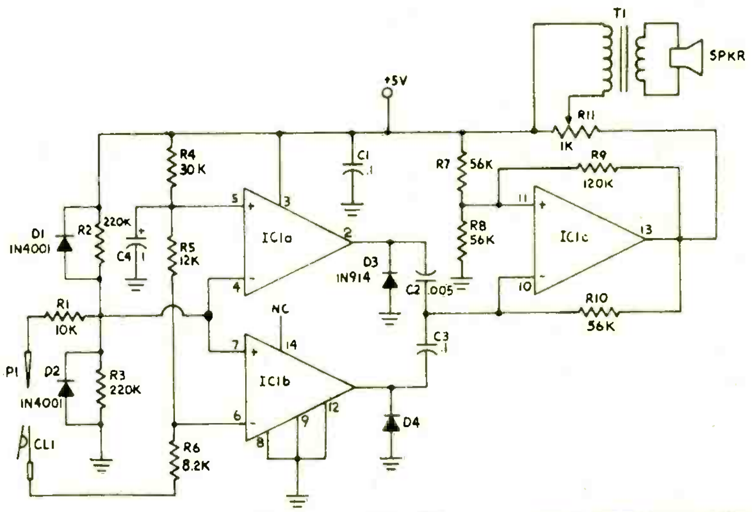


80 Audible Logic Probe

☐ 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-O 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 AUDIBLE LOGIC PROBE

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

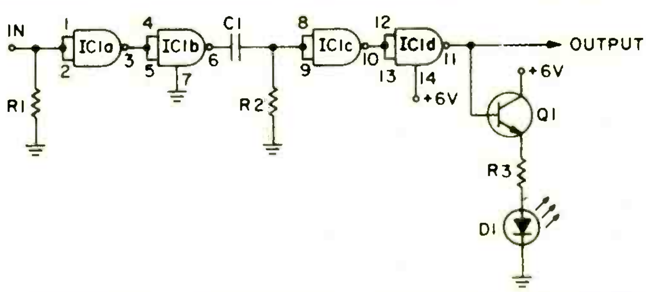


81 Improvised Monostable MV

☐ 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 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.

PARTS LIST FOR IMPROVISED MONOSTABLE MV

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



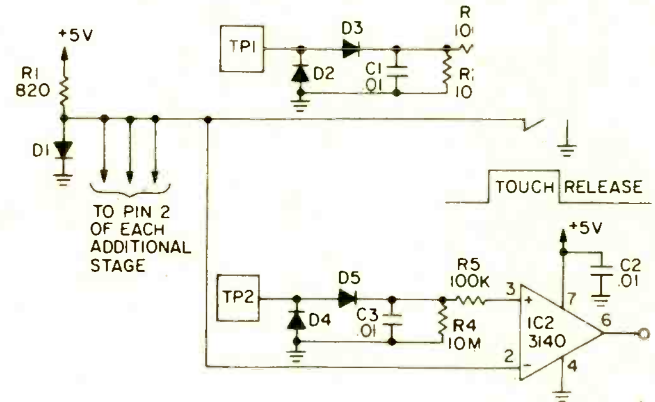
82 Touch Keyboard

☐ 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 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)



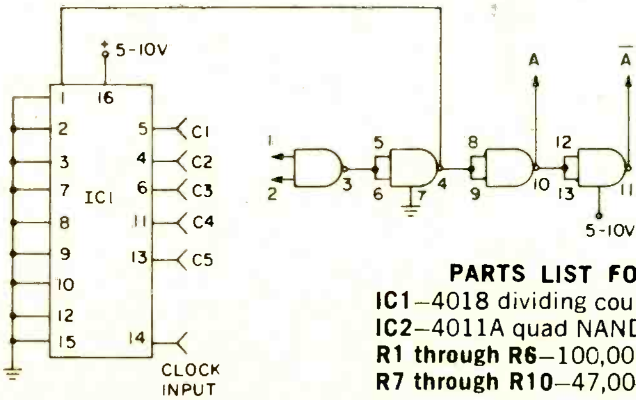
83 Divider Decider

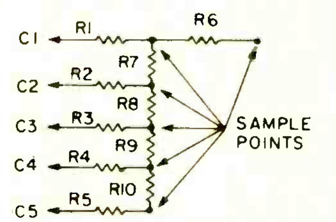
☐ The type 4018 programmable counter is a useful digital tool, especially where a basic clock frequency must be divided down for various timing operations. With proper connections, divisors of from 2 through 10 may be configured. The table shown below gives the connections. The odd divisors do not give 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

PARTS LIST FOR DEVIDER DECIDER

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

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





DIGITAL TO ANALOG CONVERSION NETWORK

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

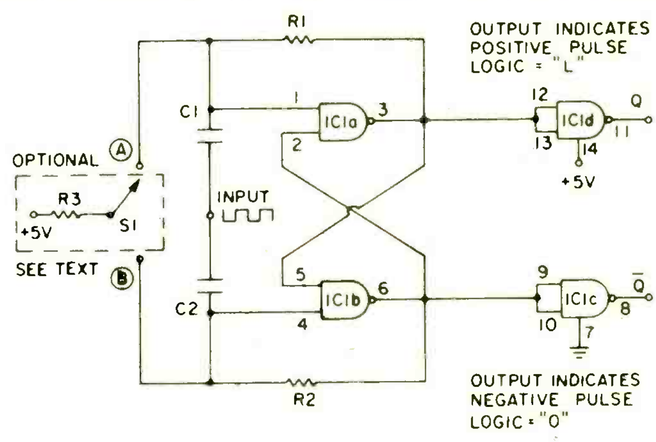
the outputs as shown. Interesting waveforms may be obtained by trying out the various dividing connections, while tying an oscilloscope into the different resistor network junctions. With the circuit set for a divide-by-ten function, a *digital sine wave* may be discovered at certain points along the network. With clock frequencies above 1 KHz, this output may be heard on an audio amplifier. Computer Music, anyone?

84 Logic Learner

□ 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 LOGIC LEARNER

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

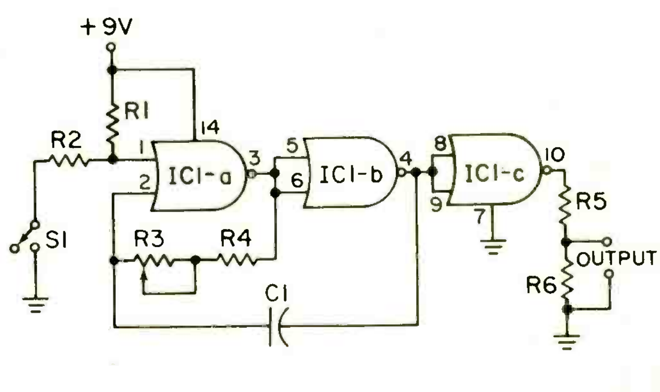


85 Code Practice Oscillator

□ 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 2-input NOR gate
R1—91,000-ohm, ½-watt resistor
R2—220-ohm, linear-taper potentiometer
R4—50,000-ohm, ½-watt resistor
R5—2,200-ohm, ½-watt resistor
S1—SPST momentary-contact pushbutton switch

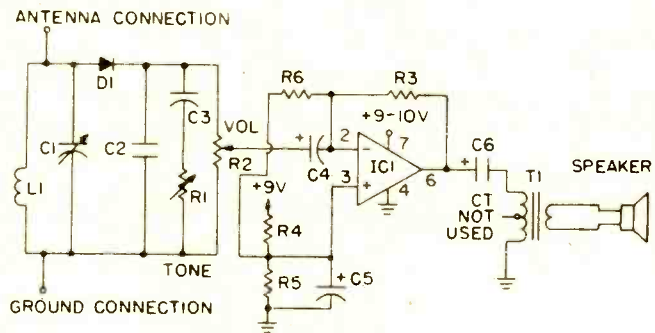


86 Crystal Radio

☐ 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 protable radio convenience for escaping the frustrations of the IC experimental test bench.

PARTS LIST FOR CRYSTAL RADIO

C1—365-uF variable capacitor
C2—0.01-uF ceramic capacitor, 15 VDC
C3—0.1-uF ceramic capacitor, 15 VDC
C4, C5—100-uF ceramic 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—25,000 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

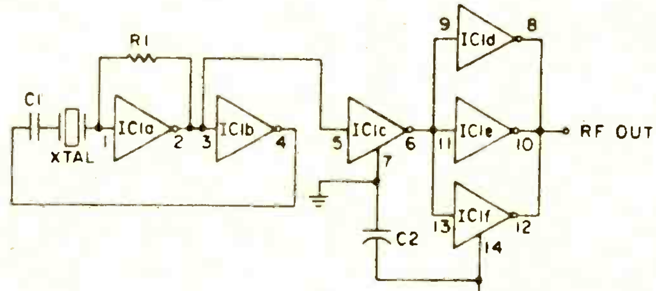


87 Crystal-Controlled Oscillator

☐ 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 OSCILLATOR

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)



88 ESP Tester

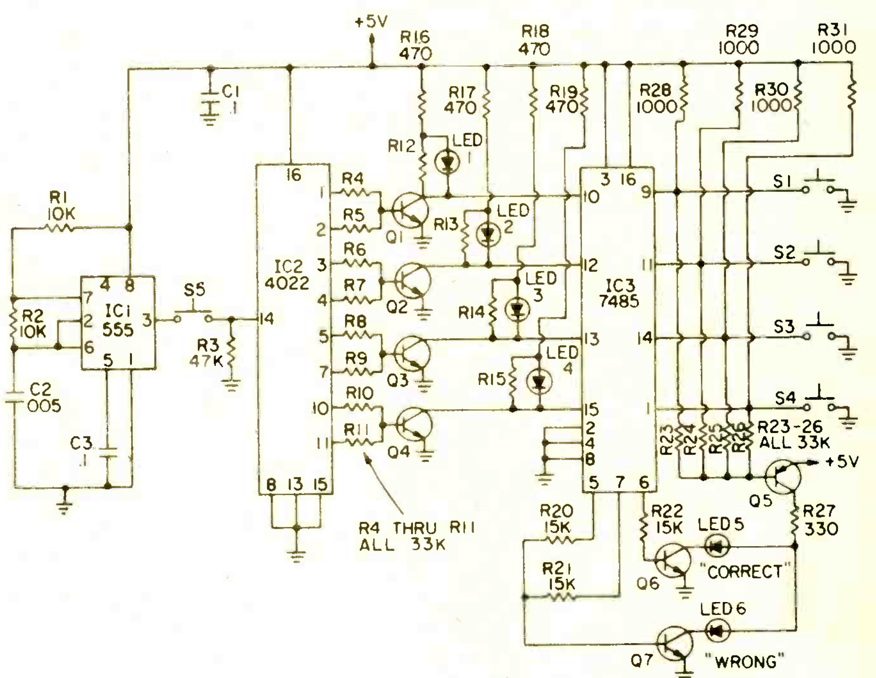
□ The closest encounter most of us ever have with psychic phenomena probably comes from in-laws with the uncanny knack for dropping by just as dinner is served. If you'd like to delve somewhat deeper into the world of the unknown, or if you just want an intriguing party game, give this ESP tester a try.

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 disposal. 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.

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



89 DC-Motor Controller

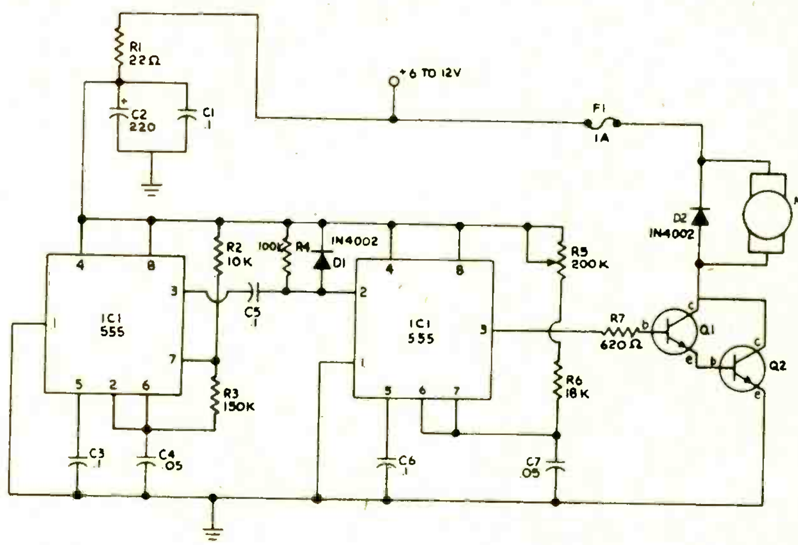
□ The obvious way to control the speed of a small DC motor is with a series rheostat. Although this has the advantage of simplicity, it is far from a satisfactory solution. Motors "choke out" at low speeds because they lose torque as well as rotational velocity.

A much better way to control the speed of a small, permanent-magnet DC motor is with the pulse-width-modulator circuit in the accompanying schematic Oscillator IC1 operates at a constant rate of 100 Hz and periodically triggers monostable IC2. Once triggered, IC2 sends its output (pin 3) HIGH for a time interval determined by R5. With the components specified, IC2's pulse duration can be set anywhere from 1 to 10 milliseconds. Transistors Q1 and Q2 couple IC2's pulse output to the motor.

Since IC2 is being driven by a 100-Hz signal (with a period of 10 milliseconds), this means that the signal at IC2's output will spend between 10% and 100% of its time HIGH. The lower this percentage is, the smaller the average current applied to the motor becomes. Naturally, this results in less velocity, but adequate torque is still maintained to prevent stalling. Be sure to mount Q2 on a small heat sink.

PARTS LIST FOR DC-MOTOR CONTROLLER

C1, C3, C5, C6—.1-uF ceramic disc capacitor
C2—200-uF, 25V electrolytic capacitor
C4, C7—.05-uF mylar capacitor
D1, D2—1N4002 rectifier diode
F1—1-amp fuse
IC1, IC2—555 timer
MOT1—DC permanent-magnet motor, 6 to 12 volts
Q1—2N3904 NPN transistor
Q2—2N3055 NPN power transistor
R1—22-ohm, ½-watt 10% resistor
R2—10,000-ohm, ½-watt 10% resistor
R3—150,000-ohm, ½-watt 10% resistor
R4—100,000-ohm, ½-watt 10% resistor
R5—200,000-ohm linear-taper potentiometer
R6—18,000-ohm, ½-watt 10% resistor
R7—620-ohm, ½-watt 10% resistor

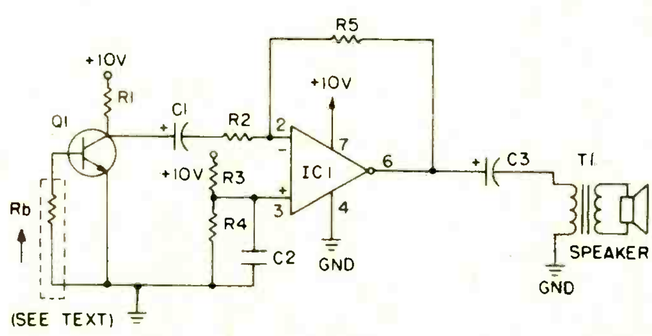


90 Light Into Sound

☐ 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 1,000,000-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

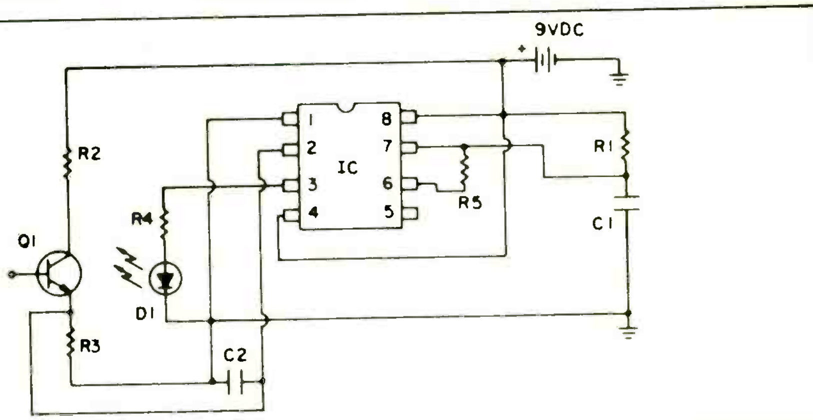


91 Optical Confusion

□ "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—220-ohm, ½-watt resistor
R4—220-ohm, ½-watt resistor
R5—2,000,000-ohm, ½-watt resistor

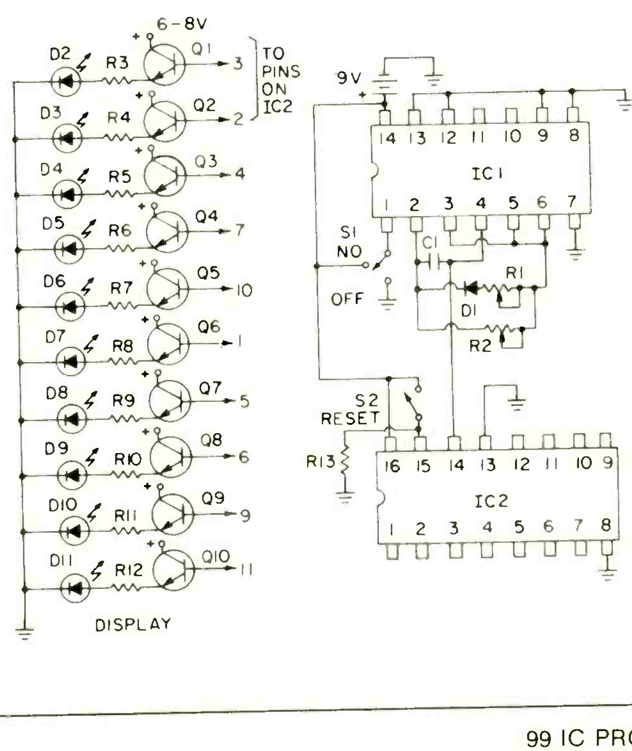


92 Chase Lights

□ The rippling or chase 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 or chase 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 smoothly.

PARTS LIST FOR CHASE LIGHTS

C1—0.01-uF ceramic capacitor, 15 VDC
D1—1N4401 diode
D2 through D11—small LED
IC1—4011 quad NAND gate
IC2—4017 diode 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

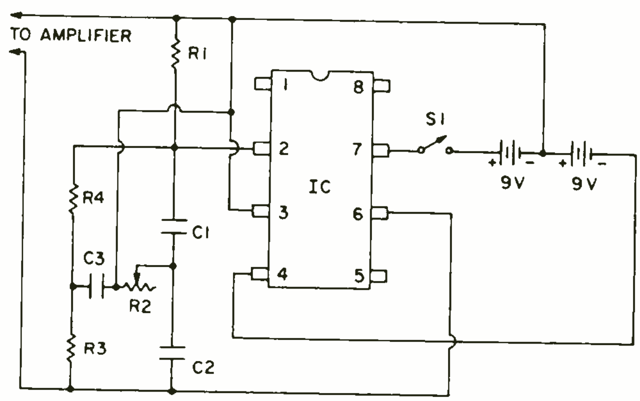


93 Howler

☐ 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 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

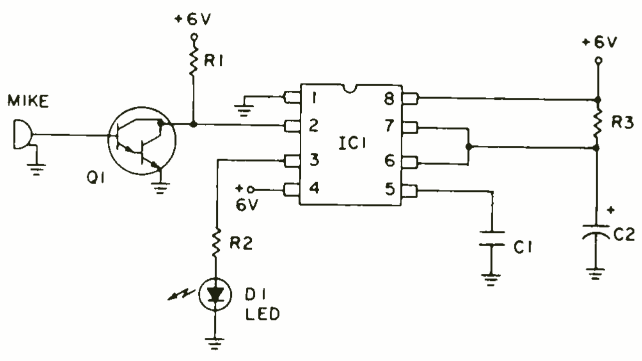


94 Robot Ear

☐ The type 555 timer cannot 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 ROBOT EAR

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

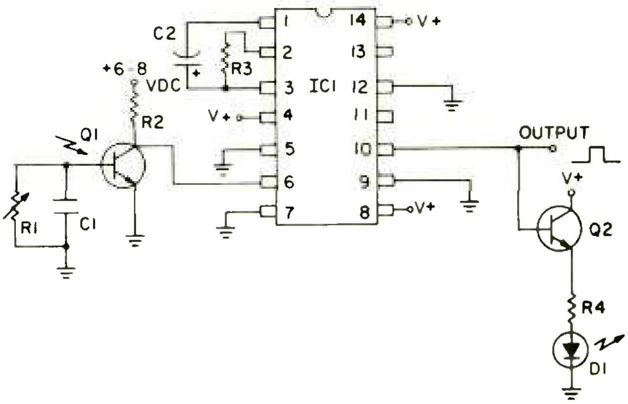


95 Robot Eye

☐ You can give to a circuit a 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. Robot Eye is always alert to unexpected light sources and never falls asleep, as may a watchdog or watch-person.

PARTS LIST FOR ROBOT EYE

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

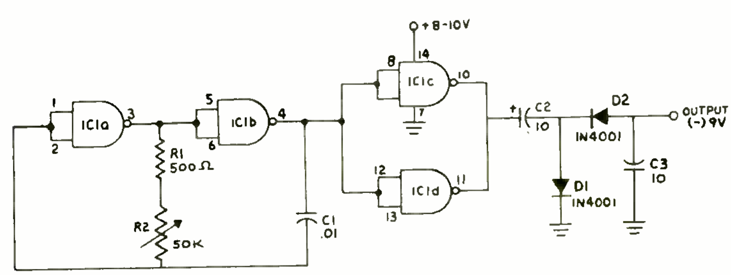


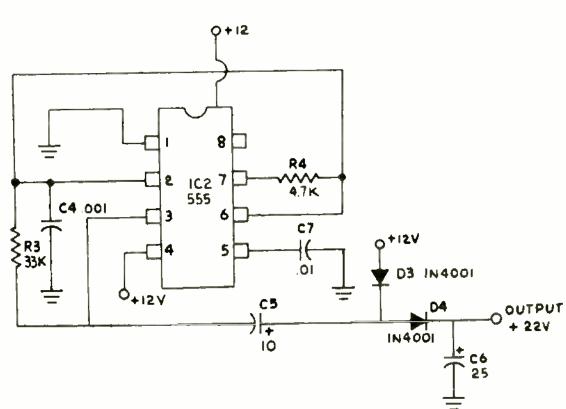
96 Positive Into Negative

□ 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 a 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, and output of about —9VDC 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-WVDC
C2, C5—10-uF electrolytic capacitor, 25-WVDC
C3—10 to 100-uF electrolytic capacitor, 25-WVDC
C4—0.001-uF ceramic capacitor, 15-WVDC
C6—25-uF electrolytic capacitor, 25-WVDC
C7—0.01-uF electrolytic capacitor, 25-WVDC
D1—1N4001 diode
IC1—4011 quad NAND gate
IC2—555 timer
R1—500-ohm, ½-watt 10% resistor
R2—50,000-ohm linear-taper potentiometer
R3—33,000-ohm, ½-watt 10% resistor
R4—4,700-ohm, ½-watt 10% resistor





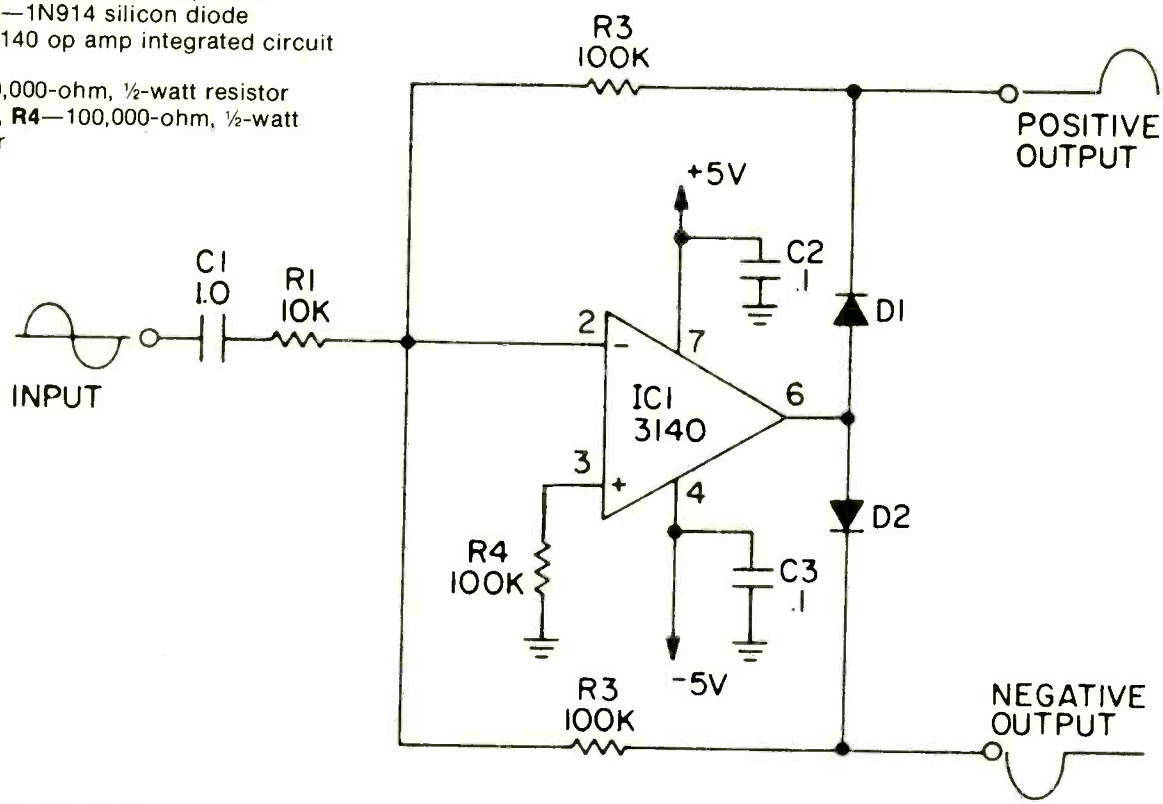
97 Precision Rectifier

☐ 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

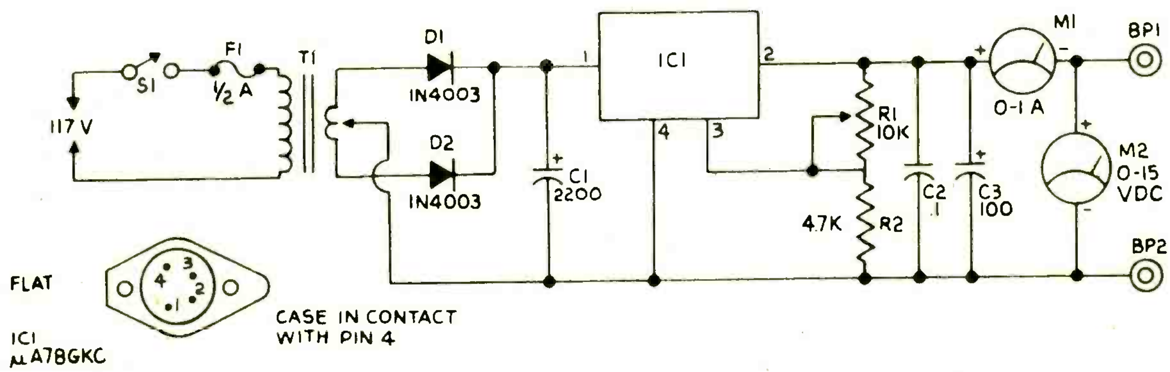


98 Vari-Reg Power Supply

☐ There 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 uA78GKC 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 28 VCT 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 VARI-REG POWER SUPPLY

BP1, BP2—binding post
C1—2200-uF electrolytic capacitor, 40-WVDC
C2—0.1-uF ceramic disc capacitor, 35-WVDC
C3—100-uF electrolytic capacitor, 25-WVDC
D1, D2—1N4003 (1A,200 PIV) rectifier diode
F1—0.5-Ampere slow-blow fuse
IC1—uA78GKC adjustable voltage regulator
M1—0-to-1 Amp DC meter
M2—0-to-15 Volt DC meter
R1—10,000-ohm linear-taper potentiometer
R2—47,000-ohm, ½-watt 5% resistor
S1—SP-ST toggle switch
T1—28-VCT, 1.2-Amp power transformer (see text)

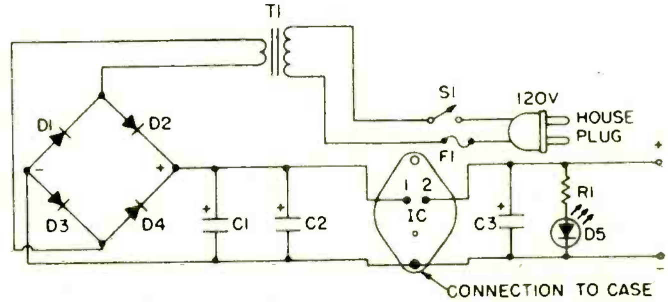


99 TTL Power Supply

☐ 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.

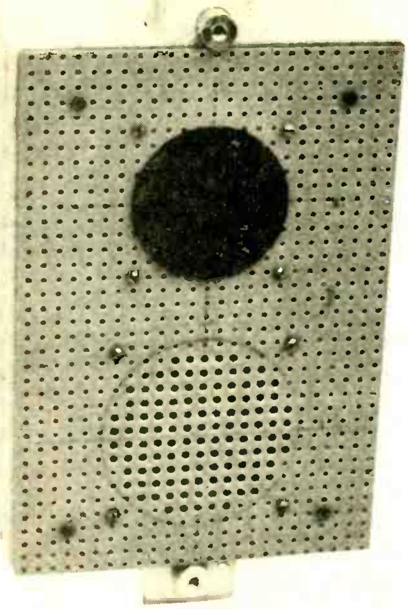
PARTS LIST FOR TTL POWER SUPPLY

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 10 12.6 VAC transformer



ICE-BOX HI-FI

This lightweight speaker system is as close as your local hardware store



HERE IS A SPEAKER SYSTEM that is small in size, light in weight, and delivers true high fidelity sound when connected to your audio power source, car radio or tape player.

This unique speaker system consists essentially of two speaker units, a light weight enclosure, a prepunched perf-board, that is modified to become a speaker mounting baffle and grille, hook-up wire and glue. Sounds simple? This do it yourself project consists of an assembly of parts, more than a complex construction job.

The speaker enclosure looks like a small cold chest made of styrofoam Breadboard. Styrofoam is responsible for the minimal weight. This material is acoustically dead. Hence, it can be used to house speaker components, if the enclosure is small enough to minimize acoustic resonance.

Styrofoam will pass low frequency sound like a sieve. This problem is solved by coating all styrofoam surfaces with white glue. Elmer's "Glue-All" or other white glue that is made for bonding styrofoam to itself or to other materials, must be used.

The cold chest box enclosure, listed in the parts list, can be found in stores, labeled as a Bait Box. It is white, speckled with spots of green. A rope handle is provided for ease of handling. The rope is driven through the cover and secured to the box. The outside dimensions are 6⅞ by 9¾-inches. The same width and length of the perf-board speaker baffle. The overall depth is 6½-inches including the cover.

The Assembly. Using a small paint brush, spread a light coating of glue over the inside of the box to seal the panel surfaces. White glue dries clear and fast, and adds strength to the styrofoam. Give it a second coat of glue to insure sound tightness. Do not coat the cover, until an opening is cut to clear the speaker components.

Figure 1 shows the perf-board modifications to convert it to a speaker baffle and grille. Check the length and width of the perf-board when you buy it, they vary somewhat in size. Cut the 2¾-inch diameter tweeter opening with a circle cutter and redrill the holes inside a 3⅝-inch diameter pencil scribed circle, forming a grille for the 4-inch speaker mounting.

The cut-out in the styrofoam cover which clears the speaker units is shown in Fig. 2. Do not glue the cover to the perf-board and mask assembly.

Figure 3 is a section view at the front of the box opening. Note that two wood cleats are glued inside the box for securing the baffle and cover to the box with six, 2-inch long machine screws that are screwed into the cleats. These screws clamp the baffle/mask assembly to the enclosure and provide access should it ever be required. The speaker components are bolted to the perf-board/mask assembly and are tightened with nuts and lockwashers.

The Speaker Components. It is unusual to see two speaker units installed in such a small enclosure as this. True "Hi-Fi" sound cannot be attained without the use of a good tweeter. Radio Shack has added a one-inch dome tweeter to their speaker line, that provides wide dispersion of high frequencies. This unit is almost as good as the

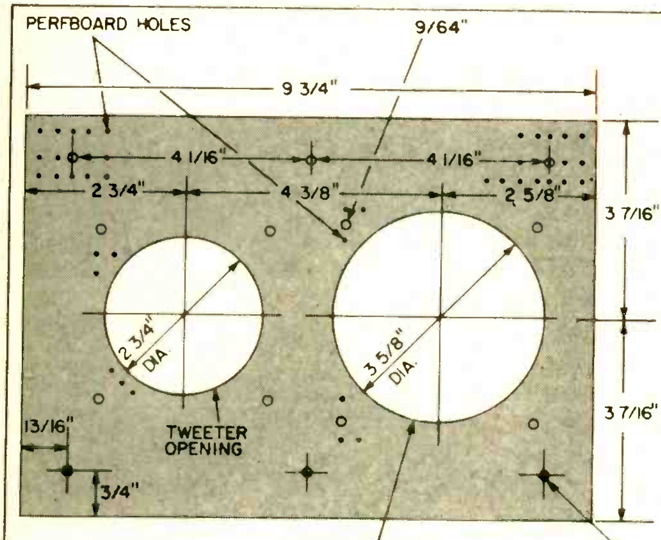


Fig. 1. Perfboard drilling for Ice-Box Hi-Fi. There are a lot of holes to drill, so be careful, because the perfboard can splinter.

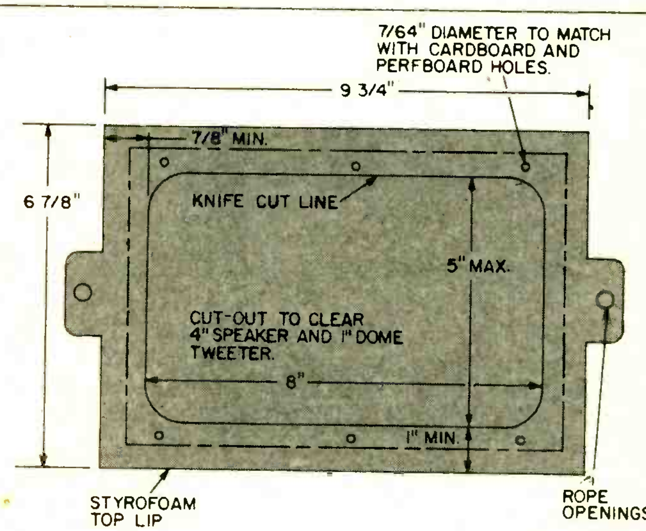
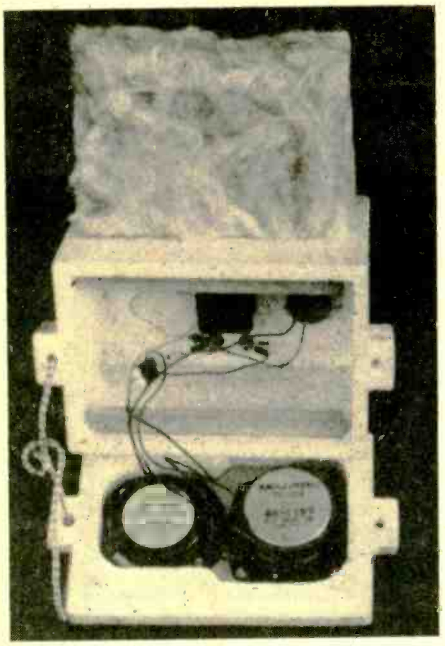


Fig. 2. Cutting and drilling outline for the styrofoam top panel. When coating the styrofoam with glue to make it accoustically opaque, let the glue dry before installing it on the main frame. You do not want to glue the two styrofoam parts together at all.



Inside look at the drivers mounted in our little speaker system. If you use care, everything will fit nicely, and snugly.

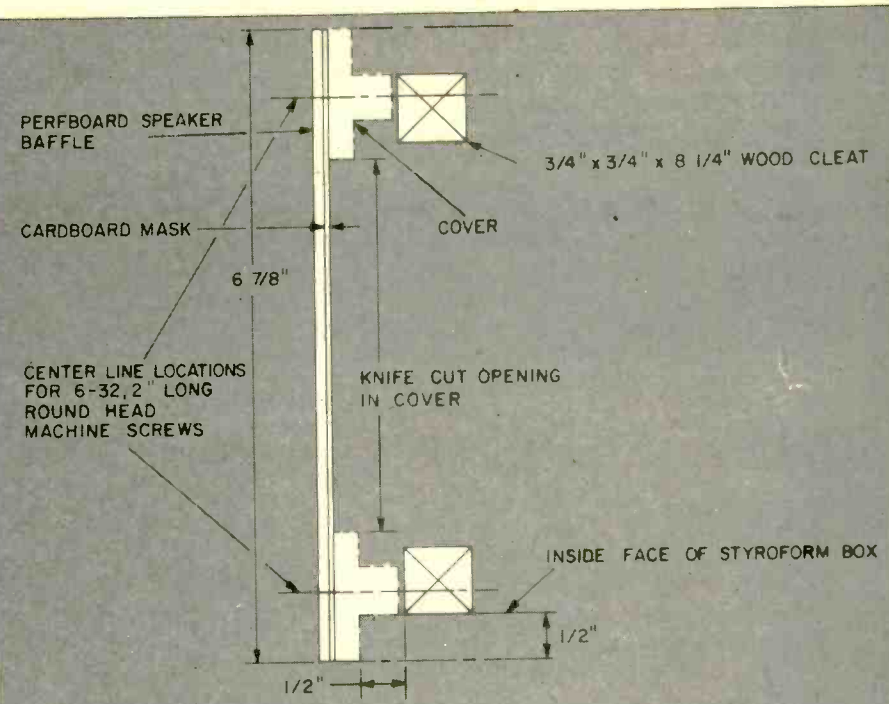
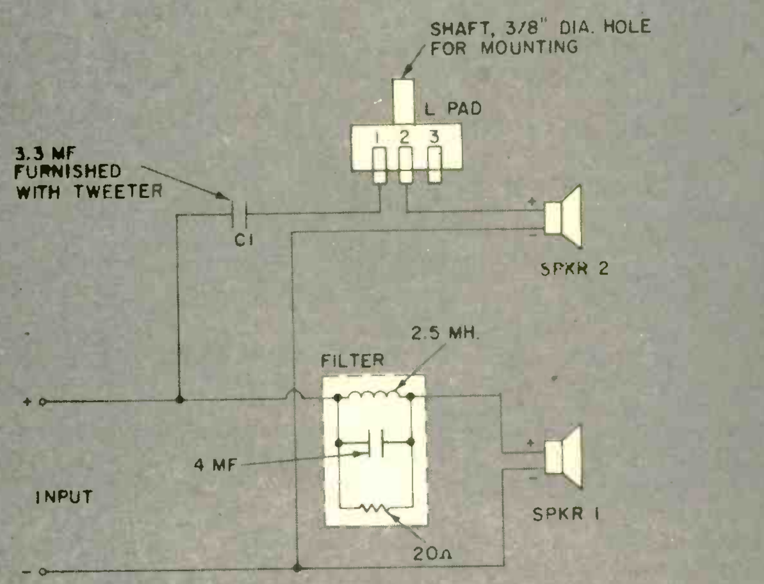


Fig. 3. Cross section of the styrofoam cover of Ice-Box Hi-Fi. The two 8¼-inch long wooden cleats are very important, since they serve to seal up the speaker.



Philips Dome Tweeter from Holland that is used in some of the most expensive speaker systems.

A 3.3-uF capacitor is furnished with the tweeter for cross over at 4000 Hz and above. High frequency attenuation is provided by use of an "L" pad. This "L" pad is hooked-up to the outside winding of the pad.

Smooth performance is assured by employing a filter network shown in the wiring diagram. The 20-ohm resistor in the network cancels the effect of the tuned circuit set up by the 2.5 MH inductance and the 4-MF capacitor in the filter.

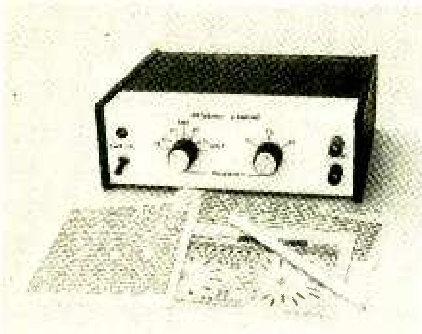
For wire connection into the enclosure cut a slot in the back for a terminal strip and secure the terminal with 6-32 by ¾-inch long machine screws or use 1-inch long brass screws with nuts and washers.

Upon final assembly, cut a section of 4-inch thick building grade fiberglass to fit inside the enclosure. Try not to compress the fiberglass around the edges. Cut a recess to clear the inductance coil, mounted in the back.

When you have completed the assembly, hook it up to one channel of your home stereo system. You will be amazed by the sound quality from such a small box. You may be tempted to assemble two of this design for stereo use, or perhaps use it as an extension speaker for high quality sound. ■

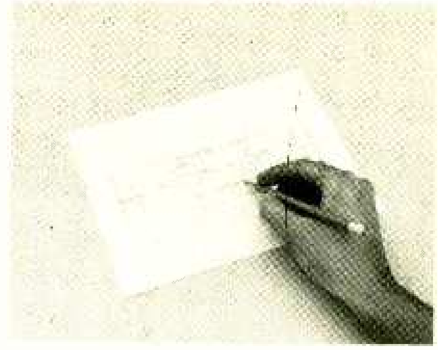
PARTS LIST FOR SPEAKER

C1—3.3-uF capacitor (see Driver No. 2)
Driver No. 1—4-inch cone type speaker (Radio Shack 40-1197 or equiv.)
Driver No. 2—1-inch dome type tweeter (includes C1) (Radio Shack 40-1276 or equiv.)
Filter—audio type filter network (Radio Shack 40-808 or equiv.)
Pad—audio type "L" pad (Radio Shack 40-980, or equiv.)
Misc.—Ice-less cold chest, without inside compartment. Mfg. by Standard Cellulose & Novelty Co., Inc., 90-02 Atlantic Ave., Ozone Park, New York 11416.
8—6/32 round head machine screws, ½-inch long
6—as above, 2-inch long
1—as above, 2½-inch long
2 wood cleats, ¾ x ¾ x 8¼-inch long
Nuts for above cardboard mask 6⅞ x 9¾-inch, see Fig. 2. Pre-punched perf-board 6⅞ x 9¾-inch, see Fig. 1. Building grade, 4-inch fiberglass 5¾ x 8¾-inch. Elmers Glue-All or equal, terminal strip or brass machine screws (see text), hook-up wire, solder, etc.



1. Why not build projects you can be proud of, in appearance as well as circuit design? It is neither difficult nor expensive as you'll note when you follow this unit on a step-by-step journey from a blank, machined panel to real artistic beauty.

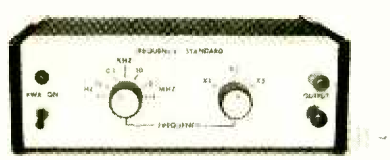
2. You will need spray and brush-on protective coating, plastic tape, various types of rub-on lettering and designs, and a burnishing tool (the white cylinder) to effect the transfer of the letters from the carrier sheet to a project's front panel.



3. You can't fashion it if you have never seen it before—at least seen it on paper. First, make a sketch and work on the arrangement until you are quite satisfied with it. Using the quadrille paper, as pictured here, makes the job easier.

LOVE THAT

Press-on decals will turn



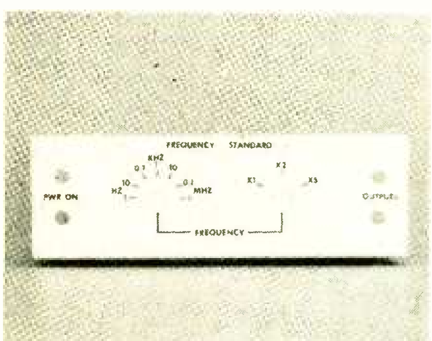
14. And now—the finished project, a delight to the eye! Once you try this method on one of your projects you'll never go back to ugly again. You don't have to be an artist, and it does not add much to the cost. Electronics can be beautiful!

WHEN YOU GIVE birth to an electronic project, don't send it into the world illiterate. As shown in this article, it's easy to apply lettering and designs to give your projects a professional appearance, as well as for functional reasons. This is accomplished by using a product called *rub-on lettering* (or *dry-transfer lettering*), which consists of letters, numbers, or designs with an adhesive on their back side so that they can be affixed to a panel or other surface. The letters come attached to the back of a transparent plastic *carrier sheet*, from which they are transferred to the panel by rubbing or *burnishing*. Follow the photos to see how it is done. The process may seem complicated at first, but with a little experience you will find that the steps go quickly.

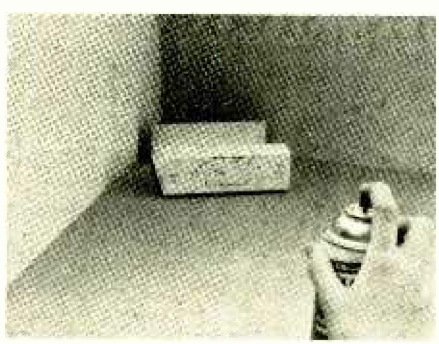
Rub-on lettering is available in various sizes and colors (black and white are the most common). Sets may contain complete words, individual letters or numbers, or a combination of these. Sets consisting of index marks and other designs for rotary switches and dials are also available.

A small set, which should see the average hobbyist through half a dozen projects or more, costs only about two dollars. Your local electronics store probably carries rub-on lettering and related supplies, if not, try the suppliers listed at the end of this article. Rub-on lettering is also available from art, graphic arts, and office supply stores. Although the type they carry is intended primarily for other purposes, it can be used for electronic projects.

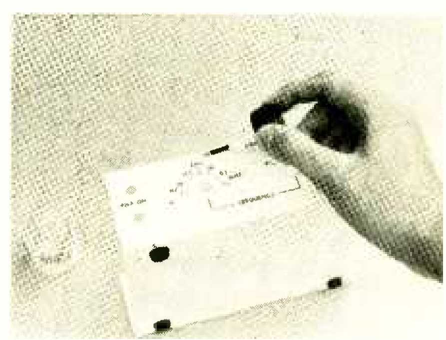
In addition to the lettering and a few household items (cellophane or plastic



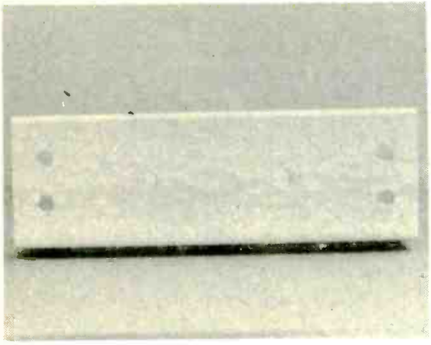
13. Here you see what the panel looks like after the lettering has been completed but before the parts have been mounted. It already has a clean, professional look, more like something out of an assembly-line factory than from your workbench!



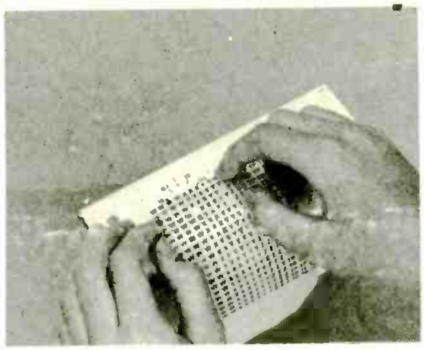
12. You can also buy spray overcoating as pictured here. Spray is more even than the brush-on, but the brush-on can be applied thicker. This method too requires that you carefully check for the compatibility of the overcoat with both letters and panel.



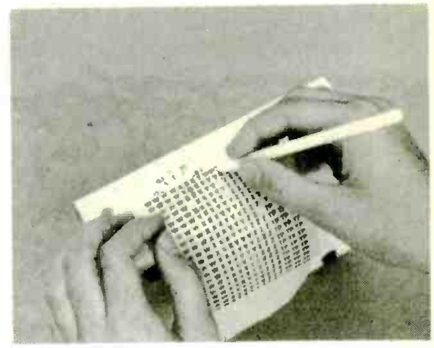
11. You'll want to protect that final panel, and there are two methods you can use. Here we show the brush-on method of overcoating. First, check on a scrap or hidden area for compatibility with both rub-on lettering and the panel finish.



4. Once you know where it is all going to be at, you can begin to machine the panel. Follow your quadrille-paper layout carefully and don't make last minute, poorly planned changes! Then make certain the panel is clean and dry and free of any imperfection.



5. Locate the desired letter (or word, or design) on the carrier sheet, place it in position on the panel and press the sheet against the panel. The back of the sheet is tacky so it will not easily slip. Here we have already applied some of the letters.



6. Transfer the letter to the panel by use of the burnishing tool. Rub over the letter several times, increasing the pressure each time until the transfer is complete. As you do this a slight change in the letter's appearance verifies transfer is working.

LETTERING

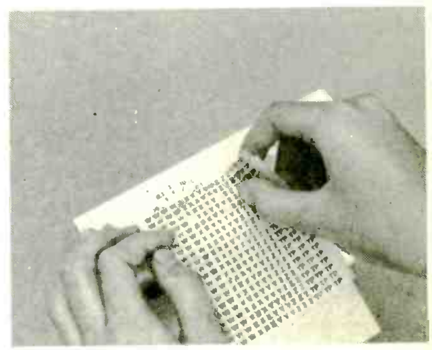
projects into works of art

tape, ruler, paper, etc.), you will need a blunt-pointed tool to burnish the letters into place. Tools for this purpose can be obtained where art supplies are sold, or you may be able to find something around the house that will serve the purpose. However, a pencil or ballpoint pen tends to be too sharp, and may also obscure the lettering. The burnishing tool shown in the photos was made from ¼-inch diameter plastic rod sanded round on one end and tapered and rounded to about ⅛-inch diameter on the other end. It could also have been made from a wood dowel.

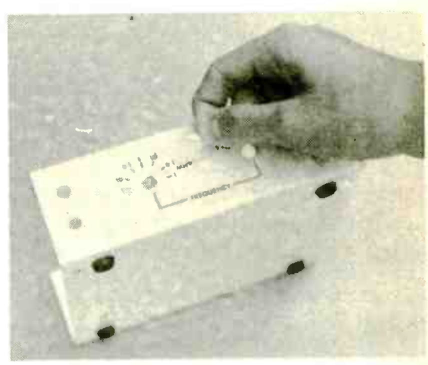
The panel or other surface to which you intend to apply the lettering should be clean and dry. Any oil, grease, dirt, or moisture will hinder adhesion of the lettering. Soap and water can be used for cleaning, except on bare aluminum. Rinse and dry the panel thoroughly; after wiping off excess water, use a heater or warm oven to dry. Solvents can also be used for cleaning; test first for compatibility with the finish. *Do not* use a heater or oven with solvents. To clean bare aluminum, solvents can be used, or chemical preparations for this purpose are available from paint and hardware stores. After cleaning do not touch the areas where you will apply the lettering.

If you use solvents or other chemicals be sure to follow the manufacturer's directions and particularly observe the appropriate safety precautions. Spend a little extra time and effort to be safe and minimize the possibility of injury.

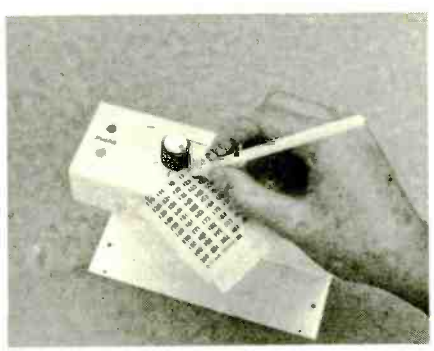
After you have applied the lettering, you will probably want to protect it with a brush-on spray coating. ■



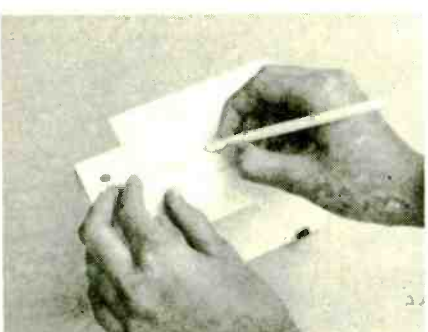
7. Peel the carrier sheet away from the panel, starting from one end and holding the other end in position against the panel. Check that the letter has completely transferred. If it has not, all you have to do is lay the sheet back down and burnish over.



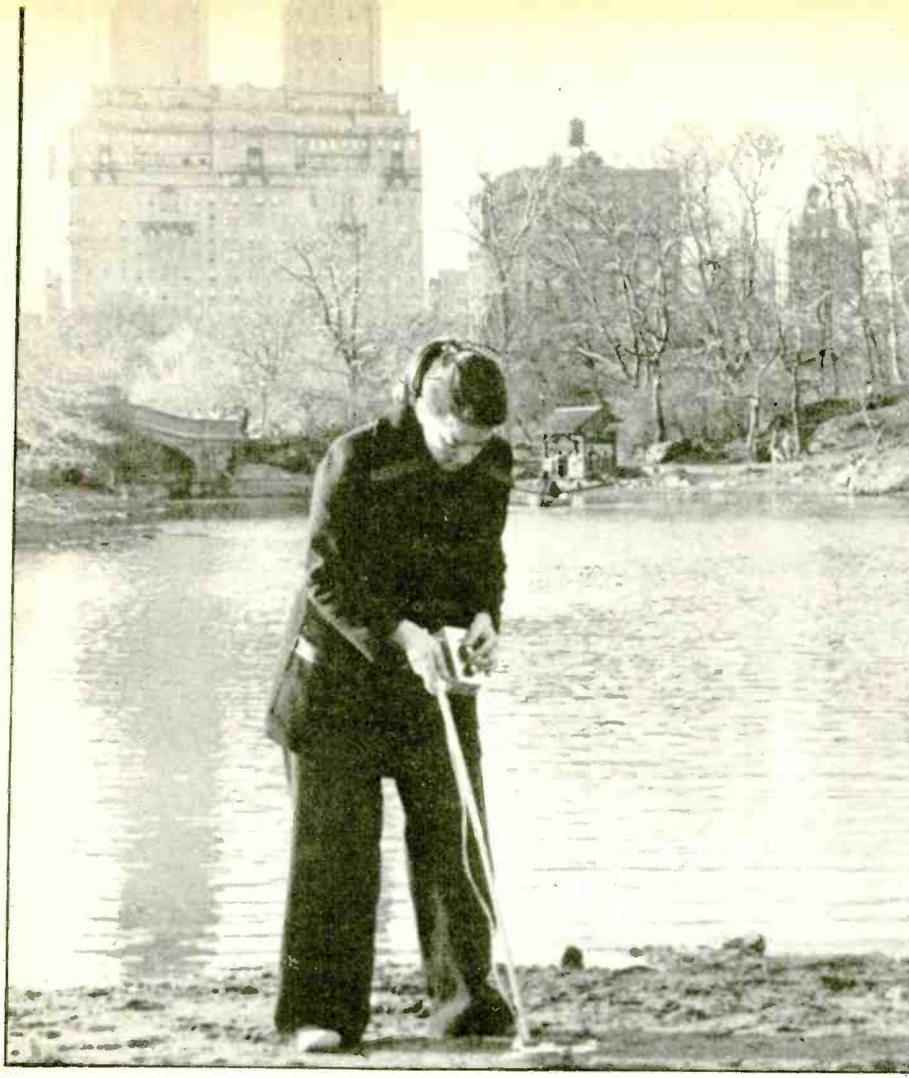
8. Make a mistake? It's no disaster. To remove an error, press ordinary cellophane or plastic tape over the offending letter and then simply lift it off. This may be repeated if needed, until all is clear. An eraser may also be used.



9. Positioning index marks is done by temporarily mounting both a switch and its knob. Turn the knob to each position and align the mark with the pointer. As you see here, the number "1" makes a good index mark, certain other letters may be used.



10. Once all lettering is applied, and you are satisfied with it, burnish one more time. Use a backing sheet of slick paper, so the lettering will not stick to the backing sheet, and go over the whole panel. Use the blunt end of the burnishing rod.



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.

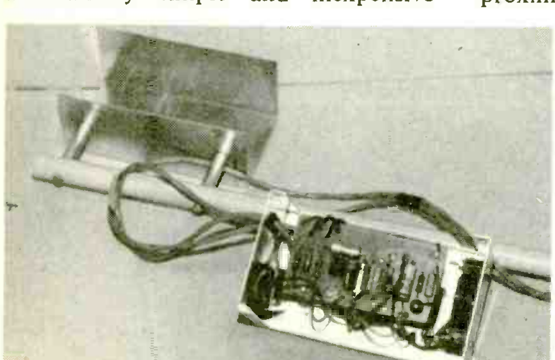
Operational Principle. *Houndog's* "nose" consists of three large inductance coils which, when placed in proximity with a conductive metal will exhibit a change in their total inductance value, the change being read by the circuitry and translated into an audible signal. In short, when *Houndog* "barks,"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

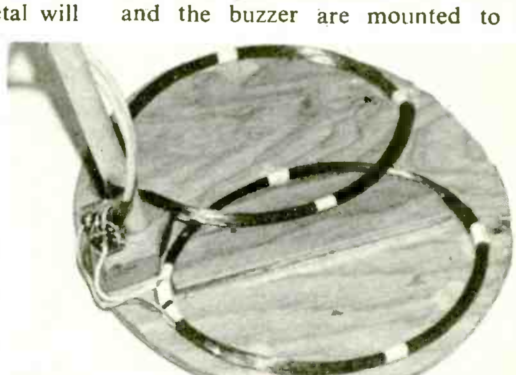
When a conductive metal enters the field, it changes the distribution to the effect that the field across L1 and L2 is no longer zero, and a voltage appears across the amplifier's inputs. The coil connections are such that when this condition exists, the positive input voltage is in phase with that of 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).

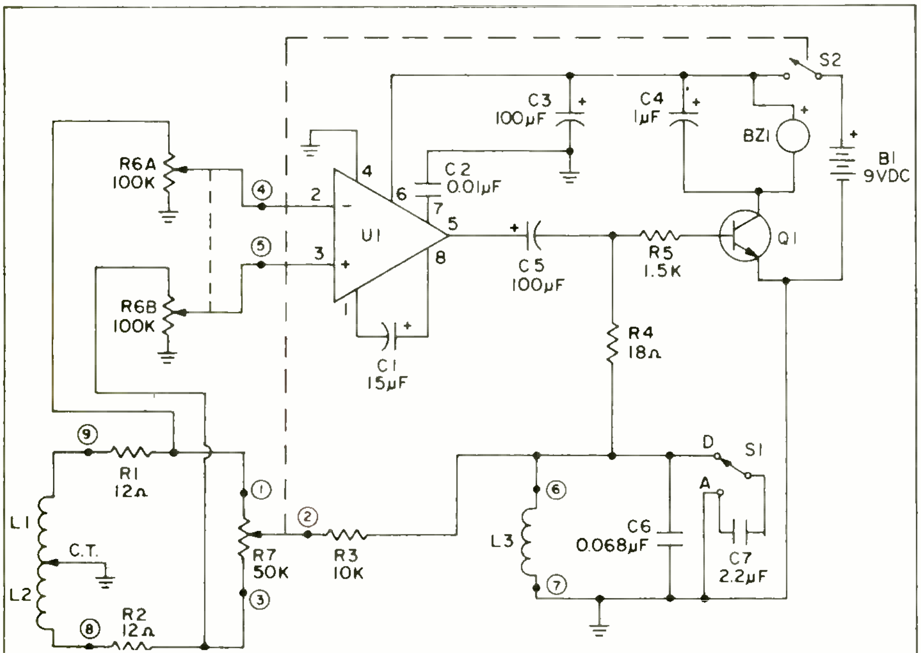
When the coils are completely wound, bind them with tape before removing them from the form. This will help to hold their shape until they are installed on the search head.

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,

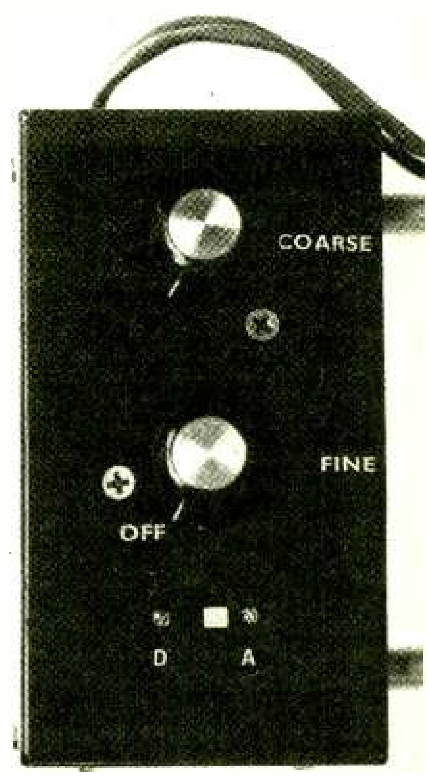


PARTS LIST FOR HOUNDOG

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, 200-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.

For pricing on parts and pre-etched, printed-circuit board for Houndog write to Niccum Electronics, Rte. 3, Box 271B, Stroud, OK 74079. Be sure to include a stamped, self-addressed envelope.



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

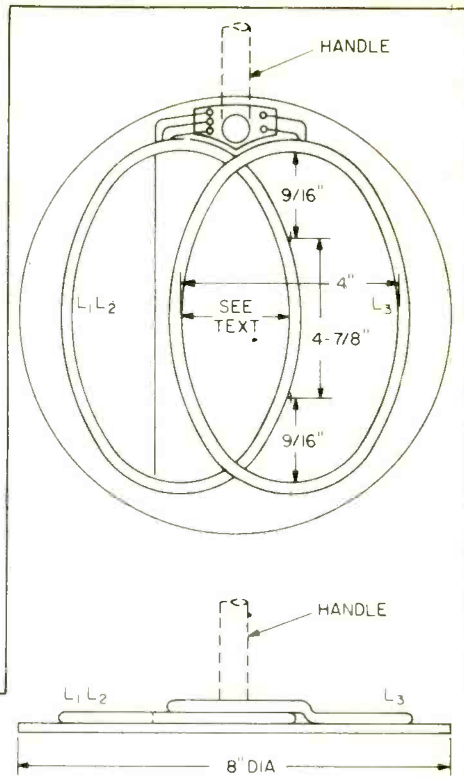
HOUNDOG

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.

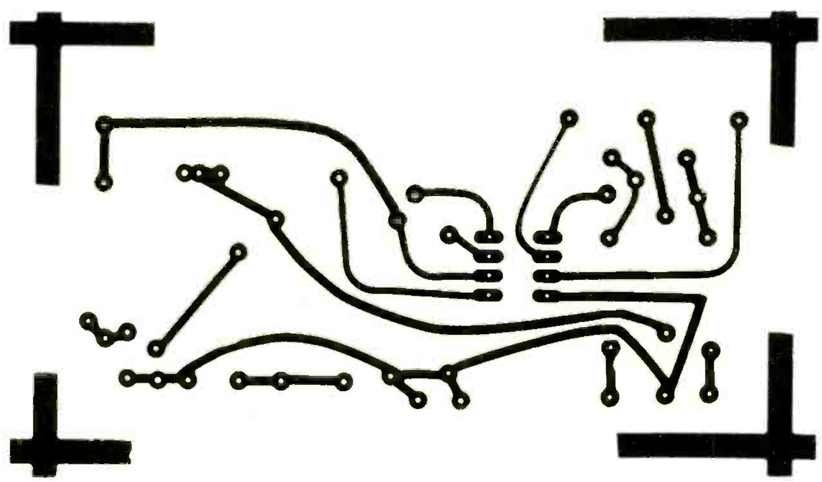
Remember that when conducting these tests, you should be in an area free from the presence of large metallic objects, such as radiators, pipes and ducts, etc. Their presence may cause you to set the sensitivity of R6A/R6B too low, making actual measurements against coins ineffective to the point of believing 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.

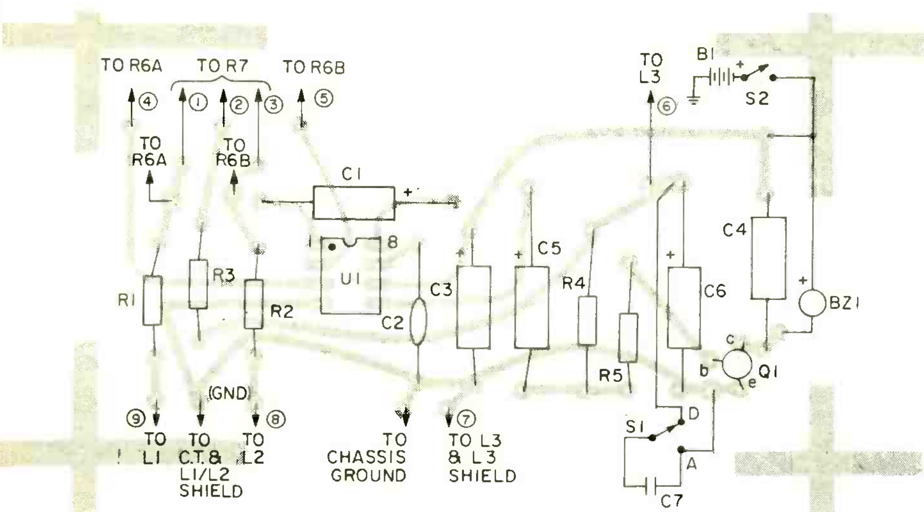
Conclusion. Once you get out of doors with *Houndog*, it might be wise to bury some treasure of your own, and adjust the controls for maximum sensitivity depending upon the type of soil found in your locality. These adjustments will vary from area to area, depending upon soil composition, which is why 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. ■



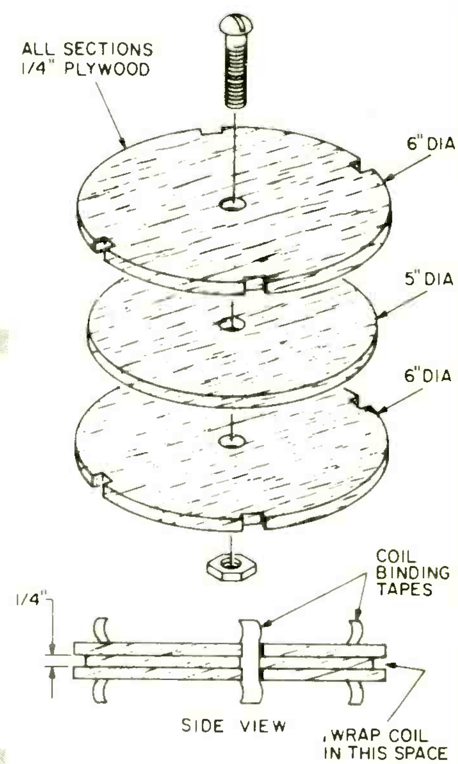
The dimensioning guide for the search head shows you how to bend round coils into the elliptical shape necessary for installation on the search head plywood base.



Here is the full scale etching guide for Houndog's PC board.



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.

WITH A LITTLE BIT OF time and effort, anyone with a well equipped darkroom can turn out good prints. However, problems come up when someone gives you a 36-exposure roll, all with different densities and asks for a full set of wallet-size prints.

Even if you don't mind the cost of test strips and wasted prints, it will take at least an evening to bang out 36 prints to your satisfaction.

But if you use a Photometer to determine exposure and paper grade, you'll cut wasted paper to an absolute minimum and total processing time to an hour for 36-exposures.

If a stabilization machine is used, you'll be able to develop a black and white prints in less than a minute. The Photometer allows a good print to be made with every attempt.

Unless you're making artistic prints suitable for exhibition, good tonal balance is any print with white highlights and jet black coloration. It doesn't matter how black the print is, it can be a spot, but the eye expects to see black. If there is no black, the print appears flat (lacking in contrast).

Dense Negatives. Pure white highlights and jet black detail are determined by various paper grades (#1-#5). The density range of the negative determines which grade to use.

The Photometer, by analyzing a negative that is projected by the enlarger (it is not fooled by condensed or diffused enlarger illumination) indicates the paper grade required by a negative. It can be used to determine lens aperture for an exposure time.

The Photometer has a row of five red light emitting diodes (LEDs), a yellow LED and a green LED. The green LED is used for determining exposure. Centered in a white target area, there is a ⅛-inch diameter photoresistor that is small enough to represent a spot on a final print.

Projecting the negative, adjust the enlarger for the desired print size, focusing on the easel with the lens diaphragm wide open and place the Photometer on the easel with the photo resistor under an area of maximum light transmission (minimum density). Adjust the Photometer's CAL (calibrate) control until just the five red LEDs are clearly lit and glowing.

Move the Photometer so the photoresistor is under the minimum transmitted light (maximum density). Count the number of red LEDs that remain lit; that's the standard paper grade for the negative. If two red LEDs are lit, the negative calls for a #2 paper.

The yellow LED checks the contrast reading. After you make the initial reading, which should take no more than a few seconds, return the photoresistor to the point of maximum light and adjust the CAL control so the yellow LED just lights.

Rock Control. Rock the CAL control a few times to be certain its at the setting that just lights the LED. Move the photoresistor back to the point of minimum light and count the number of lit red LEDs. If the number remains the same the contrast is in the approximate center of standard contrast range.

If the next higher red LED lights during the yellow test, the contrast range is closer to the top of the initial lower range. For example, if the first test lit two red LEDs and the yellow test lights three, #3 paper should be used or #2 with slightly extended development. Almost a #3 is the same as using Polycontrast #2½ or #3 photographic filters.

(Note. Variable contrast filters are not the equivalent of standard paper grades. It all depends on the filter and the particular type of variable contrast paper being used. Crossindex the measured contrast range with the specified range for variable contrast filters from the manufacturer's data sheet.)

Constant Exposure. The green LED allows setting the aperture for a constant exposure time. Make a good print using your favorite exposure time: 10, 15 or 20 seconds. Without touching the enlarger adjustments, place the photoresistor under maximum light and adjust the EXP (Exposure) control until the green LED just snaps on.

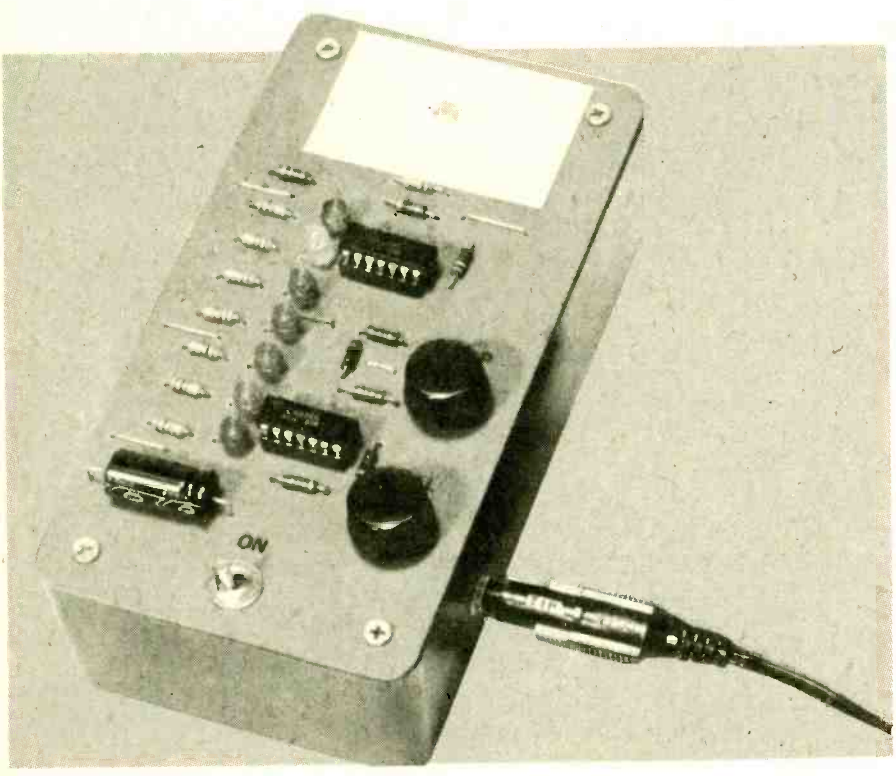
Set the EXP controls so the green LED goes from off to on. The Photometer is now set for what you consider proper exposure.

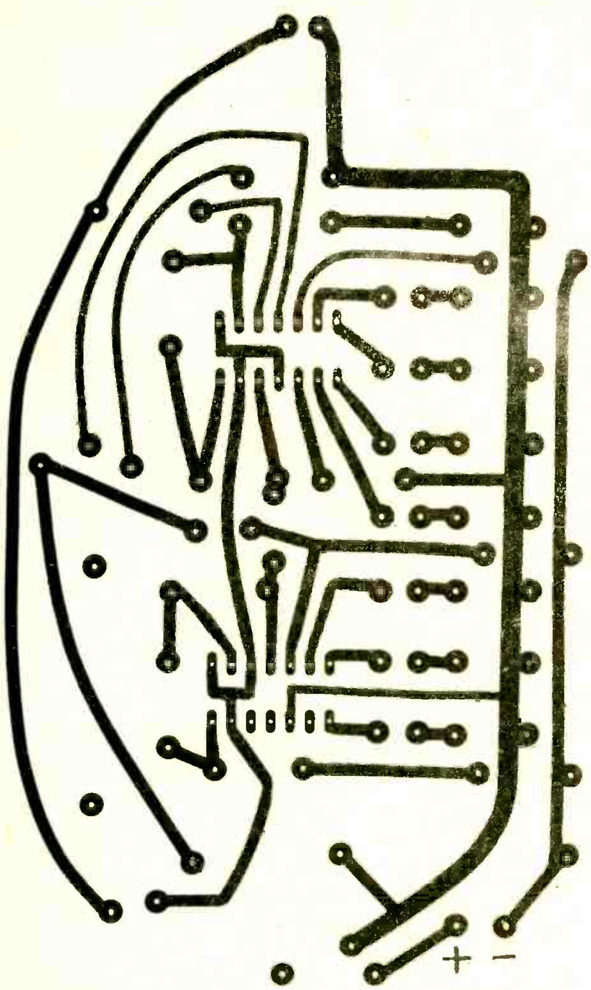
Assume you have used a 10-second exposure. You rack up the next negative, compose, focus, and make the contrast measurement. (Remember, the lens is wide open.) Place the photoresistor under maximum light transmission, the same spot used for the contrast calibration, and slowly step down the lens until the green LED lights.

That's the right amount of light for a 10-second exposure. Because of memory in the photoresistor, you cannot rock the lens's diaphragm for the green LED adjustment. The diaphragm must

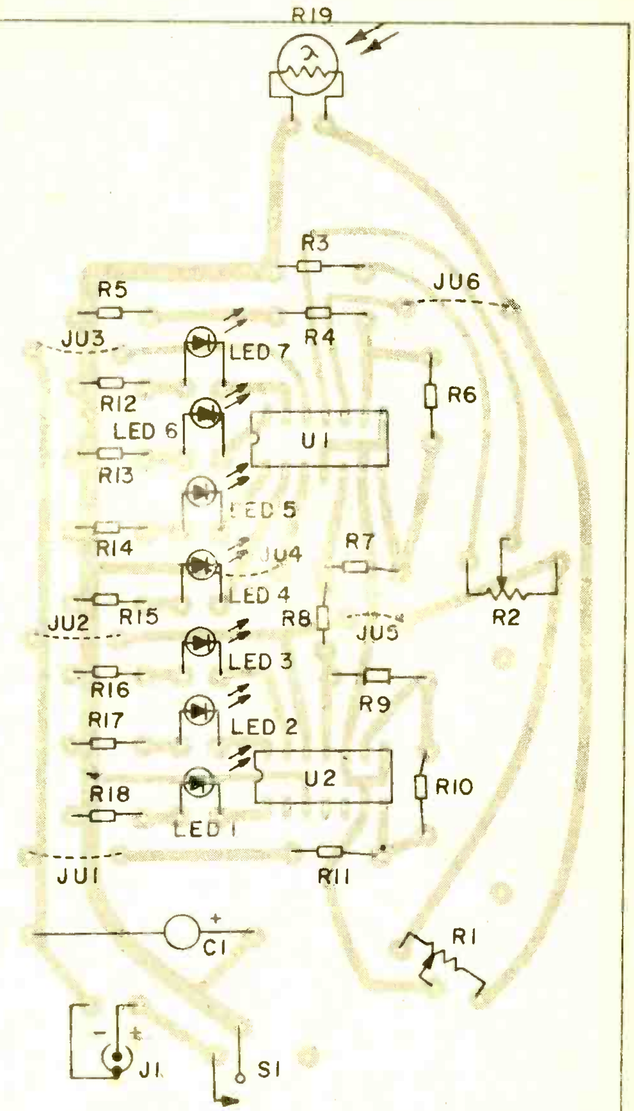
PHOTOMETER

You will make the grade and get good exposure with the photometer





This project is for the complete do-it-yourselfer. The printed circuit board given here is not available through any outfit, so you must etch it yourself. An alternative to etching the board is wire-wrapping your project. By following the PC diagram, you can easily see how to connect the wires to each other in a simple and orderly manner.



When installing the components in your Photometer, observe polarity; otherwise you could fry part of the circuit.

be started from the wide open setting (the same one that is used for the contrast measurement).

If the lens is adjusted beyond the setting where the green LED snaps on go back to maximum light for 3-5 seconds for a precise adjustment.

The entire project, except for the power supply, is built on a printed circuit board that also serves as a cabinet cover. The power supply can be any 9 volt AC adapter. Any current rating greater than 100 mA will work well.

Critical Parts. There are three critical parts in assembling the Photometer: the cabinet, whose height establishes the operating parameters for photoresistor R19; the photoresistor itself, which is a version specifically designed for linearity and EXP control R1, which must be as close as possible to 50,000-ohms.

All other components are common tolerance and substitutions can be made as long as the tolerance, where specified in the parts list, is not reduced.

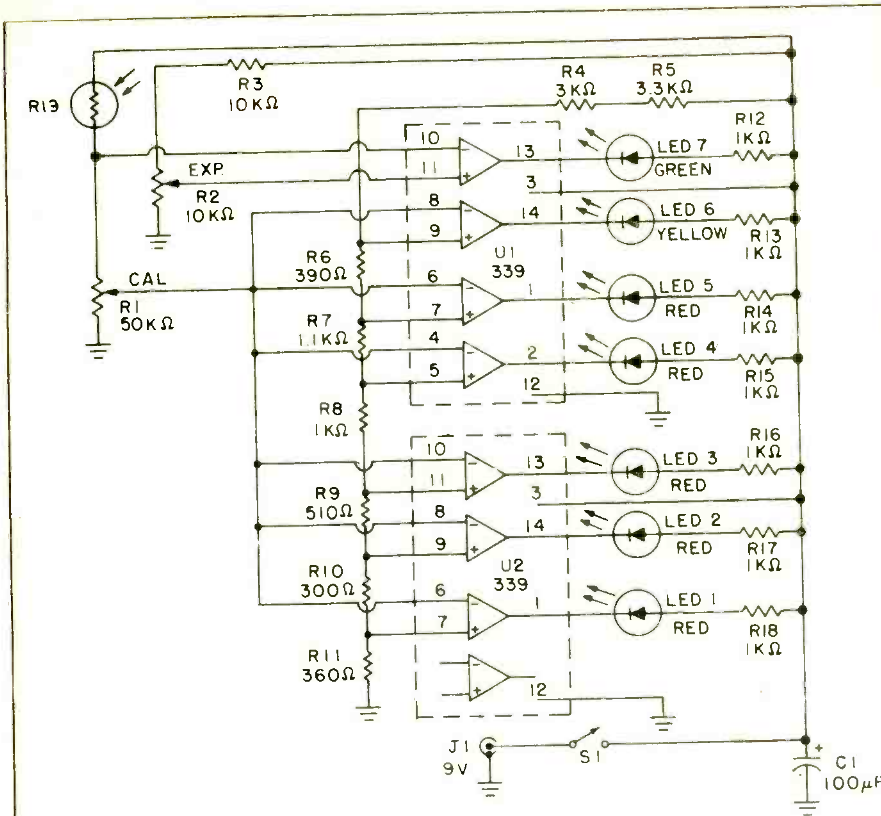
The cabinet *must* be 2¾-3 inches high. No substitute can be used for R19; any other photoresistor will give the user completely erroneous contrast measurements.

Socket To U1. Sockets are suggested for U1 and U2. They prevent butchering of the PC board if you must remove an IC. The ICs are installed with pin #1 facing the LEDs.

Before installing R19, cement a white target approximately 1⅜ by 2-inches to the PC board and punch-through the holes for R19. Then install R19 so its top is ⅛" above the PC board. If you must bend R14's leads, brace them with long-nose pliers directly behind the photo-resistor—the pliers should actually touch PR1. (Careful, R19 tends to be fragile when bending its leads.)

Finally, install J1 and connect it to the PC board. Double-check the polarity of the 9 volt adapter. Some have the plug tip *negative;* if so, be certain you connect J1's tip to the negative foil on the PC board.

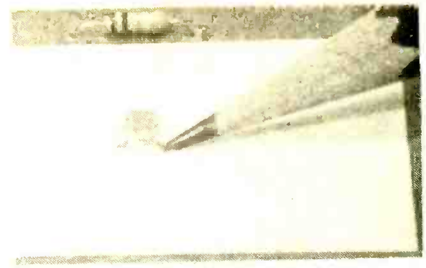
Check It Out. Under normal room lighting, set CAL control R1 fully counter clockwise. Set EXP control R2



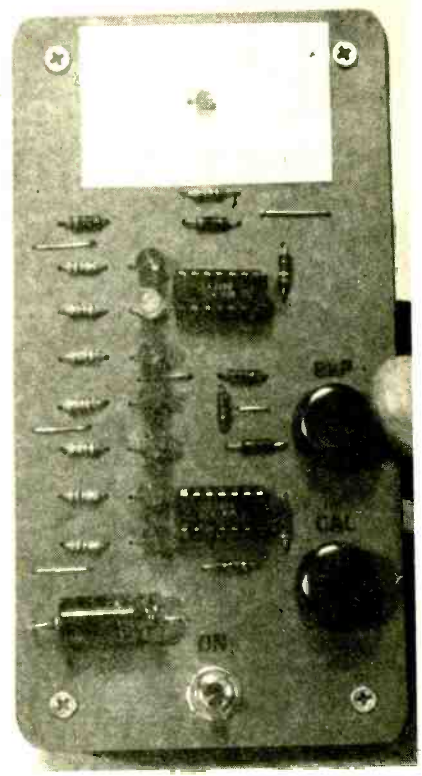
PARTS LIST FOR PHOTOMETER

C1—100-uF, 35-VDC electrolytic capacitor
J1—Jack to match power adaptor
LED1-LED5—Red light emitting diode (LED) fresnel lens
LED6—Yellow LED
LED7—Green LED
R1—50,000-ohm potentiometer, linear taper see text) all resistors are ¼-watt, 5%, except potentiometers)
R2—10,000-ohm potentiometer, linear taper
R3—10,000-ohm resistor
R4—3,000-ohm resistor
R5—3,300-ohm resistor
R6—390-ohm resistor
R7—1,100-ohm resistor
R8—1,000-ohm resistor
R9—510-ohm resistor
R10—300-ohm resistor
R11—360-ohm resistor
R12-R18—1,000-ohm resistor
R19—Photoresistor, Custom Components PRLL9
S1—SPST mini-switch
U1, U2—Quad Comparator LM339 Integrated Circuit

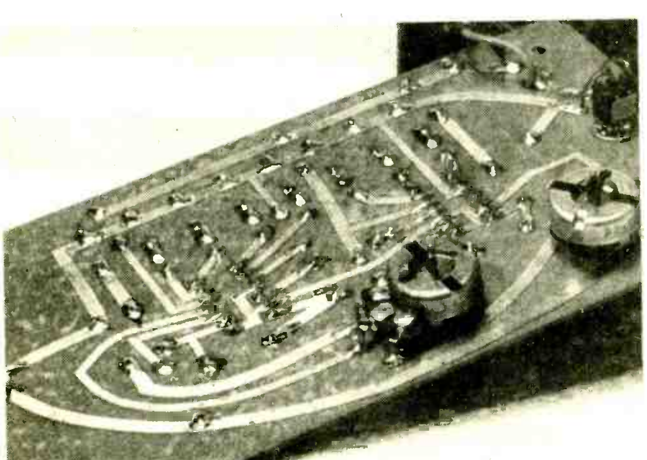
Misc.—Cabinet, 9-volt power adaptor, IC sockets, PC material, solder, wire, hardware, etc. (Photoresistor PRLL9 is available for $5 plus $2 postage and handling per order from Custom Components, Box 153, Malverne, NY 11565. N.Y. State residents must add sales tax. No foreign orders except Canada. Canadian orders must be in $US.)



This photoresistor is the heart of the Photometer. Be sure you get the right one.



The Photometer is compact and easy to use. Photometer's circuit is totally exposed and allows easy removal of circuit parts.



Two potentiometers and an On/Off switch are connected to the back of the PC board. The battery is connected to the case.

fully clockwise. Turn the Photometer on. Cover R19 with your thumb; all LEDs should be out.

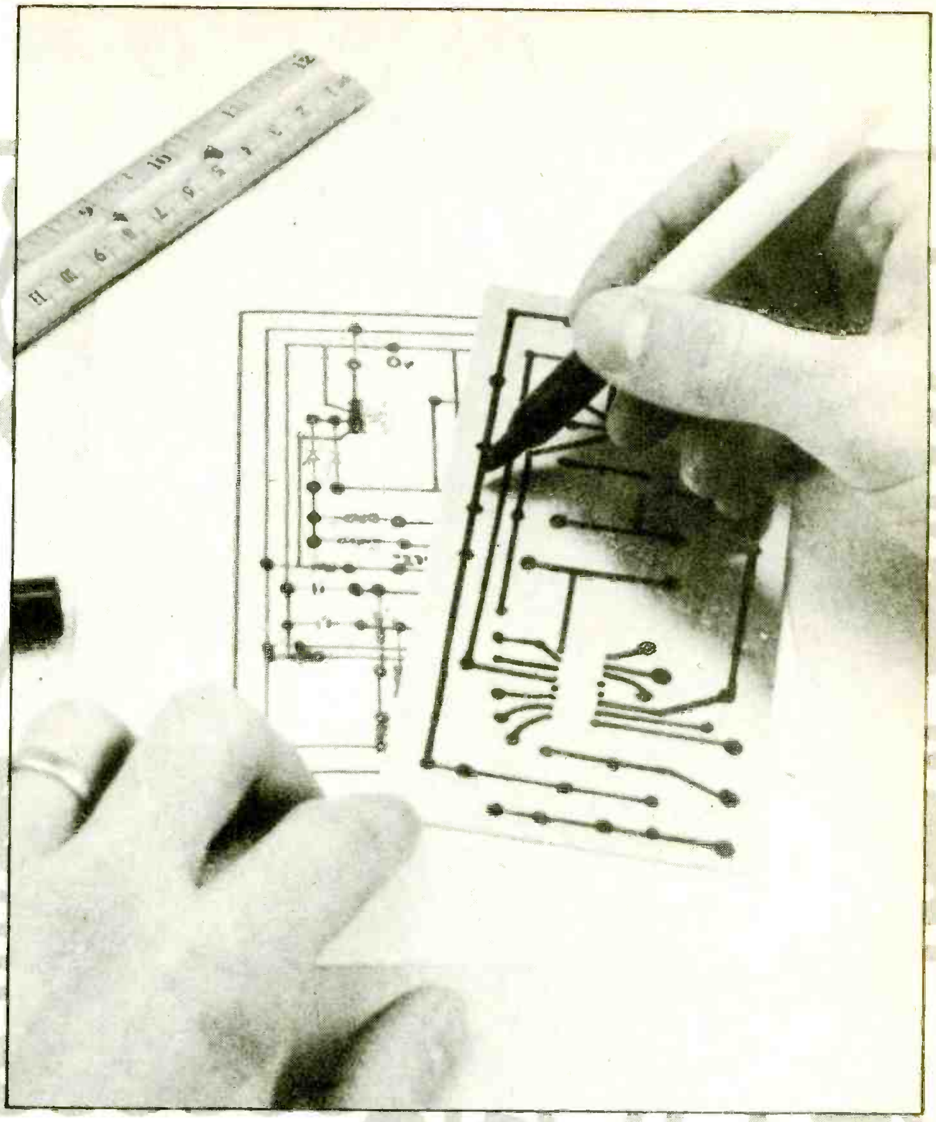
Advancing CAL control R1 should cause the red and yellow LEDs to light one at a time. Adjusting EXP control R2 anti-clockwise should cause the green LED to turn on.

If you don't get this response, there is a wiring error or a defective component. (Note: Under full room illumination, with no covering of R19, the green LED can remain lit through R2's range of adjustment: this is normal.)

With your Photometer operating, you can spend less time and money in the dark and more time in the light doing what you want to do: taking pictures. ■

CIRCUIT BOARD ETCHING

A step-by-step guide to making project boards



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.

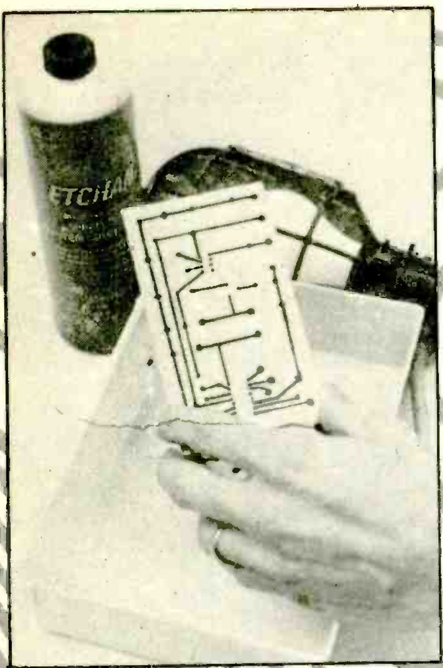
2. Etchant Solution. There is a variety of etchant solutions currently on the market, both in crystal form and already mixed. An inexpensive, pre-mixed solution of ferric chloride is good for a starter; it conveniently provides a uniform end product. Although the solution used during an etching (several 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.

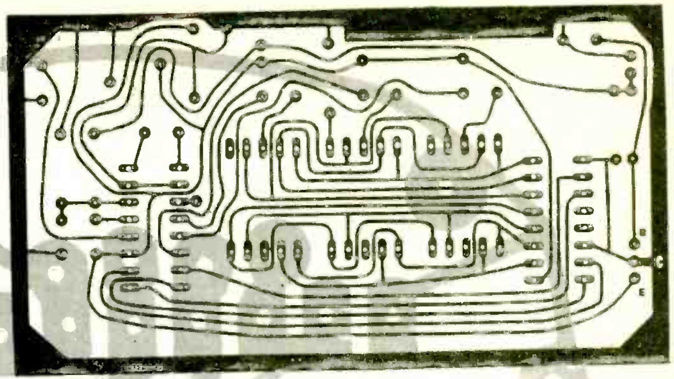
5. Heat Source. A thermostatically controlled heat lamp would be the ideal heat source to be used during the etching process. However, an ordinary 60-watt light bulb suspended near the solution pan will accomplish the same thing for less expense. A droplight with a 60-watt bulb works well. Use a plastic 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.

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.



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.

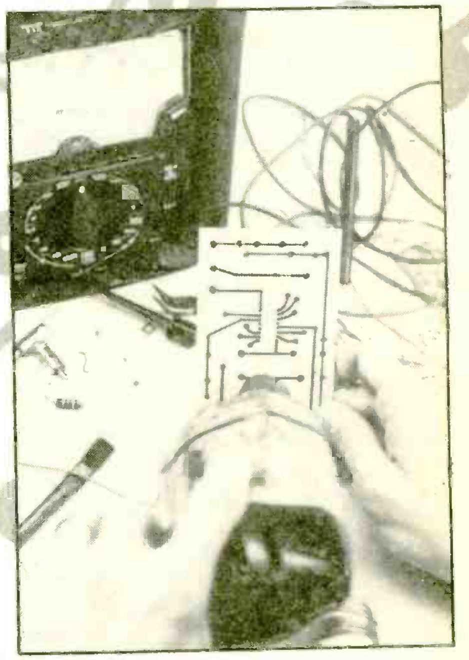
The etching process can be undertaken with success using no heat source if the etchant solution temperature is above 60°F. The process takes approximately one hour with no applied heat, but the results are not as certain.

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.

DIGI DICE

An electronic dice game with infinite possibilities

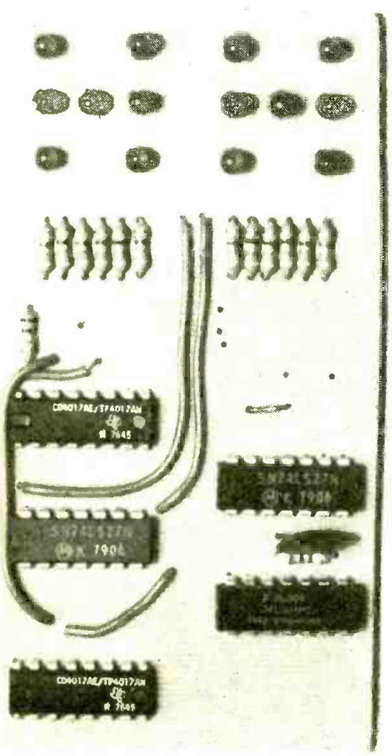
HERE IS A PROJECT for those of you tired of rolling old fashioned mechanical dice. *Digi Dice* can be used anywhere normal dice are used, and has been designed to be cheap, portable, and fun. And, since it is an electronic device, it is probably more random than any regular dice with their inherent mechanical 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.

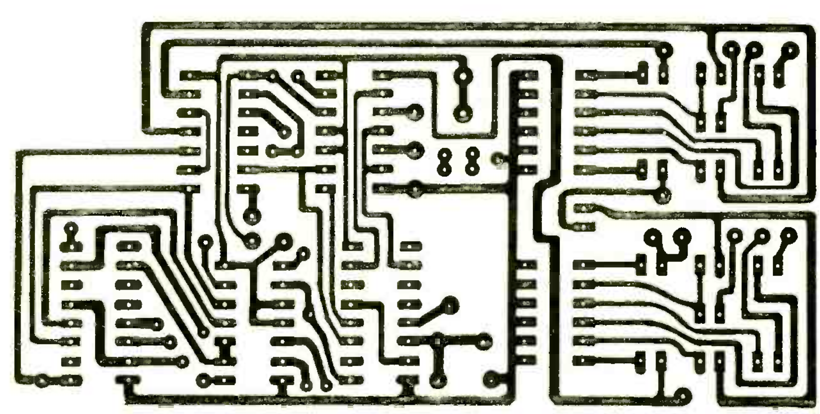
The net result of all this is a two-place base six (modulo six) counter. If we now interrupt the count at some point, each 4017 will contain a value of 0 through 5. If then, and this is the heart of the circuit, we run the counters so fast that we don't know where they are when we halt them, we have 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.

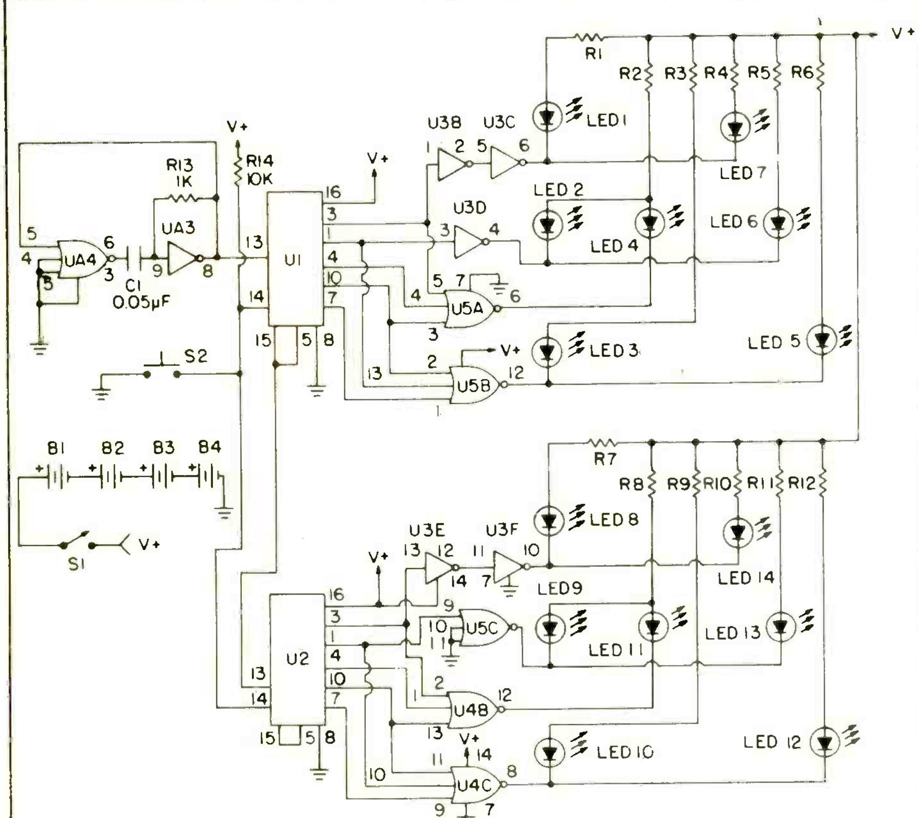
Construction. A full size PC board layout is shown for your use. As the pattern is very tight, we recommend that only advanced hobbyists attempt a reproduction. Wire wrapping is a bit more tedious and time consuming, but easier to correct. Anyway, if you do choose the PC route, carefully check for breaks 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 4$^1/_{16}$-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.

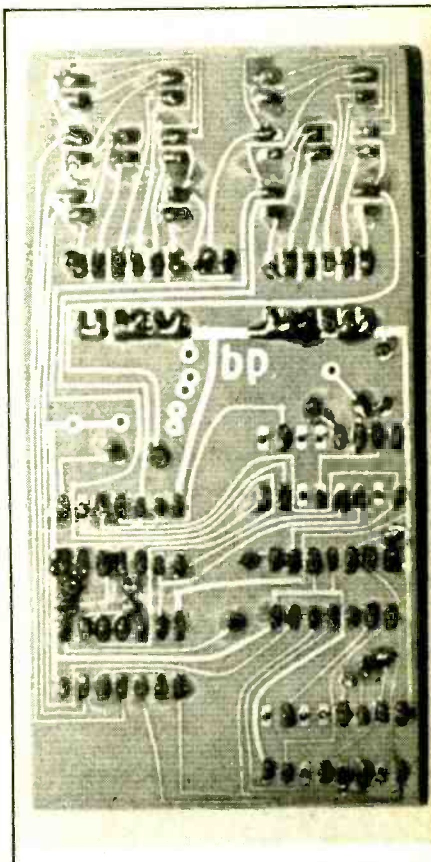
Operation. Closing switch S1 activates the circuit. Don't be surprised if an unusual combination of lights appears when the unit is first turned on. Now press pushbutton switch S2. All of the LEDs will illuminate, some more brightly than others. Releasing the pushbutton will force *Digi Dice* to display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

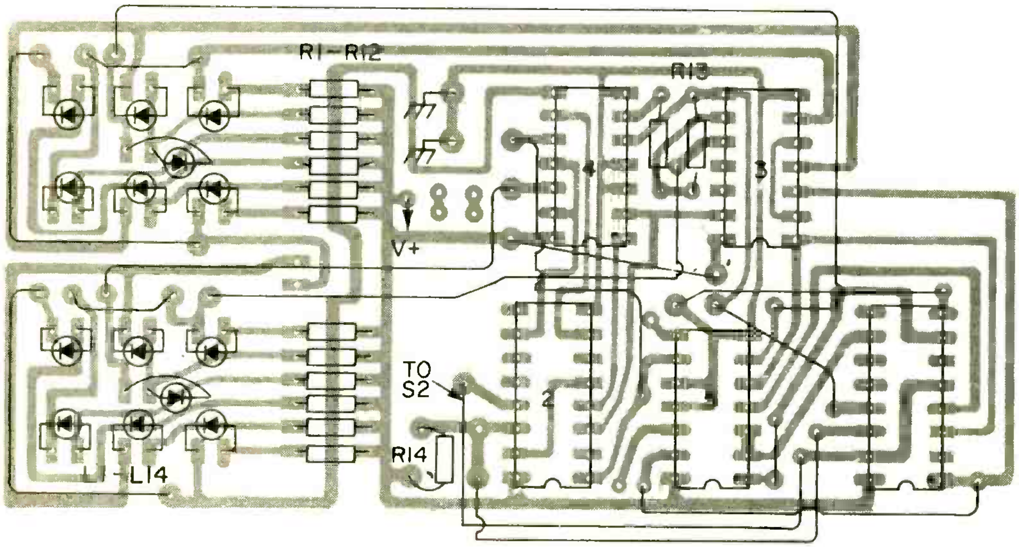
B1 thru B4—1.5 VDC battery
C1—0.05-uF, 50 VDC ceramic disc capacitor
LED1 thru LED 14—light emitting diode rated 20 mA @ 1.7 VDC
R1 thru R12—470-ohm, ¼-watt resistor, 10%
R13—1,000-ohm, ¼-watt resistor, 10%
R14—10,000-ohm, ¼-watt resistor, 10%
S1—SPST subminiature slide switch
S2—SPST normally closed 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.



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! ■

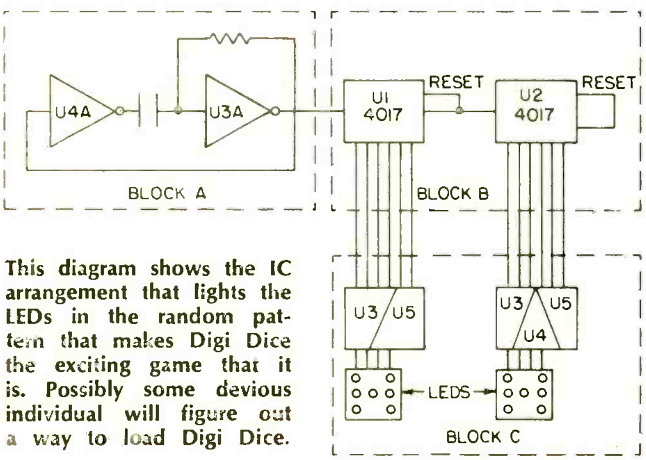


The parts overlay diagram shows the placement of components on the PC board. As in all projects using a number of delicate ICs care must be taken with the pins and with the use of soldering irons too near to the chips. Digi Dice is a project to gladden a gambler.

STATISTICAL BREAKDOWN OF 100 ROLLS

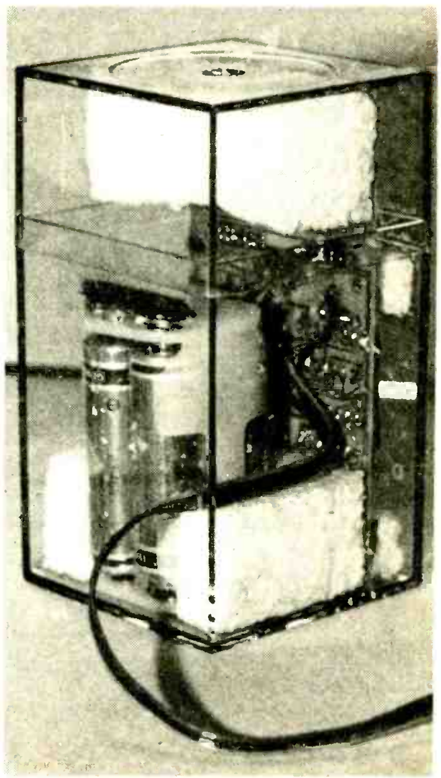
Face Value	Die #1/100 Rolls	Die #2/100 Rolls
1	18	16
2	14	18
3	18	14
4	15	17
5	18	16
6	17	19
Total	100	100

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.



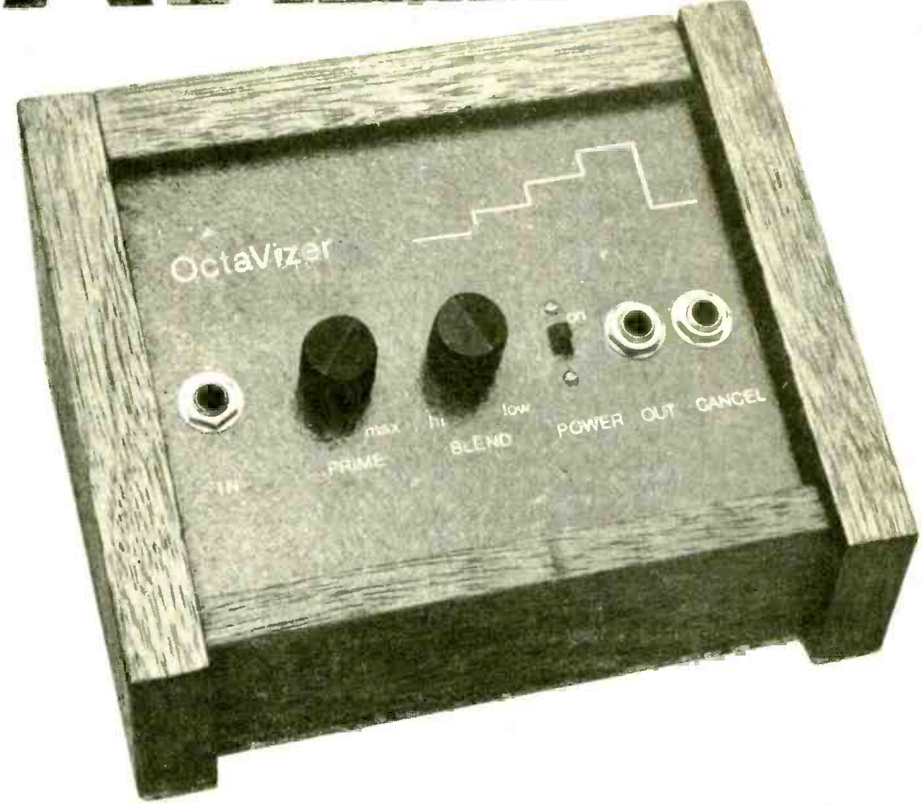
This diagram shows the IC arrangement that lights the LEDs in the random pattern that makes Digi Dice the exciting game that it is. Possibly some devious individual will figure out a way to load Digi Dice.

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.



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.

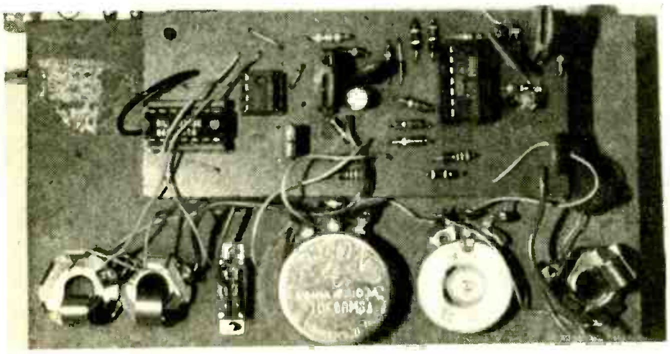
The *blend* control adjusts the relative magnitude of the two square wave signals, while the *prime* control adjusts the amount of input signal which is fed through to the output. The footswitch-operated cancel function disables the square wave outputs when activated.

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.

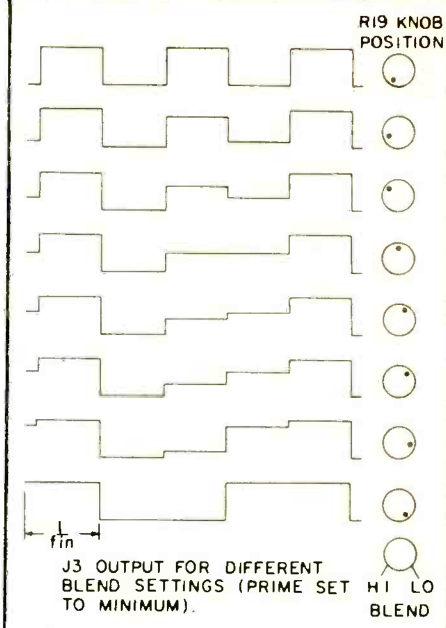
The final step is a fine adjustment which will maximize how long the signal lasts while minimizing false triggering. This adjustment consists of alternately adjusting R12 and R2 until you are satisfied you have obtained maximum duration and minimum (if any) false triggering.

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.

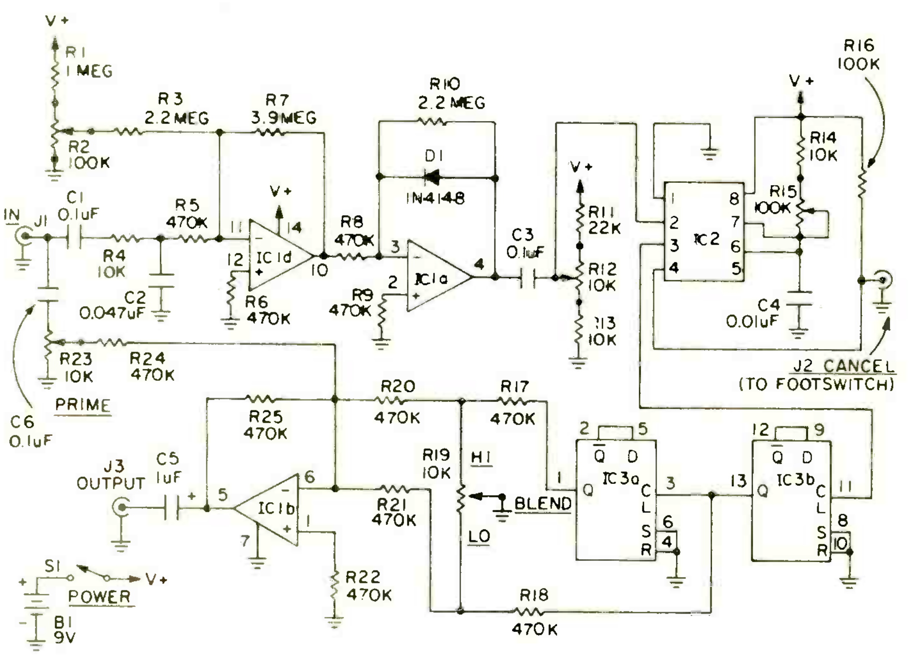
As you familiarize yourself with this new tool, you will find it an interesting and useful special effects device. ■



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

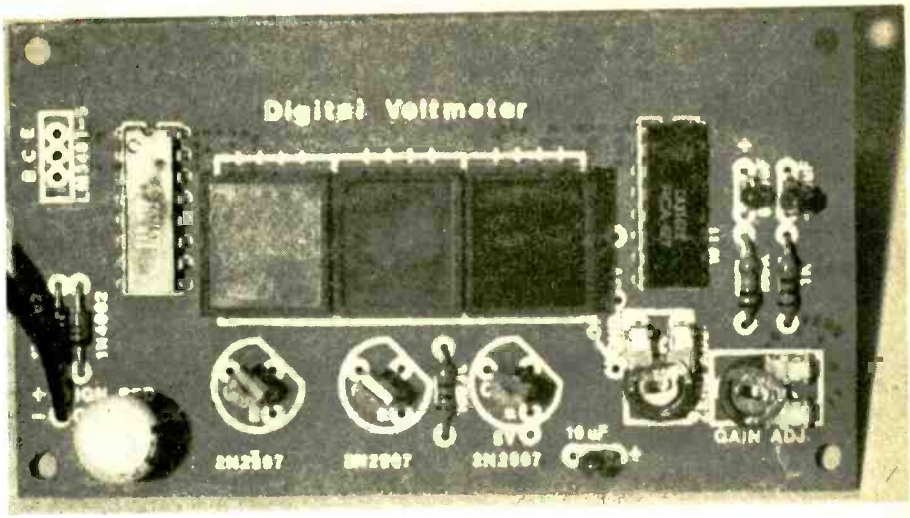
B1—9-volt transistor battery
C1, C3, C6—0.1-μF, 25-VDC disc capacitor
C2—0.047-μF, 25-VDC disc capacitor
C4—0.01-μF, 25-VDC disc capacitor
C5—1.0-μF, 16-VDC electrolytic capacitor
D1—1N4148 diode
IC1—LM3900 quad op amp
IC2—555 timer
IC3—CD4013 dual flip-flop
J1, J2, J3—standard 2-conductor phone jack
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.

Dashboard Digital Voltmeter

Keep an electronic eye on the voltage level 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.

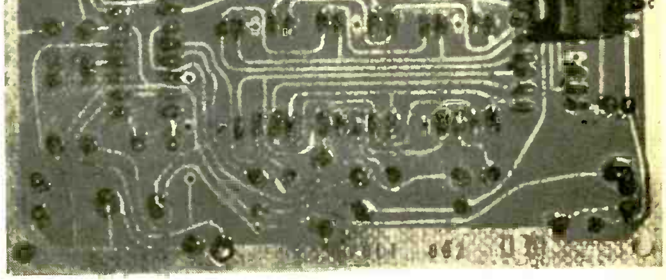
Two New ICs. The system is built about three ICs: the LM340T-5 (a 5-volt regulator now available for several years); a CA3162E; a CA3161E; and a support combination of diodes, resistors, and capacitors. It is the CA3161E and CA3162E that now open the door to new horizons in possible applications not 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).

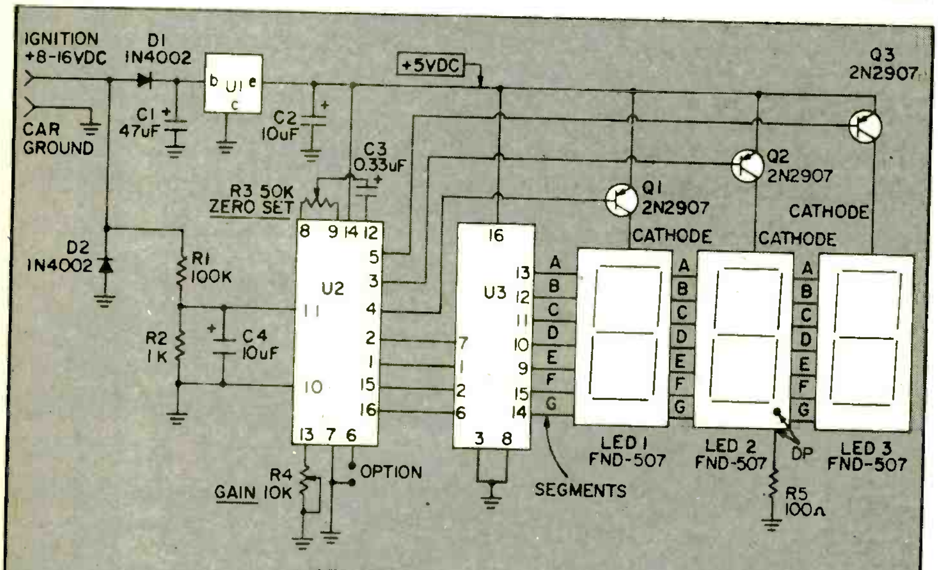
Reverse the circuit board and install the LM340T-5 regulator. *Caution!* This must be correctly placed or it will destroy your unit when power is applied. The *metal side* of the regulator must be facing the FND 507 pins. Recheck it to make sure.

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.

For pricing on parts and pre-etched, printed-circuit board for Digital Voltmeter write to Digital World, P.O. Box 5508, Augusta, GA 30906. Be sure to include a stamped, self-addressed envelope.

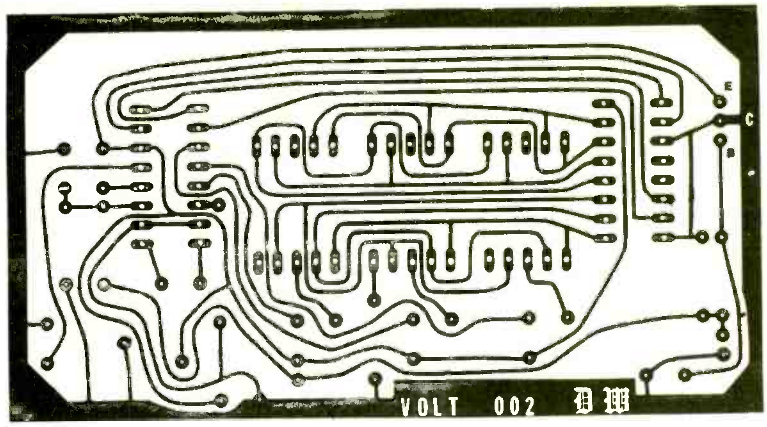
used as a template for the plexiglass cover dimensions. One-eighth or 1/16-inch thickness plexiglass works well and is relatively easy to cut using a roofer's shingle cutter knife. Place two clamps on a straight line along the template edge, then cut one side at a time. Scribe it deeply with a dozen 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.

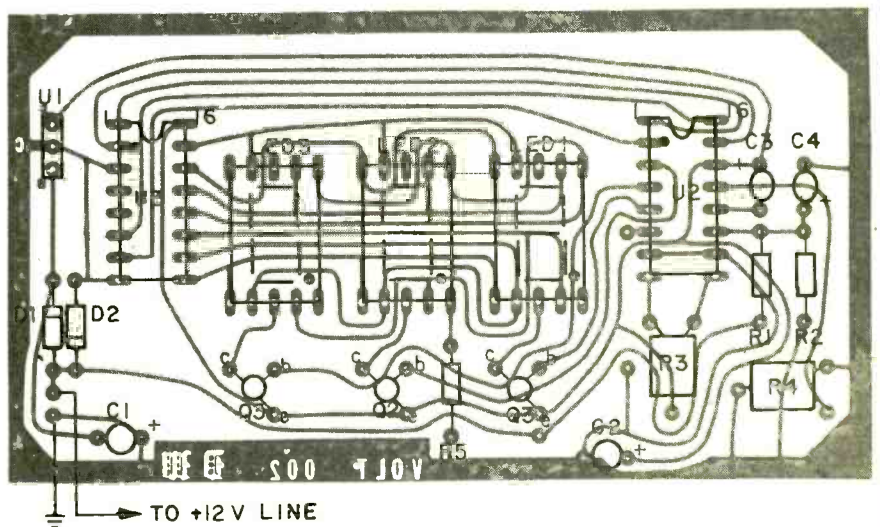
Troubleshooting. If the unit does not light up for the calibration procedure, first check that the wiper of R3 is centered. If it still does not light up, recheck your work. Carefully inspect for possible solder bridges and loose connections. If a solder bridge is discovered, remove it carefully. It 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. ■



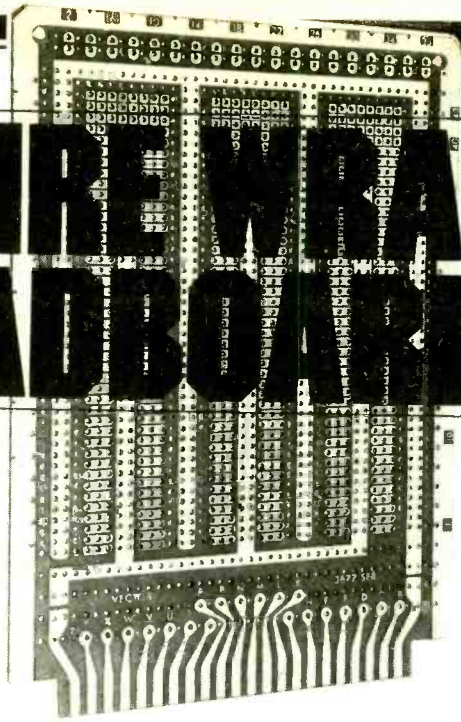
This full-scale etching guide for the voltmeter's PC board is one of the trickiest we've offered. Unless you know your stuff, we suggest you use a Digital World board.



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.

WIRE WRAP BREADBOARDING



A survey of this method and its special tools

FOR 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.

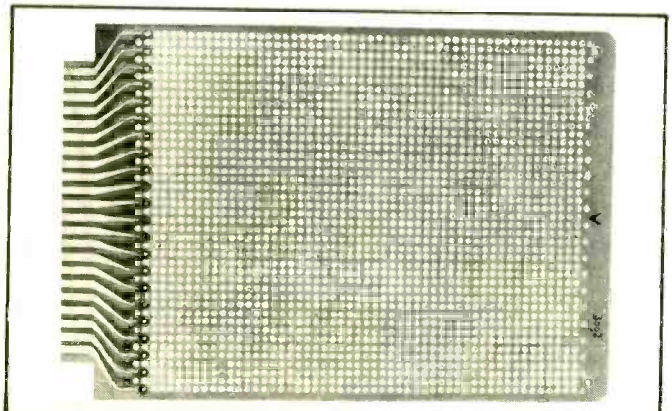
However, the finished product is rugged and, if designed with care, usually compact in size.

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).

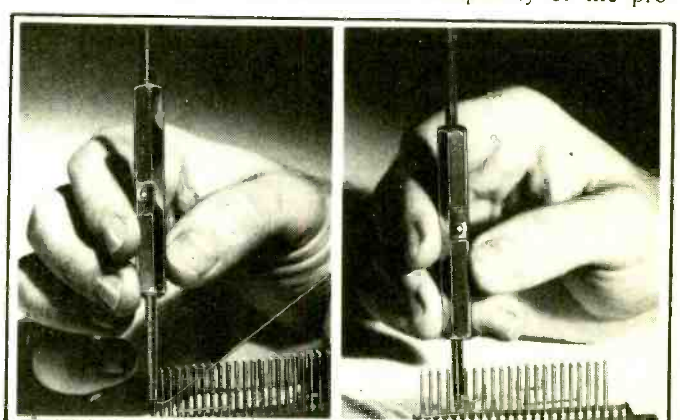
The Best of Both. This brings us to the relative newcomer in the hobbyist construction field, the wire-wrapped breadboard. We use the term "relative newcomer," because in fact wire-wrapping as a method of connecting components together on a circuit board has been around for close to twenty years, but 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-



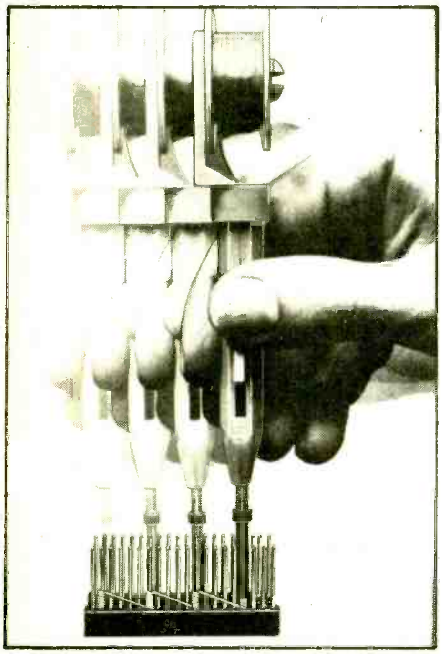
An excellent example of a "basic" matrix board is this model 3662 Plugboard™ from Vector. In addition to the edge-pin terminals, this model has hole spacing which accomodates that of DIP ICs.



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

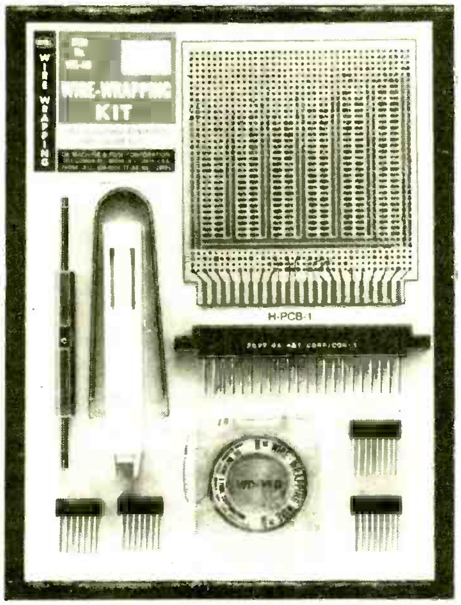
jects available for the hobbyist to build. One can literally build her or his own microcomputer from scratch these days, and the complexity of the circuitry involved dictates that the medium upon which the circuit is constructed be flexible enough to allow rearrangement of components and connections 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



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.

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.

What You'll Need. The basics you'll require for wire-wrapping are: the wrapping tool, wire (usually the wrapping tools can accommodate anything

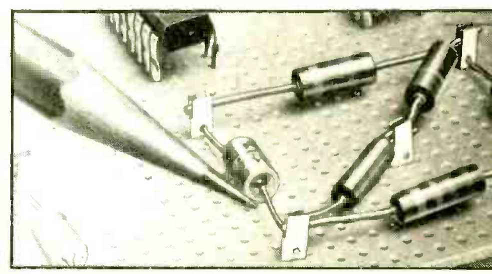


A good starter kit is OK's WK-4B, which contains all you'll need to begin to execute your projects in wire-wrapped formats. Make sure the terminals you buy are the correct diameter for your boards' holes.

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 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.)

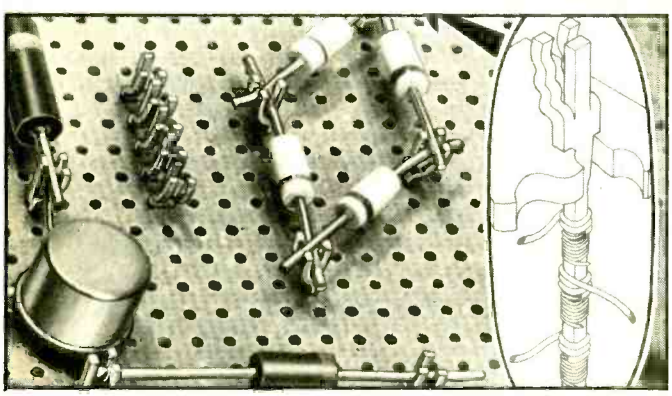
The base for your wire-wrapped circuitry can be as simple as a regular, perforated phenolic board, or something as esoteric as an epoxy/glass copper-clad board. The simpler perforated boards require that you merely insert wire-wrap terminals at the points where component leads meet on the board, and 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)



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.

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.

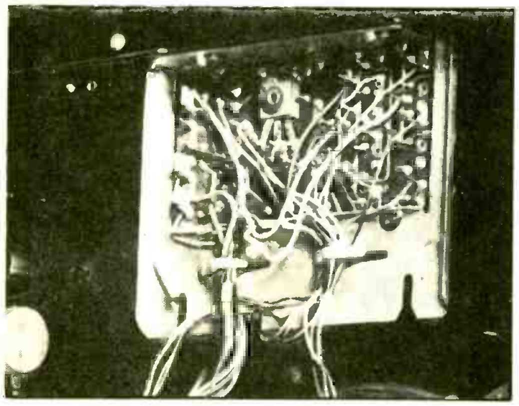
Some Nice Touches. Additionally, there are many specialized board designs available for computer-type circuitry, with special end terminal accessories for mating with standard ribbon connectors and/or PC card 44-pin edge connectors. For breadboarding peripheral circuitry for home computers, wire-wrap 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.

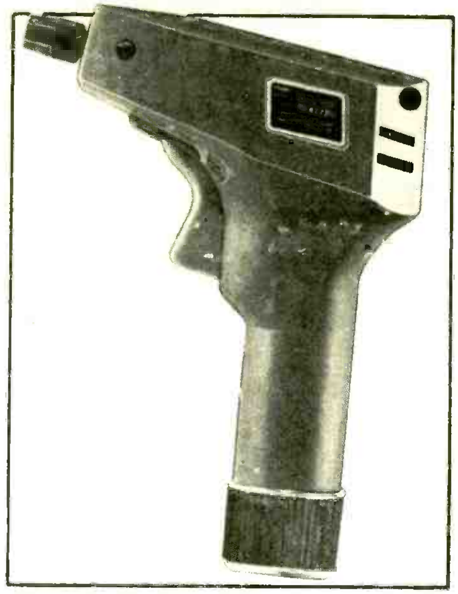
The more complex copper-clad boards which we referred to earlier also allow the builder to create "hybrid" circuit boards, utilizing the copper traces for standard printed circuit assembly of some components, while still being able to insert terminals through



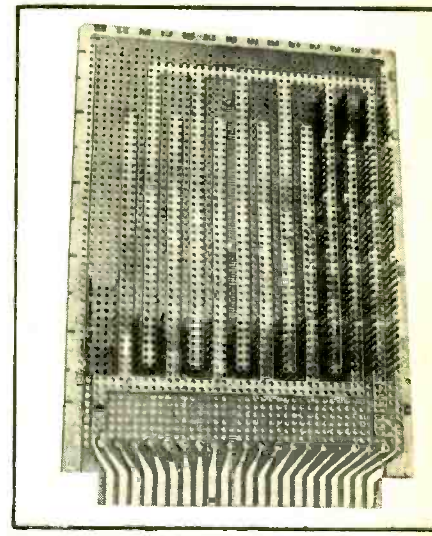
The high-voltage circuit board of this mid-1960's TV shows the use of wire-wrapped terminals combined with printed circuits. This type of hybrid can be built using the type of matrix boards seen on this page.

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.

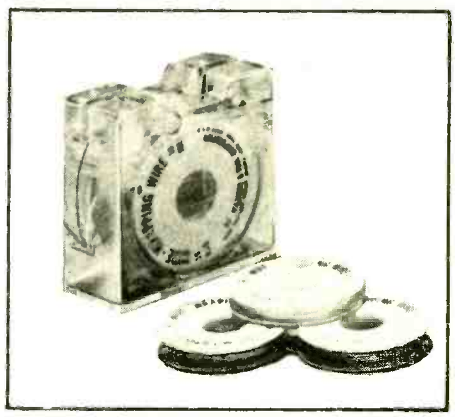
Where to Get Them. If the possibilities we've presented here appeal to you, then by all means do some further investigating on your own, either at your local electronics supplier, or by contacting the manufacturers directly. OK Machine and Tool Company, one of the largest hobby supplier of wire-wrapping 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. ■



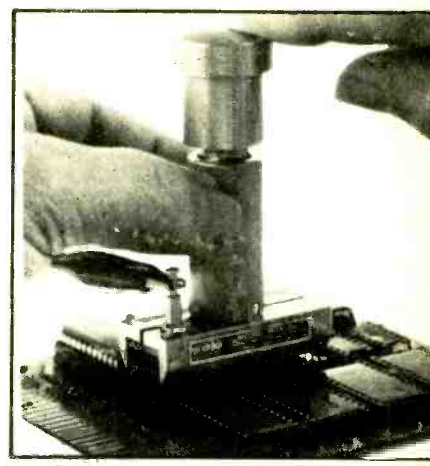
If you decide to go into wire-wrapping in a big way, a battery-operated wrapping tool can be a real time and work-saver. Interchangeable bits accommodate all wire sizes commonly used for wire-wrap construction.



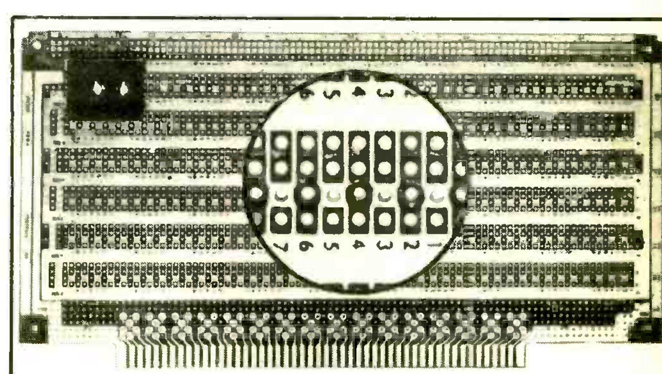
This Plugboard™ (model 3682-4) has etched copper bus strips for soldering as well as holes for wire-wrap terminals. This allows you to build rugged, yet flexible circuitry for virtually any electronic application.



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.

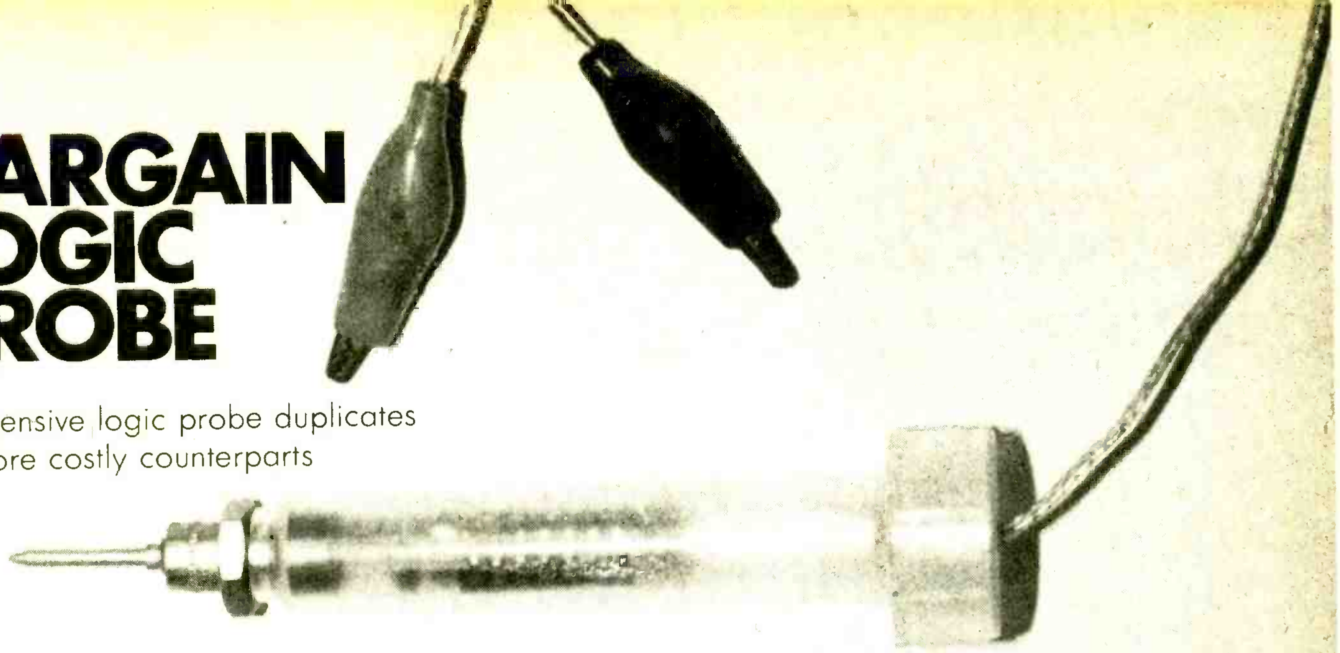


For safe and sure removal of delicate CMOS (as well as other types) ICs, an insertion tool is recommended. OK's MOS-40 has a lug for grounding the tool, this prevents damage caused by static electrical charges.



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.

BARGAIN LOGIC PROBE



Inexpensive logic probe duplicates its more costly counterparts

WHEN WE ARE DEALING with varying voltages, that is called analog data. In the digital world we do not find a variable signal. It is either on or off, just as a switch would be either on or off. Another way of saying this is high or low, or 1 or 0. Each high or low bit is put together to make up a basic character or Byte. Sometimes these Bytes are called words.

If we have 1001, then we can call that a 4 bit Byte. That is the smallest Byte ever to be encountered in the computer world. It can be used where the data accuracy is not critical and the amount of data is small. To illustrate this, if 1001 were sent and interference generated a pulse at the moment of the third bit, then we have been left with false data of 1011. Its meaning would be completely different. To increase accuracy and handle more data, we could go to 8 bit Bytes. Such as 10101010. A logic probe allows us to look at a particular point in the circuit to determine if a low (0) or high (1) is present.

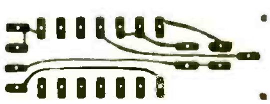
For most of our electronic experiments, we don't need expensive logic probes costing upwards of $40. Here is a cheap unit which can signal high level (1), low level (0), and oscillation. No pulse detection feature was included thus keeping the size small and the price low, around $2. The probe is designed for TTL signal levels and can be used for 5 volt CMOS circuits although loading may occur.

Theory of operation: Bargain Logic Probe uses only one IC, a 74L04 hex inverter shown in the schematic. The input to inverter A normally floats high, making its output low so as to light L1. The output of inverter B is high so L2 is off. If you now make the input of inverter A zero volts, L1 will turn off and L2 will illuminate. When oscillation is present at the input, both L1 and L2 will light at some intermediate brightness depending on the duty cycle of the signal being observed.

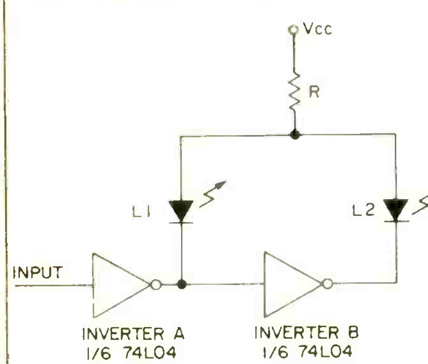
Using a 74L04 is important, the "L" series only requires the driving signal to sink 180 μA max, much below the 7400 series 1.6 mA max or even the 74LS00 series 400 μA requirement.

Construction: A full scale PC board layout is shown in addition to the parts layout on the component side. I slid the entire PC board inside a used syringe cover (available at hospitals for free), and attached a readily available test probe tip. Using different color L.E.D.s to signal high or low will help to quickly distinguish the signal level. Power is supplied by the circuit under test, and runs around 10 mA. Note, voltage requirements for the "L" series are 5 ±.25 V nominal.

So far, Bargain Logic Probe works great. It fits in my pocket and gives me a quick handle on circuit performance. It can also be used to show oscillator output in low power transmitter stages, SW converters & receiver local oscillators. ■

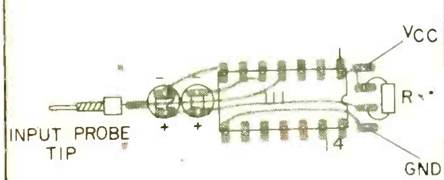


Here's the extra-small printed circuit board template for Bargain Logic Probe.

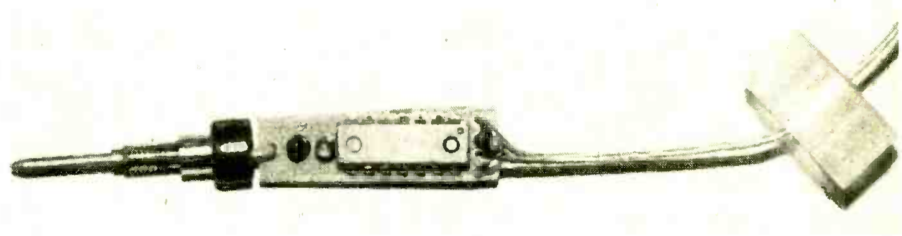


PARTS LIST

- **L1**—light emitting diode, red
- **L2**—light emitting diode, yellow
- **R**—1,000 ohm, ¼-watt resistor, 5%
- **U1**—74L04 hex inverter
- **Misc.**—probe tip, syringe cover, pc board, aligator clips, wire.



This will give you a good idea of parts layout on PC board. There are few parts.



This photo of the Bargain Logic Probe will give you some idea of the simplicity of the unit. It's small, but there aren't very many components. When done, just cap it up.

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