99 IC PROJECTS

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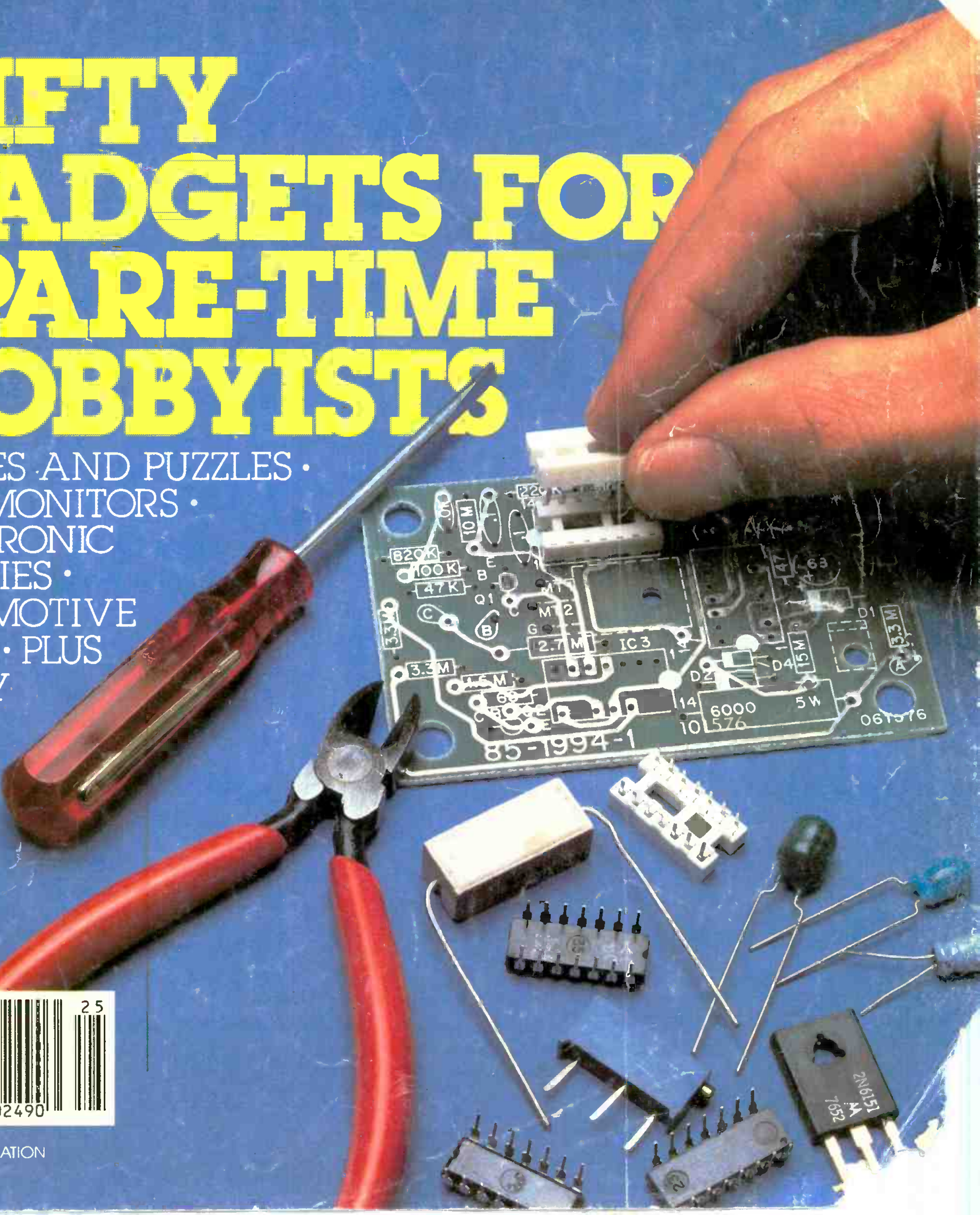
TRANSISTOR PROJECTS

NIFTY GADGETS FOR SPARE-TIME HOBBYISTS

GAMES AND PUZZLES • TEST MONITORS • ELECTRONIC SENTRIES • AUTOMOTIVE GEAR • PLUS MANY MORE



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A DAVIS PUBLICATION

NEW PRODUCTS

Sealing Cover for Pushbutton Phones

The first environment-proof cover for standard single-line telephone pushbutton keyboards, Teleseel is now available. The cover seals the keys of a pushbutton telephone set to keep out dust, dirt, and moisture even coffee and soda spills. Each cover comes with an adhesive backing and provides a

CIRCLE 20 ON READER SERVICE COUPON

tough sheet of quality elastomer over the complete face of a pushbutton telephone (fixed or mobile). In addition to sealing the openings around each individual key, the cover also seals the perimeter of the telephone set face plate. Standard telephone nomenclature is molded on the key covers in clear, legible characters. The new keyboard cover is available in all standard telephone colors including ivory, beige, white, blue, black, red, yellow and green. Thus, placing the Teleseel cover over a pushbutton telephone will leave the telephone appearance unchanged. Suggested retail price is $4.99 each. For literature and application assistance, write or call Teleseel, Inc., 44 Honeck St., Englewood, NJ 07631; or phone 201/569-5700.

Hand-Held Synthesized Scanner

The Bearcat 100 hand-held portable scanning radio is fully synthesized, and requires no crystals. The unit has a full 16 channels with extended frequency coverage. Power consumption is kept extremely low by using a liquid crystal display and several low power integrated circuits. The Bearcat 100 produces audio power output of 500 milliwatts and a hefty one full watt when used in conjunction with the accessory AC adapter included in the package. The unit has patented Track Tuning, selectivity of better than 50 dB down, and sensitivity of less than a microvolt on all bands and all channels. The unit operates on 6 AA batteries and has a battery low LED indicator to signal when to recharge. The unit's wide frequency coverage includes all public service bands (low, high, UHF, and "T" bands), both 2-meter and 70-centimeter amateur bands, plus military and federal land mobile frequencies. The unit has direct channel access and a built in automatic scan delay. The package includes a sturdy carrying case, earphone, battery charge/AC adapter and has a suggested retail price of $449.95. Complete details are available by writing to Electra Company, 300 East County Line Road, Cumberland, IN 46229.

CIRCLE 21 ON READER SERVICE COUPON

Weatheradio

Radio Shack's new three-channel VHF-FM weather broadcast receiver features crystal control of tuning for instant station selection with a simple three-position switch, eliminating the problem of off-channel tuning and drift. The new Crystal Controlled Weatheradio (12-152) receives NOAA (National Weather Service) broadcasts on any of the three channels used: 162.550, 162.475 or 162.400 MegaHertz. Be-

(Continued on page 4)

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99 IC PROJECTS

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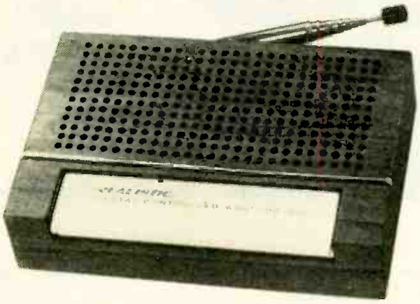
cause of the precise frequency selection possible with drift-free crystal control, stations can be accurately selected with a three position switch instead of the usual manual tuning knob. A "front end" RF (radio frequency) amplifier in



CIRCLE 22 ON READER SERVICE COUPON

this new Weatheradio brings in NOAA VHF weather stations loud and clear at a range of up to 50 miles, making this receiver effective virtually anywhere in the United States. Signals are captured by an attached antenna, which telescopes down and folds behind the unit. Power is provided either from a 9 Volt battery (not supplied) or an optional AC adapter. The Model 12-152 Crystal Controlled Weatheradio is available now for $24.95 at Radio Shack stores and participating dealers.

Converting Measurements

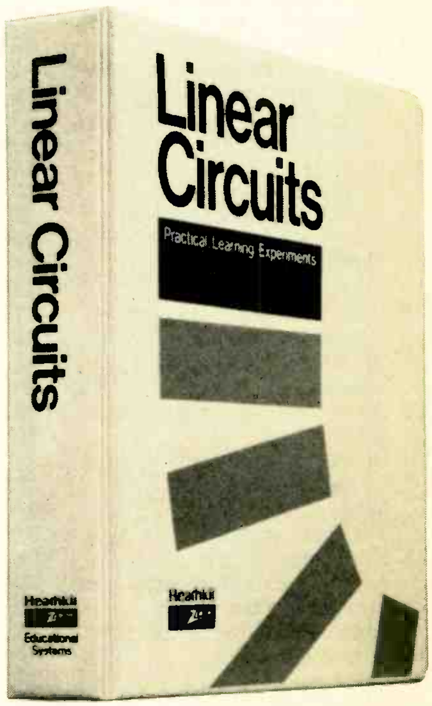
A new unit measurement converting/calculating kit, the TI Converter, includes the TI Converter, The Calculator and Converter Handbook, and the TI Converter Quick Reference Guide. You can use the kit to calculate and convert English and metric measurements quickly. The TI Converter contains 194

CIRCLE 23 ON READER SERVICE COUPON

built-in conversions for unit measurements of capacity, length, temperature and weight. Users can convert pounds to kilograms, miles to kilometers, Fahrenheit to Celsius, quarts to liters, and many more. In addition, conversions can be made within the same system of measurement, such as yards to inches or meters to kilometers. Consumers will find many uses for the TI Converter in day-to-day measurement problems. In addition to making quick measurement conversions, the TI Converter offers all the basic functions of a calculator. Its liquid crystal display shows up to eight digits. There are three convenient memories. The TI Converter also features APD (automatic power down) which automatically shuts off the calculator after a few minutes of non-use. Suggested retail price for the TI Converter Kit is $24.95. It is available through retailers. For more info, write to Texas Instruments Inc., Consumer Relations, P.O. Box 53 (Attn: TI Converter Kit), Lubbock, TX 79408.

Linear Circuits Course

A new "hardware-oriented" course in Linear Circuits has been introduced by Heathkit/Zenith Educational Systems to meet the needs of the elec-



CIRCLE 24 ON READER SERVICE COUPON

tronics student, experimenter, radio amateur or computer enthusiast who would rather learn by doing than by reading. The student learns how each circuit operates by building the circuit and observing its performance. And when the course is finished, the individual has a handy circuit reference file for future use. The Course is mail order priced at $49.95, FOB Benton Harbor, MI 49022. For more details on the EH-701 Linear Circuits Course, see the latest Heathkit Catalog. For a free copy, write Heath Company, Dept. 350-155, Benton Harbor, MI 49022.

Foxy Scanner

The Fox BMP 10/60 (base, mobile, portable) is the world's first scanner to offer the unique features of base, mobile and portable systems in a sleek, compact and lightweight unit. The unit offers 60 pre-programmed active frequencies scanning the airwaves for up to the moment breaking news on police, fire, weather, marine and mobile telephone calls. The scanner also offers more common features of skip, pause and action. Scanner listeners are able to skip individual channels not currently of interest; activate a pre-selected action channel of their choice, so no action is missed; and also pause longer on individual channels in order to hear all of the two-way communications, between police car and dispatcher. In addition, the BMP 10/60 has a semi-automatic "Seek" feature that seeks out unknown frequencies. The unit sells for $349.95. For more info, write to Fox Marketing, Inc., 4518 Taylorsville Road, Dayton, OH 45424.

CIRCLE 25 ON READER SERVICE COUPON

New μSystem

Personal Micro Computers has added the PMC-81 microcomputer system to its product line. The PMC-81 has 16K of RAM memory, 14K of ROM, utilizes a Z-80 microcomputer and provides a keyboard, cassette interface and video monitor interface in the unit. The PMC-81 uses the EXP-100 Expander to add interfaces for minifloppy disks, printer, RS232C and S-100 bus. The PMC-81 has been added to the product line to fulfill the requirements for a disk oriented computer. The PMC-81 has a 15 key numeric pad and has a complete professional keyboard with lower case letters and true descenders provided as standard. Additional features which are available to the PMC-81 user are: automatic repeat on every key, print screen from keyboard command and shift lock command to switch the keyboard from BASIC mode (all caps with shift to get lower case) to typewriter mode and back. The new keyboard routine is resident in permanent memory in the PMC-81. A flashing cursor is displayed when the routine is operating. A large flashing cursor designates the BASIC mode and a small flashing cursor designates the typewriter mode. The PMC-81 retails at $740, and does not include disk drives and printer. For more information, write to Personal Micro Computers, Inc., 475 Ellis Street, Mountain View, CA 94043.

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VHF Band Expander

The MFJ VHF Band Expander, model MFJ-312 converts any two-meter synthesized, VFO, or VXO rig to receive the VHF highband police, fire and weather frequencies. If your rig cover 144-148 MHz, just insert the MFJ-312 in line with the antenna, connect power, and turn on the converter, now you are ready to receive 154-158 and 160-164 MHz in two ranges. If your rig covers a larger or smaller band segment than 144-148 MHz, then with the MFJ-312 you can receive a correspondingly larger or smaller segment of the VHF highband. On the first range, 154-158 MHz, you have direct frequency readout from your rig. If your rig indicates you are receiving 145.55 MHz, just turn the converter on and you are receiving 155.55 MHz. On the second range, 160-164 MHz, slight interpolation is required to know the megahertz range but kilohertz are still read directly. The VHF Band Expander, model MFJ-312 is available from MFJ for $59.95 plus $4.00 shipping and handling. To order call toll free 800/647-1800 or mail order with check or money order to MFJ Enterprises, Inc., P.O. Box 494, Mississippi State, MS 39762.

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Clean Sweep

The new model 3015 Sweep/Function Generator from B&K-Precision is a compact instrument, designed principally for audio and ultrasonic applications. The instrument covers a frequency range of 2 Hz to 200 kHz in three ranges, with each range providing

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NEW PRODUCTS

1,000:1 frequency control. The 3015 can be used for most measurement and troubleshooting applications in the audio and ultrasonic ranges. Its built-in linear and log sweep capabilities are pushbutton selectable and may be operated at three different sweep rates.

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For specialized applications, the sweep/rate may be further increased by adding an external ramp-timing capacitor to terminals on the rear panel. By using the sweep mode, the audio response of amplifiers, preamplifiers, tape recorders and other devices can be quickly determined. The sweep rate may also be controlled by an external signal of 0 to 1 volt. An output terminal is also provided on the rear panel of the internally generated sweep ramp voltage. Sinewave distortion conservatively rated at less than 1% from 2 Hz to 20 kHz—the full audio spectrum. It is available with power supply options for either 120 or 220 VAC. Sells for $270.00. For additional information on the 3015, write to B&K—Precision Product Group, Dynascan Corp., 6460 W. Cortland Street, Chicago, IL 60635.

Memory Code Keyer

The new Heathkit SA-5010 μMatic Memory Keyer uses a custom microprocessor to provide up to 10 buffers for storing up to 240 characters of text or commands. These variable-length buffers eliminate wasted memory space by letting the user store text in several buffers and then string them together in any sequence. Command strings can also select the speed, weight, spacing and auto-repeat count for each message so selected. The SA-5010 employs a 20-position keypad for entries, and features easy-to-use integral capacitive

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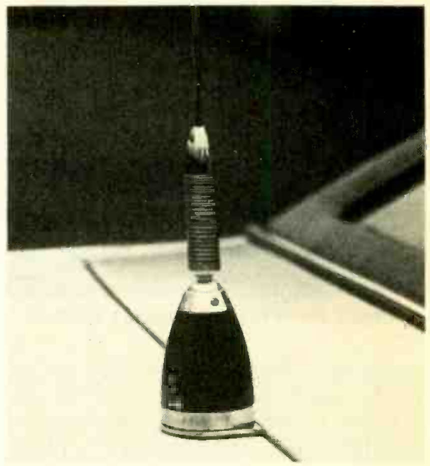
"touch" paddles. A rear panel jack is provided for use of a mechanical paddle with the SA-5010, if so desired. A "practice" mode sends random code groups of random length and selectable types. The 100 different random sequences are repeatable, so the Ham can check copy for accuracy. Mail order priced at $97.95, FOB Benton Harbor, MI 49022, the SA-5010 features built-in side tone oscillator and speaker with variable pitch and volume controls. Phone jack and ear phone are included for private listening. A plastic case covers the die-cast zinc base, which is weighted to reduce movement during keying. The keyer requires the optional 120 VAC Heathkit PS-5012 Power Supply.

Low-Profile Trunk Mount CB Antenna

The new 40-channel plus TAK-20, extra low-profile Trunk/Lip Mount, 26.5-28 MHz mobile CB Antenna introduced by Armstrong Industries features high performance, water tight construction and only 1¾ turn, quick disconnect from the heavy-duty triple chrome plated mounting bracket. The TAK-20 is engineered for standard vehicle trunks and hatchback designs. Also, featured is a ball joint that permits a 45-degree whip tilt in all directions for vertical positioning from most mounting angles. A stainless steel shock spring is also provided. The new antenna's base load with 42-in. long semi-



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rigid whip may also be instantly remounted onto six other style mounts sold separately and operate at top efficiency. The TAK-20 with shock spring has a suggested list price of $44.50. The TAK-10, without shock spring, is $40.50. For more data on this new CB antenna and other antennas in the "All-American" line, write to Armstrong Industries, Div. of MCS, Inc., Route 24, P.O. Box 237, Watseka, IL 60970.

Desolder Pump

The new DP-1 Desolder Pump from OK Machine and Tool Corporation offers full industrial performance and features at an economy price. The DP-1 features all metal construction with precision components for maximum reliability and ease of operation. Compact size facilitates comfortable one

CIRCLE 31 ON READER SERVICE COUPON

hand operation. Suction is precisely regulated for efficient solder removal without damage to delicate circuitry. Self-cleaning on each stroke, the DP-1 is quickly disassembled without special tools for maintenance or repairs. Rugged Teflon tip is easily replaced. Priced at only $10.95, DP-1 is available at local electronics retailers and distributors or directly from OK Machine and Tool Corp., 3455 Conner Street, Bronx, NY 10475. ■

INPUT/OUTPUT

Hit or Miss?

How come I hear so much talk on how computers can do everything, and now I hear that computer controlled missiles have a high miss probability? What's going on?

—A.N., Waterloo, Ont.

Missile accuracy is affected by several factors. The first is bias error. Created mostly by the combined gravity of the earth and the moon, this tug on airborne missiles can create a target error of up to several miles. Figuring the effect of gravity into a guidance system is too complicated because several unknown factors are involved. The effects of the moon's pull on different parts of our land and water surface, although generally known, change every day as the moon moves. The earth is a mosaic of its own gravity anomalies, patches of stronger and weaker gravity created by the earth's rotation and motion within the earth's core. Opposing countries have naturally not tested their missiles over opponent's territory. Thus, they have no idea what gravitational patterns would do to the paths of their missiles. In figuring gravity's effects, an error of even four parts per million can throw missile accuracy off by 300 feet. Once an ICBM has begun its descent, its path cannot be changed. Traveling at 16,000 mph, it becomes wrapped in an ionized shock layer that makes its computer guidance systems unreachable. Circle of error probability (CEP) also affects missile accuracy. Created by random errors in missile alignment, velocity formulas, gyroscope guidance, rocket timing, computer instructions, and simple "glitches" in parts from ignition switches to bomb fuses, this type of inaccuracy can be considerable. A system that is initially fairly correct can quickly be thrown off substantially by vibrations and changes in temperature and humidity. A CEP of 300 feet is often claimed for ICBMs, but 600 to 900 feet is more likely. Bomb size can also throw off accuracy. There are many other considerations that the apparent strike capacity of ICBM's out of the 100% hit class and reduce the hit score to the lower percentiles. Computers would work fine if the world was truly round.

Cross My Heart

I hear a lot about REACT. Is it all true?

—F.B., Columbus, OH

REACT (*R*adio *E*mergency *A*ssociated *C*itizens *T*eams), with approximately 2,000 teams and 30,000 members, has been providing organized emergency communications services to local communities throughout the U.S., Canada and many foreign countries for nearly 20 years. Believe me, what you hear is true. CB radio owners and dealers wishing to know more about REACT may write to REACT International, Inc., 75 E. Wacker Drive, Chicago, IL 60601. Tell them Hank sent you!

Easy Stuff

I'm looking at a functional black diagram of a computerized machine and find abbreviations like SISO and PISO. What do they mean?

—C.M., Harbor City, CA

Easy once you see it!

Serial-In-Serial-Out	SISO
Serial-In-Parallel-Out	SIPO
Parallel-In-Parallel-Out	PIPO
Parallel-In-Series-Out	PISO

See what I mean!

First Line of Defense

What is the cheapest burglar alarm system I can buy?

—G.A., Philadelphia, PA

It eats hamburgers and goes, "Woof, woof." Seriously, a good perimeter burglar alarm system using window tapes and door switches goes for about $800 installed. You can do it a lot cheaper by doing the installation yourself. I did it for under $150. Consider the value of your home, possessions and loved ones first, then try to skimp on costs. By the way, back up the burglar alarm system with a large dog—the results are outstanding.

T Up

What country uses T as a ham prefix to a call?

—B.D., Riverdale, NY

None, but several use T as the first letter: TA-Turkey, TF-Iceland, TG-Guatemala, TI-Costa Rica, T19-Cocos I., TJ-Cameroon, TL-Central African Empire, TN-Congo, TR-Gabon, TT-Chad, TU-Ivory Coast, TY-Benin, and TZ-Mali. I hope my dart was up-to-date because some countries change names weekly, and others phase in and out!

What's It

My teacher mentioned a "Clark cell" in class. What is its voltage output?

—E.N., Lodi, NJ

A Clark cell was formally used as a standard source of e.m.f. for reference in laboratories for voltage comparison. Used properly, it should be "nulled" against a voltage to be measured so no current flows through the cell. It consists of a mercury cathode coated with mercury sulphate, and a zinc anode. The electrolyte is a zinc sulphate solution. The voltage output is 1.4345 volts at 15-degrees Centigrade. The Clark cell has been replaced by the Weston cell which produces 1.0186 volts at 20-degrees Centigrade. The Weston cell voltage output varies very little with room temperatures.

Tweet

I've been fooling around with sound recording for some time, and now I'm recording the sound of birds for a friend. I need a parabolic reflector so I can assemble a directional longrange microphone. Where can I get one?

—L.P., Ridgefield, NJ

Edmund Scientific, East Gloucester Pike, Barrington, NJ 08007 has an 18-in. job that goes for under $20. Get their catalog, and tell them who sent you.

Wrap Up

Hank, this wire-wrapping is a lot of bunk. It doesn't save time at all.

—R.H., San Francisco, CA

Okay, you have your opinion. The other day I put together a small project with four ICs and three LED displays. If I tried to solder that project, I'd end up with one large glob of molten solder. Also, I'm human—I made a wiring error. It was easy to find, and even easier to repair. Patience and a little practice may convert you yet!

A Lot of Noise

A book I was reading said that linear ICs are noisier than digital ICs. Then, nothing more was said on this subject. Hank, can you tell me if this is so, and why?

—J.O., Butte, MT

I'm not too sure you are quoting the text too carefully. I would say that linear ICs generally require more external components like capacitors and resistors than digital ICs when both types are hooked up into circuits. Thus, linear IC circuits have increased susceptibility to external noise either generated by or picked up by these external components. However, the noise in one circuit is characteristically different from the other, and I don't see how they can be compared.

Ring Them Bells

I have four telephones at home. I own them, but the phone company has been informed that they are connected to my telephone line. Their original phone was disconnected and returned to the telephone company for credit. Now the phone company tells me to disconnect one of my four phones because they are equivalent to more than five phones. Sounds like Ma Bell is double talking me. Can you set me straight, Hank?

—J.K., Bronx, NY

FCC rules place a limit of five ringers or ringer equivalences on single party telephone lines. The ringer equivalence number on each telephone item tells how many standard ringers the ringer in the phone item is equal to. For example, a ringer equivalence number of 1.5 means the telephone item has a ringer equal to 1½ standard ringers. Since FCC rules place a limit of five ringers or ringer equivalences per line, the customer can use any combination of phone items so long as the total ringer equivalence is 5.0 or less (most telephone company-supplied phones have a ringer equivalence of 1.0). A total ringer equivalence of more than 5.0 can cause erratic operation. No, the phone company is giving it to you straight. Just disconnect one of the ringers and all will be well.

Ribbon Cables

Hank, I'm having trouble with ribbon cables, and their press-on fittings. I tested two brand new cables only to discover that both had at least one open circuit. And, would you believe, I once tested a cable that had six open leads. My question is, since cables must be checked, how can I do it quickly?

—F.N., Melbourne, Australia

If your cable terminates on a printed circuit board, take a double-sided copper-clad board, cut it to size, connect both foil surfaces together and to the common terminal of an ohmmeter. Use the other probe to check out each lead on the other connector (or connectors, if there are more). At each touch of the probe tip to the terminal connector point at each jack and/or plug on the cable, a short circuit, or zero ohm indication, should appear. Should the meter pointer not move indicating an open circuit either at that point or the corresponding point at the other end of the cable, you have an open circuit. Guess which end it is at, open the connector, replace if necessary, and resecure. Recheck your work to be sure you fixed the defective contact(s) and introduced none of your own. Be patient. Ribbon cable assembly testing should not be rushed.

Where to Buy

I purchased a Panasonic multiband receiver and overnight I became a SWLer. In my town there are no special outlets to assist me in my hobby. Do you know of any?

—A.N., Concord, NC

Even in the big burgs you will have trouble finding an outlet. A local Radio Shack may have some things you need. Check them out. I suggest you write Gilfer Shortwave, Dept. E-1, Box 239, Park Ridge, NJ 07656 and ask for their catalog. They're specialists to the shortwave hobby.

Tubes Never Die

Hank, no one advertises tubes for sale. I'm fixing some 20- and 30-year-old radios and TVs and can use a reliable supplier. Can you help?

—W.A., Albuquerque, NM

I checked around a bit and discovered three. They are:

Cornell
4217-W University
San Diego, CA 92105

McGee
1901 McGee Street
Kansas City, MO 64108

Steinmetz
7519-EE Maplewood
Hammond, IN 46324

When you write for information and prices, send a business sized envelope with postage attached to speed the return mail.

Generation Gap

I purchased an old book that gives tips on constructing old time radios and receivers. The book, published in 1921, gives details on a spark-gap transmitter. I'm going to build one for the CB band. How can I be sure I don't exceed the power input requirement?

—W.E., San Antonio, TX

By not turning it on! Home brew CB band transmitters are taboo! Also, spark-gap transmitters are not suitable for communication because they are broadly tuned and very rich in harmonics. Forget the idea.

Dollar Saver

I find project building very expensive so I use IC sockets whenever I can, so I can strip projects with little loss by damaged parts. I think you should pass this tip on to your readers.

—R.E., Pinellas Park, FL

Good idea, but go a bit farther. Avoid soldering whenever possible. Use solderless breadboard when possible. Also, think about wire-wrapping parts together. There are lots of little gimmicks you can come up with to keep parts like new as you go from project to project. However, should you want to keep a project, think in terms of soldering it together for good mechanical and electrical connection.

Broke a Leg

Hank, how do you solder on a broken contact onto an integrated chip? I blew it on an expensive chip and don't want to go through the expense of buying a new one.

—A.N., Greenville, SC

How? Very carefully. In fact, more carefully than the technique you used to break the leg of the bug. I've tried on several occasions to do just that by using a very low-wattage narrow-tip soldering iron. My results on the "fixables" were 33⅓% successful. I saved one chip and heat destroyed two others. Several chips were beyond saving because not enough of the leg protruded from the insulating body of the chip. If you are salvaging chips from surplus circuit board assemblies as I was, take a tip from one of my readers. His idea for "one of a kind" and very expensive chips, was to cut the board using a table jigsaw all around the chip about ⅛-in. space between the chip and cut. Attach wire leads to the cutout with a low-wattage iron, then wirewrap these leads to a standoff insulator or header that is sized to insert into an IC socket. My big fingers found the job very difficult, but it worked. There must be better ways to do it, so please write and advise me. Finally, no matter if the chip is new or old, cheap or costly, always use care when inserting an IC into a socket. I use a magnifying glass to check that all the legs on the chip are seated in the IC socket before I press down. Also, an IC insertion tool (and IC puller) are invaluable during the hand operations.

Solar Dollars

I truly want to use solar power electricity, but find the initial cost is so very high. I don't see how I can justify an installation of any type.

—H.O., Island Harbor Beach, FL

I agree to a limited degree. Solar power electricity from solar cells requires a large investment to avoid paying all or part of your electric bill. However, there is no reason why you cannot solar power your transistor radio for beach use. Dry cell power is expensive, and solar cells can compete successfully. There must be other ideas you can think of. One reader told me he uses solar cells to trickle-charge his car battery when he leaves his car behind for weeks during business trips.

(Continued on page 98)

COVER TO COVER

YOUR ELECTRONIC BOOKSHELF

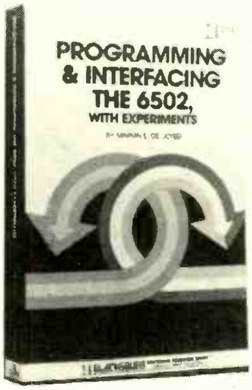
Computer Guide. Sybex has published *Your First Computer—A Guide to Personal and Business Computing* by Rodnay Zaks. Originally published in 1978 as *An Introduction to Personal and Business Computing,* this widely acclaimed best seller has been completely revised, redesigned and expanded. The computer section has been totally rewritten and represents an up-to-date summary of

Soft cover
258 pages
$7.95

Your first computer. Circle number 47 on the reader service coupon.

equipment available in the marketplace. The business section has been expanded to show actual examples using a word processing system or a mailing list system, two important applications for any business user. *Your First Computer* has been designed as both a basic introductory text and a reference manual, making it equally useful for people just becoming curious about computers as well as experienced programmers about to purchase their own system. Published by Sybex, Inc., 2344 Sixth Street, Berkeley, California 94710 or, telephone 415/848-8233.

Learning the 6502. *Programming & Interfacing the 6502* by Dr. Marvin L. DeJong conducts the reader step-by-step toward an understanding and competence in assembly-language communication with 6502-based microcomputers. Experiments and examples are written so that a KIM, AIM, or SYM system may be used to reinforce the material presented. Proceeding from carefully worded instructions on writing and executing simple programs using data transfer instructions to simple I/O techniques, the author then examines logical operations, arithmetic operations, branches and loops, register-shift

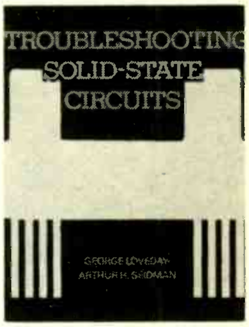


Soft cover
414 pages
$13.95

Guide to 6502 Microprocessors. Circle number 42 on the reader service coupon.

instructions, indexed addressing, subroutines, the stack, interrupts, and interval timers in Part I on programming. The experiments reinforce the concepts, building confidence in the reader to perform increasingly complex operations. Part II on interfacing extends the development, concentrating on interfacing integrated circuits and devices up to and including I/O ports. The basic theme is developed by configuring several memory-mapped I/O ports grouped by pin functions specifically, the address bus including decoding and generating device select pulses, the control bus, and the bidirectional data bus. The final chapter illustrates several finished projects. Published by Group Technology, Ltd., P.O. Box 87, Check, VA 24072; or telephone 703/651-3153. Include one dollar for shipping and handling.

Fix it Fast. How many times have you pondered over a simple transistor radio or computer board unable to discover a fault? To often, you say? Well, dig into *Troubleshooting Solid-State Circuits* by George Loveday and Arthur H. Seidman. The text provides a concise description of major solid-state devices and their operation in practical circuits, then, it illustrates circuit failures, and what troubleshooting techniques are employed to isolate and correct the fault in minimum time. A series of practical exercises with answers on back pages enable the experimenter to

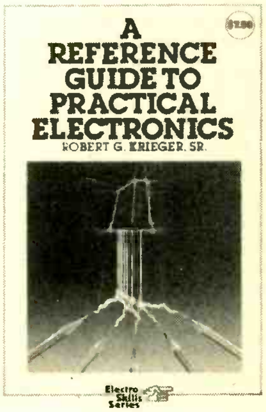


Soft cover
110 pages
$7.95

Repair electronic circuits. Circle number 44 on the reader service coupon.

educate himself. Chapter 8 on linear and digital integrated circuits is worth the price of the text. Published by John Wiley & Sons, One Wiley Drive, Somerset, NJ 09973.

Practical Guide. Here's a highly organized and concentrated volume of data providing quick reference to 100 of the most commonly used electronics equations—*A Reference Guide to Practical Electronics* by Robert G. Krieger, Sr. The equations presented cover five major



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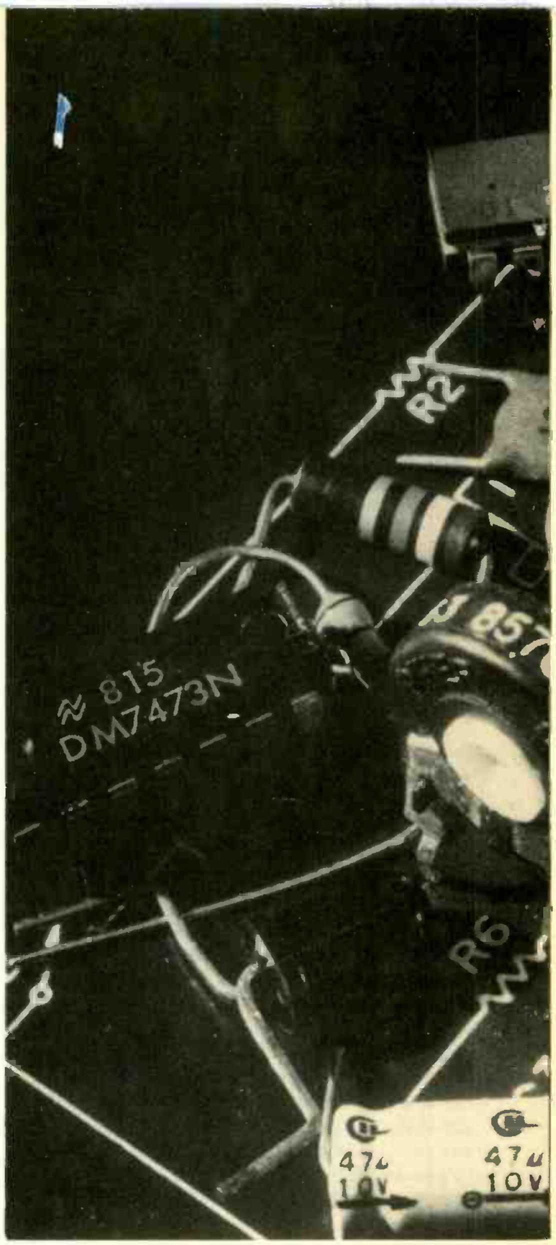
areas of electronics: DC circuits, AC circuits, active devices, circuit analysis, and communications. Three indexes provide easy access to the equations by term, subject, and actual equations. Each equation presented in this guide is accompanied by a definition of the terms of the equation, a straightforward explanation of what the

(Continued on page 102)

99 IC PROJECTS

1982 EDITION



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

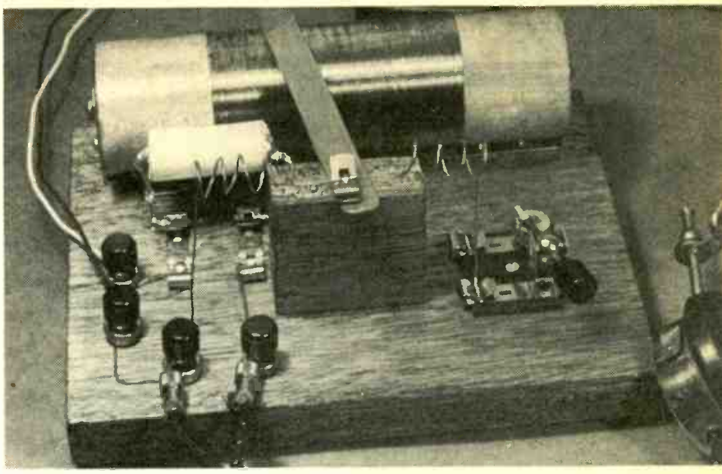
YOU'VE BEEN PUTTING OFF YOUR INTRODUCTION into the fascinating world of integrated circuit construction for too long, and the time to get your feet wet is now. The electroncs field is moving ahead so rapidly that you really cannot afford to sit back and let it happen around you. That in itself is the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

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

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

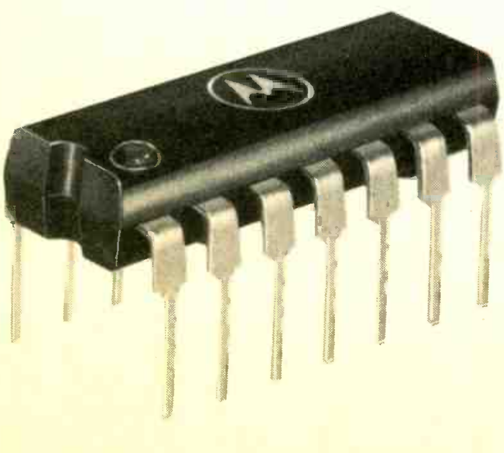


The most rudimentary (and least expensive) method which you can use to breadboard a circuit is to use, well, a breadboard. Obviously this is where the name came from. You can use Fahnestock clips (left, center) to secure components on the board.

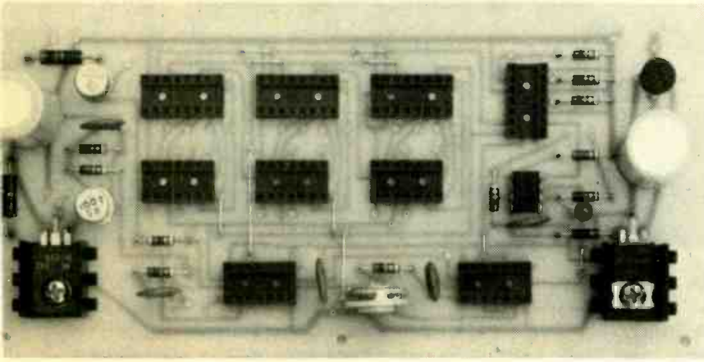
soon see that many of the projects are compatible with each other. For instance, many of the burglar alarm circuits for both home and car require some sort of alarm device, such as a bell, buzzer, etc. You can combine them with the Two-Tone Siren to create a really formidable protection system.

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.

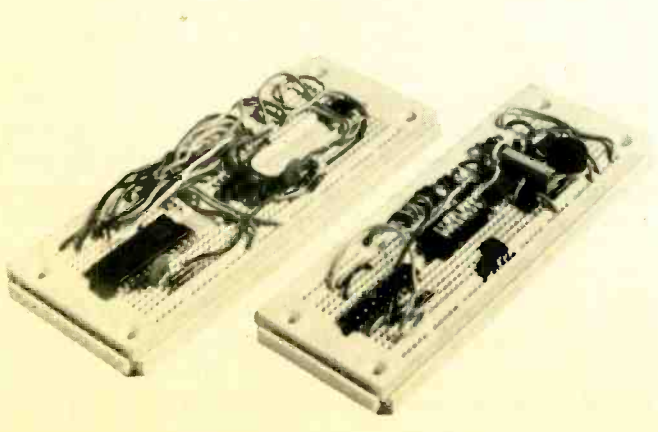


Here's what it is all about, a typical DIP (dual in-line package) integrated circuit. This is a 14-pin package, the most commonly used in our projects, but 16-pin units are also used. Note indentation at the left end—(facing towards you), the first pin to the right is #1. Pin numbers ascend in counter-clockwise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



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.

99 INTEGRATED CIRCUIT PROJECTS
1982 EDITION

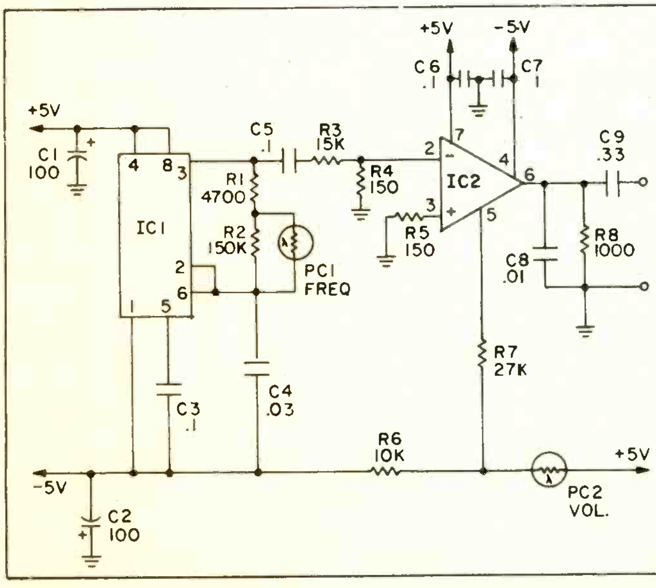
1. Son of Theremin

☐ 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 its shortcomings, the Theremin is great fun to play, so we decided to create a simple solid-state circuit, Son of Theremin, 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 controls 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 SON OF THEREMIN

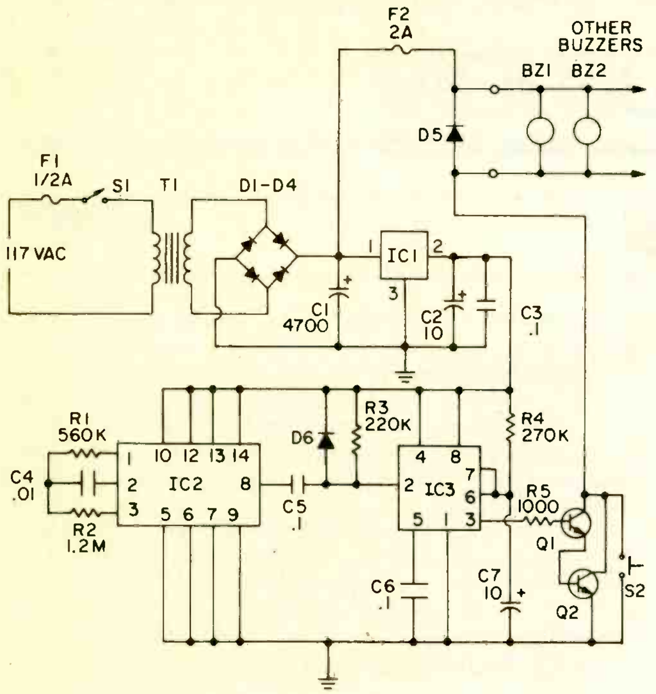
C1, C2—100 μF, 16V electrolytic capacitor
C3, C5, C6, C7—.1 μF ceramic disc capacitor
C4—.03 μF mylar capacitor
C8—.01 μF mylar capacitor
C9—.33 μF mylar capacitor
IC1—555 timer
IC2—RCA 3080 transconductance op-amp
PC1, PC2—cadmium sulfide photocell (Radio Shack 276-116 or equiv.)
R1—4,700-ohm, 10%,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

2. Bird Blaster

☐ Most of us would agree that birds are a very valuable resource, since the bugs they devour would quickly ruin our agriculture if left unchecked. There are times, however, when the birds themselves can be a nuisance to the gardener by pulling up young seedlings before they have a chance to mature. Naturally, no one in his right mind would want to destroy the birds, so the usual course of action is to build a scarecrow. But the birds eventually see through this charade and return to peck, dig and yank.

Out of desperation the Bird Blaster was created to scare birds off with a periodic blast of noise. IC2 consists of an oscillator and a sixteen-stage binary divider. With the components chosen, a squarewave with a period of approximately 14 minutes is produced at pin 8 of IC2. This drives monostable IC3 which, when triggered, sends its output (pin 3) high. This turns on Q2 and Q3 and produces a blast from the buzzers. IC3's output remains high for about three seconds and then drops low, only to be triggered again some 14 minutes later.

We used about a dozen buzzers dispersed at regular intervals throughout our garden. Old tin cans make excellent housings for the buzzers; just tie or nail the cans to wooden stakes driven into the ground. The buzzers specified in the parts list draw about 100 mA each, so you can use up to 20 units if you like. Pressing S2 will allow you to trigger the buzzers manually when necessary.



PARTS LIST FOR BIRD BLASTER

BZ1, BZ2, etc.—12VDC buzzer (Radio Shack 273-051 or equiv.)
C1—4,700 μF, 35V electrolytic capacitor
C2—10 μF, 25V electrolytic capacitor
C3, C5, C6—.1 μF ceramic disc capacitor
C4—.01 μF mylar capacitor
C7—10 μF, 20V tantalum electrolytic capacitor
D1 thru D5—1N5404 rectifier diode (Radio Shack 276-1173)
D6—1N914 silicon diode
F1—½-amp fuse
F2—2-amp fuse
IC1—7812 12-volt regulator
IC2—Motorola MC14541B oscillator/divider
IC3—555 timer
Q1—2N3904 NPN transistor
Q2—2N3055 NPN power transistor
R1—560,000-ohm, 10%, ½-watt resistor
R2—1.2 Megohm, 10%, ½-watt resistor
R3—220,000-ohm, 10%, ½-watt resistor
R4—270,000-ohm, 10%, ½-watt resistor
R5—1,000-ohm, 10%, ½-watt resistor
S1—SPST switch
S2—SPST normally open pushbutton switch
T1—12.6 VAC, 3A transformer (Radio Shack 273-1511)

3. Moriarty's Challenge

☐ Recently, we received a rather curious letter accompanied by a hastily scrawled schematic diagram. Our first instinct was to send it directly to the circular file, along with a writer's proposal for an article on CB in Bulgaria. However, the signature on the note in question convinced us that the matter might deserve more careful consideration. Readers of an inquisitive mind are invited to examine the schematic and excerpts from the letter that follow:

I peered quizzically at the odd black box Holmes was manipulating. "What do you make of it?" said I, leaning forward for a better look.

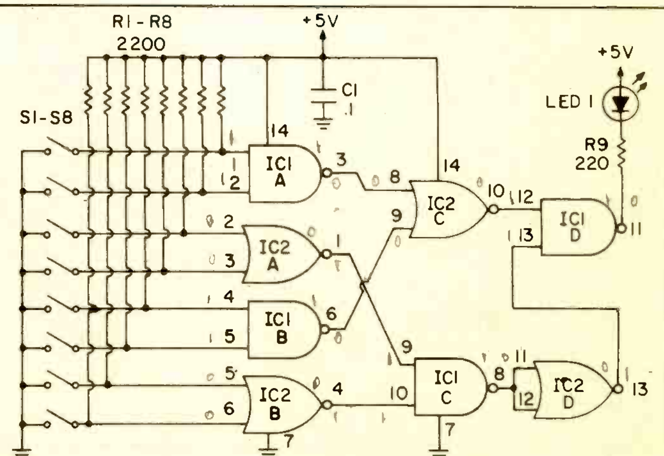
"Stand back, old fellow," snapped Holmes. "This deadly little trinket is a gift from my old nemesis, Prof. Moriarty, who has seen fit to issue me a challenge. I am to determine the proper combination of switches necessary to ignite this tiny light-emitting diode. In so doing, I shall obtain a clue to the fiend's present whereabouts."

"Humpphh. Seems easy enough," said I. "There are but eight switches here. Therefore, the number of possible combinations is . . . Let me see . . . two, four, eight . . ."

"Precisely two hundred and fifty-six, Watson."

"Yes, yes. Just what I was about to say. In any event, if we begin trying the various combinations now, we should be finished by lunch, what."

"Finished indeed, Watson. Look here." With that, Holmes



PARTS LIST FOR MORIARTY'S CHALLENGE

C1—.1 μF ceramic disc capacitor
IC1—7400 quad NAND gate
IC2—7402 quad NOR gate
LED1—light-emitting diode
R1 thru R8—2,200-ohm, 10%, ½-watt resistor
R9—220-ohm, 10%, ½-watt resistor
S1 thru S8—SPST switches

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removed the cabinet's cover to reveal a quantity of plastic explosive. Evidently, certain switch combinations were wired to detonate the explosive, and us as well.

"We must resort to deductive logic, rather than trial-and-error, to solve this fiendish puzzle, Watson." Thereupon, Holmes began tracing out the circuit's schematic diagram with the assistance of several excellent books on the new science of electronics. Once finished, Holmes pondered the design thoughtfully and, before one could say "The Giant Rat of Sumatra," he made for the door in a mad dash, shouting: "I have it, Watson!"

Needless to say, I still do not have it. Perhaps you or your readers would be so kind as to afford me an explanation of this baffling conundrum.

Respectfully yours,
Dr. John Watson, M.D.

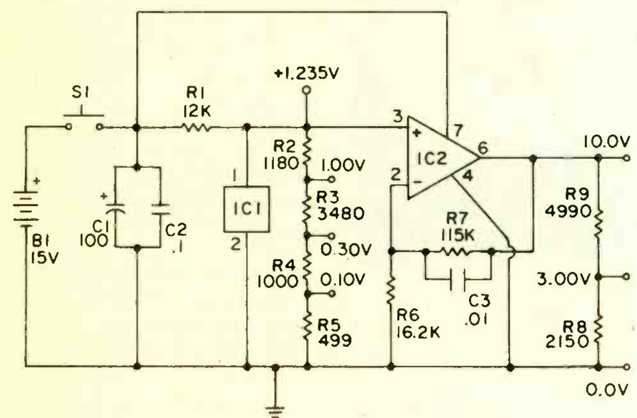
4. Precision VOM Calibrator

☐ 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 volts ±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 μF, 25V electrolytic capacitor
C2—.1 μF ceramic disc capacitor
C3—.01 μF 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, 10%, ½-watt resistor
R2—1,180-ohm, 1%, ½-watt resistor
R3—3,480-ohm, 1%, ½-watt resistor
R4—1,000-ohm, 1%, ½-watt resistor
R5—499-ohm, 1%, ½-watt resistor
R6—162,000-ohm, 1%, ½-watt resistor
R7—115,000-ohm, 1%, ½-watt resistor
R8—2,150-ohm, 1%, ½-watt resistor
R9—4,990-ohm, 1%, ½-watt resistor
S1—SPST normally open pushbutton switch

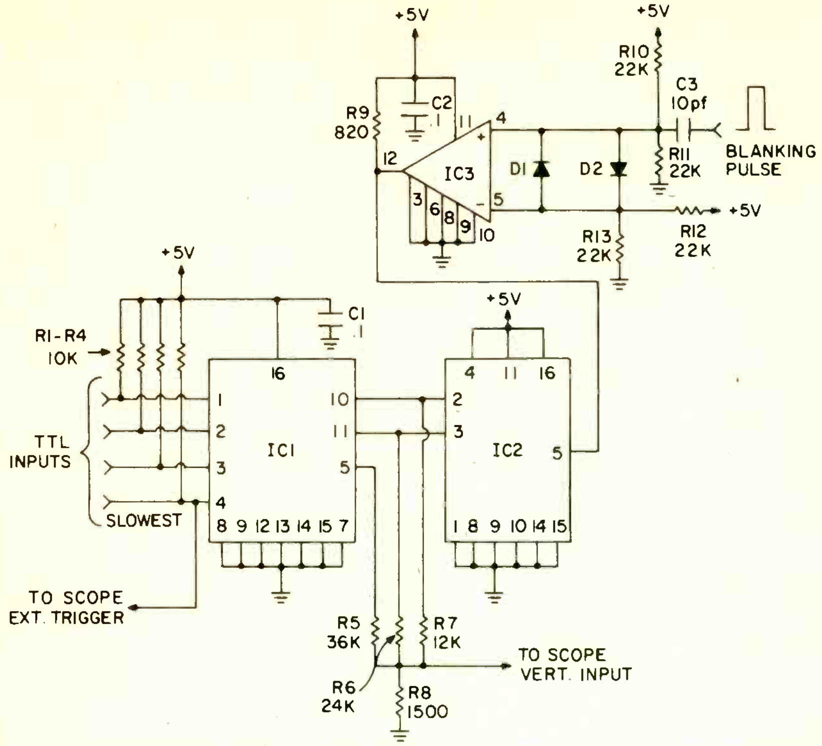
5. Multi-trace Scope Adapter

☐ If you experiment with digital circuits, then you will recognize at once the usefulness of this device. Our multi-trace adapter allows you to view four digital (TTL) waveforms simultaneously on the screen of your triggered-sweep oscilloscope. The four images are not traced out simultaneously, however, but alternately.

Up to four separate channels of information can be fed into the inputs of multiplexer IC1. If all channels do not have the same frequency, make sure that the channel whose frequency is lowest is the one fed back to your oscilloscope's EXT. TRIG. input.

As noted above, this multi-trace adapter operates in the alternate mode; hence, it will be necessary to locate your oscilloscope's *blanking pulse* and feed it to comparator IC3. The blanking pulse prevents any visible image from forming as the CRT's electron beam returns from the right side of the screen to its starting point on the left. Try to find a positive pulse of TTL magnitude (5 volts or less). If all you have is a negative pulse, exchange leads 4 and 5 of IC3.

Each time the screen is blanked, IC3's output pulses *HIGH* and clocks counter IC2, the outputs of which drive the address inputs of multiplexer IC1. Therefore, a different channel is selected after each trace. The output signal fed to your scope's vertical input consists of the multiplexer output (pin 5 of IC1) summed with a voltage proportional to the count in IC2. The latter is necessary to provide vertical displacement between the four separate traces. Use a vertical sensitivity of about 100mV/cm, and connect the adapter to your scope's input with a short length of coax.



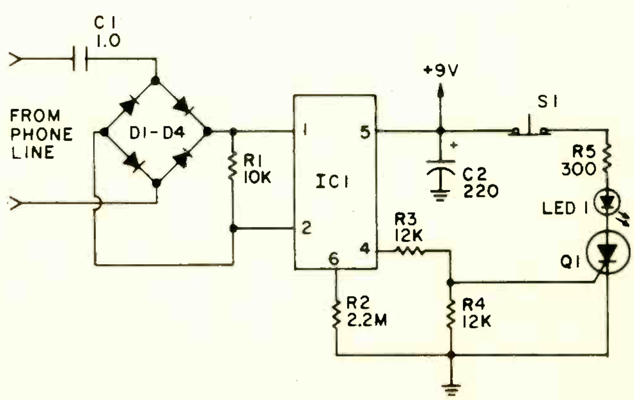
PARTS LIST FOR MULTI-TRACE SCOPE ADAPTER

C1, C2—.1 μF ceramic disc capacitor
C3—10 pF. polystyrene capacitor
D1, D2—1N914 silicon diode
IC1—74151 multiplexer
IC2—74193 binary counter
IC3—LM319 comparator
R1 thru R4—10,000-ohm, 5%, ½-watt resistor
R5—36,000-ohm, 5%, ½-watt resistor
R6—24,000-ohm, 5%, ½-watt resistor
R7—12,000-ohm, 5%, ½-watt resistor
R8—1,500-ohm, 5%, ½-watt resistor
R9—820-ohm, 5%, ½-watt resistor
R10 thru R13—22,000-ohm, 5%, ½-watt resistor

6. Phone-call Logger

☐ This inexpensive circuit is designed to let you know if a telephone call was received in your absence. Of course, it won't answer the phone or take a message, but when you consider that the necessary cash outlay is about 5% of the cost of a typical answering machine, this phone-call logger begins to look appealing.

Diodes D1 through D4 rectify the 20-Hz phone-ringing signal and feed it to the LED inside optocoupler IC1. Light from the LED actuates a phototransistor inside IC1. The phototransistor conducts and causes a pulse of current to flow to the gate of Q1, a silicon-controlled rectifier. Upon receiving the gate pulse, Q1 latches in a conducting state and lights up LED1. When you return home, you'll know that cousin Clem called. Pressing S1 extinguishes LED1 until the next call comes in. Please note that if you are hooked into a multi-party line, you will log not just your own calls, but those of everyone else on the line as well.

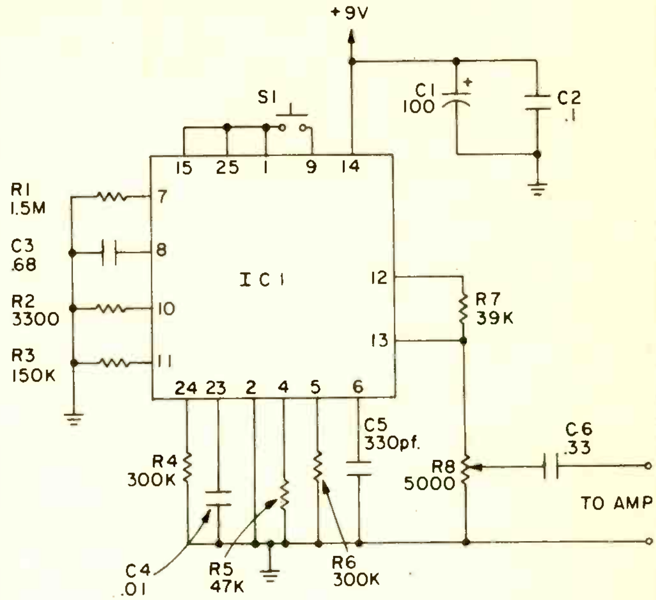


PARTS LIST FOR PHONE-CALL LOGGER

C1—1.0 μF, 200V mylar or paper capacitor
C2—220 μF, 25V electrolytic capacitor
D1 thru D4—1N4003 1A, 200PIV rectifier diode
IC1—Monsanto MCT-2 optocoupler
LED1—light-emitting diode
Q1—2N5060 sensitive-gate SCR
R1—10,000-ohm, 10%, ½-watt resistor
R2—2.2 Megohm, 10%, ½-watt resistor
R3, R4—12,000-ohm, 10%, ½-watt resistor
R5—300-ohm, 10%, ½-watt resistor
S1—SPST normally closed pushbutton switch

7. Explosion on a 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 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.



PARTS LIST FOR EXPLOSION ON A CHIP

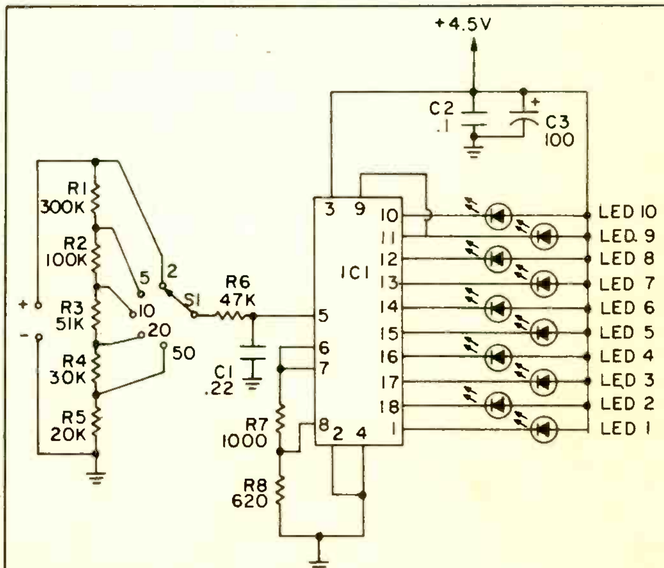
C1—100 µF, 25V electrolytic capacitor
C2—.1 µF ceramic disc capacitor
C3—.68 µF mylar capacitor
C4—.01 µF mylar capacitor
C5—330 pF. polystyrene capacitor
C6—.33 µF mylar capacitor
IC1—SN76477 sound-effect generator
R1—1.5 Megohm, 10%, ½-watt resistor
R2—3,300-ohm, 10%, ½-watt resistor
R3—150,000-ohm, 10%, ½-watt resistor
R4, R6—300,000-ohm, 10%, ½-watt resistor
R5—47,000-ohm, 10%, ½-watt resistor
R7—39,000-ohm, 10%, ½-watt resistor
R8—5,000-ohm audio-taper potentiometer
S1—SPST normally open pushbutton switch

8. 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 bar-graph 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 V on the 2-volt range will just be shrugged off, and proportionately higher overloads can be tolerated on the higher voltage ranges. Full-scale sensitivities of 2, 5, 10, 20 or 50 volts 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 µF mylar capacitor
C2—.1 µF ceramic disc capacitor
C3—100 µF, 10V electrolytic capacitor
IC1—LM3914 dot/bar display driver (National Semiconductor)
LED1 thru LED10—light-emitting diodes
R1—300,000-ohm, 5%, ½-watt resistor
R2—100,000-ohm, 5%, ½-watt resistor
R3—51,000-ohm, 5%, ½-watt resistor
R4—30,000-ohm, 5%, ½-watt resistor
R5—20,000-ohm, 5%, ½-watt resistor
R6—47,000-ohm, 5%, ½-watt resistor
R7—1,000-ohm, 5%, ½-watt resistor
R8—620-ohm, 5%, ½-watt resistor
S1—SP5pos. rotary switch

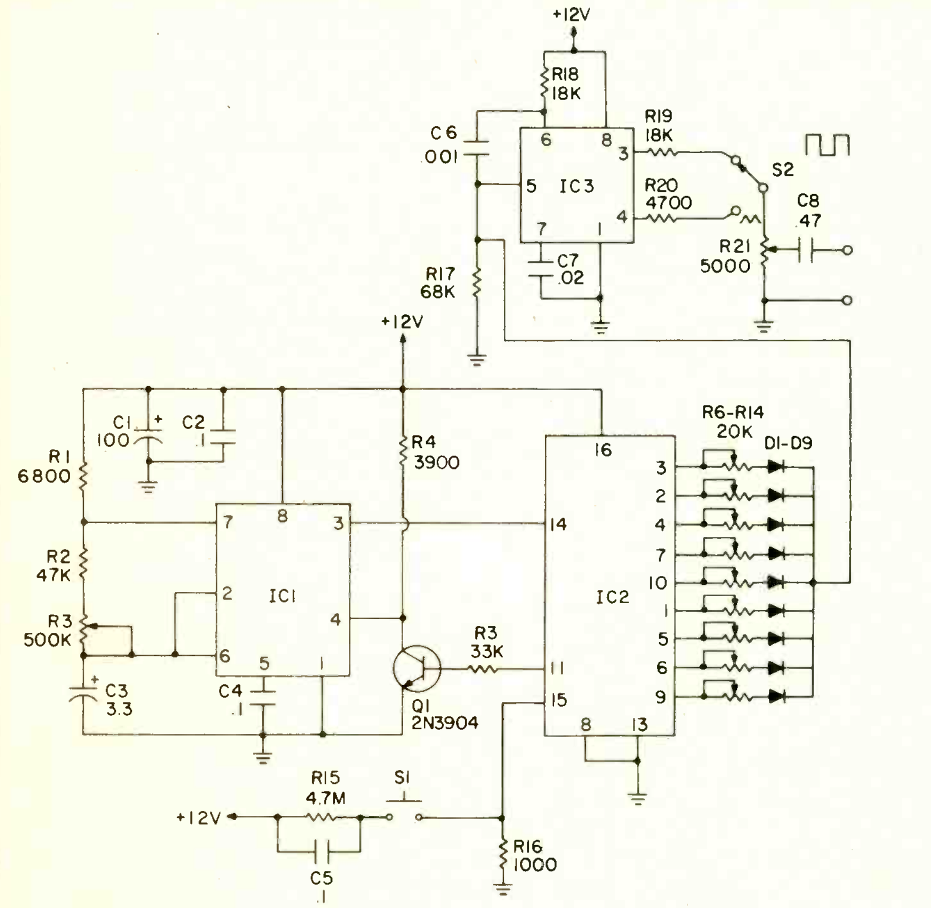
9. Melodious Sequencer

☐ 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 2000 Hz. If you desire a shorter sequence of notes, omit pots and diodes from the end of the sequence starting with pin 9 of IC2 and working backwards.



PARTS LIST FOR MELODIOUS SEQUENCER

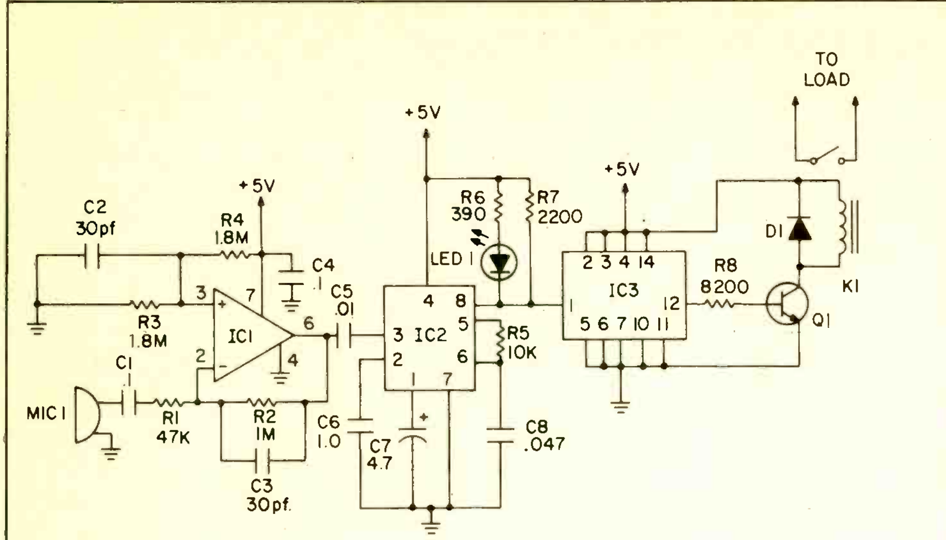
C1—100 µF, 25V electrolytic capacitor
C2, C4, C5—.1 µF, ceramic disc capacitor
C3—3.3 µF, 25V electrolytic capacitor
C6—.001 µF, polystyrene capacitor
C7—.02 µF, mylar capacitor
C8—.47 µF, mylar capacitor
D1 thru D9—1N914 silicon diode
IC1—555 timer
IC2—4017B CMOS decade counter
IC3—LM566 voltage-controlled oscillator
Q1—2N3904 NPN transistor
R1—6,800-ohm, 10%, ½-watt resistor
R2—47,000-ohm, 10%, ½-watt resistor
R3—500,000 trimpot resistor
R4—3,900-ohm, 10%, ½-watt resistor
R5—33,000-ohm, 10%, ½-watt resistor
R6 thru R14—20,000 trimpot resistor
R15—4.7 Megohm, 10%, ½-watt resistor
R16—1,000-ohm, 10%, ½-watt resistor
R17—68,000-ohm, 10%, ½-watt resistor
R18—10,000-ohm, 10%, ½-watt resistor
R19—18,000-ohm, 10%, ½-watt resistor
R20—4,700-ohm, 10%, ½-watt resistor
R21—5,000-ohm audio-taper potentiometer
S1—SPST normally open pushbutton switch
S2—SPDT switch

10. Sonic-Control Receiver

☐ This easy-to-build circuit will enable you to control an electrical device or appliance with an audio tone. The section diagrammed here is the receiver. If you have perfect pitch and can whistle at 2,000 Hz, this is all you will need to build.

Audio signals picked up by the crystal microphone cartridge are amplified approximately twenty times by IC1 and fed to tone-decoder IC2. Using a highly selective phase-locked loop, IC2 is designed to respond only to a 2,000-Hz tone. When such a signal is received, the tone decoder's output (pin 8) drops LOW, thereby turning on LED1 and clocking flip-flop IC3. After the input signal subsides, IC2's output returns HIGH.

Flip-flop IC3 drives a small relay through transistor Q1. You can use the relay to control any electrical load as long as the relay's contact-current rating is not exceeded. Successive tone bursts cause IC3 to flip and flop; hence, relay K1's contacts can be alternately closed and opened.



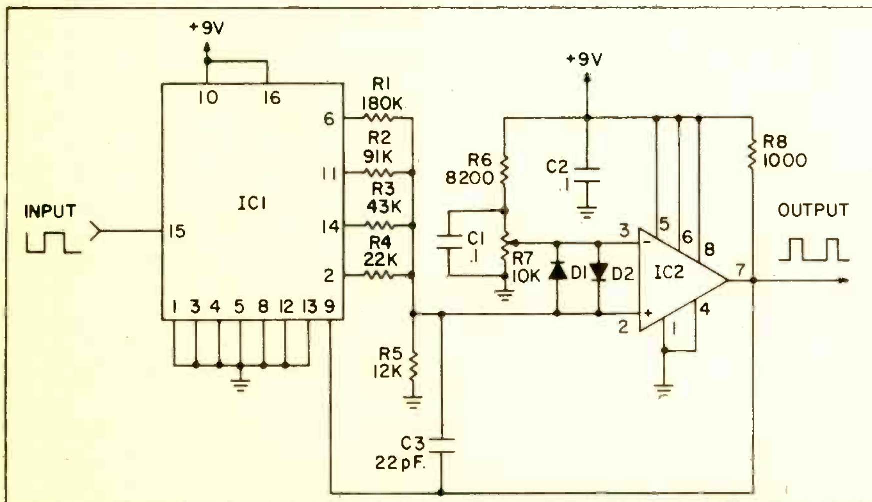
PARTS LIST FOR SONIC-CONTROL RECEIVER

C1, C4—.1 μF ceramic disc capacitor
C2, C3—30 pF polystyrene capacitor
C5—.01 μF mylar capacitor
C6—1.0 μF mylar capacitor
C7—4.7 μF, 10V tantalum electrolytic capacitor
C8—.047 μF mylar capacitor
D1—1N914 silicon diode
IC1—RCA 3140 FET-input op amp
IC2—Exar 567 tone decoder
IC3—74LS73 J-K flip-flop
K1—6-volt, 500-ohm relay or 5-volt logic-type relay
LED1—light-emitting diode
MIC1—crystal microphone cartridge
Q1—2N3904 NPN transistor
R1—47,000-ohm, 10%, ½-watt resistor
R2—1 Megohm, 10%, ½-watt resistor
R3, R4—1.8 Megohm, 10%, ½-watt resistor
R5—10,000-ohm, 5%, ½-watt resistor
R6—390-ohm, 10%, ½-watt resistor
R7—2,200-ohm, 10%, ½-watt resistor
R8—8,200-ohm, 10%, ½-watt resistor

11. Frequency Divider

☐ Most digital frequency dividers are controlled by a binary word—that is, a set of 4, 8 or more electrical signals that must be either HIGH or LOW. These signals may be supplied electronically or by means of a specially encoded thumbwheel switch. The circuit presented here, however, allows you to quickly and easily set the division ratio with just a potentiometer.

The outputs of 4-bit binary counter IC1 are summed by R1 through R5 to yield a linear staircase waveform having a maximum amplitude of 4.7 volts. When this staircase's level exceeds comparator IC2's reference potential (set by R7), the output of IC2 goes HIGH. As a result, counter IC1 gets reset, which causes IC2's output to drop LOW once again. The time between the pulses at IC2's output can be adjusted with R7. Frequency division ratios between 1:1 and 1:15 are possible with this circuit.



PARTS LIST FOR EASILY ADJUSTED FREQUENCY DIVIDER

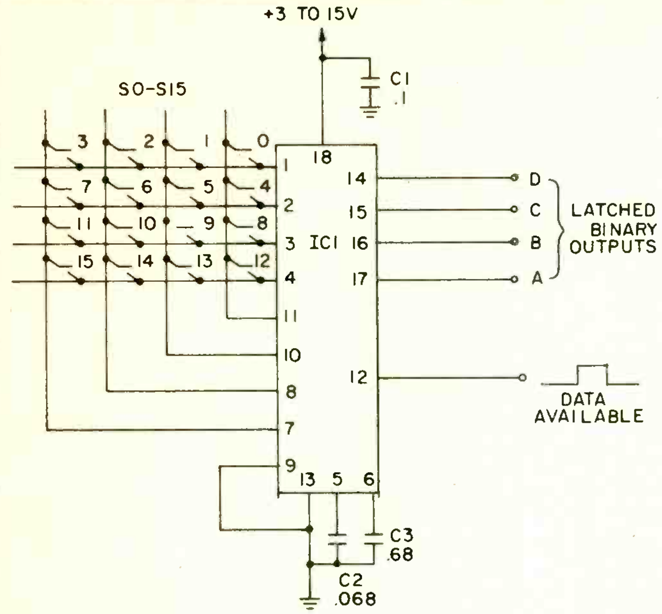
C1, C2—.1 μF ceramic disc capacitor
C3—22 pF polystyrene capacitor
D1, D2—1N914 silicon diode
IC1—4516B CMOS binary divider
IC2—type 311 comparator
R1—180,000-ohm, 5%, ½-watt resistor
R2—91,000-ohm, 5%, ½-watt resistor
R3—43,000-ohm, 5%, ½-watt resistor
R4—22,000-ohm, 5%, ½-watt resistor
R5—12,000-ohm, 5%, ½-watt resistor
R6—8,200-ohm, 5%, ½-watt resistor
R7—10,000 linear-taper potentiometer
R8—1,000-ohm, 5%, ½-watt resistor

12. Keyboard Encoder

☐ Undoubtedly, most readers are aware of the fact that switches bounce, that is, their contacts vibrate and produce multiple closures on make or break. Although bouncing is generally of no concern in an analog circuit, it can be extremely troublesome in digital circuits. Fast logic gates sense and respond to each bounce of the switch contacts, producing erroneous results.

The simple circuit in the accompanying schematic not only debounces an entire hexadecimal keyboard (16 switches), it also produces a unique binary code for each switch. When a key is pressed, IC1 waits long enough for key bounce to subside before sending its *data available* output HIGH. This indicates to external circuitry that the data on pin 14, 15, 16 and 17 is stable and ready to be used.

Once the key is released, the *data available* signal immediately drops LOW, but the binary data on pins 14 through 17 remains latched. It will stay that way until another key is pressed. Each key produces an unique output corresponding to its label in the schematic. For example, S7 produces a binary 7. Note that the D output represents the most significant bit, while A is the least significant. Any supply between +3 and +15 volts can be used.

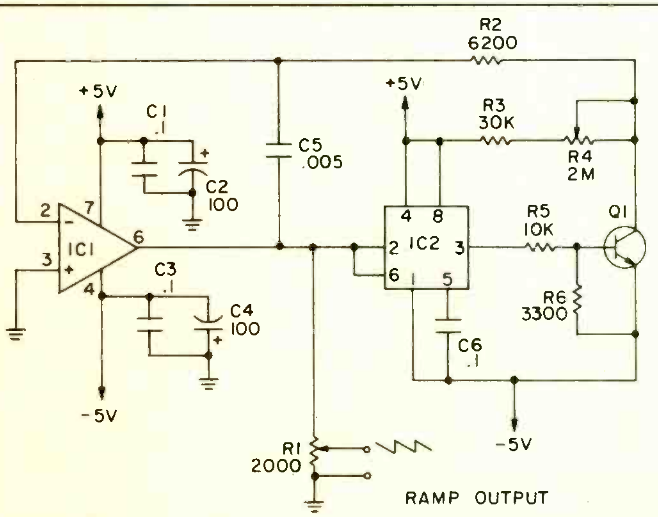


PARTS LIST FOR KEYBOARD ENCODER AND DEBOUNCER

C1—.1 μF ceramic disc capacitor
C2—.068 μF mylar capacitor
C3—.68 μF mylar capacitor
IC1—74C922 CMOS keyboard encoder/debouncer
S0 thru S15—SPST normally open keyswitches

13. Ramp Generator

☐ We present yet another application for the versatile 555 timer. In this ramp generator, the 555 functions as a Schmitt trigger that controls the current fed to integrator IC1. Potentiometer R4 determines the frequency of oscillation over the range from 150 to 10,000 Hz. Maximum output amplitude is ±1.67 volts with respect to ground (3.3 volts peak-to-peak). Potentiometer R1 allows you to trim the amplitude to any desired size. Note that this circuit produces a *very good* ramp waveform with slow descent and a rapid climb back to maximum.



PARTS LIST FOR RAMP GENERATOR

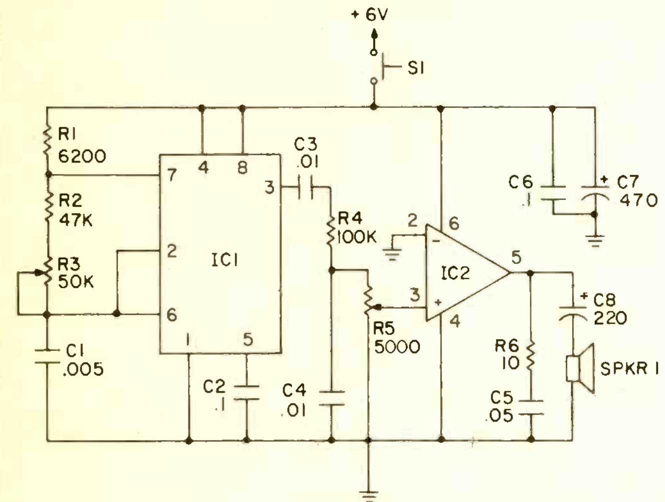
C1, C3, C6—.1 μF ceramic disc capacitor
C2, C4—100 μF, 16V electrolytic capacitor
C5—.005 μF polystyrene or mylar capacitor
IC1—741 op amp
IC2—555 timer
Q1—2N3904 NPN transistor
R1—2,000-ohm linear-taper potentiometer
R2—6,200-ohm, 10%, ½-watt resistor
R3—30,000-ohm, 10%, ½-watt resistor
R4—2-megohm linear-taper potentiometer
R5—10,000-ohm, 10%, ½-watt resistor
R6—3,300-ohm, 10%, ½-watt resistor

14. Sonic-Control Transmitter

☐ This audio transmitter is designed to produce the 2000-Hz tone needed to control the sonic receiver described in the previous section. IC1 is a standard squarewave oscillator based on the familiar 555 timer. The output of IC1 is attenuated, filtered, and fed to audio amplifier IC2. Approximately 250 milliwatts of audio power can be pumped into an 8-ohm speaker by IC2. Switch S1 turns the unit on and off, while R5 adjusts the output volume. R3 is used to tune the transmitter's frequency to match that of the sonic receiver presented earlier.

Now for the tune-up: First, turn on your receiver circuit. Get your hands on the transmitter, and set R3 to its midpoint. Now, adjust R5 for maximum volume, and press S1. If all is well, you will hear a high-pitched whistle. Adjust frequency control R3 until your receiver's LED just turns on.

Cut back on the volume (with R5) until your receiver's LED extinguishes, and re-adjust R3 so that the LED comes back on. Use successively lower power levels until you reach the point where the receiver can no longer be actuated. Leave R3 right where it is; tune-up is now complete. R5 can, of course, be adjusted to any desired level according to the distance between transmitter and receiver.

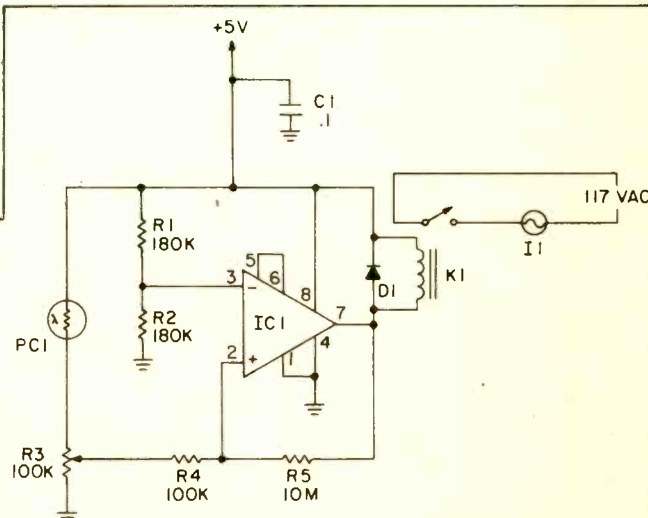


PARTS LIST FOR SONIC-CONTROL TRANSMITTER

- **C1**—.005 μF polystyrene or mylar capacitor
- **C2, C6**—.1 μF ceramic disc capacitor
- **C3, C4**—.01 μF mylar or polystyrene capacitor
- **C5**—.05 μF mylar capacitor
- **C7**—470 μF, 16V electrolytic capacitor
- **C8**—220 μF, 16V electrolytic capacitor
- **IC1**—555 timer
- **IC2**—LM386 audio amplifier (National Semiconductor)
- **R1**—6,200-ohm, 10%, ½-watt resistor
- **R2**—47,000-ohm, 10%, ½-watt resistor
- **R3**—50,000 trimpot resistor
- **R4**—100,000-ohm, 10%, ½-watt resistor
- **R5**—5,000-ohm audio-taper potentiometer
- **R6**—10-ohm, 10%, ½-watt resistor
- **S1**—SPST normally open pushbutton switch
- **SPKR1**—miniature 8-ohm speaker

15. Automatic Night Light

☐ When night falls, this night light turns on. Later, when daylight breaks, it turns itself off automatically. Potentiometer R3 can be used to set the light level at which IC2 switches on and off. The lower you set R3's wiper, the brighter the trip point becomes. Just one note of caution: Do not let the light from I1 fall on PC1's photosensitive face, or you'll end up with a flasher instead of a night light.



PARTS LIST FOR AUTOMATIC NIGHT LIGHT

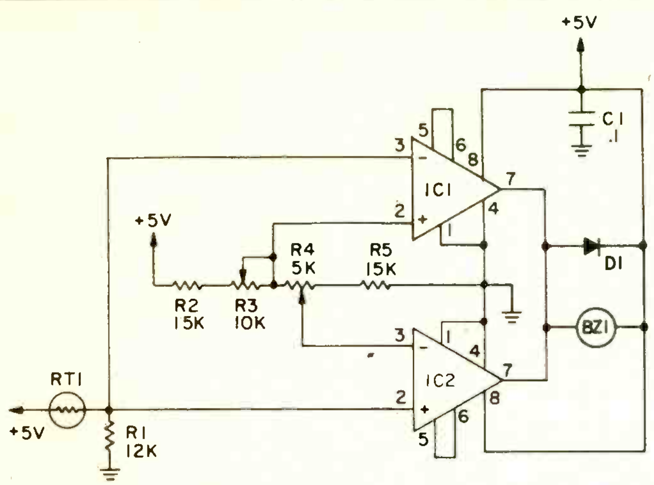
- **C1**—.1 μF ceramic disc capacitor
- **D1**—1N914 silicon diode
- **I1**—7-watt incandescent lamp
- **IC1**—311 comparator
- **K1**—6-volt, 500-ohm relay or 5-volt logic-style relay
- **PC1**—cadmium-sulfide photocell (Radio Shack 276-116 or equivalent)
- **R1, R2**—180,000-ohm, 10%, ½-watt resistor
- **R3**—100,000 linear-taper potentiometer
- **R4**—100,000-ohm, 10%, ½-watt resistor
- **R5**—10 Megohm, 10%, ½-watt resistor

16. Temperature Monitor

☐ This handy circuit will alert you with a raucous buzz whenever the temperature of a photographic solution (or anything else) strays beyond user-defined bounds. As temperature increases, thermistor RT1's resistance decreases, and the voltage across R1 rises. When the temperature rises above a level set by R3, IC1's output (pin 7) conducts current and turns on buzzer BZ1. Conversely, if the temperature drops below a level set by R4, IC2's output conducts, and again the buzzer is turned on.

Note that R3 and R4 are wired in such a way that the lower temperature threshold must always be *less than* the upper threshold. With the values shown, the upper temperature threshold can be set anywhere between the approximate bounds of 60° and 80° F. The lower threshold can be from zero to 30°F below the upper threshold.

Adjustment of the temperature thresholds is very simple. *First make sure that RT1 and its lead wires are completely encapsulated in epoxy.* Then immerse RT1 in water at the desired upper temperature, and allow several minutes for the thermistor's resistance to stabilize. Adjust R3 to the point where BZ1 just comes on. Now, place RT1 in water at the desired lower temperature, and again allow two or three minutes for RT1 to stabilize. Adjust R4 until BZ1 just comes on. Calibration is now complete.



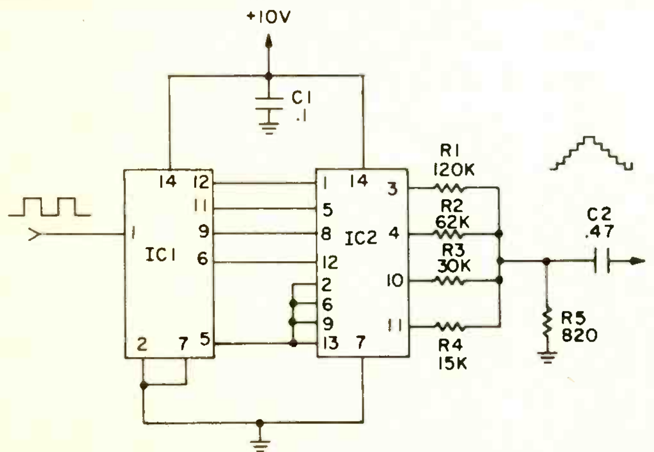
PARTS LIST FOR TEMPERATURE MONITOR

BZ1—6-volt DC buzzer
C1—.1 µF ceramic disc capacitor
D1—1N4002 rectifier diode
IC1, IC2—311 comparator
R1—12,000-ohm, 10%, ½-watt resistor
R2, R5—15,000-ohm, 10%, ½-watt resistor
R3—10,000 trimpot
R4—5,000 trimpot
RT1—Fenwal GB41P12 glass-bead thermistor, 10K ohms @ 25°C, or equiv.

17. Tri-Wave Synthesizer

☐ Here is a new twist on the old trick of using a binary counter and an R-2R-4R-8R resistance network to generate a staircase approximation to a linear ramp. We have hooked up a quad exclusive-OR gate (IC2) in such a way that it alternately generates *true* or *complement* versions of counter IC1's four outputs. IC2's outputs are then resistively summed in the usual manner. The resultant waveform is a staircase approximation of a triangular wave with sixteen discrete levels and a frequency equal to the input frequency divided by thirty-two.

Use a 10-volt squarewave or pulse input. Peak-to-peak output amplitude is approximately one volt. This circuit should be especially valuable in electronic-music applications. If desired, a small capacitor across R5 could be used to smooth out the steps somewhat, but the amount of capacitance needed will be frequency dependent.



PARTS LIST FOR DIGITAL TRI-WAVE SYNTHESIZER

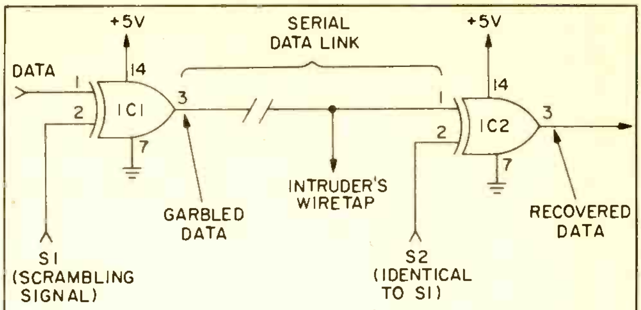
C1—.1 µF ceramic disc capacitor
C2—.47 µF mylar capacitor
IC1—4024 CMOS binary divider
IC2—4070B CMOS quad exclusive-OR gate
R1—120,000-ohm, 5%, ½-watt resistor
R2—62,000-ohm, 5%, ½-watt resistor
R3—30,000-ohm, 5%, ½-watt resistor
R4—15,000-ohm, 5%, ½-watt resistor
R5—820-ohm, 5%, ½-watt resistor

18. Data Scrambler

☐ When the topic of espionage comes up, we are inclined to think of international intrigue and shifty-eyed subversives wearing shabby trenchcoats. However, there is a less publicized but equally sinister spy game, industrial espionage, in which trade secrets rather than state secrets are bought and sold. The same techniques are employed in both forms of espionage, and this includes wiretapping.

The accompanying schematic shows one way of transmitting data in a garbled form to render it unintelligible to the wiretapper. The serial data link is illustrated here as a simple wire, although modems and telepone lines or fiber-optic cables might also be employed in communication. As far as we are concerned, however, the nature of the transmission medium is irrelevent. Exclusive-OR gate IC1 receives both data and a scrambling signal, S1. When the scrambling signal is LOW, unaltered data is transmitted, but when S1 is HIGH, data polarity is inverted. S1 is not static, but instead repeats itself in a fairly long, pseudo-random digital sequence. Hence, what comes out of IC1 is digital garbage.

However, at the receiving end of our link we have another Ex-OR gate (IC2), fed by signal S2, which must be identical to, and synchronized with, S1. This arrangement decodes the data to its original form so that it is once again intelligible (to a machine, that is). Our intruder, meanwhile, is pulling his hair in rage and shredding his Ian Fleming novels.



PARTS LIST FOR DATA SCRAMBLER

IC1, IC2—¼ of a 7486 quad exclusive-OR gate

19. High-Q Notch Filter

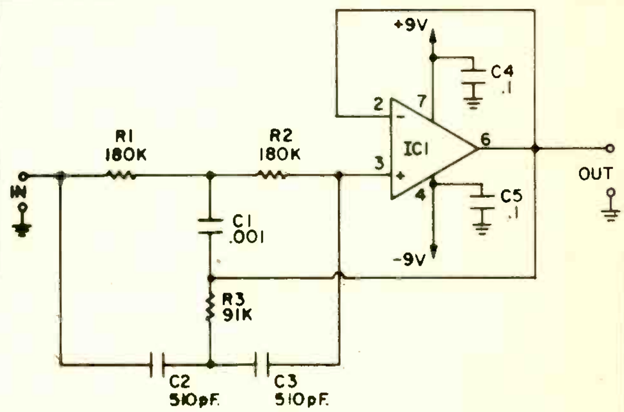
☐ A notch filter can be used to eliminate or notch out a very narrow band of frequencies while passing all others with no effect. The high-Q circuit diagrammed here is very selective when precision components are used. All capacitors should be of the polystyrene type (5% or better), while resistors should have a tolerance of at least 5% (1% if you're finicky). The notch frequency is given by:

$$f = \frac{1}{2\pi R1\ C2}$$

where

$$\pi = 3.14159$$
$$R1 = R2 = 2R3$$
$$C2 = C3 = \tfrac{1}{2}C1$$

Capacitance is measured in farads—resistance in ohms. With the values in the parts list, our filter has a notch frequency of 1733.7 Hz. The unit's selectivity, or Q, depends on how well the components are matched, so use the tolerances specified.



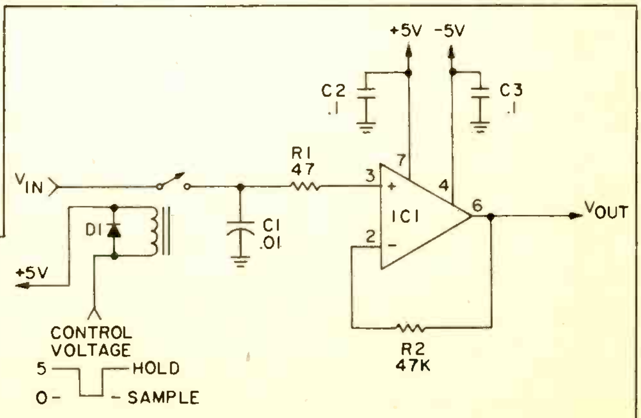
PARTS LIST FOR HIGH-Q NOTCH FILTER

C1—.001 μF polystyrene capacitor (at least 5% tolerance)
C2, C3—510 pF polystyrene capacitor (at least 5% tolerance)
C4, C5—.1 μF ceramic disc capacitor
IC1—LM310 voltage follower
R1, R2—180,000-ohm, 5%, ½-watt resistor
R3—91,000-ohm, 5%, ½-watt resistor

20. Sample-and-Hold

☐ Sample-and-hold circuits grab onto a transient voltage and store it for some interval of time. A capacitor is used as the storage element, and it is extremely important that the capacitor be loaded very lightly. Otherwise, charge would drain away, and the voltage on the capacitor would gradually diminish (or "droop," in professional parlance).

The circuit illustrated utilizes a high-quality polystyrene capacitor buffered by a voltage follower with FET inputs.



PARTS LIST FOR SAMPLE-AND-HOLD

C1—.01 μF polystyrene capacitor
C2, C3—.1 μF ceramic disc capacitor
D1—1N914 silicon diode
IC1—3140 FET-input op amp (RCA)
K1—6-volt, 500-ohm relay or 5-volt logic-type relay
R1, R2—47,000-ohm, 10%, ½-watt resistor

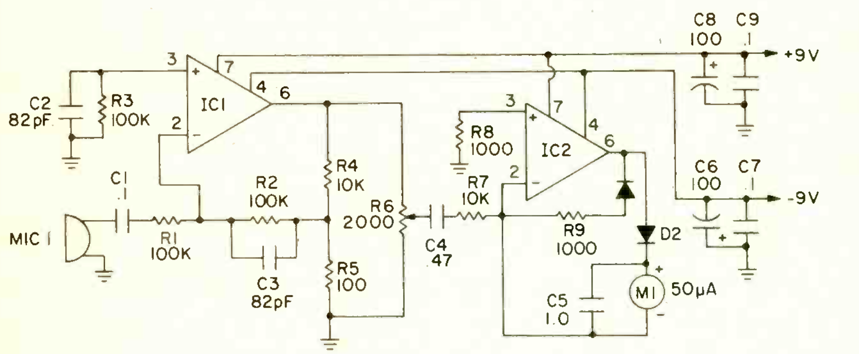
Consequently, exceedingly little current is drained from the capacitor, and the voltage can be held for a relatively long time.

When the control signal goes LOW, relay K1 closes and allows the input voltage to charge C1. Sending the control signal HIGH opens K1's contacts, leaving C1 holding the voltage, which can be read at IC1's output. Sample-and-hold circuits find application in electronic instrumentation and as memory elements in music synthesizers based on voltage-controlled oscillators. (Digital synthesizers, on the other hand, use digital memory elements, latches, to store information.)

21. Sound-Level Meter

☐ With this sound-level meter you can easily measure the relative loudness of sounds in the 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 multiplies the signals from microphone MIC1 by a factor of 100. This amplified signal is then applied to IC2, which functions here as a precision rectifier. Meter M1 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.

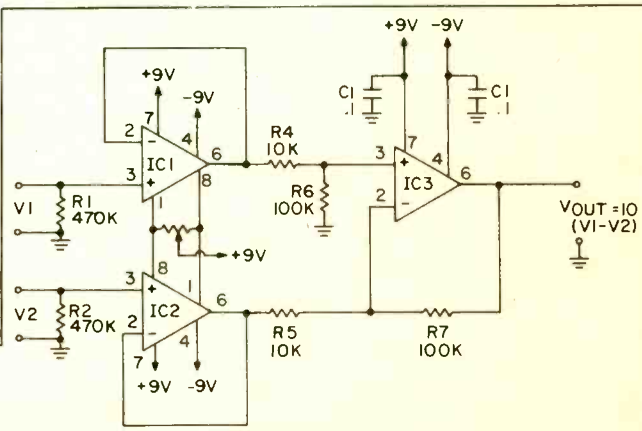


PARTS LIST FOR SOUND-LEVEL METER

C1, C7, C9—.1 μF ceramic disc capacitor
C2, C3—82 pF polystyrene capacitor
C4—.47 μF mylar capacitor
C5—1.0 μF mylar capacitor
C6, C8—100 μF 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, 10%, ½-watt resistor
R4, R7—10,000-ohm, 10%, ½-watt resistor
R5—100-ohm, 10%, ½-watt resistor
R6—2,000-ohm linear taper potentiometer
R8, R9—1,000-ohm, 10%, ½-watt resistor

22. Differential Amplifier

☐ As its name implies, a differential amplifier measures the difference between two signals. The amp illustrated here has a gain of 10, which you can change if desired. Let us point out first, however, that balance is extremely important in a differential amplifier circuit, and this is why 1%-tolerance resistors are specified. R4 must be equal to R5, and R6 must equal R7. The gain is then equal to R7/R5 (or R6/R4). To null this amplifier, ground both inputs, and adjust R3 for zero output voltage. R1 and R2 may be eliminated if the inputs are to be driven by low-resistance, direct-coupled signal sources (i.e., without coupling capacitors).



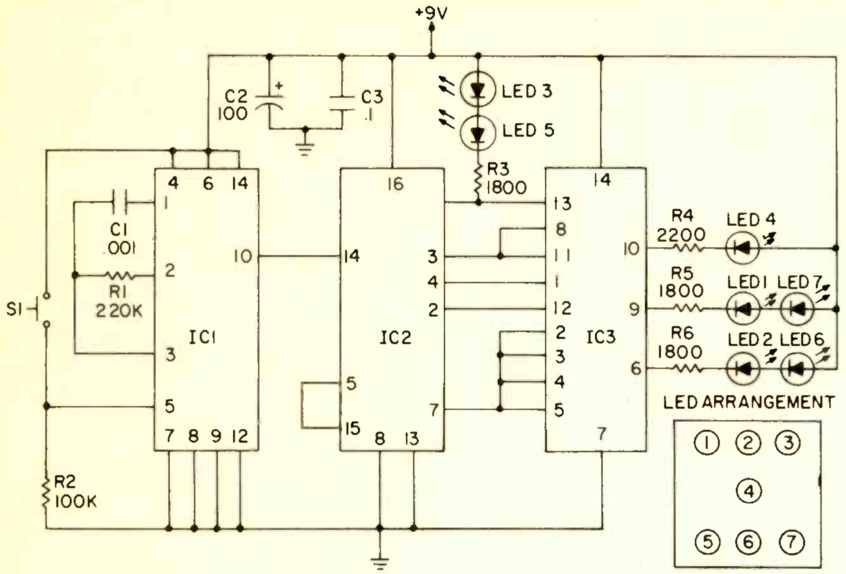
PARTS LIST FOR DIFFERENTIAL AMPLIFIER

C1, C2—.1 μF ceramic disc capacitor
IC1, IC2—LM310 voltage follower
IC3—3140 op amp (RCA)
R1, R2—470K (see text)
R3—1,000-ohm linear-taper potentiometer
R4, R5—10,000, ½-watt, 1% precision resistor
R6, R7—100,000, ½-watt, 1% precision resistor

23. Digital Dice

☐ Dice, anyone? If the answer is yes, here is just the circuit you'll be needing. Pressing S1 turns on oscillator IC1, which clocks counter IC2 at a fast 1,000-Hz rate. At the instant you release S1, you cannot possibly know the current state of counter IC2 because of the rapidity of the clocking signal. Hence, what you are in effect doing is depositing a random number in IC2.

IC3 decodes this random number and lights some combination of LEDs to simulate the spots on the face of a die. Be certain to install the LEDs in exactly the pattern illustrated here. You can build two circuits if a pair of dice is desired, or just take two rolls with one device.



PARTS LIST FOR DIGITAL DICE

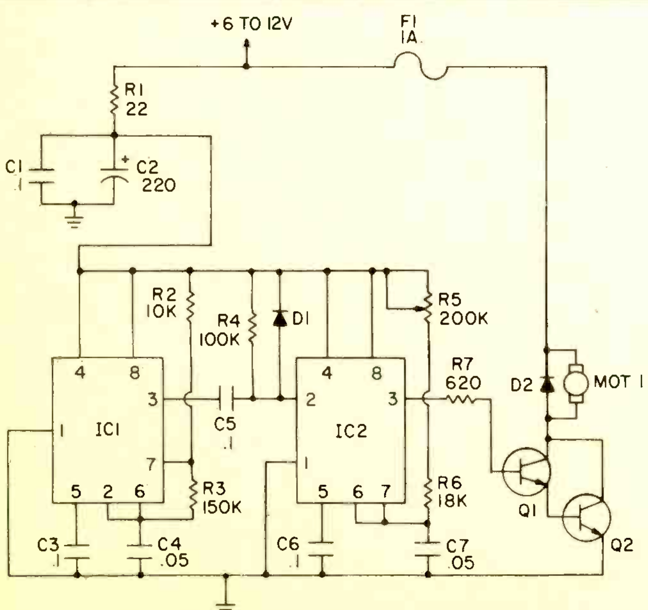
- **C1**—.001 µF mylar or polystyrene capacitor
- **C2**—100 µF, 16V electrolytic capacitor
- **C3**—.1 µF ceramic disc capacitor
- **IC1**—4047 CMOS multivibrator
- **IC2**—4022B CMOS octal counter
- **IC3**—4025B CMOS dual NOR gate plus inverter
- **LED1 thru LED7**—light-emitting diodes
- **R1**—220,000-ohm, 10%, ½-watt resistor
- **R2**—100,000-ohm, 10%, ½-watt resistor
- **R3, R5, R6**—1,800-ohm, 10%, ½-watt resistor
- **R4**—2,200-ohm, 10%, ½-watt resistor
- **S1**—SPST normally open pushbutton switch

24. 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

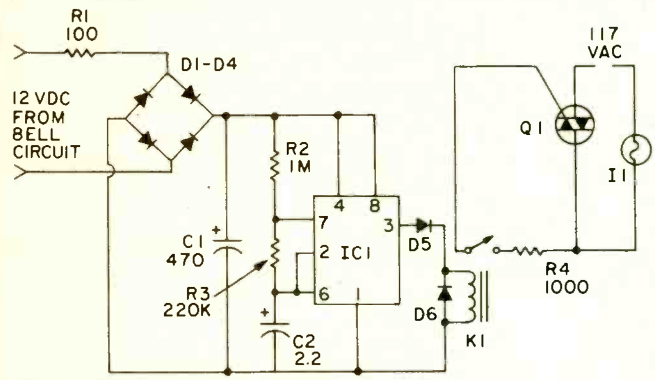
- **C1, C3, C5, C6**—.1 µF ceramic disc capacitor
- **C2**—220 µF, 25V electrolytic capacitor
- **C4, C7**—.05 µF mylar capacitor
- **D1, D2**—1N4002 rectifier diode
- **F1**—1-amp fuse
- **IC1, IC2**—555 timer
- **MOT1**—DC permanent-magnet motor, 6 to 12 volts
- **Q1**—2N3904 NPN transistor
- **Q2**—2N3055 NPN power transistor
- **R1**—22-ohm, 10%, ½-watt resistor
- **R2**—10,000-ohm, 10%, ½-watt resistor
- **R3**—150,000-ohm, 10%, ½-watt resistor
- **R4**—100,000-ohm, 10%, ½-watt resistor
- **R5**—200,000 linear-taper potentiometer
- **R6**—18,000-ohm, 10%, ½-watt resistor
- **R7**—620-ohm, 10%, ½-watt resistor

25. Intrusion-Alarm Light

☐ This circuit evolved as an attempt to add lights to a commercial alarm system equipped only with a bell. There is no need to modify your present alarm system, since this modification is powered by the 12-volt bell circuit.

When your alarm bell is triggered, current flows through the rectifiers (D1-D4) and charges capacitor C1. Although the rectifiers are not absolutely essential, they are a handy convenience because they allow you to tap into the bell circuit wiring without worrying about the polarity of the conductors.

Once powered up, timer IC1 proceeds to oscillate slowly and drive relay K1, which controls a high-current triac, Q1. Flood lamp I1 is subsequently energized by the triac in a 2-second-on/.5-second-off pattern that illuminates the culprit and attracts attention.

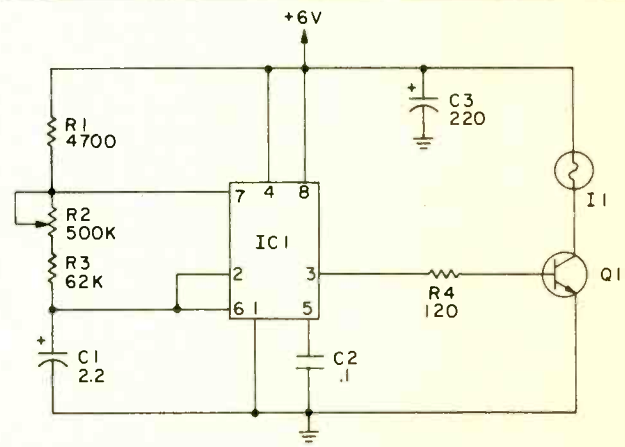


PARTS LIST FOR INTRUSION-ALARM LIGHT

C1—470 μF, 35V electrolytic capacitor
C2—2.2 μF, 35V electrolytic capacitor
D1 thru D6—1N4002 rectifier diodes
I1—250- or 500-watt flood lamp
IC1—555 timer
K1—12-volt, 1,200-ohm relay (Radio Shack 275-003)
Q1—Motorola MAC11-4 200V 10-amp triac, or equivalent
R1—100-ohm, 10%, ½-watt resistor
R2—1 Meg-ohm, 10%, ½-watt resistor
R3—220,000-ohm, 10%, ½-watt resistor

26. Mini-Strobe

☐ Connect a small 6-volt lamp to a 555 timer, and what do you get? A mini-strobe, that's what! Although the light from lamp I1 is nowhere near as intense as that from the xenon flashtubes used in commercial strobes, you can still obtain a stroboscopic effect in a darkened room. Because incandescent lamps cannot be switched on and off as quickly as flashtubes, IC1's maximum frequency has been limited to 5 Hz. Still, you can stop human motion for a novel effect. Use a 6-volt lantern battery or four D cells in series to power the circuit.



PARTS LIST FOR MINI-STROBE

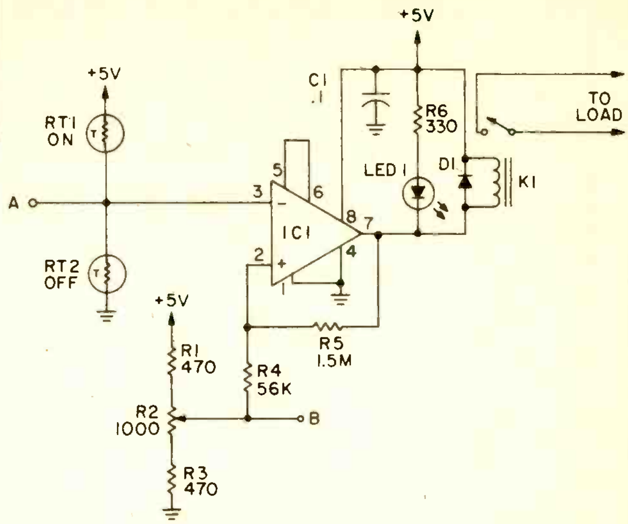
C1—2.2 μF, 10V electrolytic capacitor
C2—.1 μF ceramic disc capacitor
C3—220 μF, 10V electrolytic capacitor
IC1—555 timer
I1—type PR-12 6-volt, 500-mA lamp (Radio Shack 272-1123)
Q1—2N2222 NPN transistor
R1—4,700-ohm, 10%, ½-watt resistor
R2—500,000 linear-taper potentiometer
R3—62,000-ohm, 10%, ½-watt resistor
R4—120-ohm, 10%, ½-watt resistor

27. 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

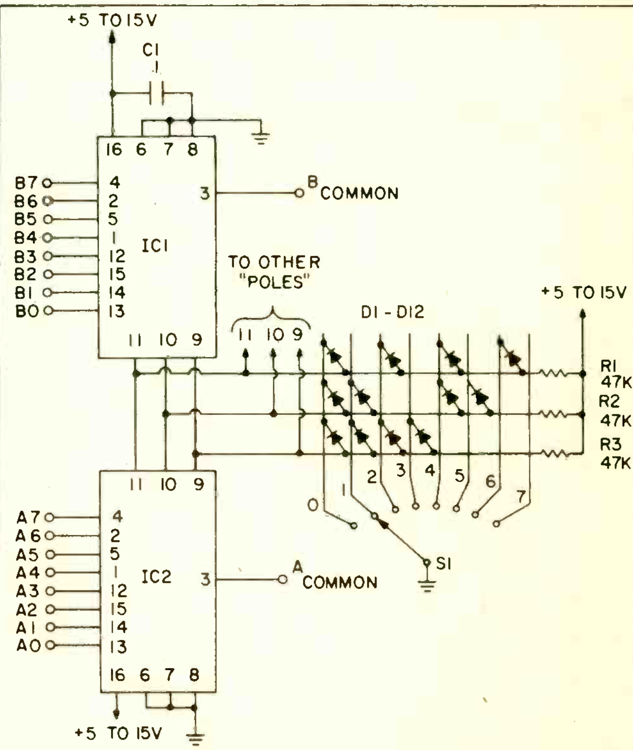
C1—.1 μF ceramic disc capacitor
D1—1N914 silicon diode
IC1—311 comparator
K1—6-volt, 500-ohm relay or 5-volt TTL-logic relay
LED1—light-emitting diode
R1, R3—470-ohm, 5%, ½-watt resistor
R2—1,000-ohm trimpot
R4—56,000-ohm, 10%, ½-watt resistor
R5—1.5 Meg-ohm, 10%, ½-watt resistor
R6—330-ohm, 10%, ½-watt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

28. Multi-Pole Switch

☐ Suppose that you happen to be working in electronic music, and that 30 poles of switching are needed to change voices. Even if you could locate a mechanical switch to do the job, it would be prohibitively expensive. Fortunately, there is a method to switch an arbitrarily large set of analog or digital signals electronically. You can add on as many poles as you like at very little additional cost.

When S1 is in position 3, input A3 is connected to A-common, and input B3 is connected to B-common. As you change S1's position, the input connected to common on each IC changes likewise. Multiplexers IC1 and IC2 are bidirectional (which means, for example, that A0-A7 can be inputs, and A-common can be the output; or that A-common can be the input, and A0-A7 can be outputs).

Supply voltages between +5 and +15 VDC can be used, and input/output signals should fall somewhere in the range between ground potential and the supply voltage. Extra poles can be added by connecting pins 9, 10 and 11 of the additional 4051 multiplexers as indicated in the schematic.



PARTS LIST FOR MULTI-POLE ELECTRONIC SWITCH

C1—.1 μF ceramic disc capacitor
D1 thru D12—1N914 silicon diode
IC1, IC2—4051 CMOS 8:1 multiplexer/demultiplexer
R1, R2, R3—47,000-ohm, 10%, ½-watt resistor
S1—Sp8pos. rotary switch

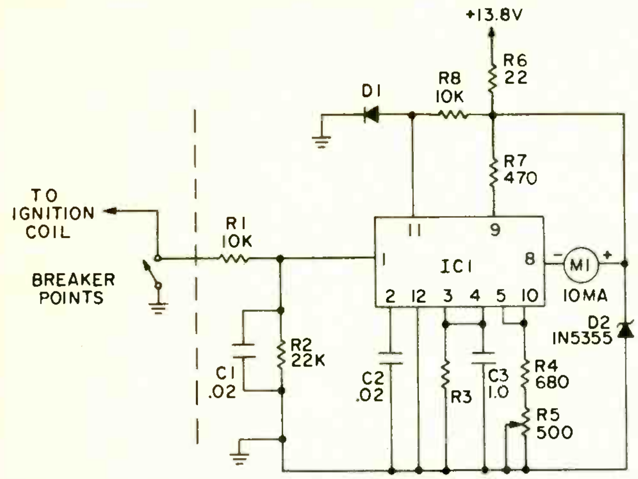
29. Automotive Tachometer

☐ For tune-up and maintenance of your car's engine, an accurate tachometer is a must. The one-IC tach featured here is powered by your car's "12-volt" electrical system. (Actually, the potential of a fully charged lead-acid storage battery is equal to 13.8 volts.) Input signals for the tach come from your ignition system's breaker points, which make and break the circit on the primary (low-voltage) side of your ignition coil. Readout is provided on a 10-milliamp DC meter.

Although you could purchase a meter for this unit, we fed the output signal to our VOM (10-milliamp range), thus saving seven or eight dollars in the process. Since our tach gets only infrequent use, this was a sensible move. Note that R3 should be 91K for an eight-cylinder engine and 120K for six cylinders.

To calibrate the unit for six cylinders, feed a 300-Hz, 2-volt peak-to-peak squarewave signal to the input, and adjust R5 until meter M1 reads exactly 6. The calibration is 1000 rpm per milliamp; i.e.: 6 mA = 6000 rpm. For an eight-cylinder engine, use a 400-Hz signal, and proceed exactly as above.

A note to hot-rodders: A dashboard-mounted tach should be equipped with a large, rugged, easy-to-read meter that swings through 300° of arc. Unfortunately, such special meters are not generally available to the experimenter, except by coincidence as surplus. We recommend, therefore, that you buy rather than build a tach for racing, and use the unit presented here for its intended purpose: tune-ups.



PARTS LIST FOR AUTOMOTIVE TACHOMETER

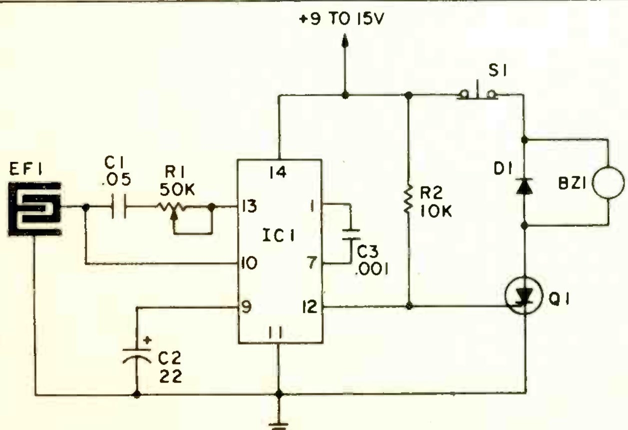
C1, C2—.02 μF mylar capacitor
C3—1.0 μF mylar capacitor
D1—IN4002 rectifier diode
D2—IN5355 18V, 5W zener diode
IC1—LM2917 frequency to voltage converter
M1—0-10 mA DC meter
R1—10,000-ohm, 10%, ½-watt resistor
R2—22,000-ohm, 10%, ½-watt resistor
R3—91,000 (8 cyl.) or 120,000 (6 cyl.), 5%, ½-watt resistor
R4—680-ohm, 10%, ½-watt resistor
R5—500-ohm trimpot
R6—22-ohm, 10%, ½-watt resistor
R7—470-ohm, 10%, ½-watt resistor
R8—10,000-ohm, 10%, ½-watt resistor

30. Swimming Pool Sentry

☐ Want to keep freeloaders out of your swimming pool in the hot summer months ahead? Then build this pool sentry. Whenever pool water splashes into the gap between the conductors of sensor EF1, IC1 triggers the silicon-controlled rectifier (Q1), which latches in a conducting state and turns on the buzzer. To turn the buzzer off, first wipe the sensor dry, and then press S1.

You can easily fabricate EF1 by etching a pattern of two interdigitated conductors on a piece of copperclad printed-circuit laminate. Another possibility is to attach a series of copper or aluminum strips to a piece of plexiglass.

Mount your sensor a few inches above water level. When someone jumps in, the crest of the wave that forms should touch the sensor and trigger the alarm. Trimmer R1 adjusts the unit's sensitivity to match the conductivity of your pool water. Greatest sensitivity occurs with maximum resistance. Incidentally, it should be apparent that the pool sentry could be a real lifesaver.

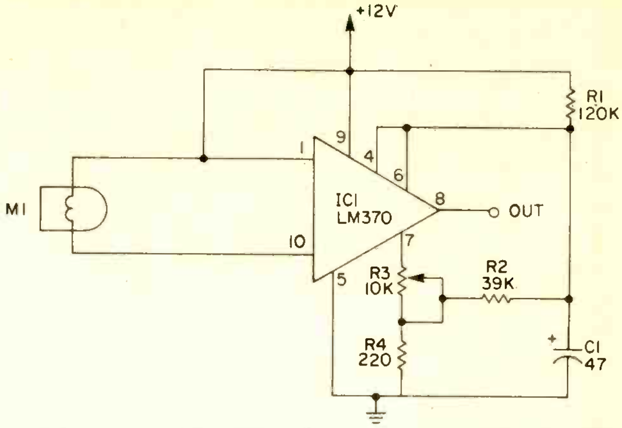


PARTS LIST FOR SWIMMING POOL SENTRY

BZ1—12 VDC buzzer (Radio Shack 273-051 or equiv.)
C1—.05 μF mylar capacitor
C2—22 μF, 25V electrolytic capacitor
C3—.001 μF mylar or polystyrene capacitor
D1—1N4002 1-amp rectifier diode
EF1—etched-foil sensor (see text)
IC1—LM1830 fluid detector (National Semiconductor)
Q1—2N5060 sensitive-gate silicon-controlled rectifier
R1—50K trimpot
R2—10,000-ohm, 10%, ½-watt resistor
S1—SPST normally closed pushbutton switch

31. Squelched Microphone

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



PARTS LIST FOR SQUELCHED MICROPHONE

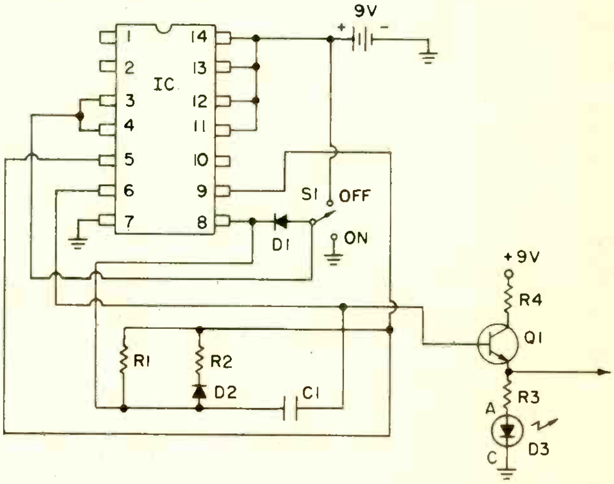
C1—47-uF, 25-VDC electrolytic capacitor
IC1—LM370 AGC amplifier integrated circuit
M1—dynamic microphone cartridge
R1—120,000-ohm, ½-watt resistor (all resistors 10%)
R2—39,000-ohm, ½-watt resistor
R3—10,000-ohm, trim-potentiometer
R4—220-ohm, ½-watt resistor

32. Pulsed Alarm

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

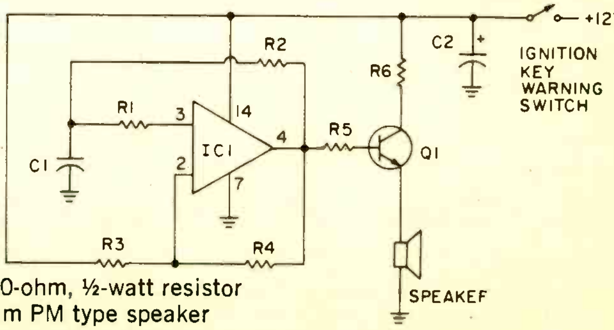
PARTS LIST FOR PULSED ALARM

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



33. Key Tone Generator

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



PARTS LIST FOR KEY TONE GENERATOR

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

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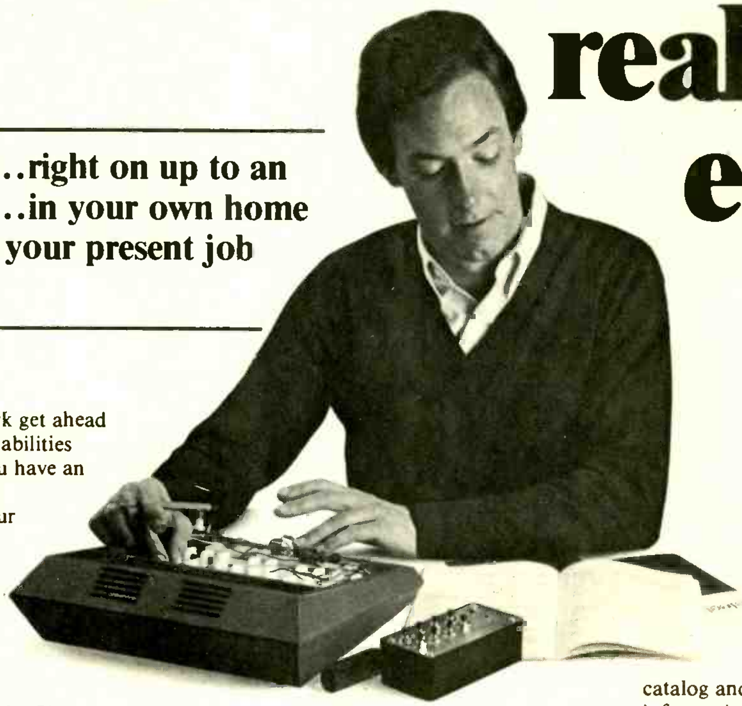

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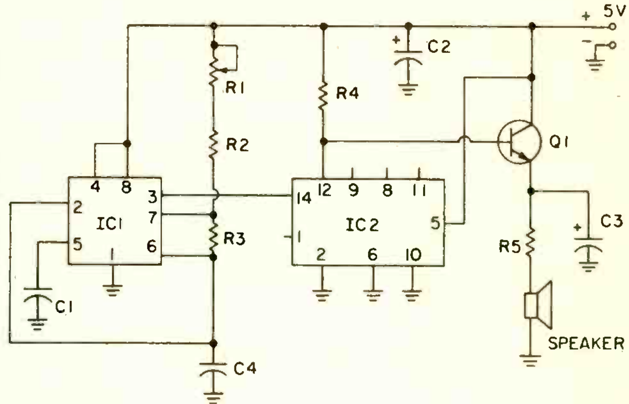
about 2000 Hertz. One section of an LM3900 quad operational amplifier is connected as a square wave generator, which is rich in harmonics and produces a pleasant sound. Current amplification to drive the speaker is provided by Q1. The frequency of oscillation is determined by C1 and R2. Total current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

34. 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. The frequency of the oscillator is set to twice this value, 164.8 Hertz, and then followed by a divide-by-two stage to produce the desired frequency. The purpose of the divide-by-two stage is to guarantee that the waveform produced has a duty cycle of exactly 50%. This produces a note with no second harmonic distortion. The frequency of oscillation of the circuit is set by adjustment of R1, R2, and C2 also determine the frequency of oscillation but these components are fixed values and need no adjustment. The output of IC2 is fed to an emitter follower to provide current gain to drive a loudspeaker. C3 acts as a low-pass filter to attenuate harmonics and produce a more natural sounding note. The circuit is powered by a 5 volt supply, and this voltage *must* fall within the range of 4.75 to 5.25 volts for IC2 to operate properly.

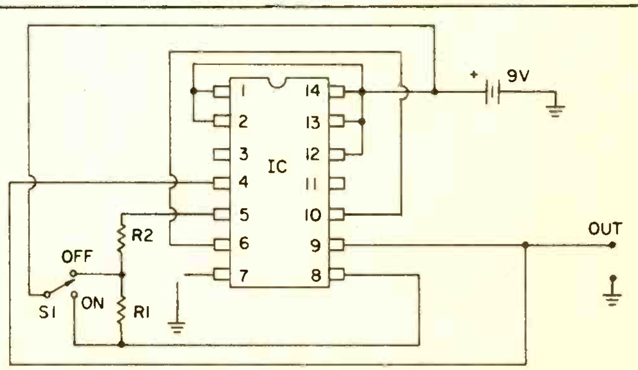


PARTS LIST FOR GUITAR TUNER

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

35. Clean Switch

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



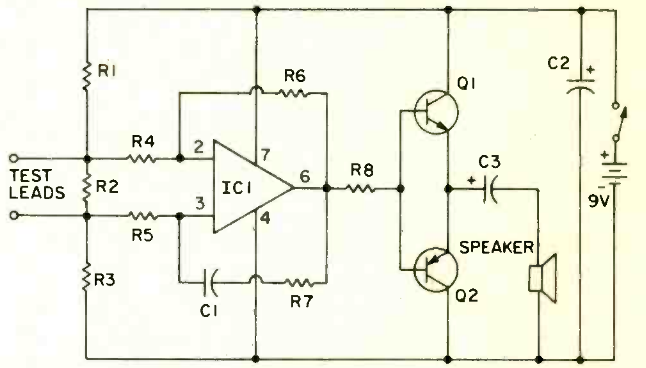
PARTS LIST FOR CLEAN SWITCH
IC1—4001 quad NOR gate
R1, R2—870,000-ohm, ½-watt resistor
S1—SPDT slide switch

36. Continuity Checker

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

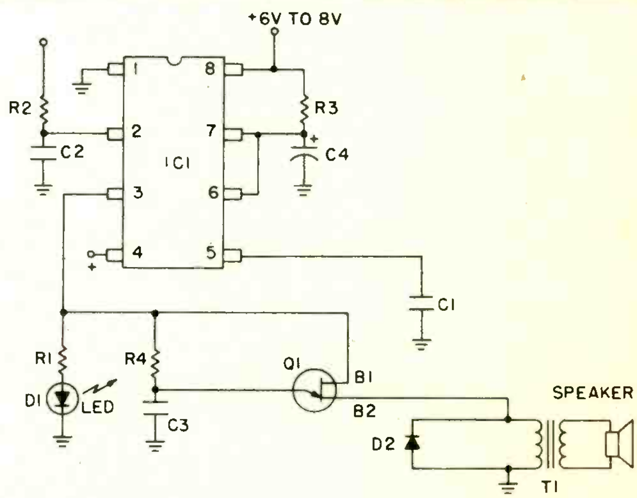
PARTS LIST FOR CONTINUITY CHECKER

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



37. Hands Off

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



PARTS LIST FOR HANDS OFF

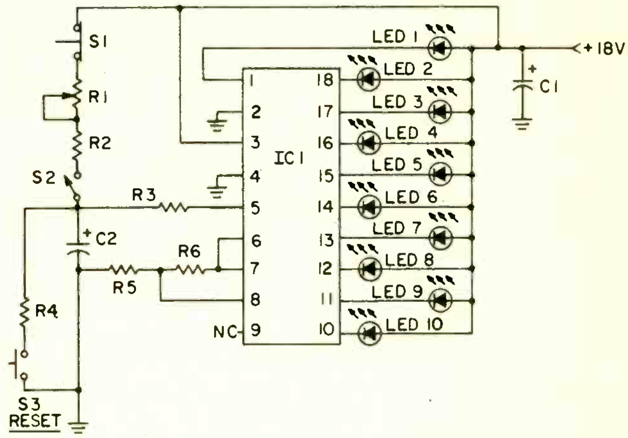
C1—0.1-uF ceramic capacitor, 15 VDC
C2—0.01-uF ceramic capacitor, 15 VDC
C3—0.1-uF ceramic capacitor, 15 VDC
C4—1-uF electrolytic capacitor, 15 VDC
D1—small LED
D2—1N4148 diode
IC1—555 timer
Q1—2N2646
R1—470-ohm, ½-watt resistor
R2—1,000,000-ohm, ½-watt resistor
R3—220,000-ohm, ½-watt resistor
R4—15,000-ohm,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

38. Sobriety Tester

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

PARTS LIST FOR SOBRIETY TESTER

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

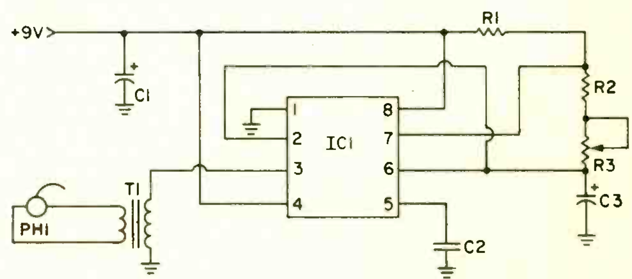


39. Jogging Pacesetter

☐ One of the problems facd 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 resistor, 5%
R2—220K, ½-watt resistor, 5%
R3—1-Megohm trimmer potentiometer
T1—miniature audio output transformer—1,000-ohm primary/8-ohm secondary

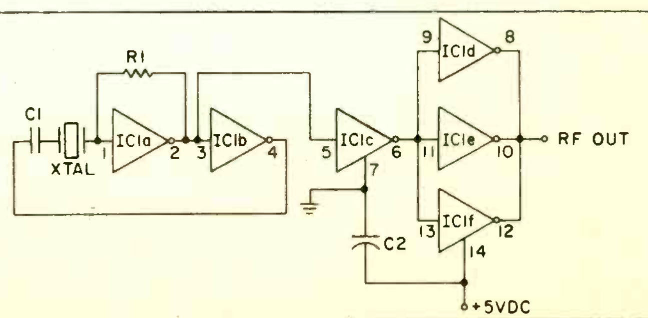


40. Crystal-Controlled TTL

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

PARTS LIST FOR CRYSTAL-CONTROLLED TTL

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



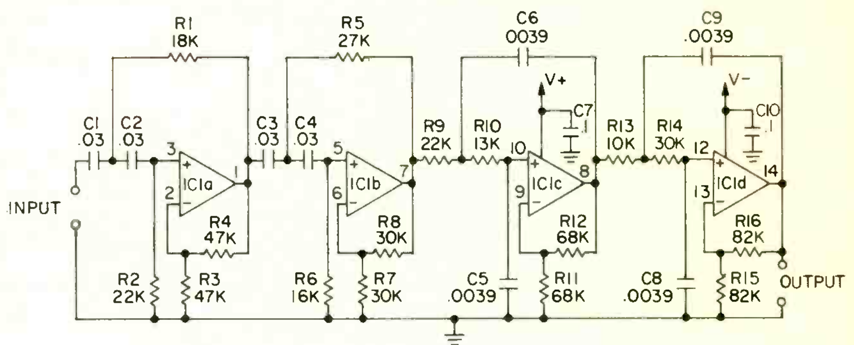
41. Audio Bandpass Filter

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

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

PARTS LIST FOR AUDIO BANDPASS FILTER

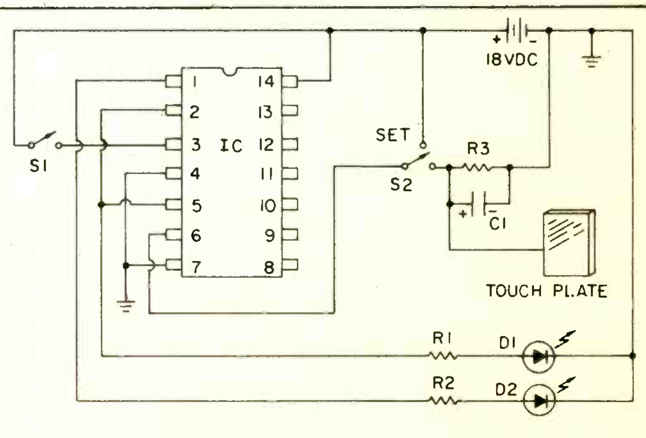
C1-C4—0.03-uF polystyrene capacitor
C5, C6, C8, C9—.0039-uF polystyrene capacitor
C7, C10—0.1-uF ceramic disc capacitor
IC1—LM324 quad op amp integrated circuit
R1—18,000-ohm, ½-watt resistor (all resistors 5% unless otherwise noted.)
R2, R9—22,000-ohm, ½-watt resistor
R3, R4—47,000-ohm, ½-watt resistor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



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

42. Touch 'N Flip

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



PARTS LIST FOR TOUCH 'N FLIP

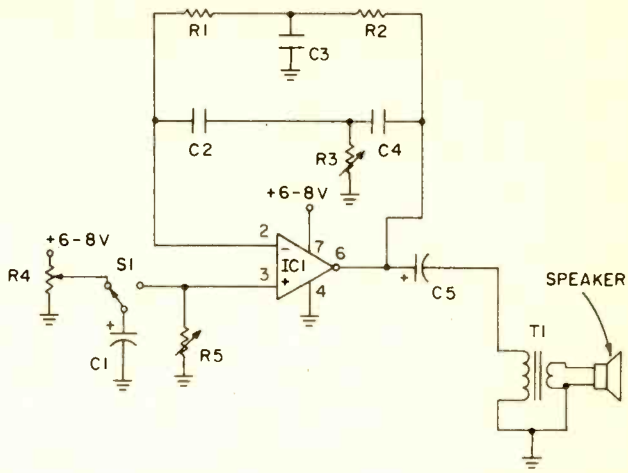
C1—4.7-uF electrolytic capacitor, 15 VDC
D1, D2—large LED
IC1—4011 quad NAND gate
R1, R2, R3—2,000-ohm, ½-watt resistor
S1—SPST momentary contact pushbutton switch
S2—SPDT slide switch

43. The 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 input. Resistors R1, R2, and R3, together with capacitors C1, C2, and C3, determine the fundamental pitch, with R3 providing a useful variation. When S1 is pushed, the potential stored in C4 is placed on the non-inverting input, causing the oscillator to function. The duration is determined by R5. The format of the whistle is modified by the setting of R4. At full potential, the effect is a sharply rising tone, followed by a more gradual decline. At about half setting, the effect is more bell-like.

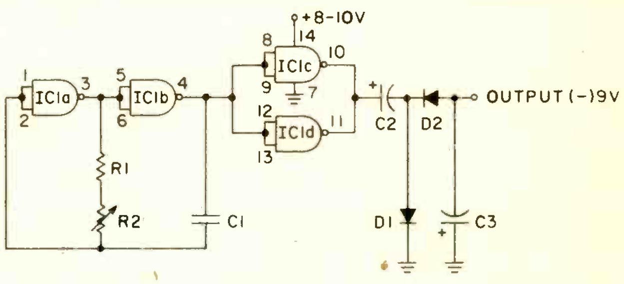
PARTS LIST FOR THE WHISTLER

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



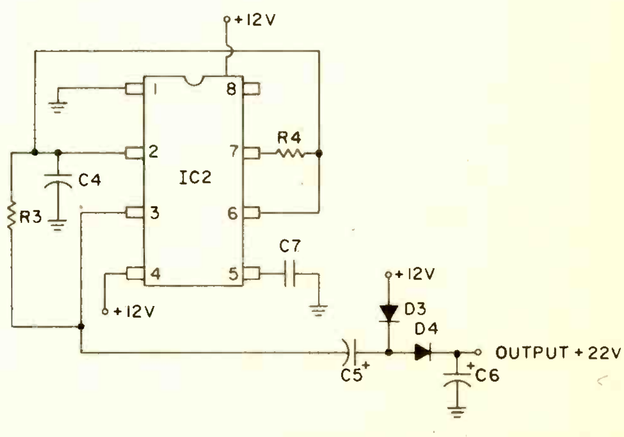
44. Positive Into Negative

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



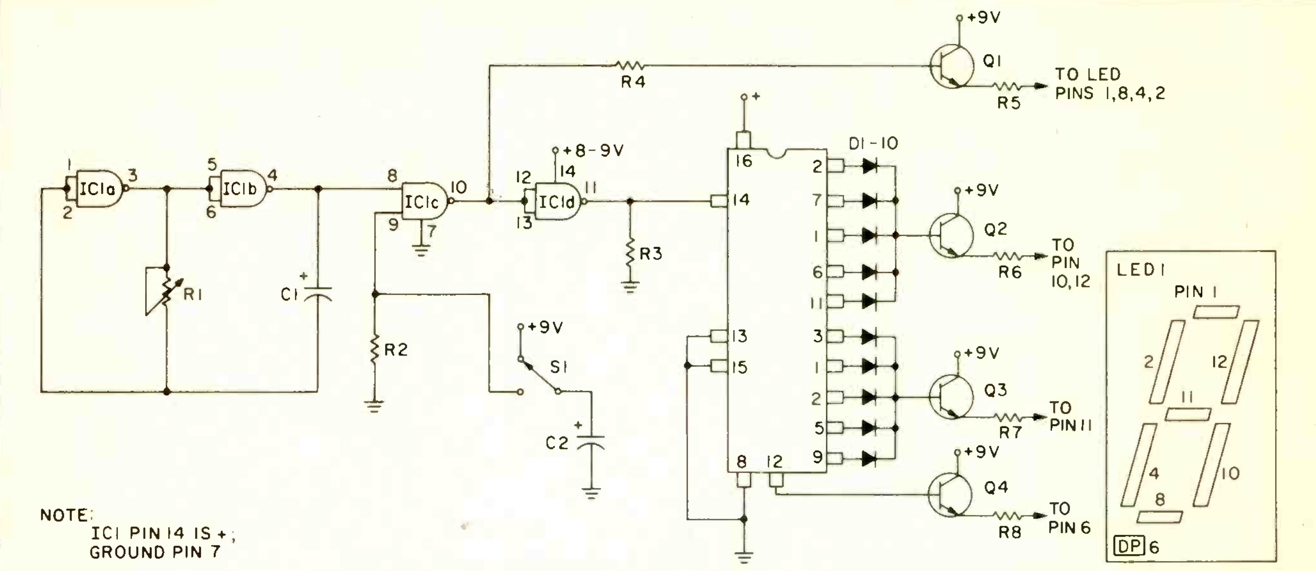
PARTS LIST FOR POSITIVE INTO NEGATIVE

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



45. Coin Toss

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

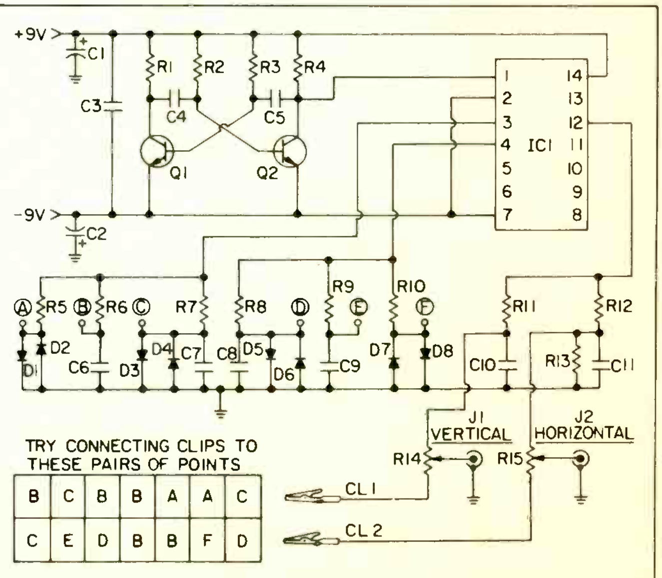


PARTS LIST FOR COIN TOSS

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

46. Video Pattern Generator

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

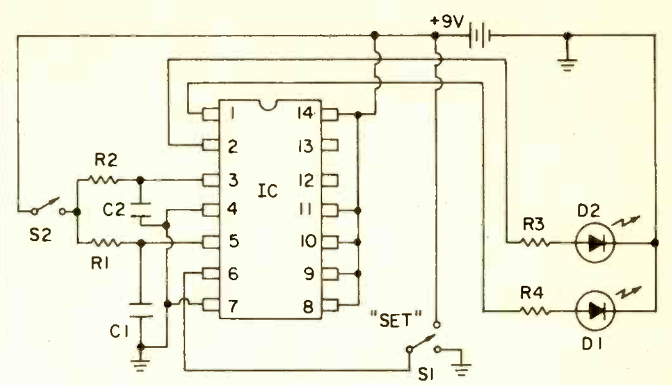


PARTS LIST FOR VIDEO PATTERN GENERATOR

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

47. 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 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.



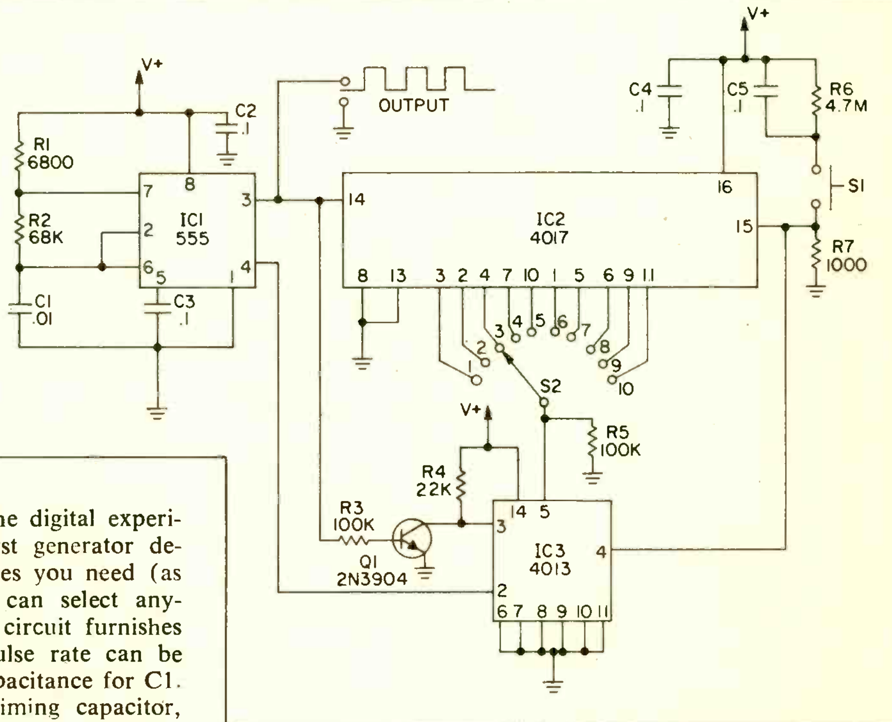
PARTS LIST FOR CAPACITOR MATCH-MAKER

- **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

48. Pulse-Burst Generator

PARTS LIST FOR PULSE-BURST GENERATOR

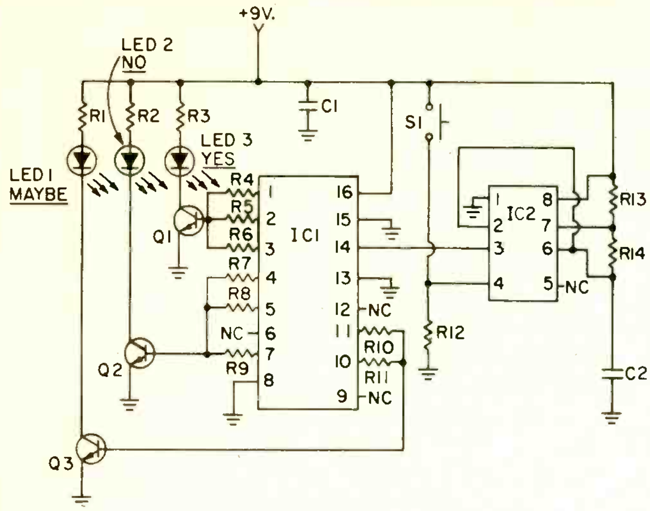
- **C1**—.01 uF-mylar capacitor
- **C2, C3, C4, C5**—0.1-uF ceramic disc capacitor
- **IC1**—555 timer integrated circuit
- **IC2**—4017 CMOS decade counter integrated circuit
- **IC3**—4013 flip-flop integrated circuit
- **Q1**—2N3904 NPN transistor
- **R1**—6,800-ohm, ½-watt resistor (all resistors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



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

49. Mystic Fortune Teller

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



PARTS LIST FOR MYSTIC FORTUNE TELLER

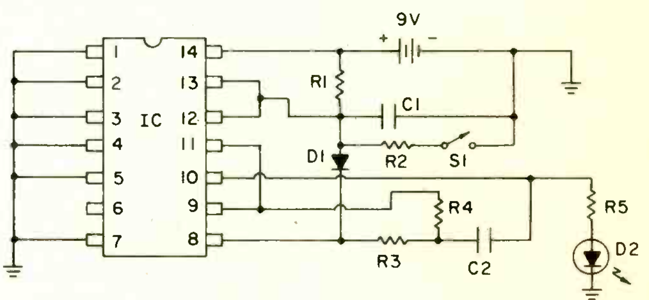
C1—0.1-uF ceramic disc capacitor, 35 VDC
C2—330-pF polystyrene capacitor, 35 VDC
IC1—4022 CMOS octal counter
IC2—555 timer
LED1, 2, 3—light-emitting diode
Q1, Q2, Q3—2N3904 NPN transistor
R1, R2, R3—680-ohm ½-watt resistor, 10%
R4 through R11—47K-ohm ½-watt resistor, 10%
R12—2200-ohm ½-watt resistor, 10%
R13, R14—18K-ohm ½-watt resistor, 10%
S1—normally open SPST pushbutton switch

50. LED Blackjack

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

PARTS LIST FOR LED BLACKJACK

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

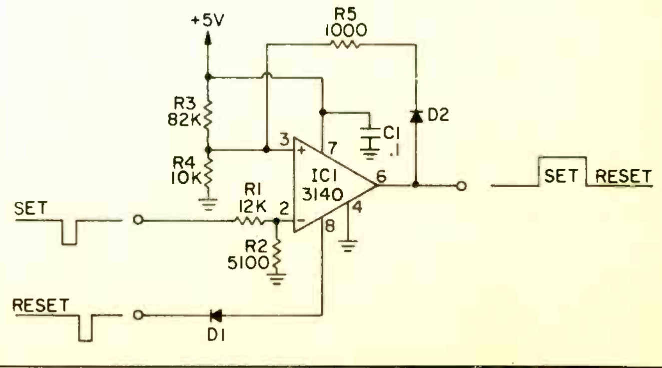


51. Op-Latch

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

PARTS LIST FOR OP-LATCH

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



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.

52. Pseudo-Random Generator

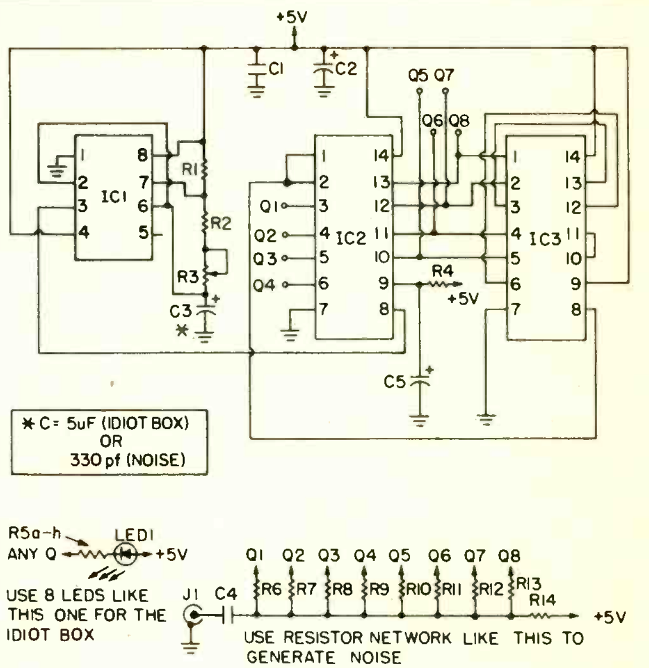
☐ A pseudo-random sequence generator is like a scrambled counter. Instead of counting 1,2,3,4,..., the PRSG might yield an output of 2,9,7,1... The PRSG shown here supplies a sequence of 255 scrambled numbers, available in binary form at the eight outputs (Q1 through Q8). Some applications:

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

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

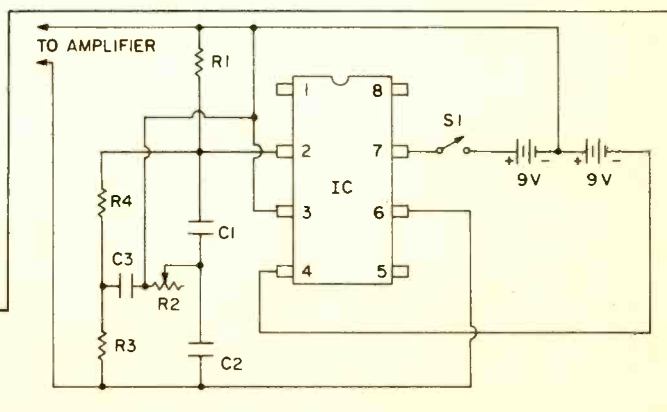
PARTS LIST FOR PSEUDO-RANDOM SEQUENCE GENERATOR

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



53. The Howler

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

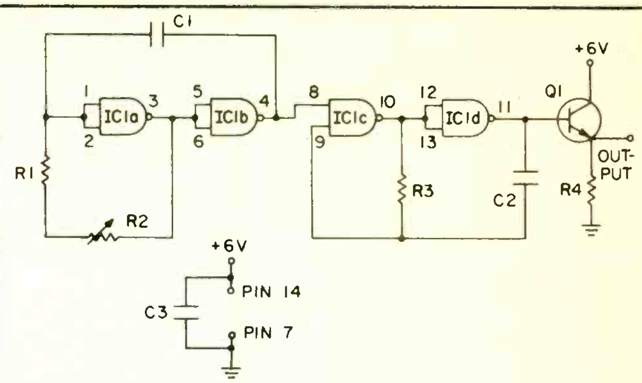


PARTS LIST FOR THE HOWLER

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

54. Digital Modulator

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

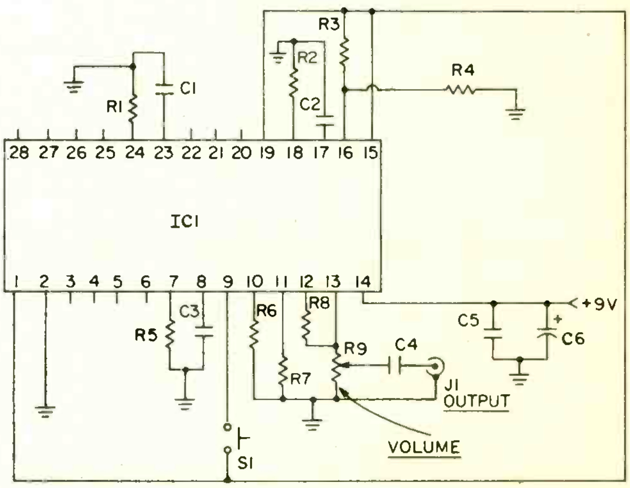


PARTS LIST FOR DIGITAL MODULATOR
C1—0.01-uF ceramic capacitor, 15 VDC
C2—100-pF mica capacitor, 15 VDC
C3—0.1-uF to 0.22-uF ceramic capacitor, 15 VDC
IC1—4011A quad NAND gate
Q1—2N4401 transistor
R1—10,000-ohm, ½-watt resistor
R2—100,000-ohm, ½-watt resistor
R3—2,200-ohm, ½-watt resistor
R4—150-ohm,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

55. Featherweight Foghorn

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

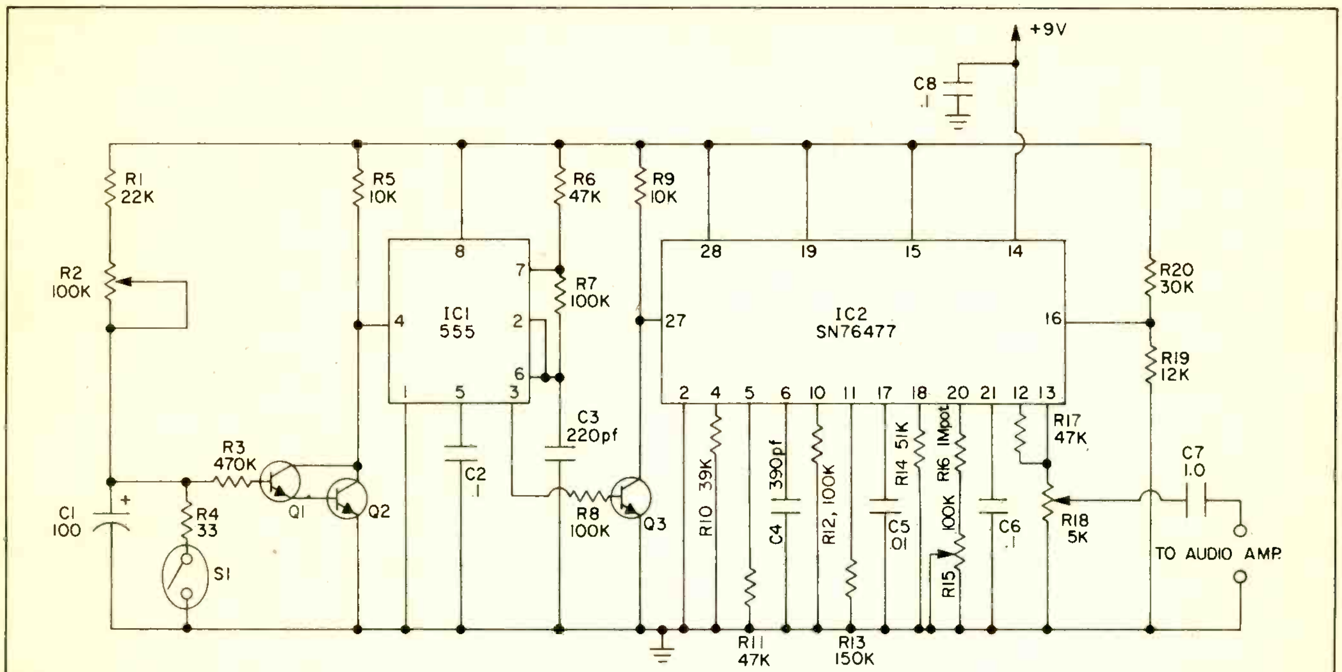
PARTS LIST FOR FEATHERWEIGHT FOGHORN
C1, C3—0.47-uF mylar capacitor, 35 VDC
C2—0.01-uF mylar capacitor, 35 VDC
C4—1.0-uF mylar capacitor, 35 VDC
C5—0.1-uF ceramic disc capacitor, 35 VDC
C6—100-uF electrolytic capacitor, 16 VDC
IC1—SN76477 sound generator
J1—phono jack
R1—1-Megohm ½-watt resistor, 10%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



56. Train Sound Effects

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

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

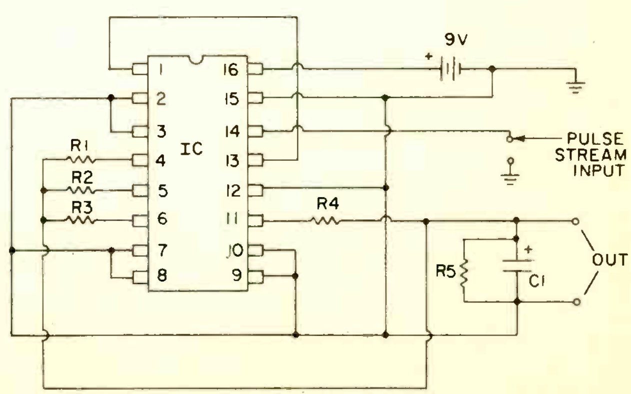


PARTS LIST FOR AUTOMATIC TRAIN SOUND EFFECTS

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

57. Sine Wave Generator

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

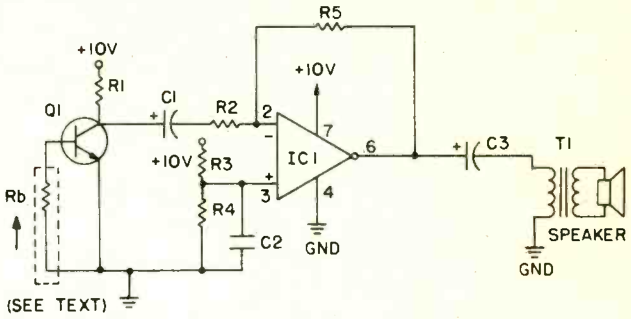


PARTS LIST FOR SINE WAVE GENERATOR

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

58. Light Into Sound

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

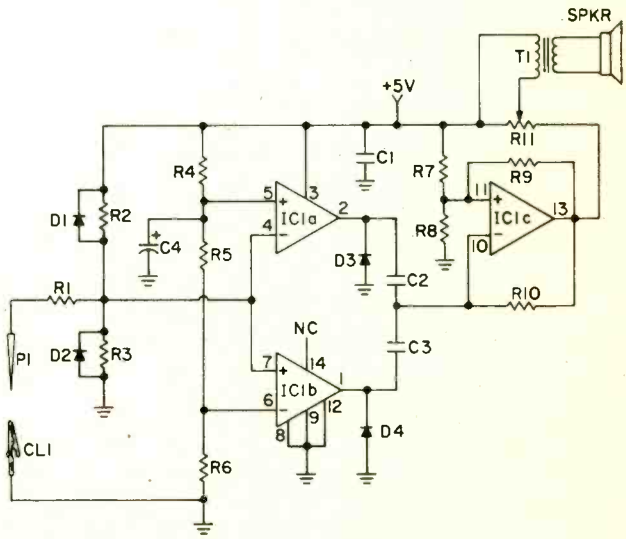


PARTS LIST FOR LIGHT INTO SOUND

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

59. Audible Logic Probe

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

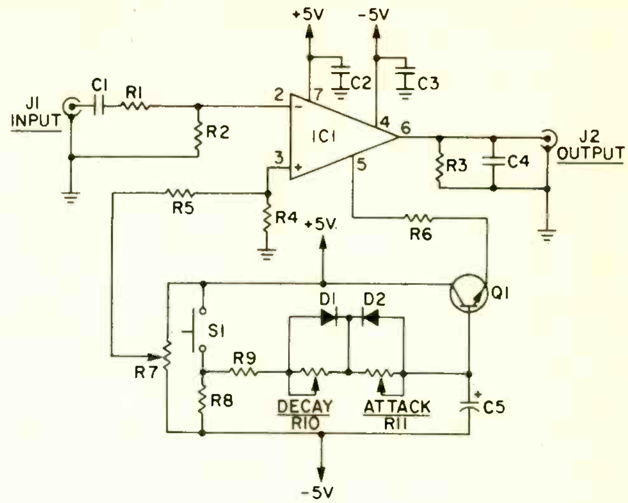


PARTS LIST FOR IC AUDIBLE LOGIC PROBE

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

60. Musical Modulator

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

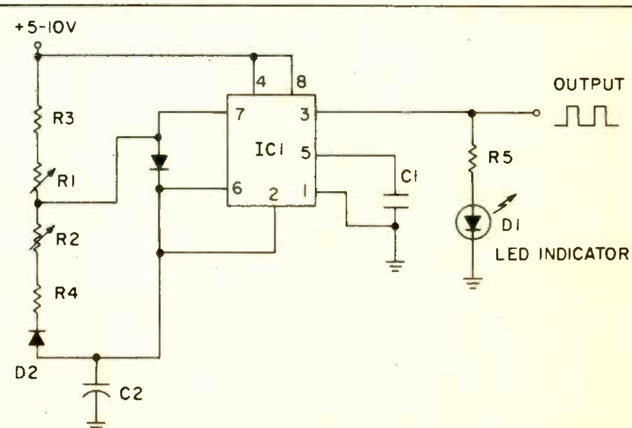


PARTS LIST FOR MUSICAL MODULATOR

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

61. Universal Pulser

☐ The type 555 timer, in its astable mode, can furnish pulses ranging in duration from about one microsecond to minutes. The version shown allows both frequency and duty cycle (on-off ratio) to be adjusted. The 555 is husky for its size, and can drive over ten TTL gates and a far larger number of CMOS gates.



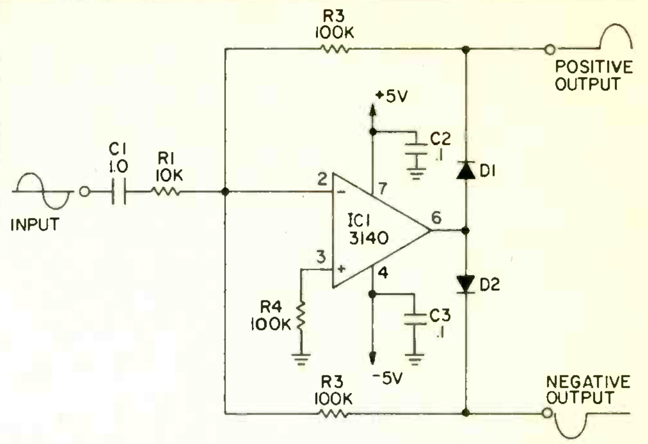
PARTS LIST FOR UNIVERSAL PULSER

C1—see table
D1, D2—1N4148 diode
D3—small LED
IC1—555 timer
R1, R2—see table
R3, R4—1,000-ohm, ½-watt resistor
R5—470-ohm, ½-watt resistor

62. 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.

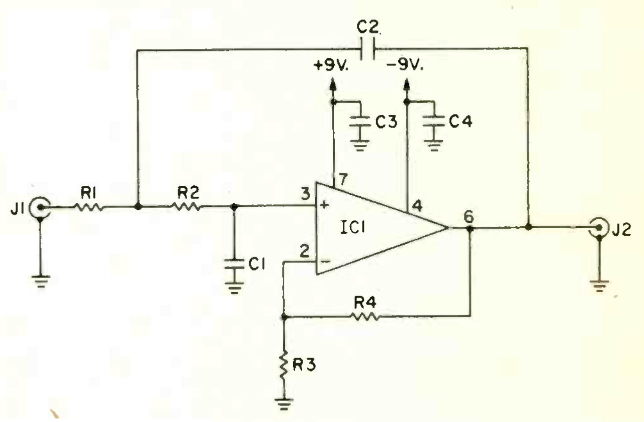


PARTS LIST FOR PRECISION RECTIFIER

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

63. Active Low Pass Filter

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

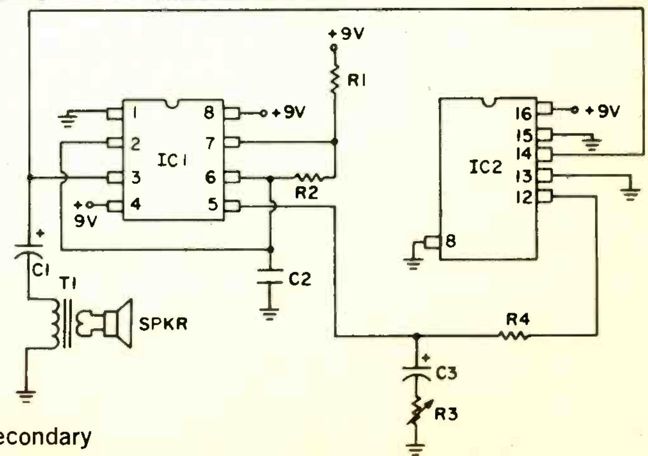


PARTS LIST FOR ACTIVE LOW PASS FILTER

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

64. Two-Tone Alarm

☐ When this circuit is triggered into action, it is hard to ignore for very long! A 555 timer is operated in the astable free-running mode, with its output powering both a loudspeaker and clocking a 4017 counter. Pin 12 of



PARTS LIST FOR TWO TONE ALARM

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

the counter provides a high-low output which changes with every five input pulses counted. This output is applied via a resistor of from 2.2K to 10K ohms to pin 5, the modulated input of the timer. This produces a strident warble that calls immediate attention. More mellow, but interesting, tones can be obtained with the addition of the RC filter shown.

65. Six-bit DA Converter

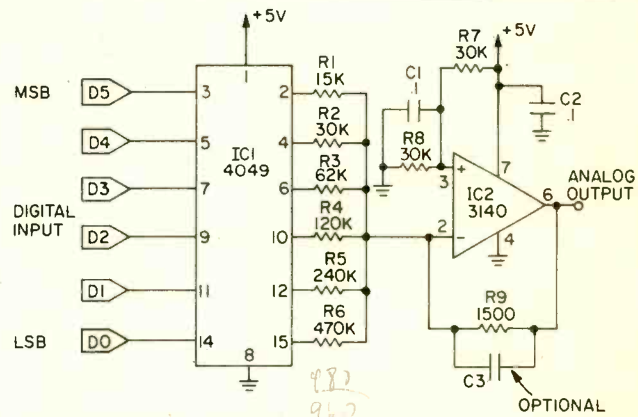
☐ Here is a simple way to convert a digital code into an analog equivalent. This circuit accepts a 6-bit binary-coded digital input. D5 is the most significant bit, and D0 is the least significant. Each one of the 64 possible digital input codes produces a unique analog level at the output. This analog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

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

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

PARTS LIST FOR SIMPLE 6-BIT DA CONVERTER

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



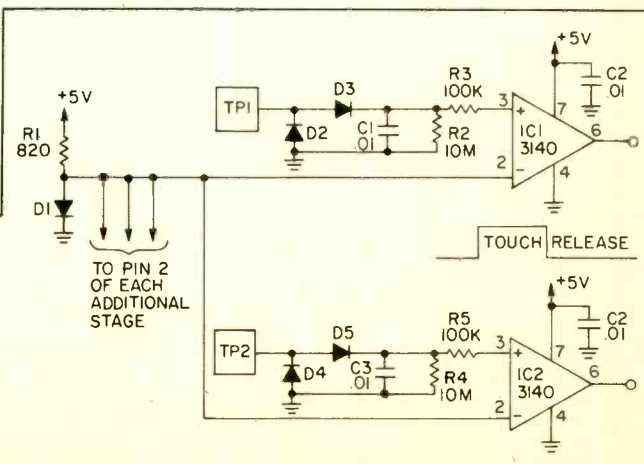
66. Touch-Sensitive Keyboard

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

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

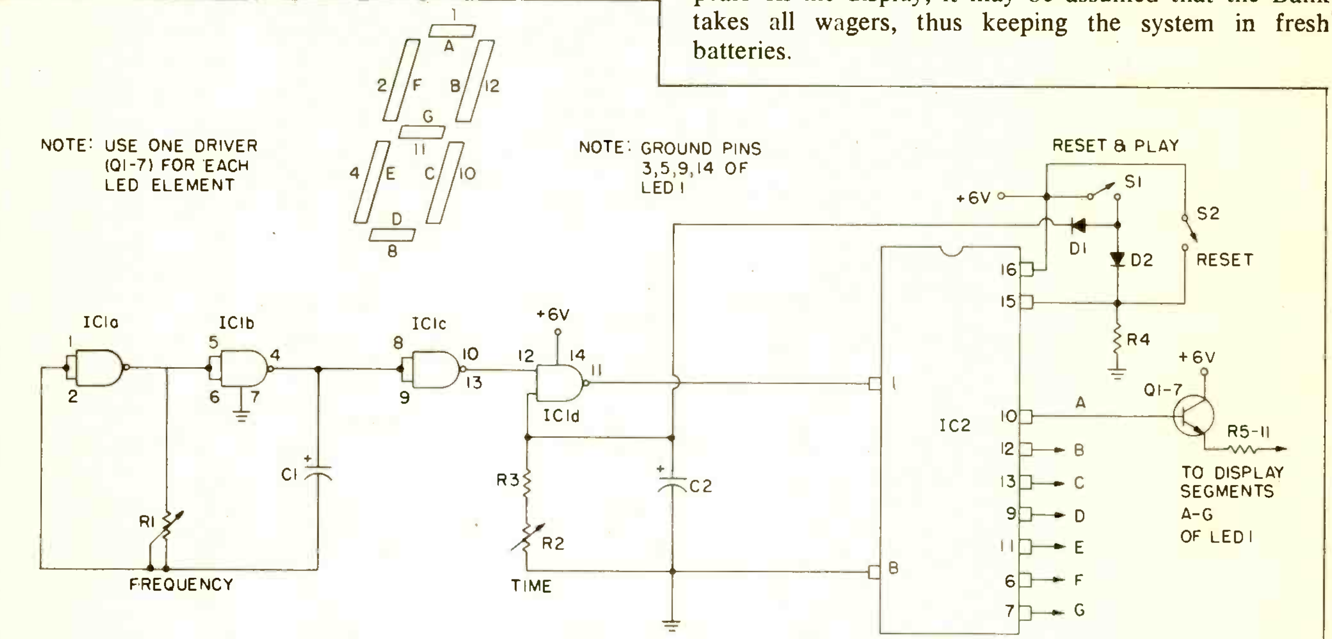
PARTS LIST FOR TOUCH-SENSITIVE KEYBOARD

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



67. Mini-Digital Roulette

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



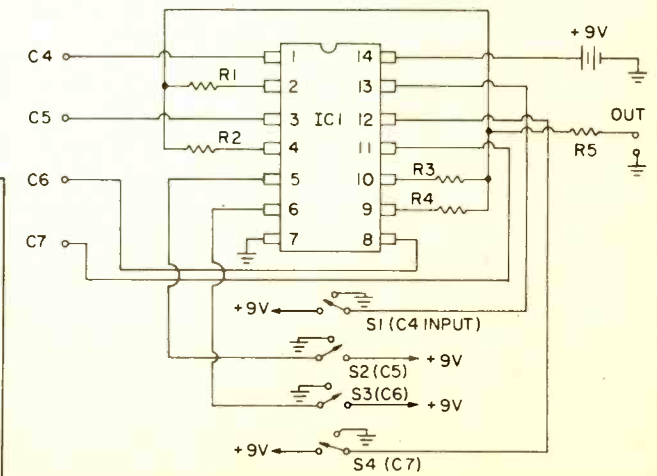
PARTS LIST FOR MINI-DIGITAL ROULETTE

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

68. Music Synthesizer

PARTS LIST FOR MULTI-INPUT MUSIC SYNTHESIZER
IC1—4016 quad bilateral switch
R1 through R5—1,000-ohm, ½-watt resistor
S1 through S4—SPDT slide switch

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

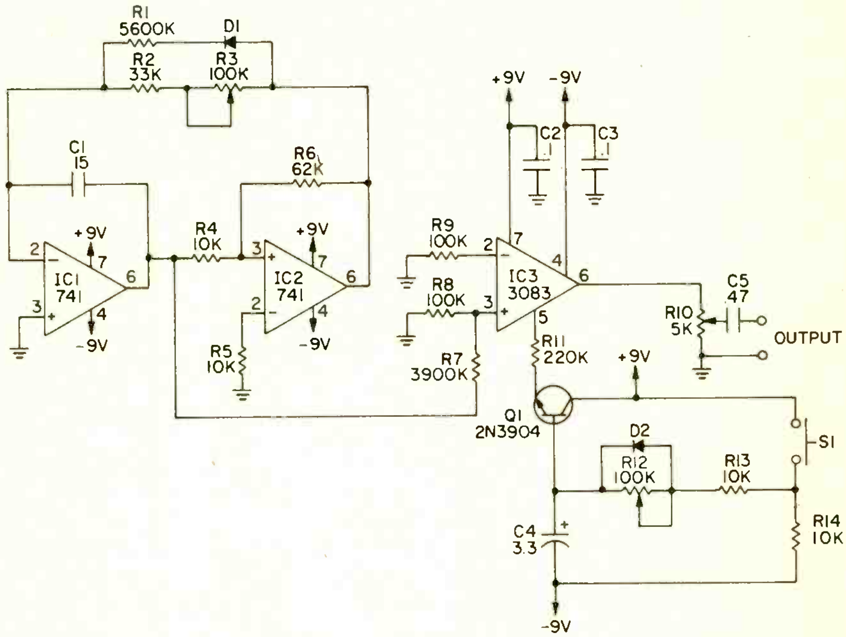


69. Slide Trombone

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

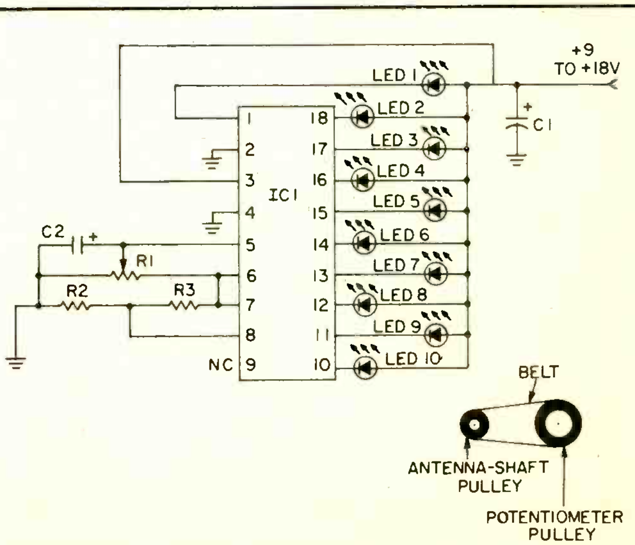
PARTS LIST FOR SLIDE TROMBONE

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



70. Antenna-Bearing Indicator

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



PARTS LIST FOR ANTENNA-BEARING INDICATOR

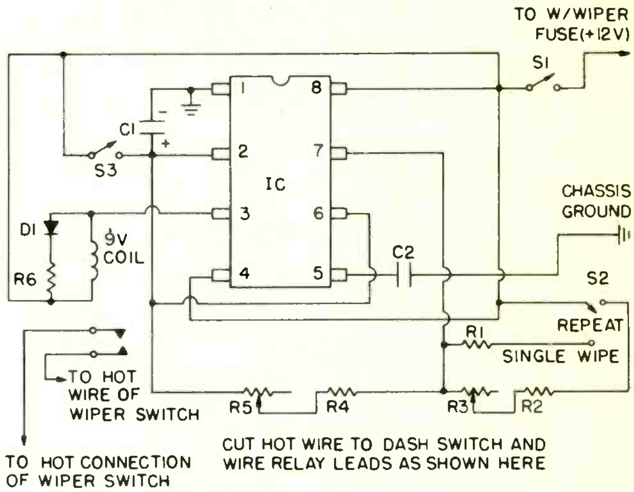
C1—100-uF electrolytic capacitor, 35 VDC
C2—5-uF electrolytic capacitor, 10 VDC
IC1—LM3914 LED display driver
LED1 through LED10—light-emitting diode
R1—25K linear-taper potentiometer
R2—3900-ohm, ½-watt resistor, 5%
R3—1200-ohm, ½-watt resistor, 5%

71. Go-Slo Wiper Control

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

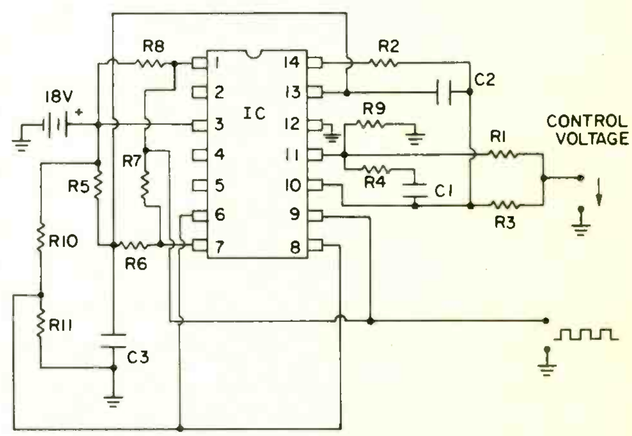
PARTS LIST FOR SELECT-DELAY WINDSHIELD WIPER CONTROL

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



72. High Frequency VCO

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



PARTS LIST FOR HIGH-FREQUENCY VOLTAGE CONTROLLED OSCILLATOR

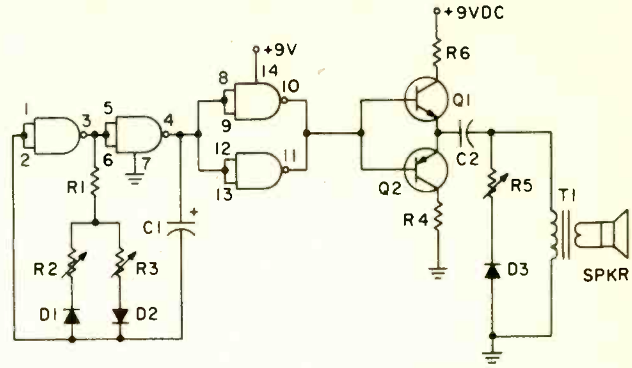
C1—0.1-pF ceramic disc capacitor, 15 VDC
C2—500-pF mica capacitor, 15 VDC
C3—0.01-uF ceramic capacitor, 15 VDC
IC1—LM339 quad comparator
R1, R7—100,000-ohm, ½-watt resistor
R2—50,000-ohm, ½-watt resistor
R3—20,000-ohm, ½-watt resistor
R4—10,000-ohm, ½-watt resistor
R5, R8—3,000-ohm, ½-watt resistor
R6—5,100-ohm,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

73. Mini-Micro Metronome

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

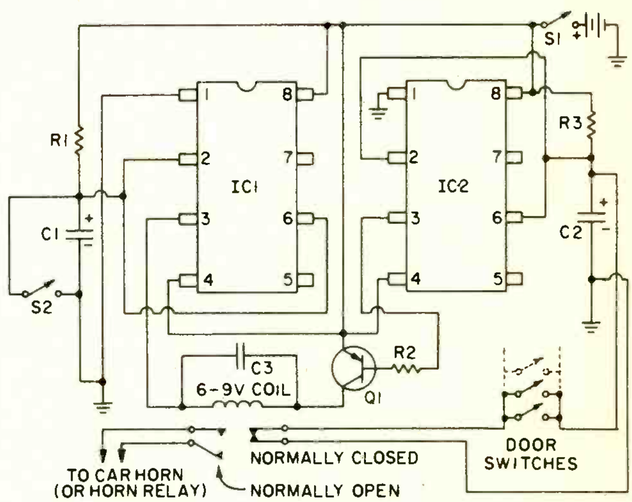
PARTS LIST FOR MINI-MICRO METRONOME

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



74. Auto Burglar Alarm

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

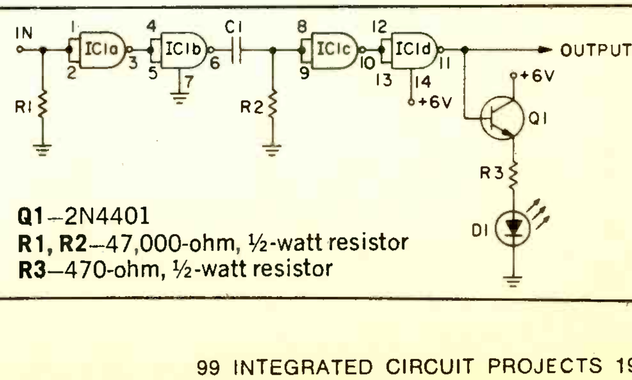


PARTS LIST FOR AUTO BURGLAR ALARM

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

75. Improvised Monostable

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



PARTS LIST FOR IMPROVISED MONOSTABLE

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

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

76. Computer-Controlled Keyer

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

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

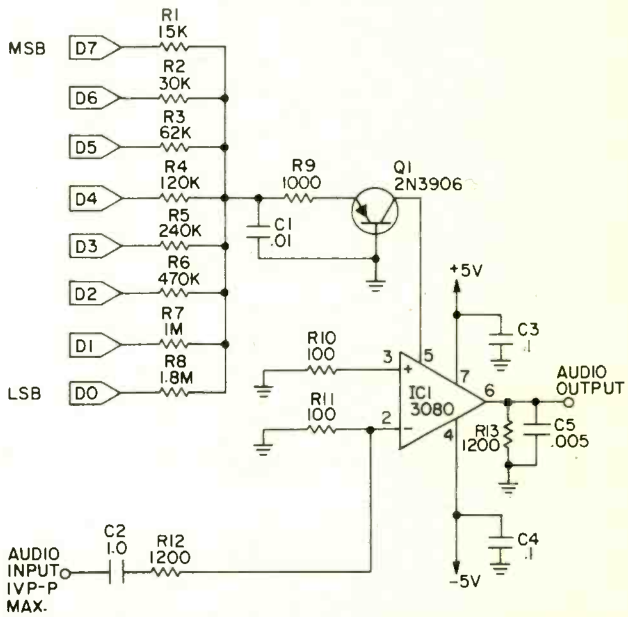
Let's say we want a fast attack time of 10 milliseconds. Using all available codes, it will take 255 steps to climb from zero to full output. For simplicity's sake, we'll let the note's amplitude rise linearly during attack, which means that the code will be incremented at regular, fixed time intervals.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

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

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

PARTS LIST FOR COMPUTER-CONTROLLED KEYER

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



77. Controlled Note Generator

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

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

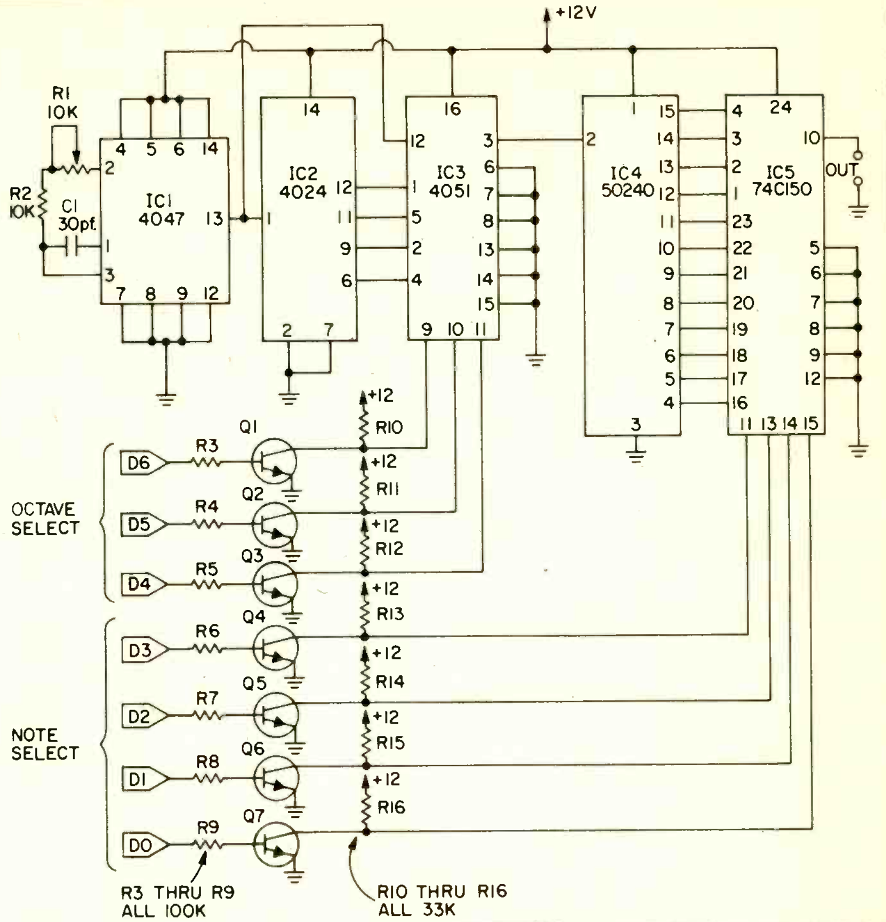
The lowest octave is selected by a binary 0 on lines D6 through D4. A binary 1 selects the next higher octave, and so on until you reach the highest octave, coded by a binary 4 (100). (Note: D6 is the most significant bit; D4 is the least significant.) Codes higher than 4 yield no output.

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

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

PARTS LIST FOR COMPUTER-CONTROLLED NOTE GENERATOR

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

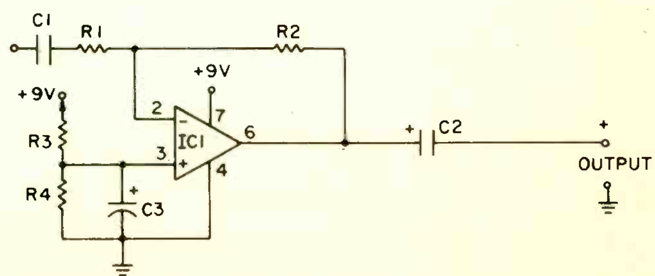


78. Single Supply Signal Shifter

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

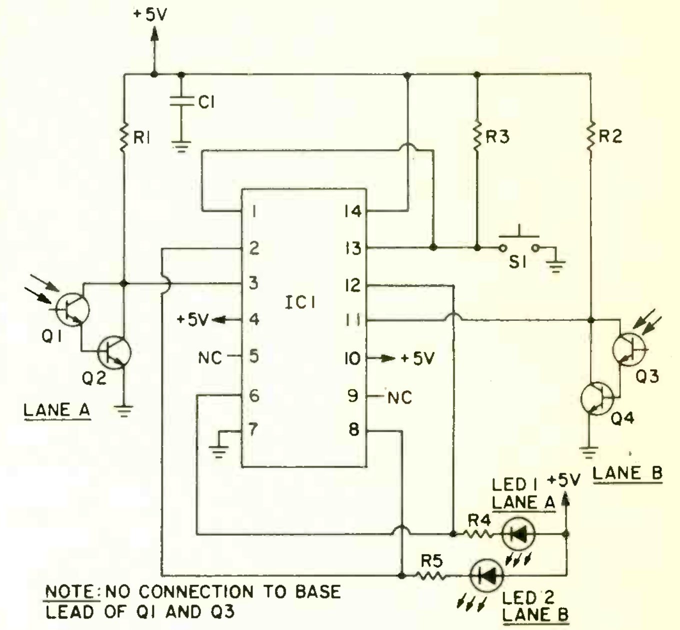
PARTS LIST FOR SINGLE SUPPLY SIGNAL SHIFTER

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



79. Slot Car Race Referee

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

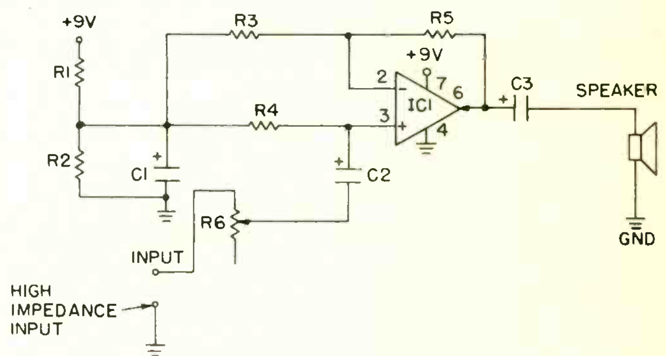


PARTS LIST FOR SLOT CAR RACE REFEREE

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

80. Micro-Mini PA

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

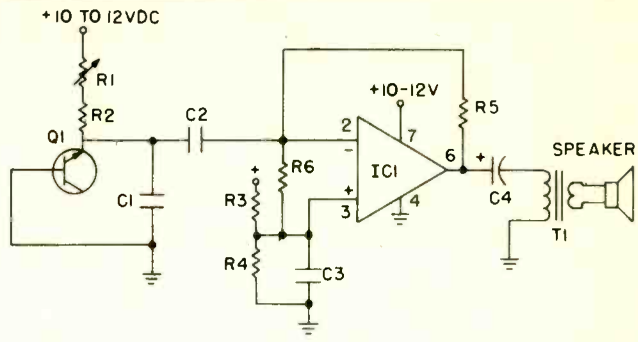


PARTS LIST FOR MICRO-MINI PA

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

81. Useful Noise

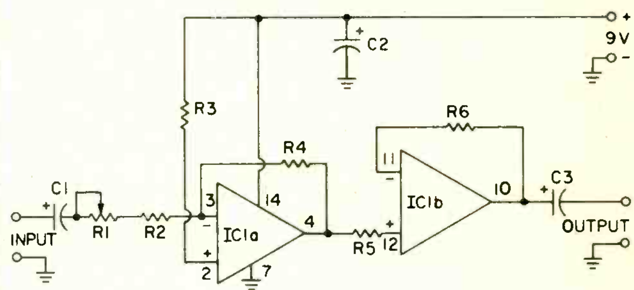
☐ Noise, more or less "pure white" from some source of uncertainty, can be filtered and shaped for various purposes, ranging from radio alignment, to music, or the simulated sounds of rain on the roof. There are various naturally random impulse sources available to the experimenter, including the plasma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



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

82. Power Mike Amplifier

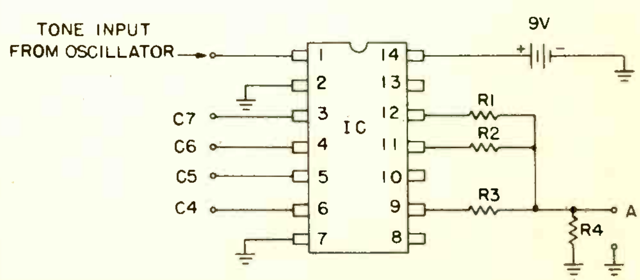
☐ A popular accessory to a CB radio is a power microphone. This circuit provides an adjustable gain of 1 to 10 which will increase the output of a dynamic microphone for higher modulation levels without shouting. The circuit has very low output impedance and will drive the microphone input circuit of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



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

83. Octave Music Maker

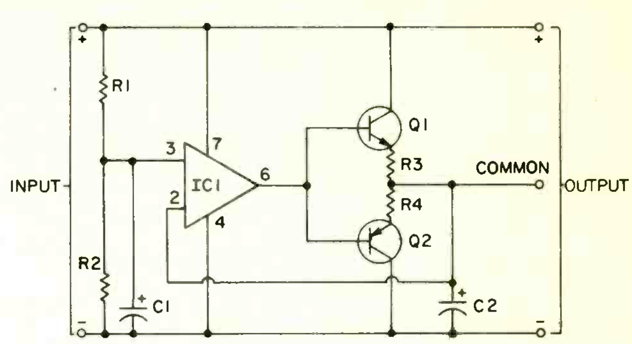
☐ This circuit will provide you with musical octaves that are very well reproduced from the top octave that you feed as an input. Putting in any tone, like the tone from an electric guitar, or from an organ, or from a CMOS oscillator, will cause C4 to be four octaves lower, C5 to be five octaves lower,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



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

84. Dual Polarity Power Supply

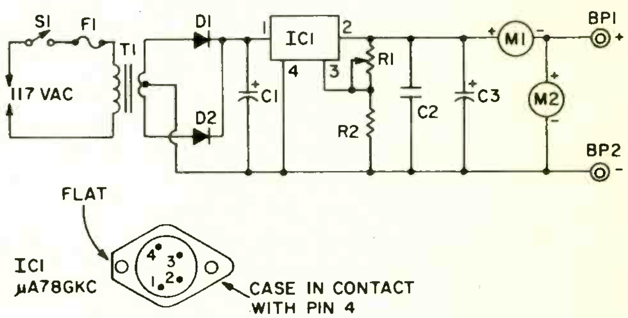
☐ Many operational amplifiers require both positive and negative supplies for proper operation. With this simple circuit you can take a floating power supply and convert it into a dual polarity supply. To provide ±15 volts as most op amps require, you will need a 30 volt supply to drive the circuit.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



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

85. Variable Power Supply

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



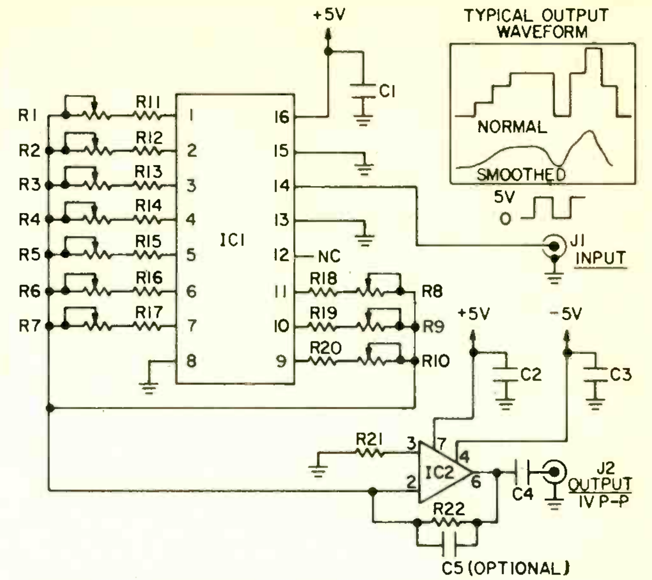
PARTS LIST FOR VARIABLE REGULATED POWER SUPPLY
BP1, BP2—binding post
C1—2200-uF electrolytic capacitor, 40 VDC
C2—0.1-uF ceramic disc capacitor, 35 VDC
C3—100-uF electrolytic capacitor, 25 VDC
D1, D2—1N4003 (1A, 200 PIV) rectifier diode
F1—0.5-Ampere slow-blow fuse
IC1—µA78GKC adjustable voltage regulator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

86. The Waveshaper

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

PARTS LIST FOR THE WAVESHAPER

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



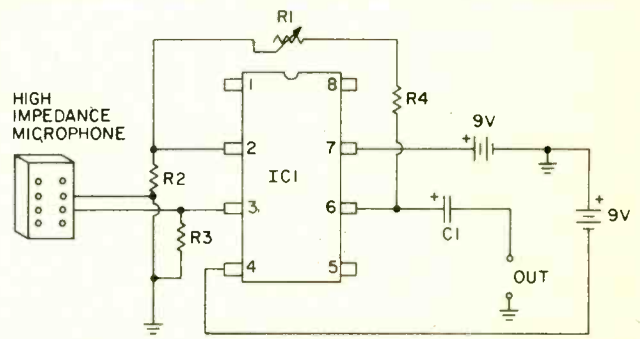
NOTE: OUTPUT FREQUENCY = INPUT FREQUENCY ÷ 10

87. High Impedance Mike Amp

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

PARTS LIST FOR HI-IMPEDANCE MIKE AMP

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

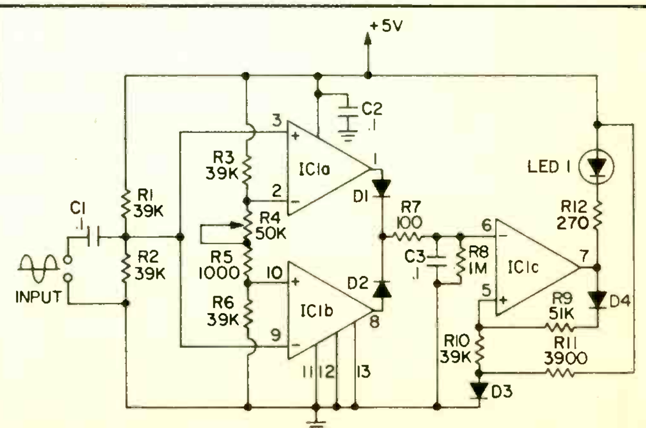


88. Peak-Level Detector

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

PARTS LIST FOR PEAK-LEVEL DETECTOR

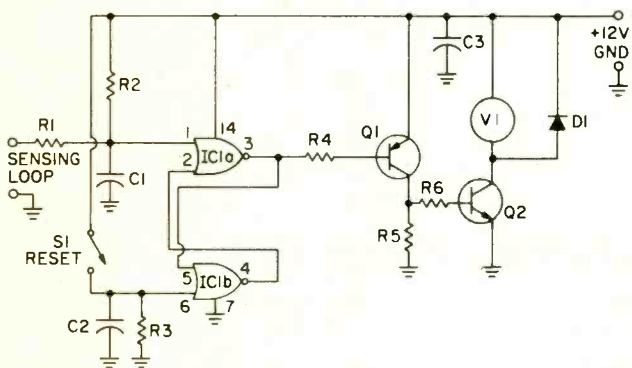
C1, C2, C3—0.1-uF ceramic disc capacitor
D1-D4—1N914 diode
IC1—LM324 quad op amp integrated circuit
LED1—light emitting diode
R1, R2, R3, R6, R10—39,000-ohm, ½-watt resistor (all resistors 5%)
R4—50,000-ohm, ½-watt trim-potentiometer
R5—1,000-ohm, ½-watt resistor
R7—100-ohm, ½-watt resistor
R8—1,000,000-ohm,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



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

89. Burglar Alarm

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

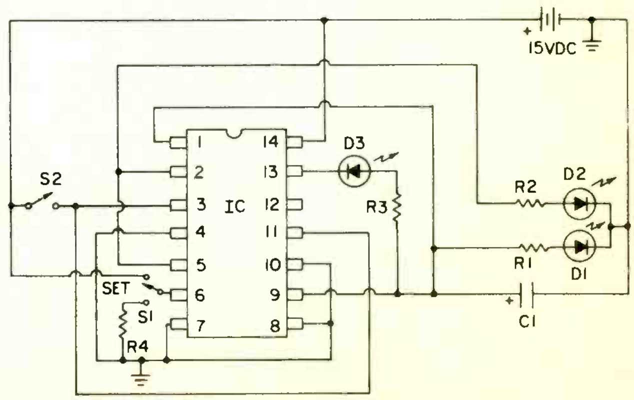


PARTS LIST FOR HOME BURGLAR ALARM

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

90. Reaction Tester

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



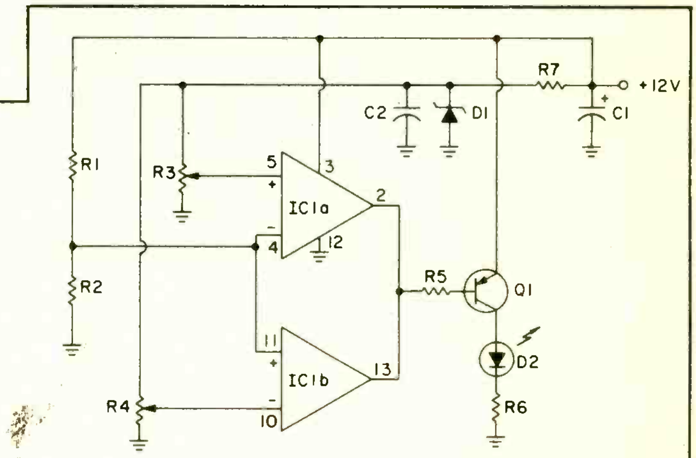
PARTS LIST FOR LIGHTNING REACTION TESTER

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

91. 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 the battery when the car is not in use. To calibrate the circuit, connect an adjustable DC power supply to the + and – inputs of the circuit. Set the power supply to 13.4 volts and adjust R3 so that the voltage at pin 5 of IC1A is maximum. Then adjust R4 so that the LED just goes out. Set the power supply to 15.1 volts and adjust R3 so that the LED just goes out. The LED will now become lit if the voltage is outside the permissable range of 13.5 to 15.0 volts when the engine is running.

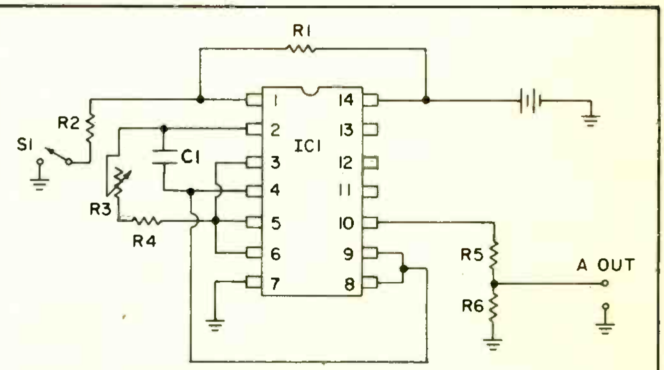
PARTS LIST FOR ALTERNATOR MONITOR
- **C1**—10-uF electrolytic capacitor, 15 VDC
- **C2**—0.1-uF ceramic capacitor, 15 VDC
- **D1**—9 VDC zener diode
- **D2**—large LED
- **IC1**—339 quad comparator
- **Q1**—2N4403
- **R1, R2, R5**—10,000-ohm, ½-watt resistor
- **R3, R4**—50,000-ohm linear-taper potentiometer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



92. 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
- **IC1**—4001 quad NOR gate
- **R1**—91,000-ohm, ½-watt resistor
- **R2**—220-ohm, ½-watt resistor
- **R3**—500,000-ohm, linear-taper potentiometer
- **R4**—50,000-ohm, ½-watt resistor
- **R5, R6**—2,200-ohm, ½-watt resistor
- **S1**—SPST momentary-contact pushbutton switch



93. Control System

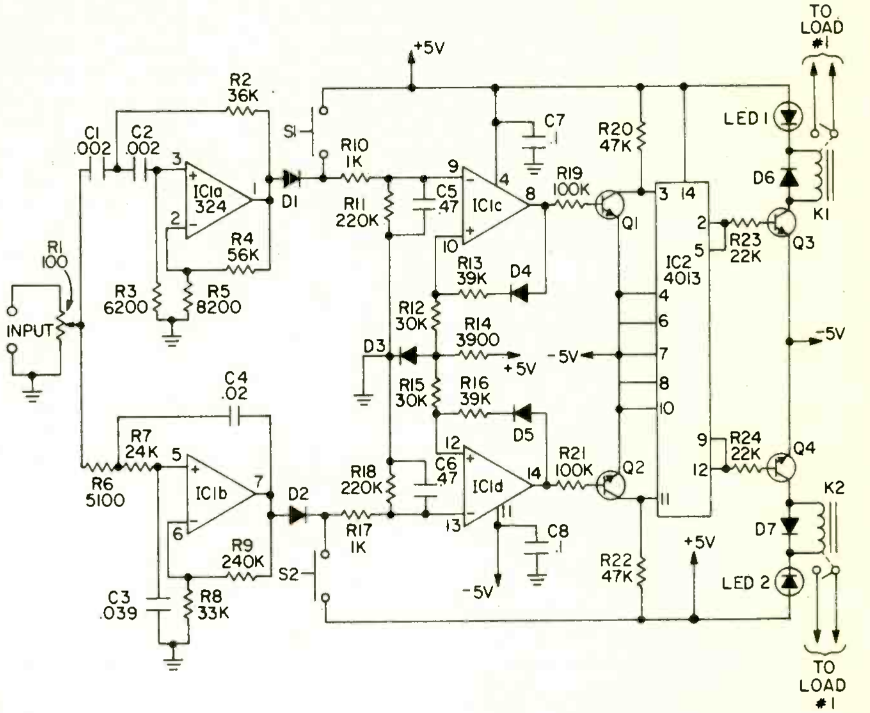
☐ Let's say that you need a programmable control system that can perform a timed sequence of operations. This sounds like a job for a high-priced computer, doesn't it? In many instances, however, just a cheap cassette recorder can do a respectable job—provided, of course, that you build this 2-channel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

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

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

PARTS LIST FOR CASSETTE-BASED CONTROL SYSTEM

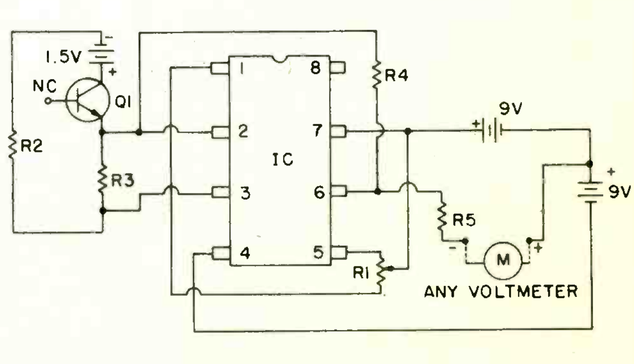
C1, C2—.002-uF polystyrene capacitor
C3—.039-uF polystyrene capacitor
C4—.02-uF polystyrene capacitor
C5, C6—0.47-uF mylar capacitor
C7, C8—0.1-uF ceramic disc capacitor
D1-D7—1N914 diode
IC1—LM324 quad op amp integrated circuit
IC2—4013 CMOS dual flip-flop integrated circuit
K1, K2—6-VDC, 500-ohm relay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



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

94. VOM Light Meter

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



PARTS LIST FOR VOM LIGHT METER

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

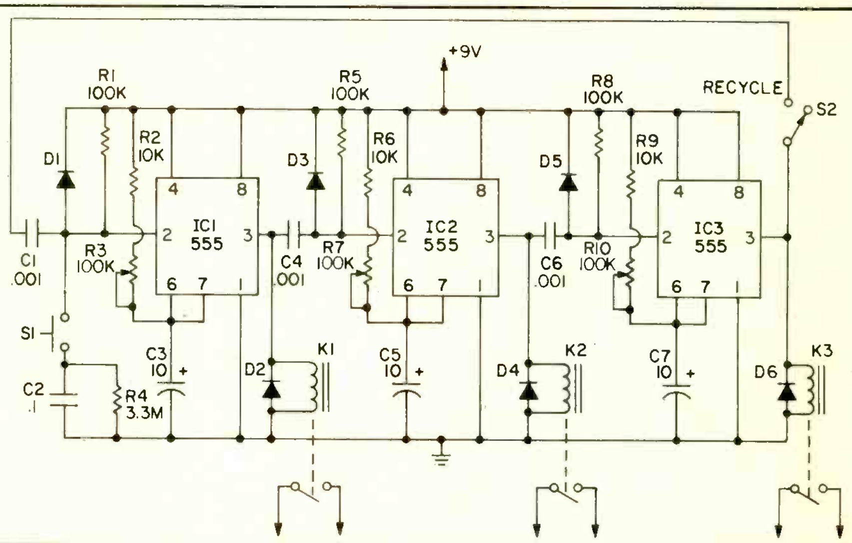
95. Sequential Timer

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

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

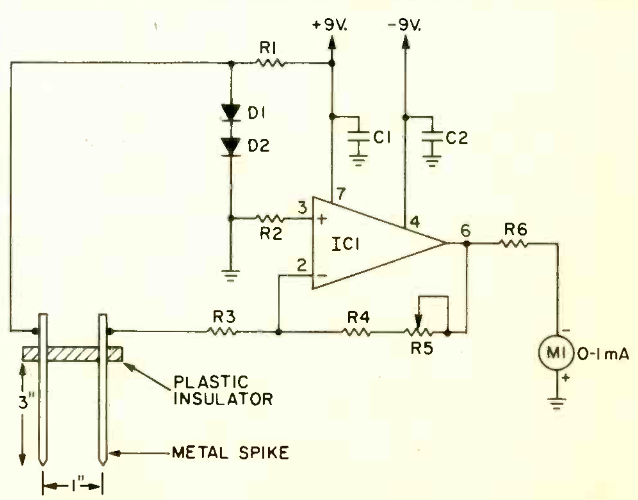
PARTS LIST FOR RE-CYCLING SEQUENTIAL TIMER

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



96. Plant Moisture Meter

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



PARTS LIST FOR PLANT MOISTURE METER

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

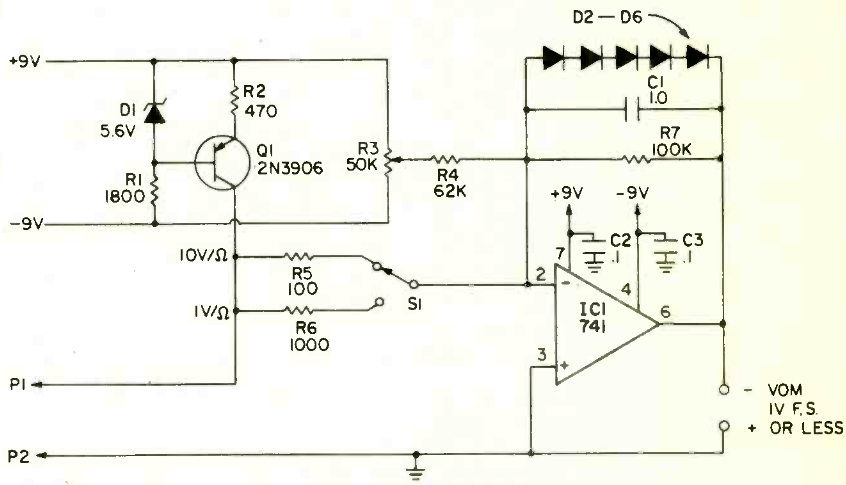
97. Milliohms Adapter

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

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

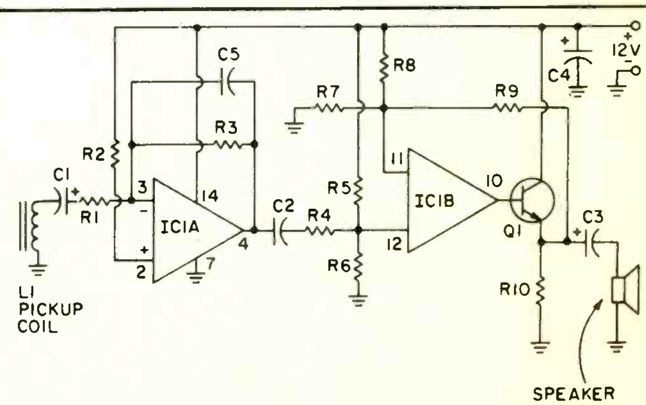
PARTS LIST FOR MILLIOHMS ADAPTER

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



98. Telephone Pickup

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



PARTS LIST FOR TELEPHONE PICKUP

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

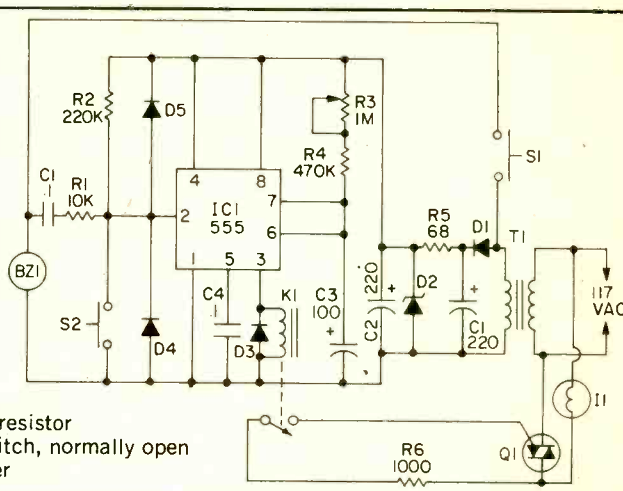
99. Smart Porch Light

☐ 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. ■

PARTS LIST FOR SMART PORCH LIGHT

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



21 Easy-to-Build Transistor Projects

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

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

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

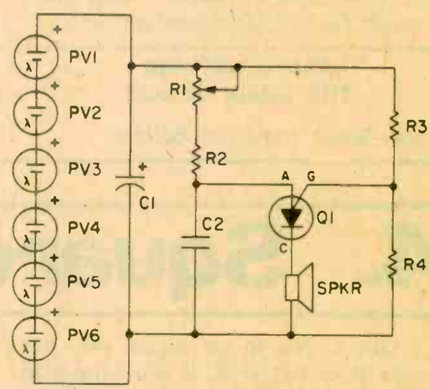
This brings up another point. While some ICs are relatively sensitive to miswiring and are easily destroyed, these discrete components, as a rule, are not. It's a lot better to make your mistakes here than on an integrated circuit project, where ruining an IC due to a reversed diode polarity might set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

1. Solar Metronome

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

PARTS LIST FOR SOLAR-POWERED METRONOME

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



2. Hi-Temp Alarm

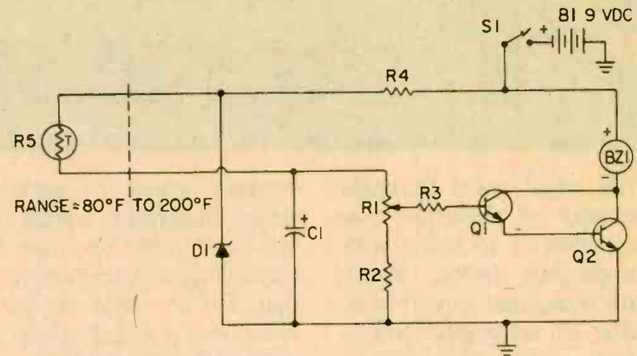
☐ Has a temperature-control problem got you hot under the collar? Well, this little temperature alarm/thermostat may be just the thing to cool you down. Temperature-sensing is done by thermistor RR5, a negative-temperature-coefficient device whose resistance varies between 10K-ohms at 77° F, and about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

Note that the thermistor must be

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

PARTS LIST FOR HI-TEMP ALARM

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

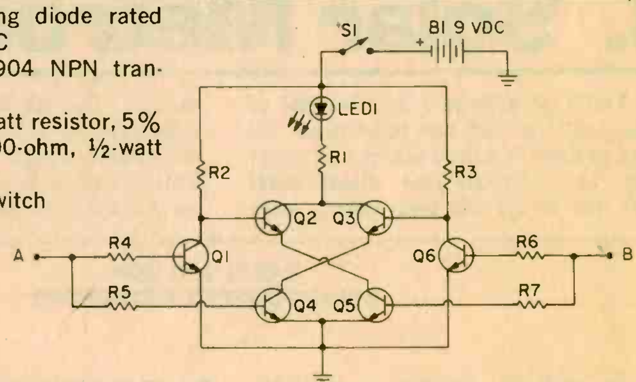


3. The Brain Teaser

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

PARTS LIST FOR THE BRAIN TEASER

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

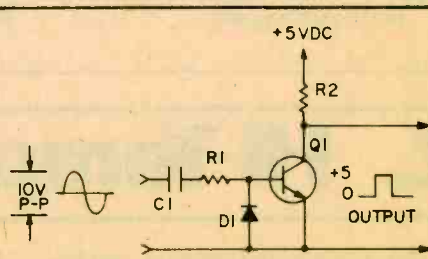


4. Square Wave Converter

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

PARTS LIST FOR SINE-TO-SQUARE WAVE CONVERTER

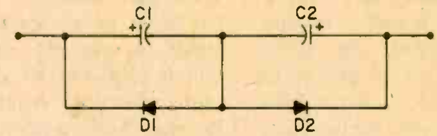
- C1—1.0-uF, 25-VDC non-polarized mylar capacitor
- Q1—2N3904 NPN transistor
- R1—4,700-ohm, ½-watt resistor, 5%
- R2—1,000-ohm, ½-watt resistor, 5%



5. NPO Capacitor

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

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



PARTS LIST FOR HOME MADE NPO CAPACITOR

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

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

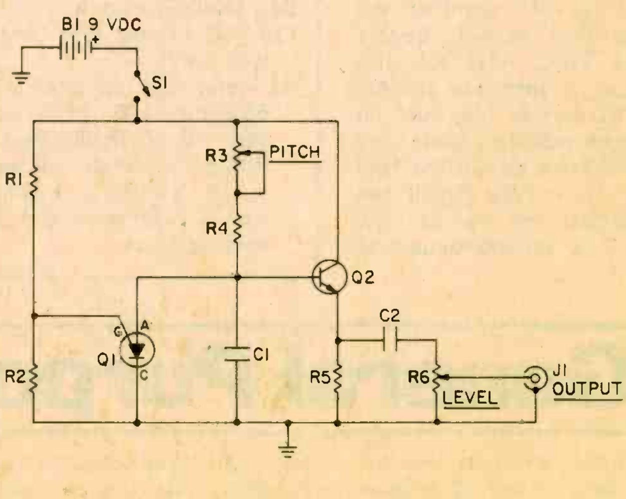
6. Moose Call

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

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

PARTS LIST FOR MOOSE CALL

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

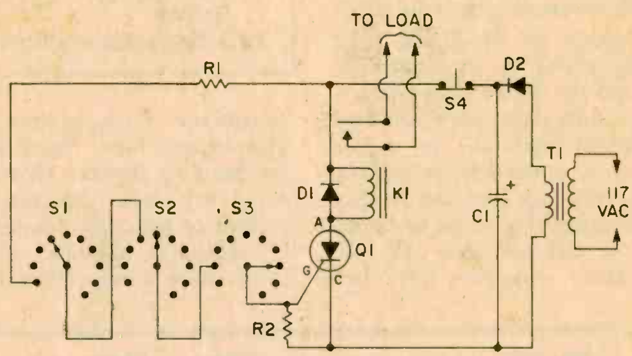


7. Combination Lock

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

PARTS LIST FOR THREE-DIAL COMBINATION LOCK

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

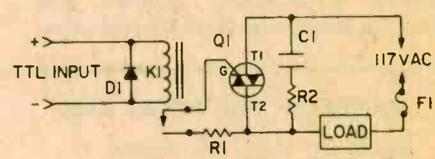


8. Computer/AC Interface

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

PARTS LIST FOR MICROCOMPUTER/AC INTERFACE

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



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

9. General Purpose Pulser

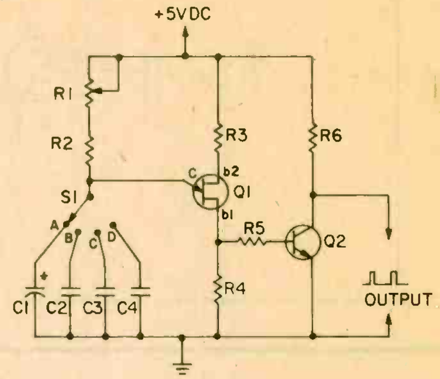
☐ Here is a simple pulse generator that can be useful in a variety of applications, from audio to logic. The heart of the circuit is the familiar UJT (unijunction transistor) relaxation oscillator, Q1. Potentiometer R1 adjusts the repetition rate over a range of one decade, while range switch S1 allows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

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

PARTS LIST FOR GENERAL PURPOSE PULSER

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

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



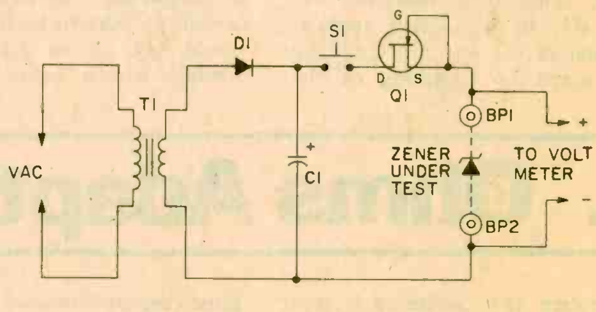
10. Zener Diode Tester

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

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

PARTS LIST FOR ZENER DIODE TESTER

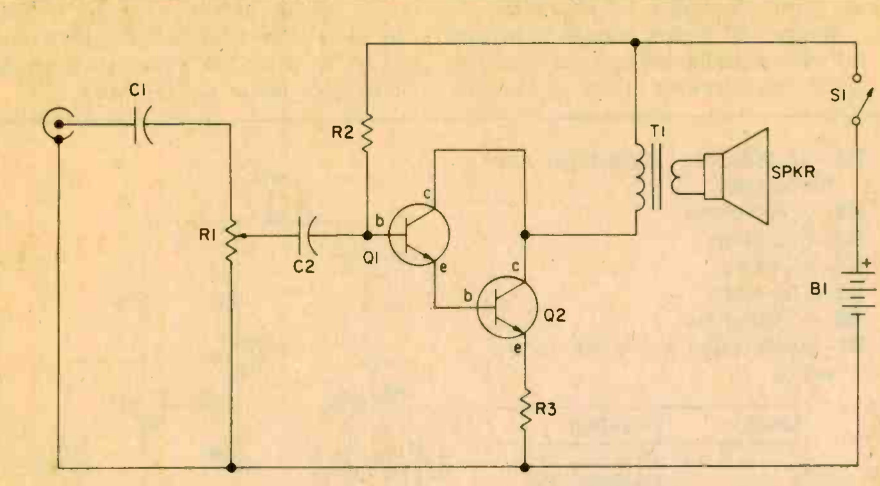
BP1, BP2—binding posts
C1—500-uF, 50-VDC electrolytic capacitor
D1—1N4002 diode
Q1—2N5363 n-channel JFET (junction field effect transistor)
S1—normally open SPST push-button switch
T1—120-VAC to 24-VAC @ 300-mA power transformer



11. Penny Pinchers Amplifier

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

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



R3—2,700-ohm, ½-watt resistor

PARTS LIST FOR PENNY PINCHER'S UTILITY AMPLIFIER

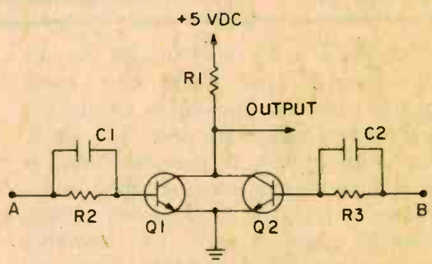
- **B1**—9VDC battery
- **C1, C2**—.1-uF capacitor
- **Q1**—PNP transistor, 2N3904 or equiv.
- **Q2**—PNP transistor, 2N2222 or equiv.
- **R1** — 1-Megohm potentiometer, audio taper
- **R2**—1.8-Megohm resistor, ½-watt
- **S1**—SPST switch
- **SPKR**—8-ohm speaker
- **T1**—500:8-ohm transformer
- **J1**—RCA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

12. Basic NOR Gate

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

PARTS LIST FOR BASIC NOR GATE

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



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

13. Ohms Adapter

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

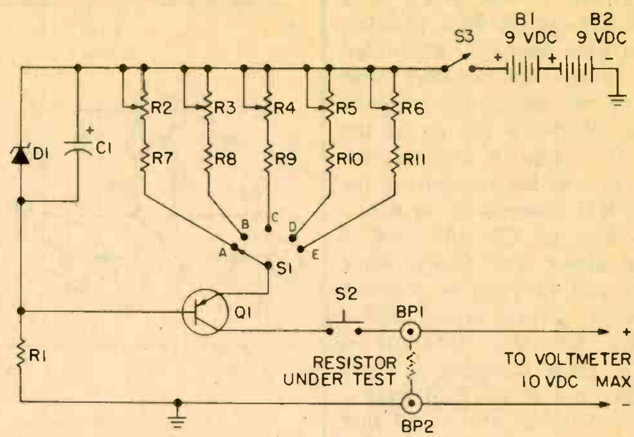
In the schematic, note that the resistor under test is tied between BP1 and BP2. Whenever S2 is pressed, a regulated current flows out of Q1's collector and through the resistor. By Ohm's Law, this current generates a voltage across the resistor that's directly proportional to its resistance. Any one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

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

When measuring resistance, use the following conversion formula:

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

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



PARTS LIST FOR CONSTANT CURRENT OHMS ADAPTER

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

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

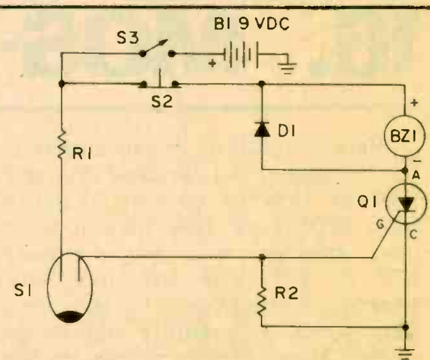
14. Equipment Theft Alarm

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

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

PARTS LIST FOR EQUIPMENT THEFT ALARM

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

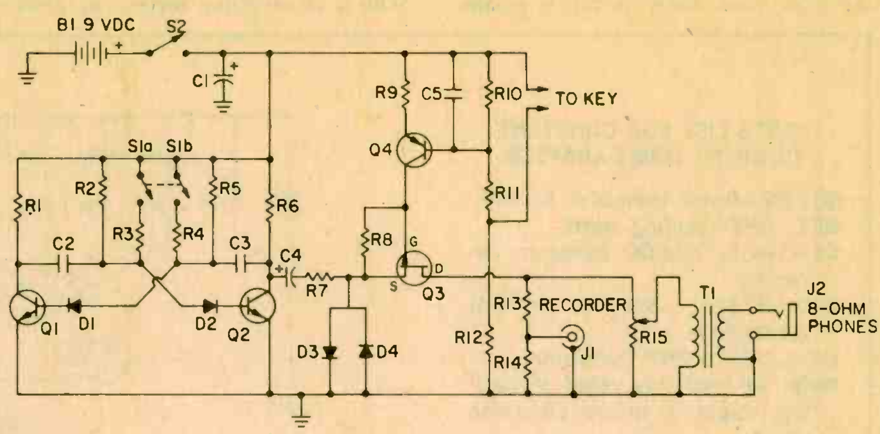


15. Code Oscillator

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

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

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



PARTS LIST FOR CODE OSCILLATOR

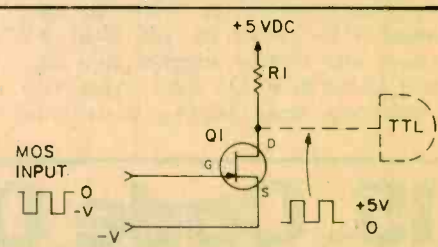
B1—9-volt transistor battery
C1—220-uF, 25-VDC electrolytic
C2, C3—0.22-uF, 25-VDC mylar capacitor
C4—2.2-uF, 10-VDC tantalum capacitor
C5—0.22-uF, 25-VDC mylar capacitor
D1, D2, D3, D4—1N914 diode
J1—RCA-type phono jack
J2—standard 2-conductor phone jack
Q1, Q2, Q4—2N3904 NPN transistor
Q3—2N3994 or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

16. MOS-to-TTL Interface

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

PARTS LIST FOR MOS-TO-TTL LOGIC INTERFACE

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



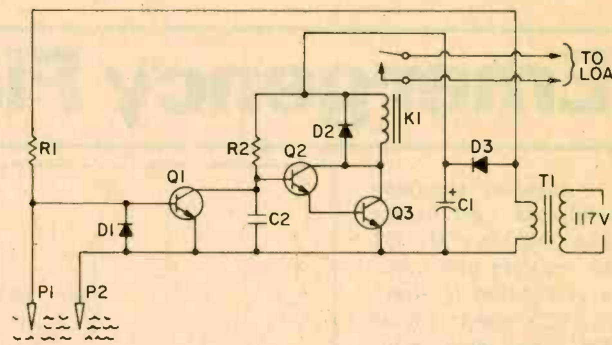
17. Fluid Detector

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

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

PARTS LIST FOR FLUID DETECTOR

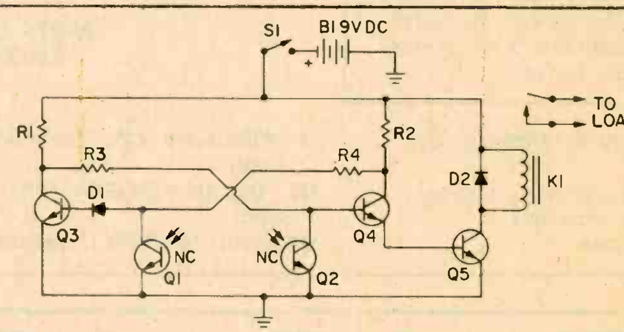
C1—500-uF, 25-VDC electrolytic capacitor
C2—0.5-uF, 25-VDC mylar capacitor
D1, D2, D3—1N4002 diode
K1—relay with coil rated 6-VDC @ 250 to 500-ohms, with SPST contacts
P1, P2—stainless steel or aluminum probes
Q1, Q2, Q3—2N3904 NPN transistor
R1—300,000-ohm, ½-watt, 5% resistor



R2—470,000-ohm, ½-watt, 5% resistor
T1—120-VAC to 6.3-VAC @ 300-mA power transformer

18. The Light Latch

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



PARTS LIST FOR LIGHT LATCH

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

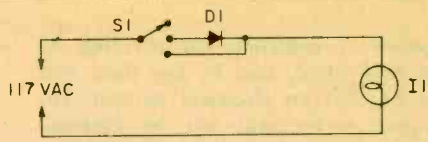
19. Photoflood Dimmer #1

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

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

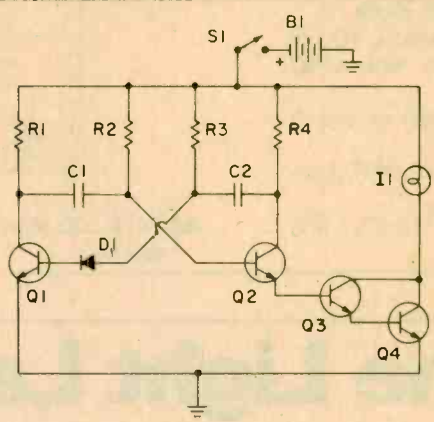
PARTS LIST FOR PHOTOFLOOD DIMMER

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



20. Emergency Flasher

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



PARTS LIST FOR PORTABLE EMERGENCY FLASHER

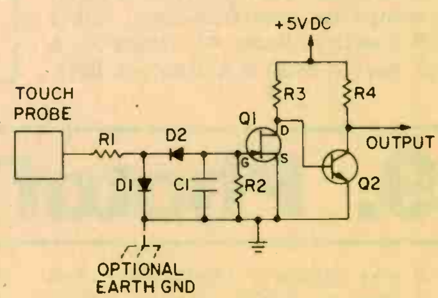
B1—6-volt lantern (heavy-duty) battery
C1, C2—1.0-uF, 25-VDC non-polarized mylar capacitor
D1—1N4002 diode
I1—#82 lamp rated 6.5-VDC @ 1-amp
Q1, Q2, Q3—2N3904 NPN transistor
Q4—2N3724A NPN transistor
R1, R4—10,000-ohm, ½-watt resistor, 5%
R2, R3—390,000-ohm, ½-watt resistor, 5%
S1—SPST toggle switch

21. Simple Touch Switch

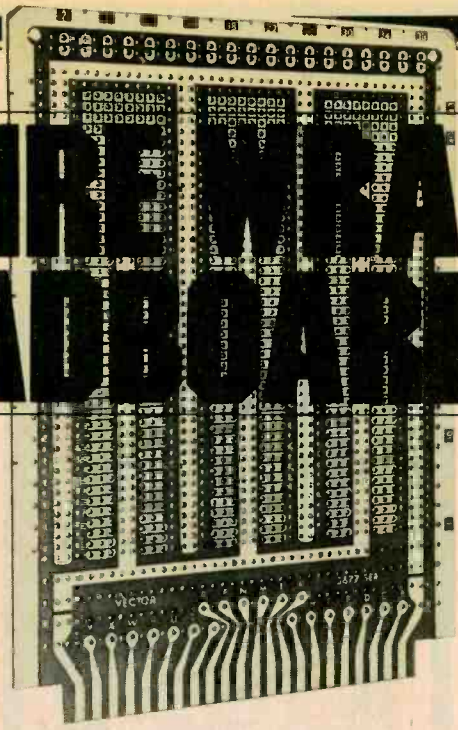
☐ Looking for a way to add a touch of class to your digital projects? Try this touch switch. Not only does it add a note of distinction to a project, but it's bounce-free as well. Whenever a finger touches the contact plate, stray 60 Hz powerline interference is coupled into the circuit due to the antenna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

PARTS LIST FOR SIMPLE TOUCH SWITCH

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



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.

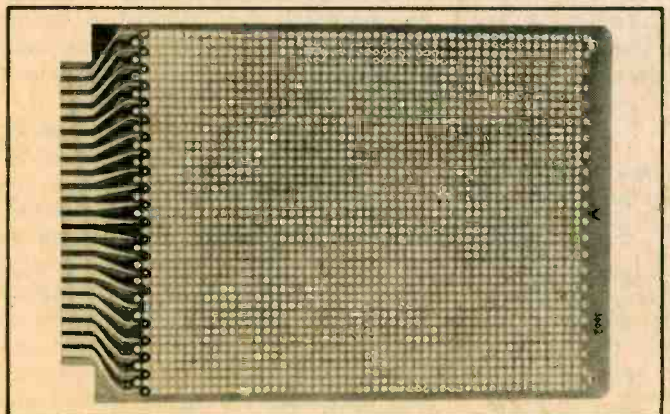
However, the finished product is rugged and, if designed with care, usually compact in size.

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).

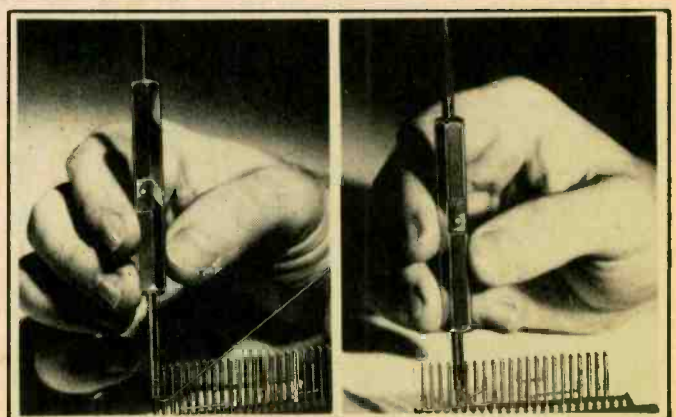
The Best of Both. This brings us to the relative newcomer in the hobbyist construction field, the wire-wrapped breadboard. We use the term "relative newcomer," because in fact wire-wrapping as a method of connecting components together on a circuit board has been around for close to twenty years, but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



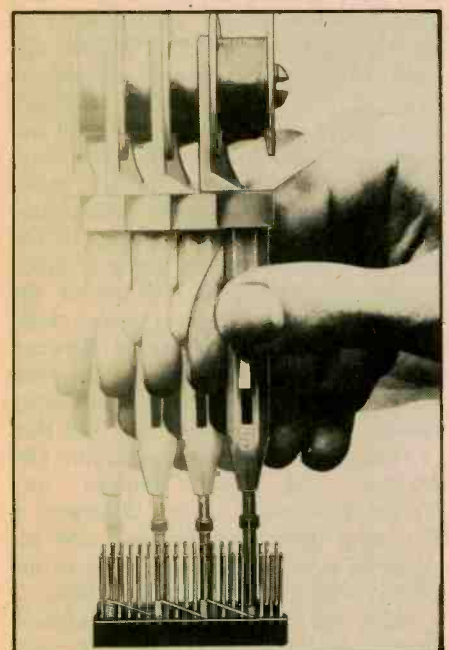
An excellent example of a "basic" matrix board is this model 3662 Plugboard™ from Vector. In addition to the edge-pin terminals, this model has hole spacing which accomodates that of DIP ICs.



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

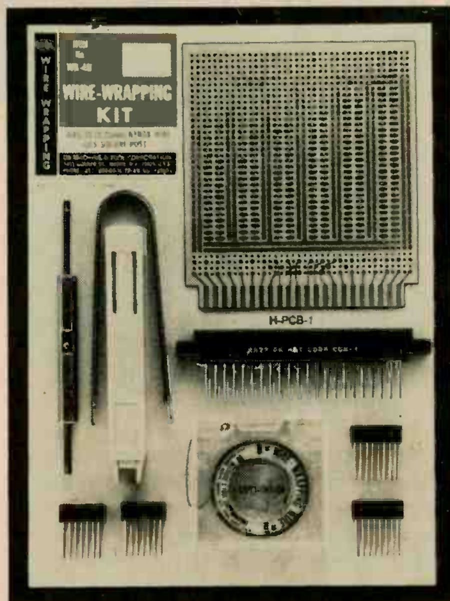
jects available for the hobbyist to build. One can literally build her or his own microcomputer from scratch these days, and the complexity of the circuitry involved dictates that the medium upon which the circuit is constructed be flexible enough to allow rearrangement of components and connections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

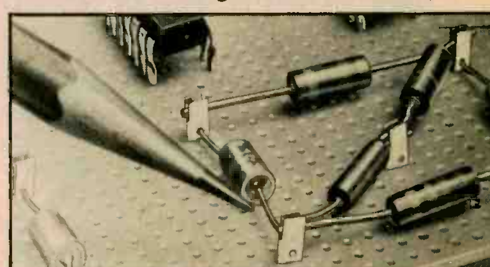


A good starter kit is OK's WK-4B, which contains all you'll need to begin to execute your projects in wire-wrapped formats. Make sure the terminals you buy are the correct diameter for your boards' holes.

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.)

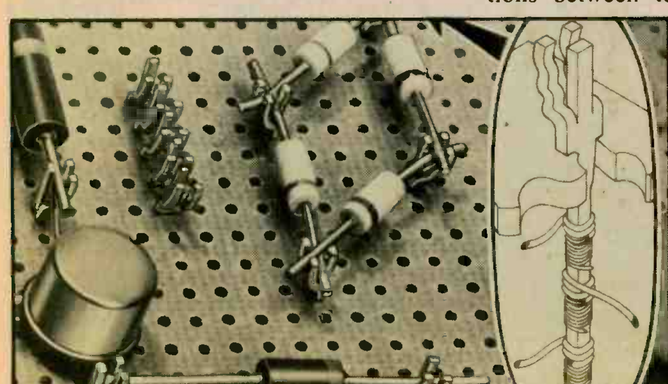
The base for your wire-wrapped circuitry can be as simple as a regular, perforated phenolic board, or something as esoteric as an epoxy/glass copper-clad board. The simpler perforated boards require that you merely insert wire-wrap terminals at the points where component leads meet on the board, and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

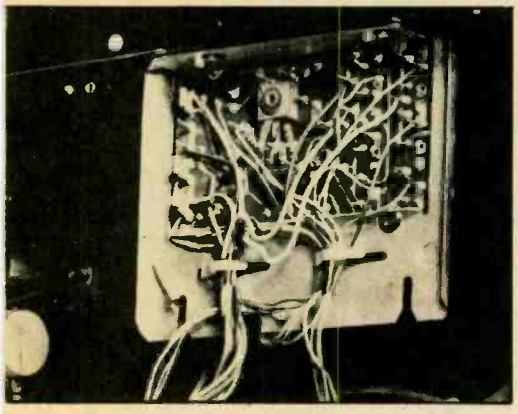
Some Nice Touches. Additionally, there are many specialized board designs available for computer-type circuitry, with special end terminal accessories for mating with standard ribbon connectors and/or PC card 44-pin edge connectors. For breadboarding peripheral circuitry for home computers, wire-wrap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

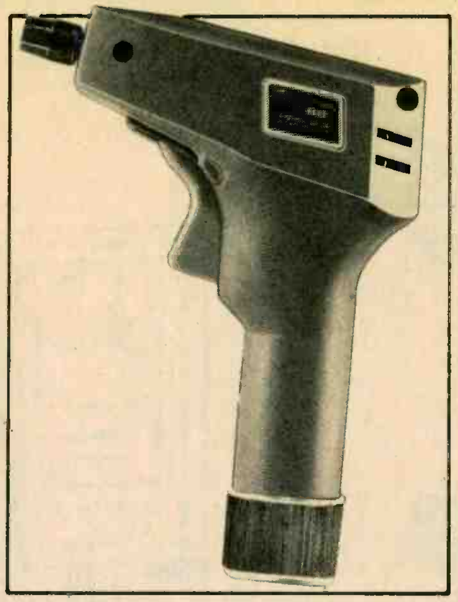
The more complex copper-clad boards which we referred to earlier also allow the builder to create "hybrid" circuit boards, utilizing the copper traces for standard printed circuit assembly of some components, while still being able to insert terminals through



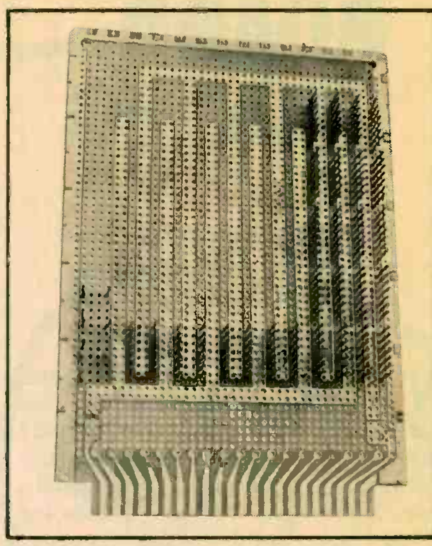
The high-voltage circuit board of this mid-1960's TV shows the use of wire-wrapped terminals combined with printed circuits. This type of hybrid can be built using the type of matrix boards seen on this page.

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.

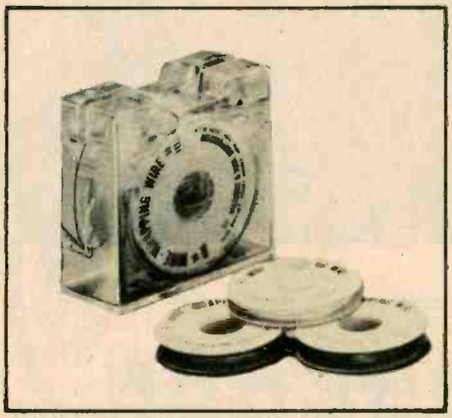
Where to Get Them. If the possibilities we've presented here appeal to you, then by all means do some further investigating on your own, either at your local electronics supplier, or by contacting the manufacturers directly. OK Machine and Tool Company, one of the largest hobby supplier of wire-wrapping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



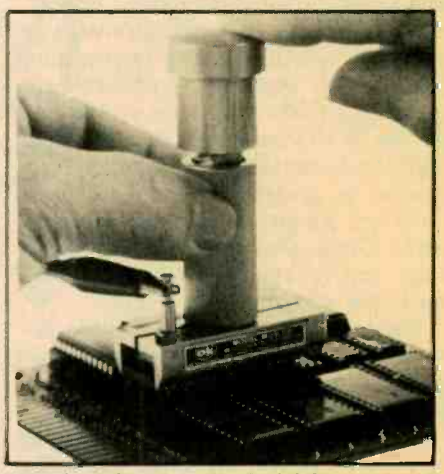
If you decide to go into wire-wrapping in a big way, a battery-operated wrapping tool can be a real time and work-saver. Interchangeable bits accommodate all wire sizes commonly used for wire-wrap construction.



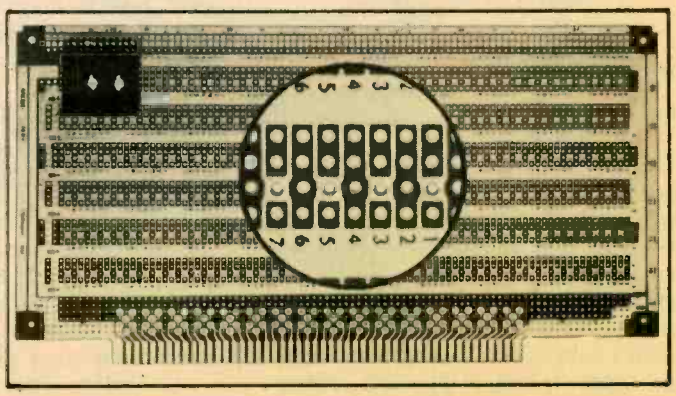
This Plugboard™ (model 3682-4) has etched copper bus strips for soldering as well as holes for wire-wrap terminals. This allows you to build rugged, yet flexible circuitry for virtually any electronic application.



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.



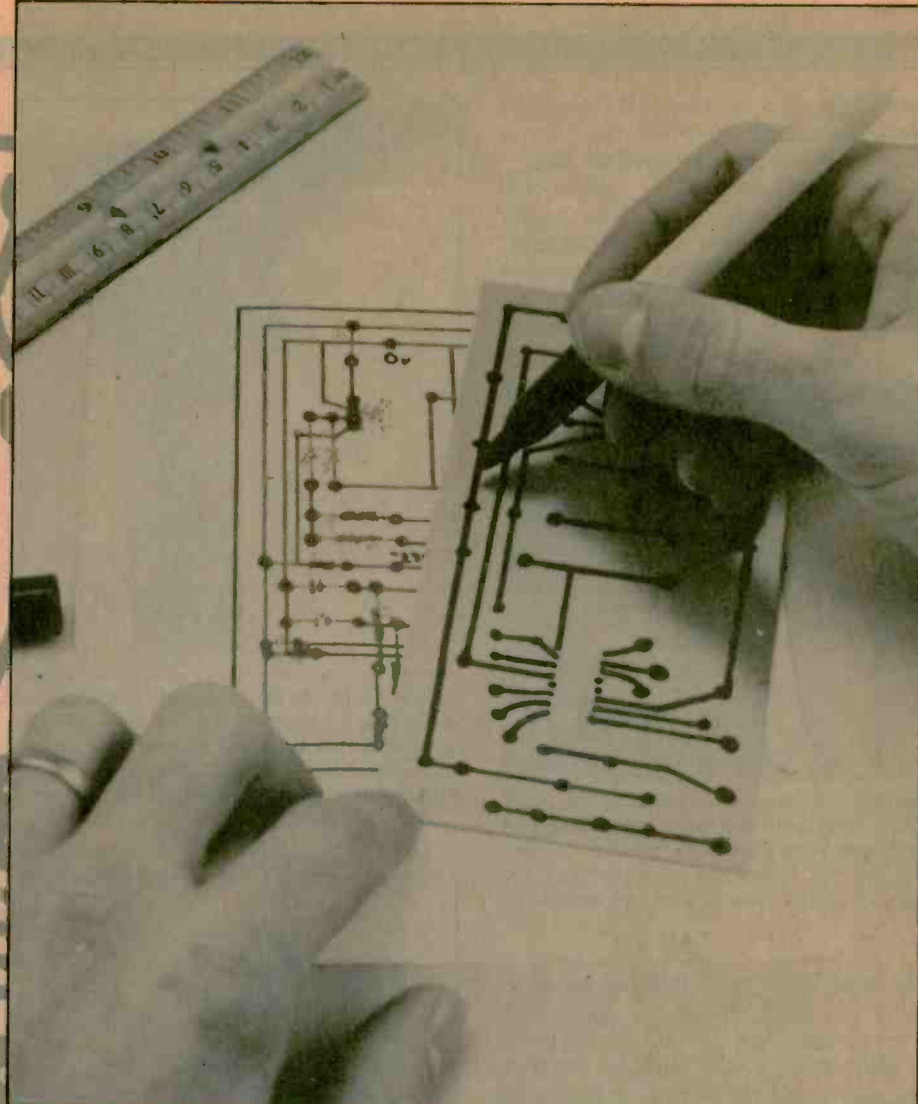
For safe and sure removal of delicate CMOS (as well as other types) ICs, an insertion tool is recommended. OK's MOS-40 has a lug for grounding the tool, this prevents damage caused by static electrical charges.



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.

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.

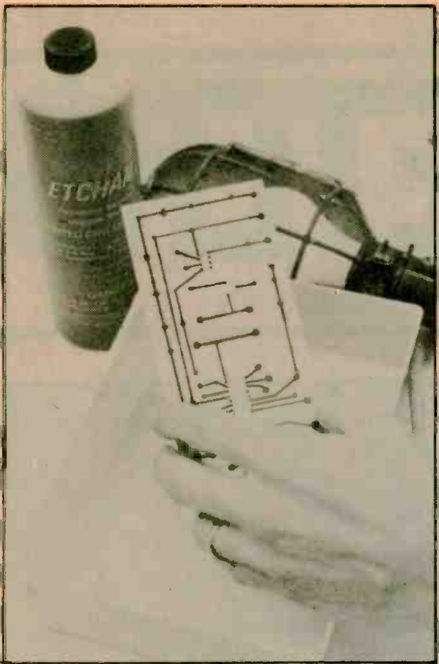
2. Etchant Solution. There is a variety of etchant solutions currently on the market, both in crystal form and already mixed. An inexpensive, pre-mixed solution of ferric chloride is good for a starter; it conveniently provides a uniform end product. Although the solution used during an etching (several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

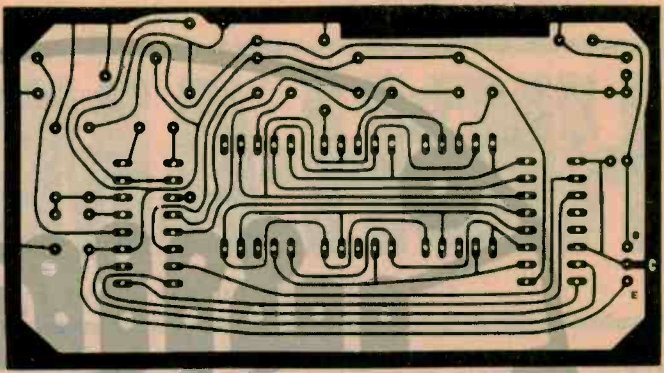
4. Shallow Pan. Do not use metal pans to etch in, because the etchant will act on the pan metal. Instead, use a glass or plastic pan close to board size to conserve the etchant solution. An inexpensive set of plastic photographic developing trays would be a good investment for etching projects. Photographic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

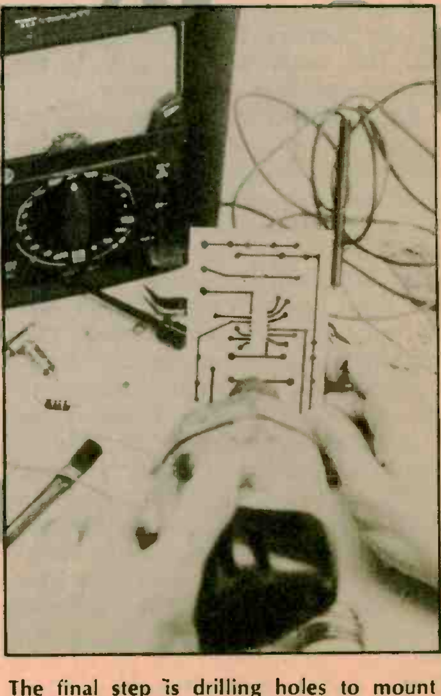
The etching process can be undertaken with success using no heat source if the etchant solution temperature is above 60°F. The process takes approximately one hour with no applied heat, but the results are not as certain.

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. ■



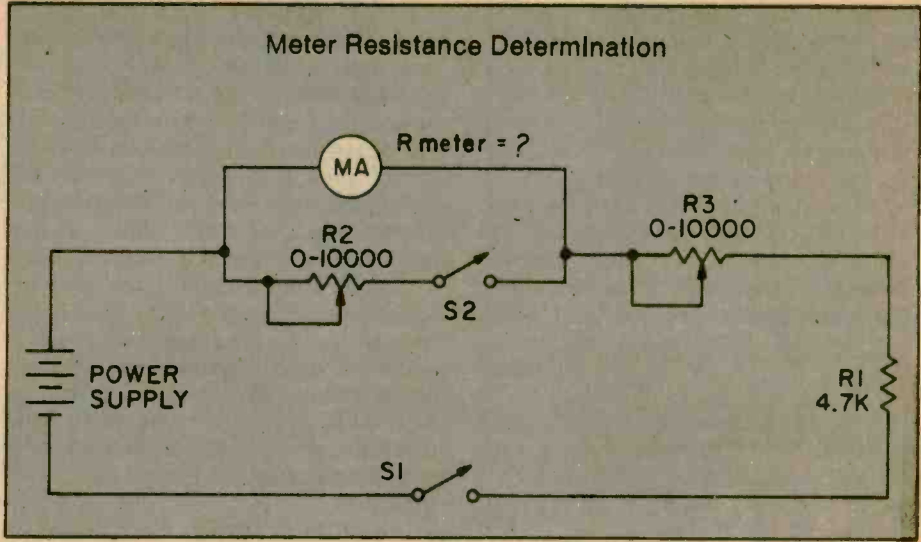
The final step is drilling holes to mount components. Use a 1/16- or 1/32-inch bit.

HIGH-AMP METERS

Keep up with current events by expanding your meter's amp-ability

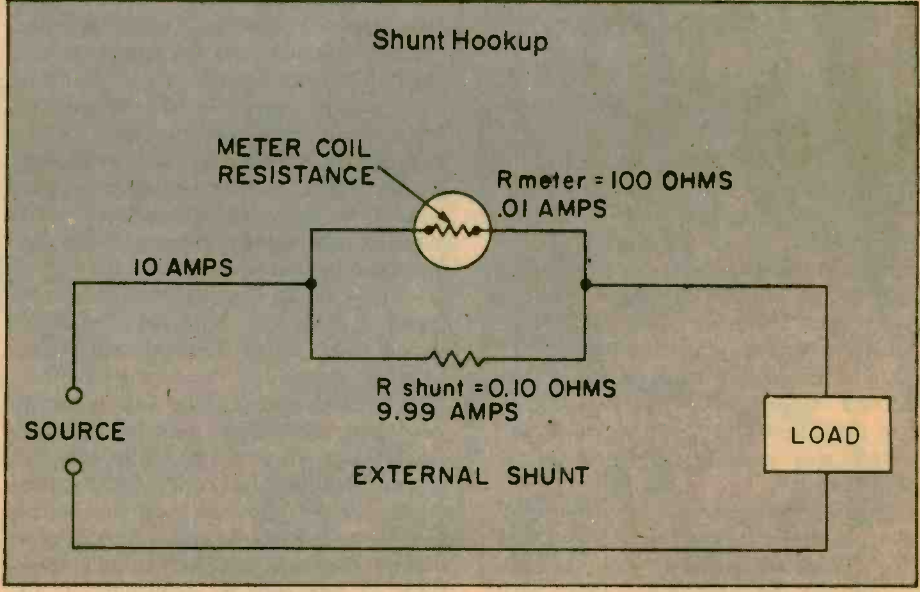
WITH THE RISING COST of test equipment it is advantageous to be able to perform several operations with one meter. For instance a DC milliammeter can be converted to read higher values of current by adding a shunt to bypass the bulk of the current around the delicate meter. By following a few simple steps a milliammeter can be converted to read 10 to 20 amps or more. The first step is to determine the internal resistance of the meter. From this you can calculate the shunt resistance needed and the type of material to be used.

To find the internal resistance of the meter, construct the test circuit illustrated here. The 4700 ohm resistor is used to limit current and serves no other purpose. Start with the power supply set to zero volts, leaving S2 open and S1 closed. Slowly increase the current flow by varying R3 until the meter needle moves to full-scale deflection. Without touching the setting of R3, close S2 and adjust R2 until the meter reads half of full scale. According to Ohm's Law the resistance of the meter and of R2 are now equal. Open switch S2 and measure the resistance across R2. This value will be equal to the internal resistance of the meter.



To determine the internal resistance of a meter construct a circuit like the one illustrated above. If you don't have the parts in your junk box then check an electronics surplus outlet.

A shunt resistor bypasses the bulk of the current around the meter while allowing a regulated amount to pass through the meter's coil and give an accurate reading. A shunt can be a resistor or a measured length of wire. Make sure it will handle the current.



Shunt. Precise shunt resistance is important for accurate current readings and must be chosen carefully. With the shunt connected across the meter, most of the current is diverted past the meter. This is the theory behind a small meter being able to read high currents. The shunt can be a wire, steel or copper bar, or almost any material that will offer the proper resistance. To determine the needed shunt resistance we will consider an example. If we want a 0 to 10 milliammeter to be able to read full-scale for a current of 10 amps. Therefore 10 mA will flow through the meter when 9.990 Amps are diverted through the shunt. If the meter resistance was 100 ohms, using Ohm's Law the voltage across this parallel circuit is found by using the following equation:

$$E = (\text{Current}) \times (\text{Resistance})$$
$$= (0.01 \text{ amps}) \times (100 \text{ ohms})$$
$$= 1 \text{ volt}$$

Using the calculated voltage and solving Ohm's Law for resistance the proper shunt can be found. This derivation is shown below:

$$\text{Resistance} = \frac{\text{Voltage}}{\text{Current}}$$
$$= \frac{1 \text{ Volt}}{9.990 \text{ Amps}}$$
$$= .1001 \text{ Ohms}$$

In this case the milliammeter would be capable of giving a readout directly in amperes.

By following these few simple steps you will greatly expand the versatility of your test equipment. It will increase your ability to handle a greater variety of test and trouble shooting situations. ■

A Basic Guide to Using Tune-Up Instruments

Do Your Own Electronic Tune-ups, and Save On Gas and Repairs

When one hears the words "engine tune-up," they usually bring to mind an automotive service which can result in a bill approaching $100.00 or more. As a result, many of us are content to forget about this facet of automobile maintenance until we are forced to do something because the engine runs very poorly or not at all. The irony of this situation is that while the engine is in such bad condition, it's costing you money in excessive gasoline consumption. Automobile tune-ups are not complicated, and the investment in parts is so small that there really is no reason why anyone, especially anyone who has a serious interest in electronics, should drive a car that is badly in need of a tune-up. The purpose of this article is to discuss the elements which comprise an engine tune-up, and to discuss some of the various electronic instruments which are being used by both professional and amateur car mechanics alike.

If possible, you should refer to the automobile manufacturer's specifications and tune-up procedures as a supplement to the information provided by this article. At the very least, refer to the tune-up information which is contained on a decal and prominently displayed in the engine compartment of your car. This will give the proper specifications for ignition timing, spark plug gap, and idle speed adjustments.

Tachometer. The basic automobile tune-up instrument is a combination tachometer and dwell meter, which is commonly referred to as a "dwell/tach." This instrument is capable of measuring engine RPM, and in those cars which are not equipped with factory installed electronic ignition, point dwell. (More about dwell later). The more elaborate instruments also include additional functions, such as voltage measurements, resistance measurements, and current measurements. For a small additional cost, some instrument manufacturers have included an alternator test function which determines the condition of the alternator diodes by measuring the level of AC ripple voltage appearing on the alternator output terminal.

The tachometer section of the dwell tach measures engine RPM by responding to the pulses which appear at the distributor side of the ignition coil (negative terminal). This is the point where the sensing lead of the instrument is connected. Referring to Fig. 1, a typical schematic diagram of a conventional (non-electronic) automotive ignition system, note that each time the points open, the collapsing magnetic field of

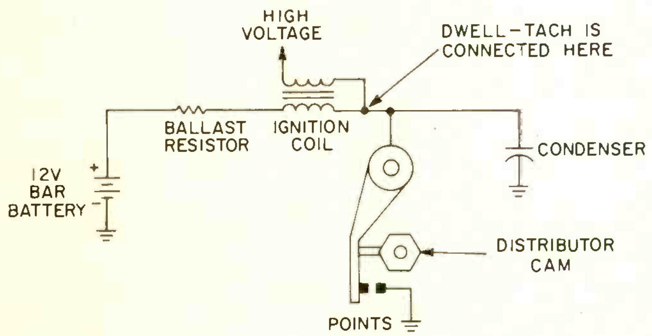


Fig. 1. A simplified schematic of an automotive ignition system using mechanical points (not electronic or "breakerless.")

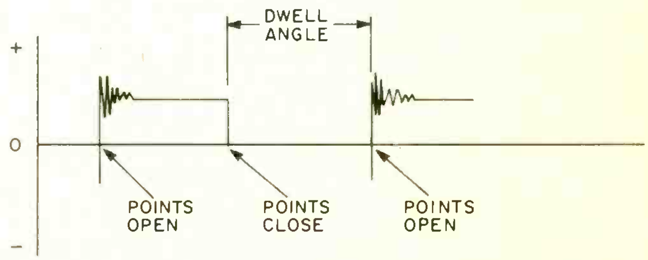


Fig. 2. This is a waveform representation of what occurs as points open and close. Dwell measurement is by averaging.

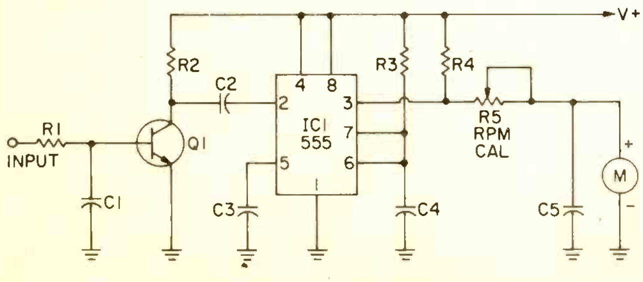


Fig. 3. This is a schematic of a simplified tachometer. It operates by counting pulses which appear at distributor side of coil.

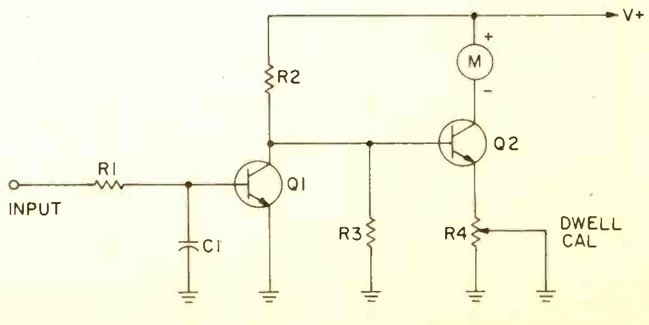


Fig. 4. This simplified dwell meter operates by reading voltage which is inversely proportional to that seen across the points.

the coil produces 20,000-volts or more at the secondary of the coil, and 100-volts or more at the primary. Fig. 2 illustrates the waveform appearing at the primary of the ignition coil, which is the voltage across the points. Since engine RPM is directly related to the number of pulses-per-second at the ignition coil, it can be seen that a simple frequency-to-voltage converter circuit can be used to measure engine RPM.

Fig. 3 is a typical schematic diagram of a tachometer circuit. Each time a pulse appears at the input to the circuit, Q1 conducts current and feeds a negative pulse to the trigger input of a one shot multivibrator, U1. The pulse duration of U1, about 4000 microseconds, is fixed. A resistor capacitor network, R5/C5, acts as a low pass filter to smooth the voltage pulses fed to the meter. The meter responds to the average of the voltage generated by U1, and is calibrated in RPM. Since the number of pulses-per-minute generated by 4, 6, and 8 cylinder engines is not the same, the meter circuit must incorporate a scale factor which automatically provides the correct RPM reading. This is the cylinder select switch which appears on tach's front panel.

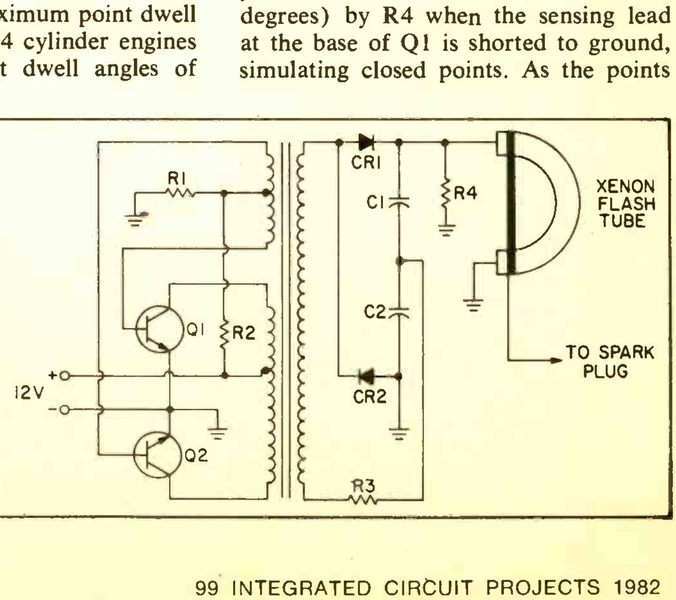
Electronic ignition systems provide a special test point which produces pulses for use with standard automotive tachometers. Refer to the service manual for your car, or ask your dealer for the location of the tachometer connection.

Dwell Meter. Point dwell is a measurement of the number of degrees that the ignition points in non-electronic systems remain closed during the rotation of the rotor in the distributor. This measurement is directly related to the point gap, and is a more accurate methor of properly tuning an engine. This measurement is made at the same test point in the system as used for the tachometer connection. Factory installed electronic ignition systems have no points, and therefore no need for dwell measurement.

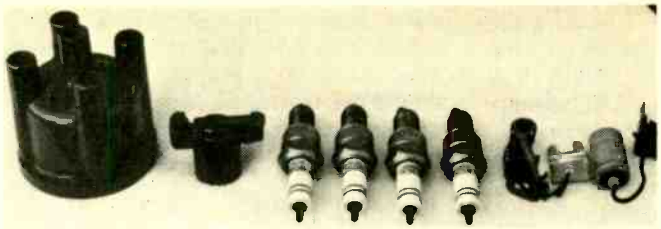
The number of degrees of point dwell depends on the number of cylinders in the engine. One full rotation of the distributor rotor is 360 degrees, and this is divided up in equal amounts for each cylinder. Thus, an eight cylinder engine can have a maximum point dwell of 45 degrees. 6 and 4 cylinder engines have maximum point dwell angles of 60 and 90 degrees respectively. Proper point dwell angle for these engines is usually slightly more than half the maximum. Typical dwell angles for 8, 6 and 4 cylinder engines would be 28, 36 and 56 degrees respectively.

The dwell meter measures dwell angle by producing a meter reading which is inversely proportional to the average voltage across the points. One such circuit that does this is shown in Fig. 4. The voltage appearing at the points is fed to the base of Q1, so that it is cut off when the points are closed, and saturated when the points are open. The collector of Q1 controls the base of Q2 which is connected as a constant current generator. Meter current is adjusted to full scale value (45, 60 or 90 degrees) by R4 when the sensing lead at the base of Q1 is shorted to ground, simulating closed points. As the points

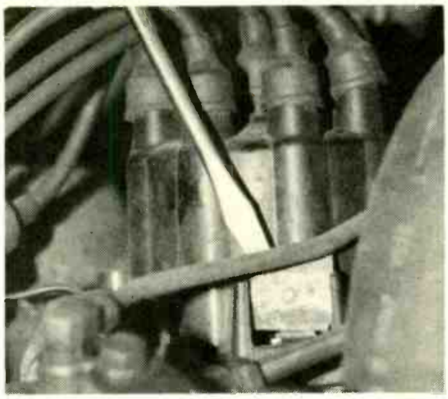
Fig. 5. A timing light uses a DC-to-DC converter to obtain the necessary high voltage used to trigger the flash tube. Stroboscopic action freezes flywheel motion to observe camshaft/valve timing.



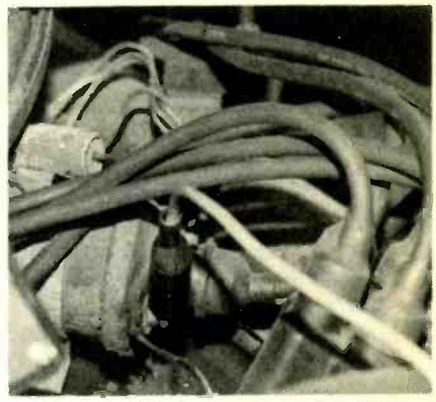
Tune-Up



This is a typical ignition tune-up kit for a 4-cylinder car. From left to right: distributor cap, rotor, spark plugs, points, and condenser.



Almost all pre-1975 Delco (GM) distributors have a window through which point gap (dwell) can be adjusted while engine is running. This saves the time needed to remove cap and rotor to reset gap.



The input lead to the Dwell/Tachometer is connected to the distributor side of the coil. You can find this terminal by tracing back the wire from the condenser to the coil. Clip on the lead at the coil terminal.

open and close at a rapid rate when the engine is in operation, the meter reading becomes the average of the two conditions and is the actual dwell angle of the points.

Timing Light. One final electronic instrument which is required for engine tune-up is the timing light. Quality timing lights are referred to as "power" timing lights, which means that the energy which fires the xenon flash tube is derived from a built-in power supply. Most units in use today use the car's 12-volt battery as the source of power. Refer to Fig. 5 which is a typical timing light schematic diagram. A DC to DC converter circuit charges two capacitors in a voltage doubler circuit to the high voltage (250 to 450-volts) necessary to fire the flash tube. The spark voltage generated by the car's ignition system provides the trigger which causes the flash tube to conduct, producing a burst of light perhaps 1/1000 second in duration. The car manufacturer has provided a timing mark on the flywheel of the engine, and a timing scale next to the flywheel. When spark plug number one fires, the stroboscopic action of the timing light enables the mechanic to visually determine if the flywheel is in the proper position. This shows engine timing.

The best timing lights on the market provide inductive coupling to the spark plug wire so that it is not necessary to insert an adapter in series with the distributor wire and number one spark plug. Spark plug wires must never be pierced to make a timing check. To do so will render the wire defective.

The Engine Tune-Up. In addition to making the electrical measurements described above when tuning up an engine, there are certain mechanical procedures which must be performed to do a complete job. These procedures should be performed before making any electrical measurements or adjustments on the engine. It is not the purpose of this article to deal in depth with the mechanical procedures, and they will simply be mentioned briefly.

A complete and proper engine tune-up will include replacing spark plugs, ignition points, and condenser (if so equipped). In addition to these items, the distributor cap, rotor, fuel filter, and PCV valve should be either replaced or examined to make certain that they are still in serviceable condition. The air filter and crankcase ventilation filter should also be cleaned or replaced as necessary. The last item on this list are the carburetor and choke linkages, which should be cleaned with a carburetor spray product made for the purpose. Once these procedures have been completed, you are ready to perform the instrument checkout.

The electrical checkout of the engine is made with the engine running and warm. On those cars which use ignition points, it will be necessary to set the point gap to the proper spacing so that the engine can be started. The only exception to this is on General Motors cars which use external adjustment Delco Remy distributors. Replacement points in these distributors usually are preset to such a gap that will permit the engine to be started without any prior adjustment.

A word of caution before making the instrument checkout of the engine: At no time should you permit your hands to come in contact with the metal portion of the test instrument's clip lead as you are connecting or removing it from the engine, if the engine is running. The test point may have sufficient high voltage to cause electrical shock. This may result in personal injury as you jerk your hand away. If in doubt, make your connections with the engine shut off.

Dwell Angle. The first measurement and adjustment to be made is dwell angle, which is necessary on all cars that have conventional (non-electronic) ignition systems. Attach the meter leads to the distributor side of the ignition coil and chassis, observing correct polarity. On negative ground automobile electrical systems (as in all American made cars), the positive lead of the meter is connected to the ignition coil. Follow the meter manufacturer's instructions for dwell measurement, and refer to the decal in the car engine compartment for the permissible range of dwell. If your measurement falls out of this range, the point gap will have to be decreased (for readings too low) or increased (for readings too high). On most General Motors cars, this is a simple adjustment which can be made with an Allen wrench while the engine is running. On other cars you will have to stop the engine, remove the distributor cap, and reset the point gap making it greater or smaller as necessary. Recheck dwell angle with the instrument after readjustment of the point gap.

Timing. After the proper dwell angle has been attained, the ignition timing can be checked and set if necessary. Ignition timing should always be checked after changing ignition points or point gap since any change in dwell angle will cause a corresponding change in timing. Improper timing will affect gas mileage, engine power, and exhaust emissions levels.

Before starting the engine, you can facilitate the timing measurement by cleaning the engine flywheel and locating the timing mark, which is usually a narrow groove impressed in the flywheel. If possible, apply a small quantity of white paint or chalk to this groove to make it more visible. You must also locate the vacuum advance mechanism which is located at the bottom of the distributor housing, and remove the vacuum advance hose which is connected to the mechanism. Plug the open end of the hose with a pencil. This procedure is necessary if the timing of an engine is to be made with the automatic vacuum advance disabled. Check to see whether or not your car requires this procedure.

Connect the timing light to the number one spark plug according to the directions provided by the timing light manufacturer. Connect the timing light power leads to the car battery, observing correct polarity. Check to make sure that no wires will be caught by the fan or other moving parts. Start the engine and measure the timing. Refer to the tune-up decal in the engine compartment, which should have an illustration of the timing scale for your particular engine. If the timing is out of spec, adjustment is made by loosening a clamp at the bottom of the distributor housing and rotating the unit to the correct spot. Tighten the clamp, and recheck the timing to make sure it did not change. Stop the engine and replace the vacuum hose if it was removed earlier.

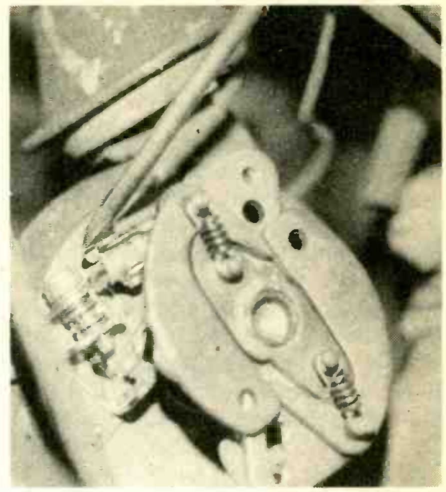
Carburetor Adjustments. All carburetors have some form of adjustment which controls engine idle speed. Single barrel carburetors have one adjustment for idle fuel mixture, and two and four barrel carburetors have two fuel mixture adjustment screws. These adjustments are performed with the aid of the tachometer, since engine RPM will vary as these adjustments are made. Since the order in which these adjustments are performed is important, the best practice would be to follow the vehicle manufacturer's sequence. Some tune-up decals in late model cars contain the proper adjustment sequence. The following procedure should prove satisfactory for most cars. Note: Some cars equipped with extensive emission control equipment have plastic caps covering the idle mixture screws, which limit the adjustment range of these screws. Under no circumstances should these caps be removed to set the mixture screws beyond the normal adjustment range. To do so may upset the engine exhaust emissions and/or affect driveability of the car.

Allow the engine to reach normal operating temperature before adjusting the carburetor. Connect the tachometer to the ignition system according to the manufacturer's instructions so that the meter reads engine RPM. Follow the information provided on the tune-up decal as to whether the transmission should be in neutral or drive, and if the air conditioning or lights should be turned on. (Be sure to set the parking brake securely before placing the transmission in Drive!)

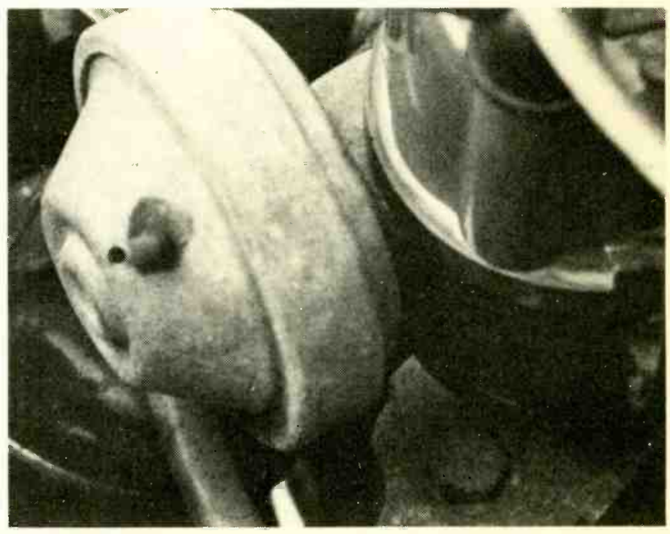
Adjust the idle mixture screw or screws for maximum engine RPM. Do this very carefully since only a small adjustment is usually necessary. Now adjust the engine idle speed adjustment to the engine RPM as specified on the tune-up decal. Very carefully turn the idle mixture screws clockwise to attain a 20 RPM drop in engine idle speed. Reset the idle speed adjustment for the recommended engine RPM.

The method just described is known as the "lean roll" method of setting the idle mixture. With this method, the vehicle exhaust emissions should be within specifications, and it avoids the necessity to use an exhaust gas analyzer for adjustment of the idle mixture.

If you have performed the various engine adjustments as specified, you should have an automobile that performs as well as it was designed. Keep a record of the date and speedometer mileage, so that you will be ready to perform the next tune-up when due. ■



With cap and rotor removed on this Delco distributor, the point gap adjusting screw can be seen. Lift the window in the distributor cap and you can turn this screw to perform point gap (dwell) adjustment.



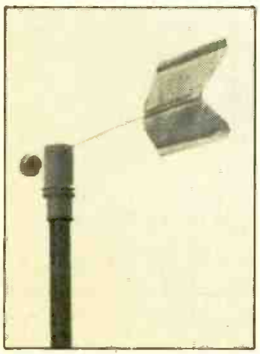
Release the distributor clamp bolt at the base of the distributor to adjust timing. Some engines need to have their timing adjusted with the vacuum advance (round object mounted on the side of the distributor) connected, and some need it disconnected. Check in your owner's manual or with your dealer.

Use of the timing light allows you to freeze the action of the flywheel and read the timing adjustment. A decal under the hood will list number of degrees (either in BTDC or ATDC) to which pointer on the flywheel must point to on scale next to the flywheel. Timing is adjusted by rotating the distributor body.

LED WEATHER VANE

Lets You Know Which Way to Bend With the Breeze

BY T. J. BYERS



The LED weathér vane should be mounted high above a roof and clear of any obstructions that might distort the flow of the wind.

WHETHER YOU ARE A PILOT, farmer, sailor, kite flyer or just plain curious about tomorrow's weather so you can go to the beach, this low-cost electronic weather vane will tell you which way the wind blows. All you need are two readily available IC chips, some variable resistors, LEDs, and a handful of junk-box parts to put it together.

By learning how the weather changes with the shifting winds you can learn to predict what is going to happen over your head over the next few hours, rather than trusting that last night's six-o'clock forecast was accurate. We don't have the space to teach you meteorolgy here, but there are plenty of books available on that fascinating subject. Or, you can ask an old-time sailor or farmer to tell you some of the tricks of weather watching.

Wind Direction. Essentially, measuring the direction of the wind is a simple and ancient process. Although there are a couple of methods (the airsock, so familiar at small airports, and the vane), only the vane is suited for our needs.

A vane is fabricated from a flat sheet of material. A pivot point is selected. The material is cut (or fashioned, as in the case of the weathercock rooster) so that one surface about the pivot has considerably more area than the other.

The vane is placed into the wind. Now as the air strikes the surfaces, a force is developed. A greater force is exerted on the larger area. This imbalance of forces causes the vane to twist, seeking an equilibrium; this occurs when the vane is pointing into the oncoming wind. When people talk about wind direction they always refer to the direction the wind is coming from. In other words a northwest wind is blowing out of the northwest towards the southeast. The weather vane would be pointing northwest. To translate this into usable information a transducer is used.

A transducer converts the outside world into a more appropriate form. For us, a potentiometer is the logical choice. By connecting the vane to the control shaft, it will rotate in accordance to wind direction.

When a voltage is applied across it, the wiper becomes a voltage divider with the resultant voltage relative to the shaft position.

The Circuit. But voltage is a very abstract value and in its raw form doesn't lend easily to interpretation of wind direction. So, we incorporate a decoder of sorts. (The two circuits will analyze the voltage as it comes from the sensor; the conversion is merely for our sake.)

The input voltage is converted to a display representative of a compass (the standard used to indicate wind direction). The decoder and display consists of two ladder-type LED driver ICs—the ones so popular with graphic power and tuning displays. U1 and U2 are LM 3914s connected in cascade. They are programmed with a jumper from pins 9 to 11 for dot display.

When a voltage is presented at the input (pin 5), a LED corresponding to that voltage will light. By matching the potentiometer range to that of the display, we represent 16 positions of the shaft, which is the number of compass points associated with wind direction.

Arranging the LEDs in a circle completes the concept, giving us the visual effect of a compass. There are, however, a few not so obvious points about the circuit.

Each IC carries a complement of eight LEDs instead of its capacity of 10. In the case of U1, it was necessary to eliminate the topmost indicator, pin 10. A curious thing occurs with this device when the input voltage exceeds full scale. The last LED will remain constantly lit. We are cascading the two units to increase the number of indicators and unless additional circuitry is incorporated, this situation would prove intolerable. Two indicators at the same time would be confusing. Eliminating this pin circumvents the problem.

In the case of U2, we want the last LED to light. To understand the reasoning behind this we must look at the potentiometer. The resistance element isn't continuous; it has a break in it. When the wiper reaches this position, the output voltage (input as seen by the decoder) goes high.

In this situation, the only lamp to light is the last one LED16. What was a problem for the first series of indicators becomes a solution for the upper set. The remaining LEDs are accordingly distributed.

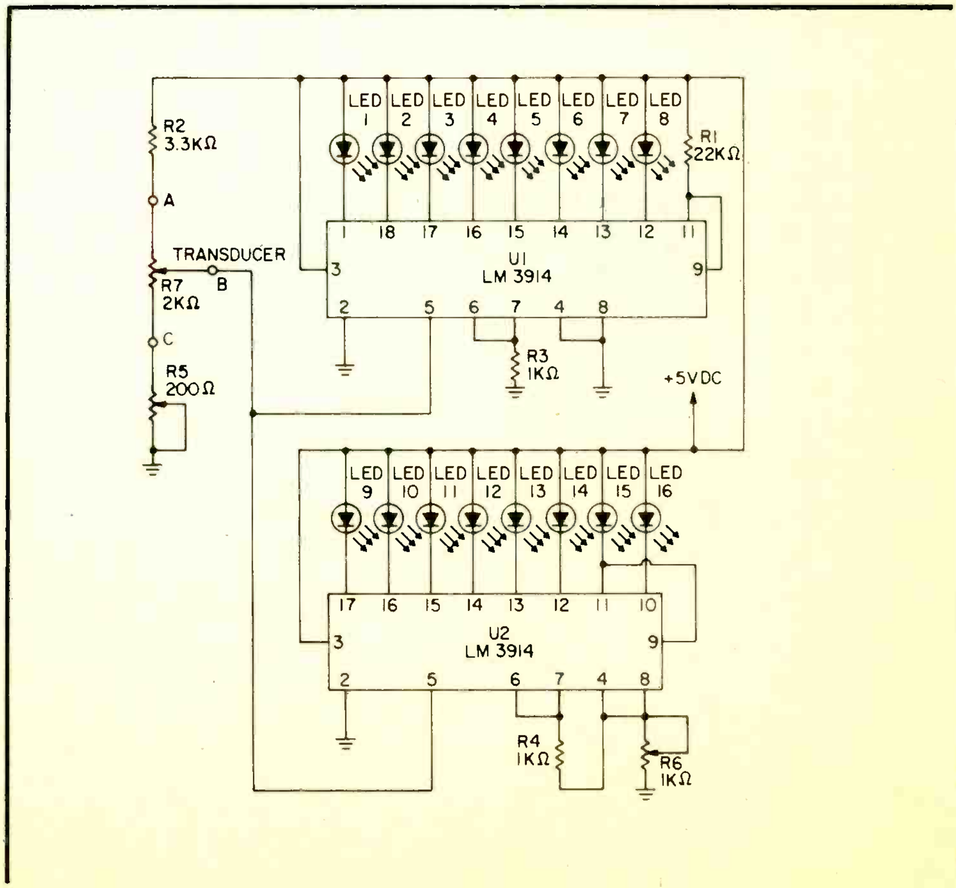
The circuit also has two adjustments to it. R6 controls the input voltage of U2 so LED9 can take over after LED 8 has extinguished. R5 is necessary to overcome the initial voltage required to begin the ladder process.

Constructing The Sensor. Since the wind vane will undoubtedly be less familiar than the electronics, let's start there. Begin by obtaining a steel bev-

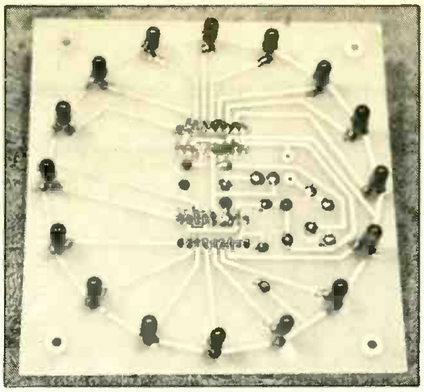
PARTS LIST FOR WIND DIRECTION INDICATOR

LED1-LED16—Jumbo, red light emitting diodes
R1—22,000-ohm, ½-watt, 10% resistor
R2—3,300-ohm, ½-watt, 10% resistor
R3, R4—1,000-ohm, ½-watt, 10% resistors
R5—200-ohm, trimmer potentiometer
R6—1,000-ohm, trimmer potentiometer
R7—2,000-ohm precision linear potentiometer, 360-degree-free rotation (Bourns model 6538 or 6638 preferred—next choice Bourns 6537 or 6637).
U1, U2—LM 3914 dot/bar display driver integrated circuit
Misc.—cabinet, prescription vial (1½" x 2½"), coat hanger, bezel, beverage can (vane), P.C. board, counterweight, epoxy, hardware, wire, etc.

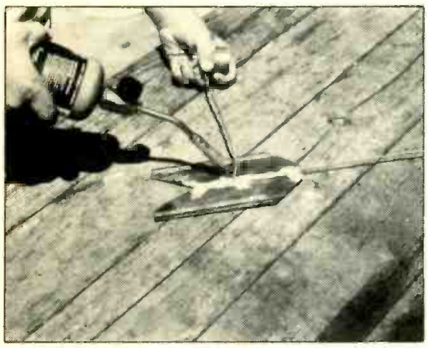
Note: An etched and drilled printed circuit board is available from Danocinths, Inc., P.O. Box 261, Westland, MI 48185, for $7.93 plus $1.50 shipping and handling. Michigan residents add 4% sales tax. Specify RW-102 when ordering.



Use tin snips to cut the sheet metal to the appropriate shape (see next page).



LEDs mount on the foil side of the printed circuit board (see text instructions).



Use a blowtorch to solder the vane to the rod. Beware of dangerous fumes released from the tin plating by heat.

erage can. But be wary, most containers nowadays are aluminum and won't work for our application. However, almost all canned teas come in steel, as do some colas. With an opener, remove the top and bottom; next cut down the seam with a pair of tin snips. Don't attempt to flatten the metal.

Remove the outside edge with the snips, then smooth the metal. Shape the vane according to the template. This isn't a necessary step—merely aesthetic. A rectangle will work equally well.

Rigidity is given to the finished piece by bending three grooves into the metal. Lay the vane over a thin metal rod along the designated lines and run a piece of wood over it. A notch in the end of the wood will impart a deeper groove.

Cut out a 10-inch section of coat hanger. Remove the paint and solder it to the center groove of the vane. This must be done in a well ventilated area. The stannous fumes are poisonous!! Avoid inhaling any fumes coming from the tin plating, which will vaporize as soon as you apply heat.

A counterweight is necessary to remove lateral pressure from the potentiometer bearing. It can be fabricated in a number of ways; ours is the decorative end from a curtain rod, along with a short piece of coat hanger filled with solder.

Here's where it all comes together. Obtain a plastic prescription vial, one about 1½ inches in diameter by 2½ inches deep. The plastic bottle will serve to keep rain and dirt out of the sensor pot as well as provide a convenient method of assembly.

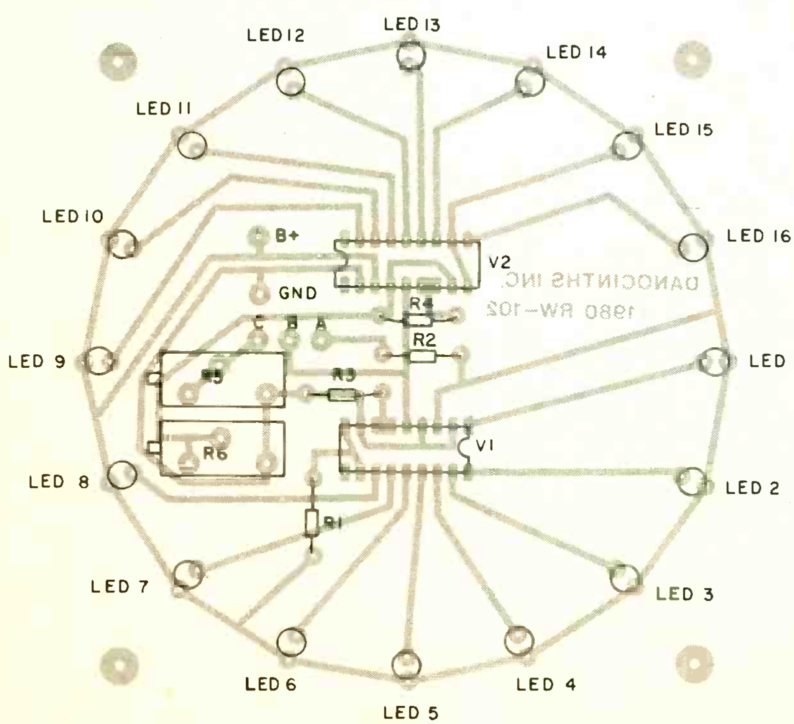
Drill two 7/64-inch holes near the bottom. Locate them so a single piece of wire will pass through the center, barely clearing the bottom. Drill a hole in the center (⅛ inch of the bottom just large enough to accept the potentiometer shaft. It should be a snug fit. Push the support wires from the vane and counterweight into the side holes and adjust the length of the counterweight until the system is in balance.

Epoxy It. Epoxy will hold everything together, but first you must provide the rheostat shaft. Take the drill bit used to make the hole and cover it with a light vegetable oil coating. Place it shank end down into the hole. Line up everything and fill the bottom of the vial with a layer of fast-setting epoxy just thick enough to cover the support wires. Make absolutely sure the drill bit is straight up and down, lest you develop a wobble when the casting is dry.

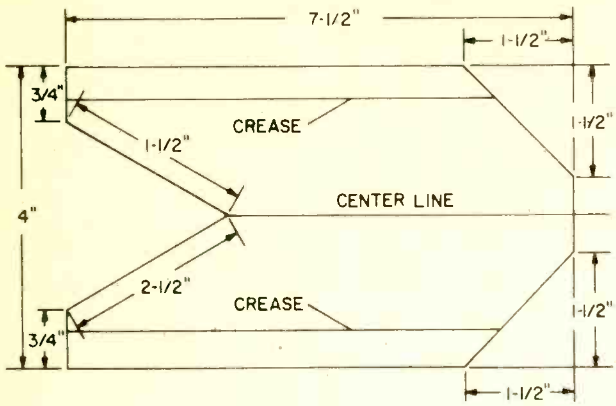
After the epoxy has set remove the drill. Now, set aside to harden overnight.

The transducer pot is mounted inside a ¾ inch plastic coupling. Let's pause for a moment and examine the sensor pot. It's a special precision pot, in that the resistance element has 340-degrees of electrical contact. An ordinary control has only about 260, maybe 290, degrees of resistance path.

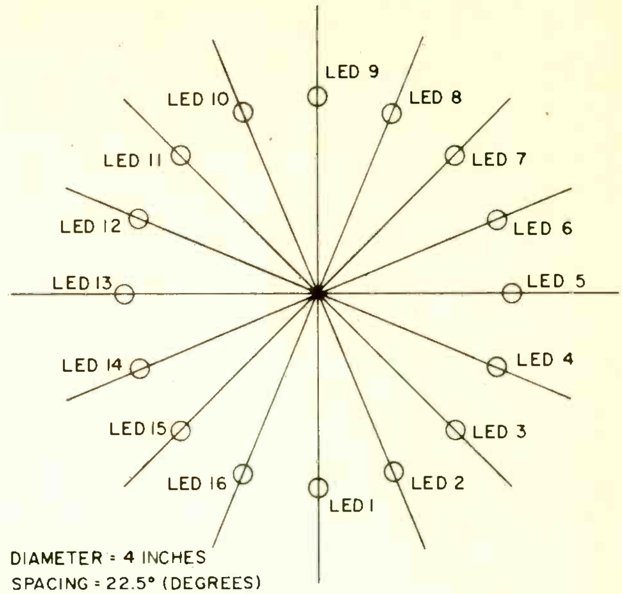
Attach three wires to the potentiometer and seat it into the coupling with silicone adhesive. Avoid getting



The above diagram shows where the parts are installed on the printed circuit board. Be sure to mount the LEDs on the foil side with cathodes on the outside ring. The flat edges of the LEDs should face the middle of the board.



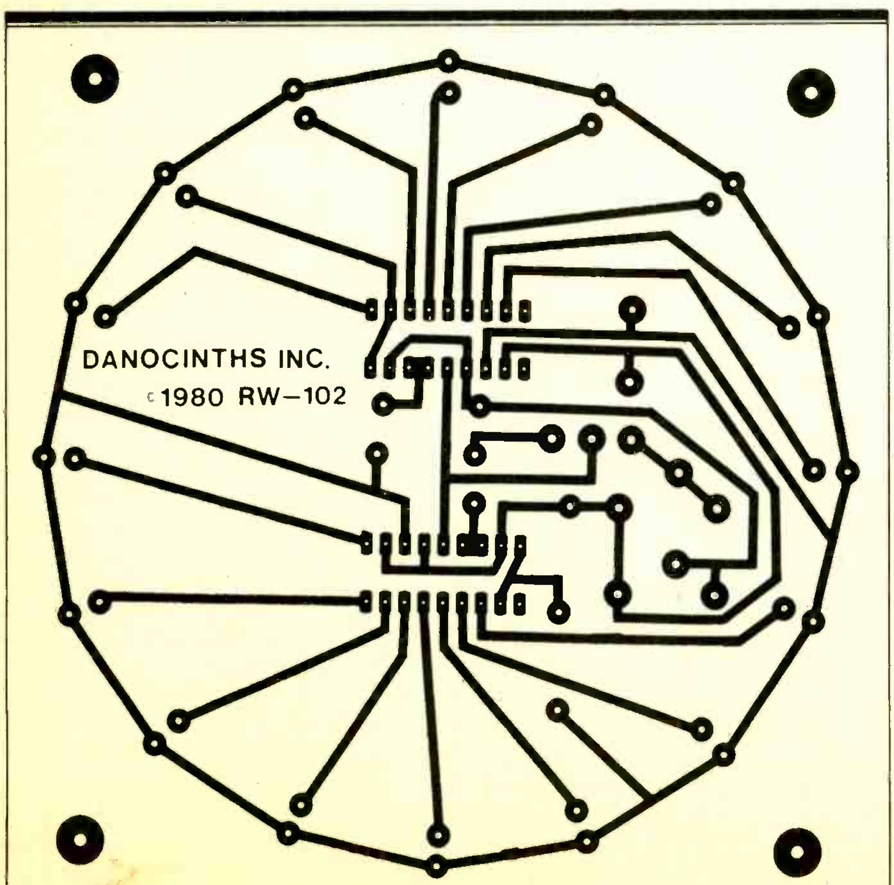
The above pattern is just a sample of a possible weather vane design. This one worked well and has proven itself quite durable. Be sure it points straight at the axis.



The drawing at the right shows the spacing relationships of the LEDs. Be very careful locating the holes and mounting the LEDs on the printed circuit board.

any on the shaft or bearing. The coupling is glued to a section of ¾ inch water pipe, which becomes the support.

Slip the vane assembly over the pot shaft and glue with Crazy Glue or equivalent. (Here's a hint: Slide the vane assembly on the shaft and push down all the way. Apply a drop of glue to the exposed shaft and immediately move the assembly upward about ¼ to ⅜-inch. This eliminates the possibility and frustration of the adhesive running down the shaft and into the bearing.)



Assembling The Display. As previously discussed, we arrange the LEDs in a circle, thus mimicking a compass. We'll start by drilling the required sixteen holes in the cabinet; the reason will become very apparent later when you arrange the indicators.

A full-sized layout of the LED positions is on these pages. Remove (or trace) the template and fasten it to the front panel of the cabinet with tape. With a center punch locate each hole to be drilled. Drill the holes with 13/64-inch bit to accommodate the jumbo LED called for.

Obviously the best way to locate and properly space the LEDs is with a printed circuit board. The LEDs solder to the clad side of the PC board, while the components assume the conventional position. But before soldering in place, read the following.

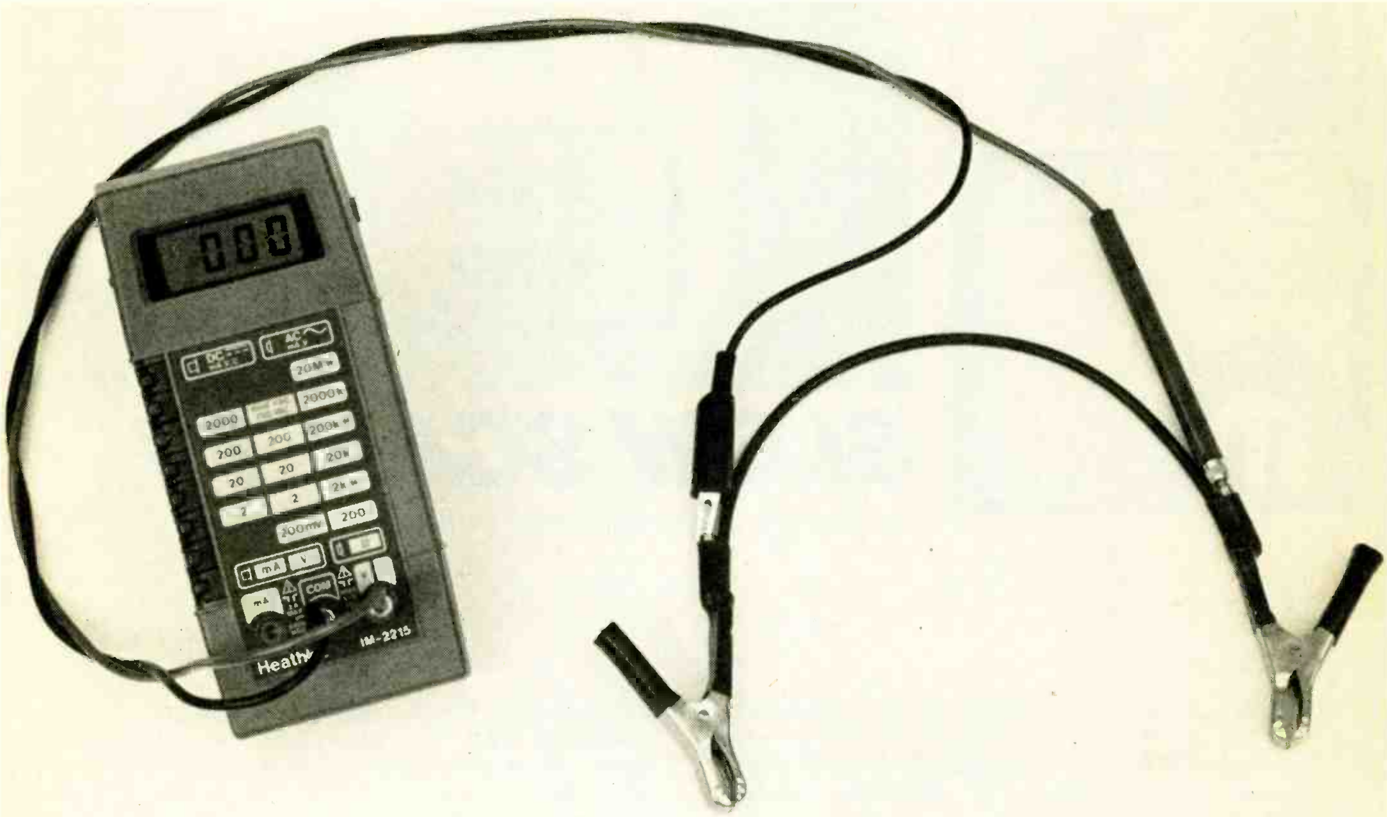
Since it's highly unlikely you'll be able to eyeball the LEDs into place sufficiently close to match the drilled holes, use this procedure. Begin arranging the LEDs on the board two at a time, LED 1 and LED 9 first (observe polarity). Place the board in the cabinet, adjustments up, and the LEDs into their respective holes. The lamps lead length is adjusted so the base is ¼-inch from the board.

Gently remove the assembly and without disturbing the relative positions of the indicators, solder them in place. Repeat this procedure, two at a time, until all are secured. You'll

(Continued on page 98)

TROUBLESHOOTING WITH A DIGITAL MULTIMETER

Check out your ignition system for fun and profit



IF YOU WANT to measure the large current from your car's alternator or starter, here are a few tricks on how to do it with your digital multimeter.

Digital multimeters (DMM) are sensitive and accurate devices. They have a much greater range than common analog multimeters; with a little help, they can measure very large currents. The help is from a low resistance shunt.

A Small Resistance. A one milliohm shunt is a very small resistance, but it still behaves as a resistor and every ampere through it causes a one millivolt drop. Digital voltmeters can read millivolts and most will read and display tenths of millivolts. This extreme voltage sensitivity allows them to work as ammeters when connected across a one milliohm shunt.

A DMM connected across the ground cable thus becomes a high-current ammeter. Similarly, a charging current of 40 amps into the battery produces a voltage drop of .040 volts across the cable.

The key is to calibrate your battery cable. It's easy. Most car low beams, including the running lights, use about 12 amperes. With the headlights on, measure the voltage drop across the ground cable. Suppose this turns out to be .020 volts.

Therefore, a starter draw of .192 volts across the cable means that 12÷20 or .6 of 192 amperes are flowing: about 120 amperes. Approximately .6 of the millivolts read on a DMM are the amperes through it.

If the 12 ampere headlight had caused a .005 volt drop across the cable, 12÷5 or 2.2 times the DMM reading of millivolts across the cable represents the amperes through it.

Needs A Strong Battery. This calibration is best done with a strong battery. Check the cable on the positive terminal, running to the solenoid. It might be more convenient to use.

If you do not like the mental arithmetic involved in converting millivolts into amperes, connect taps to the battery cable to produce a 12 millivolt drop when the low beams are on.

Puncture the cable insulation with a sharp pin. Place the tap in the middle of the region of the cable where the voltmeter reads 12 millivolts.

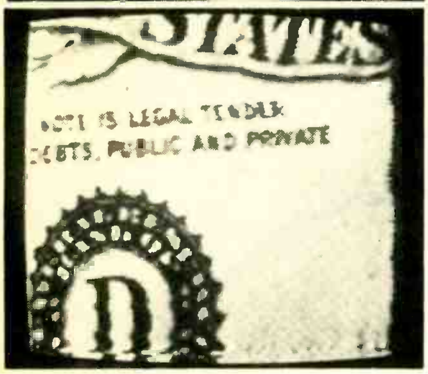
The taps are combination jacks accepting probe tips, banana plugs, or alligator clips (GC F2-883 or Allied 920-0222). Make the electrical connection with a small sheet metal screw, #4, ¼" long. It will separate the strands of wire in the cable and be held snug to the taps.

Tape it securely. This is a more satisfactory way to measure all currents in the car, even down to tenths of amperes for small lights or electronic systems, provided your DMM reads to tenths of millivolts.

Even a 20% error is acceptable when looking for trouble and will tell the difference between a shorted starter motor and a solenoid that isn't closing.

A third way to read currents in your car with a DMM is to build or buy a one milliohm shunt that can be clamped in between the battery ground cable and the negative terminal.

With this value of shunt the millivolts on the DMM connected to the shunt read accurately as amperes. ■



SLOW SCAN TV

Set Up a Bargain Basement TV Broadcast Station

☐ About two dozen years ago, a strange new warble was added to the dah-dih-dahs, buzzes and whistles on the Amateur bands. It was no convolution of a ham's voice, no alphabetic code, no teletypewriter signal; instead, hams were sending and receiving pictures of each other!

In the early days of this new mode, called Slow Scan Television, the picture shows resembled your Aunt Harriet's favorite vacation slides, or call letters pasted on *Playboy* pictorials. For many, a chalkboard or signs hastily crayoned on cardboard were the stars of the show.

But Slow Scan TV (or SSTV) has come a long way since those early days. There have been experiments with color, with 3-D, and with home computer-generated graphics.

Slow Scan Basics. It takes just a tad longer than 8½ seconds for a complete SSTV picture to appear. That's because SSTV is the result of a challenge met and conquered by its ham pioneers: to fit a video signal into the narrow bandwidth of a voice transmission. The bandwidth of an SSTV signal is only about 2500 Hz, which means it can be transmitted over voice channels like telephone lines and the amateur voice bands; compare that to the 4 to 6 *million* Hz of bandwidth required by a standard (fast scan) TV signal, which builds a complete picture thirty times a second—256 times as often.

This difference in *frame rate* was the first major concession these hams had to make in order to meet the narrowband challenge; the second was resolution.

You know that television pictures are made up of lines. A standard television picture (in the U.S.A.) includes a total of 525 lines from top to bottom. By comparison, an SSTV picture has only 128 lines from top to bottom. Also, while a standard TV picture has an *aspect* ratio of 4:3 (meaning it's ¾ as tall as it is wide), an SSTV picture has an aspect ratio of 1:1 (meaning it's square).

Audio to Video. In order to send and receive their pictures with standard ham transmitters and receivers, the SSTV pioneers were faced with the problem of how to *modulate* and *demodulate* the voltages that SSTV pictures are made of. For once, the easy and obvious answer worked! They decided to translate these voltages into tones (audio tones) for transmission, and to translate their received tones back into voltages.

In making this decision, they were also providing themselves with an easy way to record SSTV pictures—standard audio tape. Even the cheapest cassette recorders with reasonable speed stability proved capable performers.

In order to be sure that their signals would be compatible with each other's equipment, a set of standards was developed. The highest frequency, 2300 Hz, was set to represent white. Black was to be at 1500 Hz; and 1200 Hz, a blacker-than-black frequency, used for synchronization.

Sync Or Swim. Synchronization standards for SSTV were also crucial to its development. If a receiver didn't go to the next line exactly when the camera and transmitter did, the result would be a picture that swims—one with undulating edges and bits of one line appearing on the next. At best, the picture looked like it was printed on a balloon being stretched out of shape; at worst, it was indecipherable.

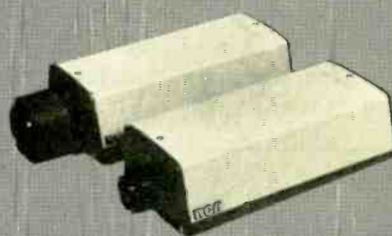
So sync standards were devolped using 60 Hz AC power line frequency as its standard, and provisions were made on SSTV monitors to de-skew slightly off-standard signals.

First, the 60 Hz signal was divided by 4 to come up with a 15 Hz line rate. Once every 1/15th second, a 5 millisecond burst of 1200 Hz sync signal (a total of only 6 cycles) is inserted onto the transmitted signal as a prompt to the receiving monitor to go to the next scan line.

This proud exhibitor at an SSTV hamfest shows off the sophisticated gear used in the pursuit of his hobby. On the right side of the table is the transmitter, to the left an audio amplifier with a cassette deck, and above the amplifier is the monitoring CRT screen. Below is a view of a ham shack with all of the equipment fired up and an SSTV QSL broadcast on the CRT display. As equipment becomes available, Amateur SSTV will grow.

The Robot keyboard is used to enter ASCII coded characters to the SSTV transmitter for broadcast over the air. This arrangement is used instead of more expensive camera.

Video surveillance cameras, such as this one from RCA, are at the top of SSTVers' wanted lists. Picture quality is excellent.



A less expensive video camera is the RCA 1000 series. Available with a variety of lens configurations, they serve the Amateur SSTVer as well as higher priced units.

The Robot SSTV transmitter has provision for all the varieties of TV transmission possible: plain characters, sound tracks, scan variations. Memory circuit preserves all.

This 15 Hz signal is again divided by 128, and once every 8.5333 seconds a 66 millisecond burst (80 cycles) of 1200 Hz sync tone is transmitted as a signal to start scanning a new picture (*raster*). In this way, exactly 128 lines are counted out for each picture.

SSTV provides a resolution of 128 dots (or *pixels*, short for picture elements) on each scan line. Theoretically, this means that each dot is transmitted during 1/128th of the period between sync pulses, which is 80/86th of 1/15th second. This, according to my pocket calculator, is 1/2064th of a second, meaning that pixels should appear at a 2064 Hz rate. In practice, this is difficult to achieve over a communications channel, but modern equipment has made it possible over closed circuits, and come close to it over the air as well.

Freezing The Image. Compared to the homebuilt receivers with long-persistence phosphor cathode ray tubes (their dim green glow had to be viewed in near darkness) that were the only way to watch SSTV in its early days, the state of the art has advanced by leaps and bounds. Today scan converters let you watch SSTV pictures on a standard TV monitor.

It works the other way, too. Camera tubes that could be scanned at SSTV rates are rare and expensive, so standard TV cameras are used and their signals sampled at SSTV scan rates. This offers the advantage of being able to see what the camera sees on a standard TV, even while transmitting slow scan.

As pictures change, a horizontal line proceeds from the top of the screen to the bottom. As it "wipes" down the screen, it discloses the new picture behind it. The new picture appears above the line, replacing the old picture which still can be seen below the line.

State-of-the-art equipment usually incorporates a good size chunk of data memory, and uses memory to store and

(Continued on page 98)

Slow Scan TV

(Continued from page 97)

recreate the picture.

Digital Pictures. We've already seen that the SSTV picture is composed of 128 scan lines with 128 pixels per line, giving a total of 16,384 pixels per picture. This fits exactly into 16 Kbytes of microcomputer data memory.

Each of these pixels is characterized by a *gray level*, a value of brightness somewhere on a scale from black (no brightness) to white.

Modern SSTV equipment provides for 16 different gray levels; these are represented as a four-bit binary words, or bytes. A binary value of 0000 represents full brightness (white), and the level proceeds through progressively darker values as the byte increases to its maximum binary value, 1111, which is used to represent black.

Cameraless SSTV. There's even a way to get on SSTV with no camera at all. It's the Model 800 Super Terminal from Robot Research, Inc., a veteran manufacturer of Amateur and commercial SSTV equipment. It connects to a transmitter, receiver, teletype loop, TV monitor, CW key or any combination, and communicates in ASCII (computer format code—now authorized on the Amateur radio bands), Baudot (teletype code), Morse code or SSTV. When used on SSTV, it can generate both alphanumerics and graphics. Actually a small computer based on an 8085 microprocessor with 4K of ROM and 2.5K of RAM, this 13-pound marvel is well worth its $845 price.

Robot also manufactures a versatile scan converter, the Model 400, for SSTVers who want to be in pictures. It interfaces with standard TV cameras and monitors to SSTV standards for communications over the air, over phone lines, or recording and playback via audio tape. All solid state and ready to hook up, it's priced at a dirt-cheap $795.

It's not all that hard or expensive for anyone to get involved in SSTV, over the ham bands or in some other form. Once you do, you'll find that the future presents some fascinating pictures. ■

LED Weather Vane

(Continued from page 94)

notice this gets easier as it goes along!

The power supply is also constructed on a PC board. Transformer T2 mounts on the board. U1 must be provided with a heat sink, since it will supply the current for the readout.

Wire Wrap. Wire wrap posts are soldered to the board to supply the voltages. Although we use only the 5-volt line for this particular board, the finished project will require all the sources (notice all but one are regulated).

Ease the completed display board into the mating panel holes. A dab of silicone glue around a couple of the LEDs will secure it in place. The power transformer (T1) mounts to the bottom of the chassis. Along side the transformer resides the power supply board, which is held in place with plastic circuit board guides fastened to the bottom. Wires interconnecting the voltage sources may be wire wrapped or soldered, as you prefer. A feed through terminal strip attached to the back provides connection to the outside world.

The wind vane is mounted atop a ¾-inch plastic water pipe (schedule 40 or similar) and the wires are channeled through the center. The pipe is then secured with conventional mounting hardware to a convenient location.

The calibration is performed in two steps. With a voltmeter on pin 5 of the IC, rotate the pot so voltage is at a minimum. Now adjust R5 to light LED1. Rotate the control until LED8 just extinguishes. If indicators LED9 through LED16 light during this procedure, ignore them. However, should the vane rotate the opposite direction of the moving display, reverse the outside leads from the sensor pot.

With LED8 off, adjust R6 until LED9 lights. Further rotation of the potentiometer will consecutively light the remaining lamps until the crossover point is reached; the gap in the resistive strip. LED16 should light at this point. If the spacing of the indicators seems uneven, you can juggle the value of R2.

Now point the vane due north and rotate the support pipe so that the north indicating LED is lit. Turn it loose and you're in business! ■

Input/Output

(Continued from page 8)

Lamp Lighter

Hank, I've gone into business repairing household lamps. Don't laugh! It's a nice part time business and with the profits I bought a new (small) car in two years. My full time occupation is student, and I'm only eighteen years old. Tell your readers what I'm doing so they can get involved also and pick up extra dollars.

—I.B., Brooklyn, NY

Good for you. In fact, many simple appliances can be repaired at home for profit. A small part time business helps support your hobby needs, and improves your lifestyle.

TVX

Don't you think some computer magazine should come up with a conversion plan to modify an old TV set into a video monitor? Also, keyboards are available, why not make it a dumb terminal?

—J.A., Birmingham, MI

Old TV sets are usually "baked" near to death after several years of average home use. Any and most parts are ready to give up the ghost, so give up the idea!

Heads Up Only

Hank, I was told that when you properly notch the flip side of a floppy disk, one could reverse its position in the drive, and the flip side of the disk can be used. Is this true?

—W. N., Sykesville, MD

I tried it and it almost works! Yes, it can be done; but before you do it, take a look inside the single-side disk drive. Note that a pad presses one side of the disk against the record/playback head. After a few runs, strange things began to happen to my BASIC program. Then, the entire disk crashed because the bootup sectors were destroyed. We know that the normal recording side of a single-side floppy has a quality surface; a test sector check always proves this point. But, the flip side has several, and they increase with time due to the effect of a pressure pad pressing against the surface.

Scan

I'd like to join a scanner club because I'm not doing too well with the unit I now own. I know it's me and not the scanner. Any suggestions, Hank?

—R.R., Deerfield, MA

Write to Scanner Association of North America. I read their publication SCAN, and it is packed with interesting tid-bits that'll spice up your hobby experience. Their address is: SCAN, Suite 1212, 111 East Wacker Drive, Chicago, IL 60601. ■

LITERATURE LIBRARY

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

397. *Instant Software, Inc.* is offering a special holiday catalog for all kinds of year 'round software package gift giving, as well as their regular microcomputer catalog.

401. *AP Products'* "Faster and Easier Book" is designed to eliminate any problems with breadboarding, interconnection and testing devices. All-circuit evaluators *with power* are featured.

402. *Technical Electonics* has descriptions galore of all kinds of electrical gadgets—transistors, computer power supplies, and logic probes—in its latest (6-80 B) mail order catalog.

403. *PAIA Electronics* gives you "Advanced Electronics For The '80s and Beyond." Brochure features computerized music synthesizers.

411. *Interactive Microwave, Inc.*, publishes a program that lets your 48K Apple II plot complex scientific graphs. Called Scientific Plotter it is just one of many programs available.

412. *Ohio Scientific* produces a Word Processor program for its various personal computers called OWP-3-1. It features no-line-numbering, elaborate cursor editing and color prompting. The company offers a vast catalog of software.

413. Asteroids in Space is just one of many programs available from *Quality Software*. This space game pits the would-be star ship commander against an impenetrable field of asteroids. Runs on a 32K Apple II.

414. For the small business operator who needs to keep track of customer orders and fulfilment, *B&B Software* has added CORP (Customer Order Review Program) for TRS-80 computers to its software listing.

415. *Texas Instruments* is making available a wide variety of software for its TI-99/4 personal computers. Statistics is just one of many solid state program modules available.

416. HEXDOS 2.3 from the *6502 Program Exchange* is not a demonic glitch excorcisor, but rather an ingenious 2K disk operating system for OSI Challenger 1P and Superboard II personal computers.

417. *Microsoft Consumer Products*, who publish the famous and almost universal Microsoft BASIC, are now offering COBOL and FORTRAN for Apple II computers with dual disk drives.

418. Included in the *Heath Company's* large software catalog is its version of Digital Research's CP/M operating system. CP/M allows Heath computers to use any of the vast libraries of CP/M compatible software.

419. *Hayden Publishing Company* has gone into software publishing in a big way. Its Data-Graph program converts raw data into lively, colorful and useful charts.

421. *Osborne/McGraw-Hill Publishing* has produced a program that contains 76 assorted and very useful number crunching programs for math and business use. Entitled: *Some Common BASIC Programs*, this is in cassette and book form for PET, CBM and TRS-80.

422. The Troll's Hole Adventure is just one of many programs from *Micro-Video* that deal with fantasy and adventure. A large vocabulary lets you move through an underground maze fraught with danger. If you are on your toes you might have a chance of surviving.

423. Your personal computer can help you track your Wall Street fortunes with this *Apple Computer, Inc.*, program: Dow Jones Series Portfolio Evaluator. With a modem you can access more than 6,000 stock quotes through the Dow Jones News Retrieval System.

425. Fasten your seatbelt for Scott Carpenter's Great Race—a 600-mile computer road race, produced by the *80-US Journal*. The company publishes many programs for Z-80 based machines.

426. One package containing 13 various business programs for TRS-80 computers is available from *Management Systems Software*. Called Business Package Program, it performs many useful accounting and analysis chores for the small business user.

301. Get into the swing of microcomputer and microprocessor technology with *CREI's* new Program 680. New 56-page catalog describes all programs of electronics advancement.

310. *Compumart Corp.*, formerly NCE, has been selling computers by mail since '71, and is offering a 10-day return policy on many items featured in their latest catalog.

313. How to plan and control effective information systems development is the subject of "Data Dictionaries and Data Administration" from the McGraw-Hill Bookstore.

320. Over 150 pages and more than 500 software entries are included in *Commodore Business Machines, Inc.* publication, "Commodore Software Encyclopedia."

327. *Prentice-Hall, Inc.* has released a popular-priced series of softcover books on personal computing, computer programming and debugging, computer repair, and digital and computer design.

328. *Tab Books* has just published "Pascal," an in depth book describing all the ins and outs of the popular Pascal language. It explains how to read syntax diagrams, use write statements, and much more.

330. There are nearly 400 electronics kits in *Heath's* new catalog. Virtually every do-it-yourself interest is included—TV, radios, stereo, hi-fi, hobby computers, etc.

333. Get the new free catalog from *Howard W. Sams*. It describes hundreds of books for hobbyists and technicians—books on computer construction projects and computer programming.

335. The latest edition of the *Tab Books* catalog describes over 450 books on electronics, broadcasting, do-it-yourself, and computers and computer-related items.

345. *Computer Science Press, Inc.* is publishing a full line of computer-related books, including "Structured Basic and Beyond," "Jewels of Formal Language Theory," and "Algorithms for Graphics."

354. Everything the small businessman needs to know about computers is contained in "Small Computers for the Small Businessman," from *Dilithium Press*.

359. *Electronics Book Club* has literature on how to get up to 3 electronics books (retailing at $58.70) for only 99 cents each . . . plus a sample Club News package.

380. *Software Publishing Corporation* has released two data-based programs for the Apple II. PFS and PFS: Report are high-quality personal information management systems.

384. *B&K Precision* has issued BK-81, a test instrument catalog featuring over 50 products including oscilloscopes, frequency counters, digital an analog multimeters and accessories.

386. If you're looking for books on computers, calculators, and games, then get the latest *BITS, Inc. catalog*. It includes novel items.

388. The CP/M HANDBOOK (WITH MP/M) from *SYBEX* will tell you everything you wanted to know about the popular CP/M Disk Operating System, but were afraid to ask.

389. You can't buy a bargain unless you know about it! *Fair Radio Sales'* latest electronics surplus catalog is packed with government and commercial buys.

390. *Hayden Book Company* is publishing a new book telling all about musical applications of microprocessors. In fact, it is called "Musical Applications of Microprocessors," certainly an appropriate title.

391. A new software products catalog for the Apple II Computer has just been issued by *Charles Mann & Associates*. The booklet contains business accounting, accounts receivable, inventory, BASIC teaching and other special purpose business applications.

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

405. *Everest House's* "Owning Your Own Computer" by Robert Perry answers almost every question you could bring to mind about owning your own computer. One chapter offers 99 common things to do with a home computer. Quite a book!

407. *Poly Paks Inc.* carries a diversified line of electronic equipment at bargain prices. They cover computer products, electronic games, tools for the hobbyist and professional, and much more.

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

409. *Connecticut MicroComputer Inc.* has issued a new catalog describing their computer interfaces for PET, APPLE, TRS-80, KIM and others as well as data acquisition modules and accessories, including a variety of connectors.

410. *Howard W. Sams'* book division has started publishing personal computer software. Many of their programs are related to electronics construction. Send for brochure.

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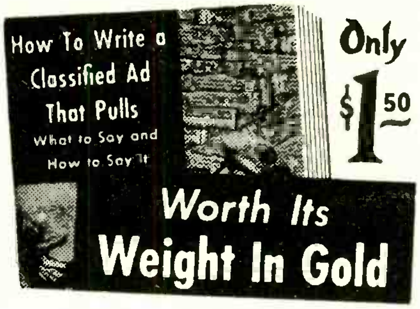

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(Continued from page 9)

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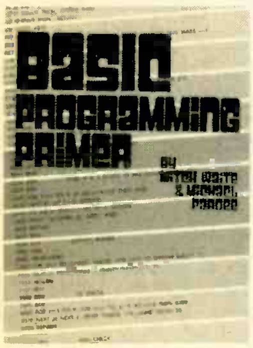

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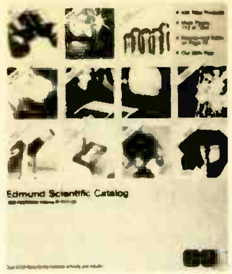

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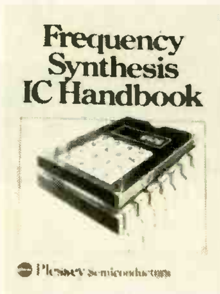

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