Radio-Electronics

Special Projects

The magazine for people who like to build electronic gizmos

#4 $2.25 SUMMER 1982

48784

Plant Moisture Meter (above)

- Hall-Effect Earthquake Detector
- Programmable Thermostat
- Tri-Voltage Power Supply

Pink/White Noise Generator

- Power Up Add-On Floppys
- Measure Engine RPM with A DMM

Photographer's Contrast Meter (far right)

- Switching Lamp Dimmer
- Unique Binary Clock
- Automobile AC-Duty Controller

3 - 30-MHz Field-Strength Meter

- How To Build Projects & Buy Parts For the Least Possible Cost
- Surge Stopper Protects Your Computer
- Instant Digital Clock

Portable Modulation Meter

- Ni-Cad Battery Zapper
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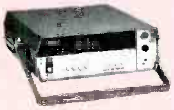

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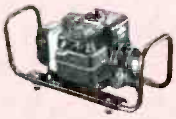
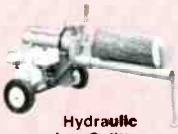


Emergency Power System



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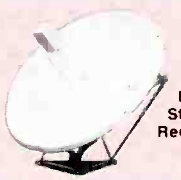

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Radio-Electronics Special Projects

#4
SUMMER

Inside this Issue

If you are a dyed-in-the-wool project builder, in all probability you have already thumbed through the pages of this latest issue of **Special Projects** and possibly read through a few of the articles before you got around to reading this page. Good! Project builders find in **Special Projects** the unrestrained excitement that fuels their hobby activities.

The Editors placed more into **Special Projects** than just the complete, pre-tested project plans for our readers to follow to the letter. In each project article, the application of the finished project will add to your enjoyment, comfort, and service. More important, the theoretical operation of each project is fully explained. That provides the project builder with additional electronics knowledge to store in his protein RAM, and the opportunity to use that knowledge to improve the project for esoteric applications, or modify it for purposes well beyond the imagination of the article's author.

Some articles, in fact, are electronics mini-courses that may appear to spoonfeed theory to the reader, but actually inspire him to think about the circuit dynamics as he assembles the project. I suggest that you read *Binary Clock by Harold Galvin, beginning on page 68.* Although the important waveforms are given in the schematic diagrams, try to visualize how all the waveforms are formed, their duration and relationship to each other. If you can't, poke into the circuit with a logic probe or oscilloscope seeking a full understanding to the circuit's logic. Do that, and attack each project you assemble in a similar manner, and you will soon discover that those dark DIP chips packages with many legs will no longer bug you. They will become friends that'll open the world of project building to new, exciting horizons.

This issue of **Special Projects** contains complete plans for gadgets and devices for your car, darkroom, computer, test bench, instrument shelf, heating system, and ham shack. That list is by no means complete. One interesting brief article, *Programming Thermostat, on page 64,* will amaze you in the realization of how a little bit of common sense and functional need can be combined in a project to save you about $100, and be more versatile in function and fuel-saving capability.

Enjoy **Special Projects!** And if, in the practice of your hobby, you should discover, design, build and successfully operate a unique gadget that you believe belongs in **Special Projects,** please let us know. Tell us about it by writing a straightforward letter describing the project; include a schematic diagram, a snapshot of the project, and some specs on its performance. We will get back to you with our comments, and, should we be favorably impressed, you will be given the opportunity to write an article about your project under your byline. In truth, that is how this issue of **Special Projects** began. Send your letters to the Editor, **Special Projects,** 200 Park Avenue South, New York, NY 10003.

Now build, build, build ... We had our enjoyment in preparing this issue of **Special Projects** for you. Now, you have all the fun!

JULIAN S. MARTIN
MANAGING EDITOR

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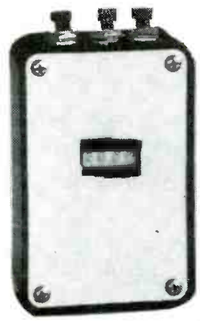
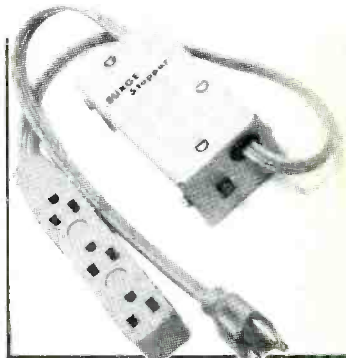
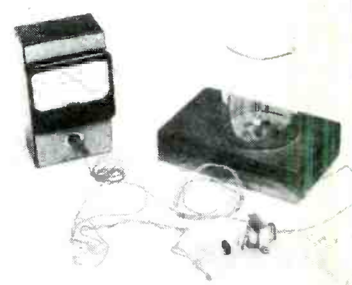
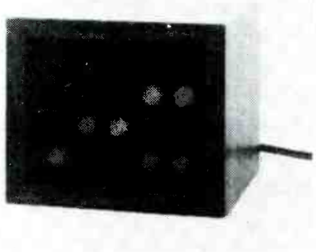
Radio-Electronics special Projects

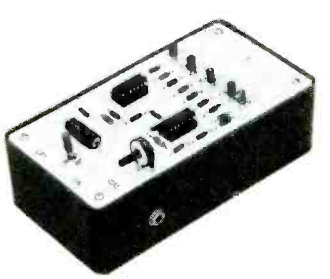
Vol 1, No 4

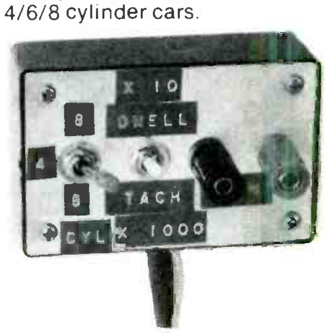


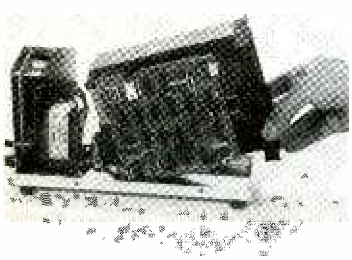


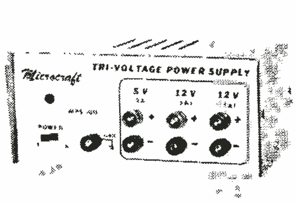


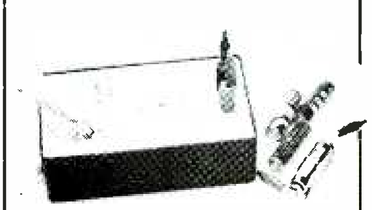












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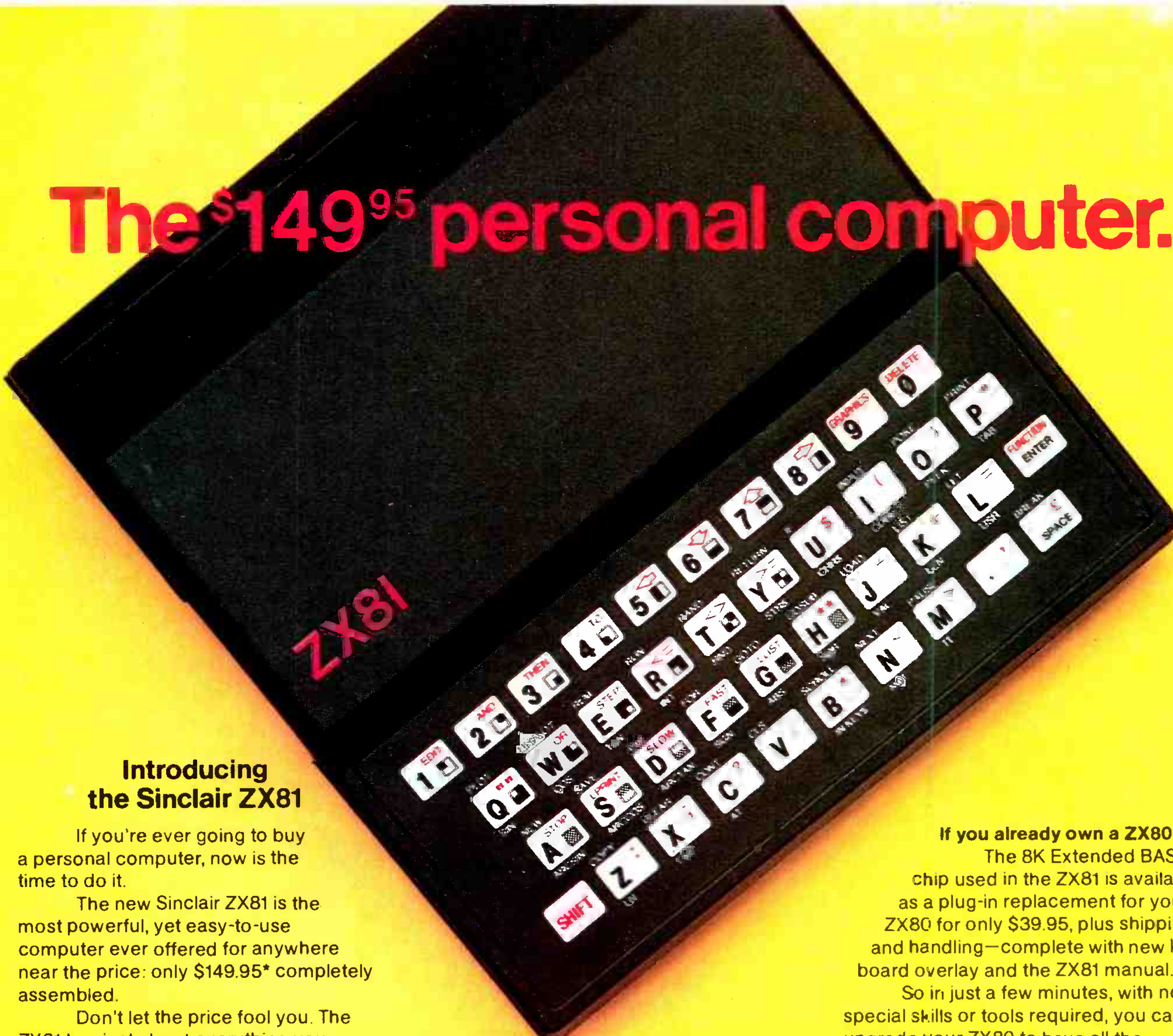
The $149.95 personal computer.



Introducing the Sinclair ZX81

If you're ever going to buy a personal computer, now is the time to do it.

The new Sinclair ZX81 is the most powerful, yet easy-to-use computer ever offered for anywhere near the price: only $149.95* completely assembled.

Don't let the price fool you. The ZX81 has just about everything you could ask for in a personal computer.

A breakthrough in personal computers

The ZX81 is a major advance over the original Sinclair ZX80—the world's largest selling personal computer and the first for under $200.

In fact, the ZX81's new 8K Extended BASIC offers features found only on computers costing two or three times as much.

Just look at what you get:

- Continuous display, including moving graphics
- Multi-dimensional string and numerical arrays
- Mathematical and scientific functions accurate to 8 decimal places
- Unique one-touch entry of key words like PRINT, RUN and LIST
- Automatic syntax error detection and easy editing
- Randomize function useful for both games and serious applications
- Built-in interface for ZX Printer
- 1K of memory expandable to 16K

The ZX81 is also very convenient to use. It hooks up to any television set to produce a clear 32-column by 24-line display. And you can use a regular cassette recorder to store and recall programs by name.

*Plus shipping and handling. Price includes connectors for TV and cassette, AC adaptor, and FREE manual.

If you already own a ZX80

The 8K Extended BASIC chip used in the ZX81 is available as a plug-in replacement for your ZX80 for only $39.95, plus shipping and handling—complete with new keyboard overlay and the ZX81 manual.

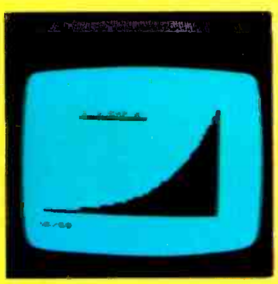
So in just a few minutes, with no special skills or tools required, you can upgrade your ZX80 to have all the powerful features of the ZX81. (You'll have everything except continuous display, but you can still use the PAUSE and SCROLL commands to get moving graphics.)

With the 8K BASIC chip, your ZX80 will also be equipped to use the ZX Printer and Sinclair software.

Warranty and Service Program**

The Sinclair ZX81 is covered by a 10-day money-back guarantee and a limited 90-day warranty that includes free parts and labor through our national service-by-mail facilities.

**Does not apply to ZX81 kits



NEW SOFTWARE: Sinclair has published pre-recorded programs on cassettes for your ZX81, or ZX80 with 8K BASIC. We're constantly coming out with new programs, so we'll send you our latest software catalog with your computer.

ZX PRINTER: The Sinclair ZX Printer will work with your ZX81, or ZX80 with 8K BASIC. It will be available in the near future and will cost less than $100.

16K MEMORY MODULE: Like any powerful, full fledged computer, the ZX81 is expandable. Sinclair's 16K memory module plugs right onto the back of your ZX81 (or ZX80, with or without 8K BASIC). Cost is $99.95, plus shipping and handling.

ZX81 MANUAL: The ZX81 comes with a comprehensive 164-page programming guide and operating manual designed for both beginners and experienced computer users. A $10.95 value, it's yours free with the ZX81.

The $99[95] personal computer.

NEW PRODUCTS

More information on new products is available. Use the Free Information Card inside the back cover.

PHASE SEQUENCE & OPEN-PHASE INDICATOR, *model PSI-8031*, is a dual-purpose tester. It indicates phase sequence using a rotating disc containing a large red dot. When viewed through the three round windows on the front panel, the red dot rotates in a clockwise direction, indicating proper phase sequence.

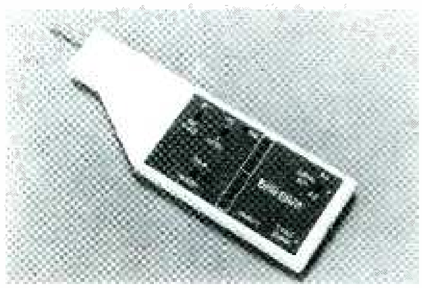
CIRCLE 621 ON FREE INFORMATION CARD

Three lamps, located on the front panel, are used for open-phase checking. Proper phase sequence will cause all three lamps to light. If the phase sequence is not correct, the rotating disc will not turn, and the lamp corresponding to the open phase will not light.

The *model PSI-8031* is sealed against dust, has no exposed metal parts, is self-contained in a shock-resistant plastic housing, and has a 60-inch line cord. A pushbutton ON switch and color-coded, and insulated alligator clips make for easy use. It is palm-size, light-weight, readily portable, and can be used on a variety of 3-phase power sources from 110-volts AC to 600-volts AC. It comes with Soft-Pak carrying case (*model C-31*), operating instructions, and a six-month warranty card. The *model PSI-8031* is priced at $49.95.—**A.W. Sperry Instruments, Inc.,** 245 Marcus Boulevard, Hauppage, NY 11787.

LOGIC TEST PROBE, the *Bar-Graf*, combines the many functions of a digital multimeter, signal generator, and oscilloscope, all in one lightweight, handheld instrument that can detect pulses as short as 20 nanoseconds.

The *Bar-Graf* can read accurately to zero volts and gives precise readings of voltages containing high noise levels, with the incorporation



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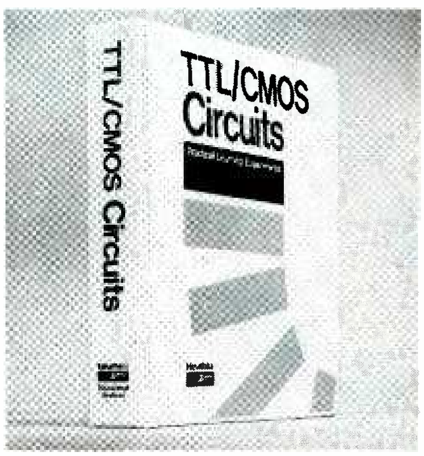
of a selectable input filter. An internal DC-to-DC converter makes sophisticated operational amplifier circuitry possible.

An instant ten-segment display with no settling time is featured. AC and DC voltages are displayed with an accuracy of 5%. Alternating voltages are displayed as peak values with both polarity and pulse indicators illuminated. The probe is reverse- and overvoltage-protected and has tip-jack outputs for all standard test leads. The *Bar-Graf* is priced at $149.00.—**AMCORP, Inc.,** 15031 Parkway Loop, Tustin, CA 92680.

STUDY COURSE, "hardware oriented", in TTL and CMOS circuits, is designed for the electronics student, experimenter, radio amateur, or computer enthusiast. Designed to give "hands on" experience, the *TTL and CMOS Circuits Course* is comprised



CIRCLE 623 ON FREE INFORMATION CARD

as a series of circuit "files" arranged in a logical progression. Each file provides the student with a description of the particular circuit and its operation, a circuit schematic, and modifications that can be performed on the basic circuit. The student learns by doing.

Text reading is condensed, and the course places emphasis on actual circuit construction. Examples of circuits the student will build include seven-segment digital displays, flip-flops, clock generators, data-selector distributors, and comparators. Sixty-five electronic components for constructing more than 50 circuits are included with the course.

The *TTL and CMOS Circuits Course* is priced at $59.95.—**Heath Company,** Benton Harbor, MI 49022.

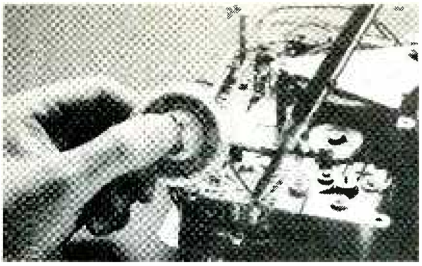
SHORT-FORM CATALOG, 4 pages, covers over 30 models of function generators, combination pulse/function generators, materials test generators, arbitrary waveform generators, IEEE-488 programmable generators, and precision current and

CIRCLE 624 ON FREE INFORMATION CARD

voltage sources. Colored cover, with photos and specs of the 520 series, 500 series, 119/121 series, 730 series, 340/350 series, and 600 series function generators on page two. Page three gives a complete spec breakdown of 36 models, and the final page has a complete list of representatives, here and abroad, with full addresses and telephone numbers. Free upon request.—**Exact Electronics, Inc.,** PO Box 347, Tillamook, OR 97141.

DESOLDERING WICK, based on Xersin chemistry, has a unique flux/preservative that avoids the problem of oxidation associated with rosin coatings. It is also unaffected by temperature and humidity, never requires any special storage conditions, and does not become brittle or flaky. It will remain pliable even after years of shelf storage.

With the reduced oxidation, complete solder removal is easier, and the wick's flexibility allows difficult-to-get-at jobs to be desoldered accurately and cleanly. The *Xersin*



CIRCLE 629 ON
FREE INFORMATION CARD

wicks are available in four sizes: 0.03 inches, 0.06 inches, 0.08 inches, and 0.10 inches and are color-coded for easy identification.

The *Xersin wicks* are priced at $1.29 to $1.59, according to size.—**Multicore Solders,** Westbury, NY 11590.

MAILORDER ELECTRONICS CATALOG, is 96 pages, and lists all manner of electronics devices, equipment, and parts from alarm parts to wire. Each issue features special close-out,

CIRCLE 625 ON
FREE INFORMATION CARD

liquidation, and bargain sales. The catalog is fully illustrated and is free upon request.—**ETCO Electronics,** North Country Shopping Center, Plattsburgh, NY 12901.

MAIL-ORDER CATALOG. 104 pages with both color and black-and-white photographs, features a new satellite earth-station kit, a low-cost µMatic memory-keyer kit for amateur radio enthusiasts, a computerized digital barograph kit (the barograph gives highly accurate, permanent records of barometric readings), an easy-to-build subwoofer kit for the audiophile, and a number of new computer software programs.

CIRCLE 628 ON
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There are state-of-the-art electronics kits for home or business, including computers, energy-saving devices, amateur radio equipment, hi-fi stereo components, color TV's, marine and aviation gear, and a line of self-instruction courses in electronics and computers, as well as other kits for home and hobby.

All kits come with step-by-step instructions, and most of them can be built by a beginner using ordinary household tools and a soldering iron. (Instruction manuals include a course on soldering for beginners.) Free on request.—**Heath Company,** Benton Harbor, MI 49022.

CIRCLE 604 ON FREE INFORMATION CARD

LETTERS

CASES FOR PROJECTS

Dear Editor:

I really enjoy the range of projects that **Special Projects** has been delivering, but I do have one problem with the parts list—I can't always find the kind of case I'd like to put the project into. Aluminum chassis, and chassis boxes, and the more commonly available plastic cases do work, but leave something to be desired when comparing a home-built project to a purchased instrument. Any suggestions?

RALPH KRIER
Pennsylvania

Dear Ralph:

*An article crammed with solutions is scheduled for **Special Projects #5.** In it, Herb Friedman explores chassis, cabinets, and cases. Tells you where you can get them, how you can make them, and how to decorate them so that your home-brew projects look like manufactured electronics products. Just be patient until September. That's when #5 goes on sale.*—Editor.

CHANGE YOUR FORMAT

Dear Editor:

I don't save complete issues of any magazine. Instead I keep only the articles that I feel are important to me. Therefore, when you end an article on a right-hand page and start the next one on the following left-hand page I can only keep one of the two. Why can't you make sure that all articles start on right-hand pages?

HAROLD T. KARL
Los Angeles, CA

Dear Harold:

*If we did what you suggest there would be a lot of blank pages in **Special Projects.** Of course, you could argue that they would be handy for notes, but wouldn't you rather have the extra article or two that now fill that space? Another way you can solve the problem is to buy two copies of **Special Projects.** Then you can separate and save every article.*—Editor

DESOLDERING IS MY PROBLEM

Dear Editor:

Having purchased and read all three issues of **Special Projects** published to date, I'd like to comment that I sure hope you can keep it going. I like the projects and the way that you present them. I do have one problem however, and believe that many other readers share it with me. When working on a printed-circuit board, I find it difficult to remove an IC when one needs to be replaced. Why don't you publish an article that will show me and other readers just how to perform that difficult job?

MALCOLM BRAGG
Dearborn, MI

Dear Malcolm:

We are trying to get just such an article now. It may even appear in our next issue. In the meantime, visit your local electronics parts store and take a look at the desoldering tools he has to offer. The right tools make the job rather easy, especially if you couple the tools with a little practice.
—Editor.

WANTS MORE GUITAR ADD-ONS

Dear Editor:

The "Superfuzz" article in the Fall 1981 issue of **Special Projects** was just what I was looking for. But how about some more add-ons? I'd like to see a "Waa-Waa", some medium-power music amplifiers and other electronic-guitar gadgets.

TOM BLACKWELL
Duluth, MN

Dear Tom:

*We'd like to see some, too. If any readers have such a project in the works, let us know. You could soon see your name and article in a future issue of **Special Projects.***—Editor.

I LOVE IT—I HATE IT

Dear Editor:

Turning a clock into a frequency counter was terrific. What a money saver! Can you come up with some others just like that one?

Great project, but it sure drives you crazy when you try to read the display and figure out what frequency you are really reading.

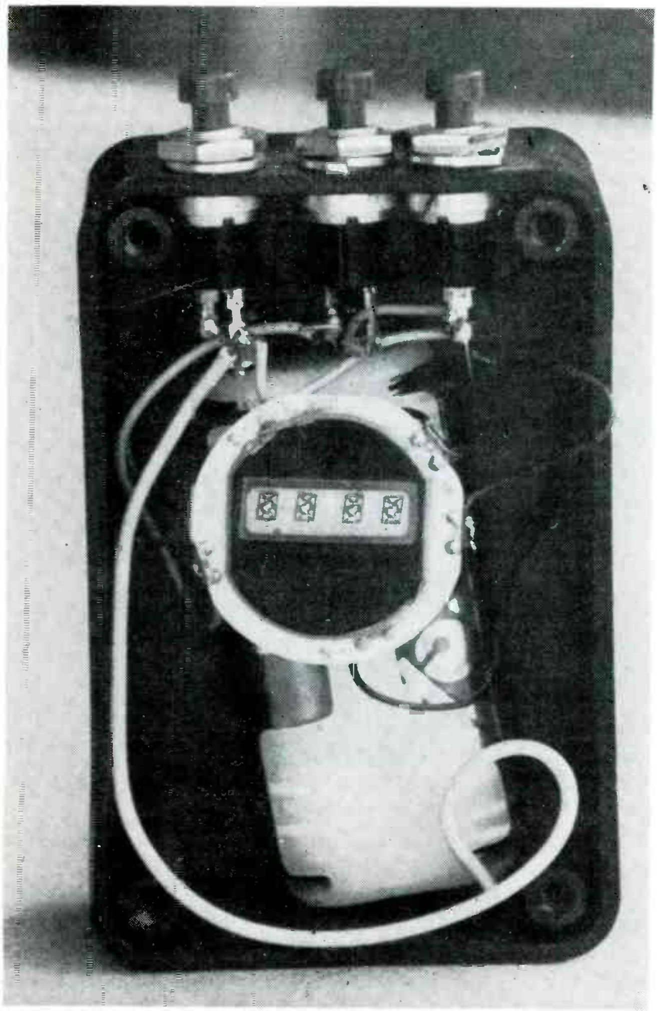
Dumbest project I've ever seen. Sure it's cheap. But the mistakes you can make reading the display destroy the savings in building the unit.

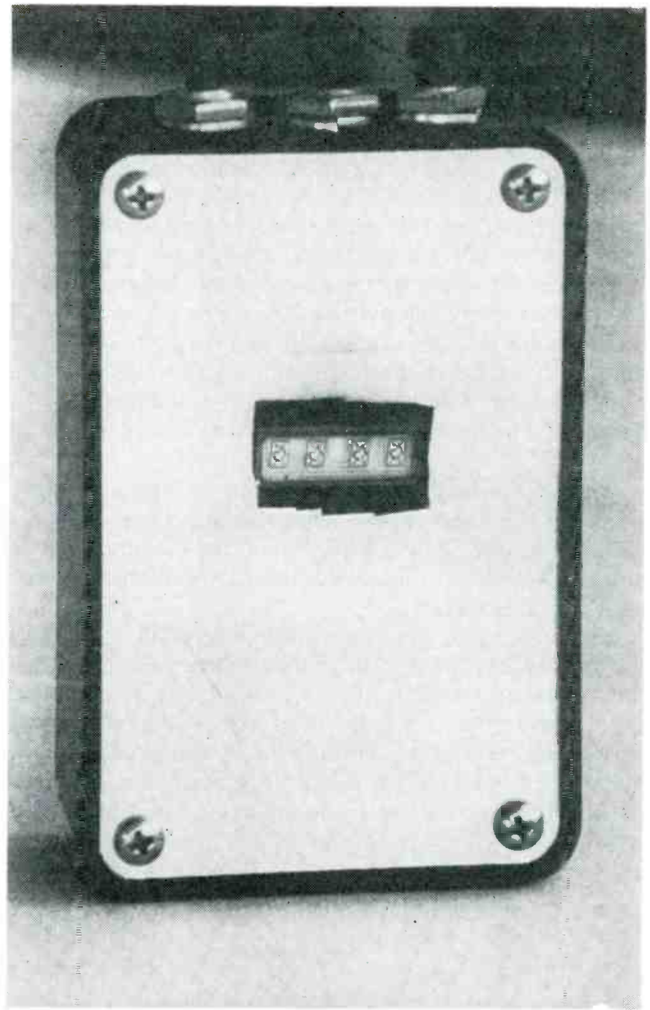
One of the reasons I build projects is to save dollars. This article is the best example of a dollar saver that I have ever seen.

Dear Readers:

Once again you've proven that we can't please everyone all the time. But if we do come up with similar projects, we do intend to keep right on publishing them.

INSTANT





DIGITAL CLOCK

Want to know what to do with those old LED watches? Turn them into portable clocks... It isn't difficult... It isn't expensive... It is FUN!

EVERT FRUITMAN

HERE IS A TIMELY WAY TO GET ADDED LIFE OUT OF OLD LED watches. Many of them were set aside when the price of silver-oxide batteries went up out of sight. By repackaging the watch, less-expensive longer-lived batteries can be used. The result is an instant digital clock that is great for use in the car, mobile home or other location where power may be limited. It should go together in one evening, and the parts (excluding the watch) should cost less than $5.00. That's about what a pair of silver-oxide batteries cost today.

The watches I used were birthday presents that got too costly to keep in batteries. They were too nice to be allowed to gather dust in a dresser drawer, but those high-priced batteries were getting to me. I worked with new parts, so you may be able to beat my cost with a bit of help from your spare-parts box.

You will have to determine how many switches are needed. Count the buttons on the sides of the watch. Usually two or three serve to set the time, calendar, and call for a display. You will need one pushbutton switch for each button on the watch. There are both miniature and subminiature switches available. Be sure that the ones you get are the normally-open types.

Decide what size box you will want. Mine are fairly small, measuring just over 3×2×1 inches. You may find it easier going with a larger enclosure. Sometimes the metal boxes seem to have more space inside. The photos show step by step how the modification is handled. The battery holder and batteries complete the parts list.

It would be best to have all the parts on hand before you take the watch apart. That way the works are protected as much as possible. In fact, the switches can be partially wired and installed before you ever start dismantling the watch.

Use a straight edge as a guide and mark the top of the box where you want the switches mounted. Drill the holes and mount the switches. The photos and Fig. 1 and Fig. 2 should help you with switch and battery-holder wiring. Making the common connection between the two cells will require a bit of care. If plastic battery holders are used, too much heat on the contact will melt the plastic. File or scrape the metal contact

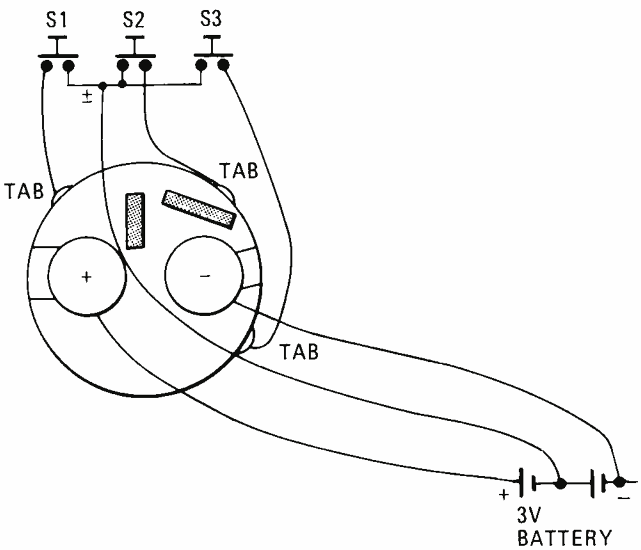


FIG. 1—SWITCH AND BATTERY WIRING diagram shows how separate pushbutton switches are wired to LED watch modules.

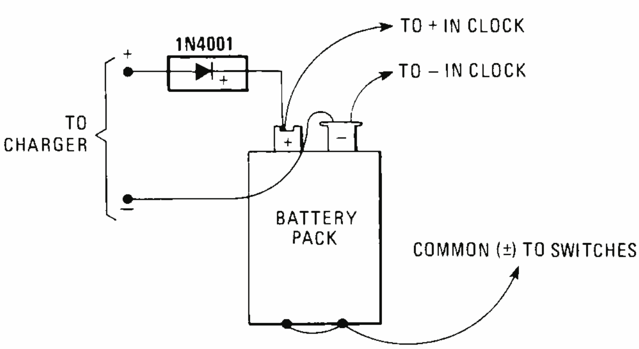


FIG. 2—A RECHARGEABLE BATTERY IS EASY TO ADD. One simple diode provides protection against polarity switching.

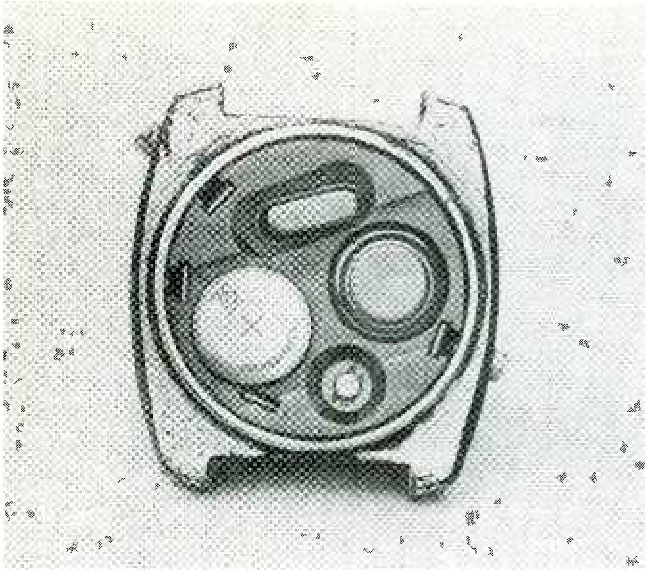
TWO TYPICAL LED WATCHES you are apt to find unused in your home. Almost any LED watch can be used for this project. If you want to use LCD watches you may have to change the power supply to 1.5 volts.

ALL THE PARTS YOU NEED to convert a watch into a clock are shown here. It's a fun, single-evening project.

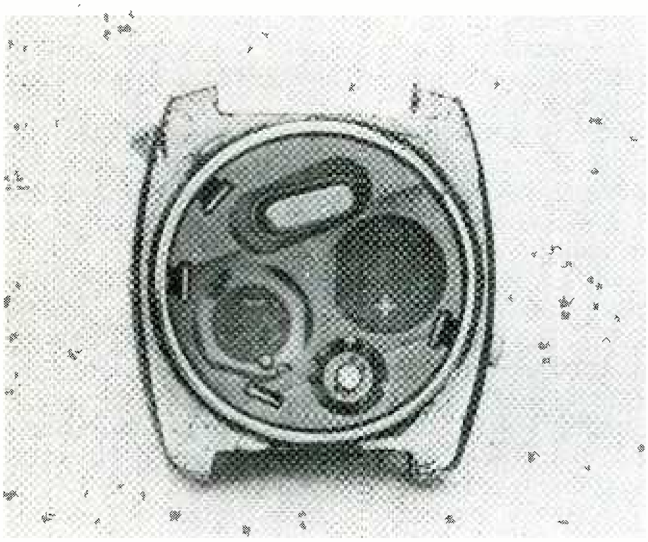
until it shines. Then quickly tin it. Tin the wire before soldering it to the contact. The other end of that wire will connect to the common connection on the switches. The positive and negative contacts are made with a regular battery clip. You can use one that you have removed from an old 9-volt battery. Attach a wire to the other side of each switch. These will be connected to the clock a little later. See Fig. 3.

Start taking the watch apart after the switches and battery holder are wired and in the box. Again, the photos show the steps. Some watch cases unscrew, some pry apart. Remove the batteries. Then carefully work the innards out of the case. Note which contact is positive and which is negative, just in case they get covered with solder later on. The red lens will usually come off of the case with a little prying and a gentle push from the back. Be careful not to scratch it.

Use a small, 15 – 25-watt soldering pencil to make the connections. The iron's tip must be clean and well tinned. No special static protection was needed even though the watches use MOS technology. Solder fine wires to the positive and negative terminals in the



REAR VIEW OF "DEAD" LED WATCH, with the back cover removed. Some back covers pry off. Others are screwed off. You may have to use your long nose pliers as a spanner wrench.



REMOVE THE BATTERIES. You may want to draw a simple diagram so battery polarity isn't forgotten.

clock. The other end of the wires go directly to the battery clip. File or scrape the tabs originally contacted in the watch for set, readout, etc., before trying to solder to them. Solder the other wire from the switches to the tabs. After that, put the batteries in the holder.

This would be a good time to start pushing buttons and find out which one does what. You may wish to label them even though I didn't. When you push a button, the display should show some sign of life. If it doesn't, carefully recheck the connections. Look for voltage or a lack of it at the terminals inside the clock. It should measure close to 3 volts from the + and − terminals. Then check from + to common and − to common. They should be around 1.5 volts each.

At this point if all is well, go ahead and slip the unit into the case. On mine, the wires were stiff enough to hold the works in place. Foam weather stripping is also useful for that purpose. Measure the distance from the top of the case to the center of the readout. Drill, nibble, or otherwise mill a slot in the cover so that the display will show. Don't worry if the hole isn't too neat. The edges will be covered by the red lens used to filter the display. Use one of the white glues to secure the lens in place. An acetone base cement may tend to dissolve the plastic. Put the front cover on and set the time, date, etc., in the usual manner. Isn't it a nice feeling not to have to worry about running down the batteries?

Now to find a place for it: I have one out in my ham shack; the power isn't always on out there. There is another one within easy reach on the nightstand.

Variations worth trying

Here are a couple of variations that we enjoyed and that you might like to try. Rechargeable batteries will work with most of the these clocks. Use a diode for protection against reversed charging current. Fig. 2 shows the details. The readout will be just a bit dimmer with NiCads than with regular batteries. (NiCads deliver a slightly lower voltage.) Terminals or wires have to be brought out of the clock to go to the charger.

If you would like to make a more permanent installation in your car, the battery drain would not be noticed. The current drain is only a few mA (10-15) with the display off, and 35–70 mA when showing the time.

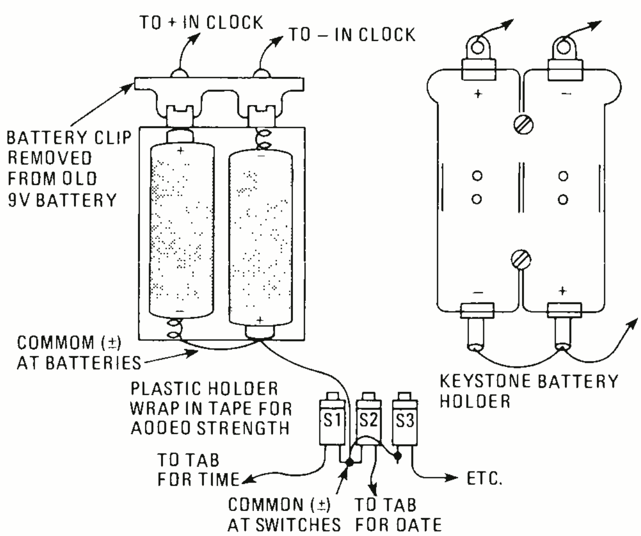


FIG. 3—INTERCONNECTIONS BETWEEN SWITCHES and batteries. An ordinary battery holder helps keep everything compact.

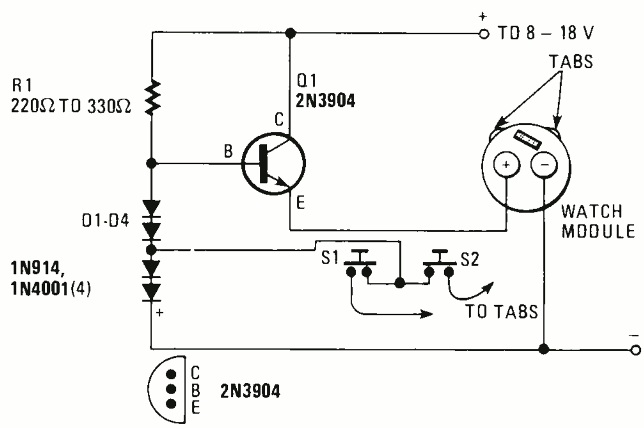
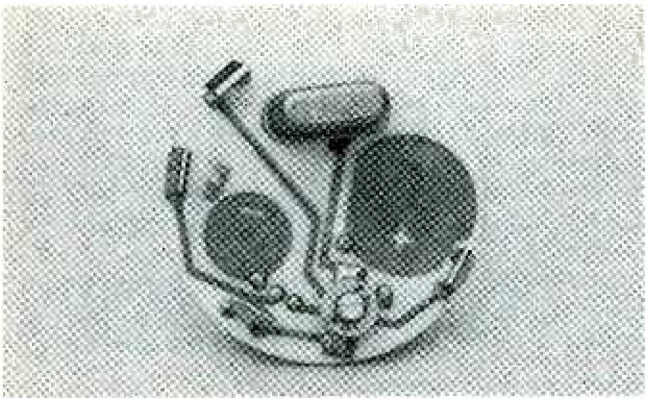
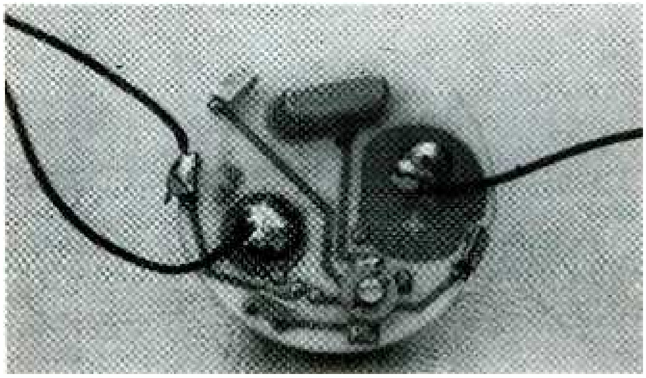


FIG. 4—REGULATOR SCHEMATIC. Use this circuit if the clock is to be powered from a car or boat battery/alternator supply.



TAKE THE WORKS OUT OF THE CASE. This becomes the clock module for your Instant Digital Clock.



BATTERY CONNECTION LEADS are soldered into place. Observe polarities. Be careful and use a low-wattage soldering iron.

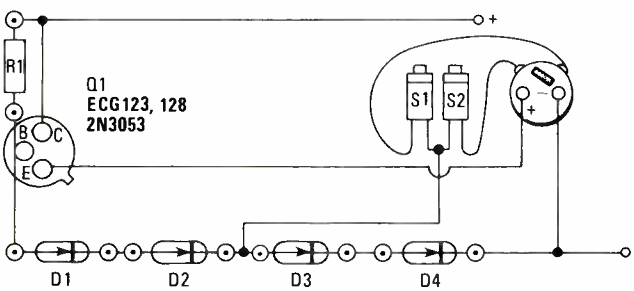


FIG. 5—SUGGESTED PARTS LAYOUT for regulator circuit. As there is nothing critical about this circuit you are free to rearrange parts to suit yourself.

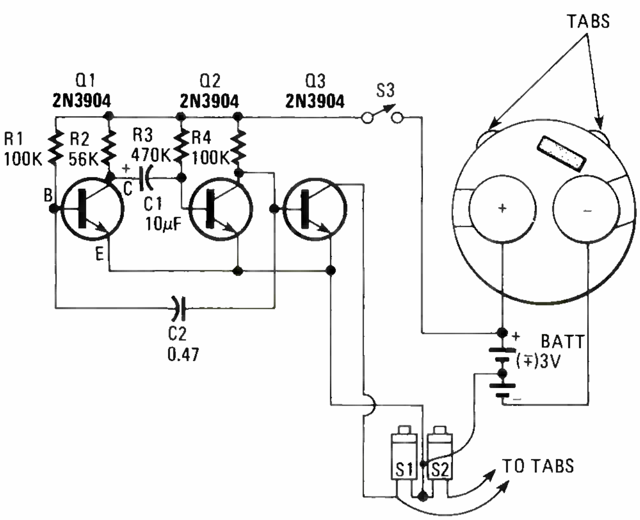


FIG. 6—FOR AUTOMATIC SEQUENCING of clock functions try this circuit. Adjusting RC values will vary the sequence timing.

The simple regulator circuit in Fig. 4 reduces the car-battery voltage to the level needed to run the clock. It is quite effective and has only three basic parts. The regulator consists of a transistor, a resistor, and a reference diode. For the sake of clarity it is strung out in pictorial fashion in Fig. 5.

The transistor is a silicon type such as a 2N3904, 2N3053, ECG123 or ECG128. The resistor may be any value from 220 to 330 ohms. A single reference diode is not practical. The tap between the middle diodes is needed for the common connection to the switches. The 1N914 or 1N4001 series of diodes is ideal. They are readily available and inexpensive.

Test the regulator before connecting it to the clock. Connect a resistor with a value between 1000 and 100,000 ohms between the emitter of the transistor and ground. The positive meter lead goes to the emitter. The negative lead goes to ground. Connect the regulator to the power source: 8 to 18 volts. The voltmeter should read between 2.8 to 3.3 volts. If it reads considerably higher, check the diodes. There should be about 2.4 volts across the entire string. Check to be sure that the transistor is correctly connected.

If the regulator is delivering the correct voltage, 2.5 to 3.5 volts, the clock may be connected to it. (Remove the voltmeter and test resistor.) The regulator may be built onto a small piece of perf board and squeezed into the clock case.

Finally, here is one more variation that we used on a two-button clock. It is an automatic sequencer, and is especially useful in a car. It can be set so that the clock will periodically display time of day followed by the seconds.

Fig. 6 shows us the heart of the sequencer which is a cheap free-running multivibrator. When it sets, that is: Q_1 on, the display comes on with the time. When it resets: Q_2 on, the system is ready to sequence again. Positive feedback in the circuit keeps the multivibrator running. The two transistors will change from on to off at a rate determined by the size of the resistors and capacitors.

When Q_2 turns off, R_4 feeds current into Q_3 and turns on the display. Q_3 needs to be on for only a few parts of a second to cause the display to turn on for its usual 1 to 3 seconds. If Q_3 is on much longer, then the display goes to the next item in its sequence. That is usually the seconds or the date.

Capacitor C_2 determines how long Q_3 is on. C_1 has the most to do with how long between cycles. The larger the capacitor, the longer the time. Change the values of C_1, C_2 or the resistors to program the sequencer. The values shown will give a display every few seconds. The toggle switch disconnects the power to the sequencer and allows normal manual operation. If you push a button while the clock is in the automatic mode, it won't do any harm.

Use low-leakage silicon transistors such as the types listed earlier. The layout is not critical. The parts can be mounted on perf board, even the same one that holds the regulator. The instant digital clock is not only a practical thing to have around, but it also makes a dandy conversation piece. You may want to scout around for spare LED watches relatives and friends are not using. They can be used for surprise gift Instant Digital Clocks in return. **SP**

HOW TO BUILD & BUY PROJECTS FOR LESS

Buying electronics parts, when you can find them at all, can set you back quite a few dollars. These ideas will make the task a little easier, and a lot cheaper!

by HERB FRIEDMAN

IT'S HARD TO BE AN ELECTRONICS-PROJECT BUILDER TOday. While few things equal the thrill and excitement that comes from building an electronics project and getting it to work, the marketplace often appears to be deliberately pricing the electronics builder out of existance—or at the very least making it next-to-impossible for him to obtain the components vital to even the most basic of magazine projects.

Few of the legendary mail-order parts houses exist today, and the blocks of parts stores that comprised the "radio rows" of our larger cities are but an old-timer's memory. Components are now job-racked in blister packages, and if a particular part is sold out because some magazine published a "hot project," the chances are that the retailer won't get the item again until he resupplies the entire rack—which could take months.

Also, job-racking and blister packaging adds astronomical markups to the price of components commonly used by hobbyists. For example, an ordinary mini-toggle switch that would be reasonably priced with a 100% markup at $2 normally sells in a blister-pack for more than $3. A resistor that is worth—tops, 10¢, goes for two-for-50¢ in some New York City "electronics" stores. Small electrolytic capacitors that I buy from a commercial supplier in single units for 26¢ are job-racked to hobbyists at 99¢.

The price of many components is now unreasonable, and often a project simply isn't worth the cost if you must buy new parts at full "list".

And even when you're willing to spend the money there's a good chance you won't find what you need because the stores only want to stock parts that turn over fast. They don't want parts lying around on their shelves gathering dust while waiting for customers. For example, for longer than most persons can remember a popular hobbyist project has been some form of short-wave receiver preselector or preamplifier.

A complete line of coils for just such a device is manufactured by the J.W. Miller Co., and those coils were always "standard stock" in the old Lafayette and Allied Radio catalogs. Miller still lists the coil, but where can the hobbyists buy them? Hobbyists often depend on rumors that so-and-so has some Miller coils, but more often than not the rumor proves untrue. And even if you could get the coils, have you seen the prices on 365-$\mu\mu$F tuning capacitors? It's a wonder that they sell any that aren't surplus (and priced accordingly low).

Yet in spite of all those obstacles, thousands of electronics hobbyists manage to build projects without taking out a second mortgage on the old homestead. How do they do it? By selecting parts carefully and making substitutions, and with "selective shopping." That means knowing who specializes in particular types of components, because specialists can often provide parts for far less than you'd normally expect to pay. Let's look at a few practical examples so you can understand what we're driving at.

Substitutions can do the job

Many authors of construction projects use those components that *they* can obtain locally, or that they have in stock. In many instances you can substitute components that *you* have in stock, or that are available inexpensively in your own area. As a general rule, construction articles will clearly state when a component type or value is critical and should not be substituted.

Transistors are a good starting point. In audio and DC applications you can generally substitute almost any transistor with similar gain, voltage characteristics, and polarity. Also, there is a standard part number for most "general replacement" devices such as those by Motorola, GE, Radio Shack, RCA, Sylvania, Zenith, etc... For example, if a project calls for a Radio Shack transistor part number 276-2009—that sells for 79¢—you can substitute the 2N2222A, which can frequently be purchased "surplus" for about 19¢.

The 1N4000 family (1N4000, 1N4001, 1N4002, etc.) of silicon rectifier diodes, are often available "surplus" at prices ranging from 5/$1 to 12/$1. You can use them to substitute for many "power rectifiers" used in construction projects. Similarly, surplus 1N914 small-signal diodes that are priced from 5/$1 to 20/$1 can substitute for most silicon small-signal diodes. The 1N60, that can be purchased for about 10¢ to 15¢, will substitute for most germanium diodes used in hobbyist projects.

The reverse-voltage (PIV) rating is usually the key to signal-diode substitution; don't substitute a diode with a *lesser* PIV rating than the one specified in the parts list. Also, don't attempt to substitute a germanium diode for a silicon and vice-versa, because the project might not work with such a substitution. A germanium diode has a forward "breakover" voltage of nominally 0.3 volts, while that of the silicon diode is nominally 0.7 volts. Since the breakover voltage might be important in the operating circuit—particularly in squelching or switching circuits—avoid the germanium/silicon swap.

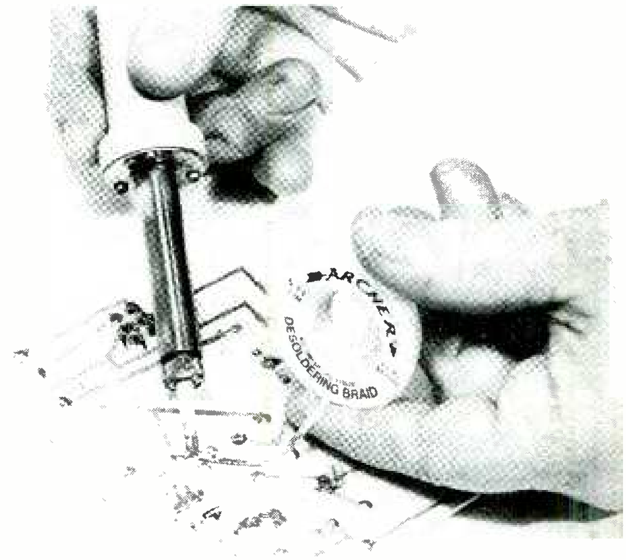
Truly great savings can often be made on electrolytic and tantalum capacitors. As a general rule of thumb, you shouldn't normally substitute an electrolytic for a tantalum capacitor, but it *can* be done in power supplies such as you might use for a digital project. Most power supplies use tantalums in parallel with the main filter electrolytics. If the input to the regulator is 1000-μF there will probably be a 2-μF tantalum connected in parallel. The tantalum is there to provide good high-frequency bypassing, that the 1000 μF electrolytic cannot offer. For that purpose you can generally substitute a conventional electrolytic that is 10× the tantalum's value—if the specified tantalum is 2 μF, use a 20- or 25-μF electrolytic—values often found in the junk box.

Also, use any electrolytic capacitor you have. The "junk" you use is money that you don't have to spend. For bypassing you can always go higher in value and voltage rating, again using values you might have lying around. For example, if a power-supply project calls for 1000-μF at 16-VDC, you can easily substitute anything larger than 1000-μF, and a higher voltage rating than 16 VDC. Electrolytic capacitor values are rarely critical except for interstage coupling, and some "feedback" bypassing—such as an emitter bypass on an audio or DC amplifier.

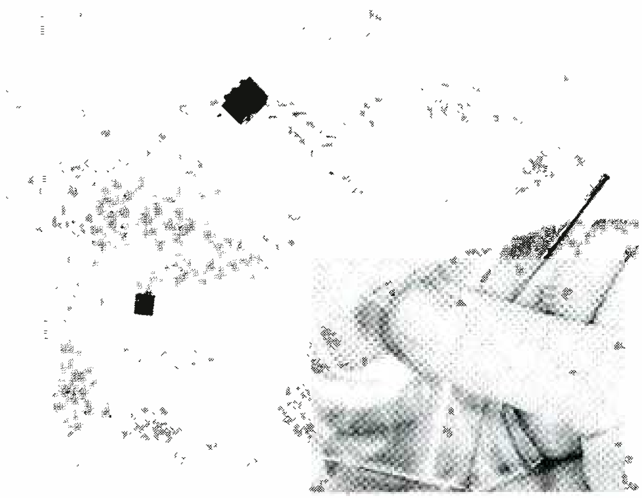
Great savings can also be made in switches and jacks. The author might have used a mini-switch because he had one lying around. But mini-switches usually cost between $1.69 and $3.19. If you can substitute a 99¢ standard-size switch, by all means do so. Same thing with jacks and plugs. The author might have preferred to use phone type plugs and jacks, but you might be able to get away with phono jacks and plugs, and you can figure each set as at least $1-$2 saved.

Quite a few dollars can be saved by not improving on the components. Silver mica capacitors are needed in tuned circuits but usually don't improve any project that calls for low-cost ceramic and Mylar capacitors. Similarly, substituting 5%- or 1%-tolerance resistors when the project specifies 10% also doesn't improve the project. The author usually specifies the component types and tolerances he used in the project, and going "better" frequently does little more than waste money. It doesn't necessarily (or usually) make for better performance.

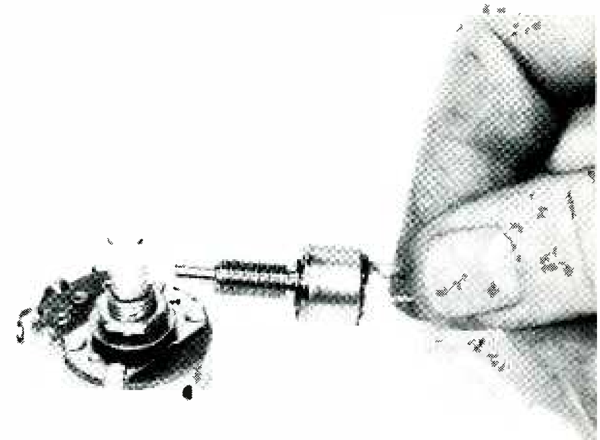
Another way to save "*Big Bucks*" is to recycle components from old projects. Now that doesn't mean that you should save each and every part, because you'll soon get tired of trying to strip a PC board or chassis loaded with resistors and capacitors, and you'll probably give up before you get to the really good, expensive stuff. Forget the resistors with short leads and the inexpensive capacitors. Go for the expensive hardware: the switches, jacks, transformers, speakers, and the like. Transistors and IC's come last if you're not



DESOLDERING BRAID MAKES SALVAGING PARTS from old equipment extra easy. Just make sure not to use too much heat. Snip off ends clogged with solder.



AN UNKNOWN COMPONENT IS WORTHLESS, so make sure that you identify every component you salvage for future use. The "locking" plastic bags shown are great for that. Baby food jars are useful, too.



WHERE POSSIBLE, USE LESS EXPENSIVE, surplus substitutes. The pot on the left sells for between five and ten times as much as the surplus unit on the right. In many cases, the surplus unit can be substituted with very good results and a cash savings.

tired of "scrounging" components.

The parts will come out easily if you remove the solder using a desoldering braid such as Solder-Wick. When you mash Solder-Wick into a connection with a soldering iron, virtually all the solder flows into the wick. If you're de-soldering a printed-circuit connection the component's leads will often be left in the center of the hole free of solder. Even if the lead is folded onto the foil, a proper "slurp" (with sufficient heat) will remove so much solder you will be able to lift up the lead with the edge of a knife or a set-screwdriver. Where desoldering braid doesn't work, a solder puller will; and if you're one of the very fortunate, use a professional desoldering tool.

Old transistor radios are a particularly good source of salvage for construction projects, because they have miniature speakers, headphone jacks and often power-supply jacks, audio transformers, ferrite loopsticks, and even "standard" transistors. Some of that hardware gets very expensive if you must go out and purchase it new.

Avoid a hell box

Place all salvaged components in small plastic bags, along with a paper marker saying what is in each one, because nothing is so easily lost as a small electronics part dropped loosely into a "junk box" along with a few hundred other salvaged parts. If the part is unmarked, forget it. Similarly, discard any salvaged component that seems to have been damaged during removal. Nothing is more frustrating, *or expensive*, than using defective components in a home-brew construction project.

Mail-order savings

When you *must* buy parts, you can often make substantial savings through mail-order surplus dealers. For example, assume that you would like to build an electronic flash of some form for photographic use, or maybe even a strobo-tachometer. Now a small, pocket-size electronic flash sells for $10 to $15 in a local camera store. Logically, you should be able to build what you want for about the same price. So you look in a standard electronics parts catalog where you find a flashtube for about $3 and a trigger coil for $1.50. You've got $4.50 invested and you don't even have the storage capacitor. Whoops!, this outfit doesn't stock a photoflash capacitor, so even if you purchase the tube and coil from them, where do you get the capacitor? Good question. Like many other consumer-products stores, electronics parts distributors often don't stock a "full family line," meaning related components that probably would be used together.

To build a photoflash project you would be best off in using a catalog from a specialist in photo-flash components such as *Chaney Electronics Inc.*, rather than a "standard" parts catalog. Chaney is a "surplus" dealer, and one of their specialties is photoflash parts—it appears they bought out the Honeywell line. Chaney sells both a flashtube and its trigger transformer for only $1.75, and they have a broad selection of photo capacitors: such as a 100 μF/250 volter priced at $1.50. Last time I purchased a "new" capacitor of approximately those ratings I paid almost $7 each, and that was eight years ago.

Chaney also specializes in gadgets and gizmos you usually can't locate easily, and again they are at a rock-bottom price: for example, trimmer and miniature capacitors. They also have inexpensive surplus standard-value electrolytic capacitors such as 33 μF/16 volts priced 5/$1, standard 1N914 rectifiers at 20/$1. Or how about jumbo red LED's at 7/$1?

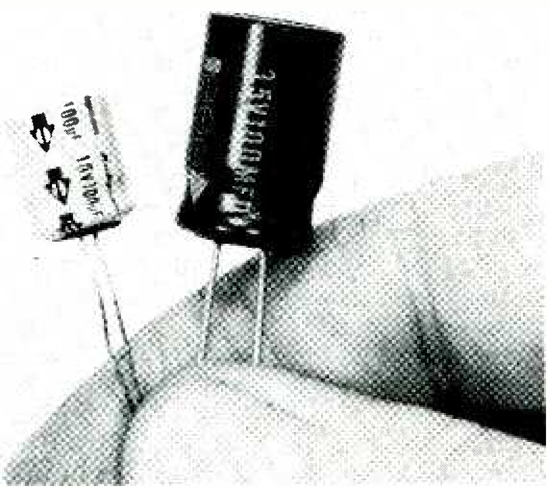
Get the picture? Go *surplus*. The savings can be enormous. Often, it pays to stockpile parts you think you'll need in the immediate future, because it might be possible to purchase somewhat larger quantities at a low cost. For example, *Poly Paks, Inc.*, publishes a giant catalog, jam-packed with surplus items that are usually offered "in bulk", like five LED 7-segment readouts, or an assortment of 100 popular value resistors, or large quantities of commonly used transistors such as the 2N2222. If you purchase an assortment, make certain that it has enough usable values. For example, some kits of 50 or 100 resistors are the "culls" —values, that no one purchased; you probably won't want them, either. Make certain that the kit contains "standard" values, such as 1K, 2.7K, 4.7K, 15K, 22K, etc.

Not all surplus dealers are giants; some have small selections but still good prices. Need line cords for your projects? *Electronic Mart* has 3-wire cords for $1.25 each. Last time I saw those in a hardware store they were almost $5. Or maybe you need a 9-volt "AC adaptor"-type power supply. Electronic Mart has them for as little as $1.25. (You couldn't buy just the power transformer anywhere else for $2, assuming you could locate one.)

How about a professional-type alarm bell for a home-brew burglar alarm system? At "list price" figure you'll be charged from $22 to $30—basically all the traffic will bear. But the *All Electronics Corp.* will sell you one for $15. All Electronics is also a good source of small (low-current) power transformers. (Get the All Electronics catalog, because they have an excellent selection of low-cost odd-value transformers—like 18 volts at 1 amp, which is perfect for many regulated 12/5 VDC hobbyist power supplies.)

Got a project that calls for tantalum capacitors? That's another item that doesn't come cheap. Occasionally you'll see a *few* values available as surplus, but you'll find a good selection of values at really cheap prices in the *H.J. Knapp of Florida, Inc.* catalog.

How about meters? Priced any lately? even a basic 0-1 mA DC panel meter is fast approaching double-digit prices. But there are many meters floating around the surplus market which were originally intended for OEM (*O*riginal *E*quipment *M*anufacturer), like CB S-meters. When CB more or less folded, so did many CB transceiver manufacturers; their excess hardware is coming into the marketplace now. An outfit like *Surplus Electronic Corp.* has a quite good selection of those surplus meters, often selling for as little as 5/$5.



AN ELECTROLYTIC IS AN ELECTROLYTIC, but the surplus unit on the left, which incidentally has a higher voltage rating, cost about ⅓ less than the new unit on the right. Always check used electrolytics for leakage.

You might not want an S-meter or a blank scale, but it's certainly worthwhile making a new scale with pen and ink, if you can save some $5 to $9 on the cost of a single meter.

While I have singled out just a few mail-order houses because some of their items are rather unusual, they are not the only places to get great buys on standard components. Among the other parts sources with acceptable reputations are *Godbout Electronics; Formula International, Inc.; Suntronics Inc.; International Electronics Unlimited*, and probably ten others I can't remember. You'll find their ads in the back pages of magazines such as this one and our sister magazine **Radio-Electronics.** Be sure to get on their mailing list by sending for a catalog. You'll find a list of suppliers at the end of this article. When you write for catalogs tell them you found their name and address in **Special Projects.**

You're probably wondering how come well-known companies such as *JDR Microdevices, Inc., Solid State Sales, Digi-Key, Advanced Computer Products*, and *Jameco Electronics* haven't been mentioned. Well, they are not primarily surplus dealers, though they do have *some* surplus at remarkably good prices, and it's surplus that we're talking about. JDR, Solid-State, and the rest are more like your local stocking distributor (assuming you have such a thing in your area that will sell retail—most are wholesale only). Those are the mail-order distributors you must depend on for those oddball—though standard—components you can't obtain locally at a fair or budget price.

For example, recently I had an idea for a small computer project using a new UART that looked real good for hobbyist use. When I called the manufacturer to find out where a **Special Projects** reader could purchase the part, he told me there was only one local source, an OEM distributor whose minimum sale—C.O.D. and credit—was $100. I called a few of the mail-order houses and *Advanced Computer Products* told me they would be stocking the part soon, at $6.95—a suitable price for the project.

Making what are normally OEM parts available to hobbyists is the primary advantage of the mail houses specializing in solid-state components: They can usually provide components you can't get locally for any price.

A few warnings about purchasing parts by mail are in order. First: Try to avoid sending cash. There are many reliable mail-order houses; I have mentioned a few. There are also many who conduct their business with the customer's money—particularly in the computer-equipment field. They have nothing in stock; when enough customers have prepaid, they then use the money to order the merchandise. You might wind up waiting months or forever for one of these outfits to ship; and getting a refund across state lines is next to impossible. Use VISA or MasterCard whenever possible, even if you must go to a different vendor. If you're stuck, order C.O.D. The extra $1.50 or so for the C.O.D. will be worthwhile. An extra advantage of the charge and C.O.D. is speed. You won't have to wait two weeks (at least) for your personal check to clear before your order is shipped.

Another advantage of the charge and C.O.D. is that you don't end up playing the "backorder" or "out of

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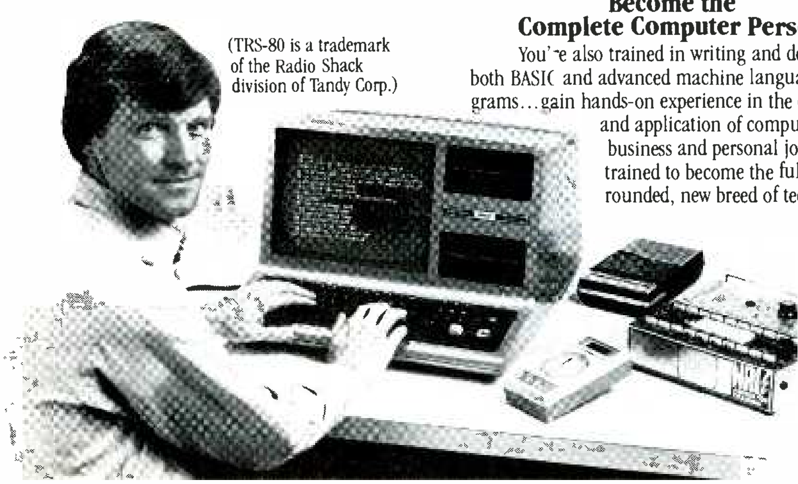

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stock" game. If you miscalculate the shipping and handling fees on a prepaid order—even by a few cents—many mail-order firms simply "backorder" enough of your order so what you paid covers the full postage and handling. Or they claim an item is "out of stock" and tell you to reorder at a later time. You get back a "credit" coupon for the remainder of your funds, but the components they didn't ship usually are the ones you can't get from any other source (Murphy's Law). So you end up delayed, and paying the postage and handling charges again. The C.O.D. and charge purchase eliminates the "phantom" backorder. If there is a backorder it will probably be legitimate if you charge the purchase.

Postage and handling

Speaking of "postage and handling," beware the excessive charges that have become a new source of extra profits for many mail-order firms. Two or three dollars should cover any small order that doesn't include something heavy, such as a power transformer. As for insurance: If you have it shipped UPS, the first $100 of insurance is free and every additional $100 costs 25¢. If the outfit charges 10% for postage and handling, consider what you're getting. If you ordered, say, $100 worth of transistors, it doesn't take $10 to ship them anywhere in the U.S. To give you an idea of what a reasonable charge is: I have had a reliable mail-order firm charge only $5 to ship a $500 computer printer across three states—now that's honesty. I have also had a box full of transistors, LED's and IC's shipped halfway across the country for $2, and was given the exact charge over the telephone when I placed the order.

Finally, try to consolidate your order so it can be supplied by a single distributor. Shipping and handling costs add up very fast. Almost everyone has a minimum order, or a minimum postage and handling fee, so if you order from two or three mail-order houses you can easily add $5 or more to the cost of a project whose component cost might be less than $20. That's like throwing your money away. **SP**

SOURCES OF PARTS FOR PROJECTS

ACTIVE ELECTRONICS
PO Box 1035
Framingham, MA 01701

ADVANCED COMPUTER PRODUCTS
PO Box 17329
Irvine, CA 92713

ALL ELECTRONICS CORP.
905 S. Vermont Avenue
Los Angeles, CA 90006

ALTEX ELECTRONICS
618 W. Sunset
San Antonio, TX 78216

ANCRONA
PO Box 2208R
Culver City, CA 90230

CHANEY ELECTRONICS
PO Box 27038
Denver, CO 80227

CONCORD COMPUTER PRODUCTS
1971 S. State College
Anaheim, CA 92806

DIAMONDBACK ELECTRONICS
PO Box 12095
Sarasota, FL 33578

DIGI-KEY CORPORATION
Highway 32 South
Thief River Falls, MN 56701

ETCO ELECTRONICS
Route 9N
Plattsburgh, NY 12901

GODBOUT ELECTRONICS
Box 2355
Oakland Airport, CA 94614

H.J. KNAPP OF FLORIDA
4750 96th Street North
St. Petersburg, FL 33708

INTERNATIONAL ELECTRONICS UNLIMITED
435 First Street
Solvang, CA 93463

JAMECO ELECTRONICS
1355 Shoreway Road
Belmont, CA 94002

JAVANCO
150 2nd Avenue
South Nashville, TN 37201

JDR MICRODEVICES, INC.
1224 S. Bascom Avenue
San Jose, CA 95128

POLY PAKS, INC.
PO Box 942
S. Lynnfield, MA 01940

PRIORITY ONE ELECTRONICS
9161 Deering Avenue
Chatsworth, CA 91311

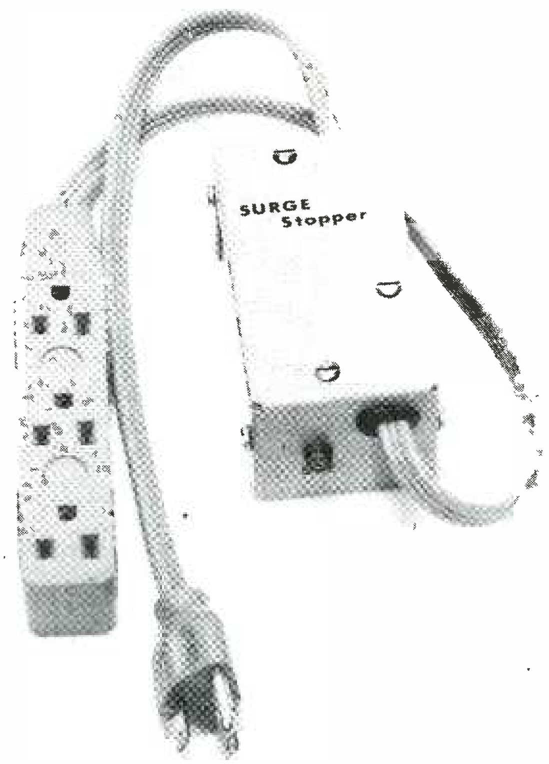
SOLID STATE SALES
PO Box 74D
Somerville, MA 02143

SUNTRONICS
12621 Crenshaw Boulevard
Hawthorne, CA 90250

SURPLUS ELECTRONICS CORPORATION
7924 NW 54th Street
Miami, FL 33166

VERMONT ELECTRONICS, Dept.3
312 W. Vermont, Suite B
Anaheim, CA 92805

SURGE



STOPPER

HERB FRIEDMAN

FASTER THAN A SPEEDING BULLET, FASTER EVEN than Superman, a transient can zip down the power lines into a personal computer and literally scramble hours of work. Yes, suddenly—for no apparent reason—4000 words of golden word-processed prose in your personal computer becomes meaningless garbage. "The Quick Brown Fox..." becomes "Txs KicY DrOn pic...", or "Now is the time..." becomes "Mpy kls −*4 #n&!...". Or maybe the transient causes what appears on the CRT screen to be 25 lines of tight, well-structured BASIC to get stored as incoherent COBOL, or is FORTRAN?; APL?; PL/1?.

One way to avoid the problem of powerline-generated garbage is the use a *SURGE STOPPER*, a device that squashes transient power-line variations before they get a chance to scramble the computer's RAM (*R*andom *A*ccess *M*emory).

But first, why do we need a Surge Stopper to begin with? Doesn't the computer's regulated power supply (Fig. 1) equalize or compensate for power-line voltage variations so that computer functions such as RAM aren't disturbed? In actual fact, it all depends on the particular power supply. Some personal computers are more susceptible to power-line transients than others. For example, my Heathkit H8/H19 computer is immune to virtually everything except a direct lightning hit. On the other hand, my TRS-80 gets scrambled RAM every time my Selectric printer is turned on. Actually, the TRS-80 *used* to get scrambled RAM. Since the Surge Stopper was installed on the power line nothing bothers either computer, and that includes a direct lightning hit on the backyard power line that was feeding both computers when they were active.

As you can see from the schematic (Fig. 2), the Surge Stopper is a straightforward project consisting of *varistor* V1, a fuse, and a neon lamp that serves as a safe power indicator, all housed in a metal cabinet. To protect against transient power-line surges, this circuit is connected *across* the power line used for the computer. To make connections to the computer a little

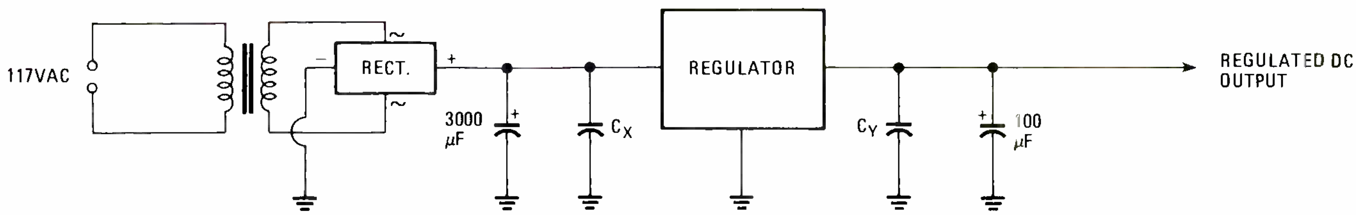


FIG. 1—TYPICAL REGULATED POWER SUPPLY used in consumer equipment. Capacitors C_x and C_y are usually 1-μF tantalum or 0.1-μF Mylar devices that serve as high-frequency filters.

more convenient, the model shown is built with a three-receptacle U-ground (3-wire) extension cord. The three receptacles provided should be enough to carry the average computer, printer, and disk- or tape-storage system.

In the circuit design shown we pass current to the computer through the same fuse that protects against a blown varistor because it provides better protection against transient damage directly to solid-state components. If the fuse protected only the power outlet loads, the transient caused when the fuse blows might produce excessive transient spikes within the computer.

If you already own a power-distribution center or strip you can eliminate the outlet extension and simply plug the device into one of the outlets in your existing power-distribution device. (But in this instance fuse F1 is only in the varistor circuit, and the computer might be subjected to a transient caused by failure of F1. As with everything else in life, you can't win them all, but it's better to have a blown fuse than to take out the entire computer. If the initial transient was so severe that it blew out the varistor, just thank heaven you only lost some data and not a handful of IC's.)

How it works

A *varistor* is a voltage-dependent nonlinear resistor whose electrical behavior simulates back-to-back Zener diodes. Below the "breakover" voltage rating, the varistor appears to be a high (infinite) impedance.

THE ACTUAL PROTECTION IS PROVIDED BY A VARISTOR. It provides a conductive path across the power line for transients that exceed the "breakover" rating—in this instance 130-volts RMS. The mounting tab, indicated by the finger, is also a conductor, and must be insulated from the metal cabinet.

When the applied voltage exceeds the breakover rating, the varistor's impedance plunges dramatically to a highly conductive level, and the destructive energy of the transient surge is absorbed by the varistor. While a Zener diode provides very effective clamping, a major limitation is its energy-dissipation capability. The Zener can "blow" before it fully protects a computer against a surge. A varistor, particularly the metal-oxide type, has relatively high energy-dissipation capacity, and can safely dissipate what might normally prove to be a disastrous overload.

Neon lamp LM1 is a safe indicator that only serves to let you know the device is still intact and is actually protecting your computer. For example, if a power-line surge is so large that it causes the varistor to short circuit (heat destruction), fuse F1 will "blow", causing neon lamp LM1 to turn off. If LM1 is off you know the varistor is *blown* and must be replaced. Without LM1 the varistor can be *blown* and you'd never know. Depending on the device that caused it, a transient surge on a 117-volt residential power line can range upwards of 400 volts, and spikes as high as 1000 volts are not uncommon.

Man-made transients are caused by the opening and closing of switches, or the passing of current through coils and capacitors. For example, we are all familiar with the "reverse diode" connected across relay coils to "short circuit" the induced *reverse emf*, that can often be so high as to exceed the breakdown rating of the associated transistors and IC's. Well, opening or closing a power switch to a "large" transformer or fan does the same thing, producing unusually large transient "spikes" on the power line unless suppressed. (...the reason the Selectric printer mentioned earlier turned data in RAM into "garbage".)

An oil burner is another excellent generator of transients, as is an electric thermostat. In fact, one of the older 117-volt oil-burner thermostats—the type that directly control the power line to the circulator or fan motor—is often a frequent and unsuspected cause of what appears to be intermittent computer RAM failure.

Transient isn't steady-state

The common regulated power supply usually used in personal computers is made to compensate for *long term* variations of the applied voltage and normal load variations within the equipment itself. Load variations are easily taken into account in the design of a regulated power supply, and power-line variations—at least in this country—are within relatively narrow limits. As each changes over a relatively long period of time the regulator adjusts itself to accommodate the variations in applied voltage and load, producing a constant voltage output. A simplified power supply of this type is shown in Fig. 1.

Unfortunately, some of these regulators cannot respond quickly enough to spikes of extremely short

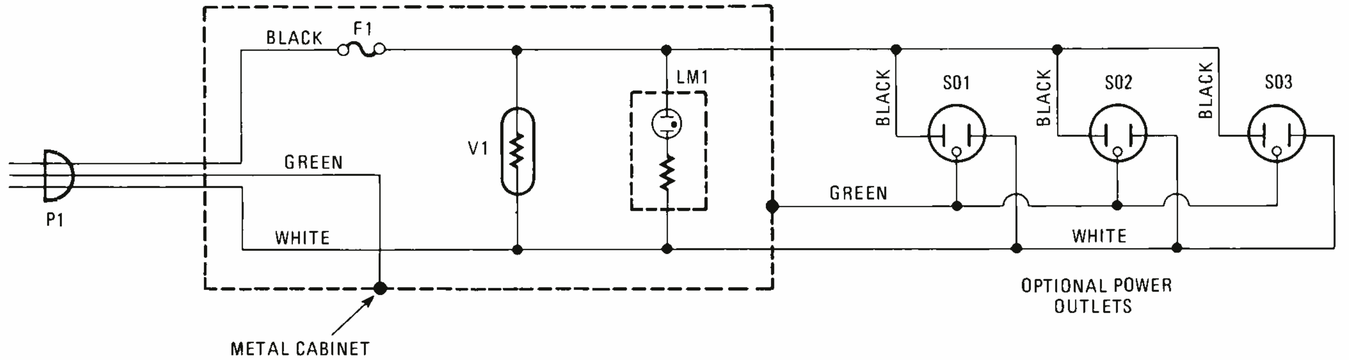


FIG. 2—SCHEMATIC DIAGRAM OF THE SURGE STOPPER. Does a powerful job for such a simple device.

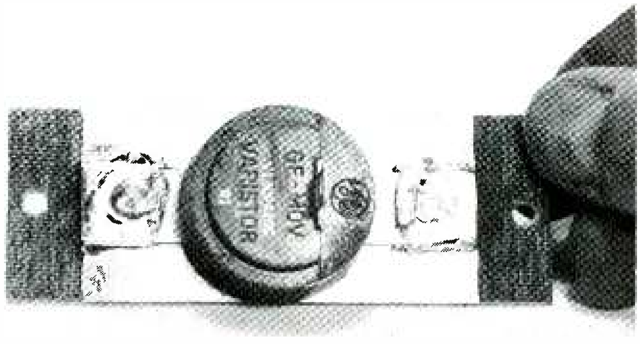
duration, say 5 μS or 20 μS. The spike zips right through the regulator and appears on the computer's 5- or 12-volts DC supply bus. True, there is considerable attenuation of the spike, but the sudden voltage increase on the rail can cause scrambled data in the RAM, or a sudden malfunction of a CPU process. As a general rule, most, if not all, of a short transient is suppressed by the 0.1-μF Mylar, or 1-μF tantalum capacitors connected across the power supply's main filter capacitor, indicated as C_X and C_Y in Fig. 1. But if the capacitors fail to filter the high-frequency transient?... well, that's when you need the Surge Stopper.

The metal-oxide varistors are available in many different voltage and current ratings. For computer protection we need something that will breakover slightly above the normal RMS power-line voltage. I find that 130 volts is the best choice for personal computers. For relatively low current rating the itty-bitty varistor types used to protect portable transistor TV's might prove adequate, but if you have a heavy transient producer on the same power line as the computer, such as a fan-cooled Selectric or other heavy-duty printer, or an oil burner, or a large refrigerator, or a copier, or a mailing machine, or you have frequent lightning activity in your area, the Series-P General Electric *GE-MOV Varistor* shown in the photographs is suggested. (This is also the size specifically recommended by G-E for medium duty of a small computer.) It's not going to protect your computer against a direct lightning hit,

THE VARISTOR CAN BE CONVENIENTLY INSTALLED by soldering the tab to a section of copper-clad PC board from which the copper has been removed at the ends.

PARTS LIST

*VI—GE-MOV Varistor, type V130PA20C
LM1—117-volt neon lamp assembly
F1—3AG fuse, 10-15 amperes (whatever is necessary—do not exceed rating of cable)
P1—U-ground AC plug (see text)
S01/2/3—U-ground AC outlets (see text)
Miscellaneous—Fuseholder, Cabinet, Etc.
***(The GE-MOV 130P is available for $12 postpaid, postage and handling included, from Custom Components, Box 153, Malverne, NY 11565. NY State residents must add sales tax. $13.50 to Canada.)**



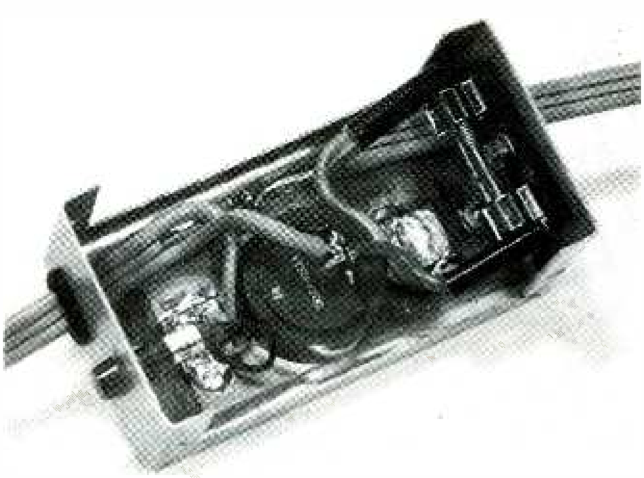
THE COMPLETED VARISTOR MOUNTING. The screws that secure the assembly to the cabinet pass through the now-insulated ends of the board.

but it can reduce or eliminate many RAM failures caused by household or office equipment.

How to assemble your own unit

The model shown is assembled in a 2 × 4 × 1⅝ inch aluminum cabinet. It should cost about $20 to build; less if you have a well-stocked junk box. If you're not used to working with high voltage in small spaces use the next larger cabinet. Except for the connections to neon lamp LM1, no wire size is smaller than No. 16, though No. 14 is specifically recommended.

Varistor V1 is not the easiest thing to locate or install. It is available from G-E electronic-component distributors, but they might have a minimum order more than three or four times what the whole project should cost. If you can't locate the required varistor in your area,



THE SURGE STOPPER SQUASHES POWER LINE TRANSIENTS that can cause a computer's memory to "flip" randomly, creating "garbage" out of what was formerly data. It also intercepts and dissipates "spikes" that can actually blow IC's if allowed to pass through the computer's DC supply.

single units can be obtained from the source in the parts list.

The tab on the bottom of V1 is not just for mounting; it is also a power-line connection, so it must be insulated from the cabinet. A small section of copper-clad PC board material not only makes an easily-installed insulated mounting; it also serves as a heat sink. Cut a piece of board that's just about the width of V1 and 3½ inches long. Using a hand grinder, or etching the foil as you would a printed circuit, remove a ½-inch strip of copper from each end so you have "insulated ends".

The mounting screws for the board/V1 assembly will pass through the insulated ends, but make certain that neither the lockwasher nor mounting nut will touch the copper foil.

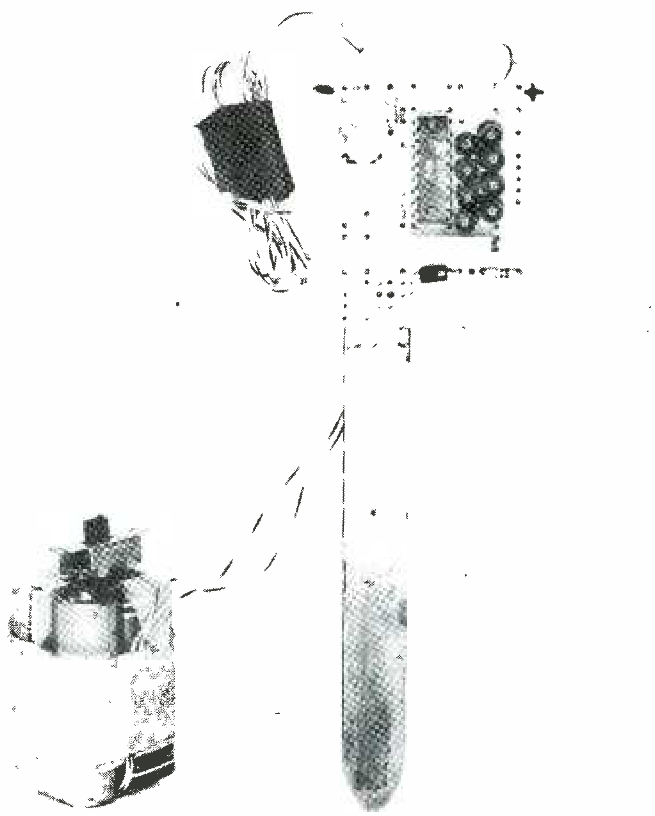
Position the varistor on the remaining foil so the ends of its tabs are exactly flush with the ends of the copper foil, and solder the tabs to the foil with a soldering iron rated at least 60 to 100 watts.

The holder for fuse F1 is mounted on one end of the cabinet. The proper rating for this fuse is 10 to 15 amperes, which might appear to be a strange value, but it's correct.

The cabinet must be grounded for safety; hence, the power plug must be the three-wire kind (the green wire is the ground). If you want an attached convenience outlet, cut a 3-foot Radio Shack 61-2762 power-center extension cord in half and use one end for "P1" and the other end for "SO1/2/3". The green ground wire from each section is secured to a solder lug installed on the cabinet adjacent to V1. One set of power-wire connections is soldered to the lug protruding from V1. The other set of power-wire connections is soldered directly to the V1 mounting strap(s) or the copper foil to which they are attached. Just make certain you don't have "cold" solder joints; V1's straps suck up a lot of heat.

To use the Surge Stopper just plug it in. As long as SAFE lamp LM1 is lit you may consider the varistor OK. (I have yet to see one that was "open".) **SP**

PLANT MOISTURE GAUGE



Measure the relative amount of water in your plants' pots with an LED column!

WARREN BAKER

AS ANY HOME BOTANIST WILL READILY ADMIT, FOR the proper growth of any form of plant life, one of the most important ingredients is the amount of moisture in the soil. The most popular methods used to control moisture usually fall into one of the following categories: 1. Periodic testing of dryness using your finger as a gauge; 2. The scheduled watering of all plants on an appointed day (or time). The first method is quite hit-or-miss and will only be done as one happens to pass by the plant and also happens to think of doing so. The second method is probably used more than the first. Watering all plants at a specified time (or day) works well and is very convenient to use.

However, neither system really takes into account the exact moisture content of the soil. In one case the plant could have used up all the moisture before being watered while in the other case, the plants will be watered even if they don't need it. There must be a better way to determine the moisture requirements.

The unit described in this article should solve the problems of when to water your plants by making use of our mutual interest, electronics. The Plant Moisture

Gauge can be tailored to suit any size or shape of container and can be duplicated for less than $25.00 depending upon the completeness of your junk box and the manner in which you purchase your new parts. In addition, the simplicity of the circuitry makes the unit a breeze to construct; and since no critical circuitry is involved, you are not "locked into" the physical format outlined in the prototype shown here. In fact, it is even possible to make one unit that will test all your plants at the turn of a switch or the press of a button. More on that later.

At the heart of the electronics package is an XR-2277 Dot and Bar-Graph Display Generator of the type normally used to take the place of the level meters on newer tape recorders and stereo systems as well as other similar applications. The XR-2277 provides up to 12 outputs with current sources capable of driving LED lamps directly. Current limiting for the LED's is handled by one resistor, R4, thus eliminating the usual individual resistors connected with each LED. Range of the XR-2277 is from −30 dB to +6 dB (referenced to approximately 0.2 volt). What all that means is that with the unit connected as shown, the LED's will light (one at a time) for each 3 dB increase in input voltage.

How it works

In the Plant Moisture Gauge circuit diagram (Fig. 1), the DC input voltage is supplied to pin #3 of the XR-2277 via a series divider network consisting of R1, R2, and R3. In practice, R2 and R3 may be varied to suit the builder's supply of trimmer potentiometers. For instance, a 25K potentiometer could be substituted for the combination. In that case, to ease adjusting the "dry" level LED, it should be a 10-turn pot. In addition, note that the schematic shows a 7.5-volt Zener diode across the R2, R3 combination. It regulates the input low level so that battery or supply changes will not affect the settings until the battery has run down below that point.

Again looking at Fig. 1, note the two "input" terminals connected in parallel with the Zener diode. That is where the senser probe is connected. When the probe is dry, it acts like an open circuit and has no effect upon the input voltage fed to pin #3 of IC1. However, when the probe is inserted into water, wet earth, or any other conducting liquid, etc., there will be leakage from one side of the probe to the other that will lower the total resistance of the divider combination resulting in less voltage applied to the XR-2277's input terminal. If you have kept track of the operation thus far, you will have discovered that the device is being used in reverse. That is, the "Dry" level is adjusted by R3 to the maximum voltage input while a fully saturated test sample will be the lowest input level.

Customize your unit

Although I used double-sided printed-circuit board stock to make my probe, you may desire to substitute some other method to sense the moisture. Although not tested, there is very little reason why two plain pieces of wire imbedded into the soil would not be just as effective. If you attach two stiff wires to the electronics package, as long as the wires would remain in position while inserting them into the soil, it may disrupt the plants roots less than the large probe. You are free to try your own method. The most that may be required, would be to alter the voltage divider ratio to obtain a useable range of readings. See Figs. 2 and 3.

Another innovation you may prefer is to use an LED array as the indicators instead of individual lamps. Those units are readily available and consist of ten (10) LED's in a DIP-style package. That would simplify construction as there would be fewer individual parts to wire together. The low cost of the little LED's, however, makes a good case in their favor as the array will cost a few bucks at the least.

The 10-μF capacitor (C1) shown, connected to pin 2 may not actually be needed in your unit. However, while breadboarding the Plant Moisture Gauge, my unit showed enough instability to cause two or more lamps to be illuminated partially under certain conditions. The bypass capacitor solved that tendency to be unstable. If

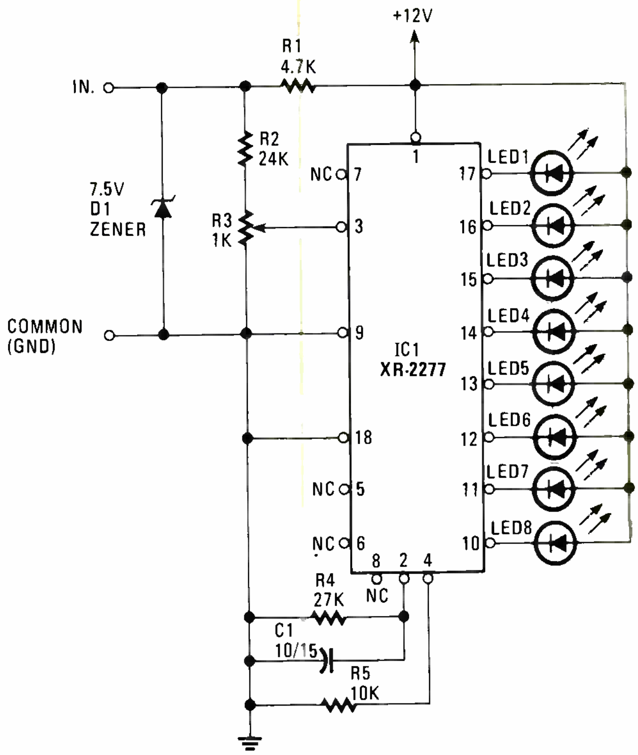


FIG. 1—SCHEMATIC DIAGRAM FOR THE POTTED PLANT MOISTURE GUIDE. The XR-2277 (IC1) Dot and Bar Graph Display Generator is the heart of this very simple and easy to assemble moisture indicating device.

RESISTORS

All ¼-watt 10% unless noted

R1—4700 ohms, 5%
R2—24,000 ohms (see text)
R3—1000 ohms, potentiometer (see text)
R4—27,000 ohms
R5—10,000 ohms

CAPACITOR

C1—10 μF, 15V

SEMICONDUCTORS

D1—7.5V Zener (1N555A)
LED 1-8—LED Lamps
IC1—XR-2277 (EXAR)

MISCELLANEOUS

Experimenter 300 board stock (Global Specialties); Double-sided Circuit-board stock, ½-inch × 5 inches.

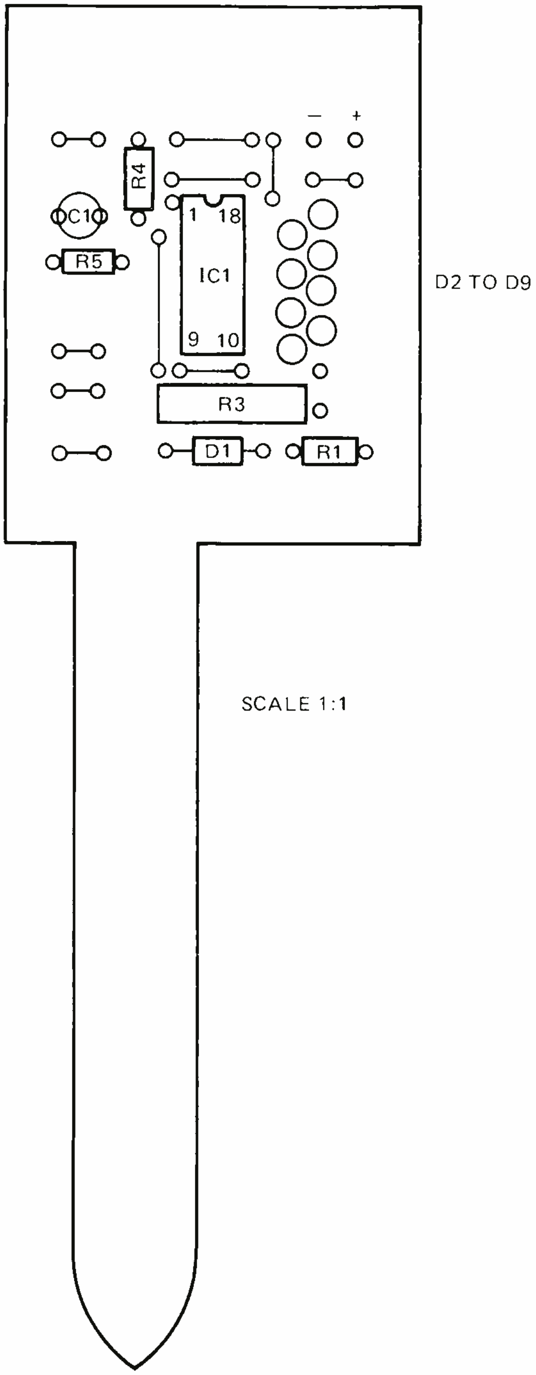


FIG. 2—HERE'S A ROUGH LAYOUT of the Plant Moisture Guide. Parts can be hard wired to a perf board since parts and wire placement are not critical at all. Long sensor probe is a double-sided copper-clad board cut to scale.

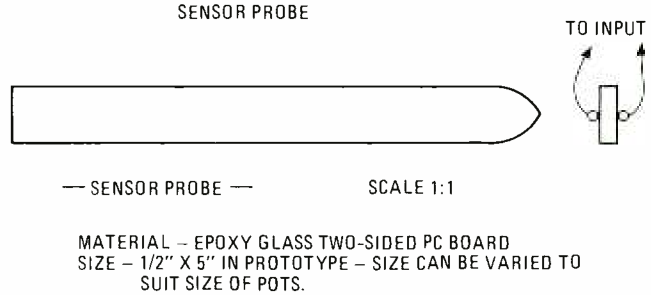


FIG. 3—DETAILS ON THE SENSOR PROBE are fully illustrated in the drawing. Epoxy glass board is less likely to absorb moisture and produce a false reading. Be sure pot has a drain hole at bottom to wash out accumulated water-borne salts.

you check the specification sheets supplied by Exar on the 2277, you will find that a 10-μF capacitor is recommended at pin 4. I found no need to include such a bypass in this application. The most probable reason is that we are applying a DC voltage and initially, the XR-2277 was designed for use with AC input signals.

The 27K resistor attached to pin 2 is the LED current-limiting adjustment. We used the value recommended by Exar. However, varying the value will increase or decrease the current supplied to the LED's and should be determined by the particular lamps you may be using. The value used will supply approximately 15 mA to the LED's.

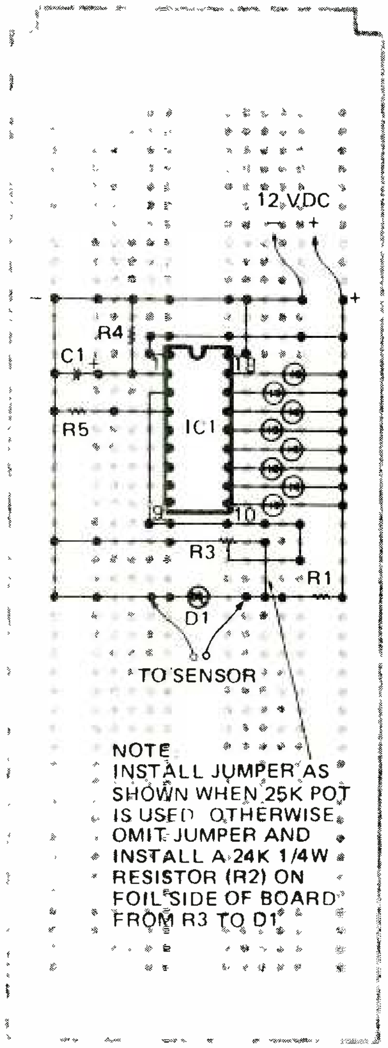
Power requirements of the Plant Moisture Gauge is limited by the XR-2277 and that figure ranges from a minimum of 10 volts to a maximum of 14 volts. We designed the unit to operate on 12 volts and that source may be from batteries or from a small plug-in supply as used with transistor radios, calculators and tape recorders. The supply could also be from a home-brew unit, but with the low cost of assembled plug-in units, building your own seems impractical.

The choice of whether you want to have continuous monitoring of the moisture content or whether you wish to check it only at random will influence your power source. Also, if you want to use it as a portable tester, then batteries are almost a necessity. Then, too, if you want to operate the gauge on a continuous basis, the AC power would be the most logical because battery life is limited.

Earlier in the article I mentioned a method of monitoring several plants with one unit. Only your imagination will limit the universal use of the Plant Moisture Gauge. For instance, by building several "probe" units and inserting one into each of the plants you want to monitor it is feasible to connect those "probes" to one central point where a switch assembly can be provided. The "Electronics Package" could also be connected to that switch to allow you merely to turn the switch to connect the gauge to each of the plants, one at a time. A set of self-cancelling pushbuttons would work very well here also. The nice part of this set-up is that, regardless of the differences in the probes and the size of the planters in use, the "dry" level will always be the same. Only the "wet" level will vary. Thus, different plants can be monitored with only one gauge unit.

I built my prototype Moisture Gauge with the aid of Global Specialties pre-etched "Experimenter 300" series of PC-board material. The system uses a 2 × 6-inch board drilled on 0.1-inch centers for easy insertion of parts. Like a breadboard, a center section will accept standard DIP units and at the same time allow for four additional connections to be made to each pin. Fig. 4 shows a suggested layout should you use that board, and is applicable to most other forms of construction as well. In my case, I cut off a 3-inch section for the electronics package and then soldered the printed-circuit-board-material probe to the underside of the package. The results can be seen in the photo at the beginning of this article. One word of caution: If you choose to use that method, be sure to cut through the foil pattern on the underside between the pins of each individual LED. In that manner, the LED's may be

FIG. 4—GLOBAL SPECIALTIES pre-etched Experimenter 300 board is shown here with the Potted Plant Moisture Gauge components wired to it. The 6 × 2-inch pre-drilled board with 0.1-inch centers makes parts layout and soldering a snap. You could crowd parts to top half of the board, cut off the bottom half, and have enough remaining to hook up another unit.



installed in already-existing holes. A small hand grinder with a burr may be helpful here. Otherwise, a sharp knife will easily cut the foil pattern.

In use, it is only necessary to set the "dry" level of the gauge and the calibration will have been completed. Before inserting the probe into a planter, turn the unit on and observe which LED is illuminated. It should be either one of the bottom ones (the choice is up to you). It is recommended that it be set to the next-to-last lamp and in this way, if for some reason a value changes, etc. it will then turn on the bottom one which can be used as an indicator for possible trouble. On the other hand, if it were set to the bottm lamp and it changed slightly, the lamps would all be unlit and you would not be sure what had occurred. Again, the choice is yours.

Once the Dry level has been set, insert the probe into the plant and measure the relative amount of water available in the soil. A reading at the uppermost lamp would indicate a fully saturated soil condition. Anything in between will indicate exactly that—somewhere in between wet and dry.

For more information on how the XR-2277 operates, get a copy of the Exar specifications sheet. It does offer a good outline of the operation. Their address is Exar Integrated Systems, Inc., 750 Palomar Ave., P.O. Box 62229, Sunnyvale, CA 94088.

In addition to the IC used in this unit, there are several other units including some that operate on a linear scale instead of the 3 dB manner of the 2277. I found the XR-2277 to be a natural for this purpose. **SP**

more new products

MICRO-TOOL FOLDER, 4 pages, covers a complete line of microminiature handtools, ultra-precision micro manipulators, and micro sharpeners, of interest to anyone engaged in microscope work. Minitool Micro-tools are the smallest available precision instruments for laboratory and precision use, and are available in 32 different tip configurations with interchangeable tool handles. Each micro-tool consists of a threaded handpiece, which holds the actual tip; the tip material is hardened toolsteel, unless otherwise noted. The folder is illustrated, and an extra sheet lists individual prices, as well as prices of assorted sets.—**Minitool, Inc.,** 1334/F Dell Avenue, Campbell, CA 95008.

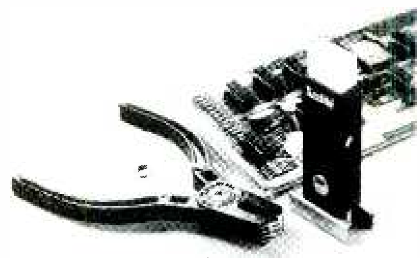
MICRO-TOOLS

FOR
RESEARCH
DEVELOPMENT
PRODUCTION

CIRCLE 626 ON FREE INFORMATION CARD

INTEGRATED CIRCUIT TOOLS, the *XD series,* includes eight insertion tools of aluminum and stainless-steel construction with varying pin capacities, featuring an adjustment for IC-tolerance variations. These long-wearing tools are safe for MOS and CMOS devices, and insert without stress on lead seals.

The one-hand *model XD-16* extractor (shown) removes 4- to 48-pin DIP's, will not bend leads, and eliminates the problem of flying solder. Individual tools are packaged in vinyl hang-up pouches, imprinted with instructions on their use. The *XD-series* tools are priced at $20.90 each.—**Xcelite,** The Cooper Group, PO Box 728, Apex, NC 27502.



CIRCLE 631 ON FREE INFORMATION CARD

"REACTANCE" POCKET COMPUTER PROGRAMMING

Why do electronic calculations the hard way when your Pocket Computer can do them for you quickly—and painlessly!

HERB FRIEDMAN

THE BASIC OF BOTH THE RADIO SHACK AND SHARP *Pocket Computers* handle variables in a slightly different manner than some other BASIC's. In the *Pocket Computer* all input variables are zero and are valued as zero if the ENTER key is pressed. The variable remains zero unless specifically altered. Similarly, any value entered for a variable will remain that value when the ENTER key is pressed. The *Pocket Computer* does not flash a "?" at you and then "hang up" until you enter a value for a variable. It accepts whatever was previously entered for the variable when ENTER is pressed. Essentially, it's a "computer shorthand" that simplifies multiple calculations of electronics formulas where one or two of the three values is a constant value. (An unknown, which is also a zero value for a variable, is considered a constant by the *Pocket Computer.*)

That lends itself ideally to solving reactance formulas because they often involve at least one constant value. For example, assume you are calculating the reactance of a capacitor at several frequencies. It is only necessary to enter the capacitor's value once. Each time a frequency is entered, the reactance is calculated and displayed; and pressing ENTER will recycle the program with the capacitance retained so it does not have to be re-entered. You could run through 25 or 30 reactance calculations in less than a minute.

The program REACTANCE will solve for both inductive and capacitive reactance. Accuracy has been set for the hobbyist and service-shop level. For laboratory accuracy (beyond three significant digits) change the PRINT USING statements to ".#####^". Each "#" character represents one significant digit.

You can run the entire program from the very beginning by entering RUN or R.; or you can access either program directly by entering RUN 100 or R.100 (or RUN 200 or R.200).

The programs are also "defined"—another "trick" of the *Pocket Computer*. Note the "L": at line 100 and "C": at line 200. The inductive program can be accessed directly from the computer's defined mode by pressing the SHIFT key and then the letter L. Similarly, the capacitive program can be accessed directly from the defined mode by pressing the SHIFT key and then the letter C. It's easy to switch back and forth.

The program in Table 1 is quite straightforward, and can be used with other BASIC's on "big" computers. Should you elect to go for "L" in the program, you will not be able to switch to capacitance calculations unless you shut down the pocket computer, or "Control C" it. Or, if you wish, you can rewrite lines 160 and 260 to read "GOTO 20", whereby at the end of each calculation you would again have to make the decision to go for "L" or "C". By now you can guess that the *Pocket Computer* is a "big" machine considering that the programs prepared for it will enable it to become a rapid-fire calculator that talks to you in English as it computes. **SP**

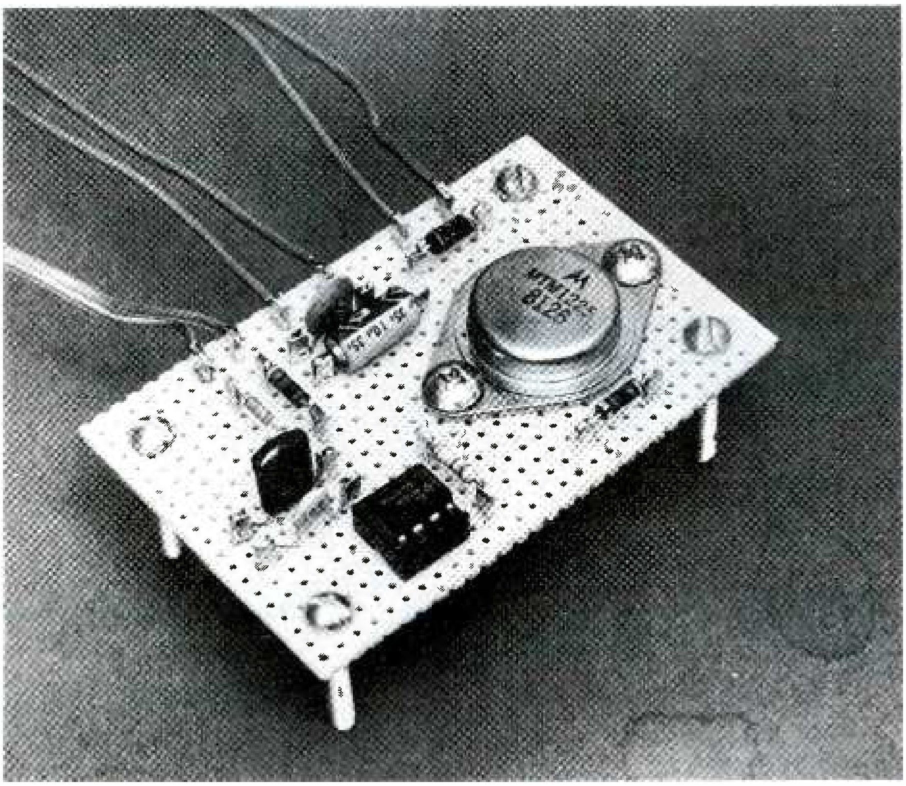
```
 5:PAUSE "FOR P
   OCKET COMPUT
   ER"
10:PAUSE "REACT
   ANCE"
20:INPUT "INDUC
   T(L) OR COND
   X(C)?";A$
30:IF A$="C"
   THEN 200
100:"L":INPUT "I
   NPUT L IN HE
   NRIES ";L
110:INPUT "INPUT
    F IN HZ ";F
120:INPUT "INPUT
    XL IN OHMS
   ";X
130:IF L=0PRINT
   USING ".##^"
   ;X/(2π*F);"
   HENRIES"
140:IF F=0PRINT
   USING ".###^
   ";X/(2π*L);"
   HZ"
150:IF X=0PRINT
   USING "#.##^
   ";(2π*F*L);"
    OHMS"
160:GOTO 100
200:"C":INPUT "I
   NPUT C IN FA
   RADS ";C
210:INPUT "INPUT
    F IN HZ ";F
220:INPUT "INPUT
    XC IN OHMS
   ";X
230:IF C=0PRINT
   USING ".##^"
   ;1/(2π*F*X);
   " FARADS"
240:IF F=0PRINT
   USING ".###^
   ";1/(2π*X*C)
   ;" HZ"
250:IF X=0PRINT
   USING "#.##^
   ";1/(2π*F*C)
   ;" OHMS"
260:GOTO 200
```

AN ACTUAL PRINTOUT from the *Pocket Computer* printer. This program is also shown in Table 1.

TABLE 1

```
  5:PAUSE "FOR POCKET COMPUTER"
 10:PAUSE "REACTANCE"
 20:INPUT "INDUCT(L) OR CONDX(C)?":A$
 30:IF A$="C" THEN 200
100:"L": INPUT "INPUT L IN HENRIES ";L
110:INPUT "INPUT F IN HZ ":F
120:INPUT "INPUT XL IN OHMS ":X
130:IF L=O PRINT USING ".##^":X/(2π*F):" HENRIES"
140:IF F=O PRINT USING ".##^":X/2π*L):" HZ"
150:IF X=O PRINT USING "#.##^":(2π*F*L): OHMS"
160:GOTO 100
200:"C": INPUT "INPUT C IN FARADS ":C
210:INPUT "INPUT F IN HZ ":F
220:INPUT "INPUT XC IN OHMS ":X
230:IF C=O PRINT USING ".##^":1/(2π*F*X):" FARADS"
240:IF F=O PRINT USING ".###^":1/(2π*X*C):" HZ"
250:IF X=O PRINT USING "#.##^":1/(2π*F*C):" OHMS"
260:GOTO 200
```

BUILD A SWITCHING LAMP DIMMER



This easy-to-build DC lamp dimmer is perfect for use in your car or recreational vehicle!

JOE H. DUNCAN

THE POPULAR LOW-COST TRIAC LAMP DIMMERS USED in many homes are switching-mode dimmers. They dissipate little heat and are compactly packaged. Such triac dimmers cannot be used with DC, because triac dimmers function by switching *on* and *off* during the AC sine-wave cycle.

DC lamp dimmers using a series rheostat dissipate a considerable amount of heat, especially when used with high-amperage lamp loads. Fig. 1 shows a switching-mode lamp dimmer that operates on 12-volts DC and may be used on incandescent lamp loads of up to 2 amps in autos or recreational vehicles. The power dissipated in this dimmer is reduced since Q1, the pass transistor, is always *on* or *off*.

How it works

The NE555 timer is used in the astable mode to produce a variable duty-cycle pulse output at pin 3. When R2 is adjusted for maximum brightness, the duty cycle is approximately 95%, and Q1, a power FET, is *on* for 95% of the time. When R2 is adjusted for minimum brightness, the duty cycle is 5%. The dimmer delivers

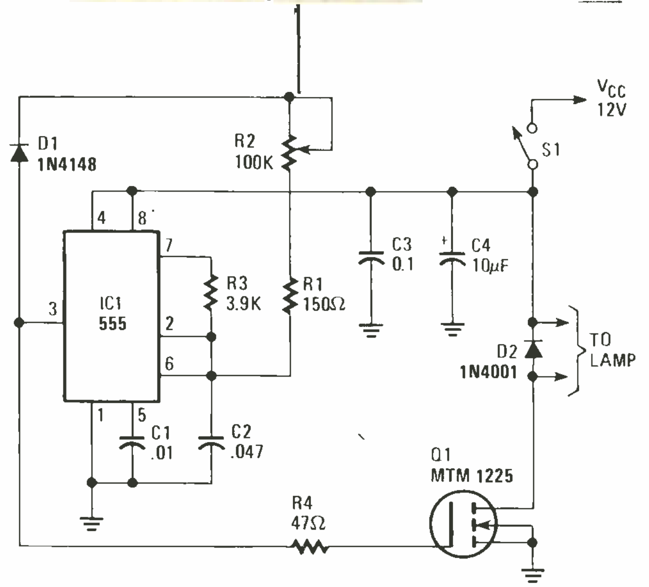


FIG. 1—THIS SWITCHING-MODE LAMP DIMMER operates on 12-volts DC and can be used with lamp loads up to 2 amps. It is ideal for use in an auto or recreational vehicle.

PARTS LIST

RESISTORS
¼ watt, 5% unless noted
R1—150 ohms
R2—100,000 ohm potentiometer with SPST switch
R3—3900 ohms
R4—47 ohms

CAPACITORS
C1—.01 µF. 50 volts, ceramic disc
C2—.047 µF, 50 volts, Mylar
C3—0.1 µF, 50 volts, ceramic disc
C4—10 µF. 35 volts, electrolytic

SEMICONDUCTORS
D1—1N4148 diode
D2—1N4001 diode
Q1—MTM1225 power FET
IC1—NE555 timer

SWITCHES
S1—SPST switch (part of R2)

MISCELLANEOUS: Perforated construction board, wire, solder, hardware, etc.

a chopped voltage to the lamp. The frequency of the chopped voltage varies from 400 Hz to 7 Khz, depending on the brightness setting. Operation on a chopped voltage does not damage incandescent lamps because there is not enough time for the filament to cool between the cycles.

Construction

All parts except R2 may be mounted on a 2-inch × 3-inch piece of perforated circuit board, as shown in the photograph. No heat sink is required for Q1. A lamp used with this dimmer must have both power leads isolated from ground. A lamp socket which grounds one terminal of the lamp must be replaced with an insulated type.

Summary

The popular No. 93 lamp used in RV's draws about 1 amp. The dimmer can drive one or two of the No. 93 lamps in parallel. Mount the dimmer close to the lamp and connect the two lamp leads to the dimmer. Mount R2 in a convenient location near the lamp. Full clockwise rotation of R2 should correspond to maximum brightness. If not, change the connection of the center terminal of R2 to the other outside terminal. **SP**

SonoAid AUDIBLE CONTINUITY TESTER

Your telephone repairman has a test gadget just like it! But, you can build yours for hundreds of dollars less—maybe free, if you have the parts!

HERB FRIEDMAN

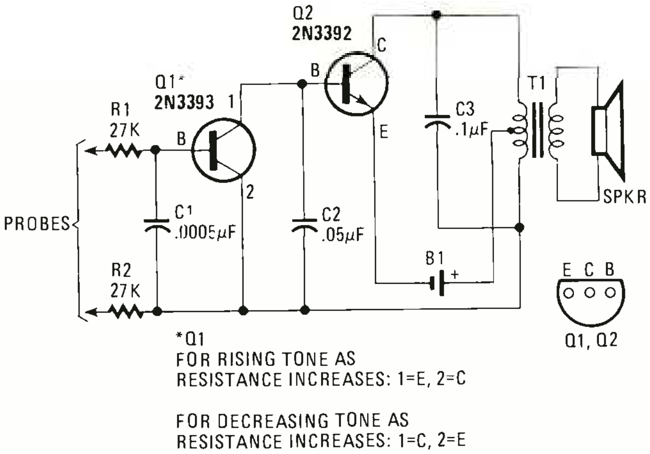
IF YOU'VE EVER HAD TO CHECK OUT A MULTI-WIRE cable or harness for continuity or short circuits, or had to check one end of a remote line for changes at the other end of the wire, you know that you can quickly get "tennis neck" or twitchy eyeballs" from swiveling back and forth between the ohmmeter and the circuit's wires and terminals.

Then again, there can be a problem when testing microphone lines for continuity. The last thing you want to do to some dynamic microphones is to pass a relatively high ohmmeter current into the mike through its cable. That's because it is possible for the diaphragm to go "pop" when you connect the ohmmeter, and then you'll need a new mike.

But use a SonoAid for those—and other—continuity tests and most of the problems will disappear.

The SonoAid is a multi-frequency audio-continuity tester that produces a tone when its test leads are shorted. Any resistance higher than 50K ohms will cause the tone to rise...or fall, depending on how you build the unit (more on that later). Also, the current across the test leads is so small that it's unmeasurable (with standard instruments), so it can be safely used to check out microphone lines without fear it will "pop" a dynamic or ribbon mike.

The SonoAid is intended as a one-evening "fun project" that can be assembled primarily with components salvaged from old transistor pocket radios—the kind that banks used to give out when a depositor opened a new account. (Some banks still distribute them.) The only exception to the "salvaged parts" rule might be transistors Q1 and Q2 because the radio might not contain suitable types to begin with. However the circuit does use types readily available, or you can substitute general purpose or "audio" NPN equivalents, as long as they fall within the proper gain (h_{FE}) range. The proper gain range for Q1 is 90 to 200. The gain range for Q2 is 250 to 500. You can substitute a transistor with a greater gain (h_{FE}) than specified, but you can't go lower and assume that the project will work. For example, you can use a Q1 with an h_{FE} of 300, but not 50. ("Gain range" is the h_{FE} within specified minimum and maximum limits.)



THE SONOAID IS A SLIDING-TONE CONTINUITY TESTER whose output frequency is determined by the resistance across the test leads. The test current is essentially unmeasurable, so the device can be used on equipment—such as certain dynamic microphones—that are sensitive to the most minute electric current. Most parts can be salvaged from old transistor radios.

PARTS LIST

RESISTORS
¼ watt, 10%
R1, R2—27,000 ohms, see text

CAPACITORS
C1—500 pF, ceramic disc
C2—.05 µF, 10 volts DC or higher
C3—0.1 µF, 10 volts DC or higher

SEMICONDUCTORS
Q1—2N3393 or equivalent NPN transistor
Q2—2N3392 or equivalent NPN transistor

MISCELLANEOUS
B1—1.5-volt battery, AA type
T1—output transformer, 500-ohm C.T. primary, 3.2-ohm secondary
PC board, cabinet, 16-ohm or less speaker (see text), wire, clips, etc.

THE TRANSFORMER LEADS ARE VERY FINE and tend to break easily. It's best to use them full length and coil the excess, using a narrow screwdriver shaft for the coil form.

THE SPEAKER IS SECURED TO THE BACK OF THE PC BOARD with a "powerful" contact adhesive such as "Barge". This cement is used by shoemakers to cement rubber soles to shoes when stitches cannot be used.

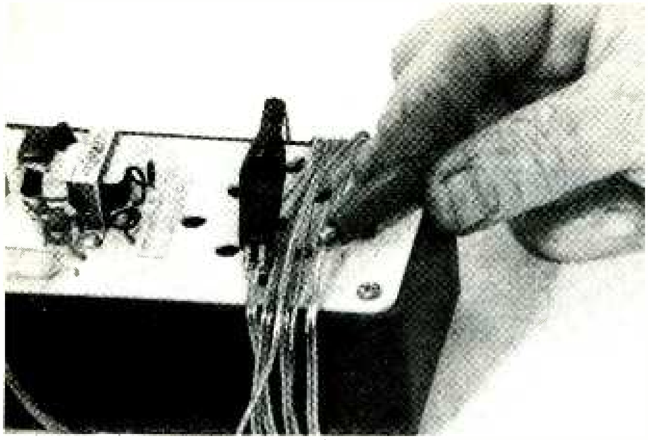
Transformer T1 is an output transformer—such as used in transistor radios—with a 500-ohm center-tapped primary and a 3.2- 4- 8- or 16-ohm secondary... it's not really critical. T1 might even have a 1000-ohm primary, or a transformer with a 4-ohm secondary might be used with an 8-ohm speaker. The most that might happen is that the output tone might be different from what you'd get with the specified T1. Use whatever you salvage from the radio.

Many early radios used output transformers with wire rather than PC (printed circuit) terminals. Use the wires full length. Don't cut them short. The wires are very fine, and often cut through or tear when you attempt to remove insulation at the tip. So try to unsolder the wires from the radio and use the "tinned" ends for your connections. The excess can be coiled up—as shown in the photographs—by wrapping each wire around a small set—screwdriver or a No. 0 Philips screwdriver.

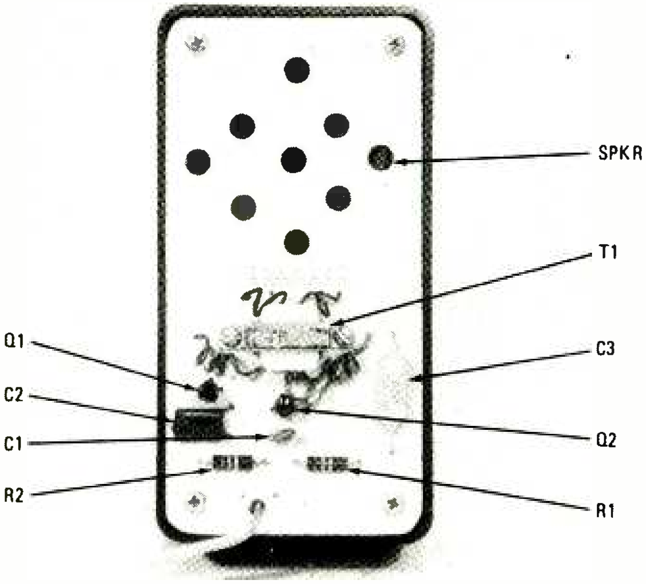
The speaker is whatever you have salvaged as long as it's 16 ohms or less. (Some very early pocket radios had 100- or 120-ohm speakers. They won't work in this project). It makes no difference, however, what kind of condition the speaker is in, because you're only interested in some sort of sound, not low distortion! It doesn't matter if the voice coil rubs or the cone looks as if the moths used it for a picnic.

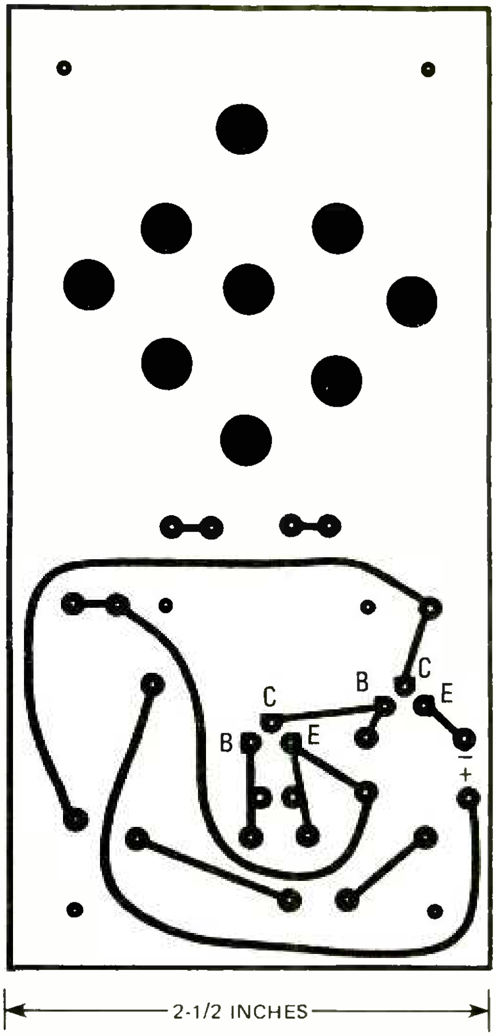
Capacitors C1, C2, and C3 are anything you can get that's reasonably near the specified values. For example, C2 can be .03-, .04-, or .05-µF: or C1 can be 250- or 750 pF. Just try to be reasonably close to C3's specified value. Don't use a .05-µF capacitor as a substitute.

Resistors R1 and R2 can be replaced by a single resistor of approximately 47K (give or take a lot of K). Two resistors are used to permit you to connect two in series to get the approximate value. For example, suppose the radio you salvage has a 33K and a 10K resistor. In series they equal 43K, which is close enough to



THERE IS NO POWER SWITCH because there is no current drain when the test leads are open. To insure that they don't touch when the device is stored, wrap the test wire around the cabinet and then clip the test clips to a wire to hold them in place. Better still, install a power switch.





THE PRINTED CIRCUIT BOARD mounts all the component parts and serves as the unit's front panel. A same-size layout for the printed circuit is shown above. The array of dots at the top is used as a hole pattern for the loudspeaker. The photo at left shows the assembly unit ready to go. Only the loudspeaker is mounted on the foil side of the board.

47K. So you use the 33K for, say, R1, and the 10K for R2. If you substitute a single resistor for R1 and R2, make certain that you use a wire jumper for the "missing" resistor on the PC board, or modify the template's foil so a jumper isn't necessary.

The output tone is determined by how Q1 is connected into the circuit. If the Q1 lead marked "1" (in the schematic diagram) is the emitter and lead "2" is the collector, the reference tone—with the test leads shorted—will be low, and will increase as the resistance across the test leads is increased. If Q1 is connected so that "1" is the collector and "2" is the emitter, the reference tone will be high, decreasing when a resistance is connected between the test leads. While the "reverse" tone is initially disconcerting, you can get used to it; and it's preferred because the reference tone is approximately 3kHz, a frequency to which the ear is most sensitive, and slight resistive changes in the circuit being checked become even more obvious.

If you look at the schematic you will have probably uncovered an "error:" There is no power switch. Actually, there's no need for one, for no measurable current (with standard test equipment) flows when the test leads are open. Simply clip the test leads so they cannot touch when storing the device and you save the cost of a switch. When the leads are shorted, the current drain is approximately 5 mA, so the battery should last essentially its shelf-life.

Now build your own

The unit shown was built on a printed-circuit board that also serves as the cover for a plastic experimenter's box that measures approximately 5 1/16 by 2 5/8 by 1 5/8 inches. The box you get might have round or square corners. If yours is square simply use the supplied template and then round off the corners with a file.

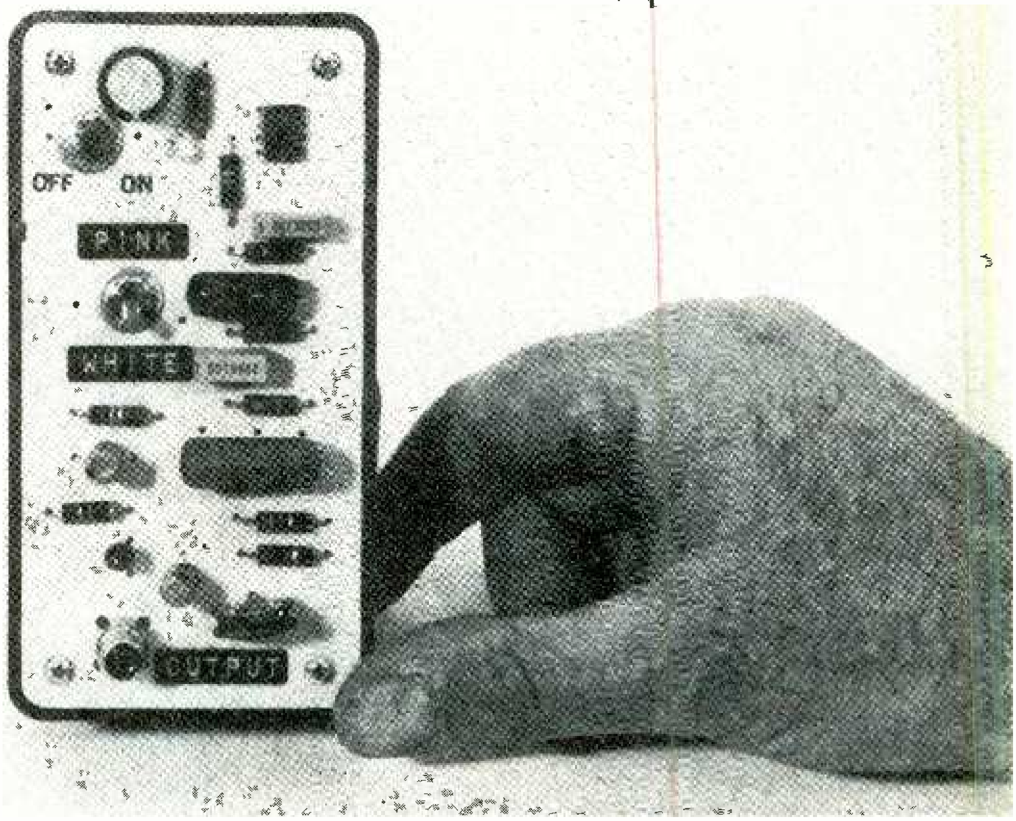
Drill or punch several 1/4-inch or 5/16-inch holes in the PC board so that, the sound from the speaker isn't muted. The small circles on the template are the locations for the holes. Use them if you like. The speaker can be secured to the PC board with a contact adhesive such as "Barge", which is available from some shoe-repair shops. That is the stuff that shoemakers use to secure rubber soles and heels to shoes without stitching or nails, so it will certainly hold the speaker in place.

The test leads can be ordinary speaker wire (No. 22 or No. 24) with small alligator clips. To provide strain relief, it's suggested that you drill a small hole between the input PC-foil terminals, pass the wire from the top of the board to the underside, and then tie a knot on the underside, connecting the ends of the wire directly to the foils without passing them through the board. But if you don't think that the test leads will be abused you can connect them directly to the foil from the top side without the hole and knot.

Check it out and put it to work

Install the battery and touch the test leads together. The tone frequency will be low or high. Then connect a resistor greater than 50K across the test leads and note how the tone changes. If the change in tone is opposite from what you intended, Q1 is installed with reversed emitter and collector leads. If you do not hear a tone when the battery is installed, first check to see if the battery is actually making contact with the holder terminals. Then check to see if Q1 and Q2 are properly installed. Some transistors have an EBC lead arrangement; others are ECB.

The SonoAid cannot be used to test solid-state devices. It is strictly a wire-circuit instrument, so there is no effective polarity to the test leads. When testing for discontinuity in wire circuits, listen for both a change in the pitch of the tone and a "noise click." A very brief discontinuity that will have no apparent affect on the tone—because the interruption is so short, you will hear "noise." SP



THANKS TO A RELATIVELY INEXPENSIVE INTEGRATED circuit that creates digitally-generated noise at "line level", it's possible for a hobbyist to build a professional-grade pink/white noise generator at a budget price. The cost is well under $20 if you can tap the junk box for most of the resistors and capacitors. (The circuit has been designed specifically to use common 5% tolerance resistor values and standard capacitor values. You don't need precision parts.)

The generator's pink noise indicates approximately 0.5 volt on an "average reading" AC voltmeter (which is what most of us use). The noise signal has a 3:1 crest factor, meaning the signal's peak voltage is three times, or 10 dB greater, than the value indicated by the standard AC voltmeter or VU meter. The white noise "combined"—or "broadband"—output is essentially the same.

Why pink and white?

White noise is constant energy per frequency: for example, the 20-kHz voltage component is the same as every other frequency. That is the kind of signal that's really wanted for equipment tests because it's a very exacting test signal, equivalent to using constant-level individual test tones...but all at the same time. It's so severe a test that it is rarely used except on the finest of equipment, because only the finest equipment will come out "looking good."

While we want constant level per frequency for testing equipment, we want something else to test what the ear hears or senses, because the ear doesn't care a fig about constant level per frequency: it is sensitive to constant power per octave bandwidth. In order to attain constant power per octave bandwidth we must attenuate the spectrum 3-dB per octave. In plain terms, that means that the output at 40 Hz must be 3 dB less than that of 20 Hz; and 80 Hz must be 3-dB less than 40 Hz.

Since that can look mighty scrambled on measuring equipment, we use a special instrument known as a ⅓-octave or 1-octave "audio analyzer" when making pink-noise tests on room acoustics, or when we're testing equipment in terms of what the ear senses. The audio analyzer consists of individual filters or tuned amplifiers spaced ⅓ or 1 octave apart and equalized in such a manner that pure pink noise will produce a broadband (20 to 20 kHz?) "flat" response on the

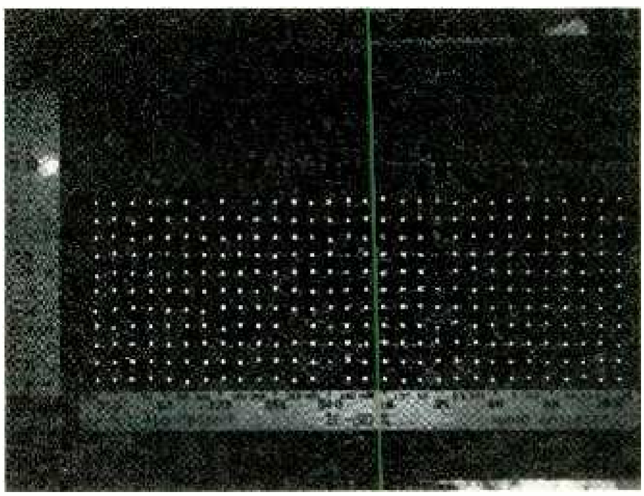


FIG. 1—THE GENERATOR'S PINK-NOISE OUTPUT is essentially ruler flat on the 3-dB/step range of a ⅓-octave audio analyzer.

PINK/WHITE NOISE GENERATOR

Put your audio analyzer to work checking out room acoustics and equipment performance helped by a gadget that makes a lot of noise!

LESLIE PIERCE

analyzer. Many audio analyzers permit measurements to be made in terms of either ⅓ or 1-octave.

Fig. 1, a photograph of just such an audio analyzer shows the ⅓-octave output of the Pink/White Noise Generator project. Note it is ruler flat on the instrument's 3-dB/step range. That is quite good for what is essentially a junk-box project.

Fig. 2 shows how the same instrument indicates the project's white noise on a 1-octave basis. Note that the audio analyzer indicates that the signal rises at a constant rate of 3-dB per octave (each step represents 3-db). That is precisely what we should get. because the audio analyzer is internally equalized to measure constant power per bandwidth rather than constant energy per frequency.

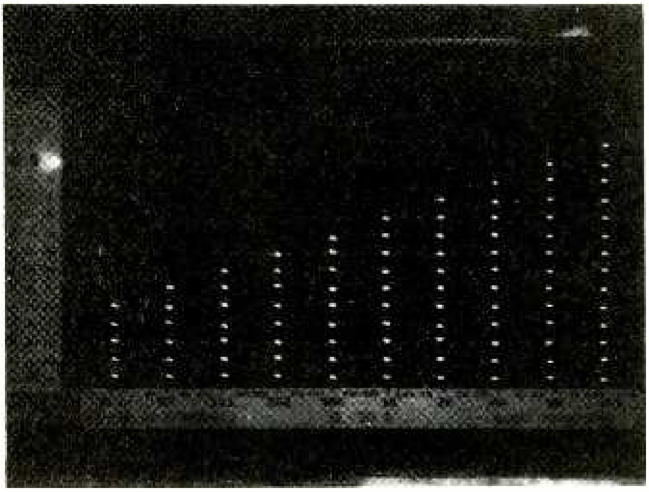


FIG. 2—THE GENERATOR'S WHITE-NOISE OUTPUT illustrates the required increase of 3-dB per octave.

Why noise tests?

Early sound-technicians tested a room's acoustics by snapping their fingers, or muttering an incantation that sounded strangely like a dog's "Woof, Woof." They then judged the ambient acoustics or amplifier equalization on the sound of the reflected finger snaps or incantation. Today, we have generally replaced the finger snap and incantation with "noise;" to be more precise, "broadband noise." The advantage of noise tests over finger snaps—and even test tones—is that all frequencies are produced simultaneously, and the amplifiers, speakers, and/or ambient acoustics must handle the entire spectrum at once, just as it will for a performance. It makes no difference whether it be a live performance, sound reinforcement via the misnamed P(ublic) A(ddress), or the reproduction of prerecorded material.

Noise is a much more severe test of amplifying and recording equipment than the more common sine-wave test tone, or even the two-tone intermodulation test, for noise demands operation at all frequencies at the peak level. It is the peak characteristic that proves the most demanding, and many a magnetic tape recorder that checks out "good," "excellent," or even "superb," using standard tests can look very poor when tested with noise. (The noise test often unearths the reason why program material sounds poor on a recorder that tests out "excellent" with test tone.)

It is not necessary, however, for a recorder to be perfectly flat to sound good. Experience has shown that if the tape recording is flat for pink noise—which might be pretty rotten for white noise—the ear will accept the recorded sound as being of "good quality." Because of that unusual characteristic of the ear to respond pleasantly to flat pink noise, at least one of the major professional tape recorder facilities in New York runs a final check on recorders for flat pink noise rather than flat response to test tones. They believe that the customer will be satisfied if the ear is satisfied, and their notably excellent reputation in sound design and service establishes that perhaps they are correct in adjusting equipment response for best response to pink noise. It's a controversial technical concept.

Whence a hobbyist's analyzer?

Audio analyzers usually don't come cheap, but it is possible to build a fairly decent model at a modest price, which is exactly what's being done with some high-fidelity equipment. Many high-fidelity amplifiers and receivers now feature 1-octave "audio analyzers," and several high-fidelity ⅓-octave graphic equalizers also feature some form of ⅓-octave metering of the signal. Such equipment can be easily used—with a high degree of accuracy—as audio analyzers for pink-noise measurements. Those of you with some form of oscilloscope spectrum equalizer can use the white noise for tests because the scope analyzers are usually designed to respond "flat" to white noise for equipment tests.

Building the noise generator

This version of a pink/white noise generator is designed to use standard-parts values generally available in local stores. While you can utilize standard tolerance components, the closer you are to the specified "filter" values for R2, R3, R4, R5, C2, C3, C4 and C5 the better the performance. Because "standard" capacitor tolerances are notoriously broad, if at all possible use a capacitance bridge or meter to select capacitors as close to the specified values as is possible.

If you can't get near a specified value use a second parallel-connected capacitor to "trim" to the specified value. A "trim" capacitor is illustrated as Cx in the

PARTS LIST

RESISTORS

½ or ¼ watt, 5%, unless otherwise specified
R1—6200 ohms, 10%, see text
R2—10,000 ohms
R3—220 ohms
R4—1000 ohms
R5—2700 ohms
R6—270,000 ohms, 10%
R7—47,000 ohms 10%
R8—27,000 ohms, 10%
R9—1000 ohms, 10%
R10—10,000 ohms, trimmer potentiometer

CAPACITORS

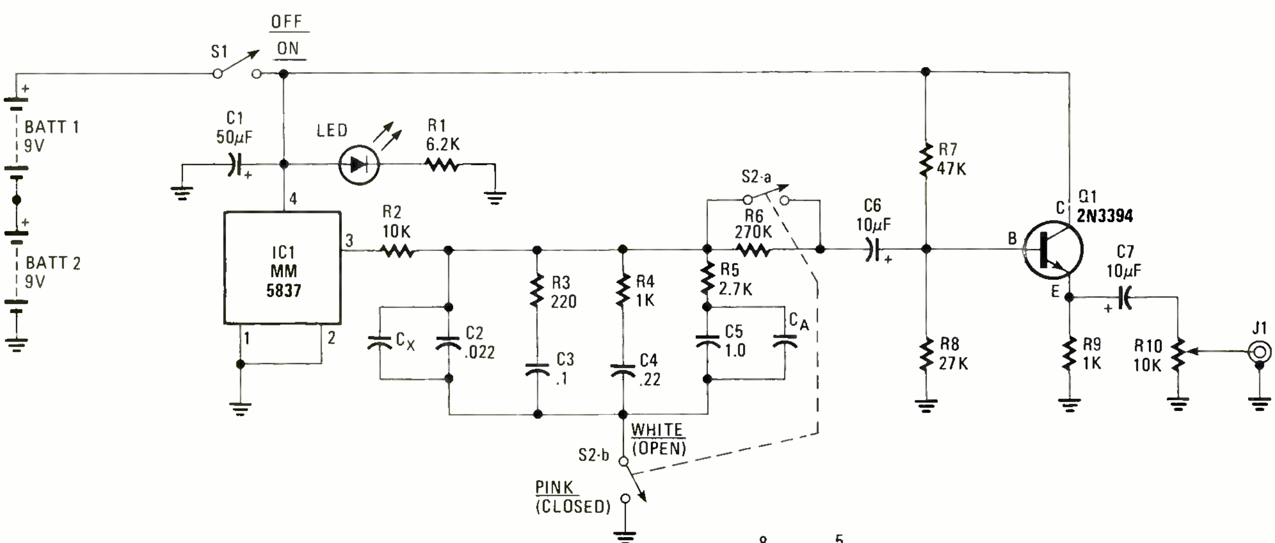
10% tolerance if possible, or see text (except electrolytics)
C1—50-μF, 25 VDC or higher
C2—0.022 μF
C3—0.1 μF
C4—0.22 μF
C5—1.0 μF, see text
C6, C7—10 μF, 10VDC electrolytic
C_X, C_A—See text

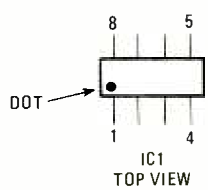
SEMICONDUCTORS

IC1—MM5837 Noise Generator
Q1—NPN transistor, 2N3394
BATT1, BATT2—9-volt battery (Alkaline)

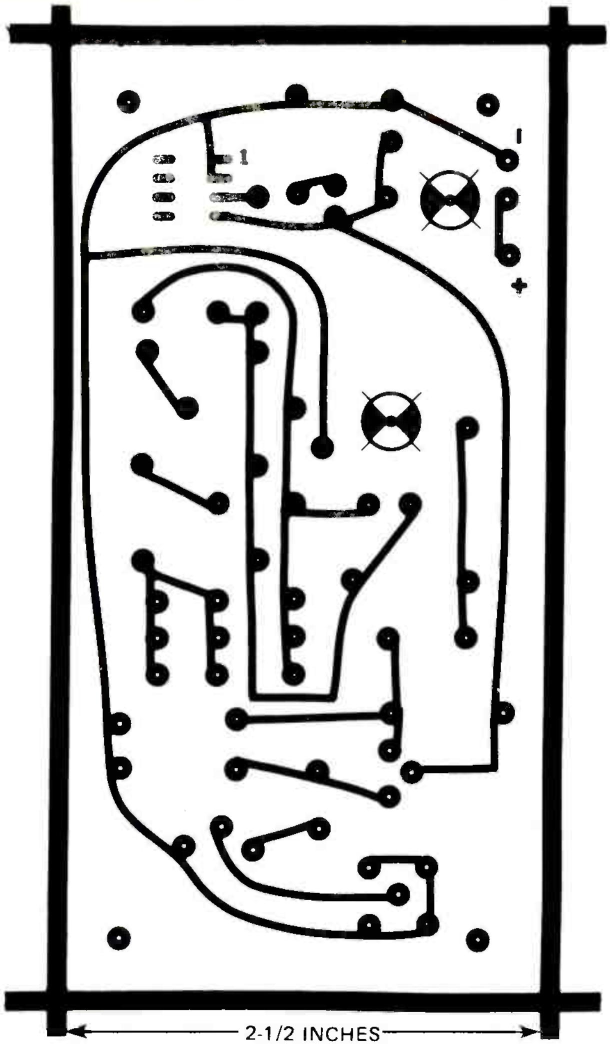
MISCELLANEOUS

LED—Clear Light Emitting Diode, see text
J1—Phono jack, see text
S1—SPST mini-switch
S2—DPST mini-switch (use ½ DPDT)
Cabinet, printed-circuit supplies, battery connectors, etc.

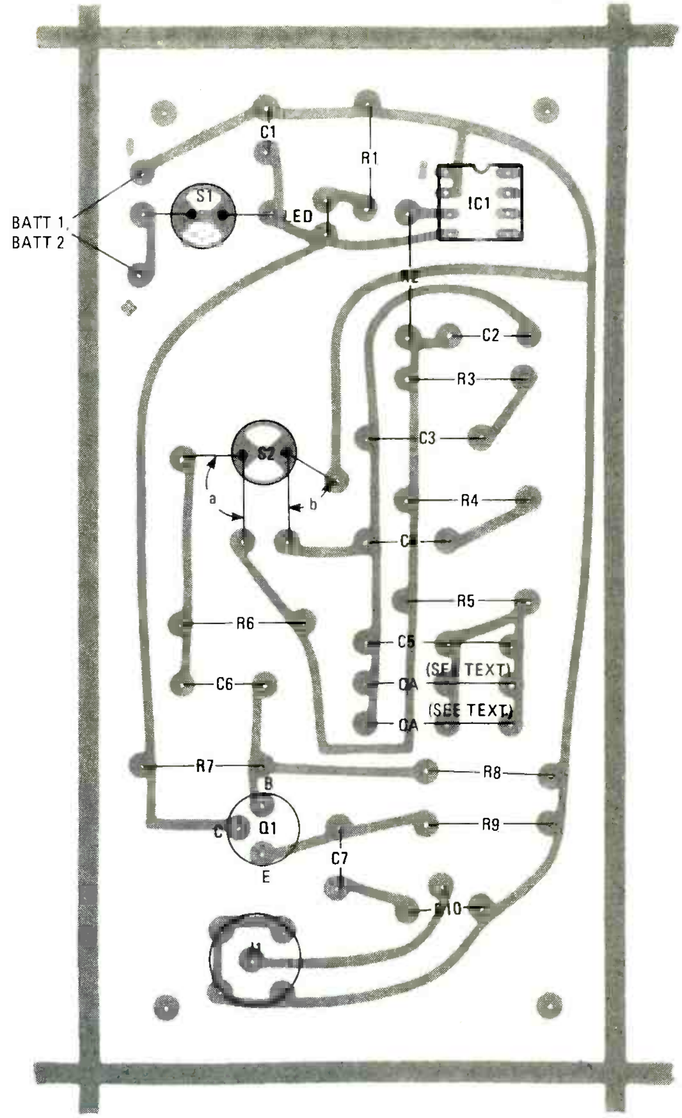




SCHEMATIC DIAGRAM for the Pink/White Noise Generator suggests of a printed circuit board. Capacitors C_X and C_A are trimmers that may be necessary to bring C2 and C5 to desired values as discussed in text. When closed, switch S2 modifies the filter between IC1 and Q1 converting constant-energy-per-frequency white noise to 3db-per-octave-roll pink noise.



FOIL SIDE OF THE PRINTED circuit board for the Pink/White Noise Generator used by the author. Economy is the byword here. See text on how low-cost switches are hard wired to the board to keep construction costs down.



COMPONENT SIDE OF THE PRINTED CIRCUIT BOARD (foil side down) shows location of parts. Switches mount through the foil side of the board. Double check wiring before applying power. Trim capacitors mount on foil side.

schematic diagram, Fig. 3. Usually, C2 will be the critical value, and the "trim" can be tack-soldered across C2 on the underside of the PC board, as shown in the photograph.

The Pink/White Noise Generator is built on a printed-circuit board that also serves as the cover for a 5⅛ × 2⅝ × 1⅝ inch plastic experimenter's box. A full-scale template for the PC board is shown. Use it any way you want to make your PC board. Either "lift" the PC foil layout with a GC "lift" kit, or make a carbon copy of the foil's layout. It isn't critical, so anything that results in a finished board can be used.

Take note that the template has several foils and holes for capacitor C5 that might not be used in the model you build. C5 is 1.0-μF non-electrolytic, which is not an easy value to obtain in some areas, nor is it inexpensive (do not substitute an electrolytic capacitor for C5). The proper value can often be attained by connecting several capacitors in parallel. For example, you might use two 0.5-μF capacitors, or two 0.47-μF capacitors in parallel with a 0.05- F, which will produce 0.99-μF—a close-enough value. The "extra" capacitors are indicated in the schematic as capacitor CA.

The experimenter's box is supplied with either square or round corners. If the one you get has round corners, simply round off the corners of the PC board with a file.

The price of non-surplus switches with printed-circuit terminals is now ridiculous, so to save-a-buck the PC layout is for standard miniature switches. Follow this procedure to connect the switch terminals to the foils without having the wires pass through to the top where they can snag your fingers: First, mount the switch on the underside of the PC board, then pass an uninsulated solid wire through the board from the top to the switch terminal, and then solder the wire to the terminal. Next, cut the wire flush with the top of the PC board. Using long-nose pliers from the underside of the board, ease the wire back towards the switch just a smidgen—enough so the cut end of the wire is below the top of the PC board but still within the hole. Finally, solder the wire to the foil. You'll have a "solid" connection that doesn't stick through the board.

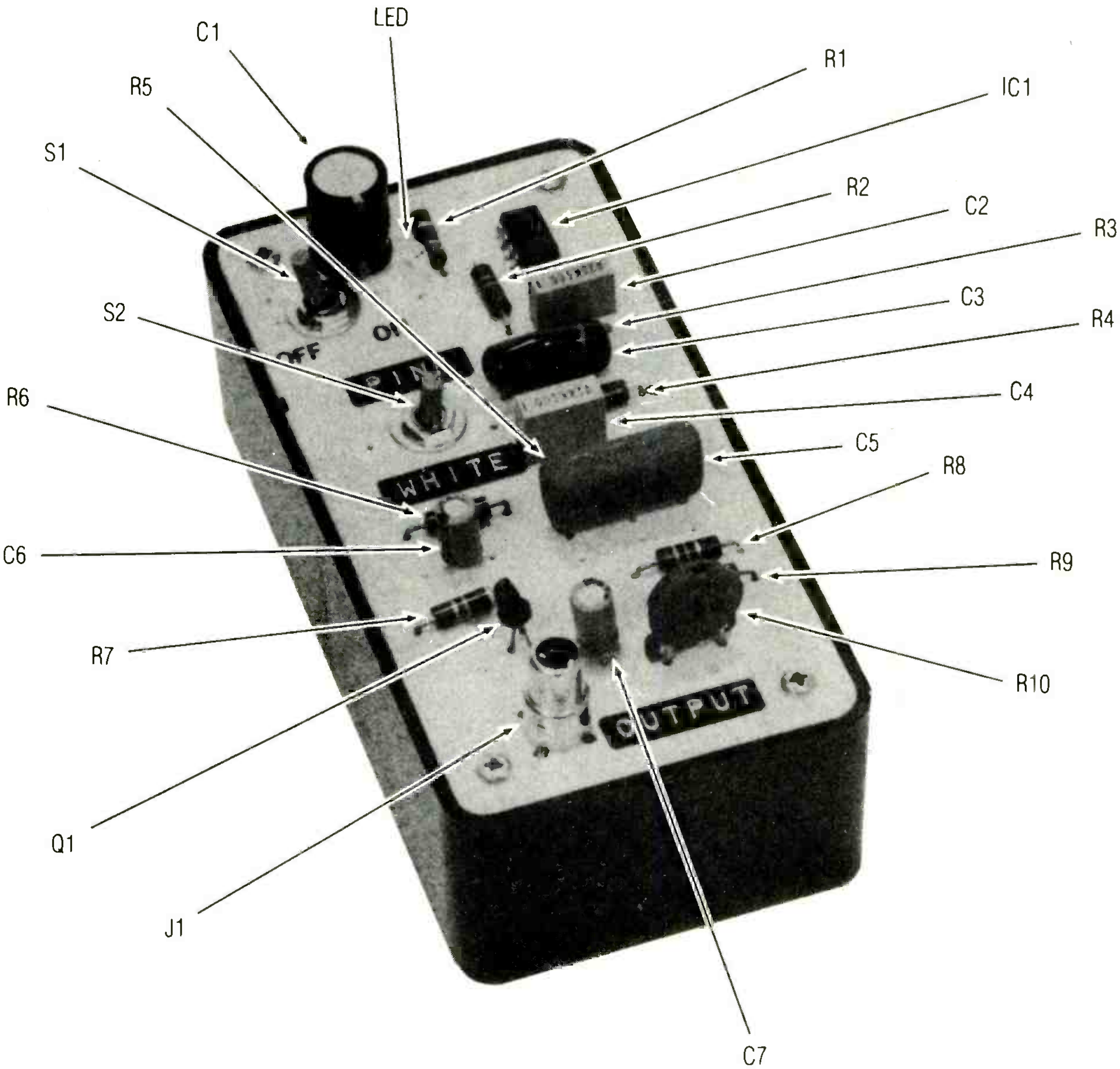
The photographs show a "printed circuit" phono jack for J1, and the PC foil is accordingly for this type of jack. They are relatively inexpensive as surplus. If you can't get one, substitute a standard phono jack for J1 and modify the PC layout accordingly. Wire the jack just as you do the switches to avoid having the connections stick through the board.

Substitutions are not recommended. If you *must* substitute for transistor Q1, make certain you use an "exact" substitute with the same gain-range. Take note that the specified Q1 has an ECB terminal arrangement. Some direct substitutes are EBC. Doublecheck your substitution. If it is EBC, either modify the PC layout or "twist" Q1 so its leads fall into the correct holes.

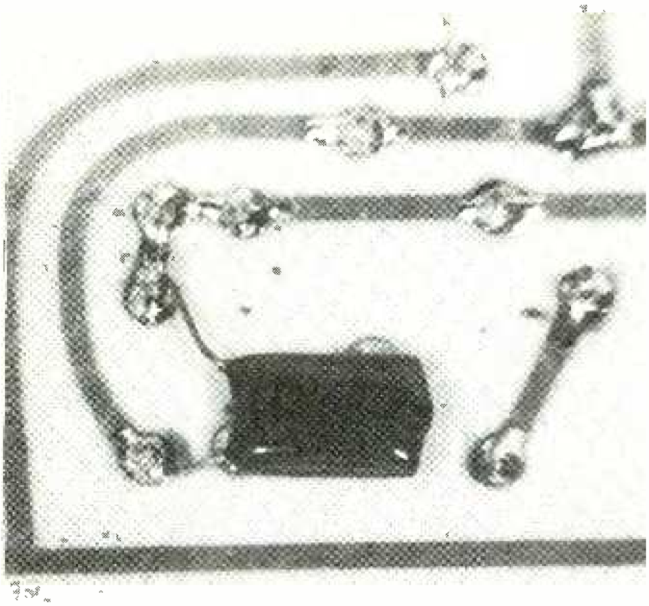
Integrated circuit IC1 is the noise generator and its #1 terminal is marked with a small dot moulded into the case opposite the #1 lead. Position IC1 so the No. 1 lead comes through the PC terminal indicated with a "1." If installed correctly, the IC end with the dot will face the nearest edge of the PC board.

Switch S2 should be DPST, but there isn't any such thing in mini-switches available to hobbyists, so a DPDT switch is used with connections to only the DPST contacts. If you make any changes in the PC foils around switch S2, make certain you get the switching correct. For pink noise both S2-a and S2-b are closed. Don't modify the wiring so that S2-a is open when S2-b is closed.

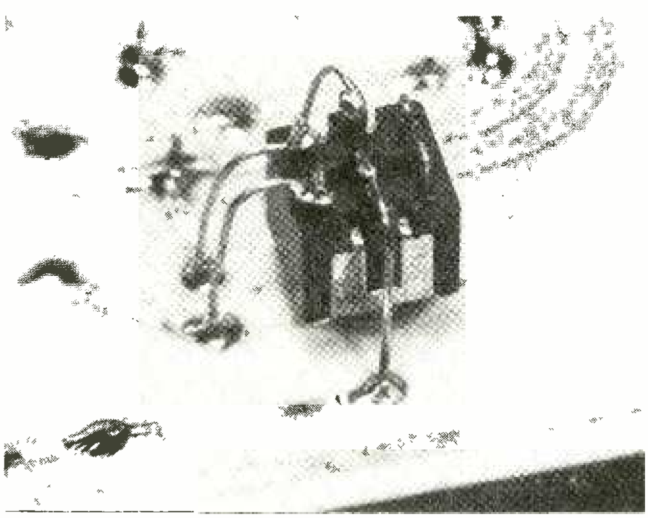
The power supply is 18 volts, provided by two series-connected 9-volt "heavy duty" or "alkaline" batteries. The total current drain from the batteries is between 15 and 20 mA, which is about the idling drain of a transistor radio. A set of batteries should last from 30 to 50 hours or more. If you make no changes to the LED power-indicator circuit, which consists of LED



THE NOISE GENERATOR IS BUILT on a printed circuit board that also serves as the cover for a plastic experimenter's box.



IF THE CAPACITANCE VALUES FOR THE PINK-NOISE FILTER need to be "trimmed" to the specified value, tack-solder the trimming capacitor across the foil pads of the filter capacitor—C2, C3, or C4.



THE SWITCH CONNECTIONS ARE NOT TACK-SOLDERED to the foil; they actually pass about halfway into a hole. After the wire is soldered to a switch terminal, it is cut flush with the top of the board, then backed off slightly so it doesn't protrude through the board, and then soldered to the foil. It takes a little extra time but it's cheaper than buying printed-circuit switches.

and R1, the LED will be barely lit when the batteries are OK, and will not be lit when the batteries are pooped out. If you prefer a brighter LED power indicator, change R1 from 6200 to 3300 ohms (or so), but keep in mind that the LED will no longer serve as a reliable battery-condition indicator. (It might or it might not, and that really isn't good enough.) The current through the LED is very low and the glow from a red lens or diffused LED will barely be seen. A "clear" LED is suggested because the intense pin-point red "burn" will be easily observed.

Final checkout

Set the noise generator's output-level adjustment, potentiometer R10, to the mid position and connect the noise generator to an amplifier's AUX (line) input.

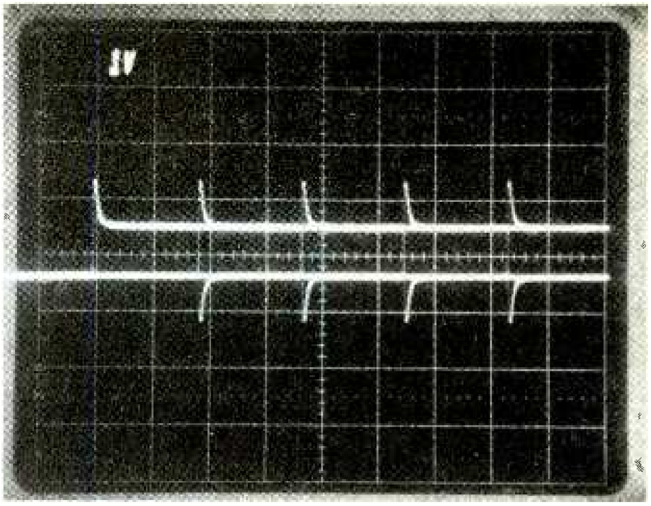


FIG. 3—THIS IS HOW THE NOISE GENERATOR'S OUTPUT should appear on your scope when the generator is in the white mode. The peak-to-peak maximum output should be nominally 2.4 volts. It will indicate approximately 0.4 volts on average-indicating AC or VU meters.

Turn power switch S1 "on." Advance the amplifier's volume control so you can hear the noise. Flip switch S2. You should hear a change in the "color" of the noise. If you get no noise, or S2 does not change the color of the noise, there is a wiring error or a defective component. (R10 can be set full open for maximum output, or for whatever output level you prefer to use.)

If you have an oscilloscope you can check the noise-output waveform. It should closely resemble Fig. 3, which is a photo of the white-noise output waveform of the unit shown in the photographs. The maximum peak-to-peak output level is approximately 2.4 volts and the waveform period (from tip to tip) is approximately 10-msec. SP

POWER UP THOSE ADD-ON DISC DRIVES

Cash in on the surplus marketplace by building a 5- and 12-volt regulated power supply and housing.

HERB FRIEDMAN

ONE WAY TO AFFORD A SECOND OR THIRD DISK DRIVE for a personal computer is to latch onto re-newed (used) or surplus units: those that are no longer wanted because they are too slow for CP/M, or are single-density, or have CRC problems for a particular model computer (though they will work just fine with others). Whatever the reason why they are unwanted, they sell for a fraction of their original (or "list") price, and we're starting to see more and more 5¼-inch disk drives coming on the market—both new and used—in the $125 to $225 price range.

The only problem is that they are usually "bare" drives, meaning they have no power supply, chassis, or cabinet. And if you look at the price lists of the few outfits that sell disk-drive components you're in for a shock. The "clothes"—the power supply, chassis, and the cabinet—cost at least $90. Add that on to the cost of the drive—no matter how little you paid for it—and you find the total expense approaches that of some new drives.

But building your own disk-power supply and chassis/cabinet is both inexpensive and moderately easy. Depending on the parts you have lying around, or where you purchase them new, you can "clothe" a disk drive for about $25 to $30.

Chassis first

The first step is to build the chassis, because the power supply will be made to fit the chassis. Fig. 1 shows the dimensions for a "universal" chassis that will fit any *Shuggart-type* 5¼-inch drive. It permits the drive to be mounted so the front "door" can be on the left or right side (putting the pilot lamp on the top or bottom), and accommodate the power supply.

The chassis shown in the photographs was made from the aluminum bottom plate supplied with a standard aluminum chassis. Any scrap aluminum large enough will do as long as it's reasonably rigid. The aluminum do-it-yourself panel sold in hardware stores is too thin and too flexible, and should *not* be used. A good material is the aluminum used in high school *aero* shops. If you know a student in such a shop, ask him to get you a scrap. As a rule of thumb, hard #18 gauge, or soft or hard #16 gauge aluminum will be OK.

Drill all holes before bending the chassis to shape. The holes in the base are for the drive's mounting screws and should clear #8 screws. The holes in the side are for the Tinnerman nuts used to secure the cabinet's mounting screws. Drill whatever size hole(s) are needed for the particular Tinnerman nuts you get. Tinnerman nuts are often sold in a "jumbo" assortment

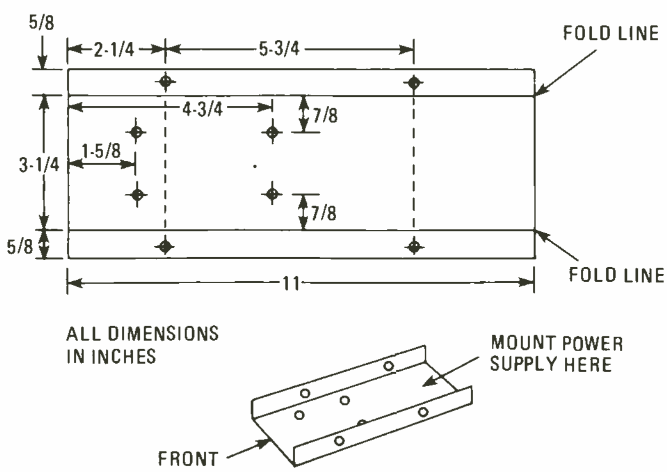
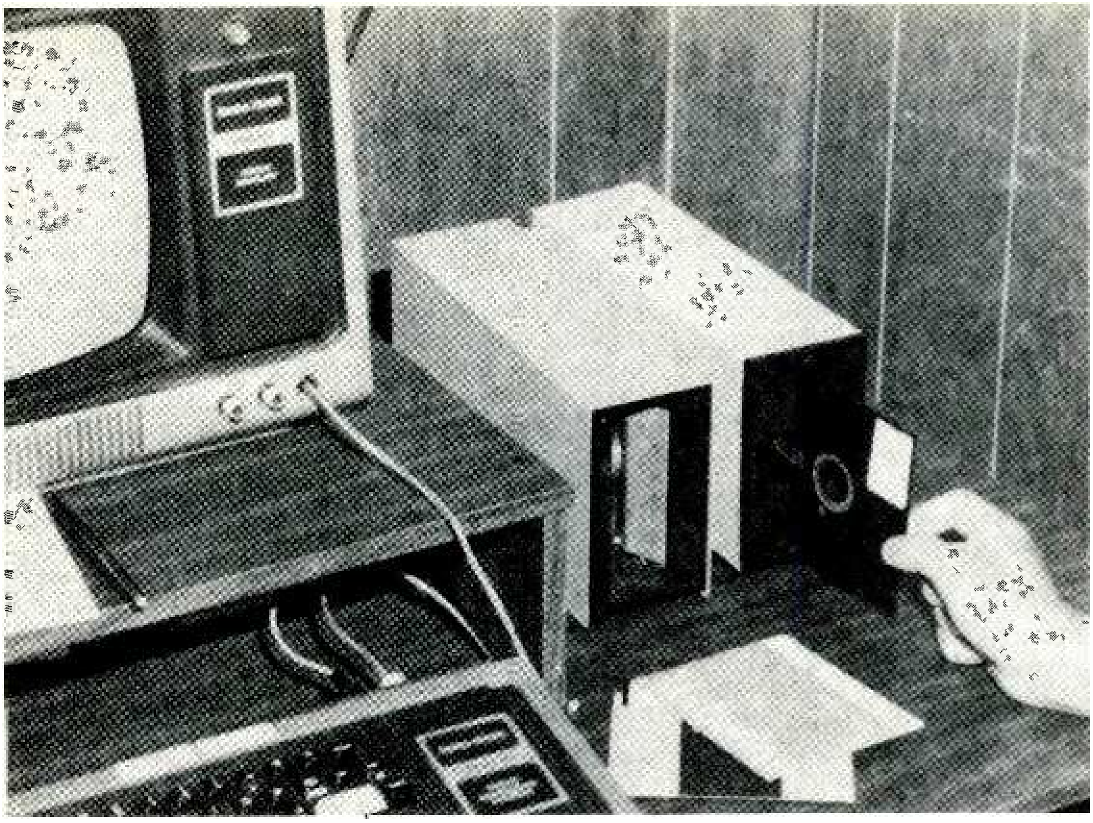


FIG. 1—ALL THE MECHANICAL DATA FOR MAKING your own subchassis is provided in this illustration.



of surplus pieces, or in a small "general purpose" assortment. Simply drill the holes in the chassis to match whatever nuts you use.

Note that there are no holes at the rear for the power supply. You drill those after the supply is finished, matching the chassis holes to the mounting nut positions on the supply.

Drill the 8 holes shown in Fig. 1 first; then fold the ⅝-inch side flanges on the "fold lines" as shown. Set the chassis aside for the moment.

Twin power

Except for power transformer T1, and IC1, IC2, the entire supply is assembled on a circuit board. See Fig. 2. You can make a printed circuit, use wire-wrap, or whatever you prefer. The supply in the photographs was assembled on a 2⅞-inch × 4-inch section of Radio Shack's *Model 276-153* Op-Amp IC Experimental Breadboard. That board has holes for "flea clip" push-in terminals, as well as small copper foils on one side that span several holes in random patterns. You can pass the leads through the holes in the board from the top side and then solder them to the underside foils. If the supplied foil pattern isn't precisely what you want, you can cut the foils to the desired pattern with a knife, or join several together with wire jumpers located on

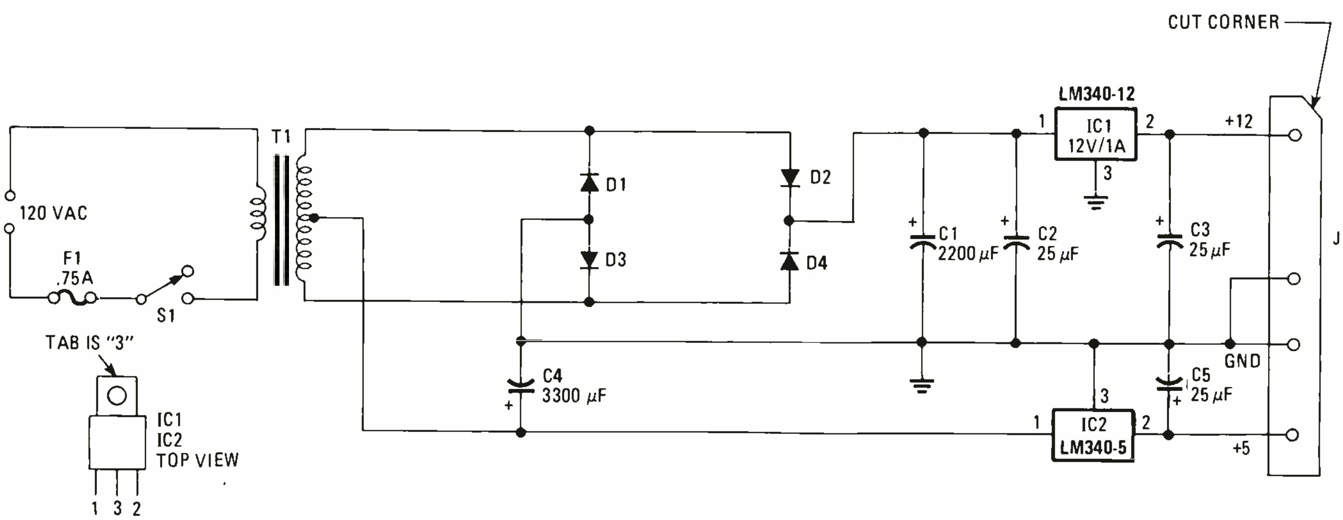


FIG. 2—YOU CAN SEE JUST HOW SIMPLE it can be to build your own 5- and 12-volt combo power supply to power 5¼-inch disc drives. Selection of IC1 and IC2 was made to keep the circuit simple and construction easy for the home hobbyist.

top of the board. In the long run it's easier to use the Op-Amp Breadboard than to make a printed-circuit board.

The layout isn't critical: just make certain that capacitors C1 and C4 are not so large that they interfere with mounting power transformer T1.

The supply delivers regulated 12-volts DC and 5-volts DC. The integrated-circuit regulators themselves are three-terminal devices that are heat-sinked to a small sub-chassis used to support the supply. Many versions of the two regulators are available in the marketplace. The Radio Shack regulators specified in the parts list are suggested particularly because their heat-sink tab is the ground connection, and the device can be secured directly to the chassis. Other versions, similar in appearance and operation, have the sink tab connected to the output and the regulators must be insulated from the cabinet with a special mounting kit that is not all that easy to find. In fact, the Radio Shack kit specifically intended for T0-220 type regulators doesn't fit all the so-called T0-220 ICs. Save yourself heartache: Use the regulators specified in the parts list.

Transformer T1 should have a secondary of 14 or 16 volts C.T. (center-tapped); the closer to 14 volts the better, as the regulator ICs run cooler. Don't use a 12.6-volt CT transformer...the supply won't work right and you'll get intermittent disk operation. It isn't all that hard to locate 14- and 16-volt transformers because most are surplus. The transformer shown in the photographs came from Bullet Electronics. It actually has two secondaries, both 14-volts RMS, but only one of the two is center-tapped. If you use a similar transformer, simply cut off the leads of the untapped secondary close to the transformer.

Make the power supply sub-chassis before assembling the power-supply board. The bracket can be formed from an old aluminum cabinet or scrap aluminum. It's sort of an "L" shape with a small mounting foot, as shown in the photos. Any dimensions that will fit it on the back of the chassis will be OK. Assume that the back part is 3-inches wide and 5¾-inches high. The foot is about 1½-inches deep, and the side of the "L" that holds the transformer is about 3-inches deep. Nothing is critical as long as there's room for the transformer and the bracket doesn't interfere with the drive itself.

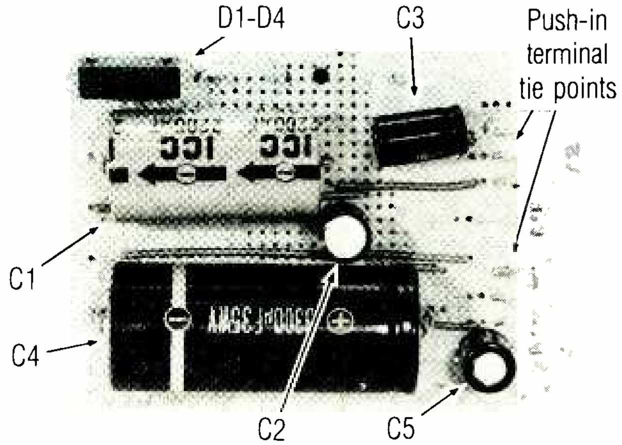
Doublecheck that capacitors C1 and C4 don't interfere with T1's being mounted. When you're certain that you have an unobstructed layout, assemble the power-

PARTS LIST

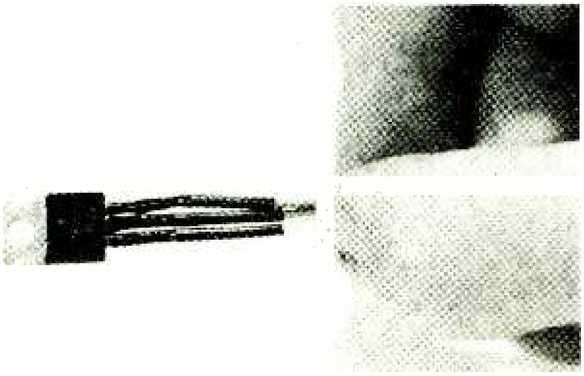
CAPACITORS
C1—2200 µF, 25 VDC or higher
C2, C3, C5—25 or 50 µF, 25 VDC or higher
C4—3300 µF, 10 VDC or higher

SEMICONDUCTORS
D1, D2, D3, D4—50-PIV, 3A silicon diodes or 4A full-wave bridge
IC1—12-volt 1-ampere regulator
IC2—5-volt 1-ampere regulator

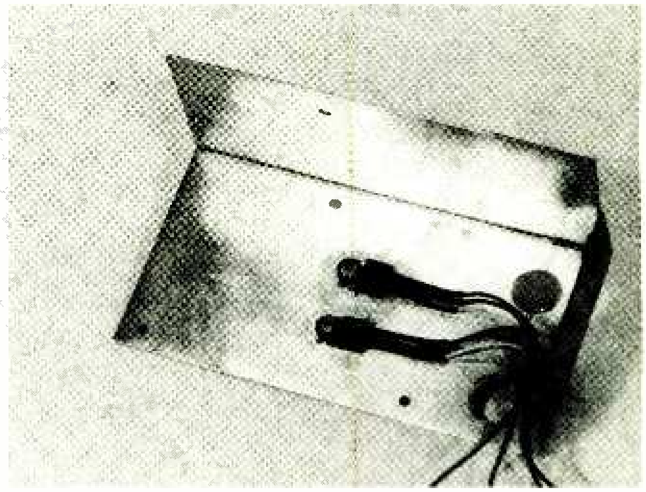
MISCELLANEOUS
F1—0.75-ampere fuse
J1—Power connector for disc drive
S1—SPST miniature
T1—117 VAC primary; 14 or 16-VAC, 1-A secondary
Circuit board (see text)
Fuseholder, aluminum sheet, hardware, shrinkable tubing, heat conducting grease, etc.



ALL POWER SUPPLY PARTS ARE MOUNTED on a perf board except for the transformer T1, two voltage regulators ICs, fuse holder and on/off switch. Layout is not critical, but use author's layout as a guide for use in assembly.



PREPARE THE VOLTAGE REGULATOR IC's for mounting by first connecting four-inch lengths of insulated stranded wire to the terminals. Shrinkable insulated sleeves are necessary to avoid accidental short circuits.



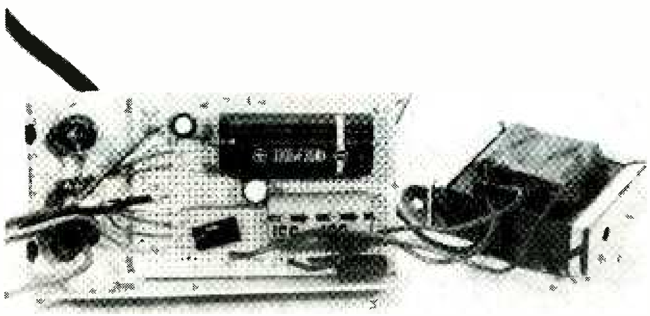
BOTH VOLTAGE REGULATORS ARE BOLTED to the power supply sub-chassis bracket. A thin coat of heat-conducting grease thermodynamically connects the voltage regulator's tabs to the aluminum plate for use as a heat sink. Note that Tinnerman nuts are in place and that holes are drilled for the line cord strain relief plug and fuse holder.

supply board. While the full-wave bridge rectifier can consist of four diodes, as shown in the schematic, an integrated bridge rectifier, such as the Radio Shack 276-1146 is easier to install and takes up less room.

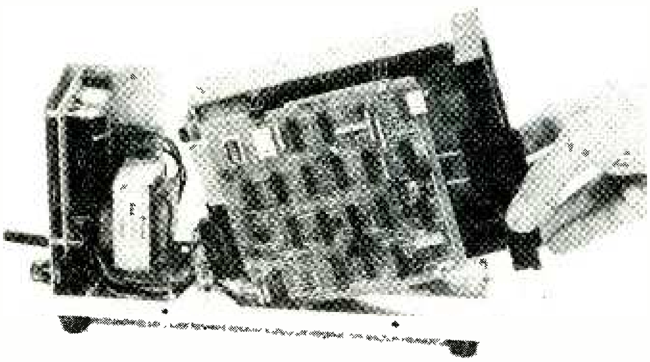
Next, install regulators IC1 and IC2 on the sub-chassis as shown in the photos. First, tack solder 4-inch stranded wire leads to each IC terminal, and cover each solder connection with an insulating sleeve. Then secure the IC's to the back of the sub-chassis as shown, using a heat-sink "grease" between the body of the IC and the chassis. Make certain that you get the proper IC in the correct location. The IC leads should come out under the power-supply board on the correct side: 12 volts in line with C1, and 5 volts in line with C4. Mount S1, F1, and the linecord, then install the power supply board using 3/16-inch or 1/4-inch standoffs between the board and the sub-chassis at each mounting screw. Make certain that the standoffs raise the board above the regulator IC's; they can be close but should *not* touch.

Connect the IC wires to the power-supply board connections, and then connect the wires from the disk drive's power plug to the appropriate board terminals. When looking at the disk-drive connector, the bottom wire is 12 volts, the top wire is 5 volts, and the two inner wires are ground, usually connected together at the disk-drive connector's printed circuit mounting. Connect as much of the linecord, power switch S1, and F1 fuseholder wiring as is possible, and then install transformer T1 on the sub-chassis. Get it as close as possible to the power-supply board—it should not touch the disk drive.

Secure the power supply to the chassis using machine screws and nuts, Tinnerman fasteners, rivits, or whatever else you prefer. Anything *except* self-tapping screws; the power supply needs more support than provided by self-tapping screws.

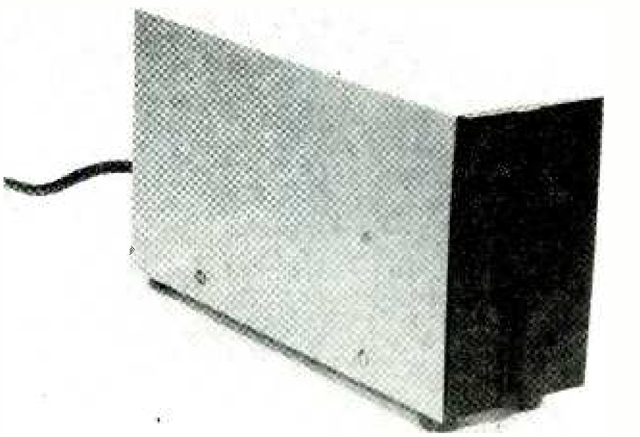


HERE IS THE COMPLETED POWER SUPPLY assembled and ready for installation and test. The perf board is mounted over the voltage regulator ICs. Be sure the weight of the transformer does not pull on the perf board terminals during final assembly.



SECURE THE POWER SUPPLY TO THE BACK OF THE CHASSIS and then slide the disk drive into the chassis. Secure the drive with two screws installed from below.

Next, install the disk drive on the chassis. Though there are four mounting holes in the chassis only two are used for securing the drive. Which two is determined by whether the drive is installed for a left- or right-handed door; or a top or a bottom positioned pilot light. *Test the power connector before you connect the power supply to the drive.* Using a DC voltmeter, test that the power supply connector's bottom terminal is +12-volts DC, and the top terminal is +5-volts DC. If you get it reversed, there will probably be no second chance. When you're absolutely certain the power connections are correct install the power plug.



THE DISC DRIVE IS COMPLETELY HOUSED and ready for use in your computer system. Rubber feet can be installed on top or bottom so that lefties as well as righties will find the disc door latch easy to operate.

Fashion a cover from scrap aluminum, or from the do-it-yourself panels available at hardware stores, and set the cover aside until you *program* the drive.

Programming the drive

If this is the second, third, or fourth drive for your system, remove the terminating resistor from its socket (it looks like a DIP IC), also program the *drive select* jumpers as indicated in your computer's technical manual. Then connect the drive to your computer. You might have to purchase a multi-drive cable, if your original cable didn't provide connectors for more than one drive. Or, you can apply an *insulation displacement* connector to an existing single drive cable. (Just line it up on the cable and squeeze it on with a vise—don't use pliers.)

Attach the cable to the disc drive, and power up your computer using a system disc that you can spare should something go wrong. Take the disc drive through its paces by booting up, running a Basic program, store a program on the disc, and do several tasks you normally perform. While you are doing this, attach two voltmeters to the 5- and 12-volt power supplies and observe that the voltage output stays steady and true. If everything works well as it should, button up the unit by installing the screws and Tinnerman nuts. One more check is in order with the unit assembled. Now look ahead for the next disc drive. **SP**

SIGNA MOD

CRAIG K. SELLEN

"SIGNA-MOD", THE TERM IDENTIFYING THIS PROJECT, was coined by the writer as best to describe the "Signal-Modifier" unit. The special sounds which can be created by this device can provide a new dimension in sound modification, thereby bringing a host of unusual effects to the performing musician's fingertips.

In reality, the Signa-Mod is centered around a basic audio amplitude modulator, which depends on external sources to supply the necessary effects such as, voice-fading technique, ring-modulating effect, frequency doubling, tremolo, and rhythm synthesizer. The external sources that would be required to attain a specified effect is shown in accompanying block diagrams or circuits (Figs. 1 and 2).

Combined with other signals selected, the characteristic sound output, if not unique, could be a good imitation of other kinds of musical instruments.

Theory of modulation

The principle of the basic audio modulator device is described most simply as an envelope-shaping unit and is readily explained by referring to Fig. 1. At the time a continuous sine-wave signal, consisting of a fixed amplitude, is placed on input 1 and a controlled voltage on input 2, we become aware that the control voltage will determine the extent of the amplitude as well as the length of the audio output. Whereby, the combination of both actions will produce a distinct envelope-outline

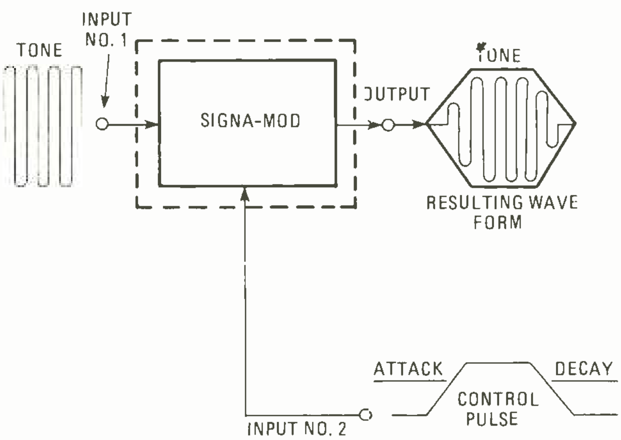
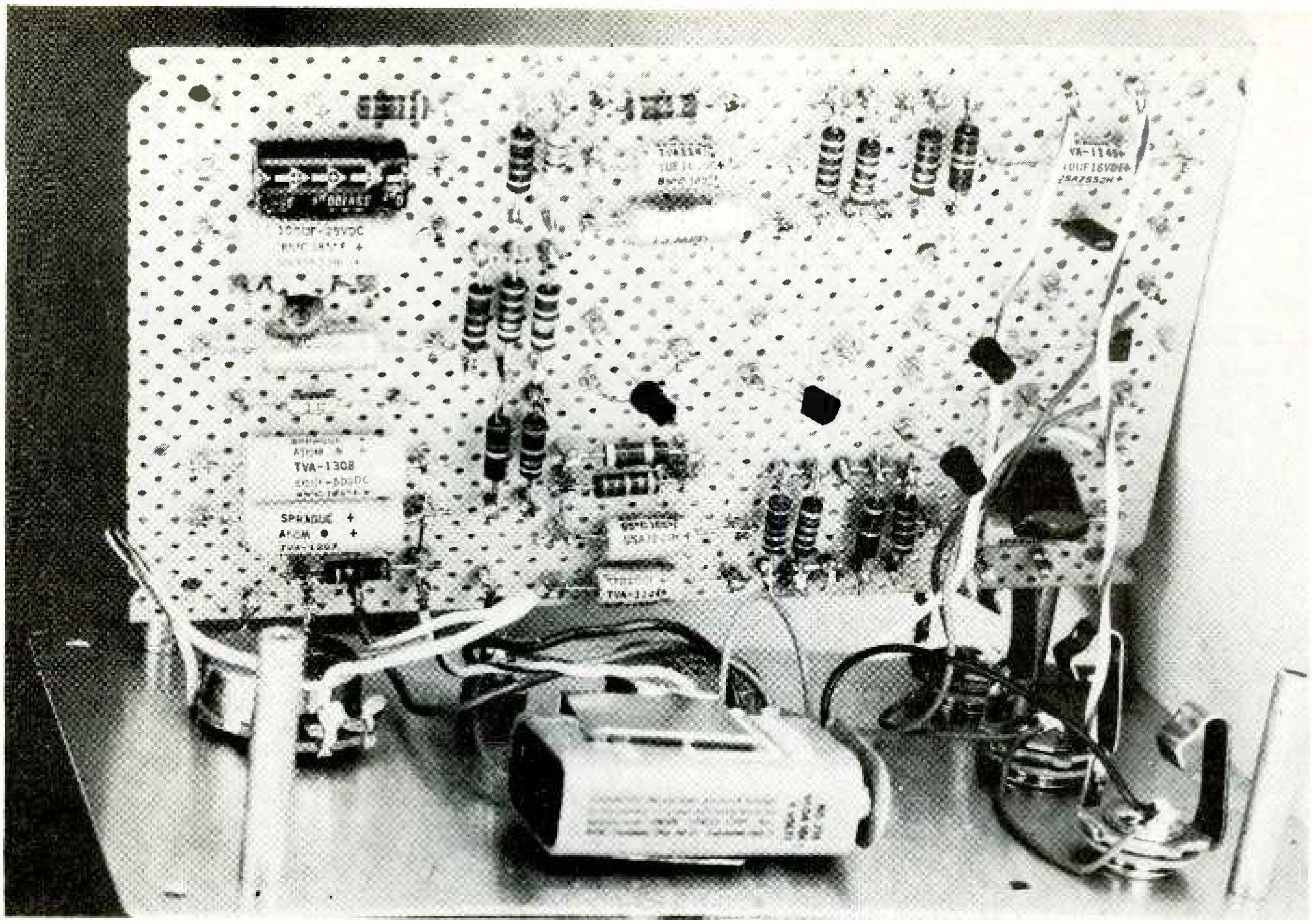


FIG. 1—WANT TO KNOW WHAT THE SIGNA-MOD DOES? Check out this diagram to be sure you understand.



Sound effects for the electronics musician

form or shape which will depend entirely on the amount of voltage directed to the Signa-Mod unit. Therefore, the frequency, tone, and type of pattern of waveform selected will decide the resulting output signal emerging from the Signa-Mod unit. Several options may be exercised: a sine-wave, saw tooth, triangle, squarewave and, of course, the trapezoidal wave.

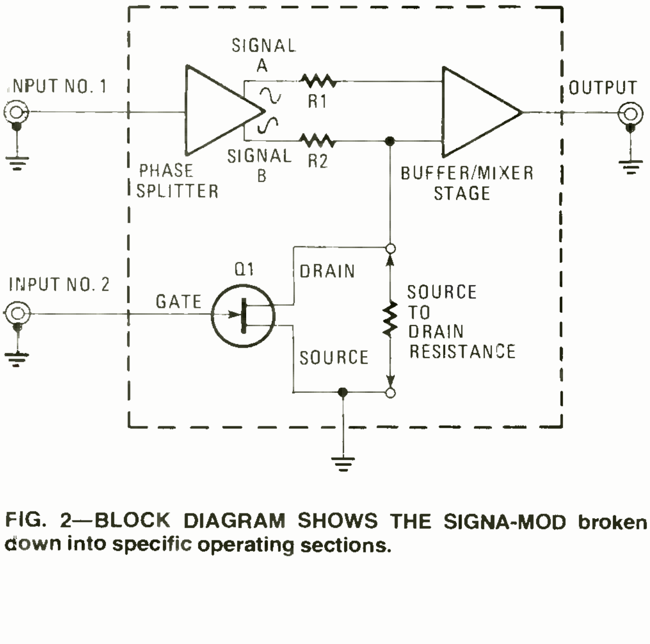


FIG. 2—BLOCK DIAGRAM SHOWS THE SIGNA-MOD broken down into specific operating sections.

The control voltage will depend upon the decay and attack rates of the pulse shape at input 2, accordingly, it is possible to create a variety of simulated percussive sounds such as the ever popular latin bongos, drums, piano, low-pitch bass instrument, and guitar. When the voltage at input 2 is at its lowest point, a corresponding lack of amplitude will be detected at the output of the Signa-Mod. Also, the action of the modulator device takes advantage of the theory that two signals, opposite in phase and possessing equal amplitudes, will subsequently arrive at a null output by canceling each other at the instant they combine.

The block diagram of the Signa-Mod as depicted in Fig. 2, reveals a pair of signals (A & B) were created by using a phase splitter from the signal applied to input 1 of the Signa-Mod. The two signals (A & B) will emerge from the phase-splitter stage possessing amplitudes of equal nature but directly opposite in phase characteristics. Thereby, phase (A) achieves a predetermined level of attenuation by R1 which is being fed directly to the buffer/mixer stage. At the same instant, phase (B)

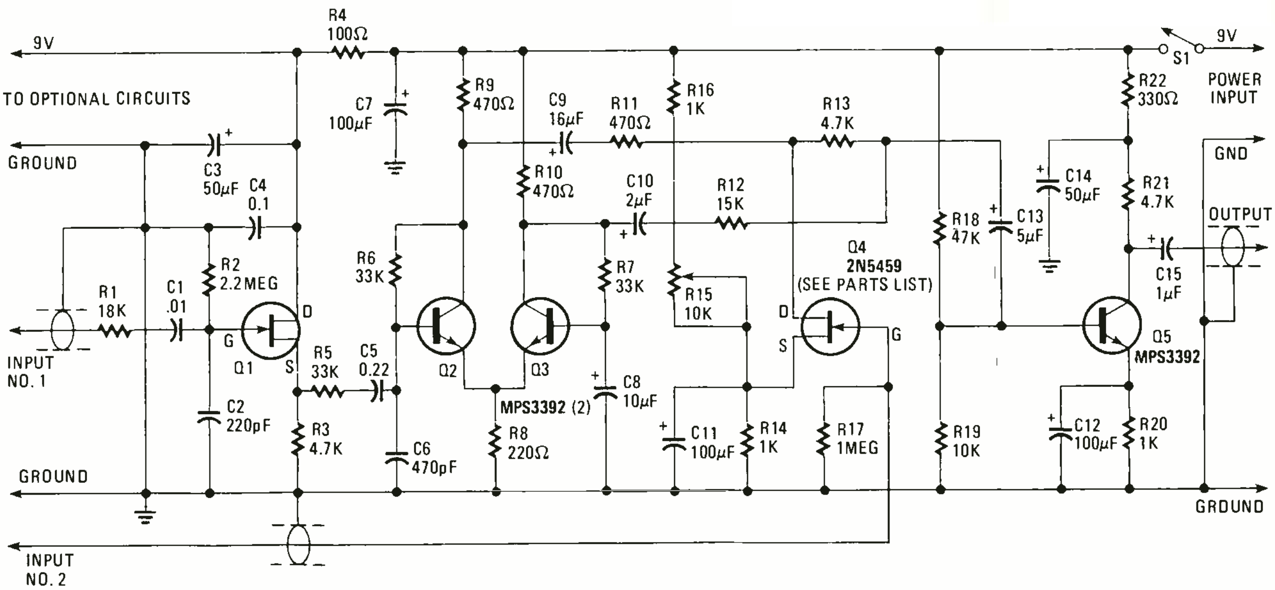


FIG. 3—FULL SCHEMATIC SHOWS THE COMPLETE CIRCUITRY. Together with the parts list you have all the vital construction details.

will receive an attenuation of like characteristics through R2. The source-to-drain resistance of the voltage-controlled attenuator Q1 will determine the rate of attenuation between R2 and the ground potential. That signal is directed to the buffer/mixer stage as well.

When Q1 is devoid of an input voltage, the gate is held at zero; consequently, both A and B signals have identical amplitudes. It is only when a change occurs in the gate voltage that the combined signals become unbalanced. A controlled voltage or modulation signal applied to the gate of Q1 alters the source-to-drain resistance, and subsequently changes the degree of attenuation that is added to signal B.

This now creates an amplitude-modulation signal and both A and B signals are then applied to the buffer/mixer stage. Therefore, any changes brought about by Q1 could be either positive or negative in nature, providing the buffer/mixer stage a proportional increase or decrease of signal output of the Signa-Mod unit.

About the circuit

The compelte schematic diagram of the Signa-Mod is shown in Fig. 3. Input buffer Q1 serving as a high-impedance input device, provides a stable load for the audio-signal source connected to input 1. Transistor Q2 serves as one leg in the operation of the long-tailed pair phase-splitter. The audio signal is obtained from the emitter resistor R8 of Q2, which is direct coupled to the emitter of transistor Q3, thereby becoming the second leg of the long-tailed pair phase-splitter.

There is a forward biasing at the base-emitter junctions of both transistors as supplied by R6, for transistor Q2 and R7, for transistor Q3. Bypass capacitor C8 effectively shorts any AC signals to ground at the base of Q3.

Two distinctively separate, but opposite phases will occur at the time an audio signal is applied to the base of transistor Q2, via R5 and C5.

Signal B (refer to Fig. 2) of the phase-splitter is taken off collector, Q2 through capacitor C9, which is then

PARTS LIST

RESISTORS
¼ Watt, 5%
R1—18,000 ohms
R2—2.2 megohms
R3, R13, R21—4700 ohms
R4—100 ohms
R5, R6, R7—33,00 ohms
R8—220 ohms
R9, R10, R11—470 ohms
R8—220 ohms
R9, R10, R11—470 ohms
R12—15,000 ohms
R14, R16, R20—1000 ohms
R15—10,000 ohms, linear potentiometer
R17—1 megohm
R18—47,000 ohms
R19—10,000 ohms
R22—330 ohms

CAPACITORS
16 volts or higher
C1—.01 µF, 10% Mylar
C2—220 pF, ceramic disc
C3, C14—50 µF, electrolytic
C4—.1 µF, ceramic disc
C5—.22 µF, 10% Mylar
C6—470 pF, ceramic disc
C7, C11, C12—100 µF, electrolytic
C8—10 µF, electrolytic
C9—16 µF, electrolytic
C10—2 µF, electrolytic
C13—5 µF, electrolytic
C15—1 µF, electrolytic

SEMICONDUCTORS
Q1—2N3819, N-channel J/FET
Q2, Q3, Q5—MPS3392 - NPN silicon
Q4—2N5459, 2N5485 or MPF 105, N-Channel - J/FET

MISCELLANEOUS
Plastic box enclosure with aluminum cover; Perforated construction board or PC board (optional); Dry transfer lettering for front panel; Wire; Solder; Stand-offs; Phone jacks; Two control knobs; Battery clip; Shielded cable; Washers; Hardware, etc.

attenuated by a divider network composed of R11, R13 and voltage-controlled attenuator transistor Q4. At that precise instant, signal B (refer to Fig. 2) drawn from the collector of Q3 through capacitor C10 and R12, which is now fixed at a predetermined level of attenuation. The two signals are combined and applied to transistor Q5 through capacitor C13. Q5 serves as a common emitter class A buffer/mixer.

In the event a zero voltage or modulation signal is evident at the input 2, then Q4 gate is held at ground potential through the resistor (R17). The source-to-drain resistance of the field effect transistor, Q4, is dependent on the bias applied to it. That is furnished by the existence of the resistors R14, R16 and the trimmer potentiometer R15, which serves as the null adjustment. A positive-bias voltage is then set at approximately (1.5 to 3 volts) to the source of transistor Q4. That arrangement will result in a direct coupling of the gate of Q4 which is Input 2. Bypass capacitor C11, which is being shunted across source resistor R14, provides a low-impedance path to the AC signals to ground potential. Thus, C11 eliminates any hum, audio, or other signal which may ride on the 9-volt bias line.

The buffer/mixer Stage, which consists of resistors R18 and R19 forms a voltage divider network that provides the essential forward bias for the transistor Q5. Resistor R22 and capacitor C14 forms another network, having a decoupling function that filters out any excessive AC signals that may be presented from the collector load of Q5.

The output audio signal is then taken off the collector load resistor R21 through capacitor C15.

Construction and testing procedures

Construction of the Signa-Mod prototype was accomplished by assembling the various components on a carefully laid out, perforated board of approximately 4 × 6½ inches. (See photo on previous page.)

A sheet of ¼-inch squared graph paper was tacked to a drawing board; then, all of the components were positioned on top of the graph sheet and moved about until a well designed pattern was formed. That method assures that all of the components would fit well within the confines of the 4 × 6½-inch board, allowing ample clearance for the standoffs.

The builder can use that perforated-board method or, if he prefers a more professional looking circuit, he can use a printed-circuit board. However, the perforated-board approach is not only easier to work with but has the added advantage of allowing the components to be repositioned when making modifications at a later date, if the builder decides to make any changes to his project.

When mounting the components to the face side of the board, take all necessary precautions in allowing sufficient room for making the connections on the underside of the board. Solder all wires in place securely, and be especially alert for dry-solder joints and proper polarity of all electrolytic capacitors.

As shown in the photo, the perf board is fastened to the underside of the front panel by four aluminum stand-offs; bolts. The perforated-circuit board and the front panel becomes one unit that can now be placed into a plastic enclosure box and held securely. The front cover plate includes three ¼-inch phone jacks and two control knobs, as well as a on-off switch. The output level can be varied by substituting R21 with a 5000-ohm potentiometer and the other control knob providing the null adjust, R15.

Suggested tests after completion

The following tests should be made after completion of the project with the use of a VOM or a DMM. With power supplied to the modulator obtained from a 9-volt battery or some optional source, the following approximate voltage readings should be observed in the device: Q1 source, 1.2 volts; Q2, Q3 collector, 5 volts; Q4 source with R15 wiper set midway, 1.5 volts; and Q5 collector, 5 volts. All voltages are positive with respect to circuit ground.

Current consumption should be within the region of approximatley 18 mA. If there should be a discrepancy in any of the above test voltages, then check for incorrectly located components, short circuits, or possibly a poor solder joint.

To determine if the Signa-Mod is working properly, apply approximately 50-millivolt rms music or tone signal to 1 input. Connect the Signa-Mod output to a audio-amplifier. The result should be a loud and distinctively clear signal at this point of the test.

With R15 set at the halfway position, slowly rock the control knob (R15) and adjust cautiously for a audio-output null response. At null point, the audio signal of the modulator device will not be fully suppressed but you will still be able to hear a very weak or faint sound. However, once you obtain a null, you should be able to increase the output of the audio volume to the full value by applying approximately a +0.5 volts to the 2 input.

The speech activated control (fader device)

This type of fader device is an essential piece of equipment often used by radio announcers and disk jockeys to lower or even fade out transmitted signals using one's voice as a means of control. That leaves the DJ's hands free to perform other duties such as changing records, taking mesages, or jotting down information.

Refer to the diagram in Fig. 4 and understand that the circuit components shown are external to the Signa-

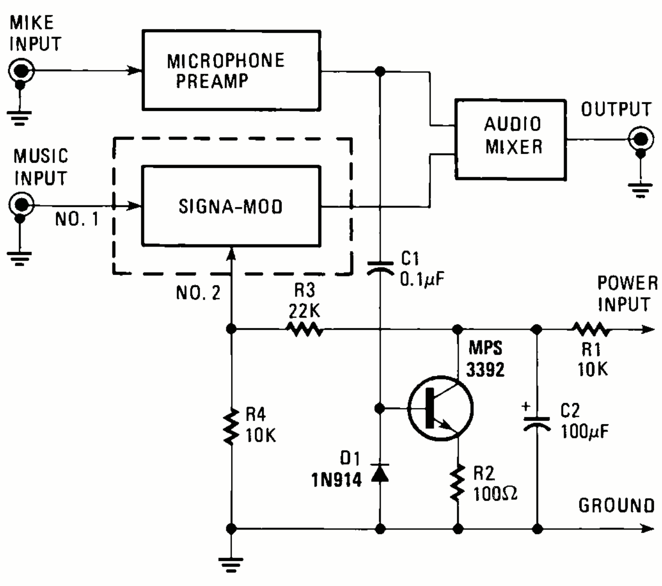


FIG. 4—THE FADING DEVICE, speech activated control.

Mod you built. At the very instant a voice signal is introduced, capacitor C2 controlling Signa-Mod No. 2 voltage, is thereby rapidly discharged by R2. That action very efficiently eliminates the music signal. However, the music signal will remain inoperative until such time that the voice signal ceases.

At that point, capacitor C2 will renew its charge characteristics through (R1) and the music signal will then renew its strength for a span of approximately 1.5 seconds, whereby it will again assume full power.

The bias (DC) intermittent that was derived through the rectification of the voltage signal (AC) issuing from the mike pre-amp will cause Q1 to switch to the *on* mode. Any fluctuations of the base bias will be cleared up by C2.

The ringing modulator

The Signa-Mod can very easily be made to serve as a ringing-modulator device as diagrammed in Fig. 5. Provide a null to either a voice or music signal that emanates from the No. 1 input of the modulating unit. Then direct a low-frequency signal being provided by some sort of external source such as a audio oscillator to the No. 2 input of the Signa-Mod unit.

Very unusual changes in both voice and music signals are possible, and altering the frequency of tone values can provide music with a type of warble-like effect, as well as some bell-like characteristics.

One suggested application of this ringing modulator would be its insertion into the hookup between the electric guitar pickup and the power amplifier.

For optimum results, the input signals to the Signa-Mod should be kept below 100 millivolts.

The frequency-doubling process

The Signa-Mod can readily be converted into a mode of frequency-doubling mode. Adjust the Signa-Mod for a null output, then connect the No. 2 input to the No. 1 input with a .1μF capacitor. Refer to Fig. (6). Frequency-doubling has its limitations with audio signal application of a complicated nature, because the human ear will sense another introduced strong harmonic signal as a harsh dissonant. However, that might be corrected by intentionally mixing back a slight degree of a frequency-doubled signal, thus creating a calculated inharmonious combination of tones.

There is an exception to this rule and it would be quite different when you are working with tone signals that have very little quality or imagination. Let's say, for example, that an ordinary electronic organ or a guitar could be enhanced with a more exciting sound by adding the doubler and then adjustments made for a partial zero status. That addition to the harmonic signal could provide some interesting changes to the audio output. Once again, the application and uses of the process are wide open to the imagination of the operator.

The application of tremolo

Various devices, such as guitar amplifiers and electronic organs, are often built into expensive electronic systems in order to provide the popular "tremolo" effect. Signa-Mod can supply that very interesting sound effect to those systems that lack the tremolo feature.

The tremolo effect is accomplished by a smooth and

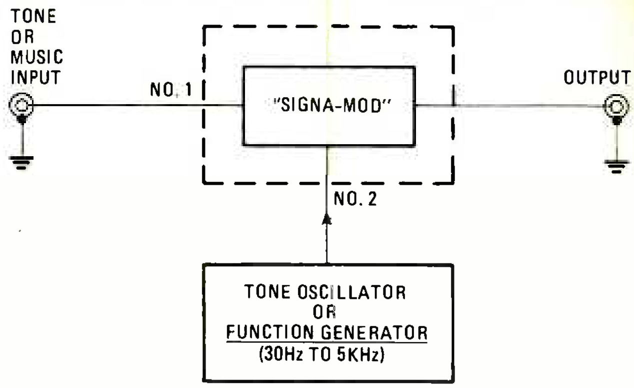


FIG. 5—THE RINGING MODULATOR. It's easier to understand when it is shown separately.

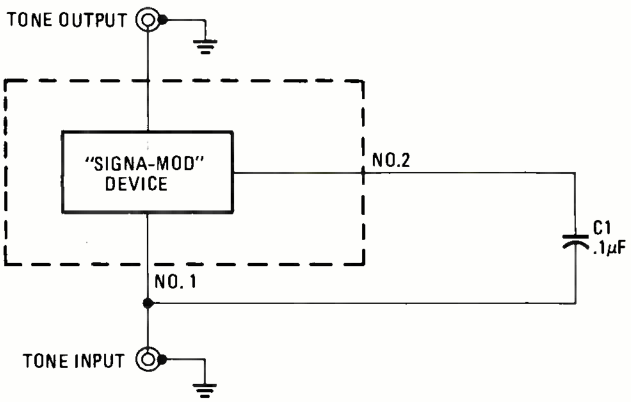


FIG. 6—THE FREQUENCY-DOUBLING PROCESS is clearly shown in this partial schematic.

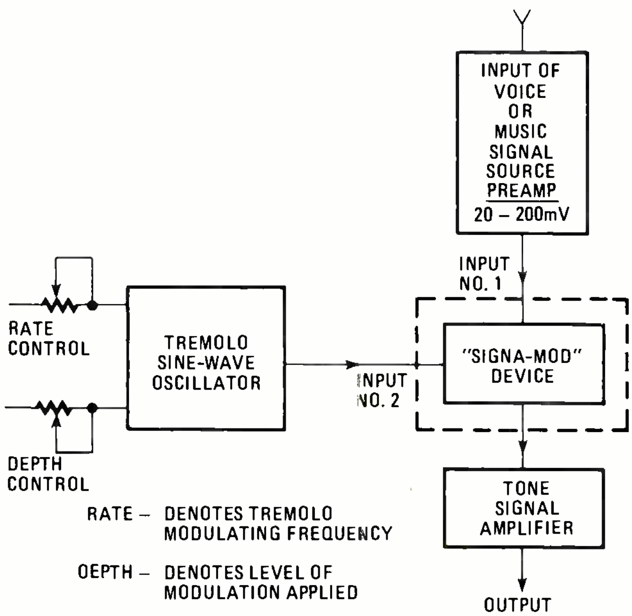


FIG. 7—TREMOLO IS ADDED by using the circuit shown here.

uniform rate of change in audio amplitude that occurs in the rise and fall of a low-frequency signal of about (6 to 12 Hz). A sinewave oscillator is used to drive a non-distorting voltage-controlled amplifier during the process.

The distortion or annoying chatter can be avoided by using a sinewave modulating signal to control-gate voltage of a field effect transistor, Q4, in this case, Signa-Mod (see Fig. 3).

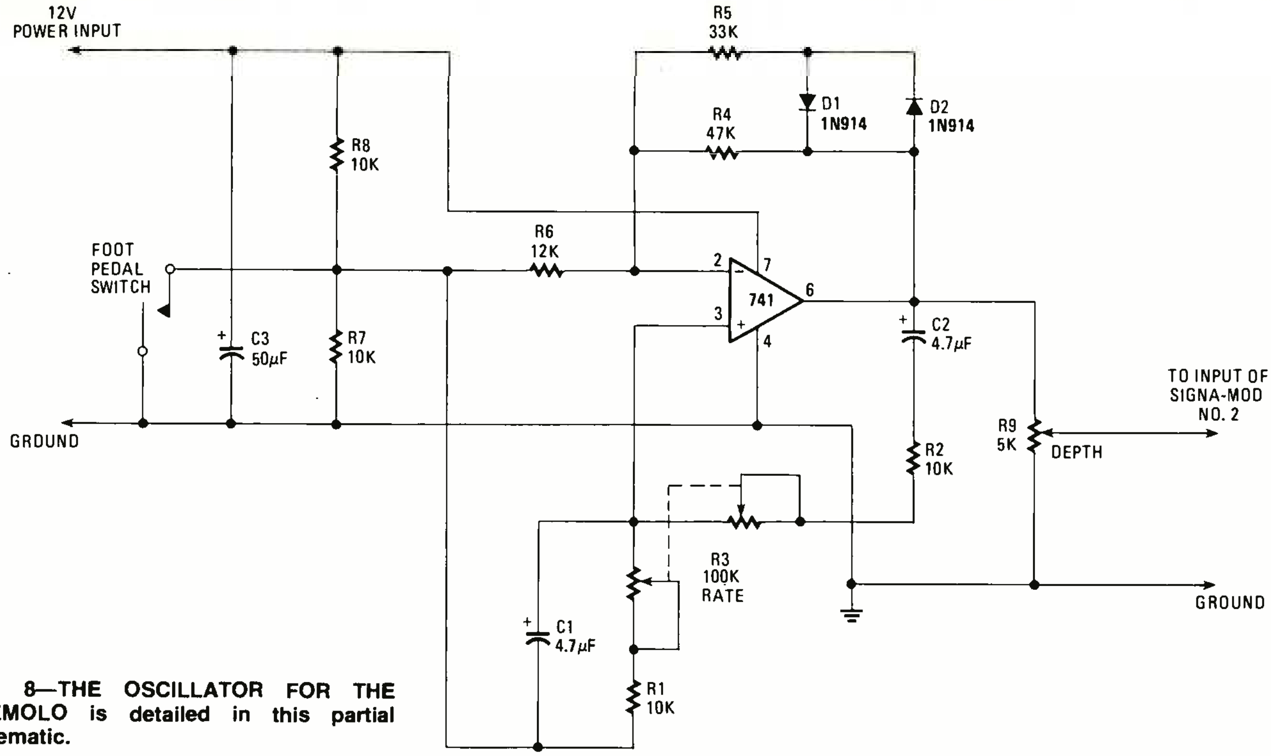


FIG. 8—THE OSCILLATOR FOR THE TREMOLO is detailed in this partial schematic.

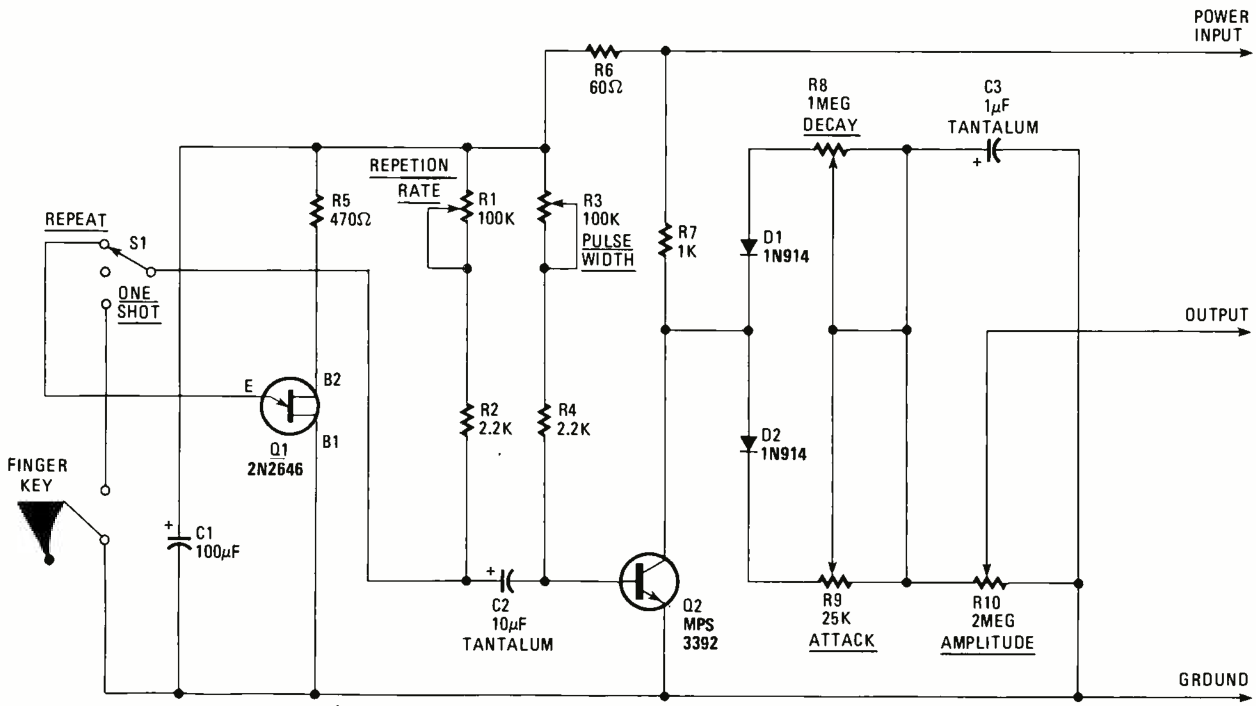


FIG. 9—VARIABLE PULSE GENERATOR circuit as it is used in the Signa-Mod.

By referring to Fig. 7, we see a typical design that will provide a conventional tremolo setup. Applying a microphone preamplifier—or, for that matter, a pickup device on a electric guitar could be implemented to supply the necessary signal source.

The oscillator for the tremolo

A simple tremolo oscillator circuit is shown in Fig. 8 which incorporates the application of the Signa-Mod. Do not confuse the component symbols in Fig. 8 with the component parts given in Fig. 3.

The oscillator circuit was designed around a 741 Op-Amp and includes a "wein" oscillator network consisting of C1, C2, R1 and R2 plus dual potentiometer R3 which controls the rate or frequency of the tremolo oscillator.

Amplitude limiting is introduced into the oscillator by diodes D1, D2 and by resistor R5, and with the resulting overall feedback to the Op-Amp by resistor R4.

A foot-pedal switch in the circuit provides the control of the tremolo to the *on* or *off* mode as required. Whenever the foot-pedal switch is open, the oscillator

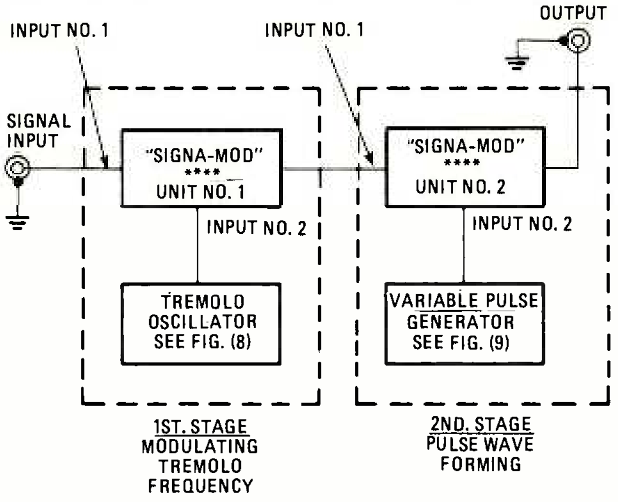


FIG. 10—UNIFORM PATTERN GENERATOR circuit. The text provides a complete circuit description.

will cancel out the signal to the modulator. Therefore, when the foot pedal is closed, the reverse procedure would be evident. The signal would then be produced and a tremolo effect created.

Aligning the tremolo unit is a simple process and consists of setting up the tremolo oscillator and Signa-Mod in the following manner. With a audio signal introduced into input No. 1 of the Signa-Mod, R15 of the Signa-Mod (see Fig. 3) is initially adjusted for a null output by rotating R9 (which is the depth-control knob of the tremolo oscillator in Fig. 8) in a counterclockwise fashion to obtain a minimum output. Having completed that procedure for optimum results, R15 of the Signa-Mod can now be adjusted for desired results by turning the knob clockwise.

It is important that the depth-control knob R9 of the oscillator in Fig. 8 has been previously set at maximum in order to provide a signal without distortions. Completion of the adjustments in a satisfactory manner should provide a rich, full "depth" of tremolo effect.

Now, additional adjustments to the modulator are no longer required, as a variety of audio signals can be directed to the No. 1 input of the Signa-Mod and any occurring changes of "rate" and "depth" can be adjusted to particular requirements via the Signa-Mod's control knobs.

Many unique and challenging types of sound effects might be created by the application of percussive shaping and that method has been mentioned in the theory of modulation.

Original tones might be altered to such a degree that they would appear to be unrelated to the original audio input. Thereby, they could be identified as percussive shapes and you could imitate certain musical instruments by carefully selecting the working-tone source. The variable pulse generator, in conjunction with the tone source, will provide the pulse shape. It is now quite evident that the variable-pulse generator must be coupled to the Signa-Mod in order to provide the capabilities of envelope shaping.

One approach to applying the variable pulse generator is illustrated in Fig. 9. The variable pulse generator will provide a suitable pulse rate that has 20 milliseconds to one full second time span, possessing variable attack and decay rates. It will, however, still retain the characteristic repeating rates of approximately 1 to 25 Hz.

Now, with S1 placed in a repeat mode, C2 will charge at a determined rate by (RC) time constant of R1 and R2. Thereby, capacitor C2 will be discharged thru R3, R4, R5 at the instant unijunction transistor emitter Q1 conducts.

Transistor Q2 will become saturated during the charge cycle of C2 which is then placed in a switched *off* mode during discharge. The cycle will continue to repeat until such time that S1 is placed in the one-shot mode.

A hand operated switch S2 will now provide single pulses by depressing the instrument key and the emanating sound on input No. 1 of the Signa-Mod will remain in a sustained mode until such time as the key is released.

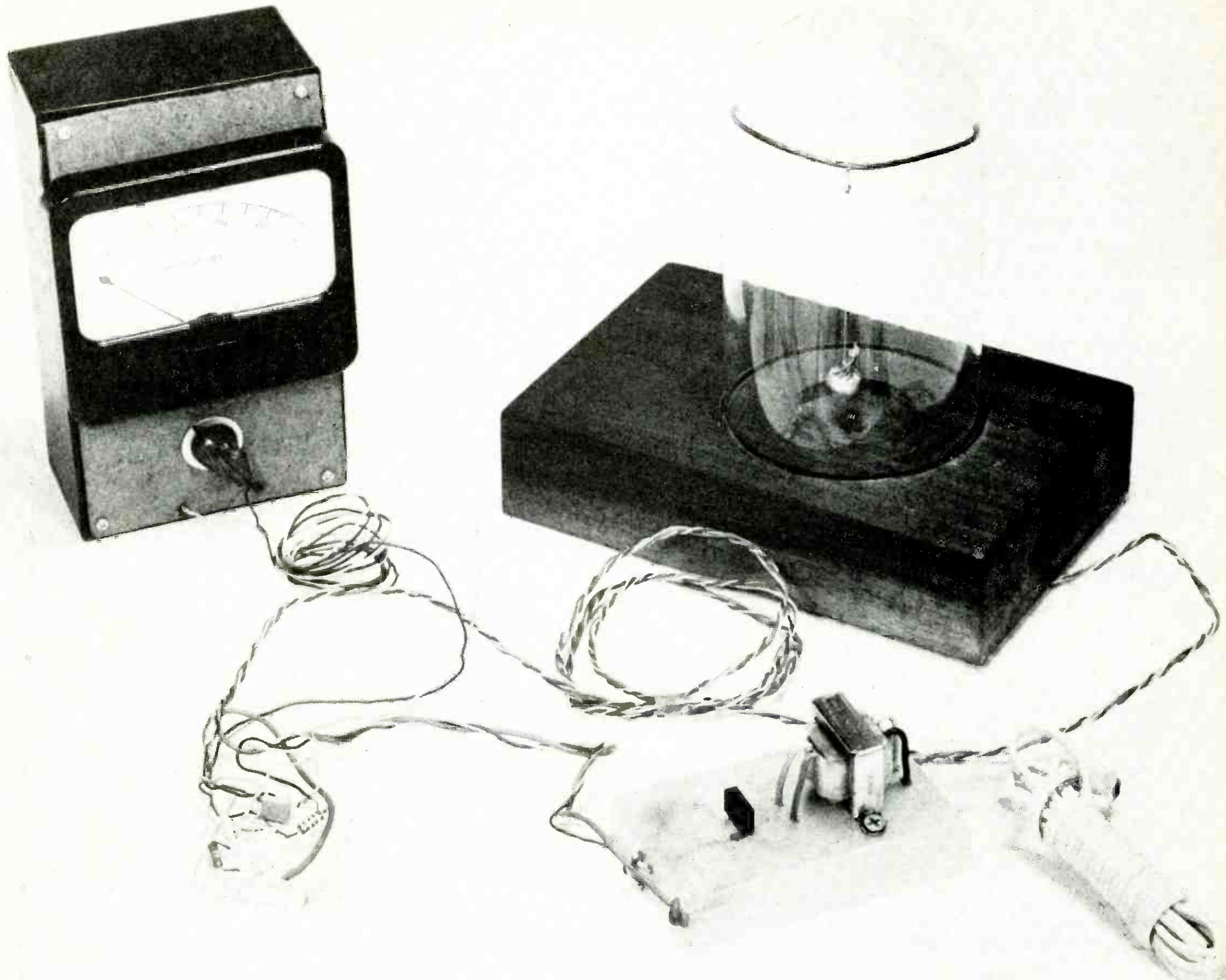
The uniform-pattern generator

A practical uniform-pattern generator (see Fig. 10) providing a variety of interesting drum sounds could be created by combining the functions of the tremolo oscillator, Fig. 8, with the variable pulse generator, Fig. 9. Both of those units have been described. However, a pair of Signa-Mods would be required to complete this uniform-pattern generator device.

In brief, the principle will allow two totally different modulating signals to act on each other. That will create a connection of tone amplitudes of a variable nature as well as a difference in timing of the resulting tone signals.

A constant tone input, having been directed to the section of tremolo unit, will then become modulated by the output of the sine-wave impulses of the tremolo oscillator. At that time, a gradual amplitude change will occur in the tremolo oscillator stage which will then be applied to the shaper stage input.

The variable pulse-generator section will alter the waveform of the tone output and transfer to it a envelope shape having percussive potentials. **SP**



EARTHQUAKE DETECTOR

Now that the Hall-Effect Detector is out of the laboratory, here is just one exciting application you can assemble!

WILLIAM H. HUEBL

IN 1879, E. H. HALL DISCOVERED THAT A STATIONARY magnetic field will induce a voltage in a current-carrying conductor. This induced voltage is perpendicular to both the current in the conductor and the magnetic field. Through modern technology, using semiconductor materials to amplify the induced voltage, which is very feeble, and integrated circuitry to reduce complexity, the induced voltage is readily usable for both digital and analog applications. And while it has taken nearly one hundred years to get this technical curiosity out of the laboratory and put it to use in practical applications, the phenomenon, now called the Hall effect, is on the verge of revolutionizing the field of electronic transducers.

First, let's take a look at the make-up of the device. The typical Hall effect detector consists of a silicon Hall effect generator, an amplifier, a Schmidt trigger, and an output transistor stage integrated with its own voltage regulator...all designed into one small monolithic silicon chip which we call a Hall effect detector (see Fig. 1 for block diagram details).

Referring to Fig. 1; whenever a magnetic field with the proper orientation and strength is present, the Hall

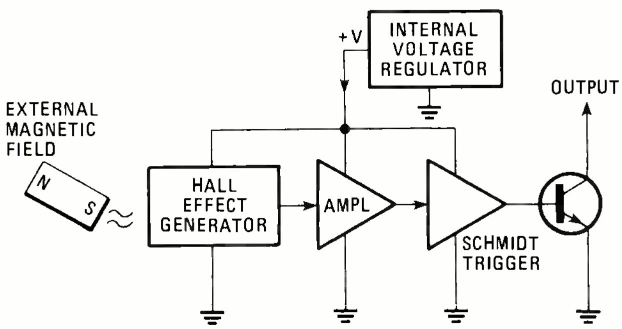


FIG. 1—HALL-EFFECT DETECTOR BLOCK DIAGRAM is quite simple compared to the theory behind the device. What was a 100 year old lab curiosity is today's technology.

effect generator produces a small voltage. In a digital operation, the amplified voltage is compared to a predetermined *operate point* and, when reached, causes the trigger to conduct. The trigger, in turn, causes a common-collector output transistor to conduct. It can handle up to 20-mA current.

The Hall effect trigger turns off when the magnetic field strength falls below the release point, which is well below the *operate point* mentioned above. This switching characteristic, known generally as "hysteresis", provides unambiguous and non-oscillatory switching, regardless of the rate of change of the magnetic field (see Fig. 2). In this circuit, a magnet is introduced to the Hall effect detector, causing the LED to light when the switch conducts. When the magnet is removed, the LED goes out.

The device is very useful in its digital (switching) mode of operation for such things as motion counters, wind-speed measurement, tachometers, and for magnetic indexing. In certain instances, for example it can even replace reed switches for burglar alarms.

Before the Hall effect detector can become useful for analog (linear) operation, the hysteresis associated with the digital action must be disabled. To do that, an inexpensive resistor along with a 22-turn potentiometer having 1,000 ohms resistance is added to the supply line. The pot alone is sufficient as long as the supply voltage does not exceed a maximum of 3.99 volts. For each volt or part of volt over 4.00-volt level, 500 ohms resistance must be added in series with the pot. For example a 9-volt supply would have (9-4) × 500 = 2,500 ohms in addition to the resistance of the pot. The resistance computed is shown as RX in Fig. 3.

Circuit modifications for analog use

Note that the 22-turn pot is required rather than a single-turn unit as the range of resistance in which the hysteresis action is disabled to quite narrow. Typically the analog operation will only work within a turn or so of the optimal setting. And the resistance should cause a voltage of about 2.41 volts to be applied to the device supply pin.

Referring to Fig. 3, when adjusted properly, the LED will now dim and brighten according to the distance of the magnet from the device rather than switching on and off abruptly, as in the previous digital mode.

A well-regulated power supply, although not essential for these experiments, is necessary if the switch is to handle any sort of a load with any reasonable degree of linearity. (Linearity is the term used to describe the degree to which the output is proportional to the input.) A several-thousand μF capacitor in parallel with the battery will help improve the performance of the circuits described. Using a 5-volt supply, commonly available in many experimenters shops, requires the addition of a 500-ohm resistor previously computed.

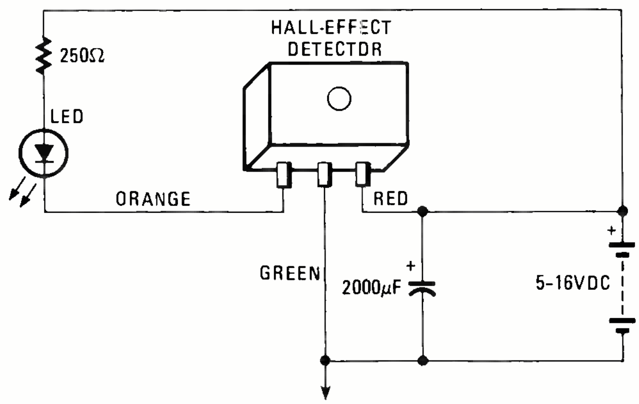


FIG. 2—SIMPLIFIED HOOK-UP of the Hall-Effect Detector is useful to illustrate how the digital (switching) aspect of the device operates. Magnet proximity turns LED on and off.

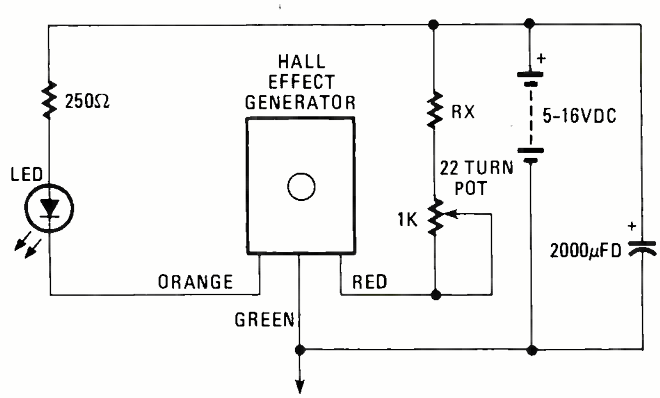


FIG. 3—MULTI-TURN POTENTIOMETER (22 turns) sets the Hall-Effect Detector voltage input to 2.41 volts. Thus powerd, the device behaves in an analog way indicating magnet motion.

While the modifications described above will successfully convert the Hall effect detector to analog operation having a linearity sufficient for these experiments, units designed specifically for analog operation are available from F.W. Bell, Inc., 8120 Hanging Moss Rd., Orlando, FL 32807. The cost of these units starts at $16.00 and provides only about 1% deviation from perfect linearity.

The Hall effect detector as altered for analog use can be used for such diverse applications as strip-chart recorders, phonograph cartridges, waveform generators, motor-speed controls, valve positioners, electromechanical multipliers, and (the subject of this article)—an earthquake detector.

The best is yet to come...there are no moving parts to stick or wear out or affect the measurements. The only thing the Hall switch needs is a weak magnetic field to provide the basis for a proportional output voltage.

Project construction

Having looked into the operation of the switch, let's now construct the detector.

The earthquake detector is a spartan version of its big brother, the seismograph. While an earthquake detector can be made into a full-fledged seismograph, unless you are prepared to shell out several hundred dollars or so for a strip recorder or to build one yourself, the earthquake detector is a logical project to demonstrate the Hall switch capabilities by itself.

Take a scrap of lumber about 6 × 6 × 2-inches and drill a hole in the center of the square side. Use a drill bit the size of a transistor socket...normally ⅜ths inch will do. Solder 3 different color wires (red, orange, and green, for example) at least 3 feet in length to a transistor socket with the green wire attached to the center lug. Braid or twist the wires together and insert them through the drill hole in the block of wood. Daub some red fingernail polish on the top of the socket on the side having the red wire attached. Insulate the center lug with spaghetti tubing.

Press fit the socket in the hole. Now test each lead for continuity with the socket and with each other lead to make sure there are no short circuits between the leads. A little epoxy glue will hold it all together permanently.

Initial experiments

Insert a Hall effect detector into the socket and bend its leads at right angles to the socket so the "O" market side is facing straight up. Make sure you have inserted the detector so that the supply lead goes into the socket hole with the red nail polish (red lead). Connect the power supply, resistor, capacitor and LED according to Fig. 2.

Before activating the power supply, see that the red wire from the Hall effect detector is connected to the positive supply line and the green wire is attached to the negative or ground. The remaining (orange) lead goes to the collector and is attached to the cathode of the LED. Check your wiring very carefully.

Place the south pole of a magnet on the switch. If the LED doesn't light, then reverse (flip over) the magnet to its other pole and try again.

If the LED still doesn't light, then here are some trouble-shooting suggestions:

Ground the collector terminal (orange wire) of the LED. If the LED doesn't light, then the LED may be reversed and installed backwards. If reversing the LED does not solve the problem then either the power supply is not on or defective, or the LED is defective.

As a last resort, set a stronger magnet or put several magnets together and try again. If this doesn't work, then the Hall Switch may be defective. To see if there are any problems, check the resistance with every combination of paired pins...the resistance should always exceed 40,000 ohms and in two cases be open circuit (100 million ohms or more).

When you have gotten your switch operating correctly, try moving the magnet up and down over the switch. You will notice the distance to the switch when the LED turns on is less than the distance to the Hall Switch when the LED turns off. This difference in the positions of "on" and "off" demonstrates the "hysteresis" mentioned previously.

Experiment with different strength magnets and try placing various materials including paper, plastic, foil and other materials between the switch and the magnet and see what happens.

Using Fig. 3 as a guide, insert a resistor (selected according to the voltage of the power supply as explained above) and the 22-turn pot between the power supply and the red terminal on the socket. With the magnet resting on the detector, adjust the pot until the LED glows brightly. Then back off the pot until the LED glow has diminished but not entirely gone out. At this point the Hall effect generator should be operating in linear mode. To test this mode, try moving the magnet and notice the LED fades and brightens slowly rather than turning off-and-on as you vary its position. This demonstrates analog (linear) action rather than digital action. Bring the magnet slowly toward the switch and the LED will gradually brighten. Try adjusting the pot to both higher and lower settings and repeat the above motions for both settings. By doing this you can determine where analog action starts and where the digital action starts based on pot settings. It will help to know this when you build your earthquake monitor. If you have a voltmeter of any kind, set it on low range for 10 volts full scale and hook it up to the positive supply

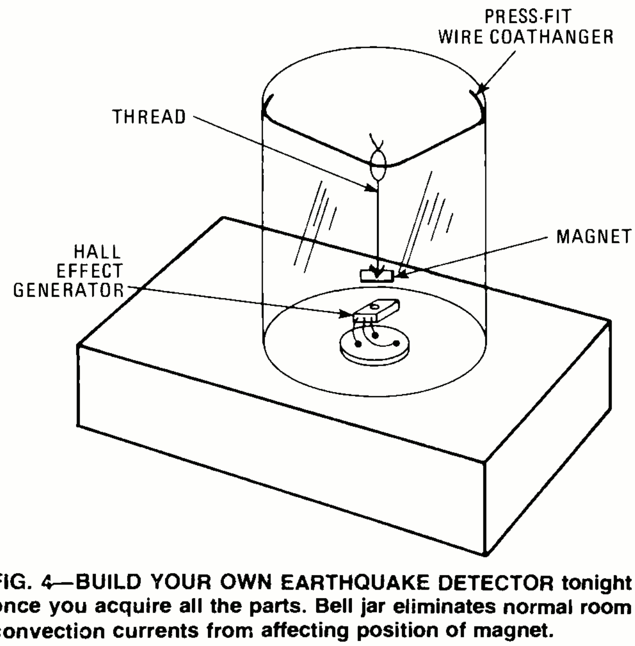


FIG. 4—BUILD YOUR OWN EARTHQUAKE DETECTOR tonight once you acquire all the parts. Bell jar eliminates normal room convection currents from affecting position of magnet.

and the collector (red) lead. Remove the LED and move the magnet as above. The meter setting will change according to the distance the magnet is from the Hall effect detector.

Building the earthquake detector

To convert your mounting block to a seismograph you need to only do two simple things:

1. Replace the voltmeter in the previous experiment with a permanent meter. A 100 microameter with a 1-meg pot can be used...adjust the pot so the meter reads full scale when the magnet is placed on the switch.

2. Cut and bend a short length of coat-hanger wire to fit a quart bottle or bell jar and suspend a magnet from the wire making sure the south pole is down when the magnet is hanging. Insert the wire so that the ends hold against the sides using care since the glass is fragile. See Fig. 4.

With the magnet in place in the jar, invert the jar and adjust the length of the thread so the magnet hangs directly over the Hall effect detector when it is in place.

The meter will respond when the magnet is over the detector and will fluctuate in response to the swings of the magnet...no matter how slight. With the jar and magnet in place, adjust the pot so the meter is mid-scale when the magnet is at rest. Any vibrations will cause the magnet to move in relation to the detector, or rather it is the detector moving in relation to the magnet due to a physical law of motion which states that bodies at rest (the magnet) tend to remain at rest.

While the project is a good way to demonstrate the use of the Hall effect detector in its analog mode and its potential as an earthquake detector, several readily apparent modifications are necessary to use the project for long-term, serious studies...either as a professional or as an amateur.

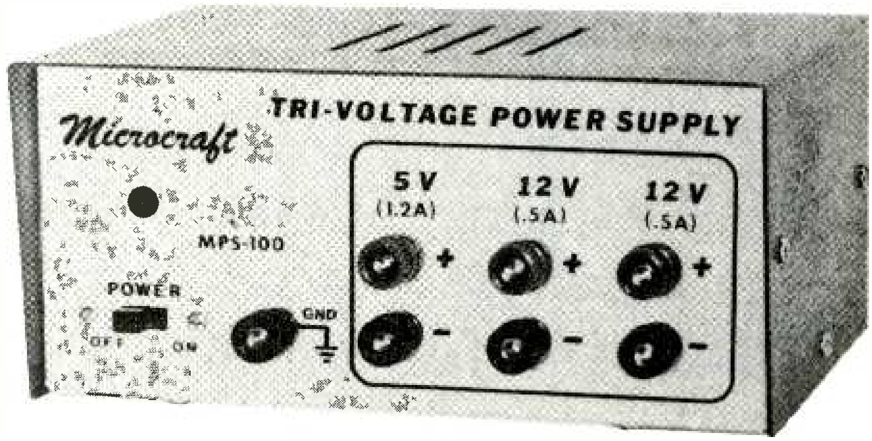
- The battery supply should be rechargeable or converted to a well-regulated line power supply.
- A strip chart recorder should be used to provide continuous monitoring of earth motions. You can buy one or build one from a kit (Heathkit makes a fine one).
- The project as modified should be secured on a concrete ground floor or buried with appropriate physical protection. These steps are necessary to reduce the interference from other natural and man-made phenomena like foot-steps, wind and other non-seismic noise sources.
- An amplifier with a gain of 100 or more, with or without a low pass filter, can be used to enhance the normally weak signal caused by seismic activity.
- An alarm system can be attached to the detector to signal when significant earth-movements are present.
- The electronics should be contained within a case, rather than on a solderless breadboard.

A 22-turn pot simulator

If you can't find a 22-turn pot, or if the price is too dear, connect two potentiometers in series—1K and 50 ohms. Set the 1K pot to its full resistance and vary the 50 ohms pot to obtain the desired LED illumination. Continue to decrease 1K pot resistance in 50 ohm steps (use ohmmeter) until desired results are obtained. Caution: remove power from circuit when measuring resistance, this technique is a bit tricky, however it's inexpensive.

Even if you decide only to try some of the experiments described above, you will be amply rewarded in the demonstration of the flexibility of this old, yet new electronic transducer, the Hall effect detector. And best of all...it will open many doors to help you solve electro-mechanical design, detection, and controls problems through the use of this device. In fact, your imagination is the only limit. **SP**

TRI-VOLTAGE SUPPLY POWER



This high-quality, low-cost power supply is sure to be useful on any workbench. It delivers the voltages you need.

GEORGE R. STEBER

EVERY ELECTRONICS EXPERIMENTER SHOULD HAVE A good, dependable power supply. The Tri-Voltage Power Supply described in this article uses integrated-circuit voltage regulators to deliver the three most common voltages needed for experimenting with linear and digital integrated circuits. In addition, the regulators provide internal thermal-overload protection and internal short-circuit current limiting. Voltages produced by the supply are 5-volts DC at 1.2 amps, and dual 12-volts DC at 0.5 amps each. By suitable resistor changes, the individual 12-volt outputs can be adjusted to provide any voltage in the range of 5 to 15 volts DC.

All three of the voltage sources have their terminals floating from earth ground. Hence, either plus or minus voltage supplies can be provided by choosing the appropriate terminal for circuit-ground. Also, the voltage sources may be series-connected in any arrangement to provide additional voltage ranges. A summary of the performance specifications for each power supply section is given in Table 1. The best news is that the complete Tri-Voltage Power Supply can be built for less than $70.

TABLE 1 - POWER SUPPLY SPECIFICATIONS

DC Source	Output Current	Output Voltage	Load Regulation	Ripple or Noise
5 V	1.2A	4.8 to 5.2V	less than 1%	less than 10 mV at 0.5A
12 V	0.5A	12 V (adj)	less than 1%	less than 10 mV at 0.2A

The complete circuit of the Tri-Voltage Power Supply is shown in Fig. 1. Notice that power transformer, T1, has three separate, *galvanically* isolated secondary windings. That allows the individual output-voltage sources to float completely with respect to any reference point.

The 5-volt circuit is driven from a transformer secondary winding which is rated at 16-volts AC C.T. at 1.5 amperes. The circuit is a standard design for a type 7805 regulator (IC1) with the exception of diode D1. That diode is provided as protection for the regulator and allows it to start up in the presence of a negative voltage at its terminals.

The two identical 12-volt circuits use individual T1 secondary windings of 15-volts AC at 0.5 amperes. Adjustable resistors R5 and R7 allow trimming the out-

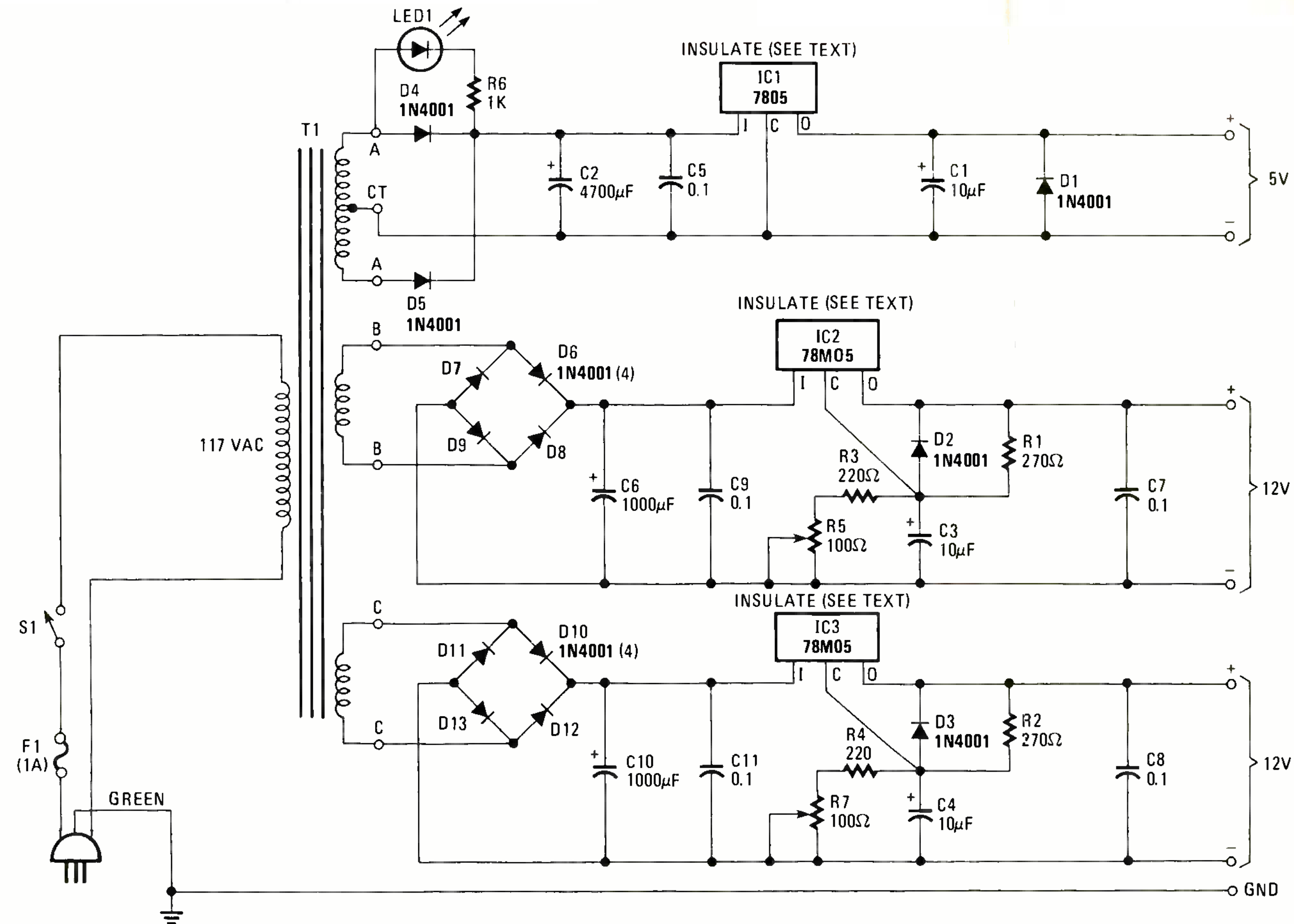


FIG. 1—COMPLETE SCHEMATIC for the Tri-Voltage Power Supply. Note that the transformer, T1, has three separate, isolated secondary windings.

put voltage of their respective outputs to exactly 12 volts. Trimming to other voltages may be accomplished by changing the fixed resistors R1 (R2) and R3 (R4) which act as a voltage divider. Voltages in the range of 5 to 15-volts DC can be obtained by appropriate choice of these resistors.

For safety purposes a 3-wire AC line cord should be used with this (or any) power supply with the third wire, *green color* (earth ground), connected to the chassis and brought out to the front panel. Also, the three regulators IC1-IC3, must be adequately heat-sinked to allow for heat transfer away from the regulators. Insulating washers and screws should be used to isolate the ICs electrically from the chassis.

Construction hints and tips

The Tri-Voltage Power Supply is most easily constructed by using a printed-circuit board. Fig. 2 shows the single-sided PC board used for the project, and Fig. 3 shows the parts placement on the PC board. A complete set of parts for the Tri-Voltage Power Supply is available as noted in the Parts List.

With the exception of the voltage regulator ICs, all parts are installed on the top side of the PC board and soldered on the bottom (foil) side. Pay particularly close attention to the cathode markings on the diodes and the "+" signs on the electrolytic capacitors for proper orientation during installation.

Pay careful attention to the installation and mounting of the voltage regulators. They are inserted into the

PARTS LIST

RESISTORS

¼ watt, 5%

R1, R2—270 ohms
R3, R4—220 ohms
R5, R7—100 ohms, trimmer potentiometer
R6—1000 ohms

CAPACITORS

C1, C3, C4—10 μF, 16 volts, electrolytic
C2—4700 μF, 16 volts, electrolytic
C5, C7-C9, C11—0.1 μF, ceramic disc
C6, C10—1000 μF, 25 volts, electrolytic

SEMICONDUCTORS

IC1—7805 5-volt regulator
IC2, IC3—78M12 12-volt regulator, ½ amp
LED1—red LED and holder

MISCELLANEOUS

F1—1-amp fuse and holder
S1—SPST switch
T1—transformer, 117-volt primary; three secondaries: secondary 1—16 volts C.T. at 1.5 amps, secondaries 2 and 3—15-volts AC at 0.5 amp
PC board, 3-wire line cord, mica washers, jacks and lugs, cabinet, chassis, etc.

NOTE: The following items are available from Microcraft Corporation, PO Box 513, Thiensville, WI 53092; (414) 241-8144: MPS-100 PCB—printed circuit board, $4.00 plus $1.00 shipping and handling; MPS-100 kit—complete kit including PC board, cabinet, and chassis, $69.95 plus $4.00 shipping and handling; MPS-100 W/T—complete wired and tested power supply, $89.95 plus $4.00 shipping and handling. Wisconsin residents please add 4% sales tax.

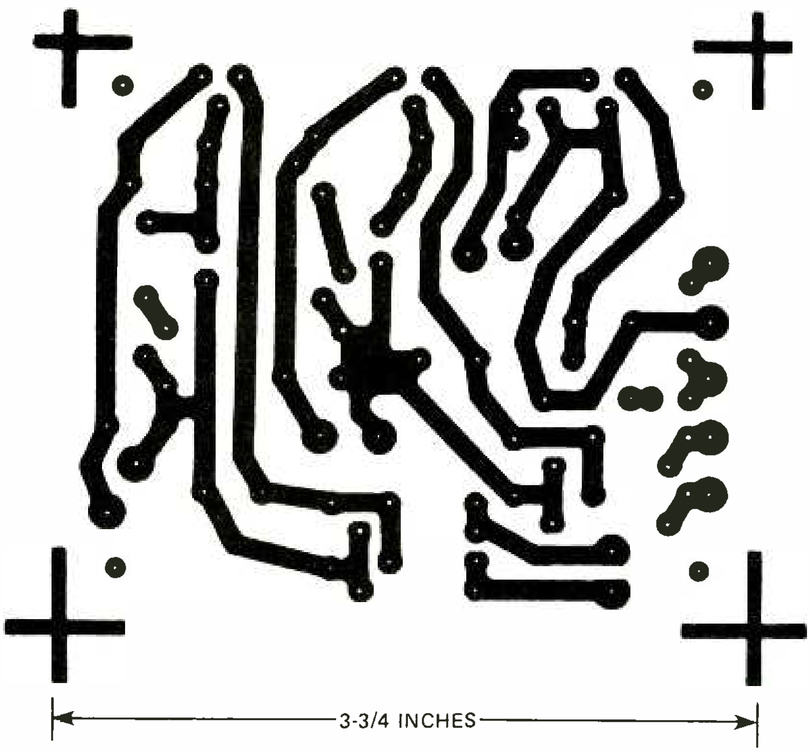
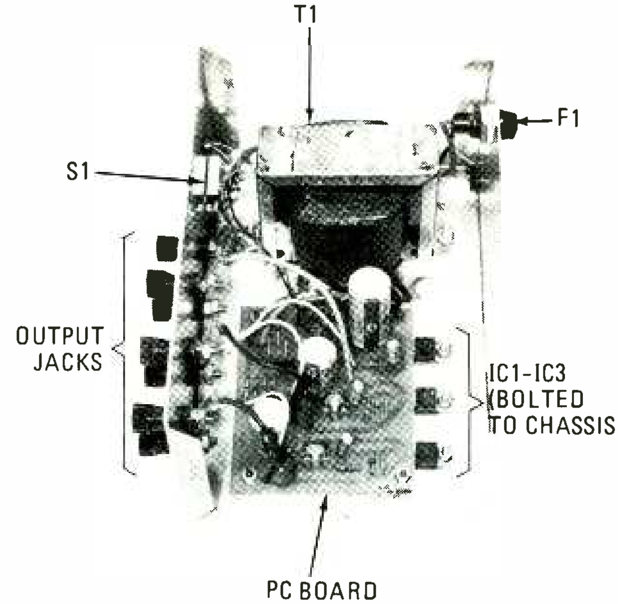


FIG. 2—THE EASIEST WAY to build this project is to use a printed circuit board. The author's board configuration is shown here.



THIS IS HOW the Tri-Voltage Power Supply should look when you've completed construction. Once you're sure that everything is operating correctly, button up the case and you are done.

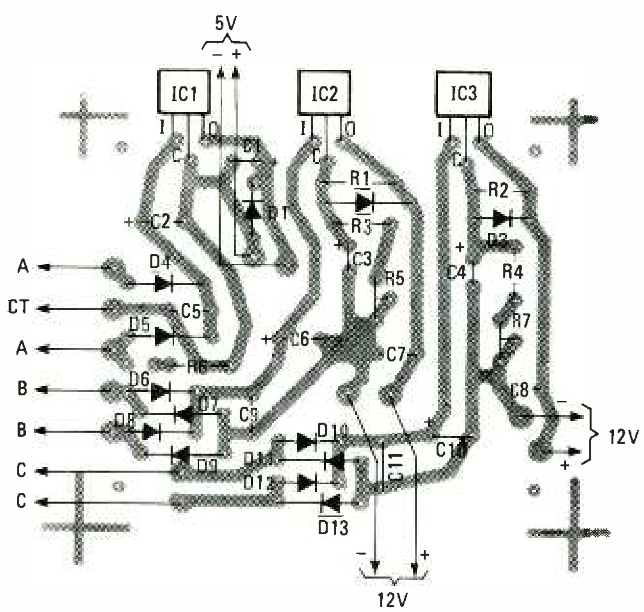


FIG. 3—PARTS PLACEMENT DIAGRAM. Note that the voltage regulators (IC1-IC3) are installed on the *foil* side of the board (see text).

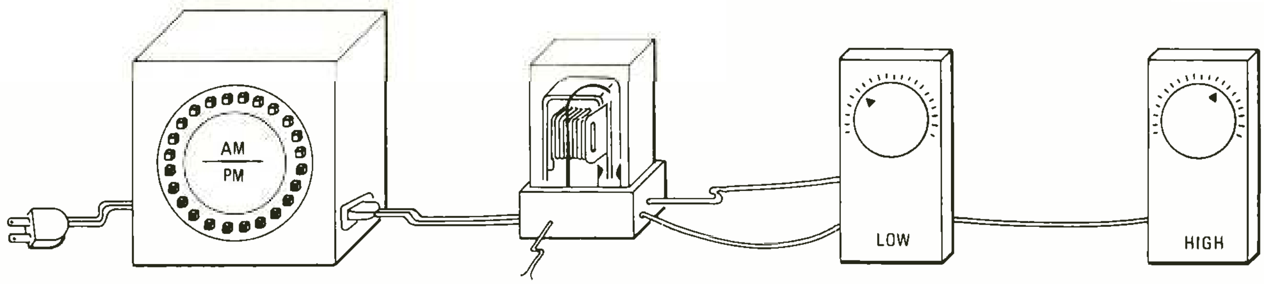
PC board *from the foil side* and the legs are carefully bent, so that the regulators extend away from the bottom of the board in a parallel direction. (Note that the PC board will be mounted horizontally, foil side down, about ¼ inch above the chassis with the regulators mounted to the chassis.)

Next, wires of the appropriate length from the 5-volts DC and dual 12-volts DC outputs are soldered to the PC board for connection to the off-board jacks. Similarly, wires to the "power-on" LED should be soldered to the PC board.

Finally the transformer leads are soldered to the PC board. It is then ready for mounting on the chassis using the ¼-inch standoffs and screws through the holes in the four corners. Each of the regulators is mounted on the chassis but must be isolated electrically from the chassis by a good insulator, such as a mica washer. Heat-sink compound should be used to improve the thermal conductivity since the chassis serves as the heat sink. Care should be taken to make sure that the screws holding the regulators are also insulated by means of a shoulder washer. The remainder of the wiring consists of connecting the transformer primary winding, fuse, switch, and line cord according to the schematic diagram in Fig. 1.

After carefully double-checking all wiring for errors, the Tri-Voltage Power Supply can be connected to an AC source and powered up. The power-on LED should immediately light. Measure the voltage at each of the outputs; they should correspond to the values shown in Table 1. The dual 12-volt outputs can be trimmed using R5 and R7, respectively.

The Tri-Voltage Power Supply may be used to power a wide variety of projects. For example, a number of projects require simultaneous +5-volts DC, +12-volts DC and −12-volts DC supply voltages. The Tri-Voltage Power Supply can easily provide those or other combinations of voltages. After a little use you will wonder how you ever got along without your Tri-Voltage Power Supply **SP**



PROGRAMMABLE THERMOSTAT

Two-level temperature regulator for your home saves thousands of BTUs a day, and 50 to 175 installation dollars if you do it our way!

NOEL BOUTIN

ONE EASY WAY TO SAVE ENERGY AND ALSO REDUCE heating bills is to lower the setting of the thermostat when nobody is at home, or when everybody is sleeping during the night. However, it is not very agreeable to put bare feet on a cool floor or to come back into an artic house. The solution to those problems is to use a thermostat that can be programmed to your own needs.

Here is a typical example. An hour before you get out of bed, your house temperature begins to rise to a comfortable one. You take your breakfast and leave the house for the day. Your house temperature begins to fall to your selected low temperature. A half or an hour before you come back home, the temperature begins to rise again to your selected comfortable one. When you go to bed, the same process occurs. You no more have to ask yourself if you really have lowered the temperature or not: it was done automatically.

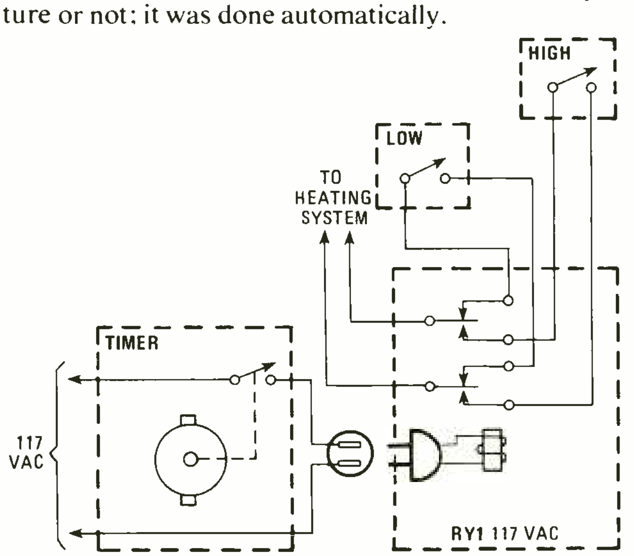


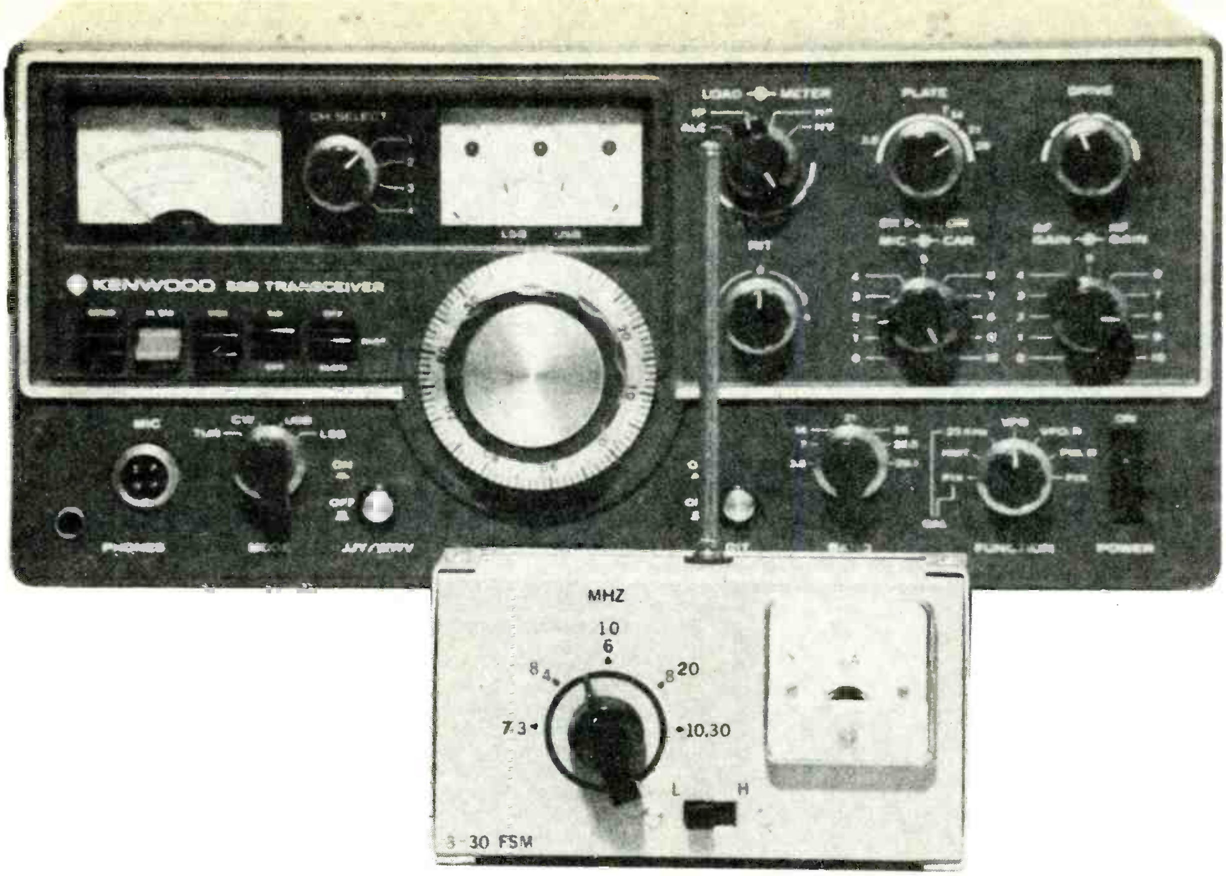
FIG. 1—HOW SIMPLE CAN IT BE? Old plus new thermostats, AC relay and 24-hour timer are all that you need to save bucks.

Of course, such programmable thermostats exist right now. However, they all have two points in common: They are expensive ($75 to $200) and they don't use your old thermostat.

The programmable thermostat proposed here can cost you less than $25 and uses your old thermostat. Furthermore, it is much more versatile than many commercial thermostats selling for three to five times that cost.

As illustrated in Fig. 1, the heart of this thermostat is a low-cost programmable timer normally used to turn appliances on and off. The more versatile the timer, the more versatile the end product will be. The Radio Shack 63-8061 is an example of a good one to use. That timer can switch a load on and off as often as 24 times a day. It can also be programmed for just one cycle or for a repetitive one. Here, the timer is used to turn on and off a DPDT relay. This relay must therefore have a 117V AC coil. A Radio Shack 275-217 is a good choice, but any surplus relay can do as well. The relay contacts select one of the two thermostats and connect it to the two-wire existing system. The required additional thermostat may be any general-purpose one having a SPST normally open contact, just like the one you are presently using. The contacts of the additional thermostat and those of the relay must have a current rating equal or greater than those of your present thermostat. A good choice for the additional thermostat would be the one used with an electrical baseboard-heating system. It is perhaps the lower cost one (about $5).

The programmable thermostat proposed here can replace any 24-volt two-wire thermostat controlling a central furnace system. By a proper choice of the relay and thermostats it can also be used for other systems. In summer, for example, it can be adapted for air-conditioning systems. **SP**



3-30MHZ TUNABLE FIELD-STRENGTH METER

Here's a simple one you can build yourself.

ALEXANDER DIEPPE

WITH THE OPENING OF THE NEW AMATEUR BANDS there will be new antennas to build, new home-brew rigs to debug, and more RF to track down. Back in the "good old days," like 1975, any of those hassles were easily handled with a relatively low cost tunable FSM (*F*ield *S*trength *M*eter), a small super-sensitive device covering the VHF amateur frequencies of approximately 3 to 30 MHz that would sniff out the weakest of RF signals, and then indicate any change in its relative intensity.

If you were tuning an antenna you could place the FSM several wavelengths away—beyond the "shock field"—and then trim the antenna for maximum FSM meter reading. If you were searching for spurious signals or unwanted harmonics, you simply placed the FSM near the rig, tuned its dial, and when the meter peaked you had tracked down the unwanted RF.

The nice part about the tunable FSM is that it doesn't use the transistor amplifier with its power-supply battery that's almost guaranteed to be pooped out—from having been baked in the trunk of the car—just when you need it the most. Yet without all the fancy solid-state technology, the "barefoot" FSM is *super-sensitive*, because it uses a tuned circuit for receiving the RF energy, and a sensitive meter movement—usually in the range of 50 to 200 μA, with 100 μA being about optimum. If the FSM proves too sensitive for a particular use and the meter *pins* you don't have any sensitivity control to fuss with; you simply detune until the meter pointer is on-scale.

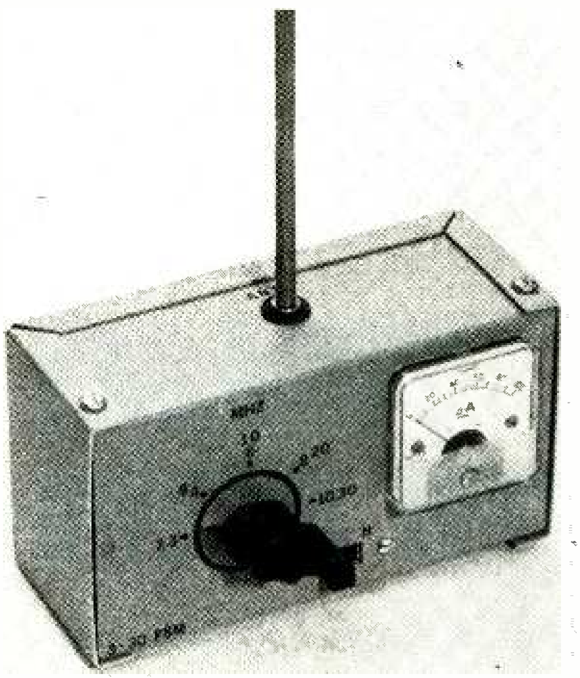
Unfortunately, in this day and age you can hardly locate a tunable FSM, let alone purchase one. A few are still found under layers of dust on the back shelves of some job-lot dealers, but as a catalog item they are long forgotten—though they are still needed.

However, the VHF tunable FSM is an easy project to build; assembly shouldn't take more than a couple of hours. What's that? You ask where you'll buy the *tank* coils? You can't buy them; you'll have to wind your own. It's an age-old skill many of you never had to learn—or thought you'd never have to use again—but there's nothing to worry about. There's certainly nothing you can break other than a few inches of wire.

Construction techniques

The FSM shown in the photographs is assembled in an aluminum cabinet approximately 3 × 2⅛ × 5¼ inches. It uses two coils to provide continuous coverage in two bands (LOW and HIGH) from about 3 to 30 MHz. The actual frequency range is slightly greater on both ends to allow for variations in winding the coils.

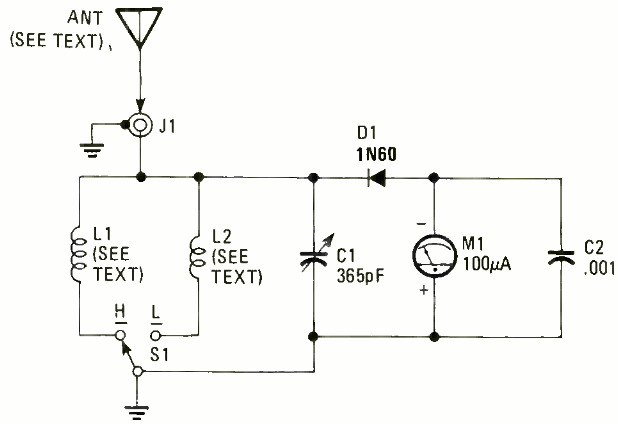
The project can be built with mostly "scrounged" components. It can get expensive if you purchase everything—in particular, the meter—new. The meter



THE COMPLETED UNIT IS SHOWN HERE. Note that the dial calibration is approximate; you'll need to use a grid-dip oscillator for more precise calibration.

movement should be 100 μA, or possibly 200 μA DC. A 50-μA meter is too sensitive, and a 1-mA movement will hardly ever budge off its pin. A "surplus" 1½-inch miniature meter is suggested because it's easy to install—you can cut the hole with a standard 1½-inch chassis punch, or use a 1⅛-inch or 1¼-inch punch and file the hole slightly larger. The meter in the model shown is a Calrad that I found in a local "job rack" electronics store for $4.95. Small-size meters are also in the Calectro line, though they are not necessarily "in stock" at every Calectro distributor.

The telescopic antenna was scrounged from an old pocket radio. Alternately, it can be replaced by a banana or pin jack and a 12-inch length of stiff wire attached to a mating plug. Tuning capacitor C1 can be salvaged from a junk-box transistor radio if it uses a



SCHEMATIC DIAGRAM FOR THE TUNABLE FIELD STRENGTH meter. To keep the cost down, use surplus or junk-box parts where possible.

PARTS LIST

CAPACITORS
C1—365 pF, miniature Polyvaricon with knob adaptor (hollow spacer), see text
C2—.001 μF, ceramic disc

SEMICONDUCTORS
D1—1N60 germanium diode, or equivalent

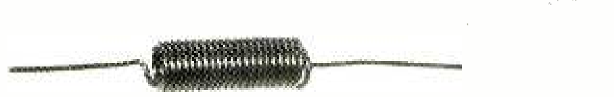
SWITCHES
S1—SPST slide switch

MISCELLANEOUS
L1—coil, see text
L2—coil, see text
M1—meter, 100-microamperes DC, see text
ANT—telescopic antenna with jack, see text
Cabinet, knob, wire, solder, hardware, etc.

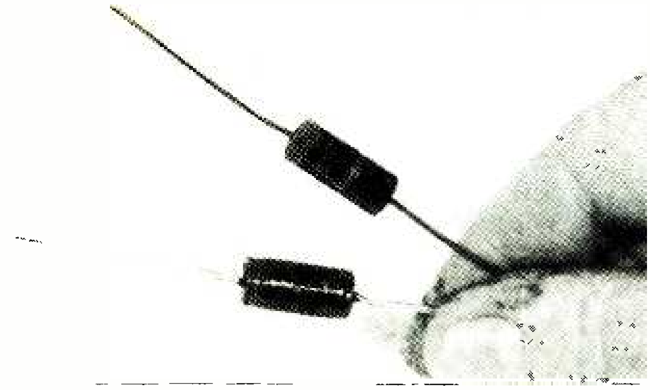
NOTE: a 365-pF Polyvaricon capacitor with a knob-adaptor (hollow spacer) is available for $4.95 postpaid from Custom Components, Box 153, Malverne, NY 11565. NY residents must add 7% sales tax.

365-pF RF tuning section. You cannot use a salvaged capacitor with an RF section of approximately 135-150 pF. (Many transistor radios use the "low capacitance" tuning capacitor.)

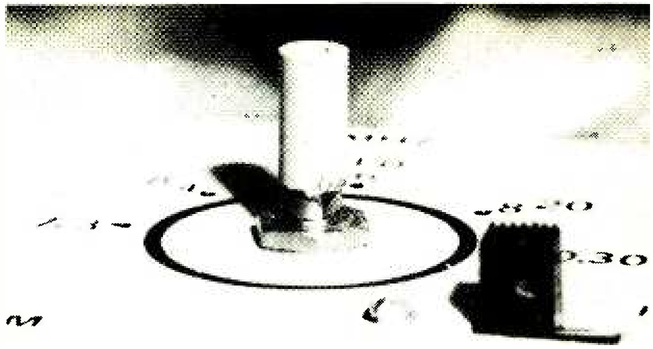
If you use the capacitor suggested in the parts list you'll find that it comes with a hollow spacer that can be epoxy-cemented to the short stub-shaft of C1, so a standard pointer knob can be attached. Apply the



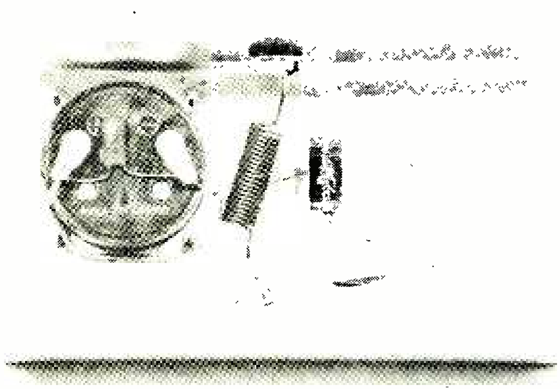
HIGH-BAND COIL, L2, CONSISTS OF 21 CLOSE-WOUND TURNS of No. 16 enameled wire. Use the shank end of a ¼-inch drill bit as the coil form.



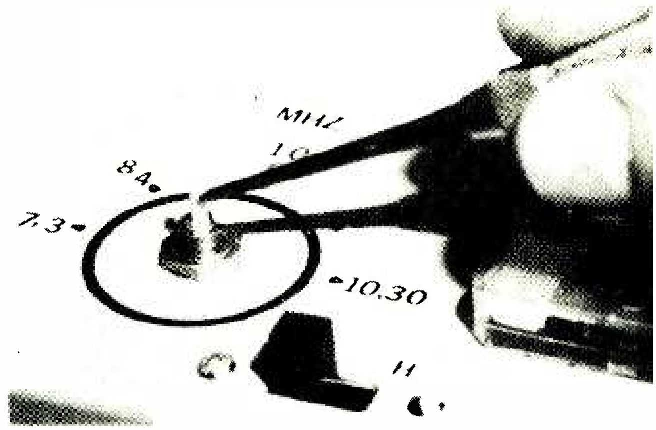
A 2-WATT CARBON RESISTOR IS USED AS THE FORM and support for coil L1. After you've finished winding the coil, apply a light coat of radio-TV service cement.



IF YOU PURCHASE C1 FROM THE SOURCE MENTIONED in the Parts List, you'll need to use the supplied hollow spacer to mount a tuning knob. To do so, first insert a ½-inch length of round toothpick, coated with epoxy, into C1's shaft.



INSIDE VIEW OF THE COMPLETED UNIT. Nothing is critical about the parts layout, so make any changes you wish.



TO FINISH MOUNTING THE HOLLOW SPACER, apply a small amount of epoxy to its bottom and seat it over the toothpick. You can mount the tuning knob 24 hours later.

spacer after C1 is mounted on the cabinet. A good way to insure that the spacer is properly centered on C1's stub is to cut a ½-inch length from a round toothpick, dip one end in the epoxy, and seat it in the hole in the stub-shaft; then apply a light coating of epoxy to one end of the spacer and seat the spacer over the toothpick. Allow the assembly to "set" in an upright position overnight. (You cannot apply the spacer to the stub-shaft before installing the capacitor on the cabinet because C1's mounting nut is a smaller diameter than the ¼-inch spacer.)

Coil winding made easy

Tuning coils L1 and L2 are wound from solid *enameled* wire. Do not use "bare" wire. Tensilize the wire used for the coils before winding them to avoid having the coils "expand" when you release the end of the wire. Unwind a few inches more wire than you think you'll need and clamp one end of the wire in a vise. Then pull on the free end with just enough force to stretch the wire very slightly. You will feel the stretch and you'll see the wire go "dead slack". Now when you wind the coils they will stay wound even when you let go of the free end.

The low-band coil, L1, consists of 35 turns of No. 30 wire close-wound on a 2-watt carbon resistor (10,000 ohms or greater) with a diameter of 5/16 inch. "Close-wound" means one turn is directly adjacent to, and touching, the previous turn. (If it comes out 34 or 36 turns just let it stand. It's not all that critical.)

If you've never wound a coil before using fine wire you might have some "tangled finger" difficulty, so try it this way: First, scrape about ¼-inch of enamel insulation from the wire with a knife and tin the wire. Using a small triangular file, cut a very small notch across one end "corner" of the resistor. Solder the wire to the resistor lead opposite the notch, feed the wire through the notch to the body of the resistor, and, starting about ⅛-inch in, wind your 35 turns. The notch will keep the wire from turning on the first few winds. Scrape the insulation from the free end and solder to the opposite resistor lead. Then coat the coil lightly with Radio-TV service cement, or plastic or wood "airplane glue."

High-frequency coil L2 is self-supporting. It is made using No. 16 solid enameled wire and consists of 21 close-wound turns using a ¼-inch drill bit for the coil form. Use the shank part of the bit for the form; not the flutes.

Diode D1 can be any small-signal *germanium* diode of the 1N60 type. Do not use a silicon diode, because its higher breakover voltage will reduce the FSM's sensitivity.

The dial calibrations shown in the photographs are approximate. If you want a precise calibration, borrow a "grid dip oscillator" from someone and calibrate the FSM to the GDO. If you place the tip of the antenna right up against the GDO coil, you should get an FSM meter reading that varies from a discernable "blip" to half-scale depending on the model GDO you use. **SP**

THE AMAZING BINARY CLOCK

HAROLD J. GALVIN

AS THE NUMBER OF COMPUTER AND ELECTRONICS PROfessionals and hobbyists increases, more and more people are becoming familiar with number systems other than base 10. Most people who have any computer background have discovered the facility that one can acquire in dealing and thinking in base 2 or hexadecimal. Here's a device which brings base 2 out of the laboratory and into the livingroom to replace the most timeless appliance in the house—namely the clock.

More than simply providing a novel way of keeping time, this attractive conversation piece was designed to play music in the tradition of the old style grandfather clocks. While you're admiring the pleasant patterns of the slowly counting lights and appreciating the workmanship of the newest addition to your mantelpiece, you can also delight in the pleasant minuet type tunes or Westminster chimes that play every thirty minutes. What your friends will see as an attractive, soothing display to you will be a valuable timepiece.

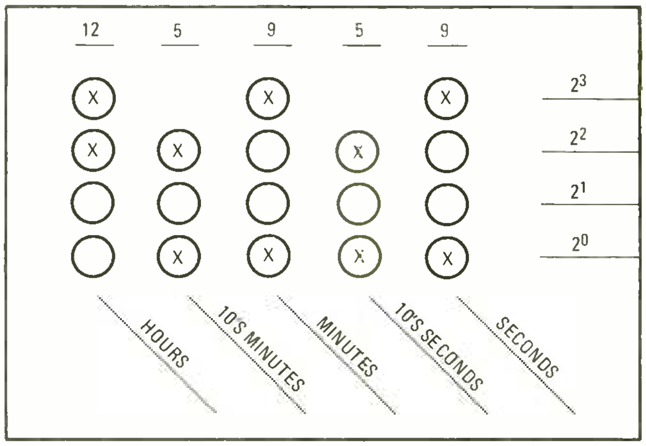


FIG. 1—EACH LAMP ELEMENT OF A VERTICAL COLUMN represents a power of 2. By adding the powers of 2 of those illuminated lights in each column you can determine the decimal digit. For example, the correct time indicated is 12 hours, 59 minutes and 59 seconds. The "seconds" column illuminated lamps sums to $2^0 + 2^3 = 1 + 8 = 9$.

Telling time

Telling time with the Binary Clock may be a bit challenging at first, but within a short time, it will be as simple as reading a conventional base 10 digital clock.

The clock face is an array of lights: five columns by four rows. Each column represents a different measure of time. As shown in Fig. 1, Column 1 (seconds) will count in binary (BCD) from 0 to 9 representing a count of zero to nine seconds. Column two will count from 0 to 5 representing a total of zero to fifty seconds. That column counts up as a result of the first column clearing to zero following a count of 9. These two columns together represent a total count of fifty-nine seconds. The minute columns operate similarly. One column increments for a total count of nine minutes, while the other will increment to 5. The maximum combined count of those two columns (5, 9) represents 59 minutes. When a minute passes following a count of 59

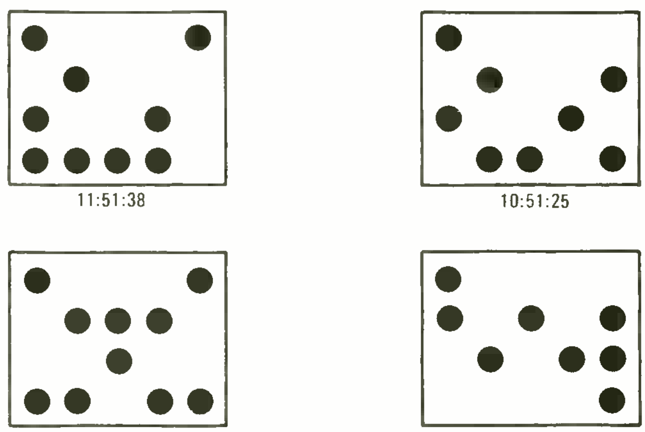
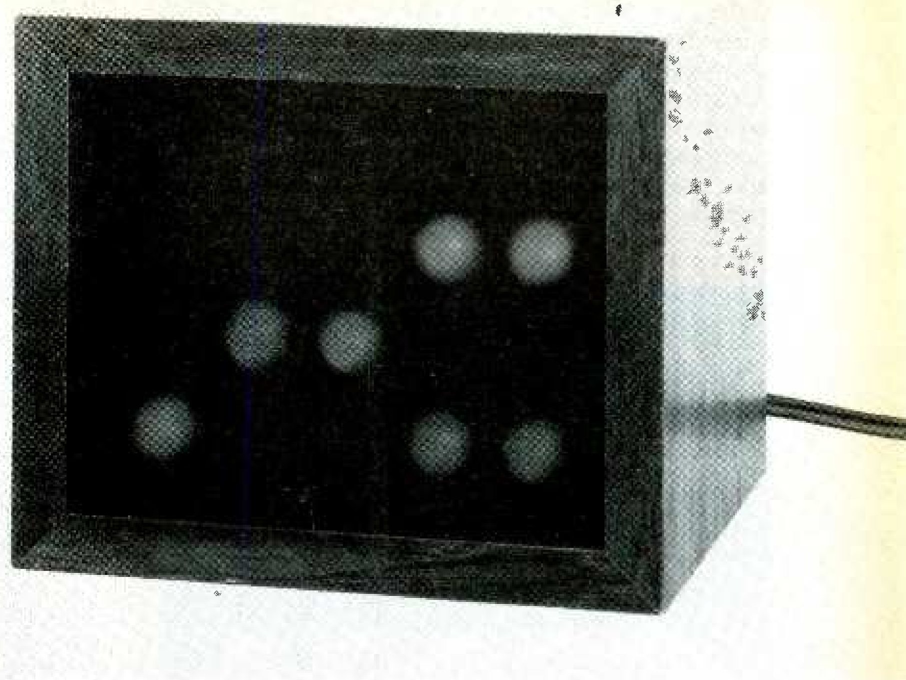


FIG. 2—PLACE YOUR FINGER OVER THE CORRECT TIME indicated below each clock light pattern and determine the time. It gets easier as you advance to the fourth one.

What may look like a random blinking light display to your friends is actually a base-2 12-hour clock you can build at home.



minutes, the two columns are cleared and the hour column is incremented by one. That column operates somewhat differently than the second and minute column in that it counts in straight binary up to a count of 12 (C_{HEX}).

Following a count of 12, on the next hour the column will reset to 1 for one o'clock.

The display dots making up the rows and columns are not visible through the red front plate unless the lights are turned on. The spacing of the columns is such that even when whole columns are not lit, it is easy to tell the weight of the lighted dots by their relationship to the edges of the face. Examples of time patterns are shown in Fig. 2 along with their corresponding times.

Major assemblies

The Binary Clock is made up of three major as-

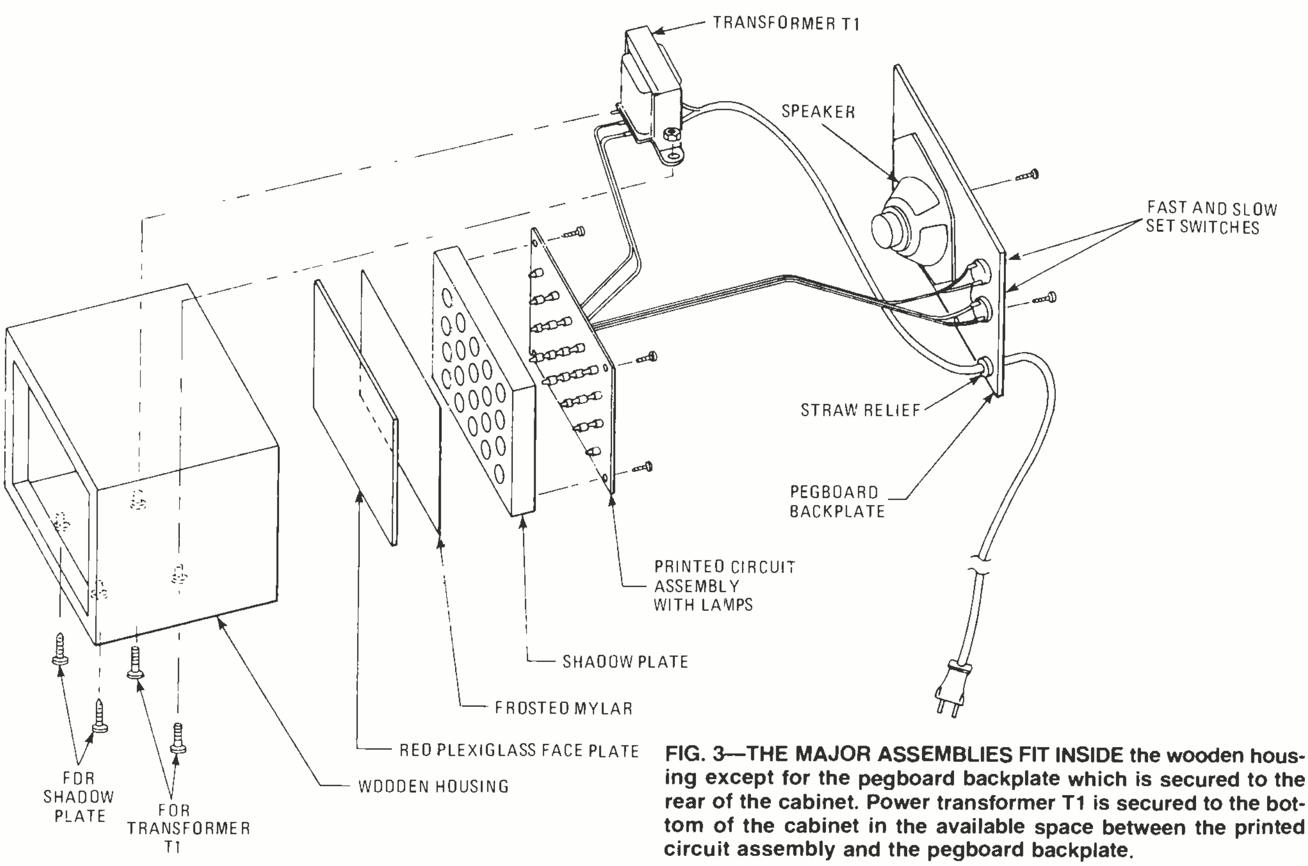
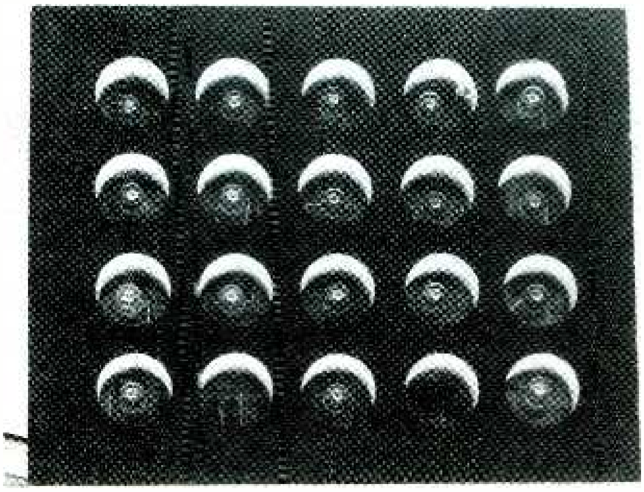
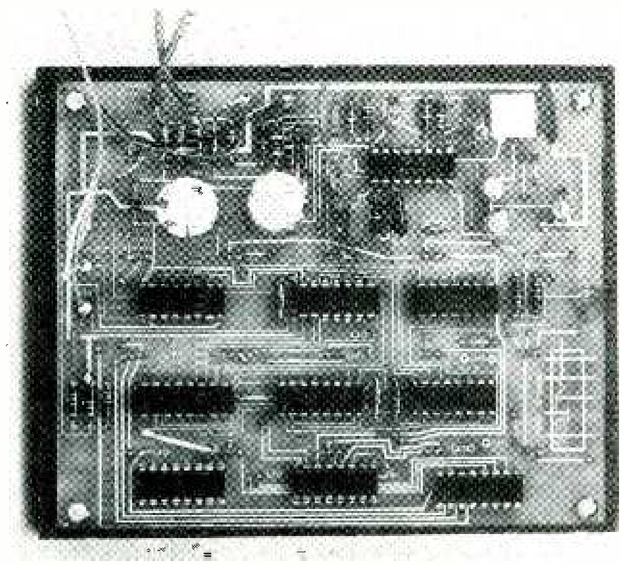


FIG. 3—THE MAJOR ASSEMBLIES FIT INSIDE the wooden housing except for the pegboard backplate which is secured to the rear of the cabinet. Power transformer T1 is secured to the bottom of the cabinet in the available space between the printed circuit assembly and the pegboard backplate.

semblies: the wooden housing case, the shadow plate, and the electronics as shown in Fig. 3, Fig. 4 and Fig. 5. The red plexiglas face plate, frosted Mylar and shadow plate are mounted thru the rear of the case and secured with two screws from the bottom of the case into the shadow plate. The printed-circuit assembly mounts flush on to the back of the shadow plate with four screws. The cabinet is closed with the pegboard backplate, which holds the speaker and set switches.



WHAT YOU DON'T SEE HERE IS THE CIRCUIT SIDE of the PC board with the lamps installed and the shadow plate on top of it. The shadow plate prevents the light from each lamp from straying about to other areas of the frosted mylar that will cover the printed circuit board assembly.



THE PRINTED CIRCUIT BOARD IS SECURED to the shadow plate with four screws. Before you do so, check the soldering carefully. Be sure the parts are installed in their correct location.

Assembly of the unit is straightforward. You can either make the double-sided PC board from the details in Fig. 6 and 7, or buy an etched PC board. See Parts List for details. Fig. 8 details the parts placement on the PC board. The lamps are not mounted on the component side of the board. Where leads etched on the board are to transfer from one side of the board to

PARTS LIST

RESISTORS

All ¼-watt 5% unless noted

R1—2000 ohms
R2, R13—30,000 ohms
R3—68 ohms
R4—1000 ohms
R5—560,000 ohms
R6, R12—120,000 ohms
R7, R8—12,000 ohms
R9—50,000-ohm potentiometer
R11—200,000 ohms, potentiometer
R14, R15, R17, R18—20,000 ohms
R16—56,000 ohms
R10—omitted to coincide with Haltek literature. See below.

CAPACITORS

C1, C10, C12—.047 μF, 50V, disc ceramic
C2, C3—2.2 μF, 20V, electrolytic
C4, C7—0.1 μF, 50V, disc ceramic
C5—500 μF, 20V, electrolytic
C6—500 μF, 10V, electrolytic
C8—51 pF, 50V, 10%
C9—not used
C11—22 μF, 10V, electrolytic

SEMICONDUCTORS

D1-D8—1N4002
IC1—7910E or O (Music Chip)
IC2—14566 (Counter)
IC3—4073 (3-Input AND Gates)
IC4—4011 (NAND Gates)
IC5—4520 (Counter)
IC6, IC7—14566 (Counter)
IC8, IC9, IC10—ULN2004 (Driver)
Q1—2N2907
Q2—2N2222

MISCELLANEOUS

LAMPS—6.3V 40mA (Chicago minute bipin No. 7380 or equal), 18 required
F1—1 Amp fuse with holder (to be added to author's original circuit)
S1, S2—SPST normally-open pushbutton switches
T1—Primary 117 VAC; Secondary 6.3 V 2A

The following are available from Haltek Electronic Specialties Co., 125 N. First Street, Minneapolis, MN 55401:

No. 6000 *a* - Melody kit - complete kit of all parts necessary for clock including bulbs, PC board, electronic parts, woodgrain case, transformer and line cord. $86.00
Plus postage and handling $7.00

No. 6000 *b* - Same as *a* but with chimes option. $86.00
Include postage and handling - $7.00

No. 6001 - Printed circuit board with assy. instructions — $23.50 Postage Paid

No. 6002 - Box kit including wood finished clock case, shadow plate, Plexiglas, Mylar and back plate - $29.00
Include postage and handling - $3.50

Assembled units available, write for prices. Minnesota residents include 5% state sales tax.

The music chip IC1 is available from Epson America, Inc., 23844 Hawthorne Blvd., Torrance, CA 90505. Specify either 7910-E (two minuets) or 7910-0 (Westminster).

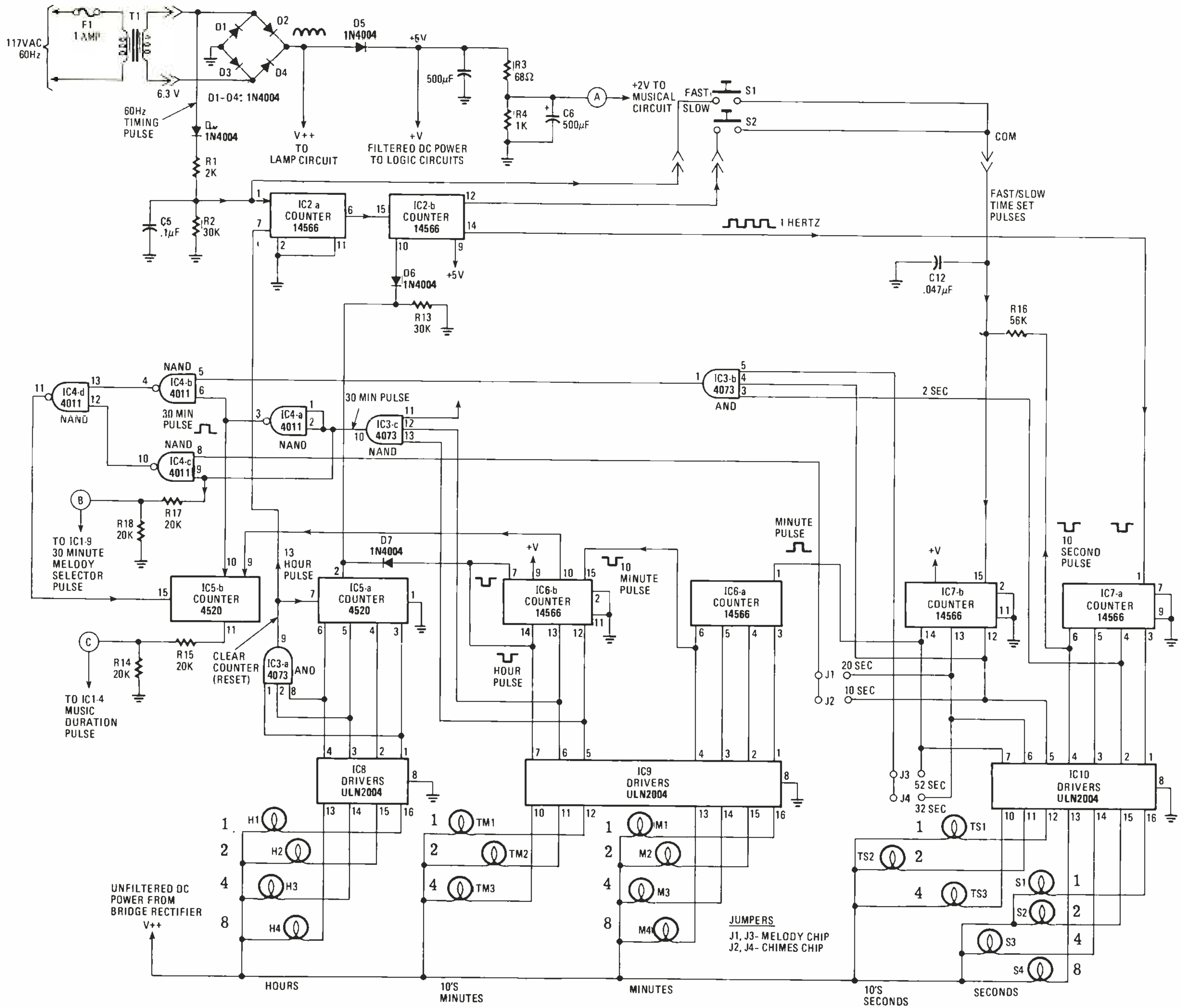
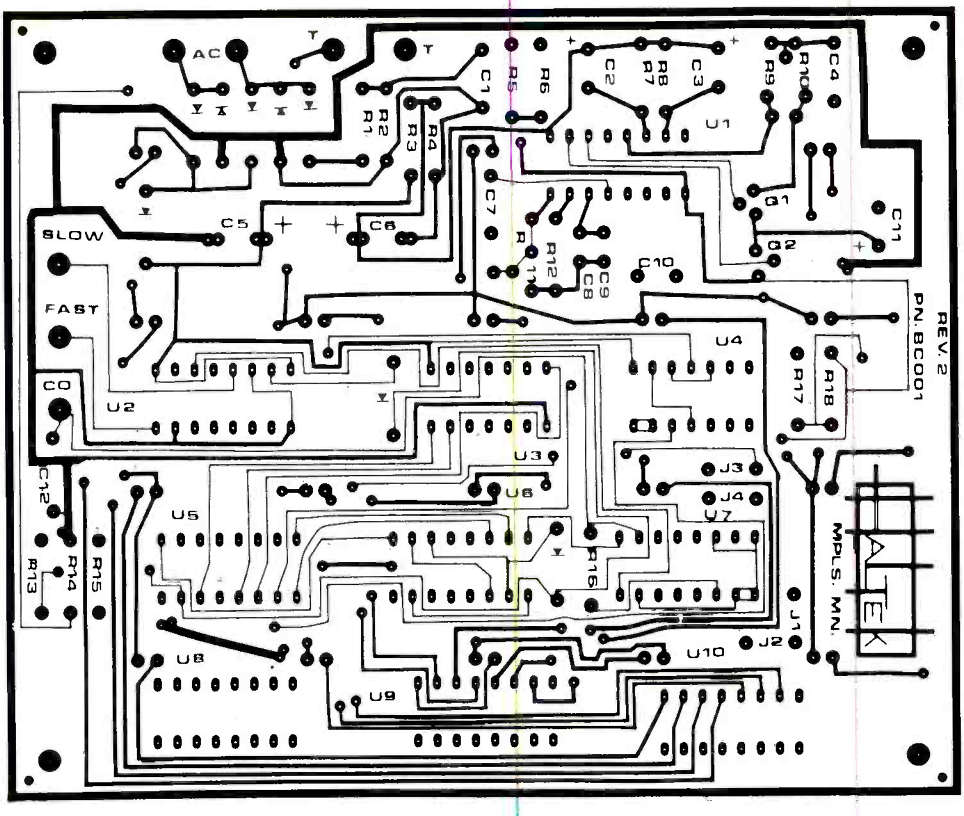


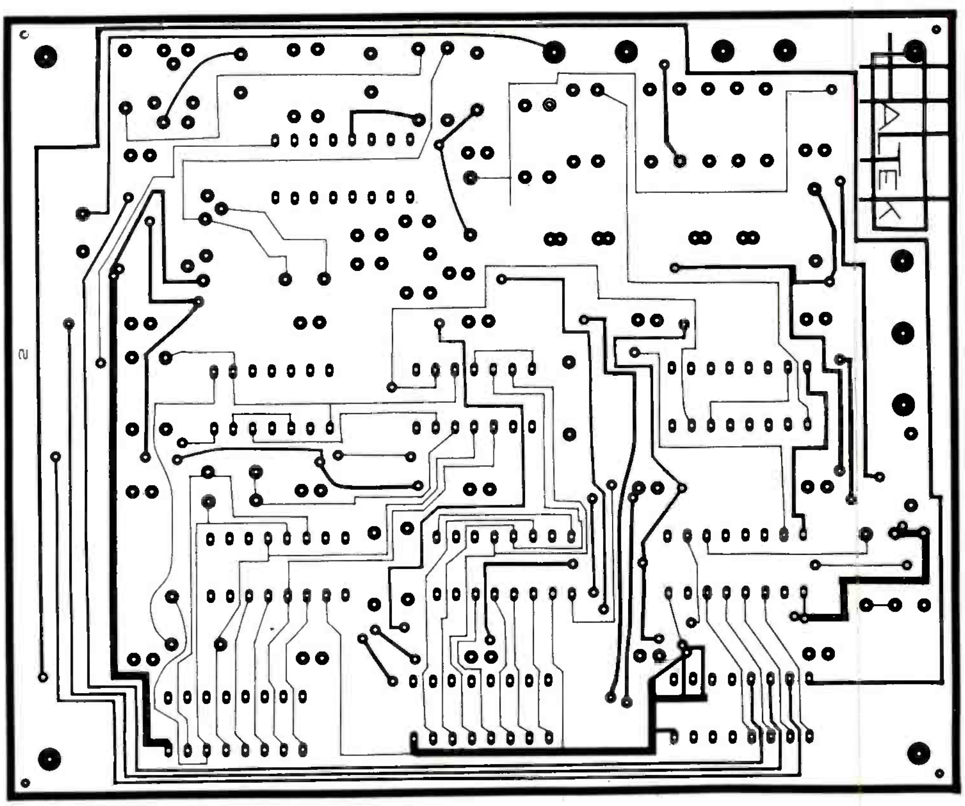
FIG. 4—SCHEMATIC DIAGRAM OF THE BINARY CLOCK showing all circuits used to generate time pulses and lamp circuits.



Component Side

FIG. 6—FOIL PATTERNS FOR THE COMPONENT and circuit sides of the printed circuit board are shown here full size. See parts list for availability in finished form.

Circuit Side



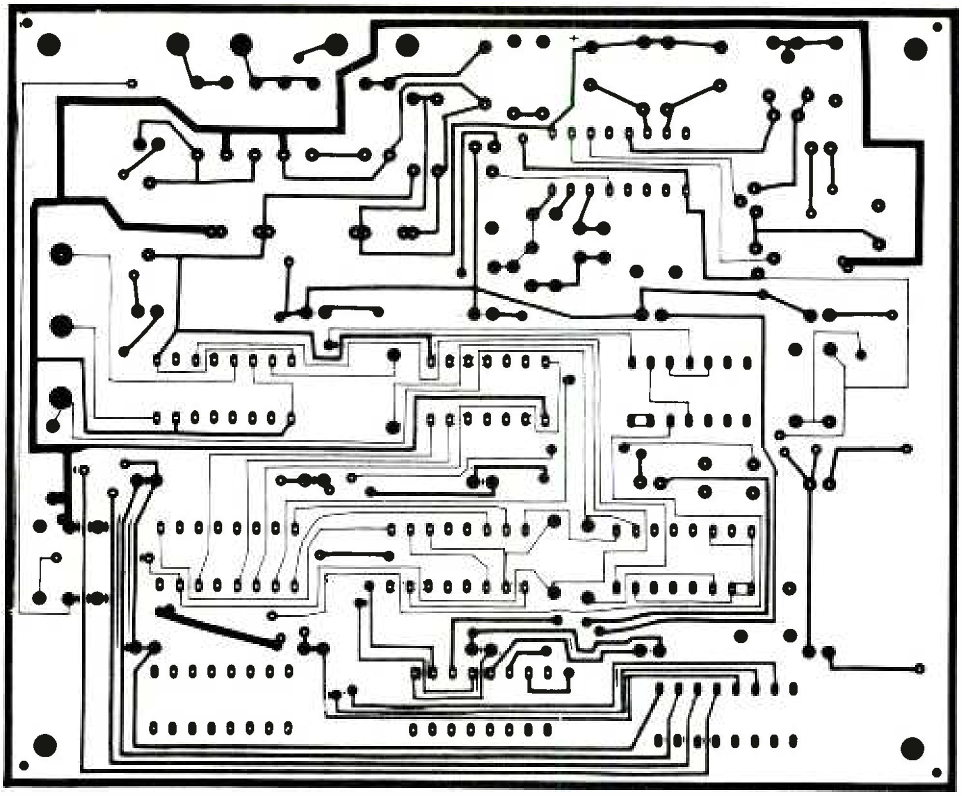


FIG. 7—X-RAY VIEW OF THE TWO ETCHED SURFACES of the PC board as they actually overlay each other. Circuit tracing is a bit easier using this illustration.

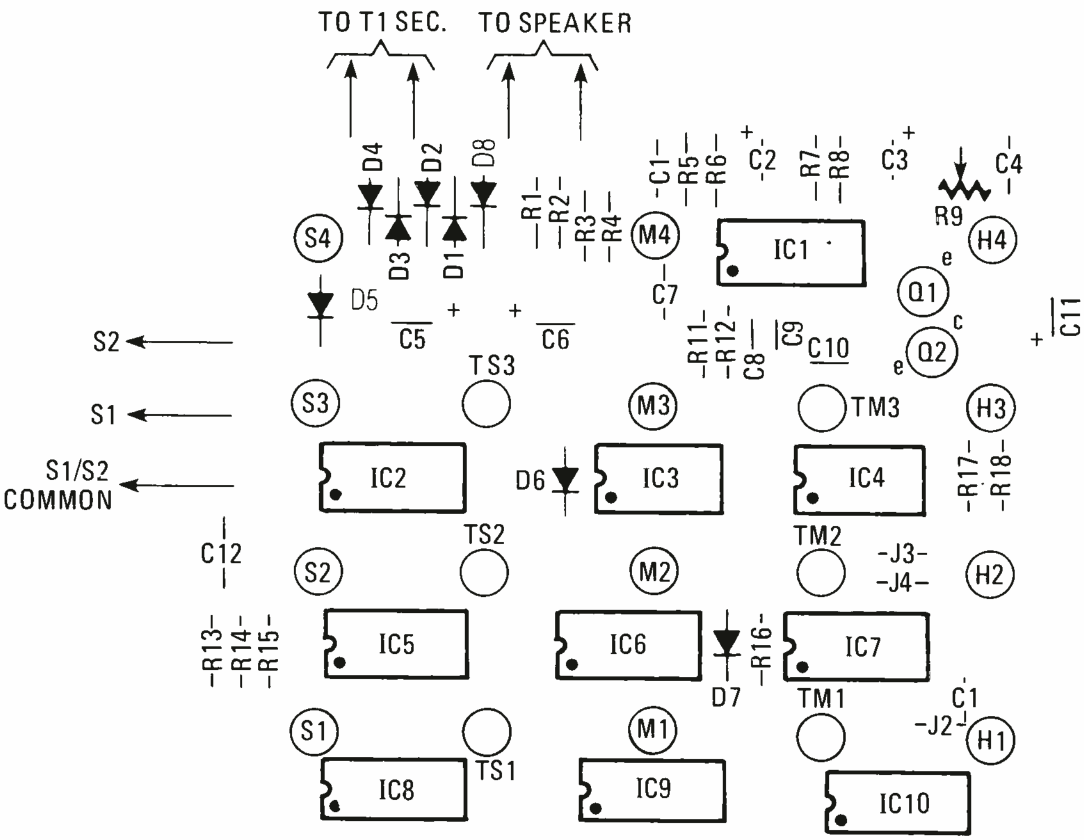


FIG. 8—COMPONENT PLACEMENT LOCATION GUIDE diagram for the component side of the printed circuit board. Use this diagram to correctly place parts, and use Fig. 7 in conjunction with this drawing to trace the circuit.

the other, insert a wire and solder both sides of the board, then cut the wire ends short. Likewise for circuit parts that have etched leads on both sides of the board for the same mounting hole. Use insulated stranded wire to interconnect the PC board to the switches and speaker on the pegboard backplate. The line cord should have a strain release plug securing it to the pegboard backplate. The original model of the Binary Clock did not have a fuse in the 117-volt circuit. Be sure your model has one. You could either hard wire a fuse holder into the backplate, or mount a pigtail wired fuse to a pair of standoff terminals inside the unit. Assembly is obvious by carefully inspecting Fig. 3 and the detailed photos. Neatness counts because the Binary Clock should be a showpiece in your home. Also, just a bit of sloppy soldering on the compact PC board will bring many hours of unnecessary troubleshooting, so solder carefully.

How it works

The basic function of the clock is to count the 60-Hz (60 pulse per second) crests from the power supply and drive the display lights. Referring to the schematic diagram, Fig. 4, the 60-Hz timing pulse is taken off the secondary winding of power-supply transformer T1, and divided down to CMOS logic level by resistance divider R1-R2 before being fed into the divide-by-60 counter, IC1-a and IC1-b. The divide-by-60 function is done by cascading the divide-by-6 and divide-by-10 functions of the chip. The resulting signal from IC1, pin 14 is a 1-Hz square wave (one second pulses) which is used by the two counters of IC7 to generate seconds and 10's of seconds. It is interesting to note that the pulse used to illuminate the 8-second lamp comes on when the time is 8 seconds and goes off when the time is 10 or "0" seconds at 10-second interval. The trailing edge of this pulse is exactly 10 seconds, and is used to trigger the next counter.

The output of IC7-b, pin 14 is a one minute cycle signal used by the two counters of IC6 to generate minutes and 10's of minutes. IC5 is a dual binary counter. One of those counters is used to count the per-one-hour cycle pulse from IC6-b, pin 14 and thereby represent the hour count. Since the count for hours must go from 12 to 1 (there is no zero), it is necessary to clear the hour counter (reset) when it reaches a count of 13 and immediately pulse the count input thereafter, causing a count of 1. That is done through the use of IC3-a to detect a count of 13, clear counter of IC5-a via pin 7, and also start the one shot which is contained in IC2, the 14566. The output of this one shot will pulse high to low causing a count input of very short duration on IC5-a pin 2. The hours counter IC5-a will now be at "1" hour. Diodes D6 and D7 from IC2, pin 10 and IC6-b, pin 14 allow for a pseudo wire-or function of the two-count sources.

If a driver chip were not needed to illuminate the incandescent lamps on the face of the clock, then drivers IC8-10 would be nothing more than straight wire connections from matching pins. For example, pins 1 and 16 would be connected to illuminate lamp I1. But we know this cannot be, so the driver chips provide the necessary buffer action and current amplification to make the circuit work. IC5-b and the remaining logic circuitry shown in the schematic diagram, Fig. 4, are used to support the timing pulses for the music generator circuit, see Fig. 5.

Musical circuit

There are two music options available with clock circuit, IC1, Westminster chimes, or two minuet-type tunes. With a few exceptions, both options operate similarly. The music is generated by music-generator IC1 and must be directly controlled by the clock logic. The logic supporting IC1 must turn the music on and off at the appropriate time. Refer to schematic diagrams in Fig. 4 and Fig. 5.

The music begins when counter IC5-b is incremented to a count of 1. That must be done when the minutes increment to a count of 30 and when the hour counter

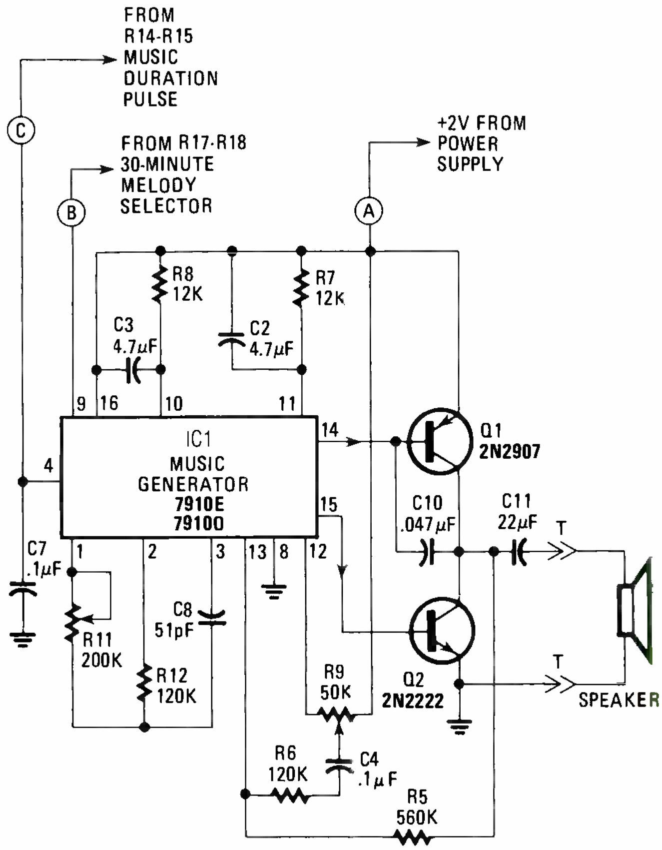


FIG. 5—SCHEMATIC DIAGRAM OF THE MUSIC GENERATOR circuit and audio power amplification.

is incremented by one. In that circuit, IC5-b is used as a flip flop and is set under two conditions: On the half hour, IC4-a, pin 3 will go high and strobe IC5-b, pin 10, thereby setting the counter to one and starting the music. Starting the music on the hour is done through the action of the one-shot contained in IC6. That one-shot is triggered by the falling edge of IC6-b, pin 14 (the same edge which increments the hour count) into IC6-b, pin 7 causing a short pulse from IC6-b, pin 10 to IC5-b, pin 9. When that occurs, the counter is set to one, and the music will begin, by the generation of the music duration pulse from IC5-6, pin 11 and sent to IC1 (see Fig. 5).

Now we come to the matter of turning the music off. Here there is a difference in approach between the melodies and the chimes selection. If the melodies chip is selected, counter IC5-b must be cleared (ending

HERE'S THE REAR VIEW OF THE BINARY CLOCK before it's buttoned up and ready for placement on your mantle at home or office shelf for everyone to see.

the music duration pulse) to turn off the music at the precise instant that either melody ends or it will start to play again and end abruptly when counter IC5-b is cleared. If the counter is cleared before the natural end of the melody, the tune will stop without finishing. If it is cleared late, the tune will have started to repeat and will stop as soon as the clearing occurs—not finishing the second run. The chimes chip on the other hand will play chimes until the counter is cleared, but will not stop until the natural completion of a chime. That chip simply needs to be strobed on and off and it will play the chime completely through. For that reason, the chimes are much easier to implement. This discussion will hence focus on the melodies selection, since both options are similar in implementation with the chimes being the simpler one.

The melody which plays on the hour must be turned off at a count of 52 seconds from its start. That time is easy to achieve. Since the music will always start at a count of zero seconds, we need only detect a count of 52 seconds and strobe the clear input of counter IC5-b, pin 15.

By inserting jumper J3, IC3-a will detect the 52-second count and cause a clear strobe to the counter. The 52-second count pulse is generated by tapping the 2-second pulse from IC7-a, pin 4, 10-second pulse from IC7-b, pin 12, and 40-second pulse from IC7-b, pin 14 and summing them in IC3-c AND gate. Similar logic is used to generate the 32 second pulse.

The tune which plays on the half hour must be turned off in 20 seconds. By making Jumper J1, a 20-second count will cause a strobe on IC5-b, pin 15. Jumpers J2 and J4 should be made with the chimes option to cause the chimes to play for 10 and 32 seconds on the half hour and hour respectively. Now that the music-support logic has been discussed, we can move on to the music chip (Fig. 5). IC5-b provides music duration pulse of the correct time length for 30 minute and hour melodies. IC3 provides a 30-minute pulse via R17-R18 divider to select the 30-minute melody. In its absence, the one-hour melody will play when the music duration pulse begins.

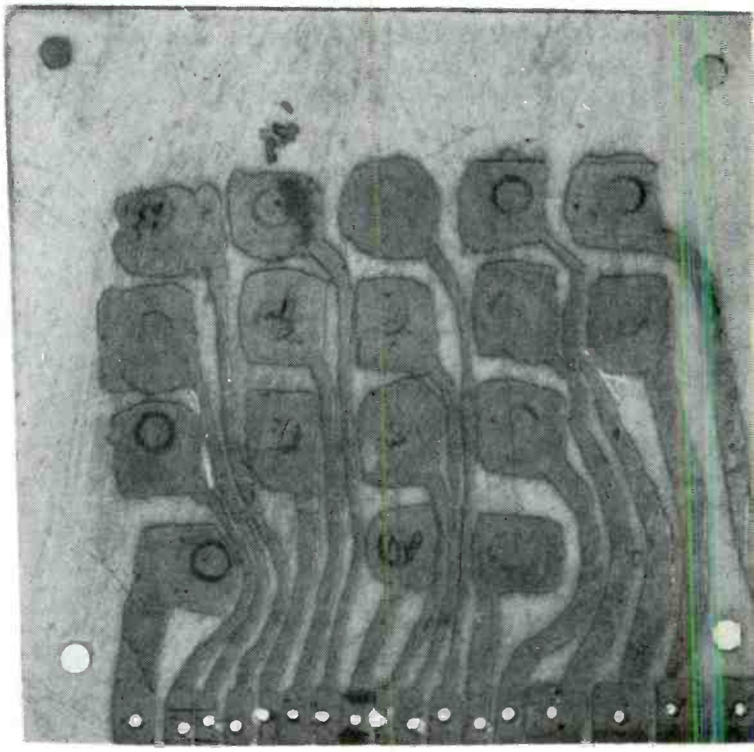
IC1 is a self-contained ROM memory sequencer and preamplifier device capable of storing and playing two tunes. See Fig. 5. The sound of those tunes is very much like that of a harpsichord or chimes, depending on the selection of output-filter components (C3, R8, C2, R7). The chip relies on external amplifiers (Q1 and Q2) for the speaker power. The volume can be controlled by 50,000-ohm pot R9 and the duration of play is controlled by pot R11. Potentiometer R11 is necessary with the melodies option and must be adjusted so that the music finishes in 52 and 20 seconds. With the chimes option, that is not needed and R11 may be replaced by a 120,000-ohm resistor.

Setting the clock

The clock is set to the proper time by using the two momentary pushbutton switches located on the back plate of the case. One button is for fast setting which should be used to increment through the hours quickly while the other is for setting minutes. Seconds are continually free counting and are not affected by the buttons. Since the clock plays music on the hour and half hour, the music will start to play at various times in the setting process. That sporatic music will vary from a quick chime to a partially played tune; however, once the time is set and the partial tune stops, the clock will function normally. **SP**

BUDGET SWITCHES AND KEYBOARDS YOU CAN BUILD IN ONE EVENING

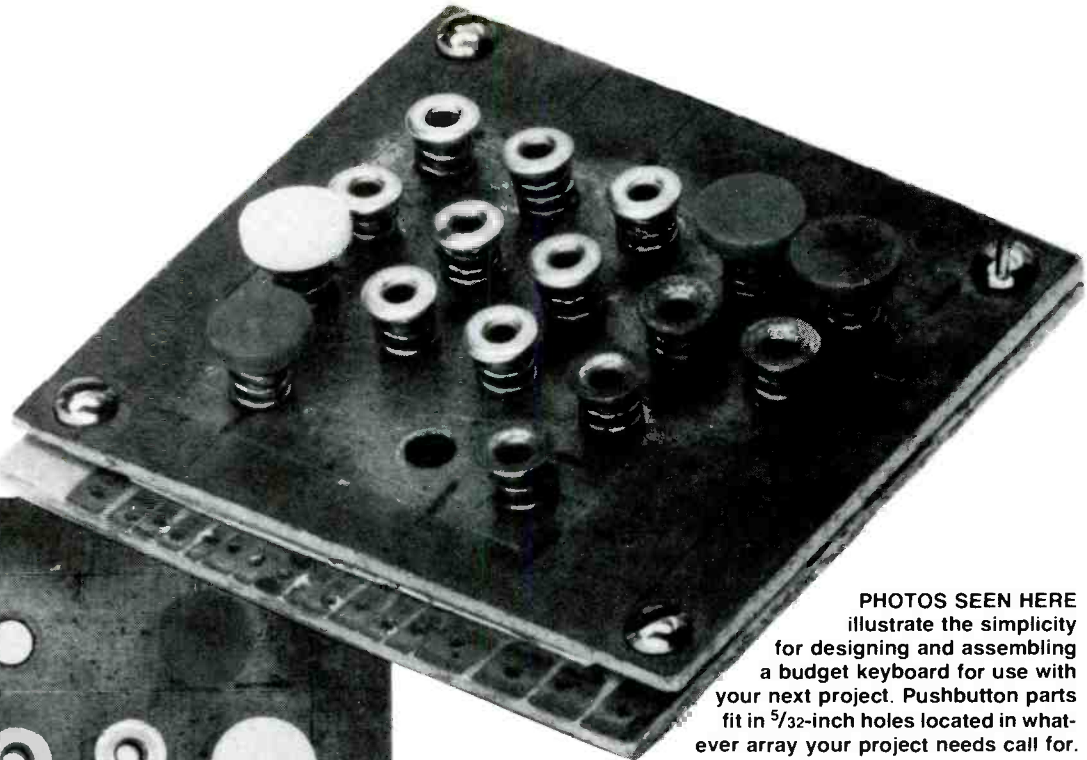
JAMES E. TEMPLE

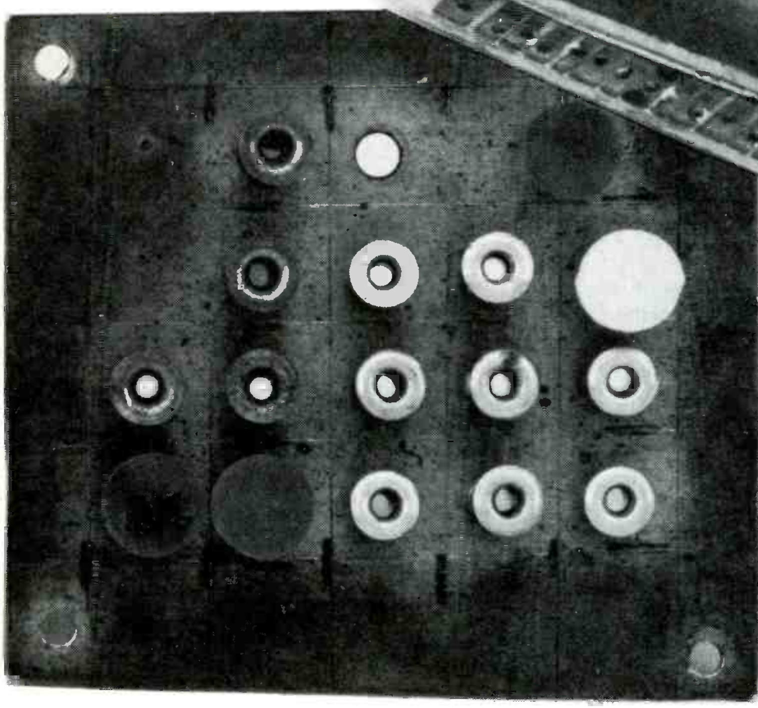


GUESS WHAT YOU CAN MAKE FROM AN OLD SPRING from a ball point pen, a pop rivet, a brass eyelet? Well, if you mount those parts to a printed circuit, and into a 5/32-inch hole, you can make any type of pushbutton switch you might need for your projects. With digital circuits now in everyday use, and just about all of them having a entry signal from a switch (mostly momentary make and break types), you may find many types of switch combinations hard to come by.

Most digital circuits require miniature switches that are pushbutton-operated. There just is not enough room (or so it seems) on most of your projects to mount all these switches. Besides, those miniature switches are not cheap. If you should need a large number of them to form a specialized keyboard, it could cost you a fortune. Here, then, is an inexpensive, sure-fire way to get the pushbutton switches you will need.

Each switch, using a salvaged spring, should cost only pennies to make. What is more interesting is the combinations, and pattern-arrays that those pushbutton switches can be made into. One part of a circuit will call for a single-pole switch to *close* the circuit,





PHOTOS SEEN HERE illustrate the simplicity for designing and assembling a budget keyboard for use with your next project. Pushbutton parts fit in 5/32-inch holes located in whatever array your project needs call for.

another a single pole switch to *open* the circuit, and still another a break-then-make type of switch. By taking a little time to design a simple circuit board to make those circuits, you can combine all three types of switches into your circuit controls. You can even make complex miniature keyboards with hundreds of switches, and use all of the single-pole type of switches that your keyboard will accommodate.

Every one of those switches can be made from only three parts mounted on a printed-circuit board. A steel pot rivet, a section of spring (4 turns) and a brass ⅛th inch eyelet are all you need. All of these parts are easily found, and even a spring from your local hardware store could be purchased for use.

Patent facts

The US government felt that it was a unique way to make those circuit switches, and awarded the Patent Number 4001534 to the author.

The author is pleased to be able to share his ideas, possibly save some hobbyist a couple of dollars and solve some switch control problems. The information presented in this article and those stated in Patent No. 4001534 are for personal use only; no license or agreement by the author and inventor is expressed or implied for the manufacture or commercial use of those switches. Manufacture for commercial purposes, in individual or specialized keyboard design using that procedure will be an infringement of the patent. To the hobbyists who need the switches in their personal projects: Please use the information presented in this article by the author.

Design and construct the switch

An area only ¼-inch square will accommodate a single switch. You need the three essential parts. First, a *steel* rivet from any pop rivet. **Do Not Use Aluminum Rivets,** they just do not hold up. Second, cut about four helices (turns) off the spring from a ball-point pen. The inside diameter of those springs fits perfectly over the steel body of the rivet. Those four helices will hold a ¼-inch rivet nicely to the board. For longer length rivets, cut the spring to size.

The third and last part you need is a brass eyelet. It can be purchased from any Tandy leather-shop outlet, Singer Sewing Center, or Woolco. Those are miniature 1/16-inch diameter (outside) by ⅛-inch long brass eyelets. The eyelet should fit snugly into the bottom of the pop rivet, after spreading the rivet slightly. You will have to force the eyelet into the rivet with a light tack hammer.

To make your switches, get the three parts, drill a 5/32-inch hole into some PCB material and mount a few of the parts into the holes. Practice that a few times just to get the hang of putting the metal assembly together. (See Fig. 1d.) After forcing the metal assembly together (rivet and eyelet), the switch should be held firmly in place by the captured spring itself to the board. Also, the metal assembly movement should not be restricted. Pushing it up and down a few times will help seat the assembly in the hole. It should move easily. If, for some reason, the metal assembly seems

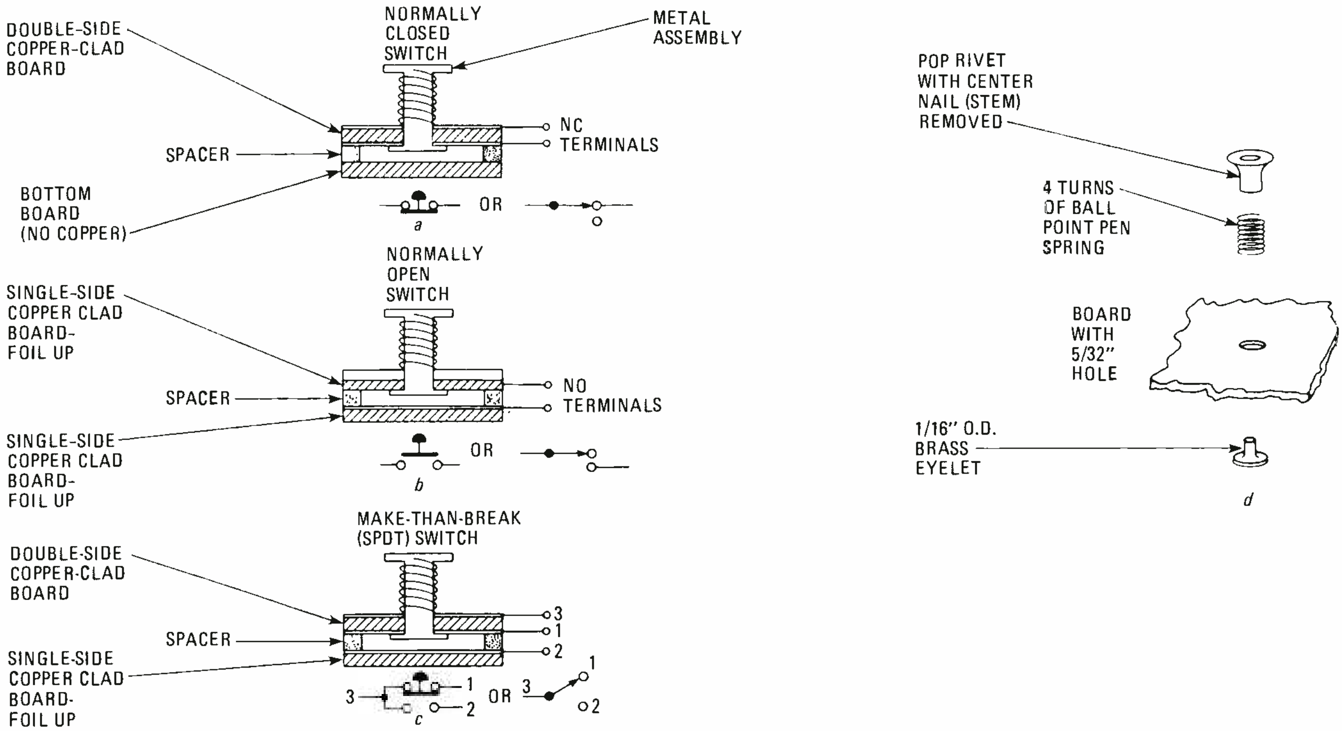


FIG. 1—ASSEMBLY DETAILS shown here give cross-sectional view of pushbutton assemblies and copper surface locations. Spacers may be rubber or plastic material.

to make too tight a fit, you might try reaming the hole with an Exacto knife or a jeweler's file before assembly.

The finished switches last a long time, with small failure rates. If a switch should fail, it's easy to plug new parts into the old space.

The kind of PCB material you need varies with what the switch should do. If you require a normally-closed (NC) switch, use double-sided copper-clad stock material, and design the circuit path from the top side, flowing through the switch metal assembly to the foil pattern on the bottom side of the board. (See Fig. 1a.) Be sure to allow for the leads that will connect the switch to the circuit that the switch will control.

Should you need a normally-open (NO) switch, follow the example in Fig. 1b. The circuit is made from the copper foil on the top board, through the switch metal assembly to the copper foil on the bottom board when the switch is depressed.

Follow the construction principles outlined in Fig. 1 to make additional switch types. For example, to design a break-then-make (SPDT) switch combine the principles of the NC and NO switches in Figs. 1-a and 1-b. Then, look at Fig. 1-c and see how easy it is. Remember that those switches are non-shorting types. That is, they must open a circuit before they close one in the case of double-throw hookups.

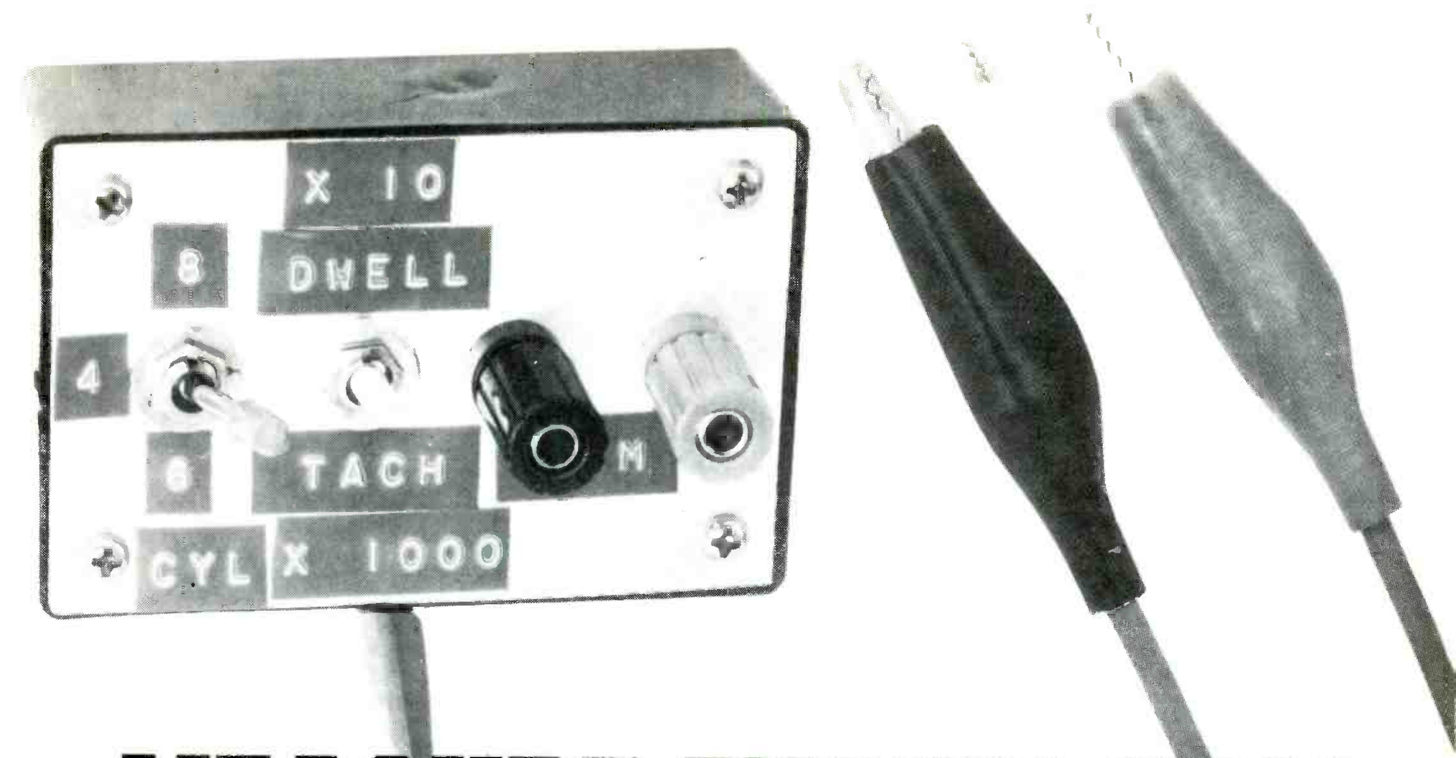
The top of the switches' metal assemblies are "hot." No, you can't get shocked considering the 5-12-volts DC circuits they are normally used in. However, insulation is a good idea. Plastic buttons or transistor lead spacers can be used. Switches can be color-coded for rapid identification. Epoxy glue buttons in place.

If possible, try to have all circuit points connect to the top foil of the top board at ground potential. Thus, the copper foil and switches' metal assemblies act as a shield to disturbing electrical and static noises introduced by the operator's finger. If that is impossible to do, then try to keep all the unused copper on the board's top surface electrically connected to ground.

How to make specialized keyboards.

By designing the function of a keyboard, even a typewriter-type keyboard, or other special keyboards, these switches require minimal space. If you need a keyboard of 20 keys, a 2 × 2-inch size board will hold them nicely. If you consider that each switch needs only ¼ × ¼-inch area, then that board will hold up to 64 keys (8-by-8 array). It is best to allow room for your fingers, though. Use a ½-in. by ½-in. spacing for your keyboard's design. Even ⅝ by ⅝ths inches is OK. It allows your fingers to get to the keys without pushing the wrong ones. When you make your keyboards, consider using two copper-clad boards. The topmost board will hold the switches, and a cardboard or scrap PC board spacer with the second copper-clad board matching up to the top board makes the whole keyboard. Of course, you will have to etch circuits into the copper-clad surfaces to isolate the switching circuits. You can make all electrical connections to the etched boards at the edges. The two etched boards and the spacer (at least 1/32nd of an inch) can be made as one piece by using 5/32nds screws and nuts to hold the two boards together. By using epoxy glue you can even mount the keyboard to any surface that is convenient. Be sure to allow for the cable connection.

If you use your imagination, there is no type of keyboard that cannot be made with those switches. Just take the time to design the etched boards to suit your projects. Why spend 20 or 30 dollars when you can make it to your needs for only pennies per switch contact? Try it; you can only save money, and come up with an excellent control console and custom keyboard for yourself. **SP**



MEASURE ENGINE RPM WITH YOUR DMM

Black box tach/dwell adapter helps you tune-up 8/6/4 cylinder auto engines quickly with the help of your digital voltmeter.

RAY CHANDOS

A GOOD TACH/DWELL METER IS AN ESSENTIAL TOOL for automotive tune-ups. The tachometer function is used to set or monitor engine speed during ignition timing and carburetor adjustments. The dwell meter aids in setting the breaker-point spacing in cars that still have them.

The simple device described here turns your DMM into an accurate tach/dwell meter with direct digital readout in RPM or degrees of dwell. Though costing less to build than a self-contained analog-readout type, this unit provides greater accuracy and readability. Four-six-or eight-cylinder engines can be tested, with power for the device supplied by the car's battery.

Circuit operation

A simplified diagram of the tach/dwell adapter is shown in Fig. 1. The input signal, taken from the negative (−) side of the car's ignition coil, is high while the breaker points are open and low while they are closed (the dwell time). That signal is fed to an inverter, whose output goes high when the points are closed, producing a rectangular waveform whose average value is proportional to dwell. An RC filter then converts the signal to a smooth DC voltage that can be read on the DVM.

For the tach function, the input is also sent to a monostable multivibrator. The monostable's output is

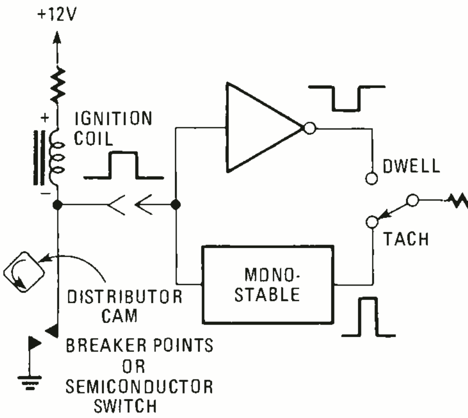
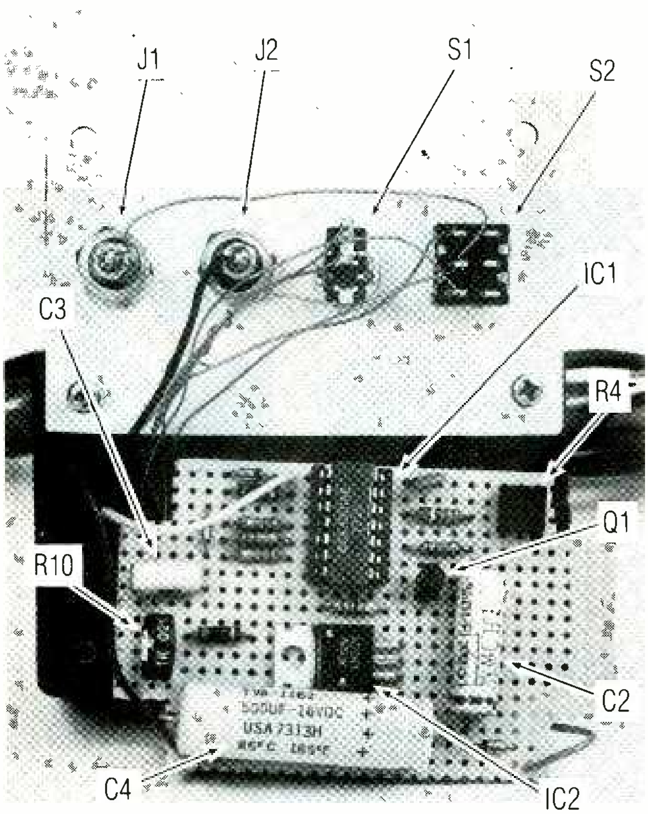


FIG. 1—SIMPLIFIED BLOCK DIAGRAM of the tach/dwell adapter points out circuit's simplicity.



NO FANCY PC BOARD needed here. With parts mounted on perf board and front panel, point-to-point wiring does the job.

a constant-width pulse, resulting in a waveform whose average DC value is proportional to the number of pulses per minute, or engine RPM. After RC filtering, that signal can be read by the DVM.

In the complete circuit, shown in Fig. 2, resistor R1, together with diodes D1 and D2 protect the IC from high-voltage input transients. The monostable multivibrator is made from IC1-b and c. It delivers an output pulse that has a width of about 3.33 ms, set by the R4-C2 time constant. Transistor Q1 quickly discharges C2 at the end of the timing period so that the monostable can be immediately retriggered by the next input pulse without error. IC1-d buffers the monostable's output pulse, while IC1-a is the inverter for the dwell function.

PARTS LIST

RESISTORS
¼ W, 5% tolerance unless noted
R1, R9—1000 ohms
R2—33,000 ohms
R3—10,000 ohms
R4—100,000 ohms, trimmer potentiometer, cermet type
R5, R6, R7—10,000 ohms, 1% tolerance or matched
R8—220 ohms
R10—1,000 ohms, trimmer potentiometer, cermet type

CAPACITORS
C1—0.001 µF ceramic disc
C2—0.1 µF Mylar Type
C3—10 µF, 16 volts, electrolytic
C4—500 µF, 16 volts, electrolytic

SEMICONDUCTORS
IC1—4001B quad 2-input NOR gate
IC2—LM317T adjustable voltage regulator
Q1—2N2222 NPN transistor
D1, D2, D3—1N4148 silicon diodes
J1, J2—banana jack/binding post; 1 red, 1 black
S1—SPDT toggle switch
S2—SPDT center-off toggle switch

MISCELLANEOUS: Suitable metal enclosure; Rubber feet or suction cups; Wire; Alligator clips; IC socket; Circuit board; Solder; Hardware, etc.

Switch S1 selects either the tach or dwell waveform and passes it to filter network R5-C3 for smoothing. Resistors R5, R6, and R7 then act as a voltage divder to scale the selected output signal for direct reading in either RPM or degrees. Switch S2 sets the correct scaling for four-six- or eight-cylinder engines.

Power for the circuit comes from the car's battery, with diode D3 protecting against accidental polarity reversal. Capacitor C4 filters the voltage, and IC2 regulates it to a constant value of about +9V.

Construction is straightforward

Circuit layout is not critical and normal assembly techniques can be used. ¼-watt, 5% resistors may be used throughout, but R5, R6, and R7 must be either 1% types, or 5% types selected for closely matched values. Also, for accurate monostable timing, C2 should be a Mylar type and IC1 a B-series 4001.

Switches are mounted on the front cover of a suitable enclosure, with the three color-coded leads passed through a hole in the back or side. Large alligator clips are used for the battery connection, and a small alligator clip for the coil connection. Rubber feet or suction cups can be mounted on the back to prevent scratching the car's finish.

Calibration is fast and easy

Potentiometer R10 is used to calibrate the dwell function. Set S1 to DWELL, S2 to 4 CYL, and connect the red and black leads to the car's battery. It is not necessary to start the car. Connect the yellow wire to the negative (−) battery post, the DVM to the output terminals, and adjust R10 for a reading of exactly +9V (90 degrees of dwell). If resistors R5, R6, and R7 are properly matched, you should now read 4.5V (450) on

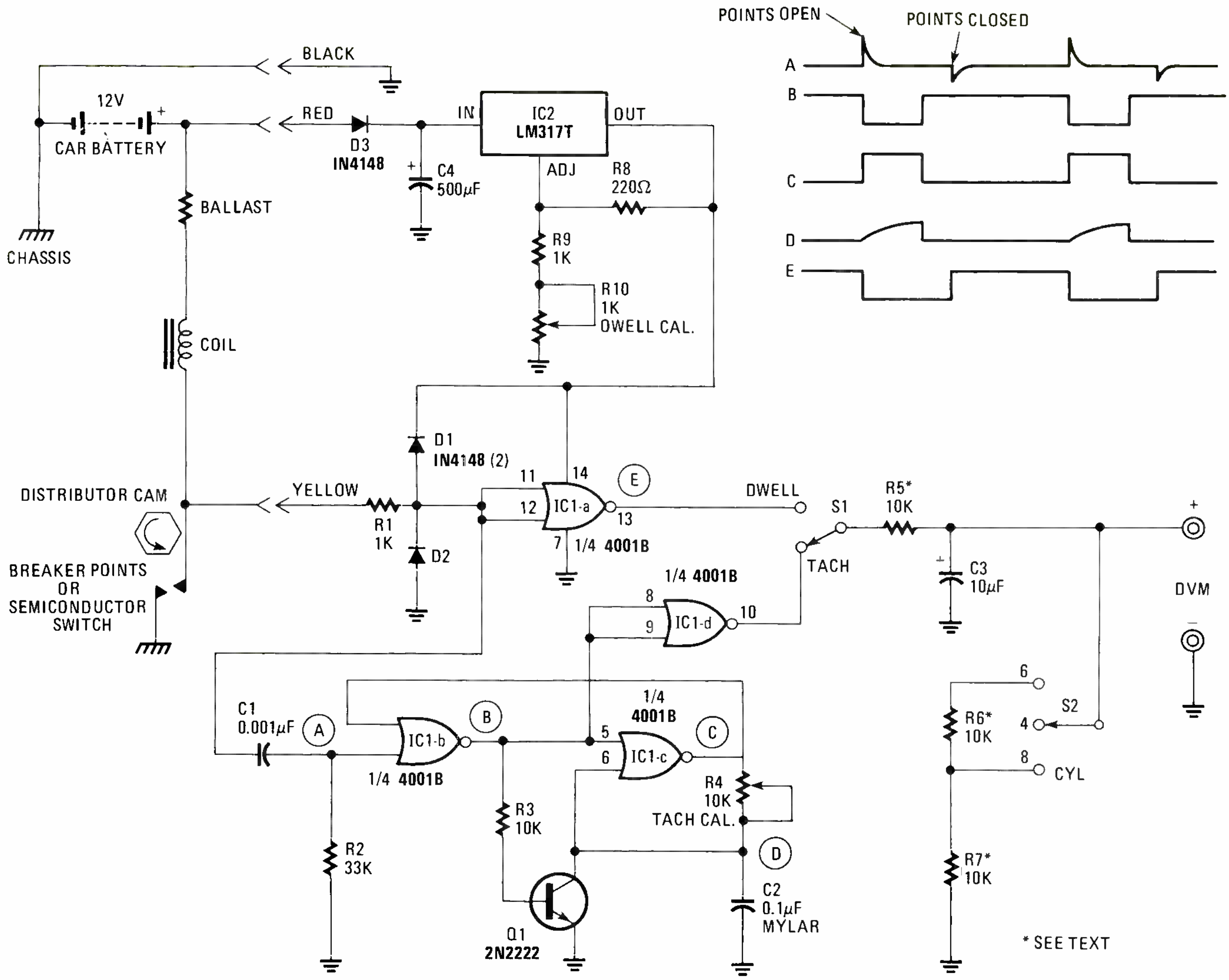


FIG. 2—SCHEMATIC DIAGRAM OF THE TACH/DWELL ADAPTER is easy to follow. Adjustable voltage regulator IC2 is adjusted for 9-volt output at DVM with R1 (yellow wire) connected to battery's negative terminal.

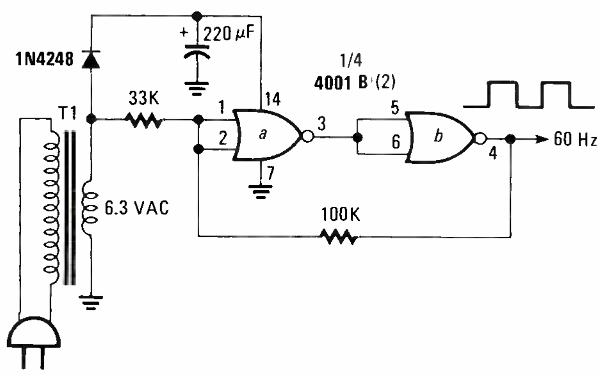


FIG. 3—MAKE YOUR OWN 60 HZ GENERATOR using a surplus 4001B chip and surplus filament transformer.

the 8 CYL position, and 6V (600) on the 6 CYL position of S2.

Now connect the yellow lead to a source of 60-Hz, 12V pulses. A bench signal generator (monitored by an oscilloscope set to line sync), or the circuit of Fig. 3 may be used. Be sure to ground the generator to the unit's ground. With S1 on TACH and S2 on 4 CYL, adjust R4 for a DVM reading 1.8V (1800) RPM.

Now put it to work

The tach/dwell adaptor can be used with both electronic or mechanical-type ignition systems, although dwell is actually a meaningless quantity for breakerless ignitions. Simply connect the red and black wires to the battery, and the yellow wire to the negative (−) terminal or the ignition coil. Set the switches for the desired function and number of cylinders, connect the DVM to the output terminals, and start the engine. You will have to multiply the voltage reading by 1000 for RPM, and by 10 for degrees of dwell. Thus, a DVM reading of 3.25V indicates an engine speed of 3250 RPM, or a dwell angle of 32.50.

A word of caution and some advice is needed here. Be extremely careful when connecting leads to engine. Should they get caught in the fan or pully system, the engine will suck up your equipment, and maybe you. Attach a terminal lug to the spark coil breaker terminal to facilitate easy and frequent connection.

Of course, the DVM should be set on the most sensitive usable range, for greatest precision. An analog meter with a high input resistance could also be used if a DVM is not available. Range of measurement exceeds 8000 RPM on the four-cylinder range, well beyond the red line of most engines. **SP**

ELECTRONIC TIMER

A few simple circuit chips and their use provide a basic primer in timers.

Donald Wilcher

HERE IS A SIMPLE PROJECT MOST EXPERIMENTERS CAN knock together with parts salvaged from old projects or found in their spare parts box. The Economy Timer consists of three basic circuits: a simple RC timer-circuit which uses a single transistor, Q1, to control relay, RY1, and a 555 (IC1) counter-circuit whose output drives an LED-display circuit.

The timer begins to count after key switch S1 is depressed, held for a moment, and released. One section of the S1 connects pin 14 of IC2 to ground, resetting the count circuit to zero. The other section of the S1 charges capacitors C2 and C3 to the voltage level of B1. When S1 is depressed, Q1 conducts and relay RY1 is energized; that in turn energizes the counter-circuit, which provides pulses to the display circuit. When S1 is released, the relay remains energized until the RC circuit has run its course, discharging through resistors R5 and R6, shutting down transistor Q1, de-energizing relay RY1, and bringing the counter-circuit to a dead stop.

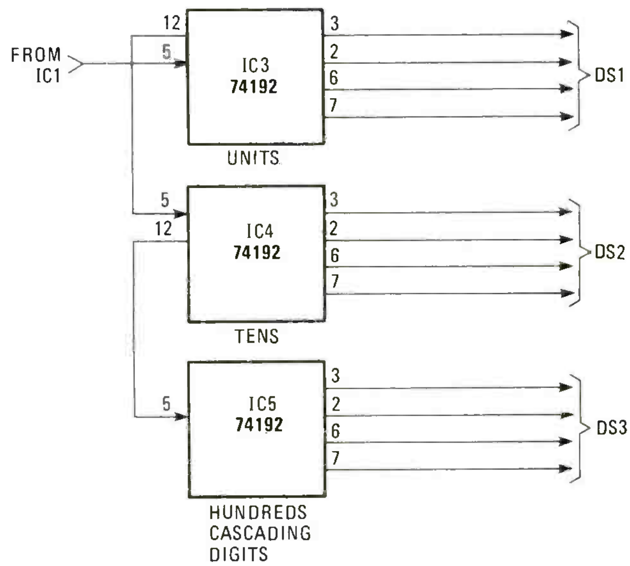


FIG. 2—THE ELECTRONIC TIMER'S CAPACITY can be increased by cascading additional 74192 IC's.

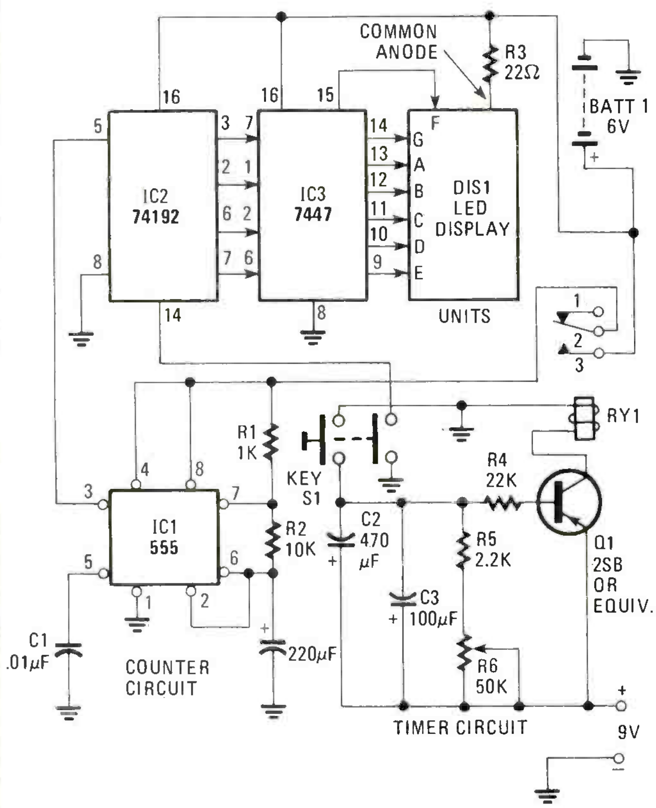
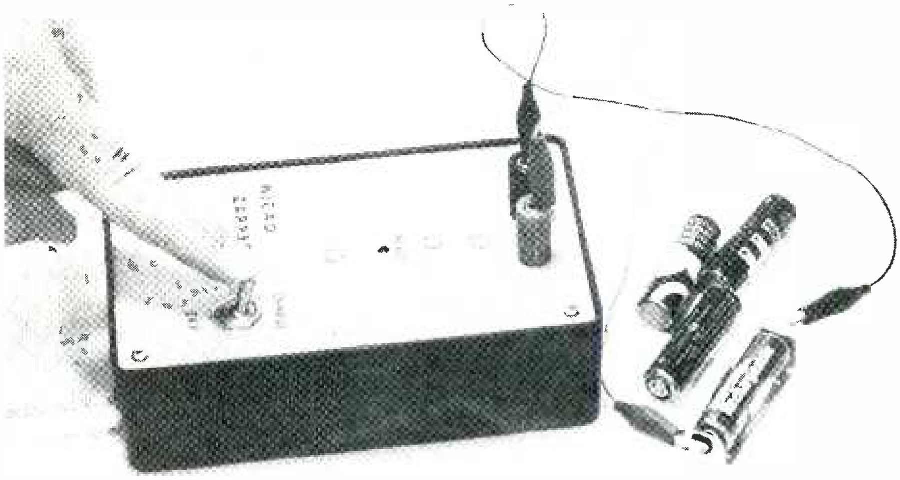


FIG. 1—SCHEMATIC DIAGRAM OF THE ELECTRONIC TIMER. Pressing S1 resets the counter to zero and starts the timer.

The display circuit will now readout the time, which can be used to calibrate the dial plate under the pointer knob of R6. Note that the count begins when S1 is released, removing the zero reset ground from pin 14 of IC2. The circuit as shown is very basic. The timer-circuit calibration depends on the regulation of BATT1. To increase accuracy, use a standard line-operated 9-volt/regulated power supply to drive Q1 and IC1. Then, tap off a 5-volt supply using a resistance network across the 9-volt supply, or, better still, hookup a voltage regulated 5-volt supply.

Resistors in this network *should not be warm* to the touch. If they do get warm, use the next higher wattage values. If you have a spare +5-volt regulator IC, this may be the easiest way to do the job. If you elect to count to tens or more, add cascading digits as illustrated in the partial diagram (Fig. 2). The Electronic Timer circuit has countless potentials for use as a darkroom timer, stopwatch, elasped-time indicator, and more. Have fun! **SP**



NI-CAD ZAPPER

When a NiCad cell goes dead you can shock it back to life with this budget project! Restoring NiCads back to service saves bucks!

HERB FRIEDMAN

MANY, PERHAPS EVEN MOST, NICAD (NICKEL-CADMIUM) batteries can be brought back from the dead to provide many more weeks or months of power for your flashlights, radios, photoflash, (strobe) lights, drills, soldering irons, or whatever else you're using NiCad batteries to power.

With the price of a set of ordinary flashlight batteries exceeding that of a pound of ground beef, NiCads are starting to look like a very attractive substitute for standard carbon-zinc cells. Although they cost about four times as much as an ordinary flashlight battery, the NiCad can be charged hundreds—almost a thousand—times. At least that's the claim made for them. Unfortunately, as many users have discovered, NiCads often refuse to accept a new charge after a mere 10, 20, or 30 recharges. Depending on the particular NiCad, you might get almost a hundred recharges—but several hundred? It doesn't seem to happen very frequently.

As a general rule of thumb, the NiCads built into portable electric drills, soldering irons, and strobe lights are of a high quality—at least in the sense that they actually can be recharged hundreds of times—but frequently they also fail to "pay for themselves" with long life.

The most common reason for the "death" of a NiCad used in consumer equipment is an internal short circuit. Then the cell or battery will produce no reading at all when a DC voltmeter is connected across its terminals. In fact, the meter's pointer won't even budge off the zero reading.

But the internal short can often be cleared by zapping the battery with a short burst of current large enough to burn open the internal short. That is done by charging a moderate-size capacitor from a high-voltage power source and then discharging the capacitor into the NiCad. Even the most stubborn short circuit can usually be opened with three to five zaps. Even if the NiCad's chemicals are dried out, zapping can often provide several weeks of additional service, often equal to the price of several sets of standard flashlight-type batteries.

As you might expect, a capacitor that has been charged to a high voltage is not the safest item to

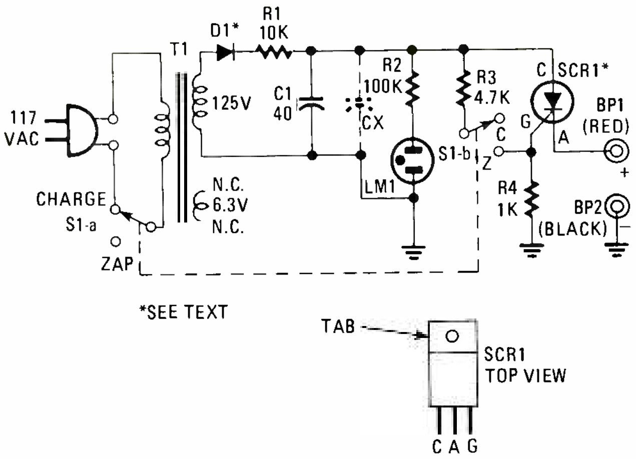


FIG. 1—ZAPPER CIRCUIT IS QUITE SIMPLE. This rather uncomplicated device does an important job and does it well.

PARTS LIST

RESISTORS
½ watt, 10%
R1—10,000 ohms
R2—100,000 ohms
R3—4700 ohms
R4—1000 ohms
CAPACITORS
C1—40-μF 250 VDC electrolytic
Cx—20μF 250 VDC, see text
SEMICONDUCTORS
SCR1—Silicon Controlled Rectifier. 200 PIV. 1 amp or better
D1—Silicon Controlled Rectifier. 400 volts. 6 amps
MISCELLANEOUS
L1—Neon lamp, NE-2 or equivalent
T1—Power transformer, 117 volts/0.15 mA, Calectro D1-760 or equal see text
BP1, BP2—Insulated binding posts
S1—Switch, DPDT
Cabinet, terminals strips, battery holders, etc.

THE ZAP IS CONTROLLED BY AN SCR with extended leads. Note that the extension wires are insulated, and a short length of tubing is slipped over the wires and over the SCR leads.

handle, nor is the spark produced by the zap, or the "explosive" noise of the spark, pleasant. The NiCad Zapper shown in the photographs, however, will zap a NiCad safely and quietly; and there will be no sparks. No matter which position FUNCTION switch S1 is in, the output is a safe zero volts. That's because the capacitor is always discharged automatically—either by a zap, or through the control circuit if the NiCad fails to zap. (A NiCad won't zap if the connections between the Zapper and the battery are accidentally left open.)

If the NiCad is the type used as a substitute for a standard AA, C, or D cell, simply install it in a matching battery holder (available from any electronics parts store) and connect it to the Zapper's terminals with clip leads. If the NiCad is built into equipment—say, a photoflash—make certain that the equipment's power switch is turned off and its charger is disconnected. Then connect the battery to the Zapper with clip leads: positive to positive and negative to negative.

Set the Zapper's FUNCTION switch (S1) to CHARGE. After a few seconds READY LIGHT L1 will turn on. Allow a few seconds for the light to reach maximum brilliance—indicating a full charge. Then set S1 to ZAP.

At the instant S1 is set to ZAP the READY LIGHT will snap off, indicating that the NiCad has been zapped. Repeat the procedure three times. If the light fades out in about 0.5 seconds—rather than instantly snapping out—it means the NiCad has not been zapped and that the internal safety circuit has simply dissipated the charge. That is generally caused by open wires between the Zapper and the NiCad. If there is a spark at a NiCad battery terminal it means that some form of invisible chemical (or dirt) coating that was interfering with proper NiCad operation has been burned off.

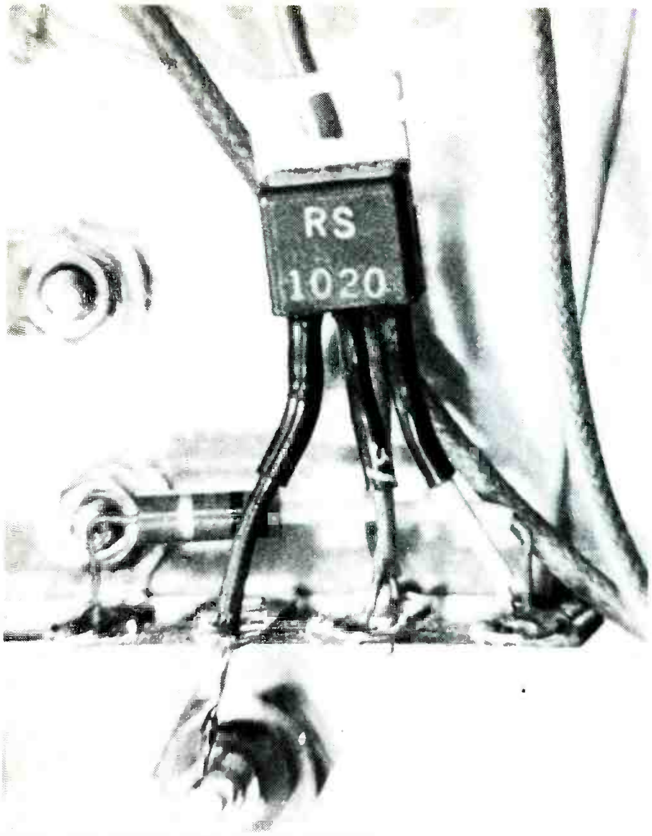
If you check a zapped battery with a voltmeter, it will produce an insignificant movement of the meter's pointer—maybe no more than the width of the pointer itself—but there will be a pointer movement of some kind. If the pointer does not move, zap the NiCad again. Keep zapping until the pointer does move. (Repeating the three zaps up to at least 20 times won't harm the NiCad; right now it's dead.)

Next, recharge the battery normally using the proper charge. If the NiCad doesn't seem to be accepting a full charge, zap it again. You'll have the most success, up to 100%, with AA, C, and D size NiCads. Your success with multi-cell NiCads used in consumer equipment will vary. Sometimes it works, sometimes it doesn't. Since replacement NiCads for consumer equipment don't come cheap (a replacement for a popular photoflash is $75), it's worthwhile trying a zap.

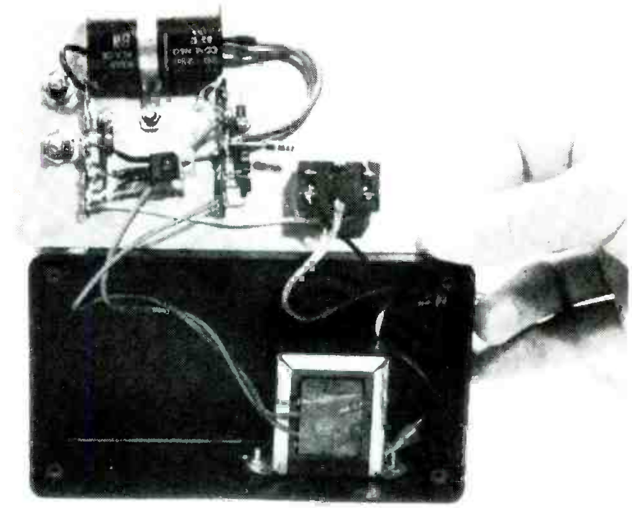
How to build your Zapper

The easiest way to build a NiCad Zapper is to assemble it on the aluminum front panel of a general-purpose chassis box. The front panel should be about 6¼ inches long by 3¾ inches wide by 2 inches deep. Only power transformer T1 is not mounted on the panel; it is installed on the side of the cabinet. T1 can be any small power transformer with a 125-volt secondary and just about any current rating. The one shown in the photographs is rated for 15 mA. Those small power transformers, such as the Calectro D1-760, often have an additional 6.3-volt output through wires color-coded green. Simply cut off the green leads close to the transformer itself. Remember, you can use any transformer that will fit within the cabinet.

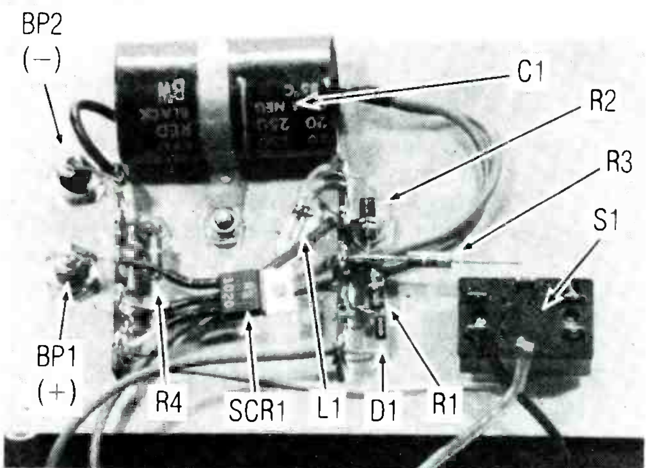
The panel components are tied down to terminal-



CUT THE SCR'S EXTENSION WIRES to the minimum needed to provide a fan-out to the terminal-strip solder lugs. The SCR is not bolted to the panel, nor should it touch the panel (see text).



THE POWER TRANSFORMER IS MOUNTED on the side of the cabinet. Leave its leads long so you're not cramped for space during the final assembly. Neatness has no effect on final performance.



EXCEPT FOR THE POWER TRANSFORMER, the entire Zapper is assembled on the front panel of an Experimenter's Box. All components are secured to terminal-strip solder lugs; none are left "floating." Keep in mind that this is not a transistor project with voltages that you can touch safely. The capacitor is charged from 150 volts, and can kick like a mule—so take care.

strip solder lugs. Make certain that all wires are soldered to a lug. You cannot have twisted (unsoldered) or "floating" connections. Capacitor C1 is 40 μF at 250 volts. If you can only locate a 20-μF capacitor, connect another—the one indicated as C_X in the schematic. Two 20-μF capacitors wired in parallel equal 40 μF.

SCR1 is a 400-volt, 6-amp Silicon Controlled Rectifier. Use only the exact part or its exact substitute. Its terminals are too short to reach the terminal-strip solder lugs, and must be extended. Tack-solder a short length of insulated No. 20 or No. 22 wire to each SCR terminal and then slip a length of insulated sleeving down the wire over each terminal. When you connect the SCR, make certain that it does not touch the panel. The metal tab of SCR used in the project was insulated from all of the SCR terminals; but design has been known to change, and the SCR you purchase might not have the metal tab insulated. Avoid all potential problems by keeping the SCR off the panel. (The wires will provide enough support for the SCR.)

Binding post BP2 doesn't have to be insulated; but because it usually comes in a matched red-black insulated pair, it's the cheapest, most convenient way to purchase the binding posts.

Double-check switch S1's wiring before soldering. Note that when S1-a closes the power connection to the power transformer, S1-b opens the connection between resistor R3 and the SCR gate (indicated as "G"). When S1-b connects R3 to the SCR gate, S1-a opens the power-line connection to T1.

Because neon lamps in DC circuits only provide a "glow" around one internal element—the entire glass bulb does not light up—position lamp L1 so the two elements within the glass are directly under a 3/16-inch or 1/4-inch hole in the metal panel.

Checkout before using

Set switch S1 to ZAP and connect the Zapper to the AC powerline. If READY LIGHT L1 turns on, you have made a wiring error. Set S1 to CHARGE. After a few seconds, the READY LIGHT should turn on. Then set S1 to ZAP. The READY LIGHT should fade out in about 0.5 seconds. If it snaps out instantly, there is probably a wiring error. If it does not turn off, there is an unsafe condition. Disconnect the power plug from the power line. If the light does not fade out after a few minutes, clip a 10,000-ohm resistor across the binding posts and wait a minute or so after the light fades out. Then check for a wiring error. Under no circumstances handle the components if the READY LIGHT is on.

If everything checks out, set S1 to ZAP, connect your dead NiCad(s) to the binding posts, set the S1 to CHARGE, and then ZAP to bring it back to life. **SP**

THE DARKROOM CONTRAST METER IS A "LIGHT METER" specifically intended to help the photo hobbyist make a good print at the very first try, so that an excellent print can be made on the second try.

Given enough time and effort, virtually anyone can make a great enlargement. But, is it all worth the effort when Aunt Mini gives you a full 36-exposure roll from her birthday party and requests "two wallet-size of each?" Or, is it worth the chemicals and test strips when you're just trying to knock out a batch of decent 8 × 10's of the local Little League team?

Use the Darkroom Contrast Meter, and your first print—certainly of wallet-size—can be a good print without all the fuss and bother of multiple-test prints. In fact, after you "lock" onto the first negative in Aunt Mini's strip you'll be able to bang out good "wallet-sizes" as fast as you can run them through the developer.

Unless you're into artistic or esoteric pictures, such as a black cat in a coal mine at midnight, acceptable tonal balance in a black-and-white print ranges from white highlights to "pure" black. In fact, even without sparkling whites, the eye will accept as good or acceptable virtually any print that has even a minute speck of pure black in the print; the black appears to key the tonal value for the eye. In short, you'll make an acceptable print at the very first try if somewhere there's a speck of black. If there's no black, the print appears to be lacking in contrast.

As a general rule, the tonal range from white to black is determined by the grade of paper (usually #1 to #4 or #5). The negative's density range determines which paper grade should be used to produce a print that appears to have normal contrast. If you use a *hard* paper (say #4) with a *normal* negative the final print will have excessive contrast. If you use a *soft* paper (#1) with a *soft* negative (low contrast) the print will appear dull and lifeless; it takes a *hard* paper to compensate for a *soft* negative.

The contrast meter will determine the matching paper grade for a particular negative in a matter of seconds. As an extra feature, though not specifically intended in the design, the meter can be used as an exposure meter, indicating the correct level of projected light from the enlarger for a specific exposure time, say 10 seconds.

The meter has seven LED's calibrated in half-step increments from grade #1 to #4. The "full grade" LED's (1, 2, 3, 4) are red. The half steps (1½, 2½, 3½) are yellow. An eighth calibration LED is green. (See photos.) To determine the "normal" paper grade required by the negative, the meter's sensor is first placed under the area of maximum light transmission (which will produce black in the final print), and the meter's CAL(ibration) control is adjusted until all LED's including the green one are lit, or the enlarger's illumination is adjusted via the lens diaphragm until all LED's are lit. The sensor is then moved to the area of minimum light (which will produce the white highlight). The number of LED's which remain lit is the required "normal" paper grade. For example, if two red LED's are lit the negative calls for a #2 paper. If three red and the next yellow LED's are lit the negative calls for a #3½ paper.

There is no official standard for paper grade vs. density. Virtually all manufacturers have their own idea of what's "normal", but there is a generally accepted *average* for printing meters, and the Darkroom Contrast Meter is calibrated to that average. Since the meter works very fast, with excellent consistency, you can correct easily for any personal preference you have, or for the specific density range of your film and paper. For example, if you produce normal prints when the meter indicates a 2½ paper, but you use #2 paper with extended development, then a meter reading of "2½" equals a #2 paper *for you*.

The sensor is a selected photoresistor of unusually small size. Its active area is not larger than ⅛-inch in

CONTRAST METER FOR DARKROOMS

Take the Guessing out of your Enlarging Technique, Use the Correct Contrast Paper the First Time, and Enjoy Excellent Enlargements.

HERB FRIEDMAN

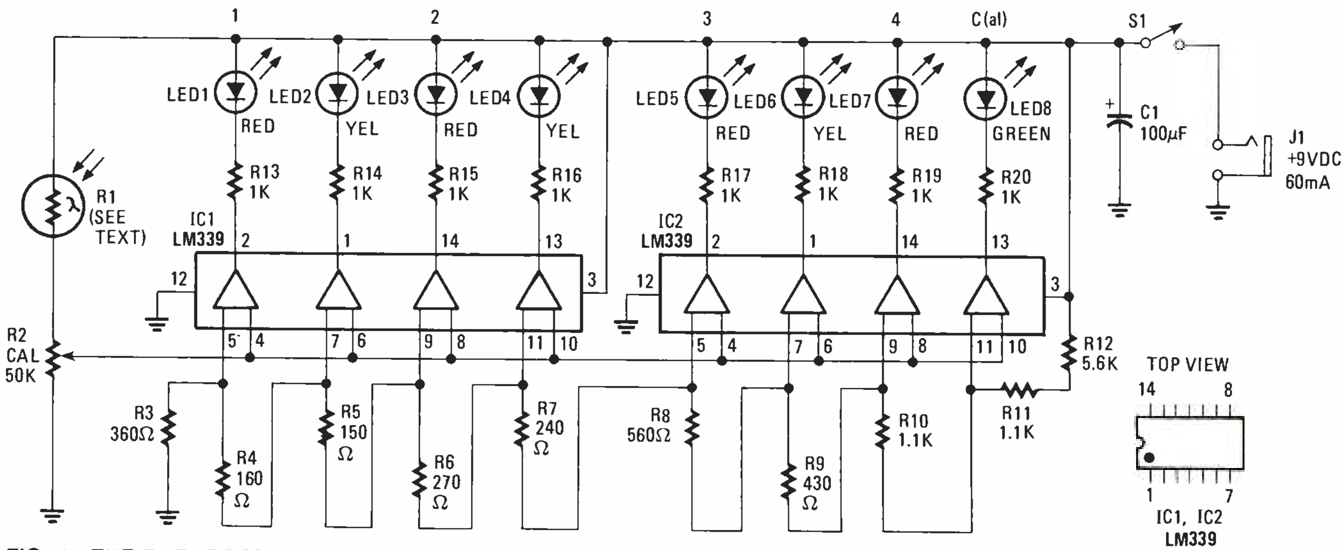


FIG. 1—THE DARKROOM CONTRAST METER uses eight low-voltage comparators in two quad IC packages to illuminate selected LEDs of different colors in proper sequence.

PARTS LIST

RESISTORS

¼ watt, 5% unless otherwise specified

R1—Photoresistor, Custom Components PRL9
R2—50,000 ohm trimmer potentiometer, see text
R3—360 ohms
R4—160 ohms
R5—150 ohms
R6—270 ohms
R7—240 ohms
R8—560 ohms
R9—430 ohms
R10, R11—1100 ohms
R12—5600 ohms
R13–R20—910 ohms or 1000 ohms

CAPACITOR

C1—100 µF/15 VDC electrolytic capacitor, see text

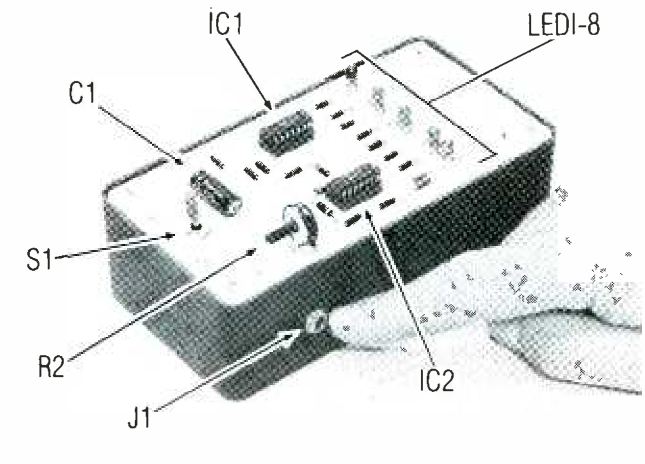
SEMICONDUCTORS

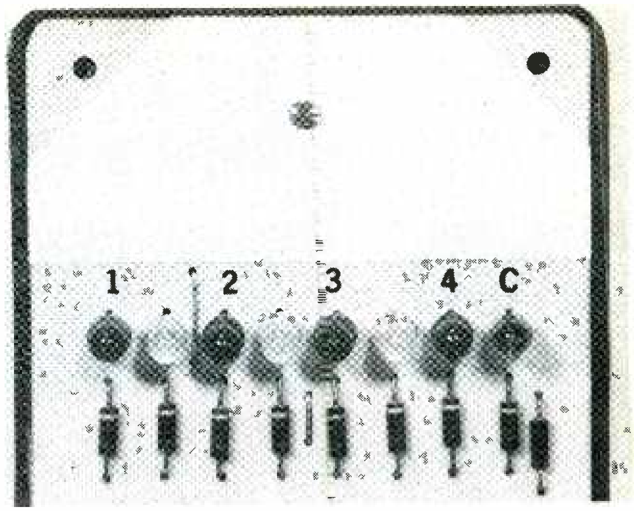
IC1, IC2—Quad low-voltage comparator LM339 or CA339
LED1, LED3, LED5, LED7—red diffused LED
LED2, LED4, LED6—yellow diffused LED
LED8—green diffused LED

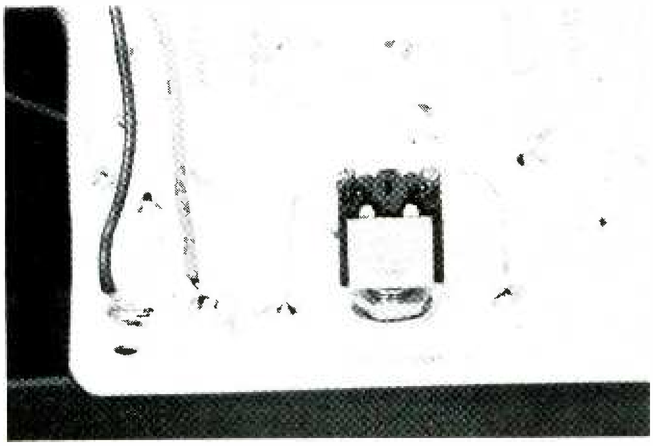
MISCELLANEOUS

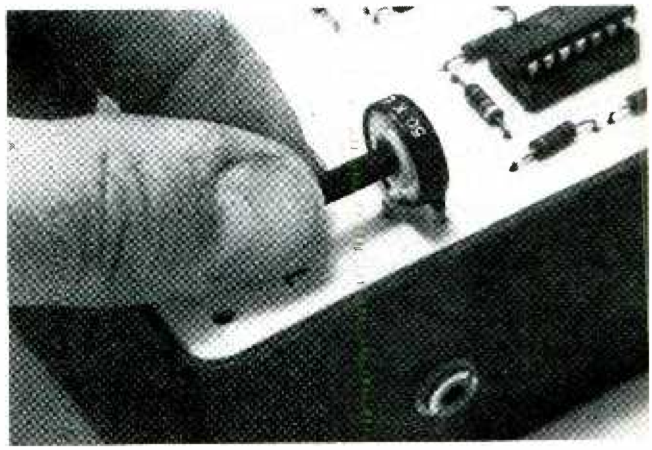
J1—Jack to match power supply plug
S1—SPDT switch, Printed circuit materials, IC sockets, cabinet, etc.

(Photoresistor PRL9 (R1) is available for $5 plus $2 postage and handling per total order from Custom Components, Box 153, Malverne, NY 11565. New York residents must add sales tax. Canadian orders in US dollars.)









Here's what it looks like (upper left) after all the work is done. The meter is actually a series of LEDS (upper right). Author's technique of switch mounting on PC board (lower left) is clever. CAL pot R2 (lower right) is only adjustment.

diameter so it can measure extremely small negative detail, making it suitable for even small—"wallet" type—prints. It is most sensitive to the color temperature of typical enlarger lamps, and has little inertia and memory, responding almost instantly to changes in illumination. All features combine to produce a sensitivity that will resolve differences in negative density almost too small to be seen by the unaided eye.

The power source is 7.5- to 9-volts DC at approximately 60 mA. Use one of the surplus battery eliminators that are often sold at rock-bottom prices by local and mail order distributors. The current requirement is relatively low. You should be able to pick up an eliminator for about $3. Until then, you can probably get by with an Alkaline 9-volt transistor radio battery, but they cost almost as much as the battery eliminator. Make certain the battery eliminator has the matching plug for jack J1 (Fig. 1), and that the center conductor is "positive". If necessary, rewire or connect a new plug to the battery eliminator.

Construction must be precise

There are three critical items. The photoresistor itself, for which no substitution may be made (the project will not work properly, if at all, with other photoresistors). The resistor tolerance: all fixed resistors should be 5%. (Don't substitute more expensive 1% resistors, because they offer no improvement in performance, but don't use 10% tolerance because readings might go "far out".) Finally, don't alter the height of the photoresistor above the easel, because the height affects R1's value when measuring light. It should be between 1⅞ and 2¹/₁₆ inches. If you use a Radio Shack type 270-223 plastic Project Case, you will automatically get the correct height when you assemble the project.

The Darkroom Contrast Meter is assembled on a printed-circuit board that substitutes for the cabinet's cover. See Figs. 2 and 3. Ue the supplied PC template, but make certain that the board will drop into the cabinet. If it doesn't, file down the edges until it drops in without any external force.

Before you make the PC board, make sure that all the components you will use match the foil template. In particular, check calibration-control R2, which is a trimpot. There are slight variations in the spacing of trimpot terminals that are great enough to interfere with its mounting. Make any necessary adjustments to the template for R2. The trimpot shown in the photographs is somewhat unusual for hobbyists because it has a small fluted shaft. It's very convenient to use, and since more of that type are appearing on the surplus market, try to get one locally.

Pay particular attention to the foil solder pads for

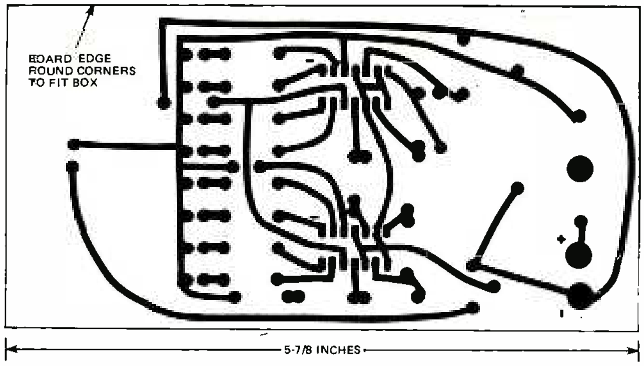


FIG. 2—TAKE THE TROUBLE TO ETCH the foil pattern illustrated here to avoid a non-pro layout. Be sure to pre-drill all component lead holes before starting assembly.

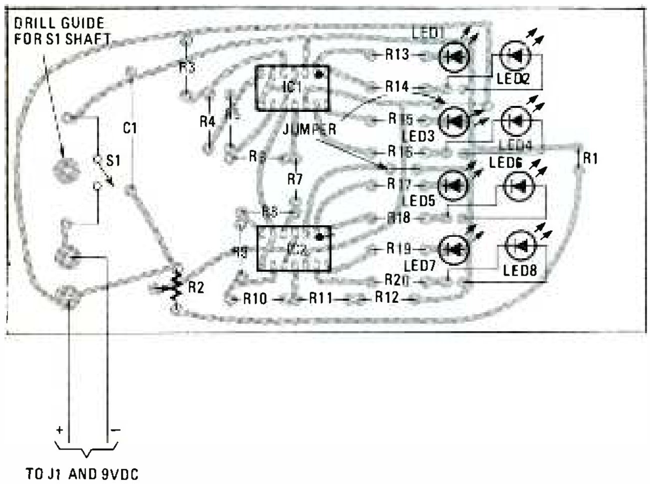


FIG. 3—PARTS LOCATION for the project shown here appears with the foil side down. Be extremely careful when mounting photoresistor R1. Text gives complete details.

photoresistor R1. R1 is somewhat fragile and it can snap in two when bending its leads. If you are somewhat experienced in close-quarter soldering, move the foil's solder pads within .1-inch spacing so R1's leads will drop straight through the board. If you can't work that close, leave the template as it is, and use *two* pair of longnose pliers to bend R1's leads. Use one plier to rigidly clamp a lead directly under the photoresistor's body—the plier should touch the body—and use the second plier to bend the lead. Repeat the procedure on the second lead.

Assembly will be somewhat easier if you use this order: The wire jumper adjacent to LED2 first, then power switch S1, and then the two sockets for the ICs. Refer to photos. Sockets really aren't required, but if you make a soldering or installation error you can ruin the IC's trying to get them out if they are soldered into the circuit. If you really think you don't need the sockets, don't use them. Then move on to the LED's.

The *diffused* type LED is recommended because it is somewhat easier to use in the darkroom. Use the least expensive LED's you can get. To make them slightly more convenient to see, tilt them about 10 degrees forward (toward the bottom of the cabinet) when soldering. Doublecheck to make sure that you have the color order correct. LED's 1, 2, 3 and 4 are red. The in-between—half step—LED's are yellow, and the C(alibrate) LED is green. The C LED comes right after LED4.

Capacitor C1 is optional (see Fig. 1). Its use depends on the particular battery eliminator you use. It is not needed for a battery power supply. Save a few cents and build the project without C1. C1 is needed only if the eliminator you use causes the LED's to flicker; if they are steady when illuminated, forget about C1.

Photoresistor R1 is the very last component installed. First, apply a white adhesive label—that will serve as a "target"—to the PC board at R1's location. Using a pointed tool, punch through the label at R1's mounting holes. Slide R1 down until it is flush with the board. If you can't get it flush don't push. (Remember, it's fragile.) R1 can be up to 3/16-inch above the board, but flush is best. Before positioning R1 on the board, clean any oxidation off its leads with a knife or sandpaper so that you can make the solder connection quickly.

Checkout before using

Set CAL control R2 to *off*—fully anticlockwise. Apply power by turning S1 ON, and under normal room illumination advance R1. The LED's should light in order starting with LED1. If they don't, check for a wiring error or a defective or wrong-value component.

Using the meter

Project and focus the negative on the easel. Close down the enlarger's lens two stops, or two "clicks" if each click is a full stop. Position R1 under an area of maximum illumination and adjust R2 so that all the red and yellow LED's light, and then ease R1 so the green LED (C) just turns on. Move R1 to an area of maximum negative density, the least light. The LED's that remain lit are the required paper grade.

Don't disturb R2. For other negatives, simply focus, position R1 under maximum illumination, close the lens and then open it until all red/yellow LED's light, and then ease the enlarger lens a smidgen open until the green LED lights. When the green LED is on, move R1 to least illumination.

At that point you should have an idea how to use the meter for exposure control. Make a good print using an exposure time of 5 to 15 seconds. Whatever time you use becomes your reference standard. Now position R1 under maximum illumination and adjust R2 until the green LED lights. You have now established the correct lens adjustment for the exposure time. For example, assume that you want to use a 10-second exposure. After you focus the negative, position R1 under maximum illumination, close the lens down and then open it up until all red/yellow LED's are lit, then ease the diaphragm until the green LED lights. Your enlarger is now set for a 10-second exposure. Go on to read the paper grade.

If you want exposure times of 20 seconds or more, bear in mind that your enlarger might not produce enough light to permit the meter to be calibrated by R2. But try it: sometimes it works, sometimes it doesn't. Exposure control is an "extra" feature: use it if you can. **SP**

AN AUTOMOBILE A/C DUTY CONTROLLER

Your auto air conditioner may be burning up to much gas unless you turn it on and off every few seconds. Here's a controller that does its duty full time!

MICHAEL J. DI JULIO

IT IS WELL KNOWN THAT TURNING ON THE AIR CONditioner in your automobile increases fuel consumption. That is caused by the increased load on the engine imposed by the compressor. When the air conditioning is turned on, an electromagnetic clutch is activated that engages a belt-driven pulley connected to the compressor shaft.

However, it is not necessary for the compressor to operate 100% of the time that the air conditioner is on. After the compressor has been going for a while, the condenser coils usually remain cold enough that they can maintain an uninterrupted supply of cool air even with the compressor off for several seconds. The scheme then is to cycle the compressor on and off, by controlling the current to the electromagnetic clutch. That reduces the load on the engine and still maintains an efficient cooling system. That such a system works is proved by the fact that most late-model cars (post 1976) have a compressor duty-cycle controller. By duty cycle I mean the ratio of the time that the compressor is on to the total time that it is off and on (t_{on}/(t_{on} + t_{off})). This article will describe the design and operation of a fuel-saving duty-cycle controller for installation in vehicles which were not originally equipped with one.

First of all, I observed a number of cars that had a compressor with a duty-cycle controller and measured the cycle with a stopwatch. Generally, in cars that have V-8 engines, the compressor operated on a 50% duty cycle with a 10-second *on* time and a 10-second *off* time. On smaller engines—such as six and four cylinders—the duty cycle is more like 33%, with the

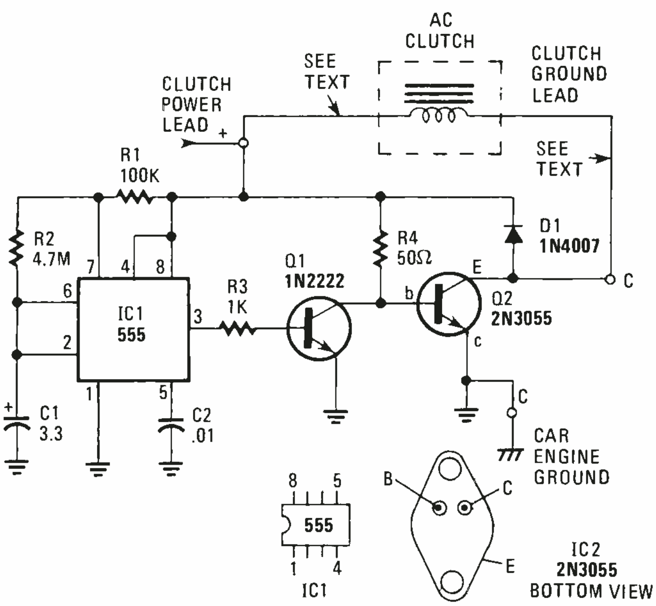


FIG. 1—SCHEMATIC DIAGRAM OF the A/C Duty Controller uses one IC and two transistors.

on time 5 seconds and the *off* time 10 seconds. I also measured the current required to actuate the clutch and found it to be 4.5 amps at 13.8 volts.

Theory of operation

My design is centered around the ever-popular 555 timer chip which seemed a natural for this application: the schematic is shown in Fig. 1. I used the standard astable multivibrator configuration of the timer chip. In that standard configuration C1 is charged from +V through R1 and R2. The output at pin 3 stays at +V until the voltage across C1 equals ⅔ of +V. When this occurs, pin 3 goes to zero volts and pin 7 of the IC is grounded discharging C1 through R2. When C1 reaches ⅓ of +V, pin 3 goes to +V again, pin 7 is ungrounded, C1 charges through R1 and R2, and the cycle continues. The salient features here are that the frequency of oscillation is independent of +V and that it is impossible to achieve a duty cycle of less than or equal to 50%. The latter is true because while R1 + R2 control the charge or *on* time, only R2 controls the *off* time. Since R2 must be less than R1 + R2, the *on* time will always be greater than the *off* time.

PARTS LIST

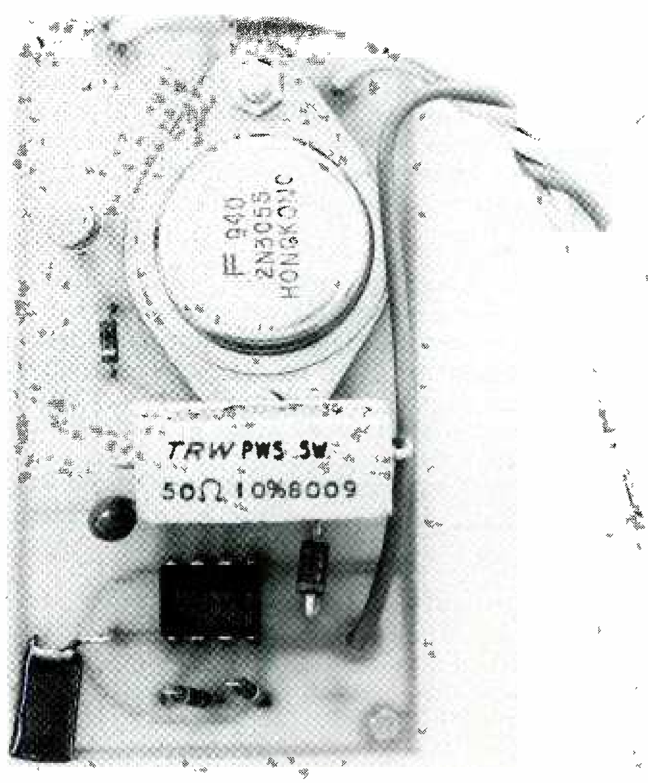
RESISTORS
All ¼-watt 10%
R1—100,000 ohms
R2—4.7 megohms
R3—1000 ohms
R4—50 ohms

CAPACITORS
All 25 VDC or higher
C1—3.3 μF. Tantalum
C2—.01 μF. ceramic disc

SEMICONDUCTORS
D1—1N4007 diode
Q1—2N2222
Q2—2N3055
IC1—555 timer

MISCELLANEOUS
PC board; enclosure; wire and hardware

NOTE: PC boards are available from the author for $5.00. Complete kits, minus the enclosure, are $20.00. Order from Michael J. Di Julio, 97 Woodside Rd., Maplewood, NJ 07040.



ASSEMBLED PC BOARD is ready for testing and final mounting in a metal protective chassis box.

What we really need is a squarewave that has a duty cycle that can be less than 50% for compressors that can work at 30-50% duty cycle while maintaining efficient air conditioning. That is why Q1 and its associated components are included to invert the squarewave coming from pin 3 into one which can only stay high (+V) less than 50% of the time. The inverted signal from the collector of Q1 drives the base of Q2. R4 limits the base current of Q2 to about 250 mA! That is

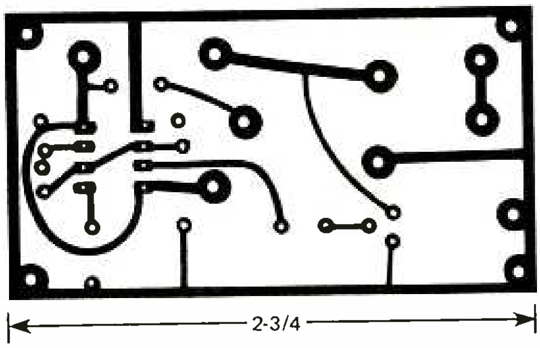


FIG. 2—PC BOARD is a must for this project to eliminate parts movement due to car motor vibrations.

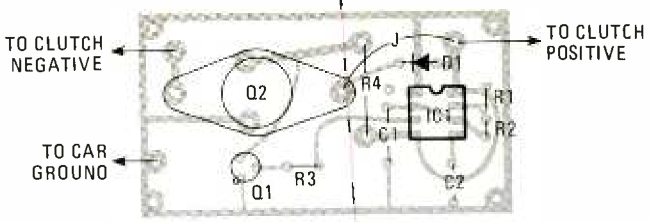


FIG. 3—PARTS LOCATION on the PC board indicates how simple this project is to build. Author offers kit.

enough base current to permit a 5A collector current with a minimum beta (current gain) of 20 for Q2. The clutch coil is inserted directly in the collector path of Q2. That is accomplished by inserting the controller in the ground connection of the clutch coil. D1 suppresses any high voltage that might occur across the coil due to the collapsing field when the clutch is turned off.

The values picked for R1, R2, and C1 are chosen for a 10-second *on*, 12-second *off*, 45% duty cycle. Ultimately, what that gives me on my car is a 50% duty cycle, because my clutch stays on for several revolutions even after current is taken away from it. I suggest experimenting with R1, making it larger to obtain shorter duty cycles and observing what the minimum duty cycle is that the system can withstand before the air conditioning becomes unacceptable.

Construction

The circuit should be constructed with top-quality components that can meet the full specified temperature range, because the engine compartment of a car is a severe environment. A PC board is recommended to withstand the mechanical vibrations of the engine. A sample PC layout is presented in Fig. 2; a parts-placement diagram is shown in Fig. 3.

Please note that no socket is used for IC1, and that C1 is a tantalum capacitor. Particular attention should be paid in construction to installing C1 and D1 with the proper polarity. The finished PC board should be mounted in a minibox, using four screws with standoffs, lockwashers, and nuts placing one in each corner of the board. The minibox should be fastened securely to the engine compartment, physically close to the compressor, to avoid a long run of the wires connected to the clutch. That will prevent wires snarling with the clutch or other moving part of the engine.

Three wires are connected to the PC board for connection to points in the car. Those wires are: ground, the collector of Q2, and +V; they are labeled on the PC board by the letters G, C, and +. The wires should exit the box via a hole protected with a grommet. The ground wire is attached to some metal point on the engine, preferably the lug to which one end of the clutch coil now goes. That grounded end of the clutch coil should be disconnected from the ground lug and connected to the wire going to the collector of Q2. The +V wire should go the other wire coming from the clutch. It should be noted that when the air conditioning is activated, it will take several seconds to come on, due to the initial charging of C1 to ⅔ of +V.

This controller is a simple device which will provide real savings on gasoline. For example, if your car normally gets 20 mpg on the highway with the air conditioner off and 18 mpg with it on, using the controller set on a 50% duty cycle will increase the gas mileage to something like 19 mpg. That is a significant dollar savings, considering the price of gasoline today! **SP**

LOW POWER OHMS ADD-ON

Check resistance of semiconductor circuits without exceeding the bias voltage of semiconductors. What you read is pure resistance, and you won't blow silicons and germaniums.

STEPHEN J. MILLER

HAVE YOU EVER TRIED TO MEASURE THE RESISTANCE value of an in-circuit resistor like R1 shown in Fig. 1? The chances are that the ohmmeter reading you obtained was much lower than the true value of R1. The reason for the low erroneous reading is that the base-emitter junction of Q1 is forward-biased. In essence, you are measuring the forward DC resistance of a "diode", which is mighty low compared to the 200 ohms of R1. An old technician's trick for getting around that problem is to reverse the ohmmeter leads. However, in directly coupled circuits such as Fig. 1, the base-emitter junction of Q2 will then be forward-biased. Now, you are shunting 500 ohms of R2 across the 200 ohms of R1 plus whatever resistance of the input network to Q2 which is not shown.

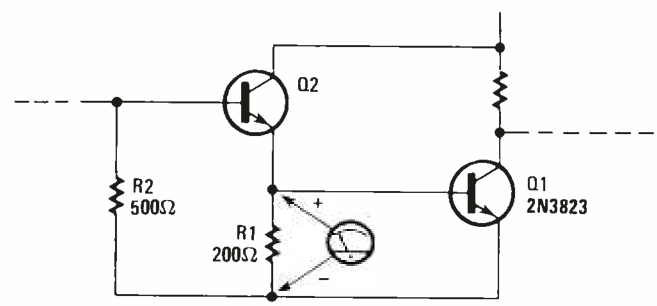


FIG. 1—READ R1 ON YOUR VOM and you may come up with 5.5 ohms or less. Q1 acts as shorting diode.

To remedy those problems low-power ohmmeters were developed. They restrict the maximum test voltage to approximately 0.1 volt. That very small voltage won't forward-bias any semiconductors. Silicons need 0.2 volts minimum. In the past, to get that function you had to bear the expense of buying another complete multimeter. Now, you can construct an add-on circuit to convert your present digital or analog meter to low-power ohms for a small fraction of the cost of another specialized multimeter.

And, there is a bonus that'll save you many dollars and headaches. Many conventional ohmmeters have high-test currents in their lower ohmmeter ranges which can damage semiconductors. That hazard is eliminated with the Low-Power Ohmmeter Add-On. We call it LOPAD. Maximum test current of LOPAD is approximately 0.6 mA.

LOPAD won't forward-bias any semiconductors (silicon or germanium); it cannot stop leakage current from flowing. In germanium semiconductor devices (not widely used) the leakage current is high enough to affect the meter reading—especially on the higher ranges. However silicon semiconductor devices (by far the most widely used) exhibit almost no leakage current. Therefore, LOPAD will function properly on any range in any silicon semiconductor circuit.

Finally, LOPAD gives you three important benefits: 1. semiconductors not powered to conduction; 2. safety to semiconductors on all meter range; and 3. linear readouts.

Some problems still exist, for example, you can't connect the unit across any and every resistor in a circuit and expect it to read the resistance of that resistor accurately. Resistors in parallel with the test resistor will still effect the meter reading. Remember, resistors in parallel *decrease* the resistance so that any resistor in circuit must read equal to, or less than the value of the color bands. If you obtain a higher reading than the markings indicate, the resistor is definitely defective.

How it works

The LOPAD operates on the same basic principle as

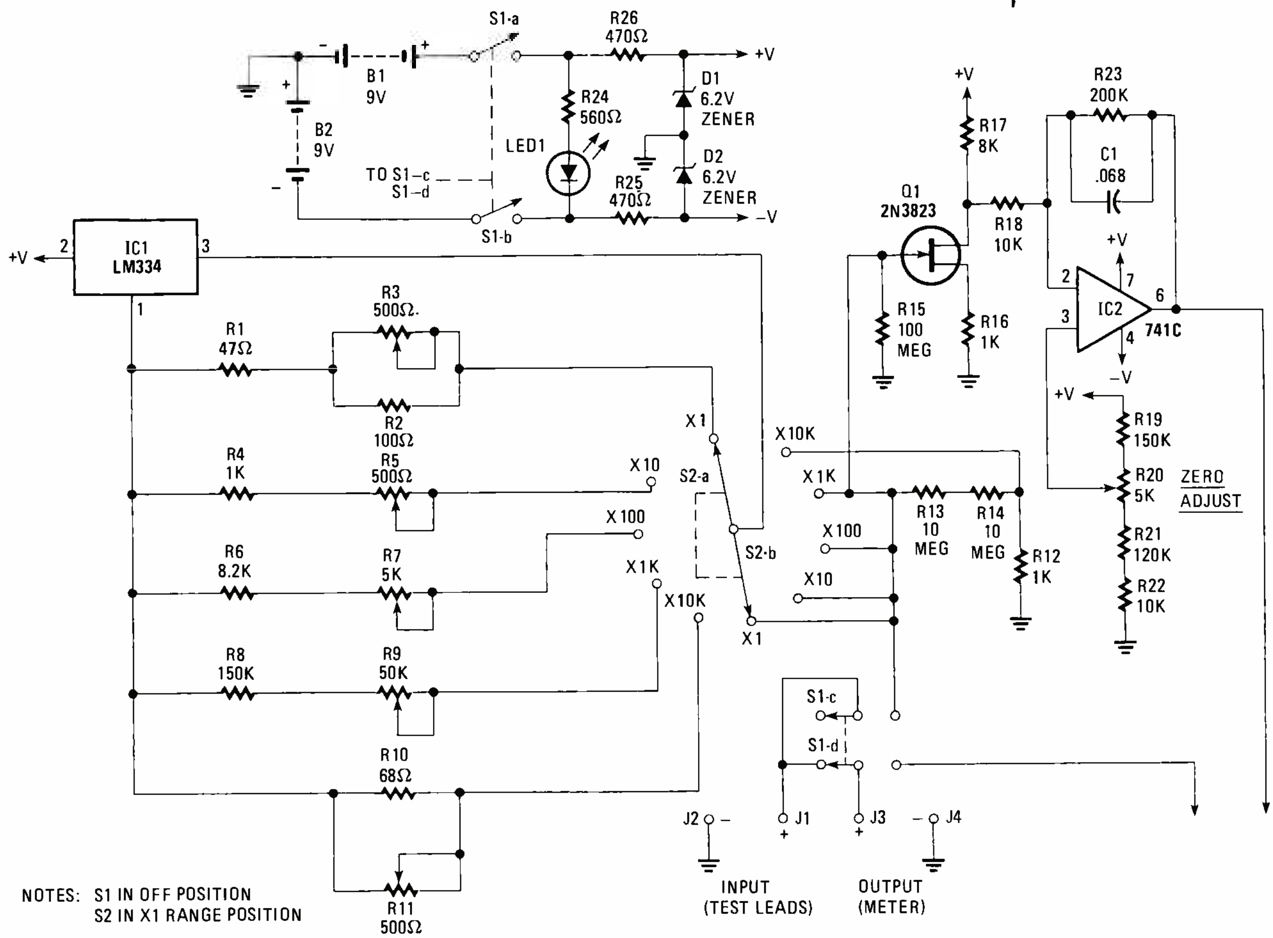


FIG. 2—BUILDING LOPAD IS LIKE adding a new low-voltage front end to your DMM or VOM. Circuit additions are shown in Figs. 3 and 4.

all other linear ohmmeters. That is, if you apply a constant current to an unknown resistor, the voltage-drop across the resistor is directly proportional to its resistance. See Fig. 2. IC1 voltage regulator is a constant-current source for LOPAD's resistance sensing circuit. By connecting different resistors between terminals J1 and J2, the test current—and therefore the resistance range—is varied. S2-a accomplishes that task. S2-b is used to switch in a special current circuit for the ×10K resistance range, since IC1 isn't able to generate a constant current of the small magnitude needed for that range.

Q1 acts as a DC-voltage amp. An FET is used to provide DC isolation between its input and +V. Q1 drives IC2, which further amplifies the voltage drop across the resistor under test. C1 is used to provide a large negative feedback for all AC signals, thus keeping IC2 from oscillating.

R20, the zero-adjust pot, is adjusted so that the output voltage from IC2 is zero when the test leads are shorted together. R19, R20, R21, and R22 are a voltage-divider network used to obtain the zero-adjust voltage. Their values are fairly critical.

S1 is a complex on-off switch. It controls the power to LOPAD, and also switches the low-power ohmmeter add-on in and out of the test lead-meter circuit. That allows the low-power ohmmeter add-on to be connected to the meter permanently. With S1 in the OFF position, the ohmmeter will function normally on

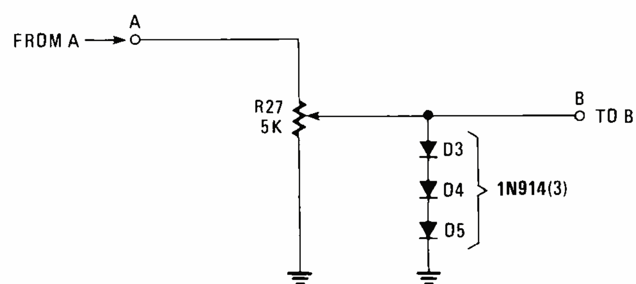


FIG. 3—DMM OUTPUT CIRCUIT uses three diodes for shunt regulation and R27 for level adjustment.

all its ranges as originally designed by the manufacturer.

The output from IC2 is fed to one of two different output circuits, depending on the type of meter being used.

The circuit shown in Fig. 3 is used with DMM which have a 0-2 volt DC scale. R27 adjusts the output level, while the diode trio, D3, D4, and D5 act as a shunt regulator. The shunt regulator is needed for the following reason: With the test leads open, IC1 tries to force all of the current through R15 (see Fig. 2), a 100-meg-ohm resistor. That causes a high-input voltage, which is amplified into a high-output voltage. That high-output voltage would overload the DMM. The diode trio acts as a shunt regulator and keeps the output volt-

PARTS LIST

RESISTORS

½ watt, 5% unless otherwise noted

R1—47 ohms
R2—100 ohms, trimmer
R3, R5, R11—500 ohms, trimmer
R4, R12, R16—1000 ohms
R6—8200 ohms
R7, R27—5000 ohms, trimmer
R8, R19—150,000 ohms
R9—50,000 ohms, trimmer
R10—68 ohms
R13, R14—10 megohms
R15—100 megohms
R17—8000 ohms
R18, R22—10,000 ohms
R20—5,000 ohms, linear taper, panel mount
R21—120,000 ohms
R23—200,000 ohms
R24—560,000 ohms
R25, R26—470 ohms
R28, R32—4700 ohms
R30—3,100 ohms
R31—100,000 ohms, trimmer

CAPACITORS

C1—.068 μF Mylar
C2—50 μF, 5-volt electrolytic

SEMICONDUCTORS

D1, D2—6.2-volt Zener, 400mW or better
D3, D4, D5—1N914
Q1—2N3823
Q2. Q3—2N2222
IC1—LM334 voltage (current) regulator
IC2—741C Op Amp
LED1, LED2—jumbo red

MISCELLANEOUS

B1, B2—9-volt transistor battery
J1-J4—banana jack binding post; 2 red, 2 black
S1—DP5T rotary switch, mm-shorting contacts
S2—4PDT rotary or toggle switch, non-shorting

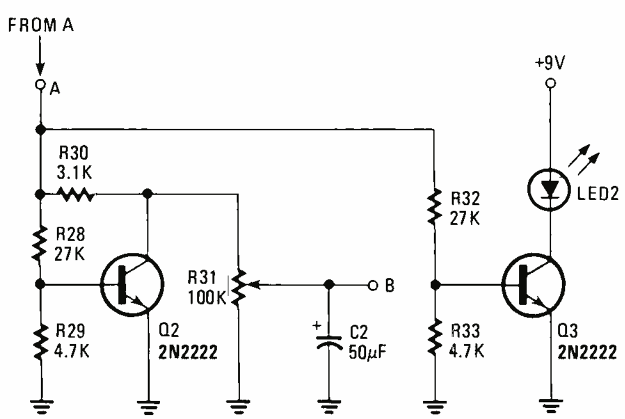


FIG. 4—ANALOG OUTPUT CIRCUIT uses Q2 as a shunt regulator to prevent accidental meter damage.

age fed to the DMM from rising above approximately 1.75 volts.

The circuit shown in Fig. 4 is used with all analog meters having a full-scale DC voltage range of 2 or less volts. Q2 acts as a shunt regulator to keep the output voltage from pegging the meter when the test leads are open. Q3 is an indicator driver for LED2. When lit, LED2 indicates that the shunt regulator, Q1, is on and the meter reading is not accurate. R31 is used to set the full-scale output voltage. C2 filters out small transient pulses produced when connections to the test resistor are made and broken.

Construction

LOPAD is relatively simple and easily assembled on integrated-circuit perforated board. Since it is primarily a DC circuit, lead length and component position aren't critical. The physical appearance of IC1 is very similar to a TO-92 transistor. Care must be taken not to interchange IC1 with one of the transistors during construction. R20, the zero-adjust pot, should be mounted on the front panel. All other pots should be mounted on the circuit board.

Test LOPAD before using

Perform the following steps to check out LOPAD's construction:

1. Set all potentiometers to their mid-range position.
2. Set switch S1 to OFF and Switch S2 to 1X.
3. Connect test leads to J1 and J2, and connect leads to voltmeter and J3 and J4.
4. Set voltmeter to range capable of indicating 5 VDC at full range, or not less than mid-scale on the meter.
5. Short test leads together.
6. Set S1 on LOPAD to ON. Meter will indicate a voltage that is either negative or positive.
7. Vary R20 in LOPAD until a zero reading is obtained. Should a zero reading occur in step 6, vary R20 to either side of its initial setting to see that the meter reads a negative and positive reading which is normal. Then set R20 for a zero reading.
8. Open test lead circuit by removing short. In DMM applications, meter should read 1.7 volts positive. Analog meters should read 1-2 volts positive with LED2 illuminated.
9. Short out the test leads again. The meter reading should return to zero.

If the results for the actions taken above do not occur, you have a circuit problem and troubleshooting is in order. Recheck the circuit carefully. Inspect solder joints. Check voltages. The problem must be removed now before you proceed with further adjustment.

Calibration procedures

To calibrate the meter, set R27 or R31 so that the wiper is grounded. See Fig. 2. Connect a 100-ohm resistor to the test leads with S2 in the ×1 position. Set the meter to the DC voltage scale which you will use for the resistance measurements (2-volts full scale for DMM; 2 or less volts full scale for analog). Turn LOPAD and adjust R27 or R31 for full scale on analog meters or 1.00 volts on DMM. Momentarily short the test leads and rezero the meter, then touch up the adjustment of R27 or R31. Switch to the ×10 scale, zero the meter, connect a 1000-ohm resistor to the test leads, and adjust R5 for 1.00 volt DMM; full-scale analog. Repeat this process using 10K for ×100 (adjust R7), 100K for ×1K(adjust R9), 1 megohm for ×10K(adjust R11). If, during calibration of any range, you are not able to achieve the proper calibration voltage, then vary R27 or R31 until the calibration voltage is achieved. After varying R27 or R31, you must return and readjust all previously adjusted ranges. (Adjust R3

continued on page 99

LOW POWER OHMS ADD-ON

continued from page 95

when readjusting the ×1 scale.) Since the accuracy of LOPAD depends on the tolerance of your calibration resistors, use the lowest tolerance resistors you have for calibration.

Using your new DMM add on

To use your LOPAD simply set the DMM to the 2-volt scale, turn LOPAD on, set S2 to the proper range, zero the meter, and read the resistance across the test leads. To interpret the resistance reading, simply take the number displayed, disregarding the decimal point, and multiply it by the range-setting multiplier. Meter readings of over 1.00 volt shouldn't be used; switch to the next higher range instead. For instance, if you are measuring a resistor with the color band markings of yellow, violet, brown; you will find the display will read 0.47 with S2 in the ×10 position. The "47" signifies the value of the first two color bands, yellow and violet. While the ×10 range setting gives the multiplier value of the third band, brown, or 470 ohms.

Using LOPAD with an analog meter

To use LOPAD with an analog meter, set the meter to the DC voltage scale you used for calibration, turn the LOPAD on, set S2 to the proper range, zero the meter, and make your resistance reading. To interpret the meter reading you must recall that you calibrated LOPAD so that with S2 in the ×1 and a 100-ohm resistor across the test leads, the meter read full scale. Thus you could make a special low-power ohmmeter scale with 100 at full scale, 75 at ¾ scale, 50 at ½ scale, 25 at ¼ scale, etc. Fortunately, on most meters, you won't have to do that because the meter already has a scale with a full-scale value of 100. That scale might be a DC or AC current or voltage scale. You won't be switching your meter to that function or switch position; you will simply be using that scale on the face of the meter.

If your meter doesn't have a 100 full scale, but does have a 10 full scale. You can use that scale. The ranges then become ×10, ×100, ×1k, ×10k, ×100k with a 10 full scale. For instance if you are measuring the resistance of a yellow, violet, brown resistor, you should read 47 with S2 in the ×10 position. The 47 signifies the value of the first two color bands, yellow and violet respectively. While the ×10 range setting gives you the multiplier value of the third band, brown or 470 ohms. If LED2 lights when you place the test leads across the resistor under test, then you have exceeded the upper limit of the resistance range. To remedy that, simply switch S2 to the next higher range. SP

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CIRCLE 627 ON FREE INFORMATION CARD

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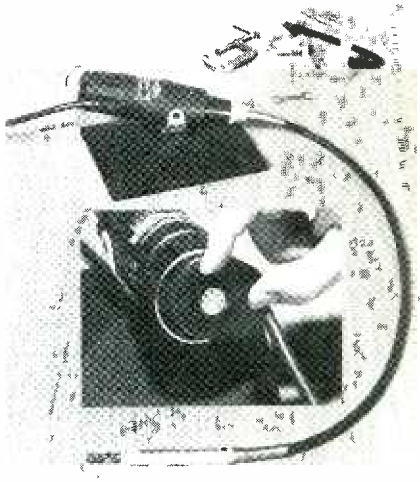
The weight of the *model 322* is 2 pounds, 1 ounce. It comes with a 1/8-inch collet and will accommodate all Dremel shank accessories. Other op-



CIRCLE 630 ON FREE INFORMATION CARD

tional collet sizes are 1/32-inch, 1/16-inch, and 3/32-inch. The tool's AC cord line is designed with a 3-wire grounding plug.

The suggested retail price of the *model 322* is $104.00.—**DREMEL,** Division of Emerson Electric Co., 4915-21st St., PO Box 518, Racine, WI 53406.

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