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Electronics**

special Projects

The magazine for people who like to build electronic gizmos

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FALL
1981

Projects.... Projects.... Projects.... Projects.... Projects....

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For Your TRS-80**

**Brake-Light Warning System
For Your Car**

**How to Make PC Boards
For Your Projects**

Electronic Finger Drums

**Turn A Digital Clock Into A
Frequency Counter**

Printmeter For Photographers

Walkie-Talkie Initiator

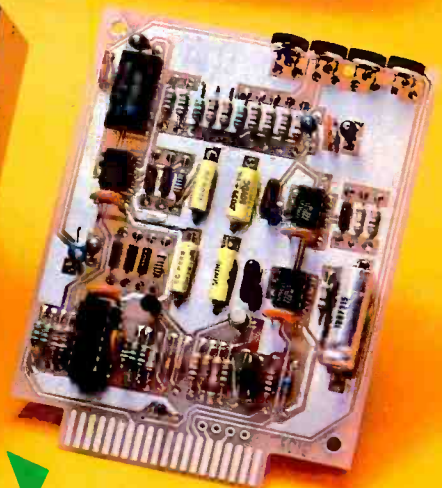
Stereo Timer

**Everything You Need To Know
About Electronic Kits**

Compresso-Amplifier

**Super-Sensitive Field
Strength Meter**

Time-Delay For Better Stereo

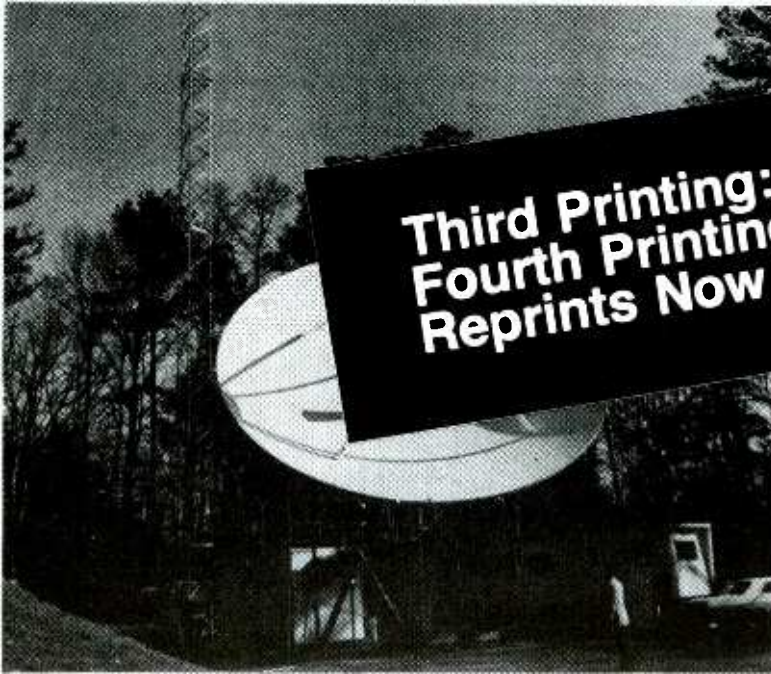


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Radio- Electronics

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Radio- Electronics Special Projects

We Keep Getting Better!

THE TITLE OF THIS EDITORIAL IS THE MOTTO OF OUR EDITORIAL DEPARTMENT—"WE KEEP GETTING BETTER". YOU ARE now reading the third issue of **Radio-Electronics Special Projects**; and just as in the two previous issues, we are bringing you a magazine that is chock full of different and interesting construction projects. Almost all have never before been published. Simple projects, complex ones, special-purpose ones and general-purpose ones. Every article is complete in this issue. And still we are not satisfied!

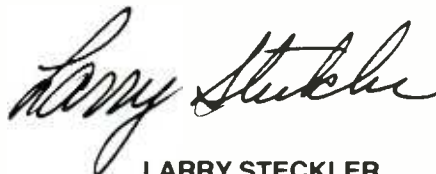
That's why there are two articles in this issue that do not tell you how to build an electronic device. However, they do tell you something you really need to know if you are going to build electronic devices at home. First there's a story on how to make your own custom printed-circuit boards. Since many of our construction articles include foil patterns for making your own PC boards, we felt that it was important to give those readers who don't already know how to make them some detailed easy-to-do instructions.

The second non-construction article is about electronic kits. It tells a bit about how the kit business got started, and then quickly goes on into the important stuff—who makes what. We tell about all the different kit makers that are in business today and the kinds of kits that each of them offers. If you find that we have left someone out, please let us know. We'll present the added information in our next issue.

To continue our policy of "We Keep Getting Better", we need your help. We need you to keep buying copies of **Special Projects**, but even more important we need you to tell us about the kinds of articles you want us to publish. Also, if you have a pet construction project of your own that you have built and are using, tell us about that, too. It could soon become an article in **Special Projects** enabling thousands of other readers to share it, too.

One last point. On pages 65 and 66 of this issue is a questionnaire that will let you tell us a little something about yourself. We need this data to help us determine the kinds of articles you want to read.

Once again, if you've read **Special Projects** before, I know you are going to like this issue even better. If this is your first look at our magazine, consider yourself hooked. Your next chance will be the Winter 1982 issue. It will go on sale December 3, 1981.



LARRY STECKLER
EDITORIAL DIRECTOR

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Radio- Electronics Special Projects

VOL. 1 NO. 3

FALL 1981

1 WE KEEP GETTING BETTER

A few words from our editorial director.

4 LETTERS

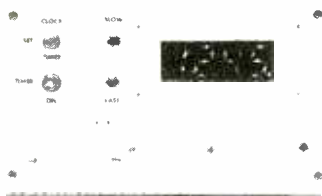
Your questions and comments.

6 NEW PRODUCTS

A selection of equipment and catalogs.

9 STEREO TIMER

You don't need to be home to record.

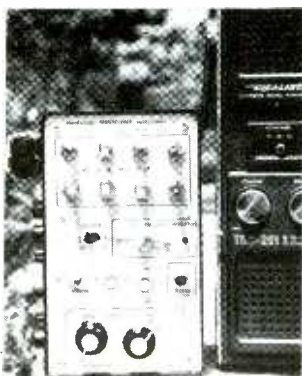


13 SUPERFUZZ FOR YOUR GUITAR



Easy to build fuzzbox you'll want to own.

20 WALKIE-TALKIE INITIATOR



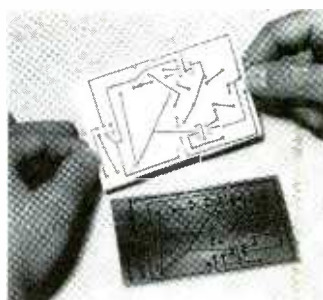
Automatic turn-on at preset intervals.

26 AUTO-POWER MIKE PREAMP



Tiny unit even turns itself off when not in use.

36 CUSTOM PRINTED CIRCUITS FOR YOUR PROJECTS



Step-by-step procedure for making your own boards. It's easy.

29 PRINTMETER FOR PHOTOGRAPHERS



Get perfect prints the easy way.

44 DIGITAL BRAKE-LAMP WARNING SYSTEM

Alerts the driver behind you when you start to stop.

53 SUPER-SENSITIVE FIELD-STRENGTH METER

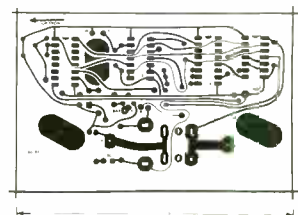


Great for 100-mW CB and other low-power xmitters.

41 INTERVAL TIMER

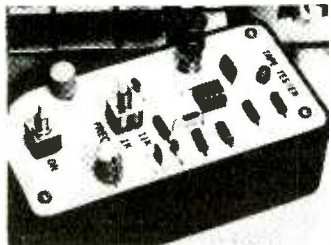


Built around a common available clock module.



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See which tapes are best for your player.



74 COMPRESSO-AMP



Equalizes the level of loud and low sounds for clear taping.

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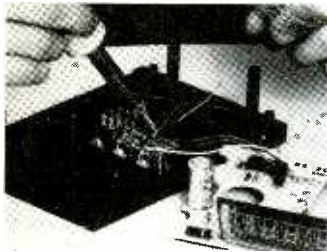
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56 KITS FOR PROJECT BUILDERS



Everything you ever wanted to know about who makes what kits.

70 TTY PRINTER CONVERTER



Lets you connect a teletype printer to your personal computer.

67 CLOCK INTO COUNTER

Take one inexpensive digital clock. Add a 555. Presto! Now you have 100-kHz frequency counter.

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We've got some questions you could help us with.

84 MOTOR-SPEED CONTROLLER

The right IC's in the right circuits.

79 ELECTRONIC DRUMS

Carry them with you wherever you go.



89 BUILD A BEEPER FOR YOUR TRS-80

Avoid double-typing and other common personal-computer problems.

93 PROJECTS FROM ENGLAND

Construction articles you'll want to build.



letters

I LIKE PROJECTS

Dear Editor:

You sure have what I want—lots of projects to build. Keep them coming. Can't you do it every month?

CHARLES WILSON
Los Angeles, CA

All we can do is keep turning them out every three or four months. You can expect to find us publishing four issues each year. Since you like us so much, why don't you help us get even better? Turn to page 65, fill out the questionnaire and mail it in. Thanks for the pat; we'll try hard to keep on earning it.—Editor

IT ISN'T ENOUGH

Dear Editor:

I loved your Spring issue, but why wasn't it larger? I'd like to get 50 projects each issue. Otherwise, just keep up the good work.

GEORGE CARLSON
Baltimore, MD

What a positive negative! If everyone else out there who likes building projects buys the next couple of issues we might be able to make you completely happy. In the meantime you'll have to settle for a little less than perfection.—Editor

CORRECTION

Dear Editor:

As promised in my recent telephone call, here is a correction to the article "A Reliable Burglar Alarm." This story appeared in the Spring 1981 issue of **Special Projects**.

Sentence number 4, last paragraph of Panic Mode, at the top of page 56 reads "Similarly, the same results can be had by adding a switch across the closed switching network." That sentence should have said; "Similarly, the same results can be had by adding a switch *in series* with the closed switching network."

This change is needed to inhibit the action of both open-loop and closed-loop switches effectively, and thereby put the alarm into a panic-switch-only mode of operation. As it was, a switch across the closed network did not prevent open-loop entry switches from setting off the alarm. If that did happen, the interior alarm would go off and give plenty of warn-

ing to shut off the system. However, it could also leave a shopkeeper unable to use the Panic Mode during business hours. He would then have every reason to feel that the system did not perform as the article claimed.

If anyone contacts me directly, I will send him or her my standard Installation and Operation instruction sheet and will underline in red the series-switch installation portion of the Panic Mode instructions.

Not mentioned in the article or the instruction sheets is the ability to make the alarm do things a bit differently. Many users want something other than a siren for exterior alarm purposes. If diode D10 and capacitors C8 and C9 are simply left off the circuit board, the exterior output becomes just a steady DC voltage that lasts for about six minutes. That can operate a relay that can, in turn, operate any AC or DC-powered noise-maker.

EDWARD R. CONNER
The Ercon Company
6744 48th Ave. SW
Seattle, WA 98136
(206) 932-6150

MEASURING CAPACITANCE

Dear Editor:

In reference to my article "Use a DMM to Measure Capacitance" in the Winter 1981 **Special Projects**, I have discovered that some recent models of DMM's do not have the standard 10-Megohms internal impedance referred to in my text.

I would suggest then that readers who have DMM's check their user's manuals and, if necessary, recalculate the proper resistance needed to produce the shunt values given in the table. Depending on the characteristics of one's DMM, the last two values in the table may be affected.

DON R. KING

FOIL-PATTERN SIZES

Dear Editor:

I was planning to "lift" the PC-board foil pattern for the Digital Do-Nothing on page 12 of the Spring 1981 **Special Projects** until I noticed that the dimensions were off—an IC placed on the pattern would not fit—so the project was scrapped. I was really disappointed. Is there anything that

can be done about this?

KEN VASSY
Shelby, NC

Depending on the size, we normally reproduced foil patterns either full-size or half-size (the dimensions indicated represent the true size of the board). In this case, we made a slip and must apologize.

What you should do now, or when a pattern is reproduced half-size, is take it to an outfit that produces photostats and ask that they make you a positive of the correct size on film or acetate. (Use the 0.1-inch spacing of the IC pins as a reference.) That positive can then be used to make your PC board.—Editor

FINDING COILS

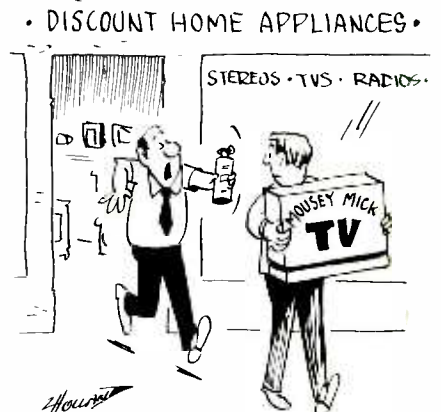
Dear Editor:

Many projects that are published, such as the Short Wave Booster feature in the Spring 1981 **Special Projects**, use tuned circuits and usually specify Miller coils.

Those coils are difficult to locate, even by mail order. Do you know a good source for them?

BRET C. SINGER
Nellis AFB, NV

One firm that has a large selection of coils in its catalog is: Circuit Specialists, Box 3047, Scottsdale, AZ 85257. They have many other hard-to-find items, too.—Editor. **SP**



"Sir, this goes with it—an emergency fire extinguisher."

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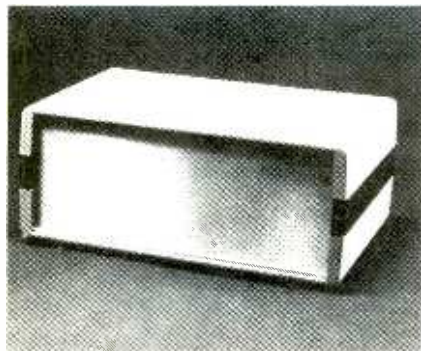
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mentation, audio equipment, small computers and just about any other kind of equipment that belongs on a bench.—**Global Specialties Corp.**, 70 Fulton Terrace, New Haven, CT 06509.

WORK CENTER, Model 324. A combination of *Model 300* Standard Base, *Model 312* Tray Base Mount, *Model 315* Circuit Board Holder and *Model 371* Solder Station. Combination is based on consumer demand, according to manufacturer, and



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offers price advantage when all units are purchased as a group. \$49.95. Solder and soldering iron are not included.—**Pana-Visé Products Inc.**, 2850 E. 29th Street, Long Beach, CA 90806.

EXTENDED RESISTANCE RANGE, Accessory for Circuitracer. Extends continuity range to 1500 ohms. *Model 221 Light*

Emitting Diode fits manufacturer's models 100, 110, 120 and 130. Extends range for continuity tester from 10 ohms to 1500 ohms. Allows *Circuitracer* to be used for tracing circuits with low resistance.



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such as heating elements or the window tape circuits of alarm systems.—**Desco Industries Inc.**, 351 F Oak Place, Brea, CA 92621.

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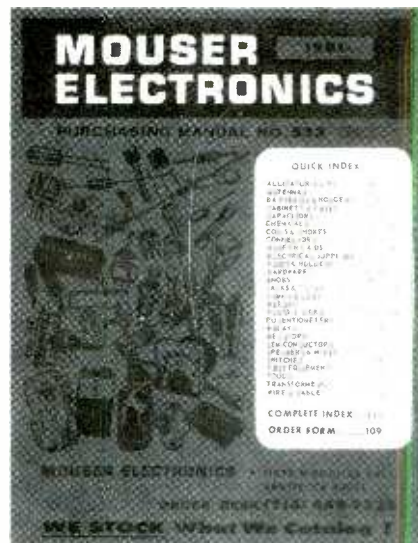


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resistor networks: 10- and 15-turn turns-counting dials; and wirewound precision potentiometers.—**Beckman Instruments Inc., Instrumentation Products, Advanced Electro-Products Division**, 2500 Harbor Blvd., Fullerton CA 92634.

PURCHASING MANUAL, No. 533, is a 112-page catalog of electronic parts, tools, and equipment, from alligator clips to wire and cable, meticulously organized

and fully illustrated. Antennas, cabinets and cases, capacitors, connectors, drafting aids, jacks and plugs, lamps and LED's, potentiometers, relays, resistors, semiconductors, speakers, and mikes, switches, test equipment, tools, and transformers are just a sample of the wide range of



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offerings. The manual No. 533 (1981) is priced at \$2.00.—**Mouser Electronics**, 11433 Woodside Ave., Santee, CA 92071.

DMM's model Tech 350 and model Tech 360, are both bench-top 3½-digit multi-meters, designed to be used by electronic engineers, technicians, and hobbyists. Both meters have a 20-ohm full scale



**CIRCLE 543 ON
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range, and feature 12,000-hour battery life, 0.01-ohm resolution, diode and transistor check, 0.1% basic DC accuracy, and a single rotary switch that selects 31 ranges in eight different functions.

The *model Tech 350* is an average-responding meter, and is priced at \$229 in the U.S.A.; the *model Tech 360* is a true RMS meter with built-in temperature measuring capability, and costs \$289.00 in the U.S.A. — **Beckman Instruments, Inc.**, 2500 Harbor Blvd., Box 3100, Fullerton, CA 92634.

SHORT FORM CATALOG, 1981, is a 28-page brochure providing complete specifications and prices for a variety of microcomputer prototyping boards, breadboarding supplies, and packaging equipment.

Included are five pages describing microcomputer prototyping boards, one page describing perforated boards, and eight pages illustrating enclosures and

card cages. Other sections are devoted to wire-wrapping tools, terminals, sockets, receptacles, and etched-circuit kits. A

Vector

SHORT FORM CATALOG
1981



CIRCLE 544 ON
FREE INFORMATION CARD

complete index appears on the third cover.

Vector Electronic Co., Inc., 12460 Gladstone Ave., Sylmar, CA 91342.

REPLACEMENT GUIDE, SK Series 1981, is 408 pages and lists over 1300 solid-state replacement devices that replace more than 170,000 domestic and foreign types. The guide shows the SK stock number, along with the stock number of the numbering system used by ECG (a trademark of GTE Sylvania), REN, and TM—thus making it easy to locate the correct solid-state replacement device in this one publication.

There is information on the complete line of RCA's replacement transistors, rectifiers, thyristors, integrated circuits,



CIRCLE 545 ON
FREE INFORMATION CARD

and high-voltage triplers, including many MRO replacements. There is also an index and comprehensive data section, with listings grouped according to the type of device.

The SK-Series 1981 Replacement Guide is priced at \$2.25—RCA Distributor and Special Products, PO Box 597, Woodbury, NJ 08096.

<p>COLOUR MODULATOR \$24.95</p> <p>This video modulator has been designed to complement the small home computer. It allows the standard colour television to be used as a high quality colour video monitor. Uses state of the art integrated circuit technology. Direct coupling is employed to provide white level compensation in the vestigial sideband output. The gain device of the LM1889's chroma oscillator is used to buffer, level shift, and invert the incoming composite colour input. The signal then passes to the RF modulator where a channel 7 carrier is provided. Requires 12 volt DC for operation.</p>	<p>ARKON LOGIC PROBE 1 \$24.95</p> <p>Easy to build Logic Probe kit. A full performance logic probe. With it, the logic levels in a digital circuit translates into light from the Hi or Lo LED. Pulses as narrow as 300 nano seconds are stretched into blinks of the pulse LED's. Specs — 300 Kohm imp. Power — 30ma at 5 volts, 40ma at 15 volts, 15 volts max. Max. Speed — 300 nano seconds 1.5 MHZ. Input Protection — + 50 volts DC continuous, 117 volts AC for 15 seconds. (case included)</p>
<p>THE BRUTE 300 WATT AMP</p> <p>This kit is not recommended for beginners or inexperienced constructors. Power output: 200 watts RMS, 8 ohms, 310 watts RMS, 4 ohm. Input sensitivity: 1V for total output. This kit uses all standard parts and comes complete with instructions and printed circuit board (mono) (transformer required) 100 VCT 5 amps. is available for \$51.00 #167P100. P.C. Board \$11.25</p>	<p>LED POWER METER \$24.95</p> <p>Uses the popular LM3915 display driver. Features switch selectable peak or average peak power level indication. The front end utilizes precision half wave rectification. LED displays included 30 db (-24 db to +3 db) dynamic range.</p>
	<p>LED VU/POWER METER \$29.95</p> <p>Same as LED power meter but uses NSM series display.</p> <p>Two types — NSM 3915 — 30 db (-24 db to +3 db power) — NSM 3816 — 23 db (-20 db to +3 db VU)</p>
	<p>POWER SUPPLY \$16.95</p> <p>This kit has been designed to satisfy the need for an economical power supply. Provides 5 volt DC at lamp for TTL projects plus a separate floating power supply that is variable from 5 to 35 volt DC at 1/2 amp for CMOS and other uses.</p>

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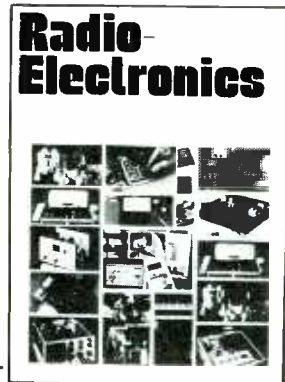


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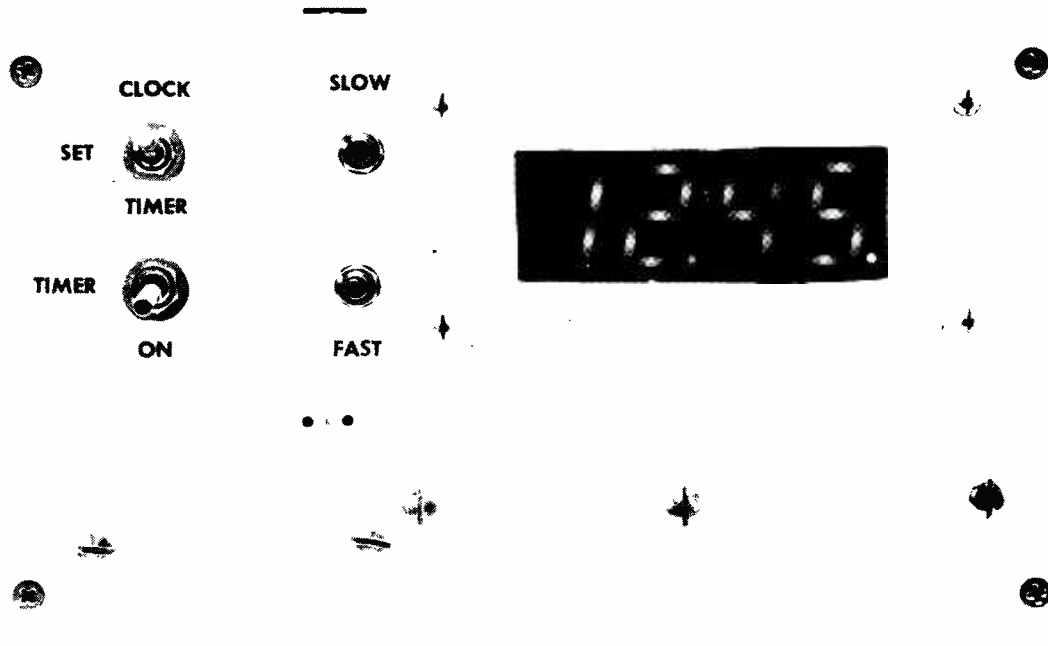
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STEREO TIMER

Record radio programs when you're not at home with this digital timer. It works just like the one on a VCR.

BY HERB FRIEDMAN

WITH THE *STEREO TIMER* YOU NO LONGER NEED TO BE home to record your favorite AM-FM programs. Now, you simply preset your tuner to the desired station; set your cassette recorder to RECORD; and set the Stereo Timer to the desired starting time. With better than 60-second accuracy, the Stereo Timer will fire up your stereo system and the recorder. That's right! It works just like the digital timers used on VCR's (Video Cassette Recorders).

You *could* use a mechanical timer such as those sold in hardware stores to do the same thing. (It's done every day.) Unfortunately, mechanical timers have an accuracy of ± 5 to ± 15 minutes. This means that you will be recording a lot of "hash" before the desired program or could lose part of the program. With an electronic timer you start right on the program—or, at worst, a few seconds early.

The Stereo Timer uses a readily available clock module as the main timing and control element. That device (originally intended to be used as a digital clock, or in a clock-radio) has an on-board control transistor that functions with the alarm mode. It turns ON for 59 minutes at the alarm set time. By using the control transistor with a self-latching relay we come out with a stereo timer. At the selected alarm time the controlled clock-module output applies power to re-

lay RY1. When the relay-contacts close, one set applies 117VAC to power outlet S01. The second set of RY1 contacts self-lock the relay. The self-locking contacts remove RY1's control from the clock module so that 59 minutes later—when the clock module releases the alarm circuit—RY1 stays ON until the user deliberately releases the timer control with switch S2.

The power-outlet control is exactly the same as the ones used for VCR's. When S2 is in its normal (timer off) position, power is continuously applied to the power outlet (S01). That allows your equipment to work normally without having to rearrange the equipment's line cords. When S2 is set to the TIMER position, power is removed from the outlet and is applied only when the clock reaches the user-set alarm time.

A logical question at this point is: "Why use a relay to switch power? Why not all solid state?" There are several reasons: the main one is that if there is trouble with the relay circuit the 117VAC line can in no way be applied to the clock module. Also, the relay is almost universally available, which is not true of many solid-state switching components. Finally, the current capacity of the controlled power is limited only by the size of the relay contacts. If you want to use the timer to start the morning coffee pot, or an electric oven, just plug in the appliance. But be certain that the relay contacts can handle the load. The relay specified in the parts list will handle up to 3-amperes. If you need to

control more power, use the next available relay size, which has 10-ampere contacts. If you plan to switch up to 3-amperes ordinary "zip" linecord can be used for all connections between the relay and the power outlet. For more than 3-amperes use at least No. 16 wire and make certain that power-outlet S01 is rated for the maximum current you plan to control.

Note that the relay has DPDT contacts, with the N.C. (normally closed) contacts unused. If you want the timer to *turn off* the power outlet at a predetermined time (rather than turning the power outlet *on*), make your power connections to RY1's N.C. contacts: those labeled A and B in the schematic.

Construction is easy

The timer fits nicely into a 7½ × 4¼ × 2¾-inch plastic utility case. **Do not use a metal cabinet or front panel:** There's too much "high voltage" loose inside the project and a single loose strand of wire can give you a *hot* metal cabinet or panel. All-plastic is less expensive and safer.

Layout isn't critical; simply approximate the one shown in the photographs. Position all the major components—the clock module, transformers, relay, and switches—on the panel and push them around until you have a usable layout. Then mark the mounting centers on the panel.

The clock module can be mounted directly to a plastic panel without stand-off insulators because there's no way that the plastic will short-circuit the connections sticking through the module's PC board. However, if you use a metal cabinet or panel (which, once again, **is not recommended**) you *must* use standoff's at each of the module's mounting holes to prevent the printed foils and connections from shorting to the panel.

Relay RY1 is supplied with a socket. The easiest

PARTS LIST

- BR1—50PIV DIP diode bridge (Radio Shack 276-1161)
- C_x—100-μF/25-35 VDC (see text)
- CM1—clock module (Radio Shack 277-1006 or equal)
- D1—see text
- RY1—12VDC/DPDT relay (Radio Shack 275-206 or equal)
- SO1—AC outlet (socket)

SWITCHES

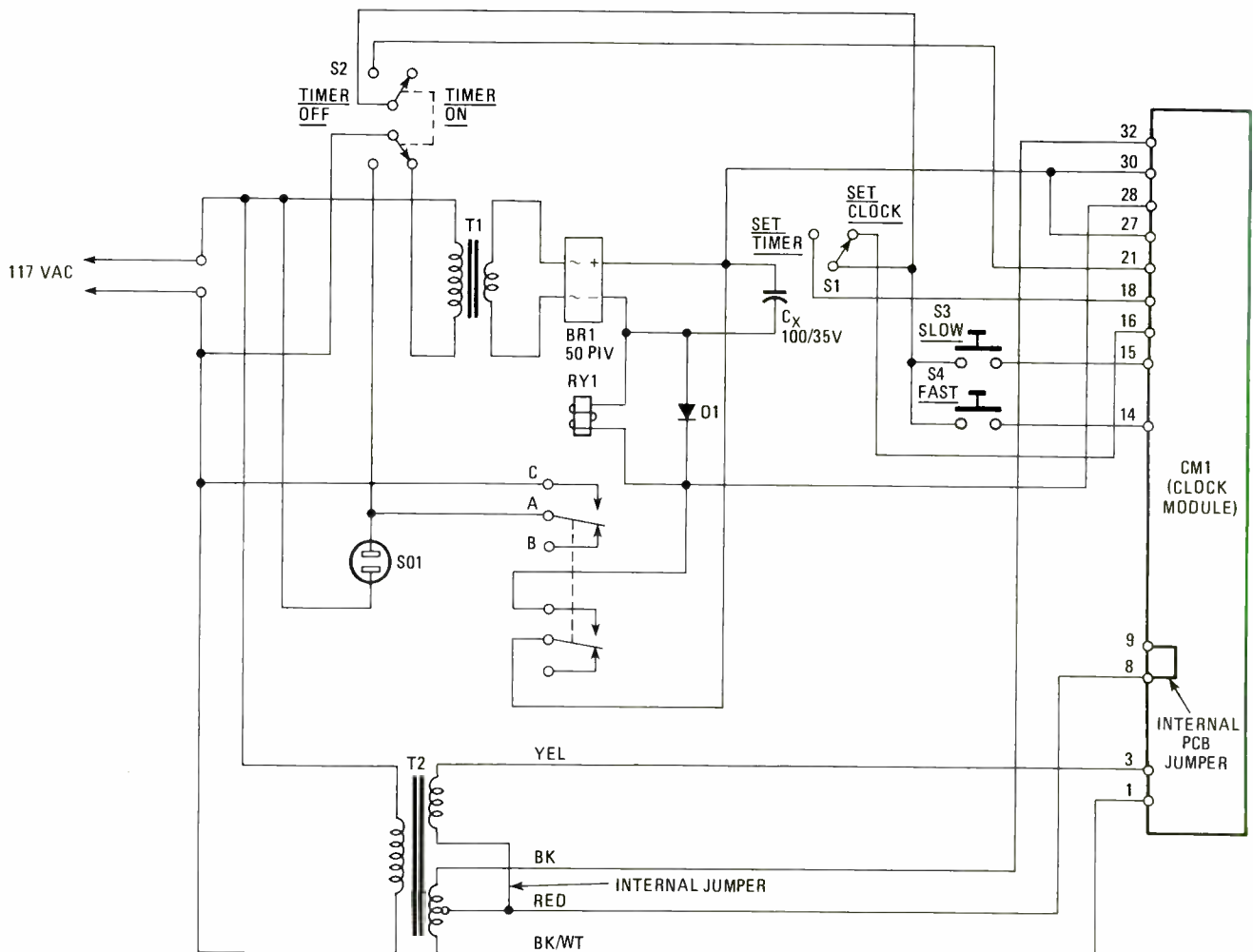
- S1—SPDT switch
- S2—DPDT switch
- S3, S4—N.O. momentary push-button switch

TRANSFORMERS

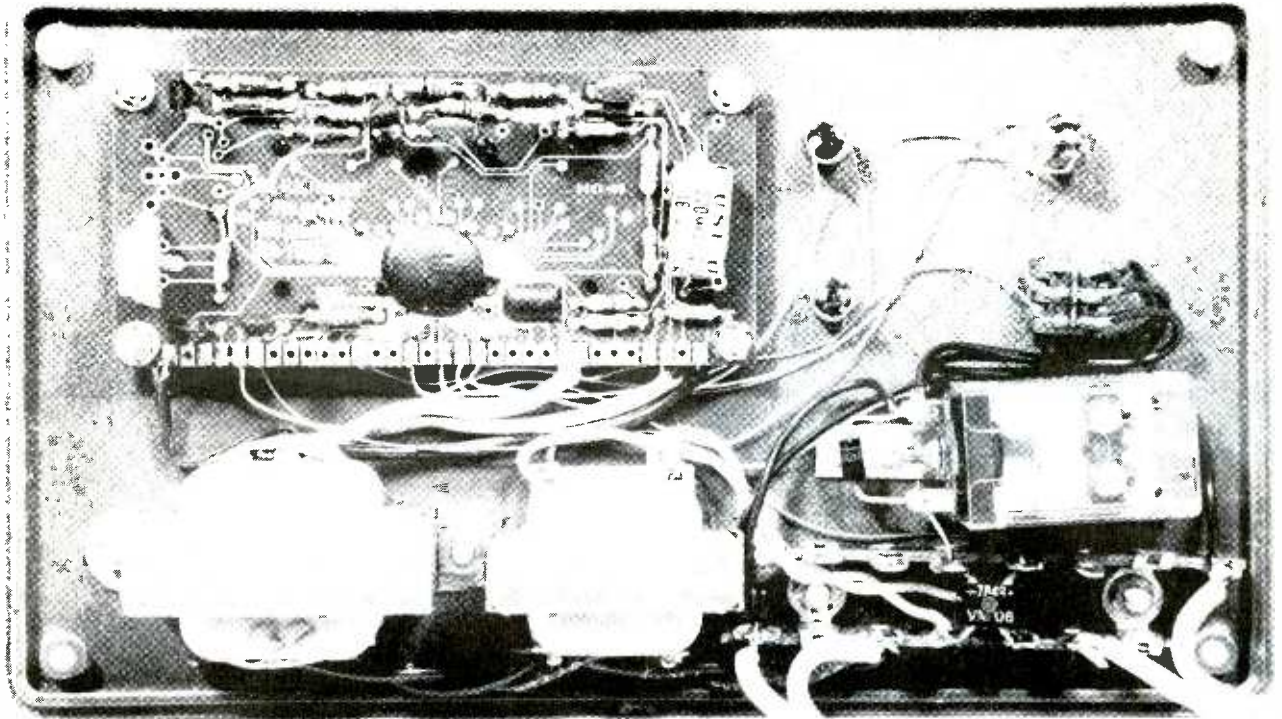
- T1—12.6V 300-ma transformer (Radio Shack 273-1385 or equal)
- T2—clock power transformer (Radio Shack 273-1530 or equal)

MISCELLANEOUS

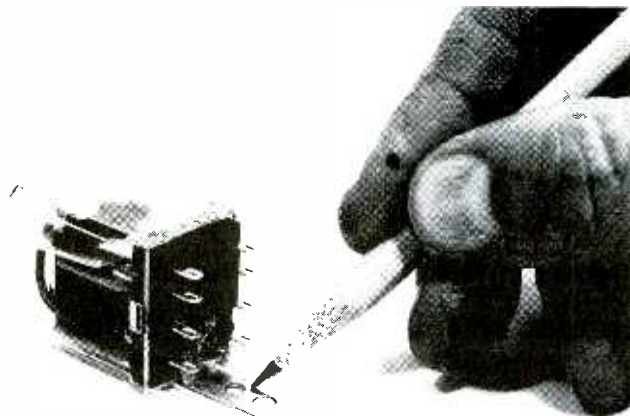
- Cabinet, wire, etc.



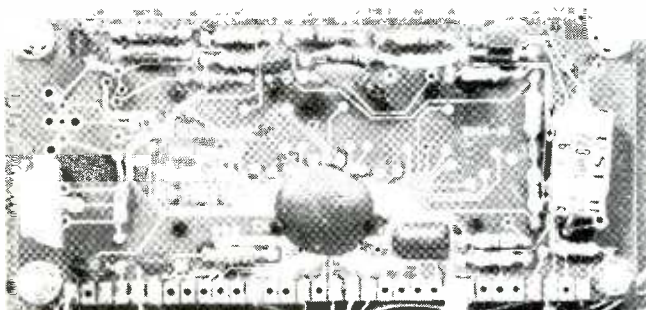
THE CLOCK MODULE is the heart of the stereo timer as shown in this schematic. The module, originally intended to be used in a digital clock, is readily available.



THE COMPLETED STEREO TIMER. Except for the controlled power leads, all connections were made with No. 30 wrap-wire with $\frac{1}{8}$ " insulation removed from the ends. Ordinary solid hookup wire can be used if desired. Do not use stranded wire for clock module connections, because a single "free" strand can easily bridge two solder pads.



A SMALL MOUNTING FOOT, fashioned from scrap aluminum, holds RY1 in place. Note the two mounting holes for two panel-mounting screws. Make certain that the relay cannot move on the panel.



THE BACK OF THE CLOCK MODULE has a row of solder pad connections along the bottom edge. The extreme right pad is No. 1, and it's the only pad that's marked. Make certain that you count all clock connections from the No. 1 terminal.

way to install it is to eliminate the socket and to solder directly to the relay's solder lugs. When you pull the socket off the relay you will find a screw sticking through the relay. The plastic on each side of the screw is cut away—forming a sort of "keyway." From scrap aluminum, fashion a small mounting foot that fits snugly into the keyway and over the screw. When the mounting nut is tightened, the keyway holds the foot from turning; that provides a "solid" mounting to the panel. The foot should be secured to the panel with *two* screws or *Pop-Rivets*. Do use a single-screw panel mounting; that will permit the relay to turn—the last thing you want in a device handling "high voltage."

Any 50-PIV bridge rectifier can be used for BR1. The one specified in the parts list, however, has both AC and both DC terminals *inline* (4-pin DIP) which allows it to span easily between two parallel terminal strips, as shown in the photographs. It simply makes for easier assembly.

The connections to the clock module are made to solder pads along one edge of the PCB. The pads are not individually numbered. While looking at the back of the module—the side to which you will make the connections (the LED displays are on the opposite side of the PCB)—with the strip of solder pads at the bottom, pin 1 is at the extreme right side.

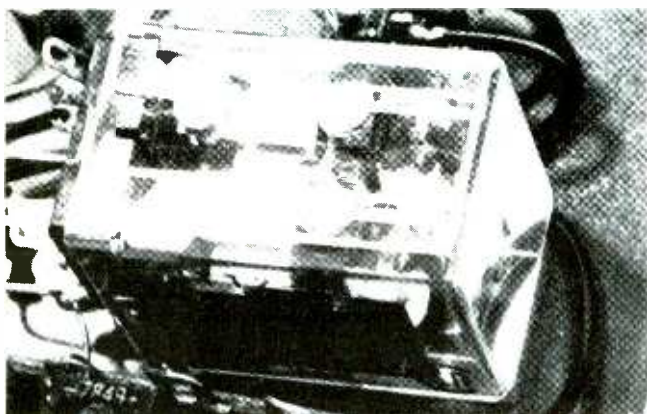
It is very easy to form solder bridges across the pads, so use a low wattage (20-50 watts) *pencil-tip* soldering iron (no solder guns). Use only *solid wire* for connections to the module; *No. 30 wrap-wire* with about $\frac{1}{8}$ -inch insulation removed from the ends is ideal. Note that there is a jumper from terminal 27 to 30.

Install the jumper before making any other connections—it's easier. There is a natural PC board bridge between terminals 8 and 9; you can make your connection to either terminal.

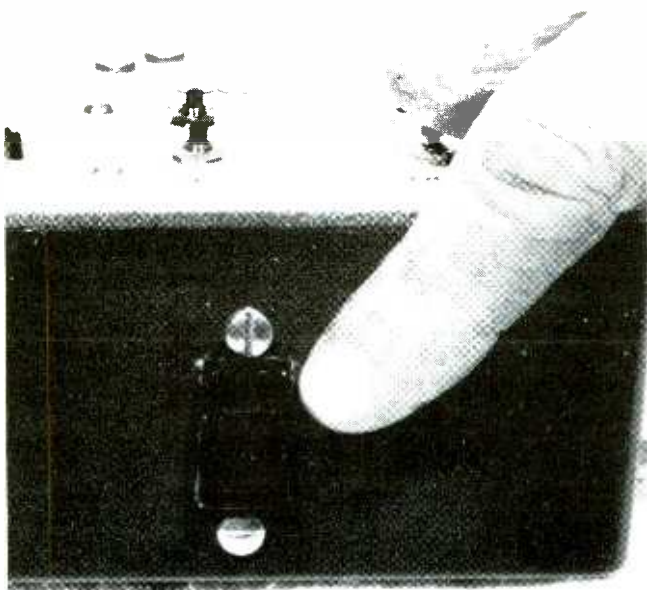
Transformer T2 is a special model, specifically intended for the clock module. It has only *four* secondary leads instead of what appears to be a required *five*. The two secondaries are connected by a factory pre-wired internal jumper.



THE NUMERIC DISPLAY HAS THREE DOTS. The flashing dot in the center is the colon. The dot at the upper left indicates PM. The dot at the lower right indicates the timer is turned on (armed).



A DIP STYLE RECTIFIER BRIDGE has the AC connections on one side and DC on the other. This allows the bridge to be spanned easily across two parallel terminal strips.



THE CONTROLLED-POWER OUTLET is located on the rear of the cabinet. All power connections to the outlet and relay power contacts should be made with standard "zip" linecord or its equivalent.

Take extra care when wiring S2, which removes power from T1 when the timed power control isn't being used. Note that when S2 "opens" clock contact No. 21 (it sets the timer mode ON), it closes the power connection to T1. Conversely, when S2 closes the No. 21 contact—which turns the timer mode OFF—it both opens the power connection to T1 and "shorts" RY1's power control contacts, thereby providing continuous power to S01.

Silicon diode D1 is an *inductive kickback* suppressor that prevents the induced emf (caused when current is removed from RY1's coil) from "blowing" the radio-control transistor in the clock module. *Do not eliminate D1.*

Capacitor C_X, 100- μ F/25-35 VDC, will probably not be needed. If RY1 "sings," or gets what you judge to be *excessively warm* after one-hour's operation, then install C_X across RECT1 (get the polarity correct the first time). C_X simply provides a "smoother" DC for RY1.

Checkout before using

Connect a light bulb (or other suitable 117-volt indicator) to power-outlet S01. Set switch S1 to CLOCK (clock module terminal No. 16 *on*) and switch S2 OFF (no line voltage to T1). Connect the Stereo Timer to a 117-volt outlet. The clock digits should turn on and *flash*. (Flashing digits means that power has been previously interrupted.) Also, the light connected to S01 should turn on. Pressing either the *fast* or *slow* clock/timer setting push-buttons will cause the clock to stop flashing. Hold down the *fast* button. As the clock cycles past 11:59 a small dot will turn on in the upper left corner: That is the PM indicator. (The clock might have first turned on with the dot *on*, and cycling past 11:59 would turn the dot *off*.)

The PM dot functions for both the clock and timer modes. If you want the timer to turn on S01 at 8:30 PM you must set the clock-module timer mode to 8:30 with the dot *on*. A dot in the lower right corner indicates that the timed outlet is "armed"; the dot turns on when S2 is in the TIMER position.

Make certain that the module does not indicate the same time for both CLOCK and TIMER modes and move S1 to the timer ON position; the test lamp should go out, because arming the timer removes power from the outlet. Note the timer set-time on the module and advance the clock display to one-minute before the timer display. When the clock steps to the timer reading the test lamp should turn on and remain on.

If the timer has been on longer than one hour the timed outlet is reset by simply moving S2 to the OFF position. If the timer has been *on* for less than one hour, first change the TIMER module set-time to any time other than the actual time (press the *fast* push-button), then open S2.

SP

SUPERFUZZ FOR YOUR GUITAR



***Get that professional rock sound
with this project.***

BY HERB FRIEDMAN

IF YOU'RE INTO THE ELECTRIC GUITAR—OR KNOW someone who is—you're probably into *rock*, *punk*, *heavy-metal*, and possibly *fusion*. All of it is music that makes use of the *fuzzbox*, the device that creates the "rough-tough" sound of an electric guitar. Actually, a fuzzbox is simply a device that distorts the electronic signal from the guitar pickup(s). By clipping the waveform, odd-order distortion products (3rd, 5th, etc.) are generated. Those create the *heavy* or *fuzzy* sound so commonly used in modern contemporary music.

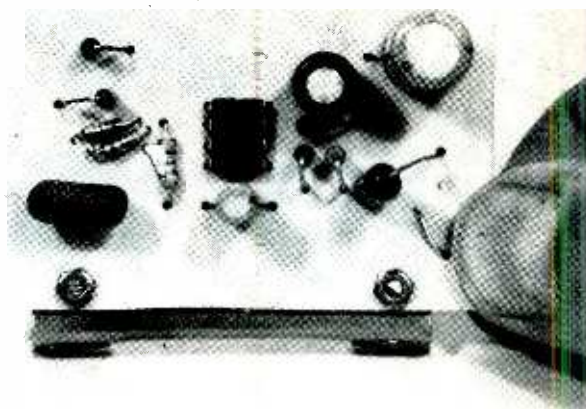
The problem is that it's difficult to get a good solid distortion with an ordinary clipping amplifier because the lower levels from the guitar tend to slip under the clipping level, and what comes out of the speaker is *clean* low level and *fuzzy* high level.

Superfuzz, on the other hand, gives you fuzz at virtually all volume levels because it has a predriver for the clipper, that is, in itself, an amplifier. The clipping is right "on the deck," so to speak. For intermediate or light fuzz effects the user simply adjusts a potentiometer that backs off the driving signal to the clipper diodes.

How it works

The input signal from the guitar pickup(s) is connected through J1 to operational amplifier IC1-a which provides approximately 10-dB preamplification. That is about the optimum value for this circuit. Don't try for "more" fuzz by increasing IC1-a's gain. The output from IC1-a is fed to the inverting input of operational amplifier IC1-b. Its gain can be varied from approximately 20 dB to unity with potentiometer R6. (The inverting input is used because it can handle the high level from IC1-a without overload.)

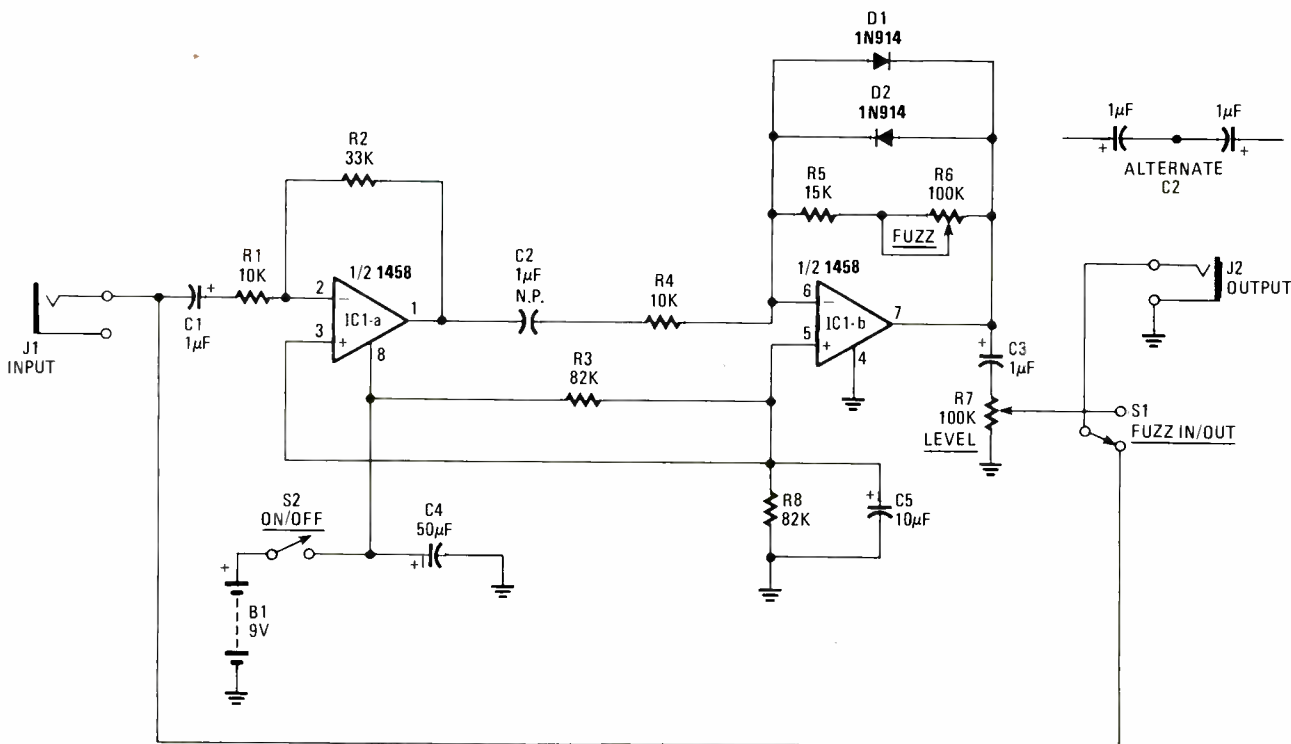
The output from IC1-b is "clipped" by diodes D1 and D2 at approximately 0.7 volt. The greater the gain



MOST OF THE CIRCUIT IS ASSEMBLED on a small printed-circuit board that is secured to the cabinet with a small L-bracket.

set by R6 the *deeper* the clipping because the weaker music signals are amplified to the clipping level. Theoretically, it's possible to get even deeper clipping by using germanium diodes because they break-over, or conduct, at approximately 0.3 volt; but it doesn't work out that way. Unfortunately, 0.3 volts is too deep, and the signal tends to get muddy. But if you want to try it, go ahead—you might like the effect.

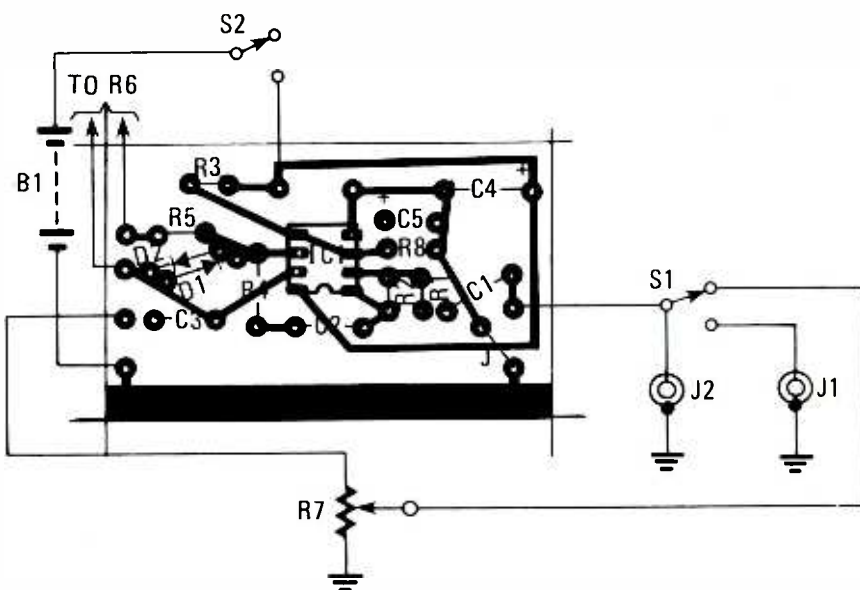
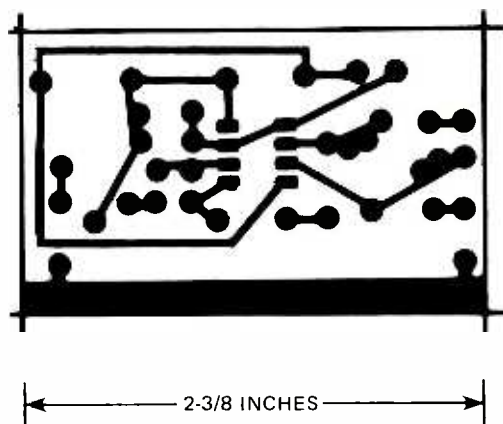
Power is provided by a single 9-volt transistor-radio-type battery that should last several weeks even with frequent use, because current drain is low—2 mA (nominal value). Though the op-amp normally requires a bipolar power supply, to keep things simple the *Superfuzz* uses a single-ended power source (common ground from one battery) by floating the non-inverting inputs of both op-amps at the power-supply midpoint, which is established by voltage divider R3 and R8.



SCHEMATIC DIAGRAM of the Superfuzz circuit. The values of capacitors C1-C3 can be changed somewhat to alter sound quality (see text).

At first glance, coupling capacitor C2 doesn't look as if it's needed; or if it is used, why a non-polarized type instead of a standard electrolytic? C2 is simply a safety device that eliminates the problems that might be created by using common-tolerance components (such as 10% resistors) elsewhere in the circuit. If you can't locate a 1- μ F non-polarized capacitor you can substitute a pair of back-to-back electrolytics: two capacitors with their negative leads joined and connected into the circuit by the two remaining positive leads, or vice versa.

FOIL PATTERN (below) for the printed-circuit board is shown full size. **PARTS PLACEMENT DIAGRAM (right)** for the Superfuzz. Layout is not critical, so the foil pattern and the parts layout can be changed if needed.



PARTS LIST

RESISTORS

$\frac{1}{4}$ watt, 5% unless noted

- R1, R4—10,000 ohms
- R2—33,000 ohms
- R3, R8—82,000 to 100,000 ohms (both same value)
- R5—15,000 ohms
- R6, R7—100,000 ohms, potentiometer

CAPACITORS

10 VDC or higher

- C1, C3—1 μ F, electrolytic, see text
- C2—1 μ F, non-polarized, see text
- C4—50 μ F, electrolytic
- C5—10 μ F, electrolytic

SEMICONDUCTORS

- IC1—1458 dual op-amp (Radio Shack 276-038 or equal)
- D1, D2—1N914 silicon diode

MISCELLANEOUS

- S1—SPDT push-push switch
- S2—SPST switch
- J1, J2—phone jack
- B1—9-volt battery
- Cabinet, battery terminals, PC materials.

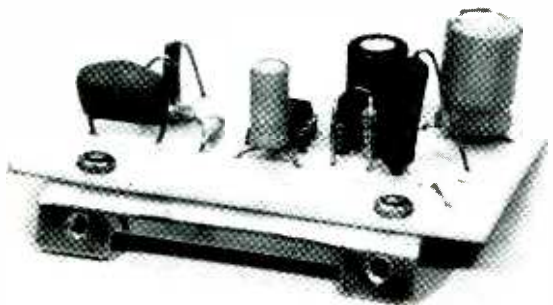
The ear hears differently

Potentiometer R7 is used to balance the *average power* of the direct guitar sound with that of the fuzz-box. When a signal is clipped and then adjusted for the desired volume level, its average power is greater than that of an unclipped signal with the same peak-signal level. The greater the clipping the greater the average power. The ear is sensitive primarily to *average power*, not peak power. If two signals both have the same peak level but one has higher average power than the other, the ear senses the higher average-power sig-

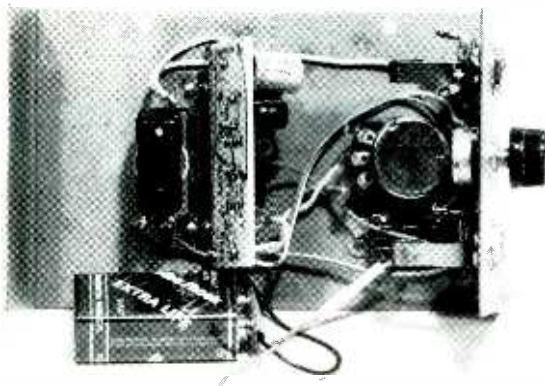
nal as the louder of the two. In fact, if one signal's peak power is considerably greater than the other but it's average power is less, the ear will sense the one with the higher average power as the louder signal even though it has less peak power. R7 is used to equalize the average power so the listener isn't knocked off his or her seat when the musician keys in the fuzz by stomping on switch S1.

It's done this way: First, S1 is adjusted so that the fuzz effect is switched out and the guitar's normal volume adjustment is set for the normal listening volume. Next, the fuzz is switched in with S1, and R6 is adjusted for the desired fuzz effect. Then R7 is adjusted so that the fuzz effect sounds to the ear as if it's the same volume level as the direct sound from the guitar—when S1 switches the fuzz effect out.

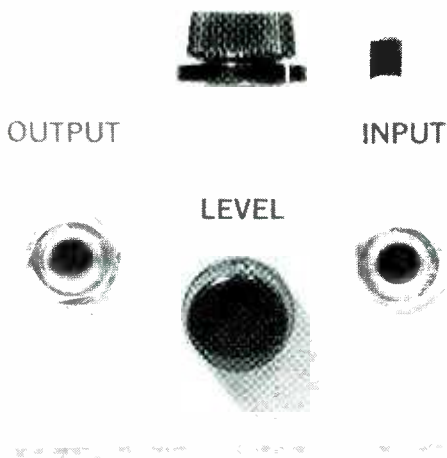
The circuit shown is designed for the widest possible low-frequency response. If you find the bass is somewhat *heavy* for your taste—if you would prefer a *lighter* fuzz effect from the lower notes—change the value of capacitors C1 and C2 to 0.47 μ F, or even 0.22 μ F. Capacitor C3 need be 1 μ F only if the input impedance of the amplifier connected to output jack J2 is 20,000 ohms or lower. If you know for certain (from reading the amplifier's specifications) that the input impedance is greater than 20,000 ohms—say 50,000 ohms—capacitor C3 can be changed to 0.47 μ F.



FOR A MINIATURE, HIGH-DENSITY ASSEMBLY, install the components mounted "on end." The PCB template shown does not provide enough clearance for resistors mounted flat on the board. If you prefer flat mounting, modify the template accordingly. Note how the L-bracket used for securing the assembly to the cabinet is attached to the PCB.



THE COMPLETE SUPERFUZZ. The on-off effects switch is directly to the left of the PCB. The unit is not sensitive to feedback from interlead coupling, so just about any layout can be used for the cabinet components.

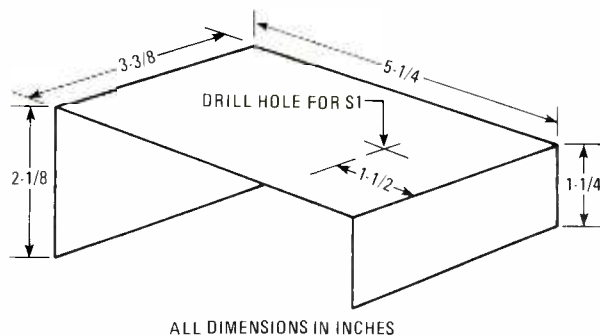


THE INPUT AND OUTPUT CONNECTIONS are on the end of the cabinet along with the level-matching adjustment. If you prefer the control on top of the cabinet, just move it; but it's best if the level match cannot be accidentally disturbed.

Construction

For the most convenient operation the fuzz effect should be switched in and out with a foot-switch. A *pedal-cabinet* assembly, like the one shown in the photographs is recommended; however, there is nothing to stop you from using a standard metal cabinet with a "hand operated" switch. If you opt for the pedal cabinet, keep in mind that switch S1 will be operated by your foot, so the cabinet must be reasonably sturdy. Do not use a plastic cabinet; the circuit must be shielded to avoid hum pickup.

Small, sloping panel cabinets are often available from surplus dealers, and some sloping sizes are available as "standard stock." (The cabinet shown was picked up from a surplus dealer and originally housed a microphone preamplifier.)



USE THESE DIMENSIONS if you are bending your own cabinet out of aluminum or steel. The dimensions shown are the minimum you should use for a comfortable pedal. Appropriate cabinets are sometimes available as surplus or standard stock, but they must be metal (to avoid hum pickup) and sturdy enough to stand heavy use.

If you can't locate a pedal cabinet you can bend one from aluminum (or steel) using the dimensions shown, which are about the minimum dimensions for a comfortable pedal.

The fuzz circuit is assembled on a 1.5 × 2.5-inch printed circuit board (PCB) that is mounted inside the cabinet with a metal L-bracket. The PCB layout isn't critical, so you can make any changes needed to accommodate the particular components you use. If you intend to make the PCB larger, make certain that it will fit inside the cabinet. Note how in the unit shown the PCB is angled to provide clearance to the bottom of the cabinet. The potentiometers can be either linear or audio taper, and any size. For example, to avoid crowding the unit shown uses a miniature pot for OUTPUT LEVEL control R7.

Jacks J1 and J2 should match your existing equipment, but bear in mind that *phone* type jacks and plugs are "standard" connectors for electronic music equipment. If you plan on giving a Superfuzz to someone as a gift *don't* substitute *phono* jacks, because the user will then either have to use relatively expensive *converters*, or non-standard cables.

Switch S1 is an SPDT push-on/push-off. It is not the easiest thing in the world to locate, though it *is* a standard switch. If you can't get one at an electronics parts distributor try the service shop of a local music-instrument store. They stock the switch generally as a replacement part for standard pedals. **SP**

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WALKIE-TALKIE INITIATOR

Turning on a hand-held transceiver at selected intervals is just one use for this device.

MARK L. McWILLIAMS



TWO WALKIE-TALKIES CAN BE PUT TO GOOD USE ON A camping trip by keeping one in the base camp and having it remain in contact with the other out on the trail. But that has two drawbacks. Unless the units have a selective-call feature, at least one will have to be on at all times. (Both parties could, of course, agree to switch on their units at pre-arranged times, but that involves a lot of clock-watching.) Not only will the batteries quickly run down over a constant-on period, but the always present noise and other communications will hardly blend in with the more peaceful melody of nature. The Initiator can eliminate all of that.

The Initiator is a two-stage timer that is designed to turn on any type of hand-held transceiver at selected intervals. It can also be used to turn on any other DC or AC device. The only constraints are that there must be some way to disconnect the power supply from the external device, and that the current drawn does not exceed the rating of the relay contacts. The first timing-stage sets the interval at which the second stage will be triggered—every 15 minutes, 30 minutes, hour, or whatever, up to a maximum of 255 minutes. The second stage determines how long the external device remains on (or off).

The Initiator works for both one-shot and astable operation. That is, the first-stage timer can be re-triggered at the same time the second stage timer is triggered, permitting complete cyclic operation.

Circuit operation

The first timing stage uses an XR-2240 programmable-timer IC. Basically, it is a 555 combined with

eight internal flip-flops, but the unit itself is programmable. Depending on which flip-flops are connected together, delays from 1 to 255 times a base-time delay are possible. The base delay (or time base) is set by a simple RC network.

The second-stage timer is built around a 556 dual-timer IC. The XR-2240 triggers the first half of the 556. After a brief 1-mS delay—long enough for the 2240 to reset itself—the first half triggers the second half and, if astable operation is selected, also re-triggers the 2240. The second half of the 556 then turns on a relay that acts as an off-on-off or on-off-on switch.

There are a few "quirks" about the 2240. It is not exactly like a 555, because it is triggered and reset by positive pulses, instead of negative ones that are used by the 555 and 556 IC's. (In this design a 4049 CMOS hex inverter makes the appropriate interfaces between the 2240 and 556.) And although the 2240 spec sheets state that it can be operated in the astable mode, that is slightly misleading. Complex waveforms are generated in the astable mode when more than one flip-flop is set, and that design is *not* practical for programmable-interval astable operation.

About the circuit

Figure 1 shows the circuit schematic. Switch S9 selects between a time base of one second or one minute for the 2240 (IC1), as C2 charges through either R6-R7 or R4-R5. It also determines whether the second half of the 556 is on for an interval in seconds or minutes as it charges through either C14 or C10 and R15 and/or R16, R17, R18, or R19. Switches S1 to S8

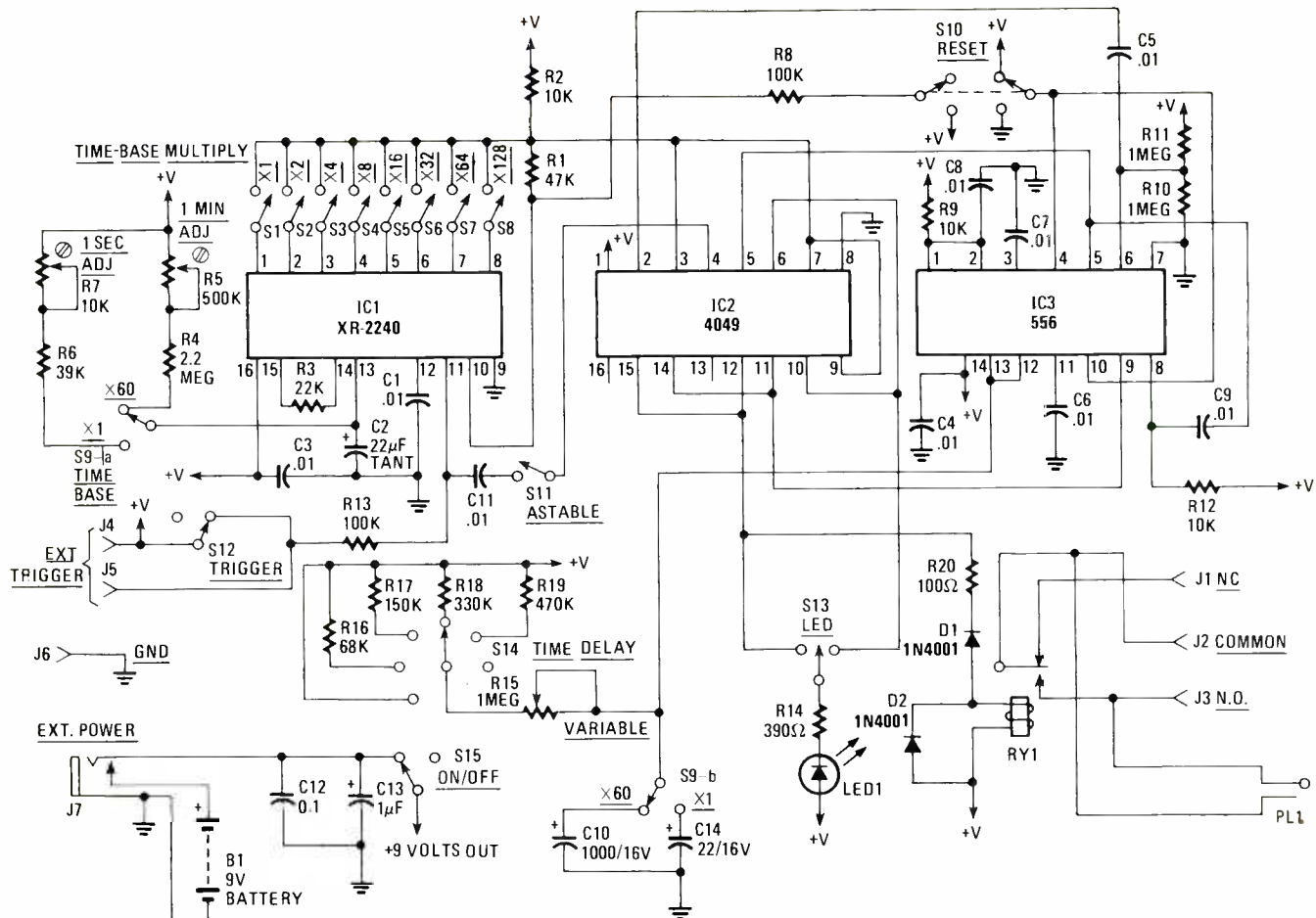


FIG. 1—A CMOS 4049 hex inverter interfaces the XR-2240 with the 556 dual timer as shown in this schematic diagram.

PARTS LIST

RESISTORS

1/2 watt, 10% unless noted

- R1—47,000 ohms
- R2, R9, R12—10,000 ohms
- R3—22,000 ohms
- R4—2.2 megohms
- R5—500K miniature PC potentiometer
- R6—39,000 ohms
- R7—10K miniature PC potentiometer
- R8, R13—100,000 ohms
- R10, R11—1 megohm
- R14—390 ohms
- R15—1 megohm linear taper potentiometer
- R16—68,000 ohms
- R17—150,000 ohms
- R18—330,000 ohms
- R19—470,000 ohms
- R20—100 ohms

CAPACITORS

- C1, C3-C9, C11—0.01 μ F ceramic disc
- C2—22 μ F tantalum
- C10—1000 μ F electrolytic
- C12—0.1 μ F ceramic disc
- C13—1 μ F electrolytic
- C14—22 μ F electrolytic

make it easy for the operator to program the 2240 for the desired time-delay. Switch S12 provides a positive pulse through R13 to trigger IC1. S10-R8 interrupts and resets IC1 as well as IC3.

A CMOS 4049 hex inverter interfaces the 2240 with

SEMICONDUCTORS

- D1, D2—1N4001 diode
- IC1—XR-2240 programmable timer (Exar)
- IC2—4049 CMOS hex inverter
- IC3—556 dual timer
- LED1—20 mA LED

SWITCHES

- S1-S8, S11—SPST subminiature toggle
- S9, S10—DPDT subminiature toggle
- S12—SPDT momentary toggle
- S13—DPDT center-off subminiature toggle
- S14—12-position single-pole rotary
- S15—DPDT subminiature slide

MISCELLANEOUS

- B1—9-volt transistor radio-type battery
 - J1-J6—banana jacks
 - J7—subminiature jack (2-conductor, normally closed)
 - PL1—subminiature phone plug (2-conductor)
 - RY1—SPDT relay, 6 volts
- Battery clip, switch knobs, case (6 1/2 x 3 x 2 inches, Radio Shack 270-672 or equivalent), PC board, IC sockets, 12-wire cable or hookup wire, dry-transfer lettering, mounting hardware, etc.

the 556 and drives an indicator LED and relay RY1. The CMOS inverter does the same function as its TTL counterpart, but needs no special interfacing and results in only about 20-mA of current being drawn by the entire circuit with the LED and relay off.

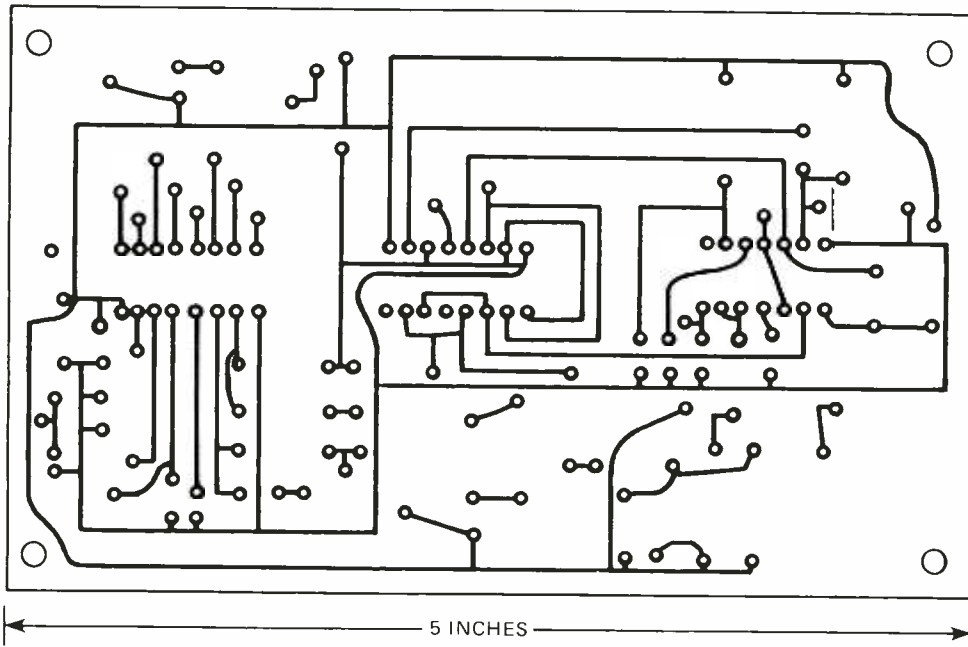


FIG. 2—THIS LAYOUT, shown full sized, should be used for the printed-circuit board. The board will fit in the recommended case.

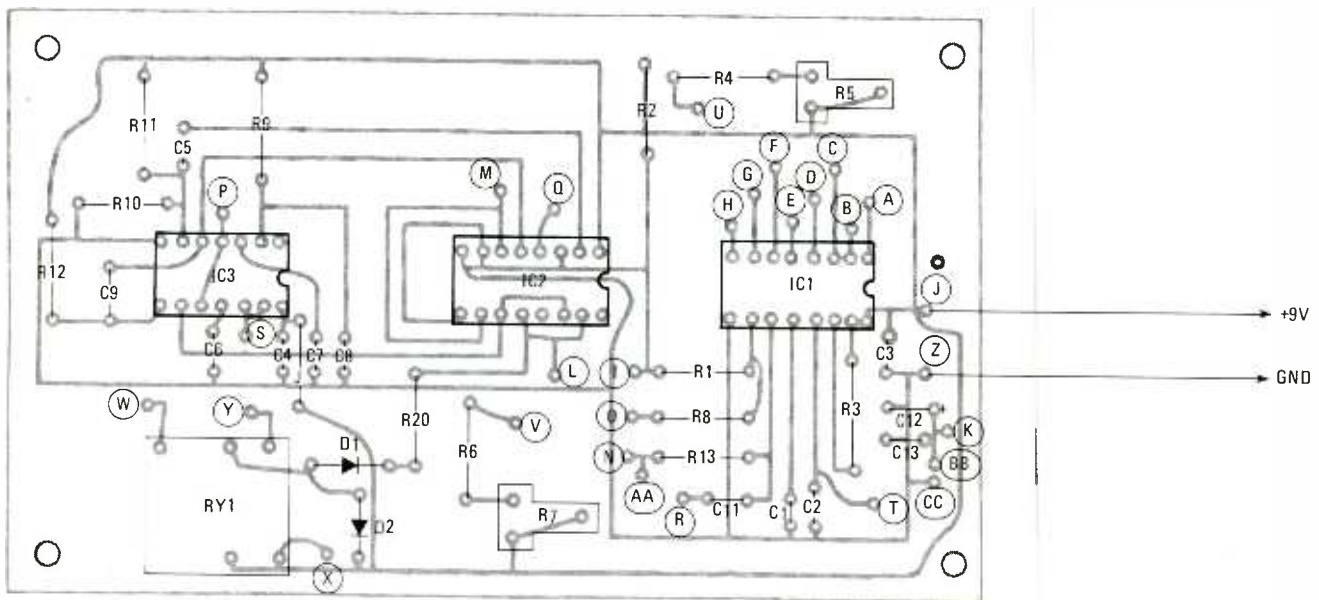


FIG. 3—THE CIRCLED LETTERS in this parts placement diagram indicate off-board connections. Use 12-wire cable to make those connections.

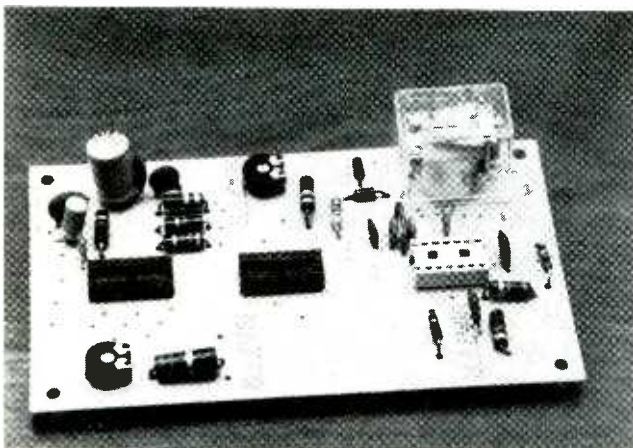


FIG. 4—THIS IS HOW the component side of the printed-circuit board should look when all parts are mounted.

C8-R9 generates a 1-mS interval in the first half of IC3. After that, it triggers the second half through C9, and also retriggers IC1 through C11 if astable operation is selected with switch S11. IC1 triggers IC3 through a network composed of C5-R10-R11.

IC3's output (pin 9/stage 2) turns on relay RY1 after it begins its timing interval. Switch S13 can be used to turn on a LED (pick one that consumes around 20-mA or less) to show if IC1 or IC3/stage 2 is timing out.

Construction

Should you elect to use it, a printed-circuit (PC) board

layout and the component installation guide are shown in Figs. 2 and 3. The board fits comfortably inside the case mentioned in the parts list. Figure 4 shows the finished board (without the hookup wires).

The control-panel layout is shown in Fig. 5 and the side layout is in Fig. 6. The component side of the control board is also shown in Fig. 7. A side view of the completed walkie-talkie initiator is shown in Fig. 8.

Since there are quite a number of wires between the control panel and PC board, you can get a neater package if you use two segments of 12-wire cable to make those connections. Choose a cable containing 24-gauge wire. It is easier to stuff into the case if you remove most of the cable insulation, and leave three or four 1-inch segments positioned along the wire bundle just to keep the individual wires in place.

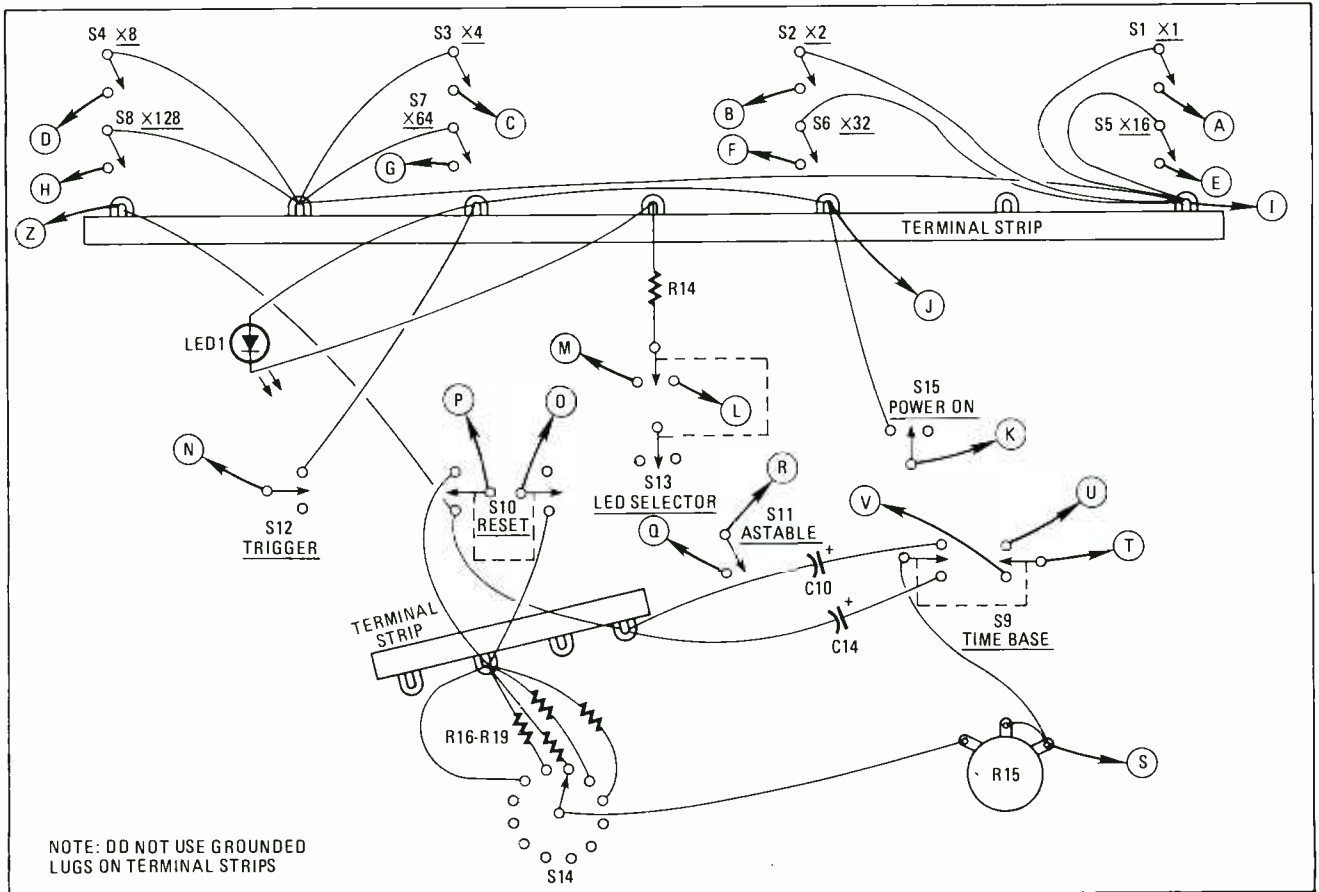


FIG. 5—POINT-TO-POINT wiring on the control panel minimizes the number of connections between the panel and the printed-circuit board.

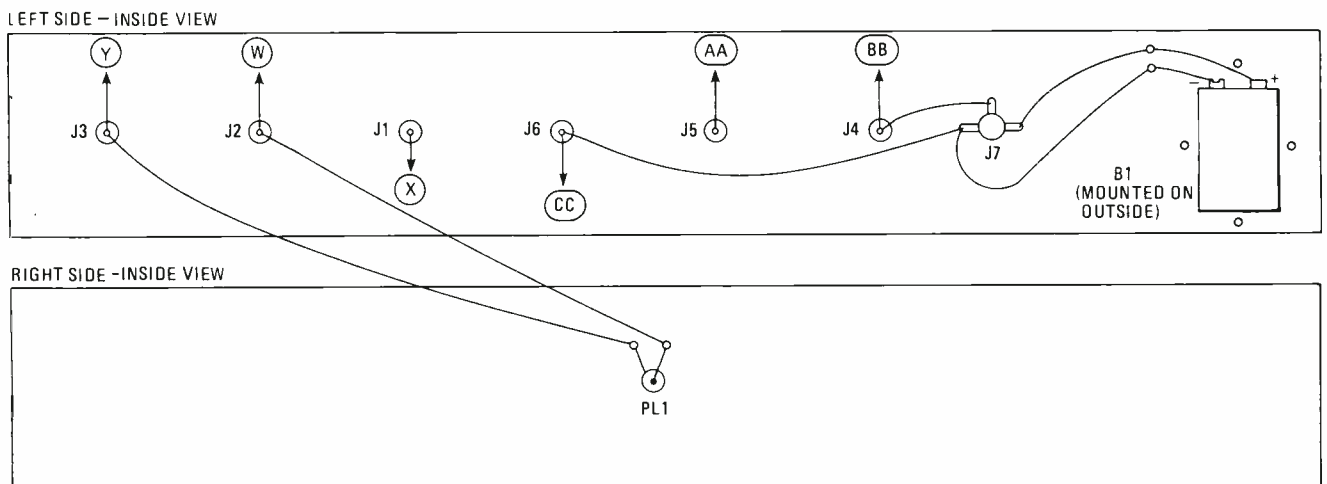


FIG. 6—ALL JACKS are mounted on the sides of the case. This layout shows how they are to be positioned.

Point-to-point wiring on the control panel minimizes the number of wires going to the board and case. Some components were mounted on the panel rather than soldered onto the PC board.

Position all switches, jacks, and potentiometers before drilling any holes in the panel or the case, to make sure that they won't bump into each other or the relay that is mounted on the PC board.

Plug PL1 can be glued onto one side of the case if you use this general-purpose timer to activate transceivers. (Of course, they can be just as easily activated by running a short cable between the normally-open and common jacks to the transceiver.) Measure the location of the plug by aligning the case with the transceiver. It is easy to mount a subminiature, normally-closed jack on a transceiver, connected so that it will interrupt the power supplied to the main on/off switch if a plug is inserted.

Checkout before using

Potentiometers R5 and R7 have to be adjusted to provide a base delay of 1 minute and 1 second respectively. With the POWER switch OFF, turn the ASTABLE switch OFF, and use the LED indicator-selector switch

to indicate the status of the 2240. Turn the RESET ON. Set the STAGE 2 DELAY for 2. If you have an ammeter handy, put it in series between the battery and the unit. Current should never exceed 50 mA with both the LED and relay on.

Choose a time base of 1 minute. Turn S1 ON and leave S2-S8 OFF. Adjust R5 for a 60-second delay. To do that, turn the RESET to OFF and trigger the unit by flicking S12. The LED should go off. Begin timing at this point, and stop when it comes back on.

Do the same thing when calibrating a time base of 1 second, except turn on switches S2 and S4 to give a total delay of 10 seconds. That way, the error is lessened by not having to measure accurately so short an interval as one second.

With the values given for R16-R19, the relay will be energized for intervals of 2, 5, 10, or 15 seconds or minutes, depending on whether S9 selects a time base in seconds or minutes. By switching the LED indicator-selector switch S13 to indicate the status of the second-stage timer, you can verify that the relay is being energized. Potentiometer R15 is added so you can choose other delays for stage 2.

Notice that at any time in its operation, turning the RESET switch ON resets IC1 back to its normal ON state and IC3 and relay RY1 to their OFF states. You can verify that with the LED indicator. By turning the ASTABLE switch ON, the unit will recycle itself over and over. The LED will turn on only very briefly to show that as soon as IC1 timed-out, it was re-triggered.

When you are sure that everything is working as it should, carefully mount the printed-circuit board inside the case. Then making sure that you don't catch any wires, mount the control panel. Your Initiator is now complete.

One final note: when you order the 2240, try to get either the XR-2240M, N, or P rather than the CN or CP types. The former have maximum timing errors of 2% compared to 5% for the latter.

Use your Initiator

Any delay from 1 second to 255 minutes is possible. Switches S1-S8 correspond to a 1-2-4-8-16-32-64-128 sequence, and the desired delay can be generated by choosing the appropriate ones. Should you want to interface the unit with a remote switch or other sensor, the external trigger jacks make that possible. Both normally-closed and normally-open jacks are provided, so the unit can generate off-on-off or on-off-on conditions.

SP

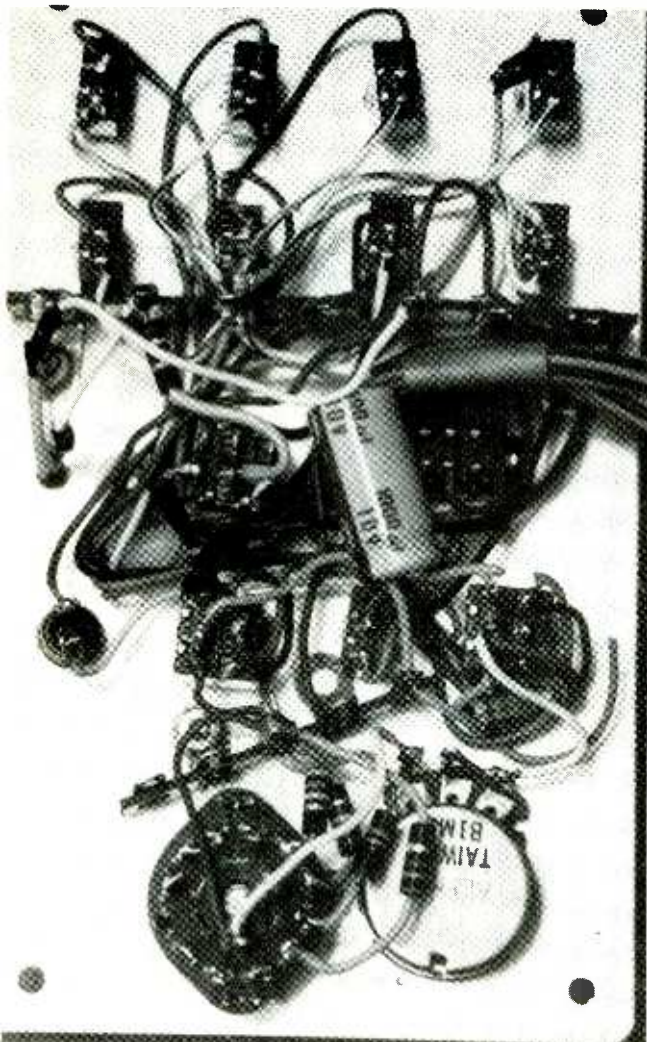


FIG. 7—THE COMPONENT SIDE of the control panel shown just before the case is closed up. The 12-conductor cable at the center simplifies the connections between the panel and the printed-circuit board.

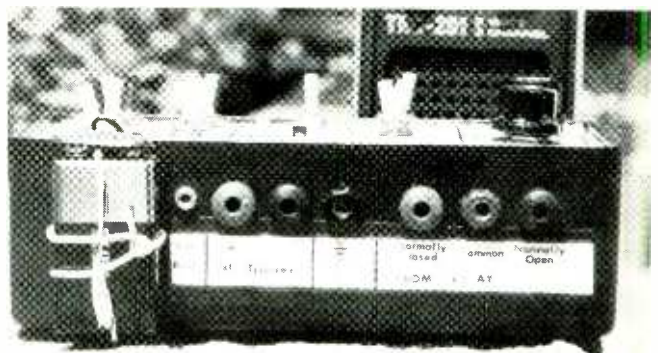


FIG. 8—SIDE VIEW of the completed Initiator. Jacks J1 through J7 are shown here. Battery B1 (at left) is mounted outside the case as shown here.

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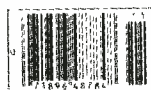
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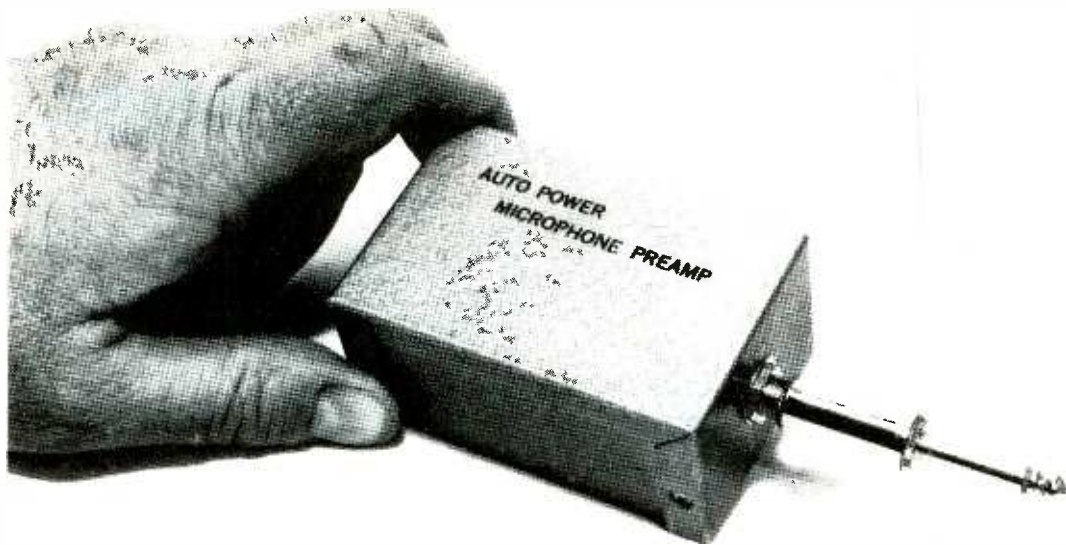
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AUTO-POWER MICROPHONE PREAMP

This tiny microphone preamp will even switch itself off when not in use.

BERT MANN

THE AUTO-POWER MICROPHONE PREAMP IS A MICROPHONE preamplifier with 25-dB gain specifically intended to reduce the possibility of battery failure caused by continuous heavy use, or by inadvertently leaving the power switch on. It is generally intended for the amateur and professional musician who might want to feed a mike through a music amplifier's guitar or bass input, or through a basic power amplifier. Of course, it can be used whenever you want to feed a microphone through a "line level" input.

Because the preamp uses only about 500- μ A current, a standard 9-volt battery can easily last through several "gigs". At the very least, you know for certain you can get through an entire weekend on one battery. As a further protection against having the battery fail during a performance, power is automatically disconnected (when the microphone is unplugged) by input phone jack J1, a special type with two sets of switching contacts that are insulated from the microphone circuit.

The battery is switched by one set of contacts. When the mike plug is inserted, those contacts switch the battery "on." When the plug is removed, spring-tension opens the power-switch contacts.

The amplifier's input impedance is slightly higher than 35,000 ohms. If you have a low-impedance microphone (rated from 150-1000 ohms) there will be virtually no perceptible effect on the sound quality caused by the relatively "Hi-Z" input impedance. Similarly, there will be no discernable effect with 50,000-ohm dynamic microphones. You cannot, however, use this preamp with ceramic or crystal microphones. They require a load impedance of 1-megohm or higher. The 35,000-ohm impedance of the preamp will cause almost complete loss of bass from ceramic and crystal microphones.

An internal volume-control adjustment lets you set the overall level into the associated amplifier. The control was deliberately placed inside the cabinet—rather than outside with an adjustment knob—to prevent "busy hands" from changing the adjustment when your back is turned. In fact, there are no outside (panel) controls at all. The preamp resembles a plain metal box with a phone jack at each end. If you want to have the preamp plug directly into the amplifier's input jack—more or less becoming an integral part of the amplifier—use a Switchcraft phone plug-to-plug adaptor for the output jack. That device consists of back-to-back

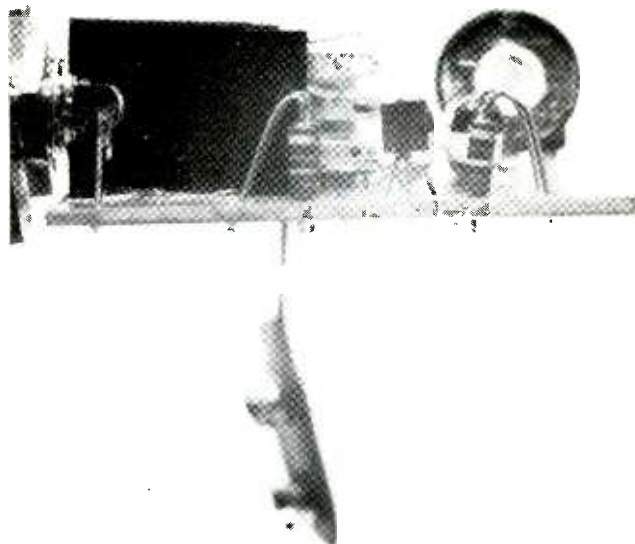
phone plugs. When inserted in output jack J2, the preamp gets a "built in" phone plug.

The overall frequency response has a slight roll-off below 100 Hz to avoid the "bass proximity effect" caused by close-miking. If you want an almost "flat" response from about 50 Hz to almost 20 KHz, change capacitor C1 to 0.5- μ F, or to a 1 or 2.2- μ F capacitor. (Watch out for the correct polarity; the positive end connects to Q1's base.)

PCB module

The preamp is assembled onto a small PCB (Printed Circuit Board) that is cemented directly to input jack J1, forming a module that is installed as a single unit inside the cabinet. Use the PCB template supplied, or make whatever modifications you prefer. The PCB shown is meant to just fit into a combination-snap aluminum cabinet approximately 3-1/4 \times 2-1/8 \times 1-5/8 inches, BUD type CU-2101 or equivalent. ("Combination-snap" means that the cover can be secured with screws or snapped into place. I suggest that you use the snap because it allows easy access to the battery and the output-level adjustment.)

Everything will just about fit into the cabinet if you drill the cabinet this way: Mark the center of the cabinet's ends for J1 and J2. Hold the cabinet so the open "U" faces up. Facing the input jack (J1) end, move the mark 1/8 inch to the left (off center). That will provide enough clearance for the battery when the cabinet's cover is snapped into place.



THE RESISTORS ARE END-MOUNTED with one end right on the PCB. Don't try to place the resistors flat on the PCB; they won't fit the template.

Temporarily install J1 in the cabinet. Position the bare PCB (no parts installed) against the left side of J1 with the component side against the jack. When you are certain you have the PCB in the correct position put a drop of contact cement on the jack and cement the PCB to the jack. Leave a very slight bit of play (about 1/32

PARTS LIST

RESISTORS

1/4 watt, 5%

R1—470,000 ohms. see test

R2—47,000 ohms

R3—10,000 ohms

R4—360 ohms

R5—100,000 ohms, vertical printed-circuit potentiometer (Radio Shack 271-220 or equal)

CAPACITORS

Rated no less than 10-VDC

C1—0.1 μ F, see text

C2—0.1 μ F

C3—25 μ F. see text

MISCELLANEOUS

J1—Phone jack with double closed-circuit switching (Radio Shack 274-277 or equal)

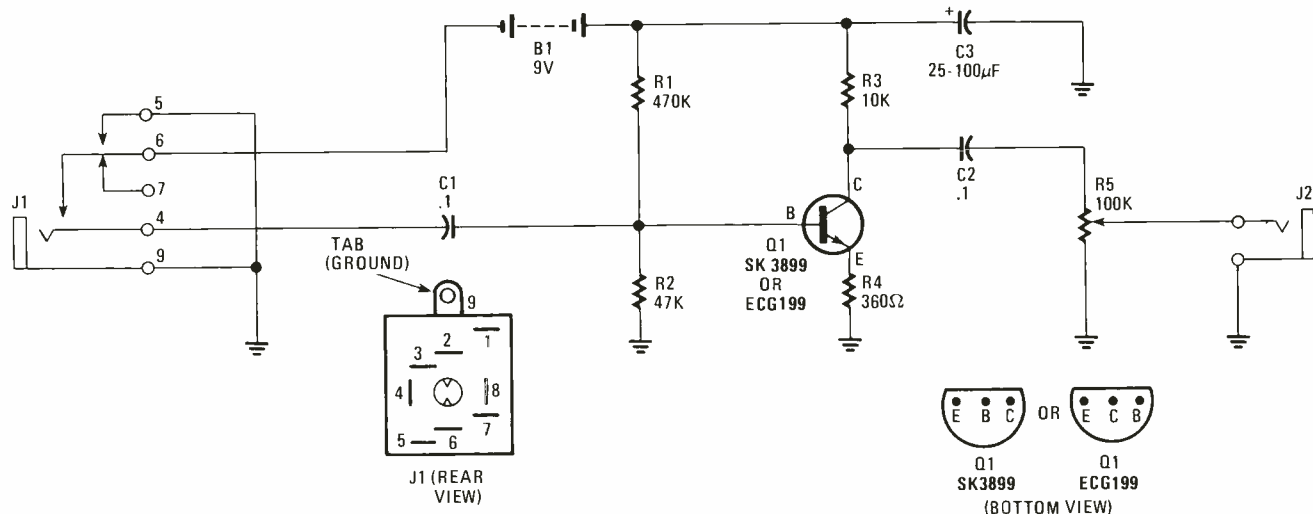
J2—Phone jack (any type)

Q1—Sylvania ECG-199 or RCA SK-3899 (see text)

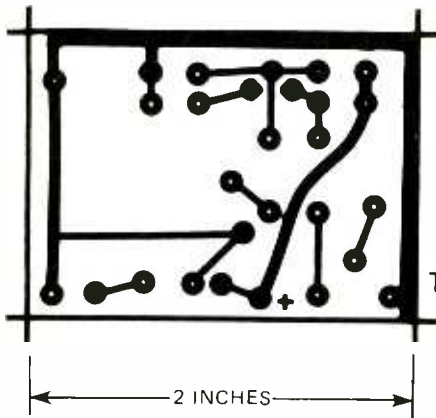
B1—9-volt battery, type 2U6 or equal

Cabinet

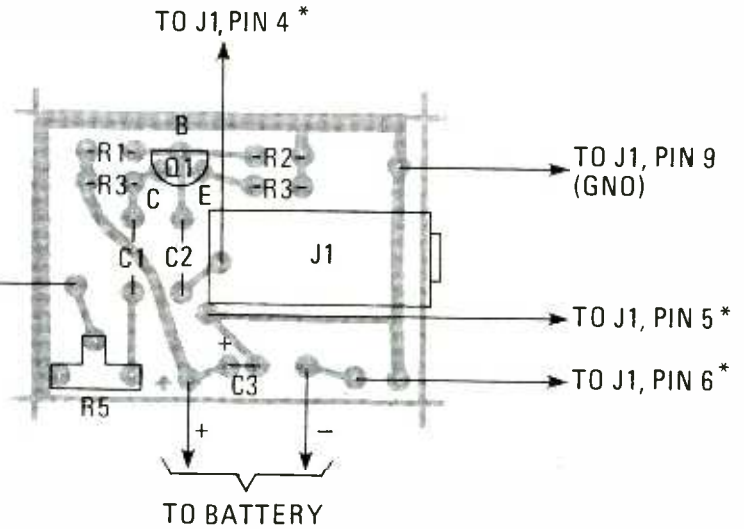
Battery terminals (see text)



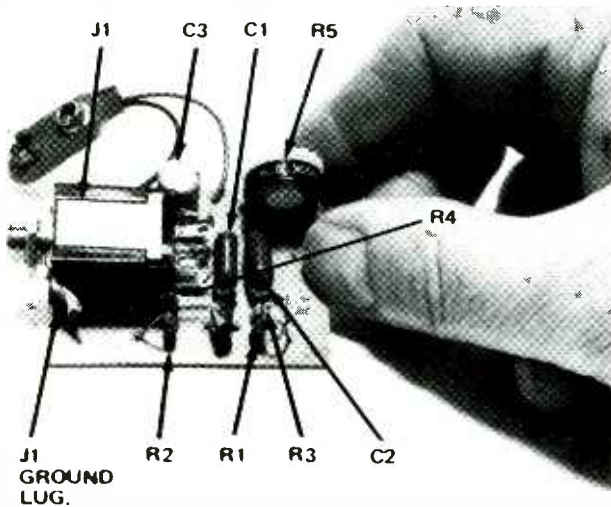
SCHEMATIC DIAGRAM of the preamp. Jack J1 has two sets of contacts, one of which switches the battery out of the circuit when the device is not in use.



FOIL PATTERN (above) for the preamp is shown full size. PARTS PLACEMENT DIAGRAM (right). Note the terminal arrangement of the transistor you are using when installing Q1.



* J1 PINS 4, 5 & 6 LOCATED AT REAR OF JACK (NEAR C2)



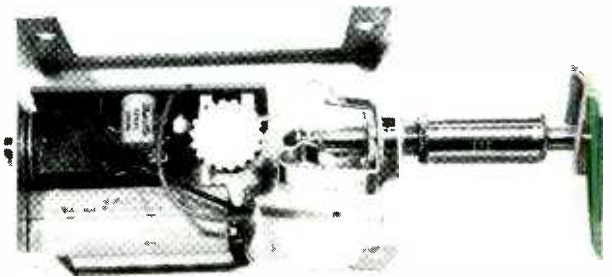
THE ENTIRE AMPLIFIER, except for the output jack, is assembled as a complete module. The PCB is cemented to input jack J1, though it is actually held in place by the connecting wires.

inch) between the edge of the PCB and the bottom of the main cabinet section, not the cover. Inspect the top of the PCB to make certain there's clearance for the cover. If not, file the top of the PCB.

Don't worry if the glue doesn't provide a rigid mounting. The wiring is what actually secures the PCB to the jack. If you mounted the PCB correctly the No. 4 terminal of J1 should be against the PCB. Connect all wires between J1 and the PCB first. Jack J1 generally has the ground lug—terminal No. 9—opposite terminal No. 2. If the jack you use has the ground lug on the opposite side you'll find an *extra* ground foil solder pad on the PCB adjacent to the "wrong way" lug. Use it; don't try to route a jumper wire to the opposite side of the PCB.

There isn't much room for capacitor C3, so use whatever fits; any value in the range of 25 to 100- μ F at a voltage rating no lower than 10-volts DC will be okay.

Transistor Q1 must be the ultra high-gain type with an h_{fe} of at least 300. The Sylvania ECG-199 or RCA



THE FINISHED UNIT. The output level is adjusted by rotating the serrated "knob" on the end of R5. Set the correct level and then leave it alone.

SK-3899 can be used, but be careful, the ECG-199 has a terminal arrangement of ECB; the SK-3899 has an EBC arrangement. Twist the transistor, if necessary, when using the ECG-199. If you bend the leads make certain that they don't touch. Transistor bias is extremely critical in this project so use 5% tolerance resistors. Note that all resistors are installed "on end;" do not place them flat—they won't fit the layout.

There is just enough clearance for the battery if the correct battery connector is used. The connector must have the wires coming out the end. A connector with the wires coming out the side will interfere with the installation of the cover.

Final checkout

The final checkout should be done using a 20,000 ohms/volt VOM, a VTVM, or a DMM. Insert a phone jack all the way into J1 to apply power and measure the voltage from Q1's collector to ground. It should measure in the range of 3 to 6 volts. If it is too high (greater than 6 volts) change R1 to 430,000 ohms. If it is too low (less than 3 volts) change R1 to 510,000 ohms.

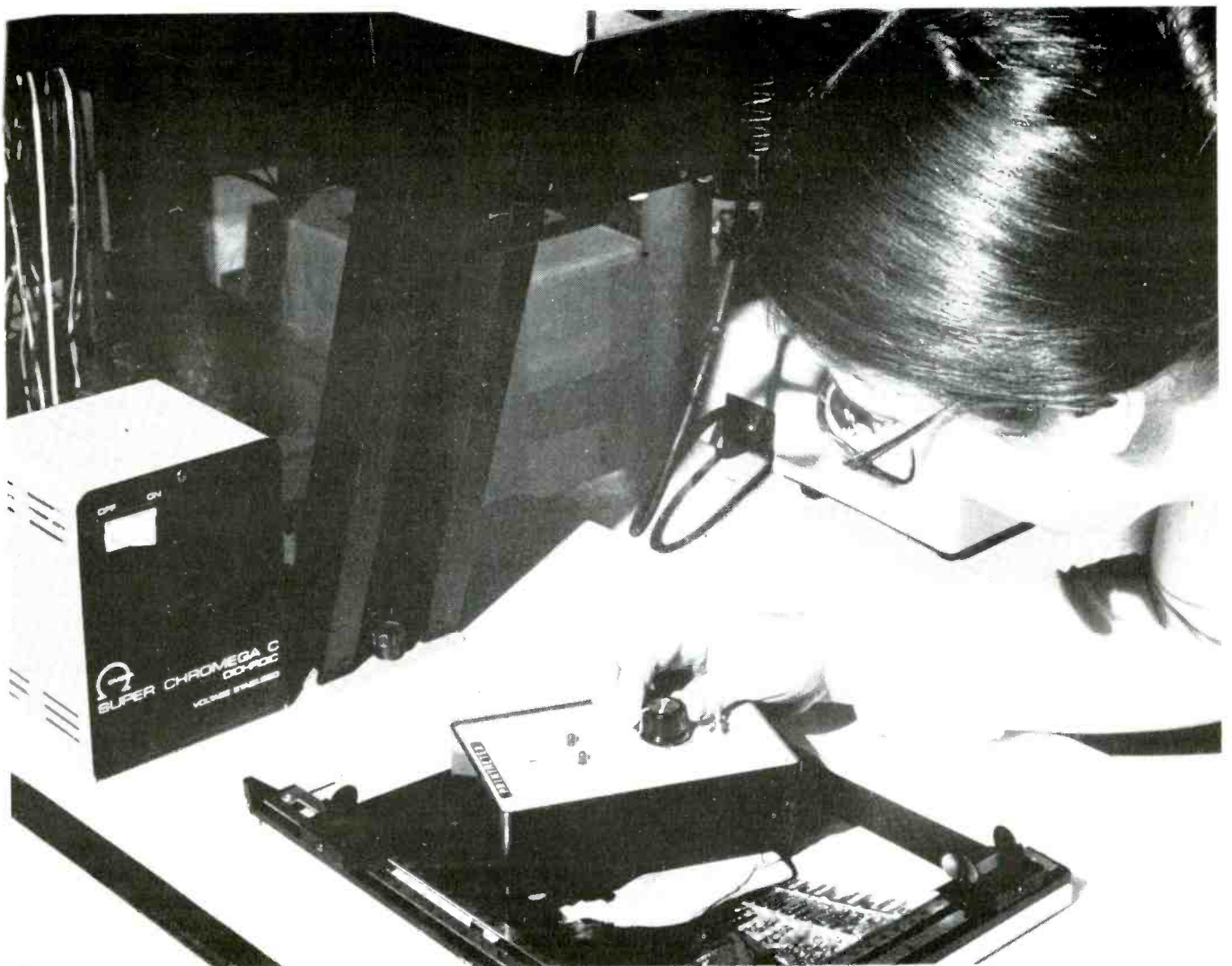
When using the preamp, set level control R5 so the main amplifier's volume control will work within its normal range when there is a "normal" or moderate voice level into the microphone.

SP

PRINTMETER FOR PHOTOGRAPHERS

Get a perfect black and white or color print almost every time with this easy-to-build printmeter.

LESLIE PIERCE



THE RECOMMENDED WAY TO MAKE GOOD BLACK-AND-white enlargements and color prints is to make a series of test strips or prints to determine the correct exposure. Unfortunately, the procedure is both time-consuming and somewhat costly in this era of spiraling prices—particularly for anything having to do with silver and photography.

A quicker way to determine the correct exposure while almost entirely eliminating test strips and prints is to use a Printmeter. This device is specifically calibrated to the print quality you prefer and your preferred exposure time(s). Simply project the negative on the easel, place the printmeter on the easel, adjust the enlarging lens' diaphragm until two LED's on the meter glow at you, and everything is set for the proper exposure at whatever exposure time you prefer—be it 10, 15, 20 seconds, or whatever.

In most instances you'll get a good print the first time. If you *miss*, the print will be "so close" that your next try will be a great print.

Black reference

Except for portraits and special artistic effects, the average black-and-white print appears "correct" if there is a touch of "pure black" somewhere in the picture. Pure black is attained from a clear area in the negative, because it is through the clear area that the maximum amount of light is allowed to pass from the enlarger's light source to the printing paper. To attain a "correct" print you need only adjust the lens opening so that the light projected through the clear area of the negative is *the minimum* required for a specific exposure time to produce black in the print.

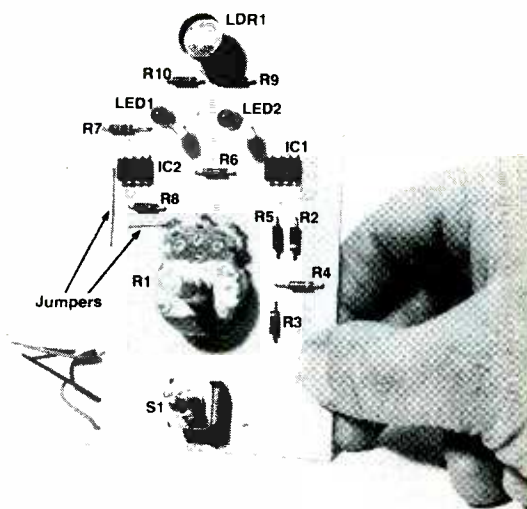
Now if you can measure the light through the clear area so that it can be adjusted for the minimum light required for black, you can be assured of a print that is pleasing to the eye without going through a series of test strips or prints. And that's exactly what the Printmeter does. It measures the amount of light falling on the easel for the black level you have previously established as the one most pleasing to you.

It's done this way: First, you select a preferred exposure time that you use at all times. Assume it's 10 seconds. Next, you select a known "good" negative, one with a wide tonal range from deep shadows (black) to bright highlights, and you make a "perfect" print through whatever system you have used previously. Then, without disturbing the enlarger adjustments, you place the Printmeter under the negative area transmitting the most light and adjust the meter's CAL (calibration) control until two LED's are lit. That's it. The meter is now calibrated to your personal print quality.

To make a print of a different negative you simply focus; place the Printmeter under the area of maximum light transmission and adjust the lens opening until the two LED's light. Give the "standard" exposure and you have a good to excellent print at the first try. As long as you don't change the exposure time or the CAL control you will get good prints from any acceptable negative.

How about color?

For color prints you cannot use shadow areas to determine exposure. Instead, you use a "light integrator" just as you would normally do when making test prints. After you have made a good color print using



NEATNESS COUNTS FOR NOTHING IN THIS PROJECT. There's plenty of room on the PCB, so don't crowd. Note that power switch S1 is a printed-circuit type whose terminals extend through the PCB. R1's terminals, on the other hand, are standard. They connect to the PCB foils through solid wire leads which also serve to secure the pot to the PCB.

the usual light integrator and matrix exposure guide, you again place the integrator under the lens, place the Printmeter in the approximate center of the easel, and adjust the CAL control until both LED's are lit. That is now the reference for all subsequent exposures at whatever exposure time you have selected.

While there are variations due to chemical aging, room temperature, etc., during a single printing session, they are generally not large enough to have a significant effect on the Printmeter's calibration. However, there is significant variation from day to day and week to week. The initial calibration, though, will put you well inside the ballpark on the first try, so it's suggested you make a mark on the Printmeter's panel indicating the calibration setting for the various enlarging papers you use.

Not critical

The Printmeter shown (see schematic, Fig. 1) was specifically designed to accommodate integrated circuits of any quality (other than totally defective) and to use resistor values usually found in the average hobbyist's shop. The circuit has not been optimized and will work with variations as much as 20%, if not greater. For example, if you do not have 1000-ohm resistors there will be no problem with values of 860 ohms or 1200 ohms. Similarly, if you want to substitute 420,000-ohm resistors for the specified 470,000-ohms, go ahead and do it. Just take care to be reasonable with your substitutions.

The only critical components are CAL control R1 and the light-dependent resistor, LDR1. R1 must be a linear taper; a log taper often used for a volume control, will result in "scrunched" adjustments too critical for practical use.

LDR1 is unlike most photoresistors in that it has virtually no memory in typical use. Most LDR's have a memory, meaning there's a lag between the time the light intensity changes and the time the resistance value changes. It can be quite disconcerting to adjust

the lens opening, see no change in the LED's, and then find that your print is too dark or too light because the LDR didn't track the lens opening. Also, the selected LDR is sensitive primarily to the color temperature of common enlarger light sources; it works well with integrated color light, and has the right resistance range for use in the Printmeter. Substituting for the specified LDR will most likely result in an unstable calibration, a meter insensitive to the lower light level of 8×10 or 11×14 enlargements, or it just won't work at all.

One more critical item: The opening through which the light falls on the LDR must be precisely $3/16$ inch—no more no less. Use a $3/16$ -inch drill bit or a metal punch.

Construction

The Printmeter makes a very nice self-contained printed-circuit project. However, if you work with very small easels, and think the meter as shown will be too large for them, you can remove the LDR and install it in a very small *completely opaque* enclosure. Use ordinary extra-thin speaker wire to connect the

LDR to the main PCB (printed circuit board). Shielded cable is not necessary and it's too inflexible.

The PCB measures $3 \times 4\frac{5}{8}$ inches. It will be secured to the panel by S1 and R1. Note that there are two unused PCB terminals for S1; they are still solder connections rather than "empty holes," because S1 carries most of the support for the PCB when it is installed on the panel. The six S1 PCB terminal pads are spaced for a Radio Shack miniature DPDT switch with printed circuit lugs. If you substitute with different dimensions, change the printed-circuit layout accordingly. The center line for the switch handle, which is the reference position for drilling the front panel, runs horizontally through the center solder pad in each vertical row. Regardless what substitution you might make for S1, keep the handle centered on a line running through the center solder pads.

All printed-circuit board component holes except those for S1 are made with a No. 60 drill bit, though anything from a No. 62 to a No. 56 will be fine. The holes for S1 should provide just enough clearance for the terminals on the particular switch you use. The terminals should not fit tight—not even snug. S1 carries

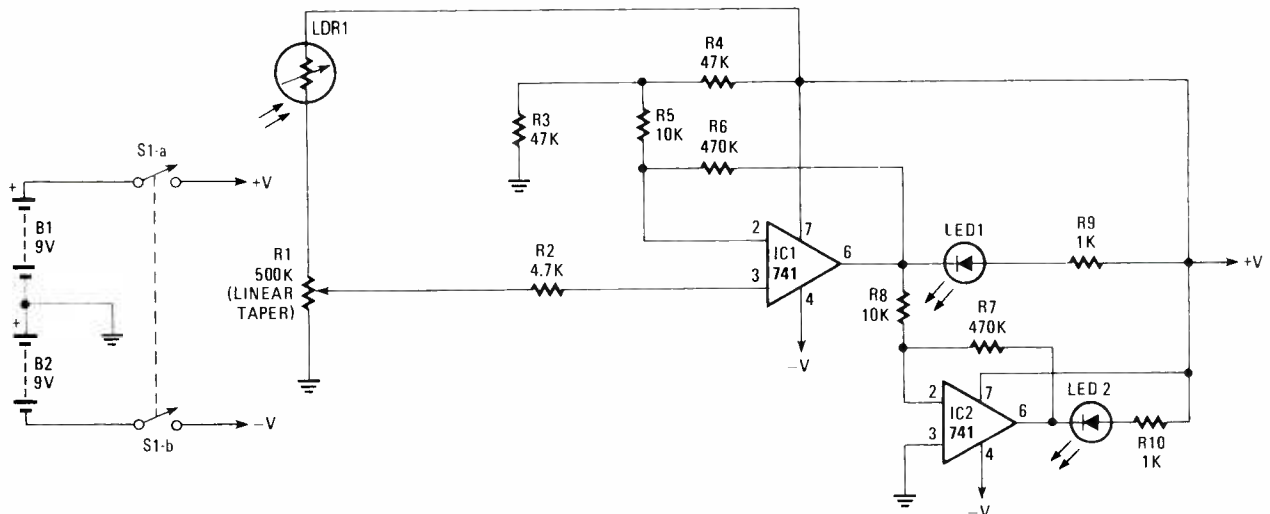
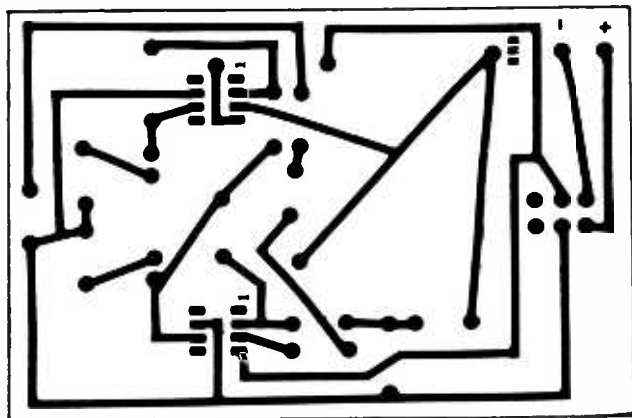


FIG. 1—ACTUAL COMPONENT VALUES can vary by as much as 20 percent from those shown in this schematic diagram. The only exceptions are LDR1 and R1—use the components mentioned in the Parts list.



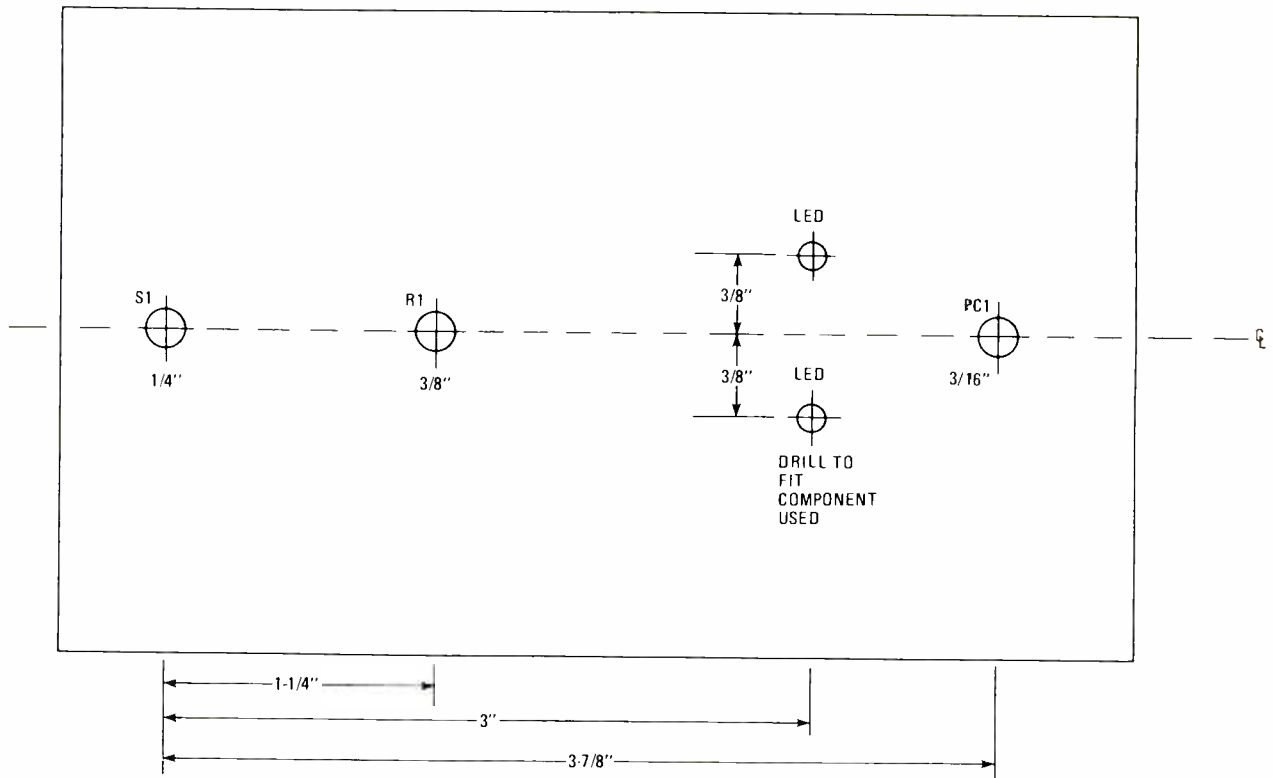
THE FOIL PATTERN for the printed-circuit board is shown here about two-thirds its actual size.

the entire printed-circuit board when the assembly is completed, and you don't want extra strain on the board caused by jamming the switch terminals into their holes.

When you install S1, tack solder one single corner terminal; then make sure that the printed-circuit board is parallel to the switch. If not, reheat the terminal, reseal the switch, and try again. Solder the remaining terminals, including the unused "dummies," only when you are certain that the PCB is parallel to the switch.

Hold the printed-circuit board so that you are looking at the top of the board—the component side, the side without copper foils, with switch S1 at the bottom. Install IC1 and IC2 so that the "notch" moulded into one end of each IC faces the left side of the PCB.

Use the largest *red* LED's you can get for the indicators, preferably the *diffused* type which provides a wider, more easily visible glow. Take note that the inexpensive LED's usually sold in "hobby" shops don't necessarily appear the same in the dark: one might appear "brighter" or more "dense" than the other. That is typical, even when both have been packaged



THE POSITION of switch S1 is used as a measurement reference when marking the front panel for drilling. Locate the switch anywhere that's convenient and follow this template.

PARTS LIST

RESISTORS

1/4 watt, 10% unless noted

R1—500,000 ohms, linear taper potentiometer

R2—4,700 ohms

R3, R4—47,000 ohms

R5, R8—10,000 ohms

R6, R7—470,000 ohms

R9, R10—1000 ohms

SEMICONDUCTORS

LDR1—National 4921

IC1, IC2—Type 741 opamp (mini-DIP)

LED1, LED2—Jumbo red LED (see text)

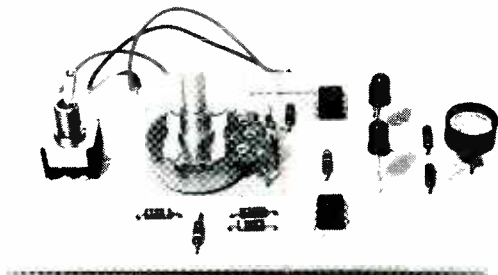
MISCELLANEOUS

S1—DPDT PC terminal switch (see text)

B1, B2—9-volt battery, type 006p or equal

Cabinet, battery terminals, printed-circuit materials, etc.

(Note. LDR1 is available for \$4 from Custom Components, Box 153, Malverne, NY 11565. Add \$2 postage and handling per total order. Canada \$1 additional P&H. NY State residents must add appropriate sales tax.)



THIS IS HOW THE PCB ASSEMBLY LOOKS after it has been removed from the front panel. Note how the LED's and the LDR are spaced off the PCB. The LED spacing isn't important, but the LDR must seat right up against (flush) the panel. The LDR is supplied in a special holder that recesses the element itself to narrow the viewing angle, thereby preventing light pickup from the LED's. Do not attempt to cut away the "excess" holder in an attempt to raise the LDR element to the panel itself.

together in a single blister-pak. If it happens to you, that's the way it is.

Mount all PCB components except the LED's, R1, and LDR1. Then install, but do not solder, the LED's. Jumbo LED's have a "flat" moulded at the base of the LED opposite the cathode lead. Install the LED's so the flat faces the nearest edge of the PCB. If your LED's don't have the flat, determine which is the cathode lead and position the LED so the cathode is opposite the nearest edge of the PC board. Push the LED's about halfway down into the holes; they will be soldered later. Similarly, push the LDR into its holes.

Solder three 1-inch solid wires to R1's terminals

(wires face towards the rear of the pot), feed the wires through the PCB holes until the pot touches the PC board, and bend the wires just enough to hold the pot in position; they will also be soldered later. Set the PCB assembly aside and prepare the front panel.

Any cabinet can be used. A plastic cabinet with an aluminum panel is probably the least expensive and most convenient. The model shown in the photographs uses a cabinet 3 1/4 x 2 x 6 1/4 inches. The drilling template for the front panel uses the position of S1 as the measurement reference. Locate S1 any place that's convenient, making certain the PCB will clear the "screw towers" moulded inside the cabinet. Also,

S1 is located on the vertical (long dimension) center-line of the panel. Measure all panel cutouts from S1's position. The LDR hole must be 3/16 inch. The LED holes fit whatever LED's you use.

When all panel openings are cut, slide a washer over S1 (remove all nuts and lockwashers) and R1 and lower the panel on S1, guiding R1's shaft through the panel. Secure S1 to the panel with a nut. Without putting pressure on the PCB, pull up on R1 and apply a mounting nut. Then flip the assembly over and solder the three wires from R1 that come through the PC board. Cut off the excess. The circuit board is now secured to the panel by S1 and R1.

Reach in with long-nose pliers and fish the two LED's through the panel until they "seat;" then solder their leads.

Similarly, fish the LDR up against the panel—make certain it's flush and that it's centered under the panel hole. If necessary, gently bend the wires until the LDR is centered *and still flush*, then solder.

Install the batteries and the Printmeter is ready for checkout and use.

Checkout

Set R1 full counterclockwise and S1 to off. If the LED's are lit, either there is a wiring error at S1's terminals, or S1 is one of those rare switches where the contacts are *on* when the handle is on the same side as the contacts. In the latter instance, change to a conventional switch.

Set S1 to ON. The right hand LED should light. Slowly advance R1. The left LED should light, and the right LED should turn off as R1 is advanced farther. If both LED's do not light, check on whether they are installed with reversed leads, and that the batteries are connected properly to create a "bipolar" power source.

Using the Printmeter

Always start with R1 full counterclockwise.

Make your *perfect* print from a *perfect* negative, note the reference exposure time (assume 10 seconds), and place the meter's LDR directly under the area of maximum light transmission. When the meter is turned on, the right LED will light. Slowly advance R1 until the left LED just "kicks" on. That is the calibrated value.

For "new" negatives: Focus and stop the lens down all the way. Position the LDR under the area of maximum light transmission and open the lens slowly until the left LED kicks on. The lens is now set for your reference exposure and exposure time. If you open the lens too much, the right LED will turn off, indicating excessive light.

If you're lucky enough to end up with "matched"



THE COMPLETED PRINTMETER. To make viewing easier a "target" cut from a white self-adhesive label can be placed around the LDR opening. Make certain, however, that no part of the opening—no matter how little—is covered by the target.

LED's, you can use as a reference the adjustment that produces equal brilliance from both LED's. It's a very narrow and precise range: the slightest variation will cause one or the other LED to turn off. If you have any problem balancing two LED's simply use the "kick" turn-on procedure.

If you're into portraiture and prefer a "skin tone" exposure reference, simply make your initial calibration off a skin tone rather than maximum shadow detail (black). Subsequent "readings" are similarly made off skin tone.

If you have difficulty "seeing" the proper position for the LDR apply a small square of white adhesive label on the panel. It will serve as a *target* area. Just make certain that the hole in the target is slightly larger than 3/16 inch, so it doesn't interfere with the LDR hole.

CAUTION. Do not attempt to "test" the unit by covering the LDR with your finger. The device is extremely sensitive and will "read" the light passing through your fingers—as little as it is. The meter will actually "calibrate" with your finger over the LDR. If you expect the meter to default to the maximum setting of R1, it simply won't. Use the meter as intended—in the darkroom. **SP**

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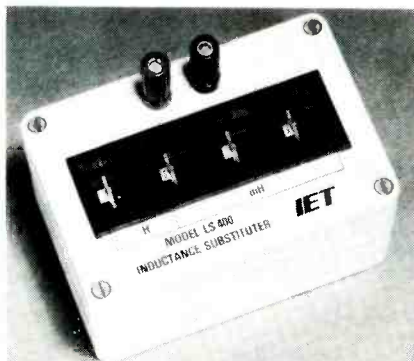
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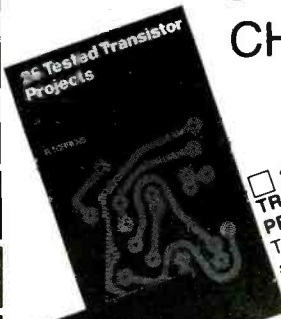
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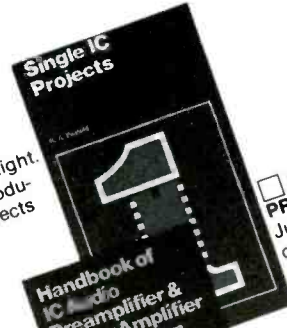
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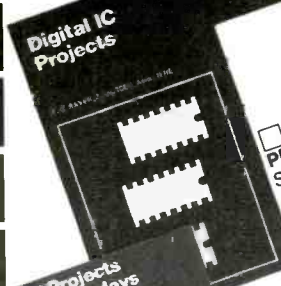
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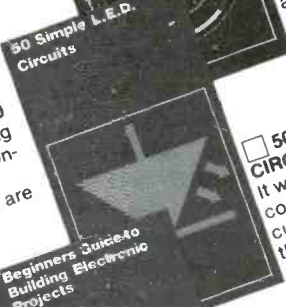
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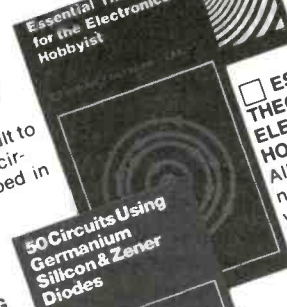
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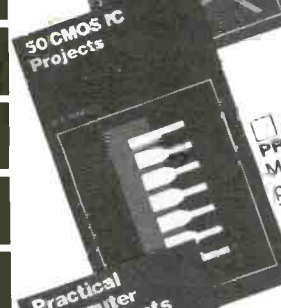
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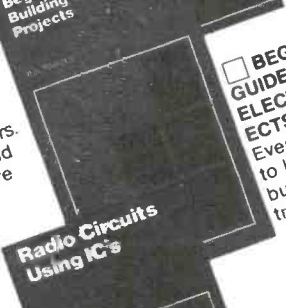
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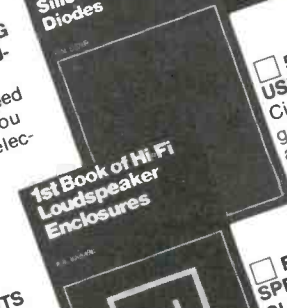
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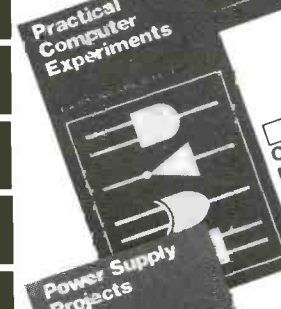
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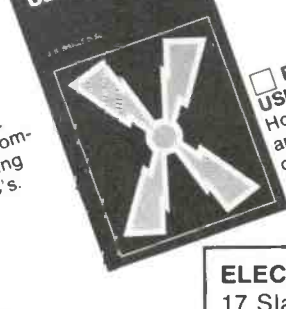
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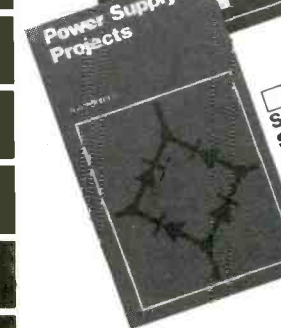
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THERE ARE TWO WAYS TO MAKE PRINTED-CIRCUIT boards: the hard way and the easy way. The hard way is to emulate commercial methods, using the "screen" or "photographic" process that manufacturers use to make thousands of printed-circuit boards (PCB), or as used by laboratories to make small multiple quantities. The problem is: If you need just one PCB for a homebrew project, the screen and photographic methods are expensive and you tend to wind up with a lot more material than you're likely to use before it goes "stale."

A faster and usually less expensive way for the hobbyist to make single PCB's that approach commercial quality is to use a product called "Dry Transfer Resist," also known as "rub-on resist." In less than an hour for a really complex PCB (or under a half-hour for typical hobby projects), the average builder can have a copper-clad board ready for the acid etch; and both the resist layout and the final etched PCB will rival many commercial printed-circuit boards. It won't be tin plated, but that's something you can also do inexpensively, and something for another time.

Dry transfer resist is produced by the Datak Corp., and the Vector Electronics Co. It closely resembles the "transfer type" used by artists whereby a letter, character, or symbol is affixed on the underside of a transparent sheet. The sheet is protected by a "slip sheet." (The slip sheet is important so keep it in mind.) To apply the letter, etc., to anything—paper, metal chassis, cabinet, etc.—the slip sheet is removed and the letter positioned where desired; then, by rubbing over the letter with a ball pen, wood stick, or burnishing tool, the letter is transferred from the transparent sheet to the device being marked. When the letter is rubbed through the slip sheet, it becomes more or less permanently attached to the device. (The slip sheet has a special coating that prevents it from adhering to the letter. Therefore, when "burnishing" the letter to make it adhere, the slip sheet must be placed on top of the

letter, between the letter and the burnishing tool.)

The dry transfer resist is handled exactly the same way, except that it is applied to the copper clad side of a PCB board instead of to artwork. The dry transfer resist comes in kits containing many full-scale patterns; among them: transistor and IC sockets (both round and DIP), various size solder doughnuts, bends, S-curves, edge-card connections, through-traces (thin foils squeezed between DIP connections), alphabets, numerals, electronic symbols such as "+", "-", and "GND", and—most important—straight lines. Using the various patterns it's relatively easy to duplicate quickly with resist any but the most complex PCB layouts. (What is meant by "complex?" A multi-IC digital project, for example. When you've got a layout with foils spaced closer than a hair, unless you're able to make a photoresist copy of the template you're better off using wire-wrap construction.)

Unfortunately, neither Datak nor Vector provide a "full kit" in the sense their kits have all the generally required resist patterns. Each kit has something the other doesn't have, so I suggest that you combine both a Datak and a Vector kit—then you have everything in the way of PCB resist patterns.

Since a picture is worth a thousand words (or at least several hundred in this era of inflation), we use pictures to show how you can make PCBs using dry transfer resist. But before we start, here are a few general notes and words of caution.

First: You cannot use transfer resist for *everything*, particularly long or serpentine (curved) lines. Either the resist will be difficult to manage on long runs, or you will be forced to bend a trace by combining several bits and pieces of straight lines. Either way you're asking for trouble. In their kits, Datak supplies (and also sells individually) rolls of resist tape that is "krinkled". The krinkling permits the tape to be shaped into curves that won't spring back into a straight line. Vector has a

similar product they call "crepe tape". Use either one. In fact, you can use any wrinkle or crepe drafting tape as resist tape. As long as it's not the shiny "plastic" drafting tape it will probably work. The acid bath might make it "rubbery" and somewhat difficult to remove from the PCB, but it will work.

Second: Forget anything you might have heard about tracing a printed circuit template onto the copper cladding using carbon paper. Except in extremely rare instances, carbon paper won't leave a mark on the copper; all you'll have is a groove in the copper, formed when bearing down on the ball pen to trace the template. If any carbon *does* get on the copper its oily surface will prevent good adhesion of the transfer resist, and possibly interfere with adhesion of very thin crepe tapes. As we show in the photographs, the way to copy a template is to locate the component mounting holes precisely, using the pattern supplied in **Special Projects**, installing the doughnuts, and then eyeballing the connecting lines.

Third: The copper surface must be scrupulously clean at the start, and it must stay that way. The slightest amount of skin oil will interfere with adhesion of the transfer resist. Always handle the PCB by the edges, and cover as much of the PCB as possible with a sheet of paper if you must rest your hand on the PCB when installing resist.

For example, if you're installing doughnuts in the center of the board you might be tempted, or feel required, to rest your hand on the board. *Don't do it!* You'll get skin oil on the copper, which will make it difficult to apply resist later. Place a sheet of paper between your hand and the board. Also, after you have resist on the board, it's possible the transfer sheet will lift off some previously applied resist as you lift it away from the last transfer. When the copper gets crowded with resist, and you think there's a good possibility you might lift some resist, screen the area you're working on with a couple of sheets of paper: one at the top, the other at the bottom. That way, you won't lift other resist patterns.

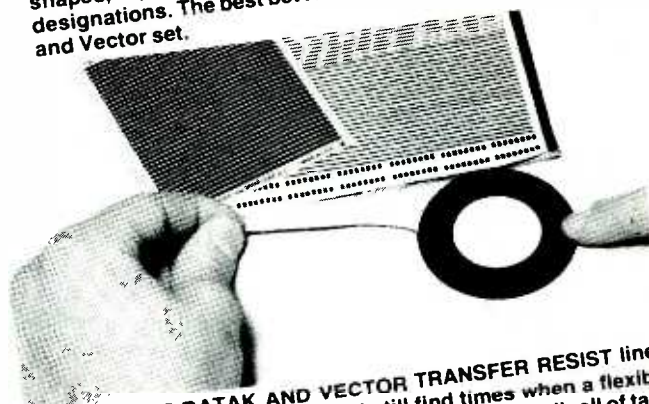
Fourth: It's going to happen. You'll transfer a resist pattern and when you pull the sheet away you'll find a few other patterns have also transferred to the copper. Until you have burnished the resist by rubbing it through the slip sheet, you can remove unwanted resist by simply touching it with a piece of cellophane tape. Use just the tip of a small piece of tape. The tape can also lift part, if not all, of previously applied resist—even if burnished—so be extra careful. Unless the resist won't lift with tape don't try to scrape it off with a knife or razor blade; generally, you can't get it all by scraping and you can end up damaging the copper.

Finally: Be careful with razor blades used to cut both transfer and tape lines. If you try to cut through a transfer line you'll end up cutting through the pattern underneath, say a doughnut, and you'll end up with hairline breaks in the copper foils. To cut the transfer resist, position one end precisely on a resist pattern (if a doughnut don't worry about covering the center hole) and adjust the sheet so that the line runs through to the resist pattern. Overlap the line slightly and simply "nick" the top of the transfer sheet with the tip of a razor blade (a sharp blade). Don't cut through. When you lift the sheet, the transfer resist line will break free exactly at the nick.



THIS SAMPLE OF A FEW SHEETS ILLUSTRATES the Datak dry transfer resist set. It is heavily into doughnuts, transistor and IC socket/mounting patterns, and relatively heavy lines.

THE VECTOR SETS HAVE THE USUAL ASSORTMENT of doughnuts and sockets, plus an excellent assortment of special shapes, alphabets and numerals, and electronic symbols and designations. The best bet for the hobbyist is to combine a Datak and Vector set.



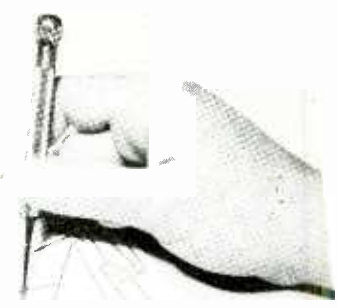
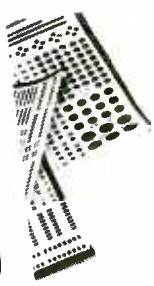
THOUGH THE DATAK AND VECTOR TRANSFER RESIST lines will meet almost all needs, you'll still find times when a flexible resist tape will be needed. Datak supplies a very small roll of tape in their kits: Spurge, and treat yourself to a full-size roll like the one shown.

To cut tape lines, again position one end directly over a pattern and unroll the tape over the next pattern. (Take care not to stretch the tape. It snaps back and you'll suddenly find it doesn't reach the pattern.) Press the razor flat down against the tape and then pull the free end of the tape upwards; the tape will cut itself off the strip. Make certain you use barely enough pressure on the razor to keep the tape that's on the copper from moving as the free end cuts itself free. If the tape starts or ends at a resist pattern, overlap the complete pattern (say, a doughnut) and make the cut at the "far end" of the pattern. In that way, extra razor pressure won't cut through the resist.

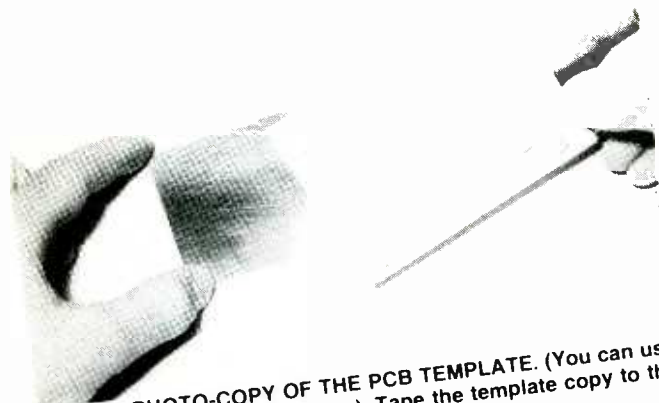
OK. Now you can follow the pictures on your way to quick and easy—but almost professional quality—PCB's. The pictures, which show the PCB for the Darkroom Printmeter that appears elsewhere in this issue, begin above and continue on the next few pages.



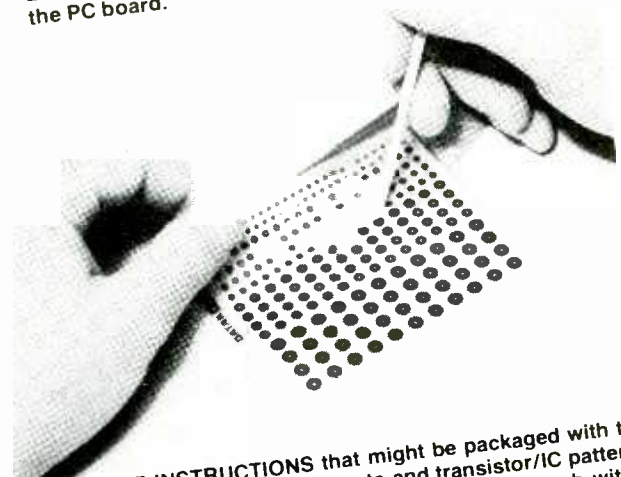
CUT A PIECE OF COPPER-CLAD PC BOARD to size and scrub it clean with *medium* steel wool (from paint-supply stores). Do not use a soaped kitchen pad—the last thing you want on the copper is a soap residue. Scrub till you have a mirror-like surface then wash the board with a *liquid detergent* and rinse extra-thoroughly. Let the board air-dry or use a fresh paper napkin. Do not dry with a kitchen or hand towel that's been used even once.



IF YOU DON'T HAVE AN AUTOMATIC CENTER PUNCH, use a scribe or ice pick. Wiggle the scribe from side to side so you get a good indent in the copper. The indent serves as a bit guide when drilling the component hole and you don't have to worry about whether the doughnut center remains open when you etch the PC board.



MAKE A PHOTO-COPY OF THE PCB TEMPLATE. (You can use the copier at your local library). Tape the template copy to the PCB with the tape on the back of the board.



IGNORE THE INSTRUCTIONS that might be packaged with the transfer resist: Apply the doughnuts and transistor/IC patterns first. Position the pattern over a copper indent and rub with a stick or burnishing tool. When you lift the sheet, the resist will remain on the copper. Don't worry if the pattern isn't precisely centered on the indent; that's why you made the indent to begin with. The indent, rather than the center of the pattern, serves as the drilling guide.



MARK THE CENTER OF EACH COMPONENT MOUNTING HOLE with an automatic hand-fired center punch, such as this General. Set the punch for medium pressure so you get a good indent in the copper foil under the template, but not enough pressure to crack the board. Try it on scrap first. Do not use a standard punch and a hammer.



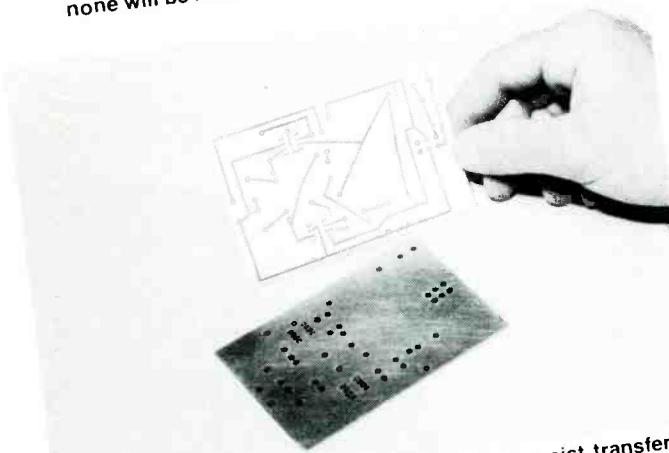
UNWANTED PATTERNS WILL COME OFF the sheet from time to time. You can remove them from the copper by touching the top of the pattern with a strip of Scotch (cellophane) tape. Try to avoid scraping the unwanted pattern with a knife or razor—it becomes a mess of bits and pieces of resist. (Note how a couple of doughnuts transferred to the table-top just under the hand.)



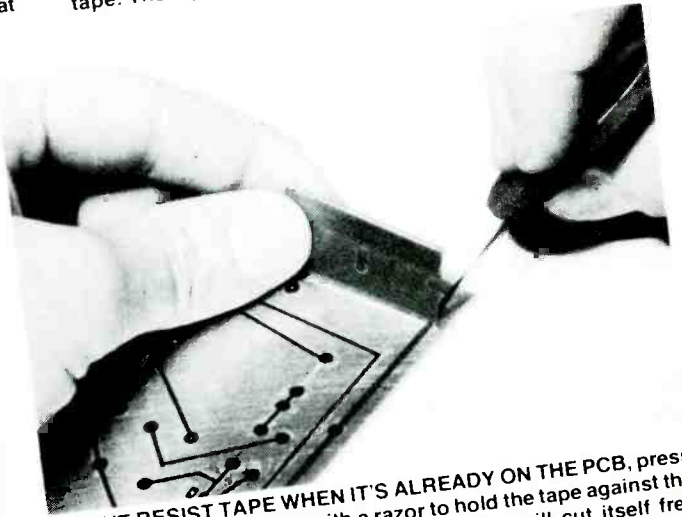
WHEN ALL THE MOUNTING HOLE (indent) resist patterns are on the copper, burnish them down by rubbing each one with your finger and burnishing tool through a slip sheet. The slip sheet is the backing sheet for each sheet of transfer resist. It is specially treated not to stick to the transfers, so you can be certain that none will be lifted when you lift the slip sheet away.



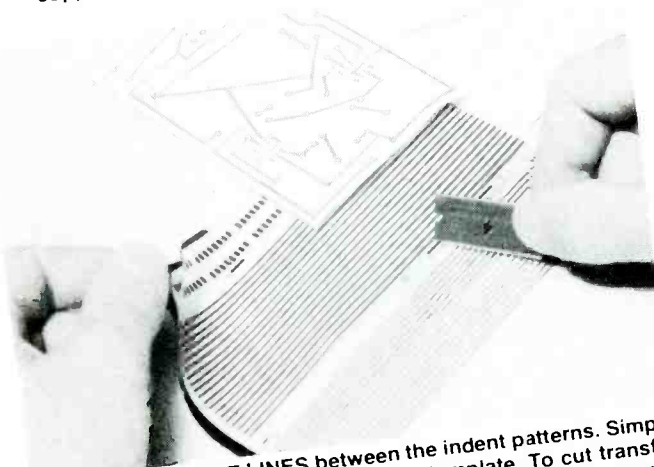
LONG-LINE RUNS ARE BEST MADE with krinkle or crepe resist tape. The tape can be carried right over transfer resist patterns.



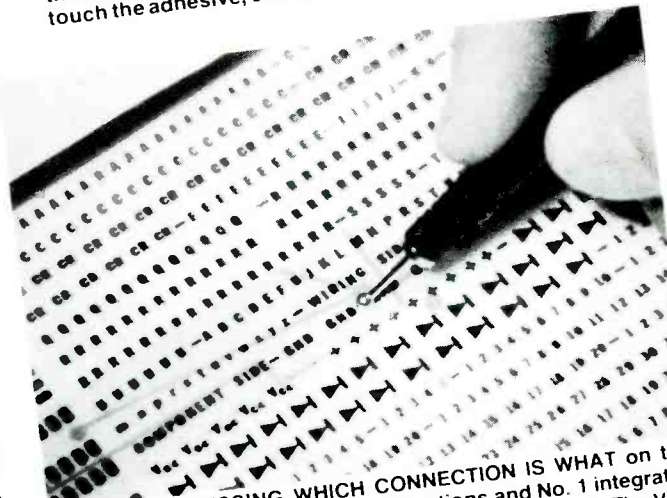
DOUBLE-CHECK AND BE SURE you have a resist transfer at each component location. Don't guess; you might have left out a copper indent. Compare the resist pattern itself with the template.



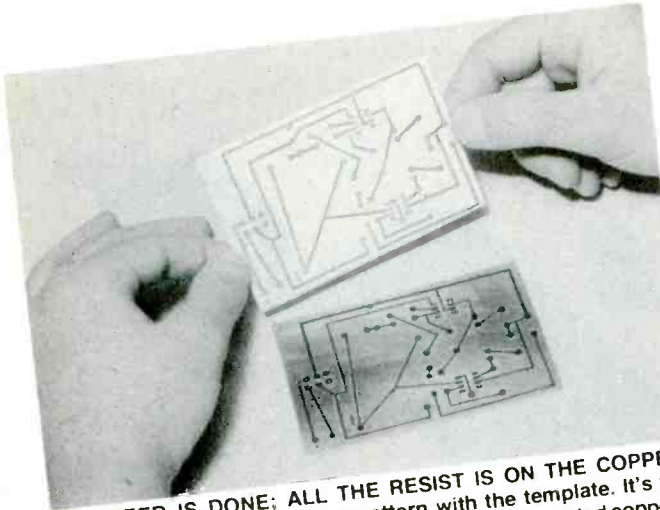
TO CUT RESIST TAPE WHEN IT'S ALREADY ON THE PCB, press down at the cutting point with a razor to hold the tape against the PCB; then lift the roll up sharply. The tape will cut itself free without disturbing the position of the tape on the copper. Keep your fingers off any part of the tape's adhesive that will be on the copper. Skin oil will interfere with the adhesion and might allow the etching acid to creep under the tape. If you inadvertently touch the adhesive, cut away the tape and use a "fresh" section.



APPLY THE RESIST LINES between the indent patterns. Simply eyeball the resist against the original template. To cut transfer lines to size, position the line and gently nick (don't cut through) the top of the transfer sheet with a sharp razor. Touch the part of the line you want transferred with your finger. When you lift the sheet, the line will break free cleanly at the nick, and you won't have damaged any previously applied resist pattern that might be under the line-cutting point.



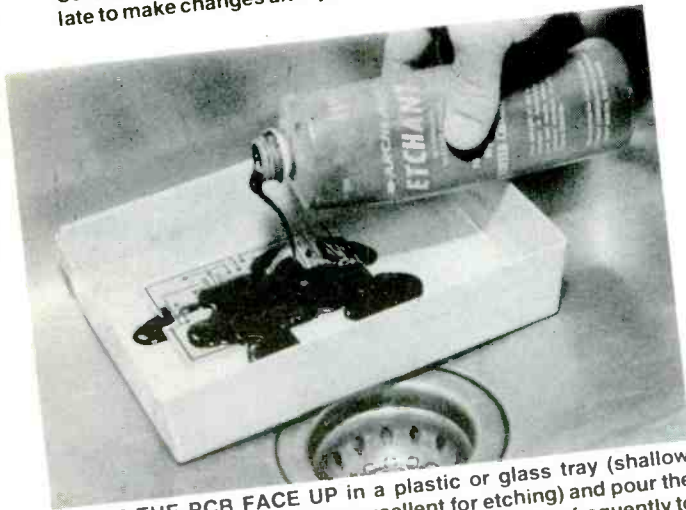
TO AVOID GUESSING WHICH CONNECTION IS WHAT on the finished PCB, label the power connections and No. 1 integrated circuit pins, and whatever else you think is necessary. The Vector resist kit provides many commonly used "labels". They are pretty close together so use a small burnishing tool when making the transfer.



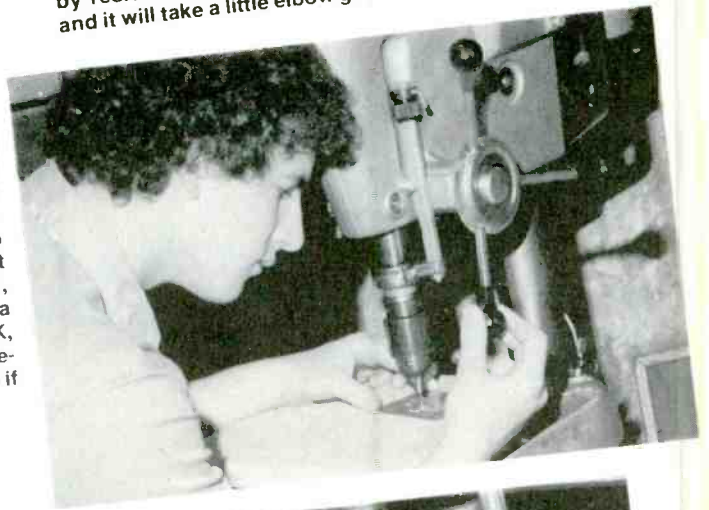
THE DEED IS DONE; ALL THE RESIST IS ON THE COPPER. Carefully compare the resist pattern with the template. It's too late to make changes after you etch away the unprotected copper.



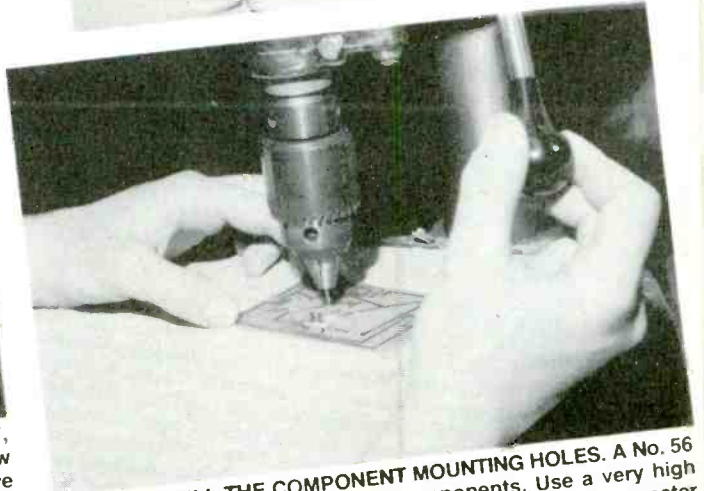
REMOVE THE RESIST WITH STEEL WOOL, solvent, or whatever. Then scrub the foils with steel wool till they shine. The "dull" finish on the copper (even after the PCB is washed) will make it difficult for the copper to accept solder, and you'll have to use excess soldering heat or excess flux. The "dull" finish is caused by resist-adhesive and acid by-products; it must be removed, and it will take a little elbow grease to get it all off.



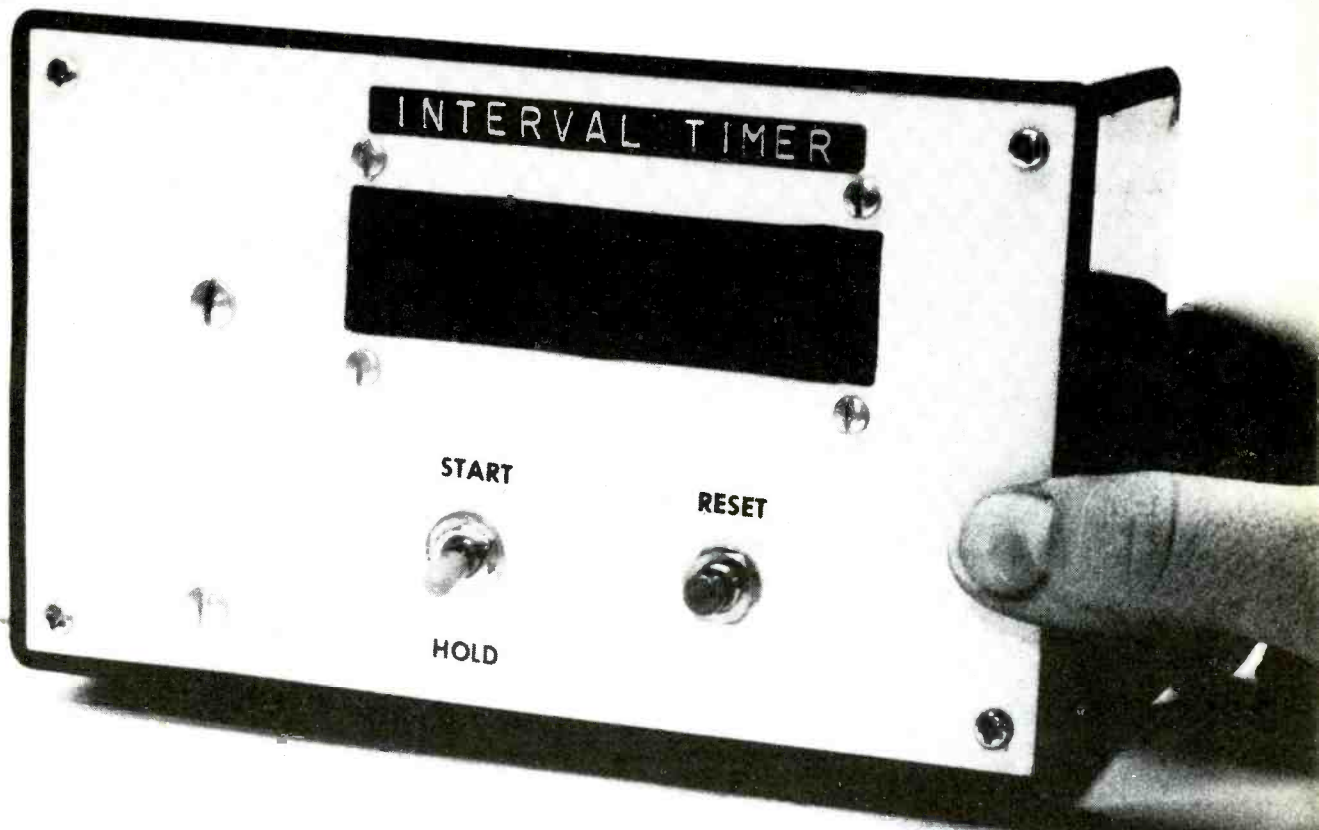
PLACE THE PCB FACE UP in a plastic or glass tray (shallow Rubbermaid drawer trays are excellent for etching) and pour the etchant to a depth of at least $\frac{1}{4}$ inch. Agitate the tray frequently to speed etching and avoid air bubbles from isolating the etchant from the copper. The etchant splashes easily and stains badly, so do the whole thing in a sink. Some etchants are supplied in a plastic bag into which you slide the PCB. Either way is OK, though the plastic bag is neater, almost splash-free, and somewhat faster; though it's more difficult to check the board to see if the etching is completed.



WHEN ALL THE UNPROTECTED COPPER IS ETCHED AWAY, rinse the PCB extra thoroughly under running water. A few specks of copper that might remain (because of air bubbles) are unimportant if they're not shorting connections.



FINALLY, DRILL THE COMPONENT MOUNTING HOLES. A No. 56 or No. 58 bit will work for most components. Use a very high speed with small bits for neat, burr-free holes. For holes greater than $\frac{1}{8}$ inch, a slower, more normal drill speed is recommended.



All the features of a popular commercial unit at a quarter of the price.

INTERVAL TIMER

HERB FRIEDMAN

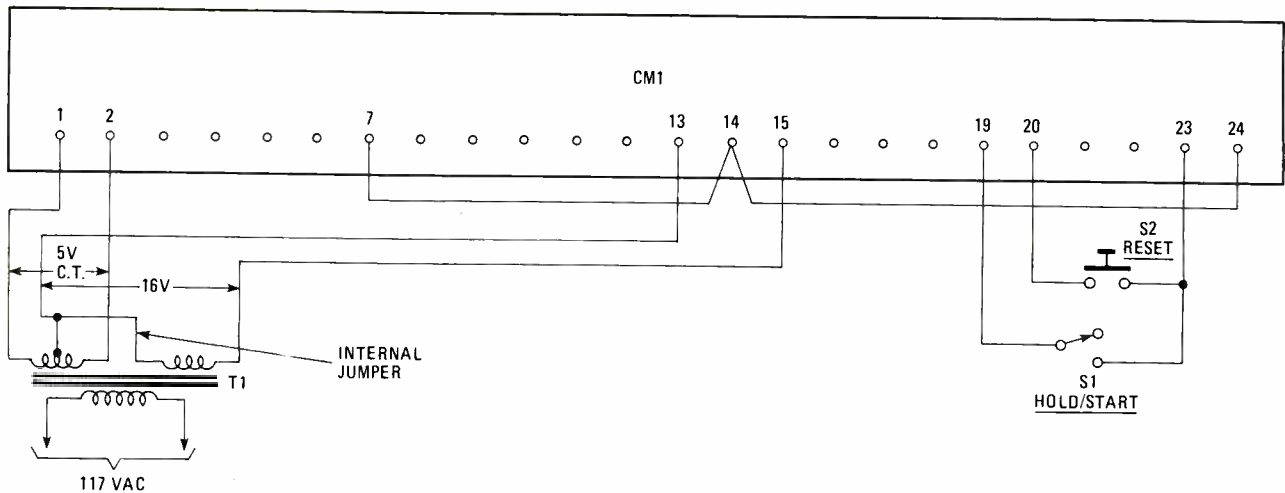
ONE OF THE MOST POPULAR COMMERCIAL INTERVAL timers costs almost \$100 in kit form (when you can get it), and well over \$100 in its wired version. The device counts from 0 to 9 minutes in 1-second intervals and then recycles through zero. Its main attraction is a *flying start* zero reset and a time-accumulation *hold*. It is generally used for such applications as developing color film and color prints, timing program segments when tape editing, and the length of record selections when making tape and cassette copies.

Using standard components an almost exact functional copy can be built for about \$25; a unit that has the additional feature of a red LED display that allows the timer to operate in the darkroom for black and white printing—as when timing an exposure by visual count.

How it works.

If you have ever seen the insides of a commercial interval timer you know it's jam-packed with parts—it is a formidable project to build. The very same functions, however, are possible from a standard "surplus" LED clock module using some unusual, though not difficult, connections. In fact, the "clock" version of the interval timer permits simplified remote control operation through foot switches: ordinary pedal switches simply connected in parallel (through jacks) with RESET switch S2 and HOLD/START switch S1.

The timer is always started with S1 in the HOLD (closed) position. The display comes on with some value—it can be anything—and is cleared by depressing RESET switch S2.



WIRING DIAGRAM APPEARS SIMPLE since so much of the circuitry is on the clock module.

To start timing, S1 is moved to START (open). The display counts from zero in 1-second increments. If reset during a count the display jumps to zero and resumes counting from zero (*flying start*).

If S1 is set to HOLD during a count, the elapsed time is held until the hold is released by opening S1. The count picks up from the held value. If it is interrupted again the count will resume from the last held value.

If reset, with S1 set for HOLD, the display will jump to zero and remain at zero until S1 is moved to START.

Regardless how many hold operations are performed, RESET will always provide a *flying start* if the timer is running (S1 set for START.)

Here's a typical example of how the RESET is used. Assume you are working on some project requiring several consecutive timed operations: such as making color prints from negatives. Color prints require at least a timed development, a timed bleach/fix, and a minimum wash.

Operations are started with the timer running (set to START).

As soon as the printing paper is placed in the developer, or the developer is poured into the developing tank, the timer's RESET switch is pressed. The timer instantly jumps to zero and starts counting. When development is completed, the solution is poured out and the bleach/fix poured in. The timer is left running during this operation as there's no need to fuss with it.

As soon as the stabilizer is in the tank or tray, the RESET is again depressed, causing the timer to jump to zero for the bleach/fix time cycle. The same procedure is used for the wash. At no time is there any fussing with the timer during the critical chemical changing, nor is there any need to interpolate cumulative timer periods. Each operation is timed from zero. If cumulative timing is necessary this is done by simply setting S1 to HOLD, at the end of each procedure.

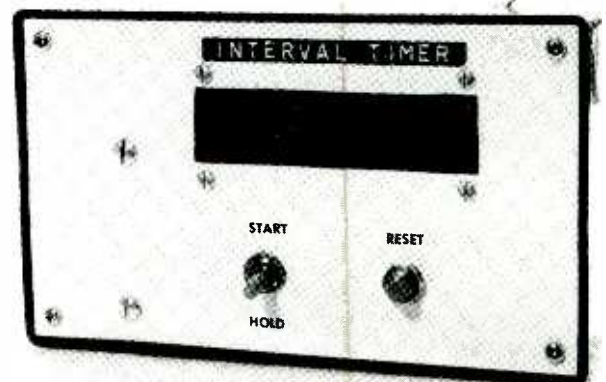
PARTS LIST

- CM1—4-digit clock module, Radio Shack 277-1001
- T1—Clock power transformer, Radio Shack 273-1520
- S1—SPST switch
- S2—Normally open momentary push-button switch
- Miscellaneous—Cabinet, AC plug, etc.

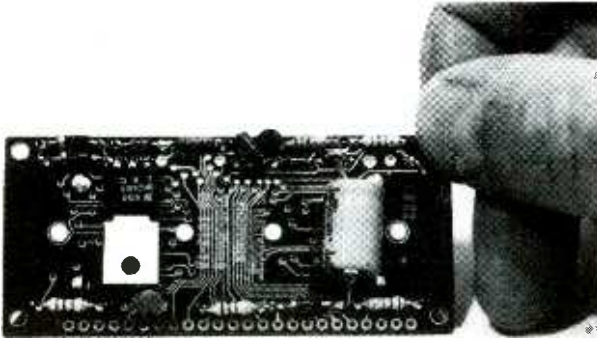
(Though it's much easier to time with a *flying start* from zero.)

Construction techniques

As you can see there aren't many parts. There certainly aren't any construction problems other than those normally associated with handling CMOS and MOS components. It's a good idea to ground yourself with a wrist strap to the electrical ground when handling MOS devices, and to use a grounded soldering iron, one with a 3-wire electric plug (where you know for certain that the third—or *green*—wire really is grounded in the electrical outlet).



THE FINISHED TIMER can be mounted in almost any type of case; if the case has a metal front-panel, mount CM1 using insulated standoffs.



THIS IS THE BACK OF THE CLOCK MODULE, the part that's inside the cabinet. All connections are made to the strip of terminal holes along the bottom edge. Do not attempt to connect to any other "solder pad" or "hole" regardless what's implied by the instructions supplied with the clock module. A small number "1" adjacent to the hole at the extreme left is the only identification for the terminal holes. You must count them off carefully from 1. The two jumper wires that convert the module into an interval timer are installed on the opposite, or front, side.

A wrist ground is simply a small alligator clip on your wristwatch band if it's metal, or the metal buckle if the strap is non-conductive. The clip connects to an electrical ground—such as a grounded receptacle cover plate securing screw—through a 1-megohm, ½-watt resistor. **WARNING—Make certain that you use the resistor. If not, you might get a nasty shock if you ever use the strap when working on line-powered devices.**

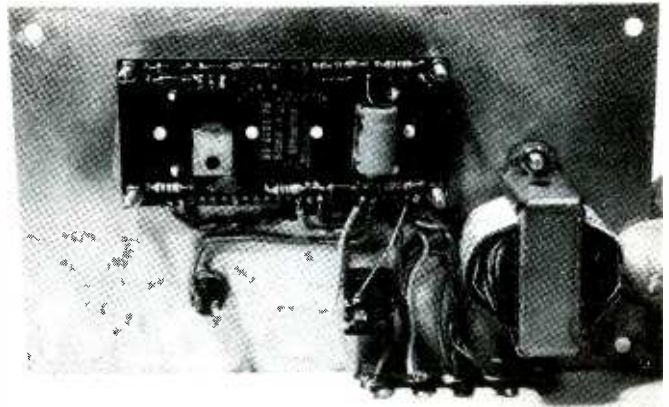
The clock module is supplied with a copper shorting foil running the length of the miniature connections on both sides of the bottom edge. This foil is only an MOS protection device. Simply peel it off.

If the timer is built into a plastic cabinet with a metal front panel (such as shown in the photographs), or a metal enclosure, the clock module must be raised away from the panel—to avoid short-circuiting the underside foils—by using 3/16-inch or ¼-inch standoffs or a stack of washers between the module and panel at each mounting screw. If the timer is assembled on a plastic panel the module can be secured directly to the panel.

The RESET switch, is a normally-open momentary-contact pushbutton. The HOLD/START switch is a standard SPST. If you also want a remote control option, simply wire connecting jacks for the footswitches directly across (in parallel with) S1 and S2.

The clock connections are arranged along the bottom edge of its printed circuit board (PCB). They are very closely spaced and it's all too easy to form a solder bridge and short out adjacent solder pads, or you might even destroy the pads with excess soldering heat. Use an iron (**absolutely not a solder gun**) with a fine "pencil" tip rated between 20 and 50 watts. One of the temperature-regulated irons is ideal.

Before installing the module on the panel install two jumpers on the "underside" of the PCB; the side with the LED display that will be facing the panel. For this and all other connections, use wire that's no heavier than solid No. 22. Try to avoid stranded wire because a loose strand too small to see can easily bridge adjacent clock module connections.



THIS IS ALL THERE IS TO THE TIMER. Note that the transformer wires are connected to a terminal strip and not directly to the clock. The leads are relatively heavy and can cause damage to the module connections. The terminal strip anchors the transformer's leads. Connections from the strip to the module are with No. 20 or No. 22 insulated solid wire.

Twist two wires together, insert them into terminal hole No. 14 from the LED side, and tack solder. Be careful that you are actually in hole No. 14. There are 24 holes along the module's bottom edge. A single numeral "1" at one end designates the No. 1 hole. There are no other hole or terminal identifying marks. Make certain you count from the indicated No. 1 hole. Spread the free ends of the wires right and left and solder one in hole No. 7 and the other in hole No. 24. Keep the wires at least 1/8-inch away from the PCB so they are not shorted when you connect the other wires from the top side of the PCB. Even if you use insulated wires keep them away from the PCB.

After the jumpers are installed mount the module, the switches, and transformer T1 on the front panel.

T1 is specifically intended for the module. It is Radio Shack part No. 273-1520. No color code for T1 is shown in the schematic because there is no fixed color code for T1. The correct color coding for each transformer is indicated directly on the transformer itself.

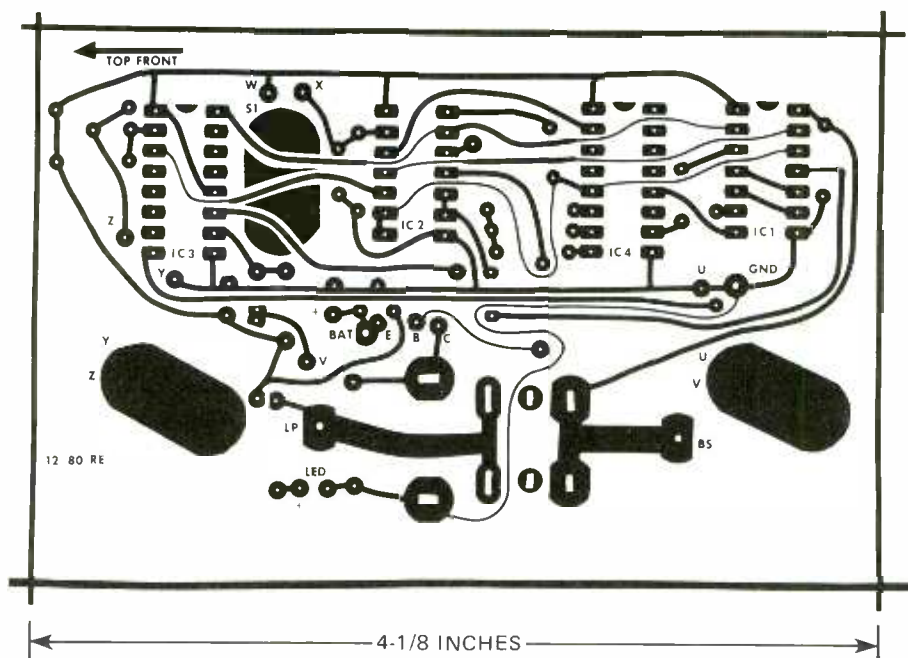
Final checkout

Set S1 to HOLD (closed) and apply power. Three display elements should light immediately indicating some time value (any value). The fourth LED on the extreme left should not light.

Pressing RESET switch S2 should reset the displayed time to zero. Moving S1 to START (open) should start the timing. Pressing RESET should reset the display to zero and the counting should resume automatically. If S1 is set to HOLD during a count the value should be maintained in the display. Releasing the hold should cause the count to resume from the previous value. The RESET switch can be used at any time.

If you do not get this precise sequence of operation check for a wiring error, or a solder bridge across a pair of clock module terminals. If you must unsolder a wire from the module, or clear a bridge, use some kind of solder remover to clear away the solder. Don't try to shake the solder loose. The extra heat necessary for "shake solder removal" can damage the module's PCB.

DIGITAL BRAKE-LAMP WARNING SYSTEM



While nothing will completely eliminate accidents, this device may help prevent some by alerting the driver behind you to a potentially dangerous situation.

THOMAS E. BLACK

AUTOMOBILE ACCIDENTS DO HAPPEN, BUT MOST CAN be avoided. Many accidents occur because of poor driver awareness, especially in rear-end collisions. Perhaps if we can catch the attention of the driver behind us, we may avoid some possible entanglements. Presented here is a digital brake-lamp flasher that allows us to do just that.

This device monitors braking inertia, and under certain conditions, flashes the brake lamps for a few moments, then lights them steadily. Incidentally, there are three brake-lamp conditions. The lamps operate normally during smooth safe stops. Quick stops cause a 3.5-Hz flash rate for four seconds before going solid, and emergency stops create a 7-Hz burst of light.

Digital counters do all the timing for the required

clock rates, and mercury switches take care of inertia detection. To maintain reliability, the circuit design uses no pots (they may go out of adjustment). The only adjustments to make are to the three hermetically sealed mercury tilt switches. There is also a manual disable switch that will provide normal brake lights during trailer towing or heavy hauling. The mercury switches are positioned for normal cargo weight; heavy loads can upset their effectiveness.

About the circuit

Mercury switches S1, S2, and S3 (see Fig. 1) are positioned to sense motion. S2 and S3 react to braking inertia, and S1 has a special purpose that is discussed later. The 4060 integrated circuit is a ripple counter

that generates the 3.5-Hz, 7-Hz, and 4-second clock rates. R8, R9, and C4 provide the 4060 IC with the 5-kHz master clock that it divides to produce the required clock rates.

During normal safe stops, flip-flops IC3-a and IC3-b are in a reset condition, and their outputs on pins 1 and 9 are held low. Because of the NAND function of IC1-b and IC1-c, gate IC1-d output goes low. This low signal is inverted by IC2-d, which turns off Q1 and the relay contacts now supply a current path to the brake lamps. It may appear that our brake lamps will never go out, since the replay contacts are almost always closed. However, relay RY1 is in series with the brake-pedal switch, and lamp current appears only when the brake pedal has been depressed. The LED lamp is also driven by relay RY1, and it will light any time that the brake lamps are on.

If a moderate stop occurs, mercury switch S3 closes and C3 provides a pulse to set flip-flop IC3-b; pin 9 of IC3-b goes high and is combined with the 3.5-Hz clock at IC1-b. The output IC1-d gates IC2-d on and off at 3.5-Hz rate, which causes RY1 to flash the brake lights.

Four seconds later, pin 15 of the 4060 IC goes high and resets IC3-a, 3-b, and the 4060. The outputs of these IC's go low and cause the brake lamps to remain on steadily (and prevent further counting of IC 4060). When the brake pedal is released, our lamps extinguish, and IC1-a output goes high and holds the 4060 IC in a reset state to insure that future counting will begin at zero.

Emergency stops allow both mercury switches S2 and S3 to close. Pins 1 and 9 of flip-flops IC3-a and 3-b are set high. Because of NOR gate IC2-c, IC3-b is immediately reset low again. The logic high from IC3-a is combined with the 7-Hz clock at IC1-c and through IC1-d and IC2-d the relay is pulsed at the 7-Hz flash rate. Reset occurs as discussed before.

Mercury-switch S1 provides an automatic disable feature to our 4060 counter. During travel on rough roads, S2 and S3 may close and cause the brake lamps to flash during very slow stops. This is undesirable because our main goal is to provide lamp flash only for quick or emergency stops. S1 is positioned so that heavy bouncing of the auto causes it to close and

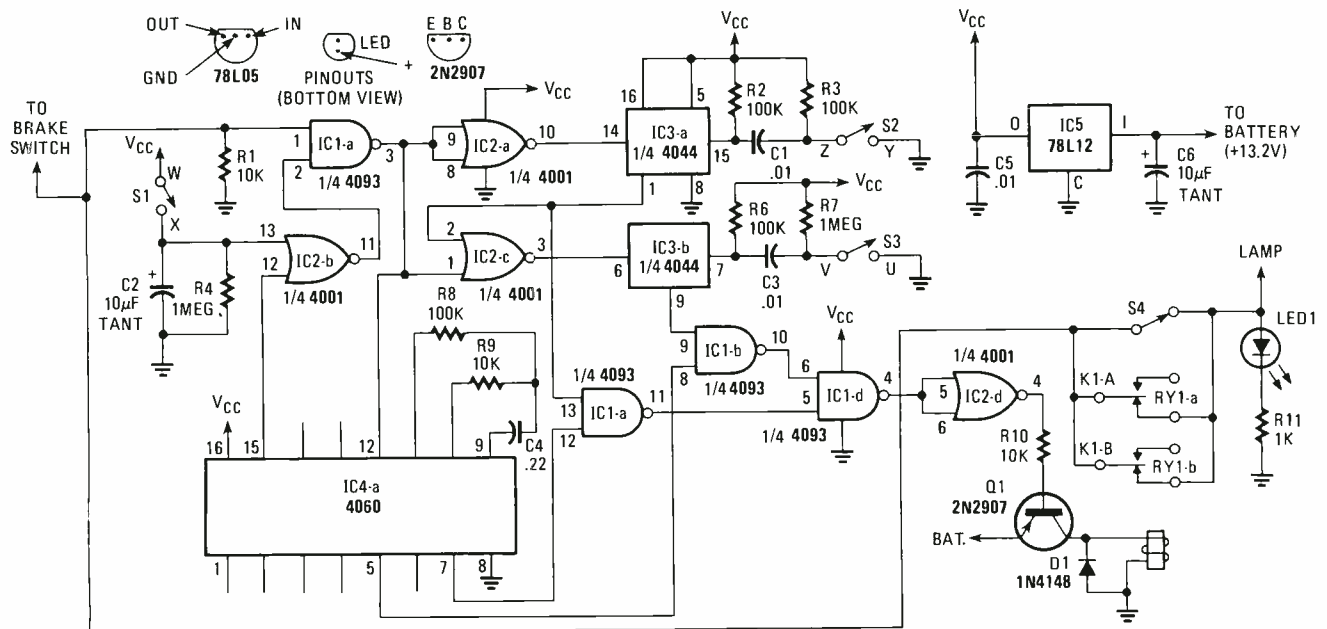


FIG. 1—SCHEMATIC DIAGRAM OF the digital brake-lamp flasher circuit. Switches S1, S2, and S3 are mercury switches used to detect motion.

PARTS LIST

RESISTORS

all resistors 1/4 watt
 R1—10,000 ohms
 R2, R6, R8—100,000 ohms
 R3, R4, R7—1 megohm
 R5—120 ohms
 R9, R10—10,000 ohms
 R11—1000 ohms

CAPACITORS

C1-C3, C5—0.01 μ F ceramic disc
 C2, C6—10 μ F, 16 volts, tantalum
 C4—0.22 μ F, 10%

SEMICONDUCTORS

D1—1N4148 or equivalent

LED1—LED lamp

Q1—2N2907 PNP transistor or equivalent

IC1—4093 CMOS NAND gate

IC2—4001 CMOS NOR gate

IC3—4044 CMOS flip-flop

IC4—4060 CMOS counter

IC5—78L12 voltage regulator

SWITCHES

S1-S3—mercury switch, one-inch or longer glass bulb type

S4—SPST toggle switch, 6 amps

MISCELLANEOUS

RY1—SPST power relay, 12 volts, 10 amps (GC Calectro

D1-996 or equivalent)

Case, 4-terminal barrier strip, wire, etc.

charge capacitor C2. This capacitor will remain charged for a few seconds and provides a reset logic level to the 4060 IC through gates IC2-b and 1-a. Any time C2 is charged, the brake lamps operate normally (no flashing). Toggle-switch S4 is used if we need to permanently disable the circuit, such as during trailer towing.

Construction techniques

A printed circuit board is recommended because it results in a compact, rugged assembly. A full-size etching and drilling guide for a suitable board is shown in Fig. 2. The corresponding component placement guide is in Fig. 3. Use a fine-tip soldering iron and small-diameter solder. Keep the CMOS integrated circuits in their static protectors until you are ready to install them.

Install the insulated jumper wires first. Next, install the resistors and capacitors and then the semiconductors. If you use IC sockets, be sure to use only the gold-plated type to insure reliability. Install the mercury switches using three-inch lengths of hook-up

wire. *Do not* cement them down at this time. The circuit board was designed to use the relay specified in the parts list, but almost any 12-volt heavy-duty relay can be adapted for use by mounting it off the PC board if necessary. The wiring for this relay and its associates must handle considerable current to the brake lamps. Use 16-18 gauge wire on all connections to the contacts of RY1. All other wiring can be made with stranded 22-26-gauge wire. After completion, inspect all wiring for errors and solder shorts.

Check out and use

Place S4 in the OFF position. Temporarily connect a 9-volt battery to the "BATT" and "GND" leads of the circuit. Connect the brake-switch lead to +9 volts. The LED should glow solidly. Position all mercury switches upright so they are open. Closing S3 should cause a 3.5-Hz blink rate for less than four seconds. Open S3, and now close S3 and S2 together. The fast 7-Hz blink rate should last less than four seconds.

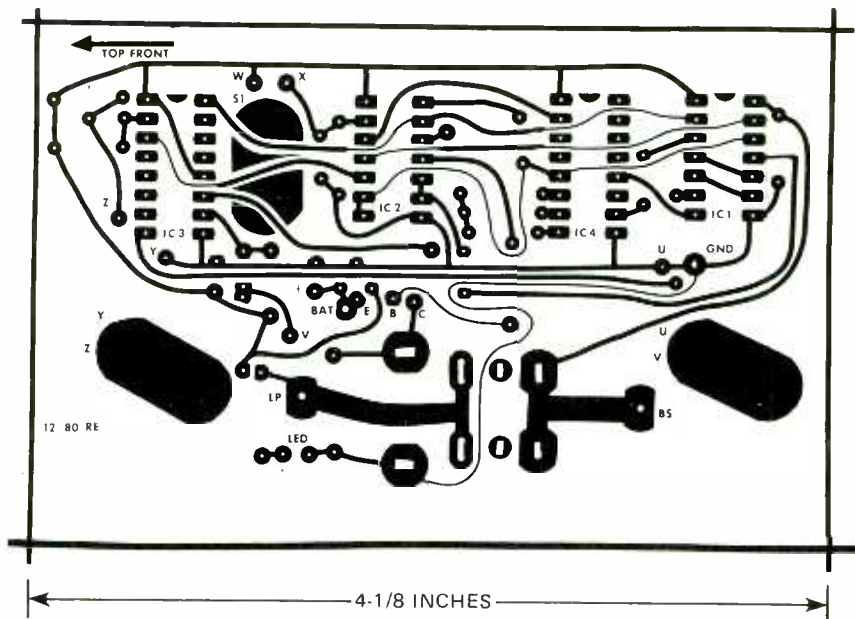


FIG. 2—A PRINTED CIRCUIT BOARD is recommended so that the device is compact and sturdy. A full-size pattern is shown here.

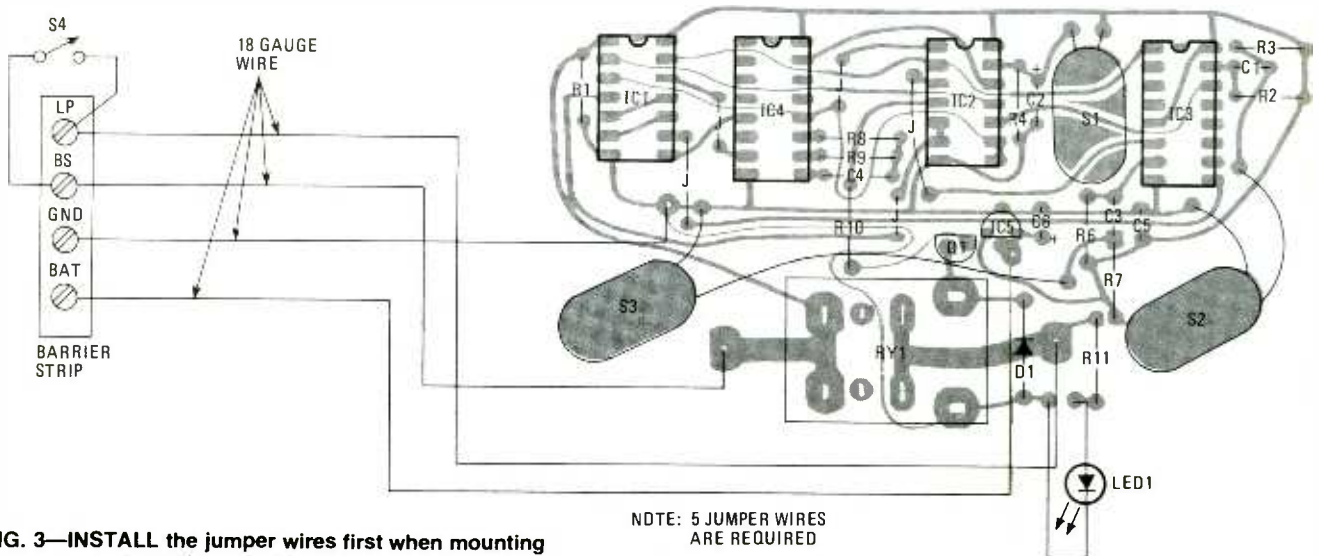


FIG. 3—INSTALL the jumper wires first when mounting the components as shown in this parts placement diagram.

NOTE:

Use of this device may violate some local motor-vehicle safety codes. To insure that you are in compliance with the law, consult your local motor-vehicle bureau.

Open S3 and S2, and close S1. S3 and S2 should have no effect when they are closed. Open all switches; wait ten seconds, and then make sure that S2 and S3 are not active.

Epoxy S1 vertically to the printed-circuit board so it is normally open. Holes W and X on the board are for mounting this switch. Use a quick setting epoxy and allow it to dry thoroughly.

Calibration is easy

Reinstate the test set-up and find a friend to drive you both to an empty parking lot. Position the circuit board so the "top front" arrow (as shown in Fig. 2) is aimed at the front of the vehicle. Be sure to hold the circuit board steady throughout your tests.

Open switch S3 by holding it upright, and then position it so the mercury rolls forward and touches the contacts during a quick but non-emergency stop. Make sure the switch remains open during a normal stop. Mark the position of S3 for later reference.

Open S3, and then position S2 so that its contacts close during an emergency stop (lamps will blink at 7-Hz rate). Mark the position of S2. Do not allow your tires to skid, and do not drive unsafely.

Remove the test set-up, and permanently install S2 and S3 with epoxy cement. Mount the printed-circuit board in a suitable enclosure, and then find a location in your car that will allow level mounting. Be sure to aim the board in the correct direction. Wire the "BAT" lead to the accessory terminal of the auto fuse-block and "GND" to the chassis. Relay RY1 is wired in series with the brake-pedal switch. Cut the output lead of the auto's brake-pedal switch, and wire terminal "BS" to the brakeswitch output and "LP" to the brake lamps (see Fig. 4).

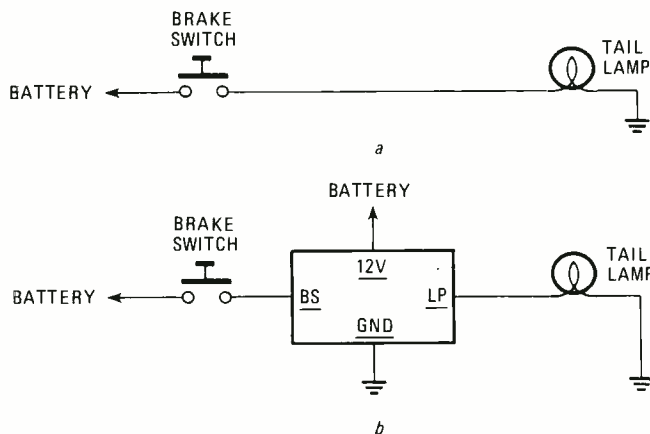
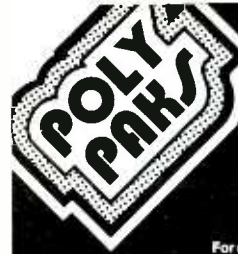


FIG. 4—TO MOUNT RY1, cut the wire between the brake switch and the taillamp (a) and mount the relay as shown in (b).

Be sure to re-check your brake lamps, and do it in a safe manner. While you are at it, this is a good time to check all the lights on your automobile. **SP**



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24-MINI-BULBS, ASST. VOLTAGES & base styles, some colored	(#6757)
125-LONG LEAD DISK, prime, marked caps, assorted material.	(#2598)
50-SLIDE SWITCHES, various shapes, sizes and types	(#2726)
25-MICRO MINI REED SWITCHES, 1" long, for alarms, relay systems, etc.	(#6263)
50-THERMISTORS, various types & styles, neg. coefficient, 100%	(#4089)
200-PRE-FORMED DISCS, caps w/leads for PC use, mixed values,	(#2605)
50-AXIAL ELECTROS, asst. values, volts, sizes, what a buy!	(#3227)
100-PLESSY CAPS, ceramic blocks in assorted sizes & values,	(#6221)
3-WATCH GUTS, 5-function, LED style, assorted sizes, untested	(#6758)
6-TIME DELAYS, solid state, asst. from 450 mSec to 8 Sec.	(#2604)
100-PLASTIC TRANSISTORS, untested, to-92, asst. types	(#2747)
75-TRANSISTOR ELECTROLYTICS, epoxy encapsulated, asst. values,	(#3057)
20-SLIDE VOLUME CONTROLS, various values & types, for Hi-Fi, etc.	(#6271)
500-PC-HARDWARE SURPRISE, (approx.) 1 lb. asst. screws, washers, etc.	(#6281)
100-POWER RESISTORS, 3 to 7 watt power resistors,	(#6238)
50-2 WATT RESISTORS, assorted rotary, carbons, films etc. some 5% ers,	(#6285)
24-SKINNY TRIM POTS, multi & single turn, asst. values & types,	(#6256)
40 CRYSTALS, assorted types, some H6/U, some frequency marked.	(#6286)
20-8V BATTERY CLIPS, snap connector, coded, insulated leads,	(#6292)
4 HEAVY DUTY LINE CORDS, 2 cond. 6ft., 16 gauge	(#2428)
200-PRECISION RESISTORS, 1/2 W, assorted wattages 1%, axial	(#6630)
30-PANEL SWITCHES, assorted rotary, micro, slide, etc. ers, etc.	(#6633)
20-PAIRS-RCA PLUGS & JACKS, popular for Hi-Fi, speakers, etc.	(#6499)
4-2N3055 NPN TRANSISTORS, 115 watts, 15 amps, TO-3, 100% mat	(#6284)
5-LINE CORDS, heavy duty, 18 gauge, 6', molded plug, 2-cond.	(#6237)
20-2N3055 HOBBY TRANSISTORS, manuf. fallout, TO-3, U-test,	(#2417)
25-PLASTIC POWERS, 25 watt, npn & pnp, 50-200 brvco, TO-220	(#6337)
150-"4000" RECTIFIERS, IN4000 series, may include; 50 to 1000V	(#6632)
30-SCRs & TRIACS, assorted values, 10 Amp TO-220, untested	(#6498)
60-IN914 SWITCHING DIODES, 4 nsec, axial, glass, untested	(#6244)
30-INSTRUMENT KNOBS, for half round shafts, some w/pointers	(#6364)
35-STEREO INDICATORS, tiny red 1.5V bulbs, for Hi-Fi replacement	(#6718)
40-EDGE CONNECTORS, asst. 4 & 6 pin, 2-sided, pc leads	(#2613)
6-MINI-MOTORS, type RE58, 1.5-6VDC, color-coded wire leads	(#6280)
25-NE-2 BULBS, neon, for 110 VAC, requires resistor, (not incl.)	(#6331)
150-METALLIC RESISTORS, mostly 1/2 watters, asst. val. 1-5% tol.	(#6370)
40-VOLUME CONTROLS, assorted values & types	(#3300)
25-2N3904 TRANSISTORS, 100% material.	(#6284)
28H-COLORED 20 MIL FIBERS, 2' lengths, assorted colors	(#6756)
125-ONE WATT RESISTORS, top names, mostly carbons some 5% ers	(#6658)
200 PC. SEMICON SPECIAL, asst. diodes, zeners, etc. untested.	(#6254)
40-STRAIN RELIEFS, asst. types in various sizes & shapes	(#6259)
1 UHF TUNER, 3-gang, 300 ohm, direct drive type	(#6267)
200-TUBULAR CAPS, asst. tubulars, 100mmf to 0.1mf to 600 WVDC	(#6667)
60 MINI LAMP SOCKETS, asst. screw, bayonet, & snap-in's	(#2551A)
150-SUBMINI IF TRANSFORMERS, asst. transistor radio types	(#6251)
10-PUSHBUTTON ALARM SWITCHES, spst n.c. 1A 125 VAC	(#6321)
25-DATA ENTRY SWITCHES, asst. 1/2" square keyboard switches.	(#6627)
10-MOTORS MOTORS, asst. size hobby motors, 1-1/2 to 12 volts	(#6634)
150-TERMINAL STRIPS, asst. screw & solder lug types	(#6225)
50-TO-5 TRIACS, asst. 50 to 600 Piv. 70% yield, gold plated, 3 leads	(#6770)
200-HI-QUALITY RESISTORS 1/8, 1/2, & 1 watters 1% & 5%	(#6902)
40-MYLAR UPRIGHT CAPS, asst. epoxy, plastic, polystyrene, etc.	(#6617)
20-HOBBY LEDS, asst. types styles & colors, mostly dims	(#6617)
12 FT.-FIBER OPTIC RIBBON, 3/8" wide ribbons conduct light	(#6617)
100-PIN SOCKETS, inline male & female crimp-on connectors	(#6617)
100-ASSORTED SPACERS, nylon spacers, washers, grommets, etc.	(#6617)

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TAPE TESTER FOR CASSETTE RECORDERS

Quickly see which brands and types of tape are best. You can build this tester using low-cost parts.

THE TAPE TESTER IS A LOW-COST EASY-TO-BUILD PROJECT that will almost insure that your cassette recordings have the highest of fidelity—or, at the very least, will be the best that your recorder can produce.

Basically, the Tape Tester allows you to check different brands and types of tape quickly, to determine the one that delivers the highest (widest) frequency response. If your recorder has a bias adjustment control, but no bias-calibration test-oscillator system, the Tape Tester will provide the required test frequencies. At the very least, the test frequencies are a lot easier to use than listening to interstation FM noise and trying to set the recorder's bias control so that the recorded interstation noise "sounds almost the same" as the noise going into the recorder.

Other than a noise-reduction system such as Dolby or dbx, the most outstanding electrical feature of the

highest quality cassette recorders is a tape bias adjustment, that is usually combined with a two-tone test oscillator.

The reason for all the extra hardware—oscillator, switching, controls, etc.—is that cassette tape is extremely sensitive to the bias level, particularly in respect to frequency response; yet, with very rare exceptions, no two cassette tapes require the same bias level.

Figure 1 illustrates the effect of bias on frequency response. Within a normal range of values, the bias level determines the high-frequency response. If the bias level is less than intended by the manufacturer of the tape, there will be a decided peak in the upper highs, that will be characterized by a "hot" or "spitty" sound quality. If the bias value is too high there will be attenuation of the upper highs, resulting in a "dull" or

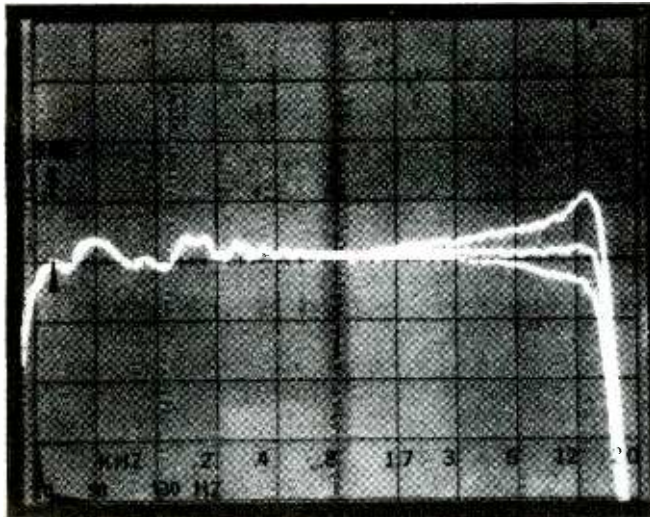
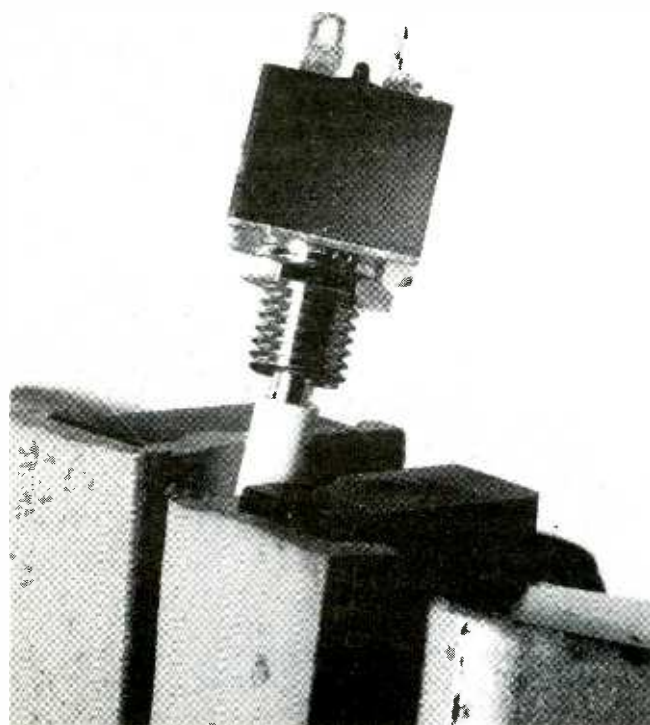


FIG. 1—THE FREQUENCY RESPONSE of a budget-priced cassette deck at -20dB record level for three values of bias for Maxell UD tape. The 6-dB peak at 13,000 Hz is caused by under-bias. The trace that rolls off 3-dB at 13,000 Hz is caused by excess bias. The trace that's flat out to almost 15,000 Hz was produced by the proper bias for the tape.



RIGHT HAND SWITCH LUG that's been cut in half and dressed with a file to convert the wire lug to a PCB solder terminal. File just enough so the terminal fits into a hole drilled with a No. 56 bit.

“bassy” sound quality—the greater the bias level, the greater the loss of high frequencies.

If the bias level is “just right” (or well inside the ballpark), the frequency response will be essentially “flat” (compared to a mid-band reference frequency) to about 11,000 to 12,000 Hz for better-quality cassette tape; 11,000 to 15,000 Hz or higher for the best quality tapes. Normally, the high-energy (best quality) tapes produce a slight “bump” in the upper high frequencies.

If your recorder is equipped with a bias-test-oscillator system it probably consists of a two-tone generator: approximately 1000 Hz and 11,000 Hz (or 13,000 Hz). You simply adjust the bias-level control until the output from the tape is more or less equal at the two frequencies.

If your recorder does not have a test-oscillator system all you need is this Tape Tester, for it provides the two necessary test frequencies.

Two ways to test tape

If your recorder has a bias adjustment but no test-oscillator system, simply feed in the signals from the Tape Tester at -20 dB below 0-VU or 0-dB record level and adjust the bias so that the tape output is more or less equal at the two frequencies. Adjusting the bias will affect the high frequencies. There will be little or no effect at the mid-band frequency within a normal bias-adjustment range.

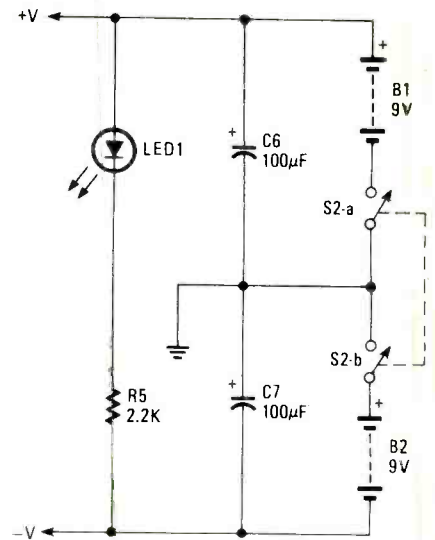
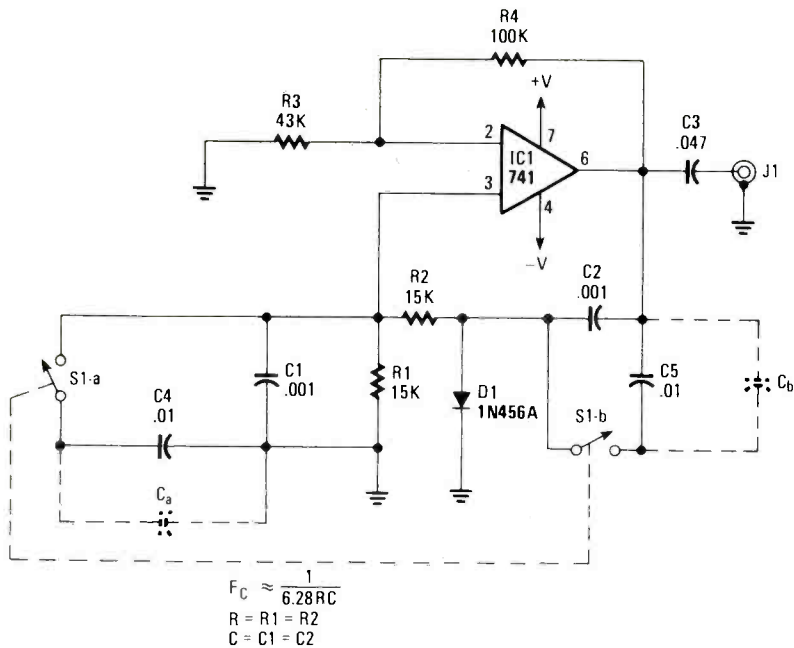
If your recorder has no bias adjustment use the same -20 dB record level and try several different tape types and/or brands. The tape that delivers more or less equal high and mid-frequency output level is the one most closely matched to your recorder's bias level, and is the tape you should use for highest fidelity recordings.

Budget parts equal high performance

This project has been designed specifically to work well with junk-box or budget components. Substituting expensive hardware isn't going to mean better performance. The circuit is a Wien-bridge oscillator that produces a sine-waveform output with about 3% harmonic distortion: a signal well suited for testing bias levels. (You don't need super low distortion to adjust tape bias.)

The output frequency is determined by resistors R1 and R2, and capacitors C1 and C2 for the high frequency; and with C4 and C5 for the mid-band frequency (see Fig. 1). C1 and C2 are a permanent part of the circuit. C4 and C5 are switched in. Capacitors indicated in the schematic as C_a and C_b are for mid-band trimming to the user's preferred mid-band frequency and are not generally needed. More on them later.

The frequency-determining capacitors are ordinary ceramic discs. The better the match per pair, the



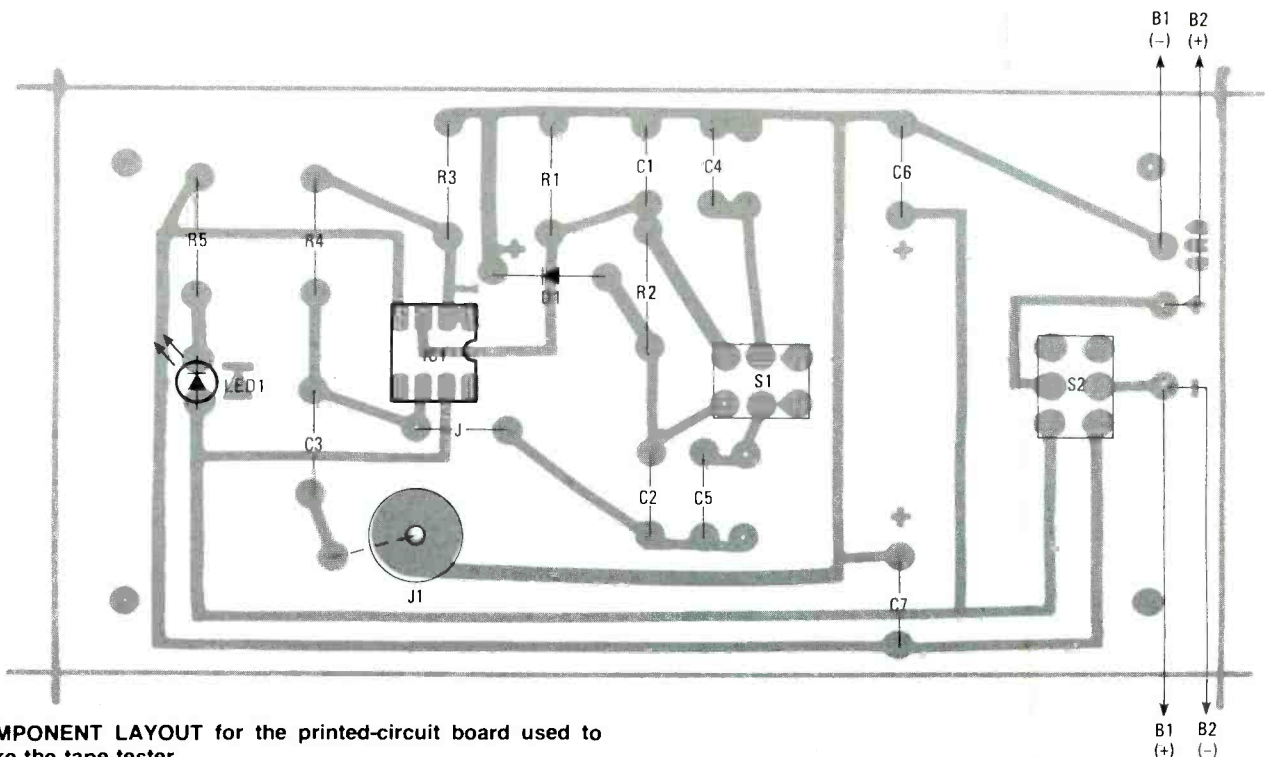
THE CIRCUIT shown in this schematic is designed to work well using junk-box or budget components.

closer the output level of the two frequencies will match. Selecting capacitor pairs at random will usually produce about 0.5-dB variation between the mid and high-frequency output levels. If C1 is reasonably matched to C2, and C4 reasonably matched to C5, the output levels might be as close as 0.1 dB, but the whole thing isn't worth fussing over. Don't substitute expensive silver mica capacitors and hope for a more precise output-level match; 5% tolerance isn't going to make much of a difference in this circuit. If you can't

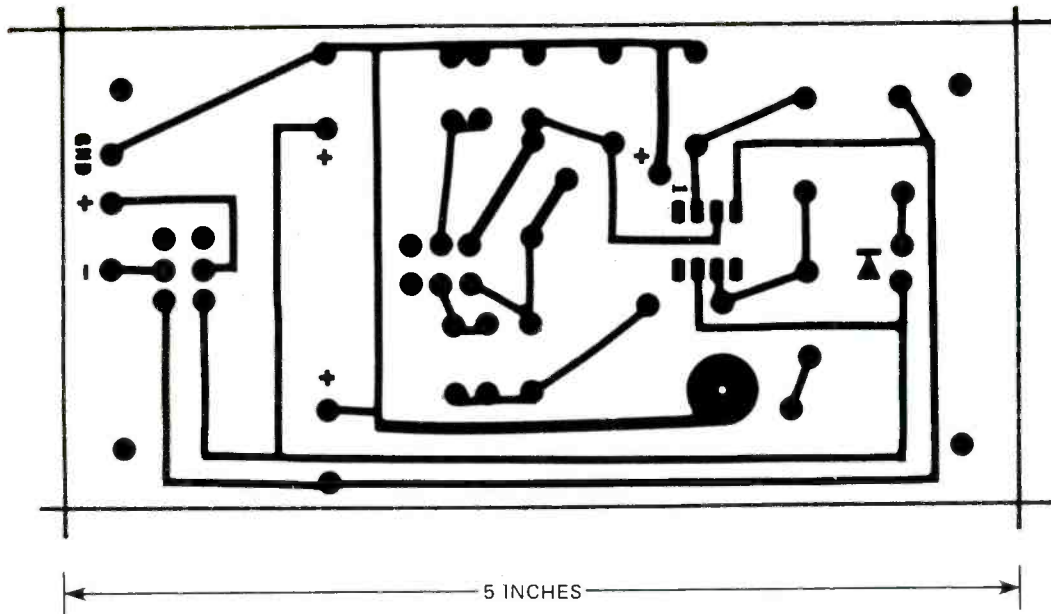
match capacitors on a capacitance bridge or meter, simply stick with low-cost ceramic discs.

Same thing goes for resistors. Stick with 5% tolerance. Super-tolerance and super-price 1% resistors won't make much difference.

The capacitor values shown will provide output frequencies of approximately 950 and 11,000 Hz. If C1 and C2 are changed to 700-pF (.0007-µF) the high frequency will be approximately 13,000 Hz. You get a 700-pF capacitor by simply grabbing a handful of



COMPONENT LAYOUT for the printed-circuit board used to make the tape tester.



THE TESTER is most easily built using a printed circuit board. The board also serves as the unit's cover.

.001's and testing them on a capacitance bridge or meter. The cheaper the capacitor quality, the better your chances of finding a pair that checks out at 700 pF.

If you would prefer a midband reference frequency closer to the "professional" value of 700 Hz, connect .001- μ F or .002- μ F capacitors at C_a and C_b (in parallel with C_4 and C_5).

Note that C_1 and C_2 are always in the circuit. Don't redo the layout so that they are switched *out* when C_4 and C_5 are switched *in*: That will cause the midband frequency to rise above 1 kHz.

The Tape Tester is most easily assembled on a PCB (Printed-Circuit Board) that also serves as a cover for a $5\frac{1}{8} \times 2\frac{5}{8} \times 1\frac{5}{8}$ -inch cabinet or "experimenter's box." If the cabinet you use is a different size, or has

rounded corners, simply trace the outline of the supplied cover on a piece of PCB material. Rounded corners are most easily made by cutting square corners and then filing them round, but do the filing before you etch the foil patterns. The bending—no matter how slight—caused when filing the corners can produce hairline cracks in fine circuit foils.

Switches S_1 and S_2 are mounted on top of the PCB. Since PCB terminal switches are somewhat expensive; it's cheaper to modify a standard miniature switch by simply filing down the terminals so that they clear a hole drilled with a No. 56 bit.

Make certain that the component holes in the PCB template match those of the components you will use. If not, modify the layout accordingly; nothing is really critical.

PARTS LIST

RESISTORS

- $\frac{1}{2}$ or $\frac{1}{4}$ watt, 5%
- R1, R2—15,000 ohms
- R3—43,000 ohms
- R4—100,000 ohms
- R5—2200 ohms (see text)

CAPACITORS

- C_1, C_2 —0.001- μ F ceramic disc
- C_3 —0.047- μ F Mylar or disc
- C_4, C_5 —0.01- μ F ceramic disc
- C_6, C_7 —100 μ F or 50 μ F electrolytic
- C_a, C_b —see text

SEMICONDUCTORS

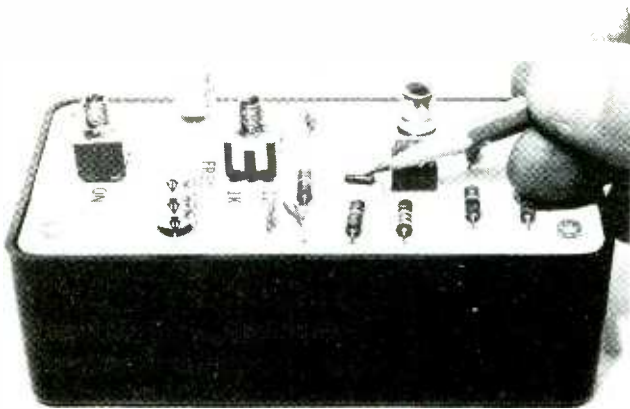
- IC1—741 op-amp
- D1—1N456A (see text)
- LED—Light emitting diode (see text)

MISCELLANEOUS

- B1, B2—9-volt battery
- J1—Phone jack
- S_1, S_2 —DPDT mini-switch (modified) (Radio Shack 275-614 or equal)
- Cabinet—Radio Shack 270-233 or equal
- PCB materials
- IC socket
- Battery terminals



TO USE THE TESTER, simply connect J1 to one (or both) of your recorder's line inputs using a shielded patch cord.



THE SPECIFIED DIODE HAS A GLASS BODY that will crack if excess pressure is applied to the leads. Bend the leads at least 1/4 inch from the body and mount the diode 1/4 to 1/2 inch above the PCB.

If possible, use a socket for IC1, just in case the IC you use is defective, or gets damaged. It's easier to pop an IC out of its socket than to start butchering the PCB. The heat generated when removing an IC will result in the foil lifting off the board.

The LED can be anything that you can see. It uses a lot of power, about 10-mA compared to the IC current of approximately 1-mA. If you can see a "duller" glow under standard room illumination, decrease the LED current by increasing R5's value anywhere in the range of 3600 to 5400 ohms. (Make certain that the calculated LED current— $18/R$ —does not exceed the maximum current rating of the LED you use.)

Diode D1 is a 1N456A, or any equivalent germanium diode. A type 1N60 may or may not work well. If you have some lying around, try them first before you buy.

A 1N914 usually won't work, but you can try it. (It's also silicon.) If your back is to the wall, and you simply can't locate a germanium diode, try a silicon 1N4001, 2, or 4. Many give a reasonably acceptable waveform.

When the project is finished, connect its output through J1 and a shielded audio patch cord to an AC voltmeter and measure the 1000-Hz and 11,000-Hz output levels. They will be approximately 0.5 volts and should be within 0.5 dB of each other, or closer if you have matched the capacitor pairs carefully. Note the difference; it will be used as a *correction factor* if you want extremely precise matching of the output frequencies *from* the tape. Actually, a 0.5-dB variation is insignificant and you really can ignore it.

Using the tape tester

Connect J1 through a shielded patch cord to one or both line inputs of your cassette recorder. Set S1 to 1000-Hz and adjust the recorder's level control for a 0-VU or 0-dB meter reading. Then adjust the level control for a -20 (dB) meter reading. Record a few seconds of 1000 Hz and then flip S1 to 11,000 Hz. When you play back the tape, note how closely the 11,000-Hz playback level compares to the 1000-Hz reference mid-band level. The best bias adjustment, or best tape to use, is the one that gives the closest match between 11,000 Hz and 1000 Hz.

Do not attempt to make tests using a 0-VU record level. The tape will overload at 11,000 Hz because of the machine's record equalization and the playback measurements will be completely erroneous. Also, making the test with the noise reduction system switched *off* is preferred; often, the NRS "tracking" is non-linear and will appear as "poor" tape performance. **SP**

**A lot of giving
from you.**

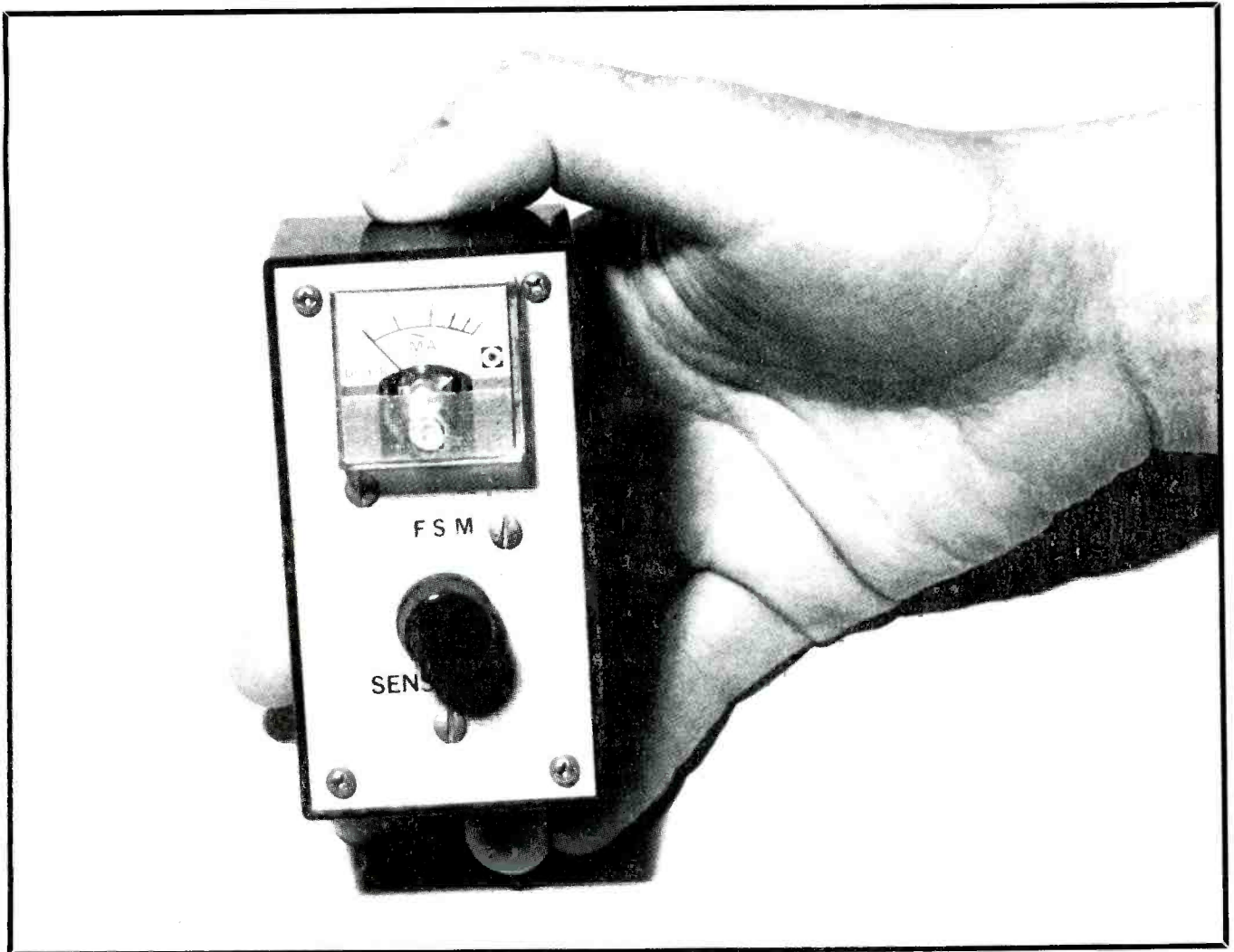


Phoebe Dunn

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SUPER-SENSITIVE FIELD-STRENGTH METER

It's perfect for low-power 27-MHz walkie talkies.

HERB FRIEDMAN

IF YOU'RE WORKING ON A 5-WATT CB RIG, OR AN ANTENNA connected to a 5-watt rig, just about anything can be used as a *Field Strength Meter (FSM)* to indicate the RF output from the antenna. A coil of wire, a diode rectifier, and an 0-1 mA meter work just fine as an RF indicator for "powerhouse" RF signals.

But when the signal strength is little more than a flea's whisper—say from a 100-mW walkie-talkie, a radio control device, or a wireless camera-shutter tripper, your FSM needs a lot of "extra" gain going for it, to produce usable meter readings. And "extra gain"—lots of it—is just what you get with the Super-Sensitive FSM, an amplified field strength meter specifically designed for sniffing any type of 27-MHz RF: from the pipsqueak signal of a child's toy walkie-talkie (I know the new ones are on 47 MHz, but there are still plenty of older 27-MHz units about) to the signal from a directional beam connected to a 5-watt CB transceiver. As an extra feature to go with the extra gain, the FSM gives clear indications of modulation: the meter doesn't just wiggle when monitoring an RF signal, it literally dances in step with the modulation.

The Super-Sensitive FSM is supersensitive because it has both a tuned antenna circuit and a high-gain DC amplifier to drive the meter. In fact, the FSM is so sensitive that it's provided with a sensitivity control, because at full gain even a weak RF signal would "pin" the meter. Because of the meter's high sensitivity there's no need for an oversize or telescopic antenna. In fact, there is no need for an outside antenna of any kind. The antenna is a short length of wire placed within a cabinet that's small enough to be easily slipped into a vehicle's glove compartment, or into a pants or jacket pocket without fear of snagging or tearing the fabric.

The circuit

As shown in Fig. 1, the FSM's input consists of a small antenna feeding a 27-MHz tuned-circuit (L1-C1). The RF voltage developed across the tuned circuit is rectified by germanium diode D1 (**don't use a silicon diode**) and applied to potentiometer R1. R1's wiper feeds high-gain transistor Q1, which drives meter M1. The specified Q1 has essentially no leakage current so there are but a few microamperes drawn from the battery under no-signal conditions, and there is absolutely no meter reading at all when there is no signal being received.

Should you forget to turn off the battery with switch S1—which is part of R1—there will be little effect on the battery's life. Capacitor C2, a 100-pF disc, might appear somewhat small at first glance; a 0.001- μ F would

be a more logical value. A value of 100 pF is used, however, to filter the RF from D1's output DC without affecting the modulation component. In this way the modulation will cause a substantial meter indication.

The FSM was specifically designed to be pocket-size so some unusual miniature components are used. If you prefer, you can substitute conventional-size components; just make certain you use a cabinet large enough to hold the larger items. For example, battery B1 is a miniature mercury-type RPX-625 (Ray-O-Vac) normally used to power 35mm camera equipment. It requires a special holder, the Keystone type 117. If your local parts dealer doesn't stock the Keystone holder you can substitute a standard 1.5-volt N or AA size battery, and a standard battery holder to match the battery used.

Meter M1 is a $1\frac{1}{4} \times 1\frac{1}{4}$ -inch subminiature 0-1 mA (DC), Calectro type D1-938. It requires a $1\frac{1}{8}$ -inch mounting hole, or a 1-inch hole filed a little larger. The entire body is threaded and the mounting nut screws directly on the body. The meter comes with a rubber gasket that must be placed between the mounting nut and the panel. If you don't use the gasket, you are likely to apply excessive pressure to the threads of either the nut or the body, and one or the other is certain to strip. Even with the gasket the nut should be set only hand tight, and then a quarter turn more with pliers. If your

PARTS LIST

RESISTOR

R1—25,000 or 50,000 ohms, miniature potentiometer with switch.

CAPACITORS

C1—33 pF, silver mica

C2—100 pF, ceramic disc

SEMICONDUCTORS

Q1—2N3391, NPN or equal

D1—1N60, germanium diode (**do not use silicon diode**)

MISCELLANEOUS

*L1—1.0 μ H, J.W. Miller 40A106CBI or equal

M1—0-1 mADC, Calectro D1-938 or equal

B1—1.35-volt mercury battery, RPX625 or equal

Battery Holder—Keystone type 117 or equal

Cabinet, wire, terminal strip, etc.

*Coil L1 is available for \$4.95, postage and handling included from: Custom Components, Box 153, Malverne, NY 11565. New York State residents must add sales tax. Canada add \$1.

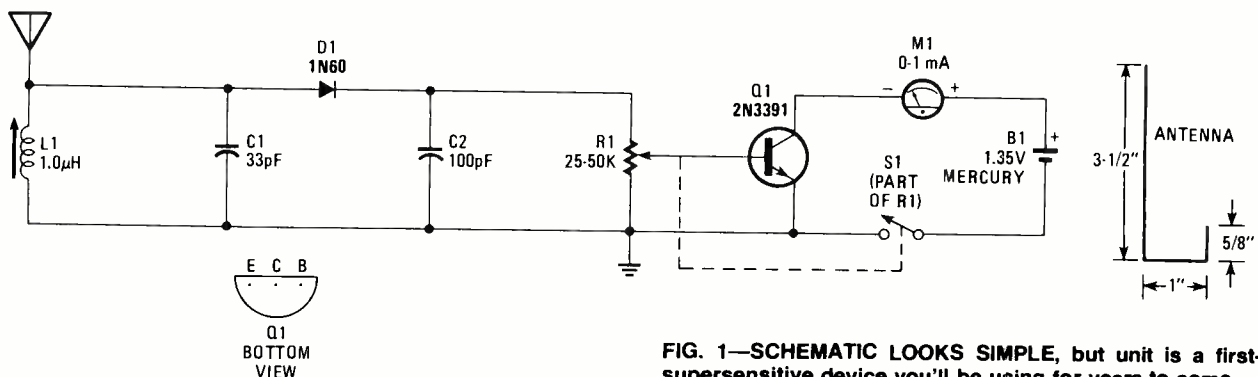
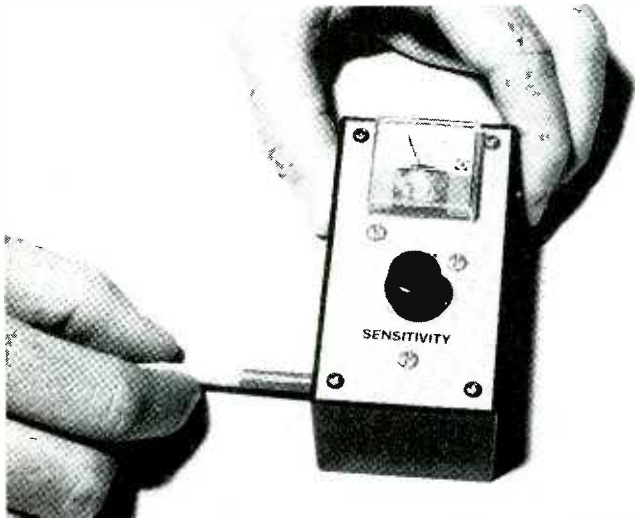


FIG. 1—SCHEMATIC LOOKS SIMPLE, but unit is a first-rate supersensitive device you'll be using for years to come.

local Calectro parts distributor doesn't stock the miniature meter you can substitute any 0-1 mA (DC) meter. Just make certain it will fit into the cabinet you use. Do not substitute a more sensitive meter or the overall FSM sensitivity will be so high that it will be near impossible to adjust SENSITIVITY control R1 for a steady reading.



TO ADJUST THE TUNED CIRCUIT, key a CB or other 27-MHz transmitter, adjust the sensitivity control for an on-scale meter reading, and then adjust L1's slug for a peak meter reading. Use a plastic screwdriver or alignment tool through the hole in the side of the cabinet to get at L1's slug.

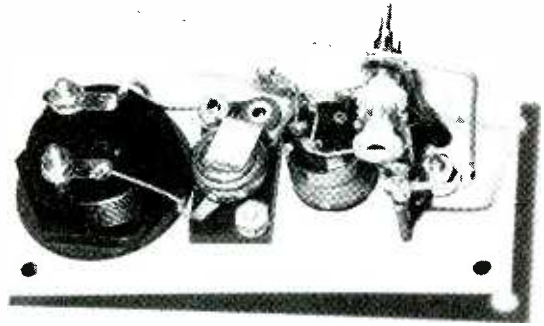
Coil L1 is a slug-tuned subminiature with a nominal value of 1.0 μ H. The list price of the specified coil is unreasonably high (more than \$16) and the project simply isn't worth the total cost if you must purchase the coil "new." It is, however, available from time-to-time from some "surplus" dealers at a much lower price. One low-cost source for L1 is given in the parts list. Alternately, you could substitute a larger or "standard size" coil; they are generally less expensive than the subminiature size.



THE TUNED CIRCUIT AND TRANSISTOR Q1 are mounted on one side of a terminal strip; C2 and diode D1 are on the opposite side.

Construction techniques

The FSM is assembled on the aluminum front panel of a $3\frac{7}{8} \times 2\frac{1}{8} \times 1\frac{5}{8}$ -inch plastic "experimenters" cabinet. Mount the meter as close as possible to the top of the panel. Drill the hole for potentiometer R1 $1\frac{3}{8}$ -inch up from the bottom edge of the panel. Everything else will now fall into place. The battery holder



THE ENTIRE METER is assembled on the aluminum panel of a plastic "experimenters" cabinet using miniature and sub-miniature components.

will squeeze between R1 and the meter, and there will be room for a terminal strip near the bottom of the panel on which L1 and Q1 are installed. The terminal strip requires four connections, of which one is a "grounded mounting foot." To be certain of a secure ground install a lockwasher between the panel and the grounding foot when installing the terminal strip.

Follow the installation of L1 shown in the photograph. Solid wire connections are used to position L1 so it will be approximately centered between the panel and the back of the cabinet: the exact measurement isn't critical. For long-term stability of the tuning adjustment, capacitor C1 should be the silver mica type.

The antenna should be the maximum length that can be fitted within the cabinet, positioned as close as possible to the back of the cabinet—away from the front panel. The dimensions shown are optimum. The antenna itself is made from solid No. 18 or No. 16 wire. If you don't have No. 18 or No. 16 don't go to unnecessary expense: use a piece of "drawn" No. 20 hook-up wire. Remove the insulation from the wire, clamp one end of the No. 20 wire in a vise and pull on the free end until the wire stretches very slightly and goes "dead slack." (It loses its "spring.")

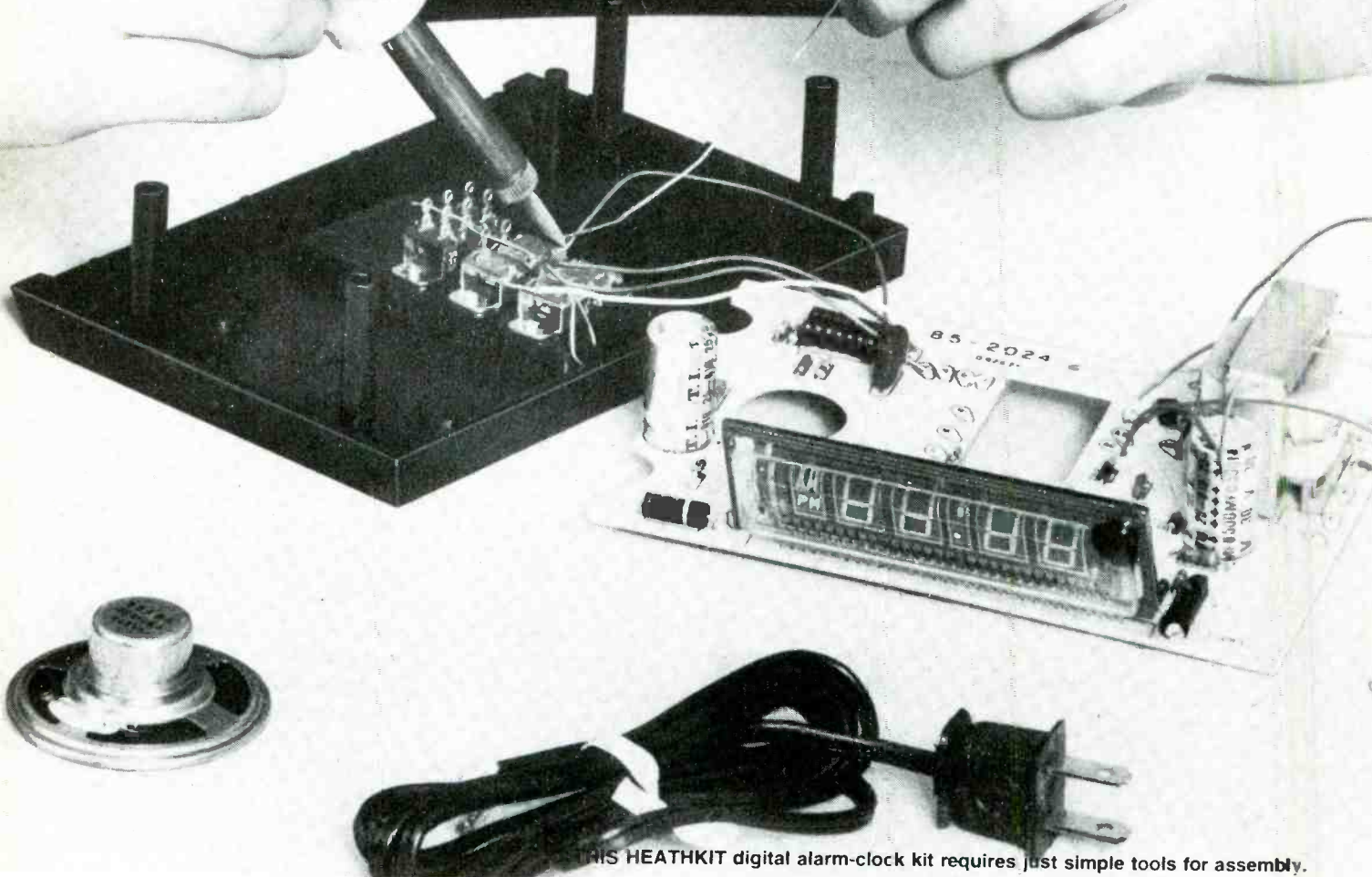
The battery is the last thing to be installed: it goes in just before you're ready for the final checkout. It is positioned with the positive side down. The small spring clip on top of the holder is the negative battery connection—the battery's "center" contact. (Remember, mercury cells are the reverse of standard carbon-zinc batteries: the shell is positive, the center terminal is negative.) When the meter is completely assembled measure the position of coil L1, mark the location on the side of the cabinet and drill a $\frac{5}{16}$ -inch hole, which will provide access for a plastic tuning screwdriver (alignment tool).

Final adjustments

Set the switch on R1 to OFF, install battery B1, and close the cabinet. Turn on POWER switch S1, key a CB transceiver or walkie-talkie, and advance R1 until you get a meter reading. Then, position the alignment tool on L1's slug (through the hole in the side of the cabinet) and adjust the slug for maximum meter reading. If the pointer is driven off the scale as L1 is adjusted reduce the meter sensitivity with R1 so the pointer is on-scale. Continue adjusting L1 and R1 until you can "tune" through a peak; then "center" L1's tuning on the peak and the FSM is ready for use. **SP**

**If it's electronic, it's probably
available as a kit. Here's
a guide to some very
special projects.**

HERB FRIEDMAN



THIS HEATHKIT digital alarm-clock kit requires just simple tools for assembly.

KITS FOR PROJECT BUILDERS

ELECTRONIC KITS HAVE BEEN AROUND FROM ALMOST the beginning of radio. The fact is, it's conceivable that the transmitter Marconi used to send the first radio signal across the ocean was built from a kit.

Seriously, though, "radio kits"—the "granddaddy" of electronic kits—go back to those long-gone days when a radio consisted of a coil wound from a hank of wire, some form of tuning mechanism, something called a "detector" (which we now call a "crystal diode"), and magnetic headphones that were called "cans" because they actually resembled big heavy cans supporting a magnet wound with several hundred or a thousand turns of wire.

As radios improved so did the kits. By the time the end of the 1930's rolled around with the famous "All American Five" superhet radio (a five-tube radio with a universal circuit design that seemed to last forever) we had the first of what is considered the modern electronic kit—complete with detailed instructions, pictorials, and troubleshooting procedures. One of the very best superhet radio kits known simply as a "Meissner Broadcast/Shortwave Superhet Radio," was produced by Meissner, an outfit that made many of the coils that went into superhet radios.

The Meissner Radio Kit was an excellent performer and was supplied with notably excellent construction, service, and alignment instructions. It was good even by modern standards and was a required construction project in many public vocational schools. The majority of "radio technicians" working in the late 1940's got their first experience in electronics by building the radio in high school. It was an outstanding school project because a teacher could stretch construction, troubleshooting, and a complete alignment from scratch into a full term's work. When finished, the student had built a really good table radio and had acquired an excellent understanding of radio service and alignment techniques.

(While some radio kits were being produced by radio and parts manufacturers, a then small outfit by the name of Heath—located in the middle of the country—was selling a build-your-own-airplane kit.)

World War II put developments in consumer projects on hold for the duration. With the conclusion of the war, there were warehouses literally stacked floor to ceiling with electronic components: everything from resistors and capacitors, to nuts and bolts, to every conceivable type of receiving and transmitting tube, to CRT's from radar sets. In the late 1940's there was enough "surplus" electronic hardware to build almost any electronic device that it was possible to conceive in unlimited quantity, and there was a market for almost anything because (except for the military) no new electronic equipment—either for consumers or technicians—had been produced during the war. We were actually on the front steps of the electronic age and there was virtually nothing available in "professional" service and laboratory test equipment other than what could be re-worked from surplus military communications equipment.

At that point in time a company previously known for its airplane kits designed a modern oscilloscope kit—housed in a modern "professional" cabinet—that used virtually all surplus components (right down to the CRT). The kit had the first of the modern assembly

manuals with step-by-step instructions and unusually detailed pictorials. They were so precise even a rank beginner at construction would have no problems. The 'scope was the first Heathkit electronic kit produced by the Heath Company, which soon became the standard of reference for "laboratory-grade kits."

A seemingly endless quantity of surplus components created a major new industry: Electronic Kits. Heathkit was joined by EICO (Electronic Instrument Company) and PACO in producing an extended line of test-equipment kits. PACO was actually the kit division of Precision Instruments, a company with a long reputation for high quality "radio instruments," and PACO kits were originally kit versions of Precision's regular instrument line. There were other kit companies using surplus but these were the "Big Three," offering a full line of service and laboratory test instruments. For many, many years the Heathkit 'scope(s) and VTVM, and EICO's VTVM were virtually shop standards, used by hobbyists, schools, and shops. Most technical students through the 1950's cut their teeth on Heathkit and EICO VTVMs.

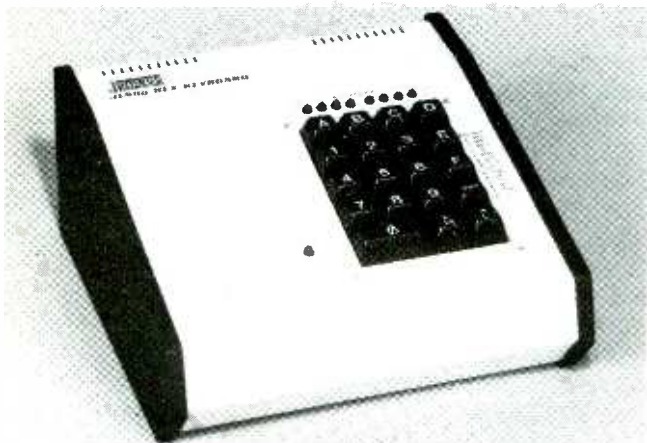
While Heathkit, EICO, and the rest were improving and expanding their test-equipment line, an almost unknown revolution was taking place. The public was searching for a "better sound" from the radio and phonograph, soon to be known as "high fidelity." What might possibly be among the first high-fidelity kits were a TRF (*Tuned Radio Frequency*) AM tuner from J. W. Miller Co., a manufacturer of coils, capacitors, and other frequency-determining devices for radio receivers. Miller's AM tuner had no tubes or power supply. It was a passive device using multiple-tuned radio frequency (TRF) circuits and a crystal detector. Since AM stations have the capability of transmitting what can be considered "good fidelity", if not "high fidelity," the TRF tuner could deliver "better" sound than the usual superhet AM tuner because it did not have the selectivity (narrow bandwidth) of the superhet. The TRF tuner had its own problems—it needed strong signals, and a strong adjacent station could wipe out a weaker tuned station—but for its day it was really high fidelity.

The early high-fidelity hobbyists had little to work with. Many experimented primarily with better quality PA amplifiers and some tube designs that produced great sound, not too much power, and enough heat to cook a five-course meal.

The modern age of high fidelity arrived when **Radio-Electronics** magazine ran an article on something called a "Williamson Amplifier," which produced superb sound (for its day), high power, good efficiency, and relatively little heat. While the "in group" of hobbyists built a pseudo-version of the Williamson Amplifier (it was impossible to get the required output transformer at the beginning) in their basement shops, Heathkit came out with a kit version of the Williamson Amplifier that brought recognition of high fidelity to the general public. In a sense, Heathkit's first high-fidelity equipment kits moved high fidelity from the basement shop to the living room.

Other kit manufacturers followed Heathkit into high fidelity, and electronic kits had become something more than primarily an inexpensive way to equip the shop with test equipment.

For many years "Hi-Fi kits" represented the leading edge in the state of the art for high-fidelity equipment. Heathkit's and Dynaco's AM/FM-stereo tuners and amplifiers were literally pathfinders for stereo design. Even today Heathkit's stereo-equipment kits rank among the very best, often incorporating features that appear later in mass-merchandised brands.



THIS HEXADECIMAL keyboard kit from Jameco includes a 19-key keypad and 9 LED readouts. The completed kit can be housed in a professional looking case (shown) if desired.

By the early 1960's electronic kits of every variety had been refined and debugged to the point where almost anyone could build a complex kit and get it working with little or no assistance from "factory service." Though we were fast entering the age of solid-state with transistorized kits and wired equipment, there was to be one major (possibly the last) really big triumph for sophisticated, expensive vacuum-tube kits. Heathkit came out with a tubed color TV that was to set the color standard for many years.

Their 25-inch GR-681 color TV with remote control option and swing-out front panel with color convergence controls had a color quality that became the standard of reference for most electronic experts. A popular saying of the late 1960's and early '70s when shopping for color TV was: "Yeah! The color's great, but it ain't no Heathkit."

But performance aside, the GR-681 and other color-TV kits had established the fact that no consumer equipment was too complex for a kit. Even when "professional" service adjustments were required, the assembly and adjustment could generally be done by most hobbyists providing there were extensive instructions (in small bites). The sky had become the limit in kits, even though Heath no longer sold airplane kits.

What is an electronic kit?

If you were to ask that question of nine people you would probably get eleven answers because everyone has a different idea. To the advanced hobbyist and professional technician an electronic kit might represent a way to afford a minicomputer, a color TV, a stereo system, or laboratory-quality test equipment because some 25% to 50% of the cost of any finished, store-bought equipment represents assembly costs. If you build it yourself you actually save money you can bank.

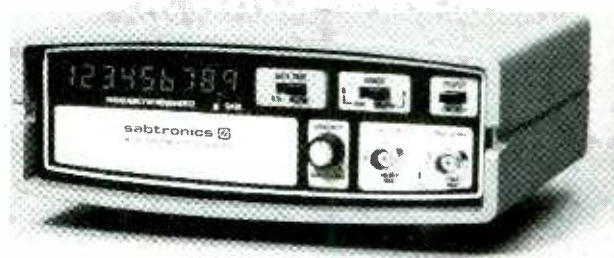
To others, an electronic kit is a way to obtain gadgets or equipment that ordinarily isn't available in retail stores. (There are many, many devices for which there simply isn't sufficient demand or profit to make them worth offering through normal retail channels; yet it is possible for someone, say a parts distributor, to package his components—which he normally stocks—and sell them as a "kit." The only thing extra that's needed in addition to what is normally found on his shelves is a set of assembly instructions.)

To still others an electronic kit is an "educational experience," a kit specifically designed to be both entertaining and instructional.

Are you musically inclined? Would you like a real "theater organ" in your living room? Those multi-voiced monsters, complete with a Leslie speaker, cost several thousand dollars; but if you take the kit route you can buy the instrument in modules as your budget permits. You not only save assembly costs but get a chance to get some extra enjoyment along the way as you personally assemble a "living instrument."

Electronic kits are also a hobby in themselves. Many so-called "one-evening projects" are available, such as electronic dice and roulette, a shooting gallery, sound-effects generator, and so on. One kit company, EICO, even job-racks an entire line of small, low cost, mostly PCB kits, in local parts-distributor stores.

We could go on and on showing other types of electronic kits but you probably have the general idea. Just about anything you can imagine is available in kit form for virtually every level of technical competence... meaning the ability to assemble a kit *and get it working*.



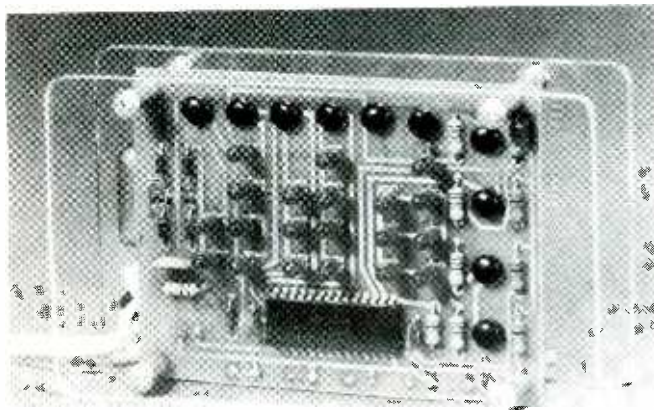
A SOPHISTICATED ELECTRONIC INSTRUMENT at a fraction of its assembled cost is one advantage of building a Sabtronics kit such as this 1-GHz frequency counter.

Getting it working is often the most difficult part of kit construction, particularly for the beginner who might have little technical background and even less in the way of test equipment. While most kit companies have technical-assistance departments that are very helpful, it's sort of difficult to troubleshoot through correspondence or telephone calls if you have little understanding of the project...but that's something we'll get to later.

Getting started.

Though most modern kits use extensive PCB assembly, whereby components are simply slipped into matching holes in a PCB and then soldered, it often is not as simple as it looks. Sure, anyone can slip component leads into holes, but do *you* know how to han-

dle CMOS IC's (integrated circuits)? Is your shop equipped with a ground strap for your wrist? Can you identify sophisticated components that resemble each other? Can you distinguish between tantalum and electrolytic capacitors? In fact, do you know the difference? Can you tell which capacitor is silver mica and which is Mylar?



YOU GET A USEFUL, entertaining device, as well as a better knowledge of electronics when you complete one of the kits from PPG Electronics. This binary clock is just one of the projects available.

When you get into the sophisticated kits, just a single interchange of somewhat similar components can keep the project from working. While there are many kits intended for the newcomer to electronic construction with components specifically selected to avoid confusion for the beginner, nevertheless it is true that the major kit outfits (in particular Heathkit and EICO) do the best job as far as the assembly instructions are concerned. They have had many years' experience in perfecting the manuals and pictorials, and their "beginner kits" are unsurpassed. In fact, Heathkit even has a whole line of beginner kits (one or two evenings) ranging from a simplified burglar alarm to low-cost test equipment suitable for a hobbyist's test bench. One of Heath's really basic kits is a digital alarm clock (GC-1107), which in appearance is more complex and attractive than most mass-merchandised digital clocks; yet it's an almost goof-proof assembly specifically intended for the beginner.

One of the primary differences between a beginner's kit and one meant for a hobbyist with experience in construction is the PCB-component layout and the manual dexterity which might be required for a mechanical assembly. Beginner kits generally have relatively oversize PCB's with components spaced a considerable distance from each other. Similarly, foils will be wide-spaced to reduce the possibility of solder-bridges. While small (and inexpensive) solid-state devices such as transistors, diodes, and LED's are usually soldered directly to PCB foils, as a general rule more expensive-to-replace components such as integrated circuits often use mounting sockets in beginner kits. (A beginner can easily unsolder a transistor or diode if incorrectly installed. Unsoldering a 14-, 16-, or 20-pin IC will usually result in destruction of the IC.)

A somewhat different approach for beginners is taken in kits particularly intended to be instructional,

such as those from the PPG Electronics Co., Inc., of Van Nuys, CA. PPG's kits are specifically designed for use where there is some form of professional instruction, though the kits are available directly to the user. The PPG kits are primarily "entertainment projects" such as a sound-activated color organ, 12-volt emergency strobe flasher, electronic dice, space-war phasor gun. Each project is supplied in modules (actually lessons) which explain the components used in the device and the device itself, leading to the actual construction of the project.

Instructional kits not only provide a useful device; they give the builder extensive insight into the device and the components that go into making the device: The builder learns a lot more than just how to assemble a PCB and solder.

Build what you can't buy

Once you get beyond the beginner kits you're ready to tackle the specialty kits, which are primarily usable devices not normally manufactured—the type of thing we mentioned earlier.

Most (but by no means all) specialty kits are provided by the modern day "surplus" distributor, who generally specializes in mail order sales. These distributors sell both a standard line of components and new "surplus," often manufacturer's excess production, or job lots. In this age of solid-state where designs change overnight, and what would normally be an insignificant tolerance variation for hobbyists is not suitable for commercial use, a lot of perfectly good hardware becomes "surplus." Many distributors handling this surplus work up their own designs and instruction, and package a specialty kit using the components they also sell as "off-the-shelf" stock.



THIS FUN-TO-BUILD KIT, the *Tele-commander I* from Hemco Inc., lets you use a telephone to control an appliance when you're not at home.

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- BETA COMPUTER DEVICES**
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- CHANEY ELECTRONICS INC.**
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- DIGITAL RESEARCH COMPUTERS
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- EICO**
108 New South Road
Hicksville, NY 11801
- ELECTRONIC DESIGN ASSOCIATES**
P.O. Box 94055
Houston, TX 77018
- ETCO ELECTRONICS**
North Country Shopping Center
Plattsburgh, NY 12901
- FORMULA INTERNATIONAL INC.**
12603 Crenshaw Blvd.
Hawthorne, CA 90250
- GLADSTONE ELECTRONICS**
901 Fuhrmann Boulevard
Buffalo, NY 14203
- GODBOUT ELECTRONICS**
Box 2355
Oakland Airport, CA 94614
- THE DAVID HAFNER CO.**
5910 Crescent Blvd.
Pennsauken, NJ 08109
- HAL-TRONIX**
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Southgate, MI 48195
- HEATHKIT**
Benton Harbor, MI 49022
- HEMCO**
3705 College Point Boulevard
Flushing, NY 11354
- INTERNATIONAL ELECTRONICS
UNLIMITED**
435 First Street
Solvay, CA 93463
- JADE COMPUTER PRODUCTS**
4901 W. Rosecrans
Hawthorne, CA 90250
- JAMECO ELECTRONICS**
1355 Showway Road
Belmont, CA 94002
- JOHN BELL ENGINEERING**
P.O. Box 338
Redwood City, CA
- MESHNA INC.**
P.O. Box 62
E. Lynn, MA 01904
- MICROACE**
1348 East Edinger
Santa Ana, CA 92705
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- PACCOM**
14905 NE 40th
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- PAIA ELECTRONICS**
1020 W Wilshire
Oklahoma City, OK 73116
- POLY PAKS**
P.O. Box 942
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- PRIORITY ONE ELECTRONICS**
91613 Deering Avenue
Chatsworth, CA 91311
- QUEST ELECTRONICS**
P.O. Box 401565
Garland, TX 75040
- RADIO SHACK**
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Fort Worth, TX 76102
- RAMSEY ELECTRONICS, INC.**
2575 Baird Rd.
Penfield, NY 14526
- SABTRONICS INTERNATIONAL INC.**
5709 N. 50th St.
Tampa, FL 33610
- SIMPLE SIMON ELECTRONIC KITS**
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Hawthorne, CA 90250
- SINCLAIR RESEARCH, LTD.**
50 Staniford St.
Boston, MA 02114
- SUNNY INTERNATIONAL**
P.O. Box 4296
Torrance, CA 90510
- SYMETRIC SOUND SYSTEMS**
912 Knobcone Place
Loveland, CO 80537
- US MICRO SALES**
11 Edison Dr.
New Lenox, IL 60451
- WERSI ELECTRONICS INC.**
P.O. Box 5381
1720 Hempstead Road
Lancaster, PA 17601

Each issue, **Special Projects** will publish the latest complete listing of kit makers that we have. We hope to be able to expand this listing to contain a brief description of the kinds of kits each company provides.

For more information and individual catalogs, contact the companies you are interested in directly. Please tell them that you learned about them from **Special Projects**.

Typical examples of what we mean by "specialty kit" are basic PCB regulated power supplies that you might build into a project of your own design, or which you might combine with another project; a power-supply voltage converter; a strobotachometer; digital time clocks such as used on videotape recorders; a "telecommander" which will operate household appliances when it senses a predetermined telephoning sequence; audio power amplifier modules for building into your own equipment; a solid-state LED VU (volume level) meter, and...well, the list goes on and on. Exactly what is available is not as important as the fact that you could not otherwise get those items. Let's look more closely at those we have mentioned.



MAJOR CONSTRUCTION PROJECTS in every respect, the organ kits from Wersi Electronics are high-quality professional instruments. The organs are designed so that you can add additional features at any time.

Jameco Electronics is a regular distributor of electronic products, particularly specializing in solid-state devices: transistors, IC's, and so on. They are also, among other things, into power-supply modules which you can build into other projects. For example, one kit is a complete (with power transformer) 5-volt, 1-ampere regulated power supply on a $3\frac{1}{2} \times 5$ -inch PCB. You can tuck one of those into almost any digital project. Another of Jameco's specialty kits is a multi-voltage board kit: This device, on a $3\frac{1}{2} \times 2$ -inch PCB, is a DC-to-DC converter. It takes 5-volts DC in and provides ± 12 , ± 9 , and -5 -volts DC output. Again, it's something easy to tuck into a home-brew digital project—and something you normally couldn't buy (certainly not for \$12.95) as a "wired device."

Anyone who has worked in or visited a mechanical laboratory, service shop, or a loudspeaker test lab, has probably seen a strobotachometer (strobotach, for short). This is a pulsating electronic flash (tube)—usually called a "strobe light"—whose rate of pulsation can be varied by a calibrated control. The pulsations cause rotary motion to "freeze," allowing the technician to study a moving device just as if it were standing still. The calibrated control tells the technician how fast the object is moving.

As a piece of test equipment, a strobotach is somewhat expensive, but a basic PCB (no cabinet) strobe kit is available for hobbyist use from Chaney Electronics of Denver, Co, for \$15.95. The user supplies only the cabinet. The strobe-rate control calibrations aren't "laboratory tolerance," but they are more than accurate enough for the hobbyist and even some service shops.

Ever see the electronic timer on a video-cassette recorder? Pretty snazzy! It can be set to better than 60 seconds accuracy; that's a lot more accurate than the usual mechanical timer, which is lucky to be somewhere in the ballpark within 15-minute intervals. But if you need an electronic timer, say to control your stereo system, you have a problem: You can't buy one in a retail store (or wholesale distributor for that matter). If you want one, you must build it from a Digi-Key kit. Digi-Key, of Thief River Falls, MN, is a regular mail-order parts distributor (with a real thick catalog) that's also into digital timers. Part of their regular line is all sorts of digital clock modules and hardware, which they package into their own digital-timer kits. They sell several different versions: with cabinets, without cabinets, whatever you want. Their kits are somewhat unusual in that they use a modular construction that rides piggy-back on the basic electronic clock. The builder ends up with a complete one-piece module that can be installed in a cabinet—or other equipment—like a meter module. Again, if you want an electronic timer you must build it from a kit: it's not sold at your local parts shop.

Ever worry if your home is safe? Are the kids OK? Is the furnace running? Or maybe you're coming home from vacation on the hottest day of the year and you would like to start the air conditioning a couple of hours before you arrive home. You've probably read how the rich folks have all sorts of burglar-alarm telephone dialers that can send and receive messages, monitor the house through a microphone, or even turn on appliances by remote control. Well, you don't have to be rich to have telephone remote control if you can handle a soldering iron. You can do the same thing with a *Tele-Commander I* appliance remote control kit from Hemco, Inc., of Flushing, NY.

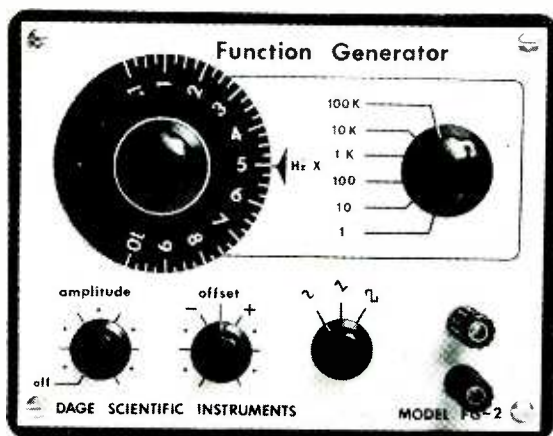


THIS ASCII encoded keyboard from Jameco can be used with almost any computer system.

This kit is a little more sophisticated than the basic PCB kits we've illustrated because it's supplied with a cabinet. The device plugs into an AC outlet and has a receptacle to which an appliance can be connected. A

microphone inside the Tele-Commander picks up telephone bell "rings." When it senses 16 or more rings, it turns on the outlet for about three hours; ten rings will turn the outlet off. The "on" cycle can be maintained by calling in before the automatic drop out-time. (Also, it can be repeated by calling in again.) Admittedly, that's not the most sophisticated way to control things through the telephone, but it's inexpensive, it works, and it's a fun kit to build.

Our final illustration of "specialty kits" are audio-power amplifier modules. Actually, we're fudging a bit because the modules—available in both mono and stereo in many different power outputs from Gladstone Electronics, of Toronto, Canada and Buffalo, NY—are supplied factory-wired. They are particularly attractive to the hobbyist who is building something



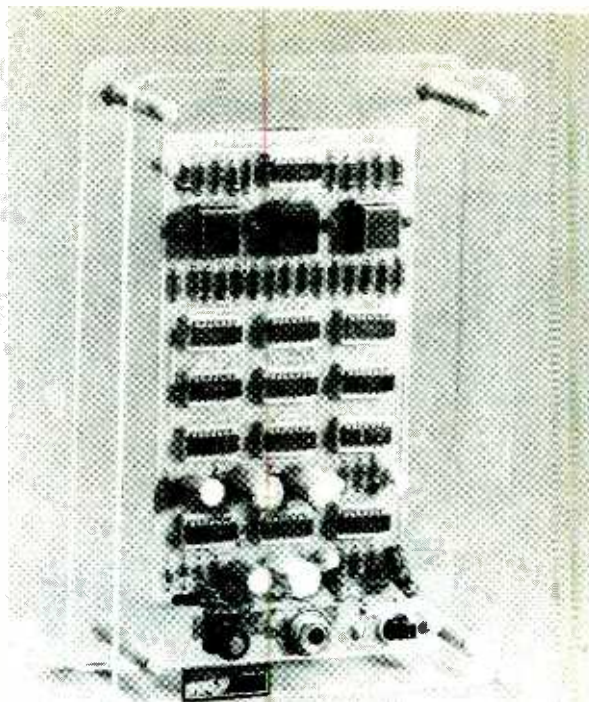
ONE OF THE LEAST EXPENSIVE ways to obtain a piece of test equipment is to build it. This function generator kit from Dage Scientific Instruments sells for less than \$60.00.

else and needs an audio-power amplifier to process the end product. For example, the hobbyist might be building a set of modular (integrated) stage monitors for a rock band. The mixer, sound processor, and speaker cabinet might be the main project. Rather than go through the hassle of also building the power amp, it might be easier to simply build in a power module. Hence, we consider it to be a "kit," though some might claim that's stretching the meaning of "kit" a bit.

Not that much detail

One way to avoid disappointment with many (if not most) of the specialty kits is to keep in mind that they are not Heathkits. You are not getting an assembly manual that spells out each step in detail, such as: "Connect a 3-inch wire from hole 34 to terminal 16," or "Install a 2200-ohm resistor (red-red-red) at location AB." The price of the specialty kits, which is often "rock bottom," represents a decent circuit and usually first-quality components. There are sufficient instructions for anyone reasonably familiar with what electronic parts look like to make a problem-free assembly.

Generally, there is a schematic; a parts list; an excellent top-view pictorial of the PCB; a set of somewhat sparse instructions as to the order in which the components should be mounted on the PCB; mechanical assembly instructions if needed, and final align-



WHILE YOU WON'T break the bank playing this electronic slot machine from PPG Electronics, the cost of the kit won't break you! The circuit originally appeared in the January 1980 issue of *Radio-Electronics*.

ment or adjustment procedure if they are needed. The key to success with those kits is usually the PCB's top-view pictorial, with every component indicated clearly as to position and part-identification. In many instances those PCB pictorials are superior to what's supplied by the "biggies;" they need to be, because of the absence of detailed step-by-step assembly instructions. The specialty kit's assembly instructions might be mimeographed on a single sheet of paper, or may be a glossy-stock fold-out that even contains a few photographs. It doesn't seem to make a real difference: The kits from the known brands appear to assemble and work equally well regardless of how the instructions are printed.

Before we leave the subject of PCB specialty kits we must not overlook Radio Shack. The "Shack," which has "complete" kits such as their Archer-Kit 20,000 ohms-per-volt volt-ohm-meter, also sells something called a "Project Board," which is an etched and drilled PCB for somewhat unusual projects. Among those are a stereo electronic reverb, an RF modulator, and a stereo-headphone amplifier. The PCB's cost from about \$2.50 to \$10 and are supplied with assembly instructions, a parts list giving values and the Radio Shack parts numbers, *but no parts*. The user provides his own components, though Radio Shack hopes that the builder will buy them from one of its stores. But you don't have to; it's often less expensive to purchase the components somewhere else.

Still saving money

Somewhere between the low-cost PCB kits and the regular line of expensive kits are "money savers" from small-kit companies with only one item (or a few) in their line. Those are full-fledged kits, usually test instruments, whose performance and "finish"—mean-

ing the cabinet and controls—are competitive with Heathkit, EICO, and of course, commercial “wired” models. The primary advantage of those kits is “sweat equity:” The time you spend in assembly is considered part of the cost.

In actual dollars, you save some 25% to 50% of what a wired model would cost. The second advantage is “new technology.” Often, the company is owned by the design engineer, or someone with a great marketing idea. They can “turn on a dime,” and will often have a new technology kit on the market before a major company can get rolling on a similar project. A typical example is Sabtronics International, of Tampa, FL. Presently, they offer a hand-held LCD digital multimeter (DMM) that closely resembles wired “big name” brands, a function generator, and by the time you read this, a 9-digit frequency counter to 1000 MHz. The kits are all supplied with a “high technology-type” instrument cabinet and notably excellent step-by-step instructions. The problem is that the user tends to under-rate the manual because it looks like a photocopy of regular typing. Nevertheless, the step-by-steps are excellent. The pictorials are broken down into sections, but are somewhat difficult for a beginner who might be used to more precise component illustrations.

Other money-saver kits are those from Dage Scientific Instruments, of Livermore, CA. They have a few instruments that the average hobbyist and service technician isn’t likely to find easily anywhere else. Among them are an autoranging 3-digit digital capacitance meter kit for less than \$80 that measures from 1 pF to greater than 1000 μ F, an electronic thermometer and controller from -300 to 1200 degrees F., and a signal processor for type “J” thermocouples. Obviously, those are not your average run-of-the-mill projects, but if you need them it’s the only way to get them at budget prices.

Again, the step-by-step assembly instructions are very good. As for the pictorials, some are excellent, others take some head scratching and some effort to figure out which component matches what outline in the pictorial. A beginner might have some difficulty, but not those with a few projects under their belt.

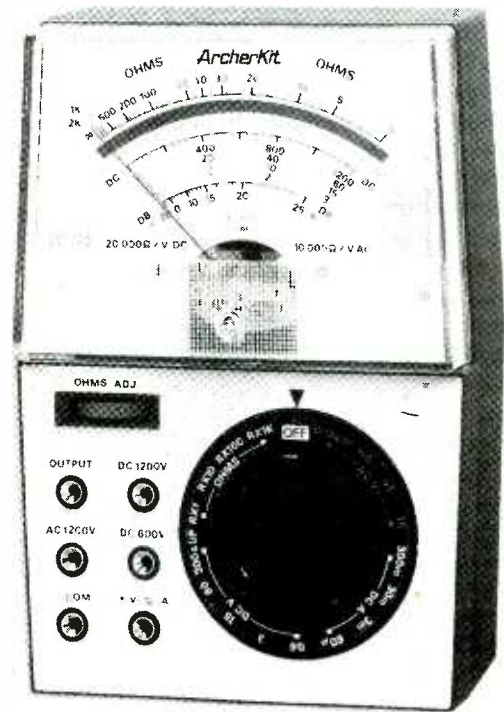
You can’t be a beginner

Once we get beyond the small beginner and specialty PCB kits we get into the big time where anything goes. Need a laboratory-quality oscilloscope? It’s available in kit form. How about a computer? Wired models don’t come cheap, but Heathkit has a computer system, the H8, that you can assemble as you go along—as your budget permits. They also have a relatively low cost all-in-one computer kit, the H89, as well as budget-priced computer-trainer kits that teach both digital and/or machine-language programming.

If you want to get into personal computing but are strapped for funds, you might want to start out with the ZX80 all-in-one microcomputer kit from Sinclair Research, Ltd. in Boston, MA; it costs just under \$100. If you look real close you’ll discover it’s really a kit version of Sinclair’s ready-to-use ZX80, which comes with an on-board BASIC and an RF modulator that allows you to use an ordinary TV receiver for the video display. It even includes a built-in cassette interface so you can store and retrieve your programs (on a cassette recorder) at the touch of a button.

Or maybe you need a chart recorder for your test lab? That’s also available in kit form. Super high-fidelity gear? Also in kit form. A weather station? Again you can take the kit route to success. The list of major kits for both consumer and technical equipment is almost endless.

Only problem, however, is that those are somewhat complex kits; the builder must have a considerable degree of assembly proficiency and a reasonable, or working knowledge, of the circuit. To explain: Firstly, those kits have many complex circuits using many components, generally packed onto a PCB with a shoehorn. Unlike the beginner and specialty PCB kits, there are no wide-open spaces between the PCB foils or the components. Often, the foil solder pads are spaced no more than a pencil-line apart.



A 25-RANGE ANALOG MULTIMETER, this Archerkit sells for less than \$20.00. One of three multimeter kits from Radio Shack, the finished project is bound to be useful in any workshop.

Like it or not, it takes considerable experience with assembling high-density PCB wiring to avoid a mess of hairline solder-bridge short-circuits in those kits. It also requires special tools: usually a temperature-controlled soldering iron with a pencil tip and desoldering tools and wicks, because as careful as you are, you are going to install at least one component in the wrong place; and if you don’t unsolder the component with the correct tools and procedures, you might not end up with a usable PCB. Also, while the instruction manuals are highly detailed as to mechanical assembly, there is usually a lot of it, and the builder must have some expertise in reading three-dimensional drawings.

Even more important, however, is some form of understanding of the circuit used in the kit, or at least sufficient technical background to follow the explanation of “How It Works” that’s provided with the

major kits. Virtually all of the major kits make extensive use of large-scale integrated circuits, and each IC might represent several different circuits and hundreds of discrete transistors. There are going to be defective components in some kits, and some builder is bound to damage some components during assembly. It is rare that the builder will be able to test anything other than transistors and diodes and resistors and capacitors.



IF YOU WOULD LIKE an autoranging 3-digit capacitance meter that costs less than \$80.00 you will have to build this kit from Dage. It's hard to find a similar instrument anywhere at any price.

More often than not, troubleshooting kit problems will mean substituting one IC for another. It can get somewhat expensive to purchase one of everything and then substitute on a random basis until the problem goes away. Also, the problem might not be a defective component. Maybe a component was installed in the wrong place, changing circuit parameters, and no matter what IC you substitute it will be zapped. For the major kits, particularly "digital circuits," you must have some understanding of the overall device, or better still, a working knowledge of the individual circuit(s) so you can describe the problem to the manufacturer's technical assistance department and understand their reply. If you have absolutely no knowledge and/or understanding of digital circuits, a major computer kit is not for you unless there's an authorized service center nearby where you can personally deliver the computer. But keep in mind that factory service to undo your mistakes and damage can be expensive.

If the only way you can afford a particular piece of major equipment is by building from a kit, and you really have no idea of the theory or circuit, find someone locally who can assist you. Either a high school technical student or a member of a local computer club. It's amazing how most major kit problems are easily resolved when you have someone who knows what the circuit's all about.

Living instruments

We have saved one type of kit for last: "Electronic Music Instruments." Generally a major construction project in every respect, the assembly and adjustment of electronic music instruments is usually tailored specifically for a beginner. Those kits are professional-quality musical instruments, not little fun-kit organs with four or eight tones, or warblers, or whatever. Those are professional instruments such as you might

purchase at the local professional music shop—the place where the real pros buy their instruments.

Most hobbyists are familiar with the Heath/Thomas organ kit, which is a kit version of an organ many people purchase for their homes. But have you heard of Wersi Electronics, of Lancaster, PA? Wersi makes a line of professional organ kits; everything from a portable-organ combo for a club or rock keyboard player, to theater and church organs, to "sidemen" (an electronic rhythm machine), to electronic rotators (which simulate the Leslie speaker), to professional mixers.

The kits are packaged in modules which you purchase as the budget permits (it can get expensive—organs are not cheap). Since many functions are complete modules, you can build in exactly the features you want, such as reverb, or string accompaniment. Nothing is closed-end. You can add any features for a particular instrument after the initial assembly, and add new features as they are introduced.

Wersi manuals are magnificent. The theory of operation, heavily illustrated with superb pictorials, are integrated into the manual so the builder not only has assembled a particular module, he understands how the circuit works, what it does in terms of musical sound, and how to integrate the sound into the performance. In fact, a Wersi kit is not just a kit; it is an experience (an expensive experience), that ends up a "living instrument."

Other award-winners in instrument kits are those from PAiA Electronics, Inc., of Oklahoma City, OK. If you go into a major music store in any large city you'll find professional synthesizers and other keyboard devices, as well as phlangers, electronic drums and battery-powered portable amplifiers, under the "PAiA" name. Many of the PAiA electronic instruments sold in the music stores are available direct from PAiA in kit form, the kit price averaging about 60% to 70% of the wired version. (You save 30%-40%). PAiA has other electronic devices not found in music stores which are also available direct from PAiA. If you're into electronic music, PAiA might well be your kind of company. Just bear in mind that synthesizers and the like are somewhat complex, and utilize state-of-the-art technology. If you have never assembled a major kit and want to build your own synthesizer, start small; try one of the special-effects devices such as a phlanger, ping-pong, or sustain.

There's still more

We have barely covered the standard kits with which you are familiar, such as those in the Heathkit and EICO catalogs; they are self-explanatory. We have pointed out some of the special kits meant for beginners, unusual kits that might be of particular interest to the electronic hobbyist, and some of the major advantages and problems common to various types of kits. Regardless what you choose to build, keep in mind that the most fun and value is attained if you end up with a working device that caused the least amount of assembly problems. Often, it's better to work your way up through basic and intermediate kits before you tackle a color TV, a laboratory oscilloscope, or a personal computer. Whatever road you chose to follow, bear in mind that kits are primarily intended to be fun...most of them are.

SP

Radio Electronics Special Projects

200 Park Avenue South/New York, N.Y. 10003/(212) 777-6400

A
GERNSBACK
PUBLICATION

Dear "Special Projects" Reader:

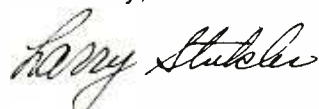
This quarterly publication is edited specially for you. Each edition contains all-new, never-before-published construction projects designed for electronics enthusiasts, like yourself, who enjoy the challenge of building exciting, functional, and imaginative equipment.

To help us serve you better—and to publish the kind of special projects you would like to build—we need to know more about you and your interests.

Therefore, will you please spend the 5 minutes it will take to fill out the following questions, remove this page, and mail it directly to me *today*.

Very many thanks.

Cordially,



Larry Steckler
Publisher

RADIO-ELECTRONICS "Special Projects"/200 Park Avenue South, New York, NY 10003

1. Please indicate below all areas of activity in leisure electronics that interest you (PLEASE CHECK ALL THAT APPLY.)

- | | | |
|--|---|---|
| <input type="checkbox"/> Audio (Hi-Fi, Stereo) | <input type="checkbox"/> Test and Measurement Equipment | <input type="checkbox"/> Automobile Hi-Fi |
| <input type="checkbox"/> Amateur Radio | <input type="checkbox"/> Scanning Receivers | <input type="checkbox"/> Automotive Electronics |
| <input type="checkbox"/> Computers | <input type="checkbox"/> Shortwave Receivers | <input type="checkbox"/> Video Recording/Playing |
| <input type="checkbox"/> Controls or Alarms | <input type="checkbox"/> CB Radio | <input type="checkbox"/> Others (PLEASE LIST BELOW) |

2. Please indicate the tools you now own, have purchased in the past year, and plan to buy during the next year.

<u>Tools</u>	<u>Now Own</u>	<u>Purchased in Past 12 Months</u>	<u>Plan to Buy in Next 12 Months</u>
Wirewrap Tools	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Soldering Tools	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Desoldering Tools	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Hand Tools	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Miniature Motorized Tools	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Bench Power Tools	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other _____ (please specify)			
None of the above owned <input type="checkbox"/>	None of the above planned <input type="checkbox"/>		

3. What is your best estimate of the total value of the tools you own...and how much of that was purchased in the past 12 months.

<u>Total value</u>	<u>Purchased in the past 12 months</u>
\$ _____	\$ _____

4. On the average, how many different construction projects do you build and complete during a typical 12-month period?

Number of construction projects built and completed _____

5. On the average, how many hours do you spend building a construction project?
 Number of hours spent _____
6. When you buy electronic equipment or supplies for construction projects, what sources do you use?
 (PLEASE CHECK ALL THAT APPLY)
- Electronics Distributor Music/Audio Store Department or Discount Store
 Electronics Specialty Store Computer Store Mail Order
 Other _____
 (please specify)
7. Would you find it helpful to see the equipment that you need in order to build our construction projects advertised in "Special Projects"?
 Helpful Not Helpful
8. In your full or part time work, is the knowledge of electronics important?
 Yes No (If "NO", please skip to Question 10)
9. What function(s) do you perform at work? (CHECK ALL THAT APPLY)
- Management Designing Engineering Servicing
 Buying Specifying Production Training/Teaching
 Other _____
 (please specify)
10. What is your job title (Owner, VP Engineering, Technician, Student, etc.)?

11. Which special interest magazines do you currently subscribe to or read regularly? (3 out of 4 issues)

12. Do you currently subscribe to RADIO-ELECTRONICS or read it regularly?
 Yes No
13. FOR CLASSIFICATION PURPOSES: May we remind you that all answers to the questionnaire are confidential and will be used only in combination with those of all other respondents to develop a composite analysis.
- A. What is your age?
- Under 18 30 - 34 45 - 54
 18 - 24 35 - 39 55 - 66
 25 - 29 40 - 44 66 or Over
- B. What is your sex?
 Male Female
- C. What is the highest level of school that you have attained?
 (PLEASE CHECK ONLY ONE.)
- Grade School Graduated College
 Attended High School Post Graduate Studies
 Graduated High School Masters Degree
 Attended College Doctorate
- D. What is your best estimate of your total annual household income before taxes? (Please include income from all members of the household including all sources, income, dividends, rentals, etc.)
- Under \$5,000 \$10,000 - \$14,999 \$20,000 - \$24,999 \$35,000 - \$49,999
 \$5,000 - \$9,999 \$15,000 - \$19,999 \$25,000 - \$34,999 \$50,000 and Over

Your City _____ Your State _____

Thank you very much for your help.

CLOCK INTO FREQUENCY COUNTER

When you finish this project, you'll have an accurate frequency counter at the lowest possible cost.

F. W. CHESSON

INEXPENSIVE DIGITAL CLOCKS, AVAILABLE FOR \$10.00 or less, can be easily converted to frequency counters, capable of indicating to 100 kHz and above, with good accuracy and stability.

The project described in this article uses a typical self-contained IC and LED display clock module, the National MA1012, and is also adaptable to several commercial digital clocks using the Texas Instruments TMS-1952NL clock module.

How it works

Both digital clocks and frequency counters count pulses. The counter records *how many* pulses occur during a fixed interval, while the clock indicates *when* a predetermined number of fixed-frequency pulses has occurred. By relatively simple conversions, the clock's display can be made to reveal frequencies other than its fixed time-keeping standard of 50 or 60 Hz.

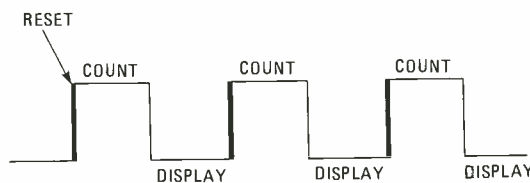


FIG. 1—A FREQUENCY COUNTER DIFFERS from a clock in that it records how many pulses occur during a fixed interval.

The requirements for a frequency counter, in terms of sequential operations are: *reset*, *count*, and *display* (See Fig. 1).

The system timer, that determines the count and

display intervals, can be clocked by counting down from the 60-Hz signal in the power supply, via a 4020 or 4060 CMOS divider IC. A more simplified but still accurate method is to use a 555 timer IC, whose on and off periods can be individually adjusted, as shown in Fig. 2.

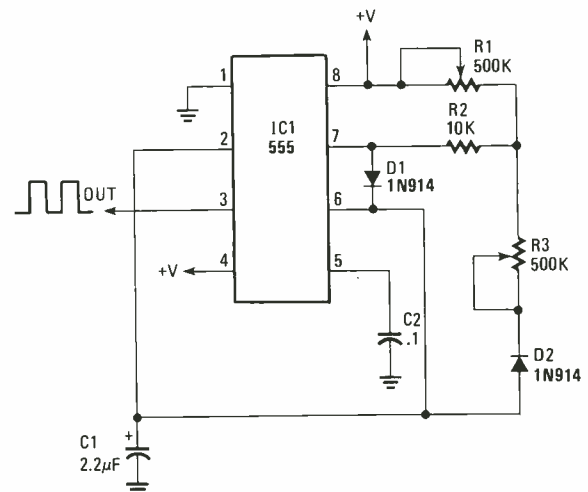


FIG. 2—A SYSTEM TIMER is required to determine the count and display intervals. The timer for this project uses a 555 IC.

The most obvious way to determine an unknown frequency is by direct input to the clock IC's input. If necessary remove or modify the R-C filter usually encountered. This method can involve either the SECONDS or ALARM display modes, available with most IC's. In all cases, it is necessary that at the conclusion

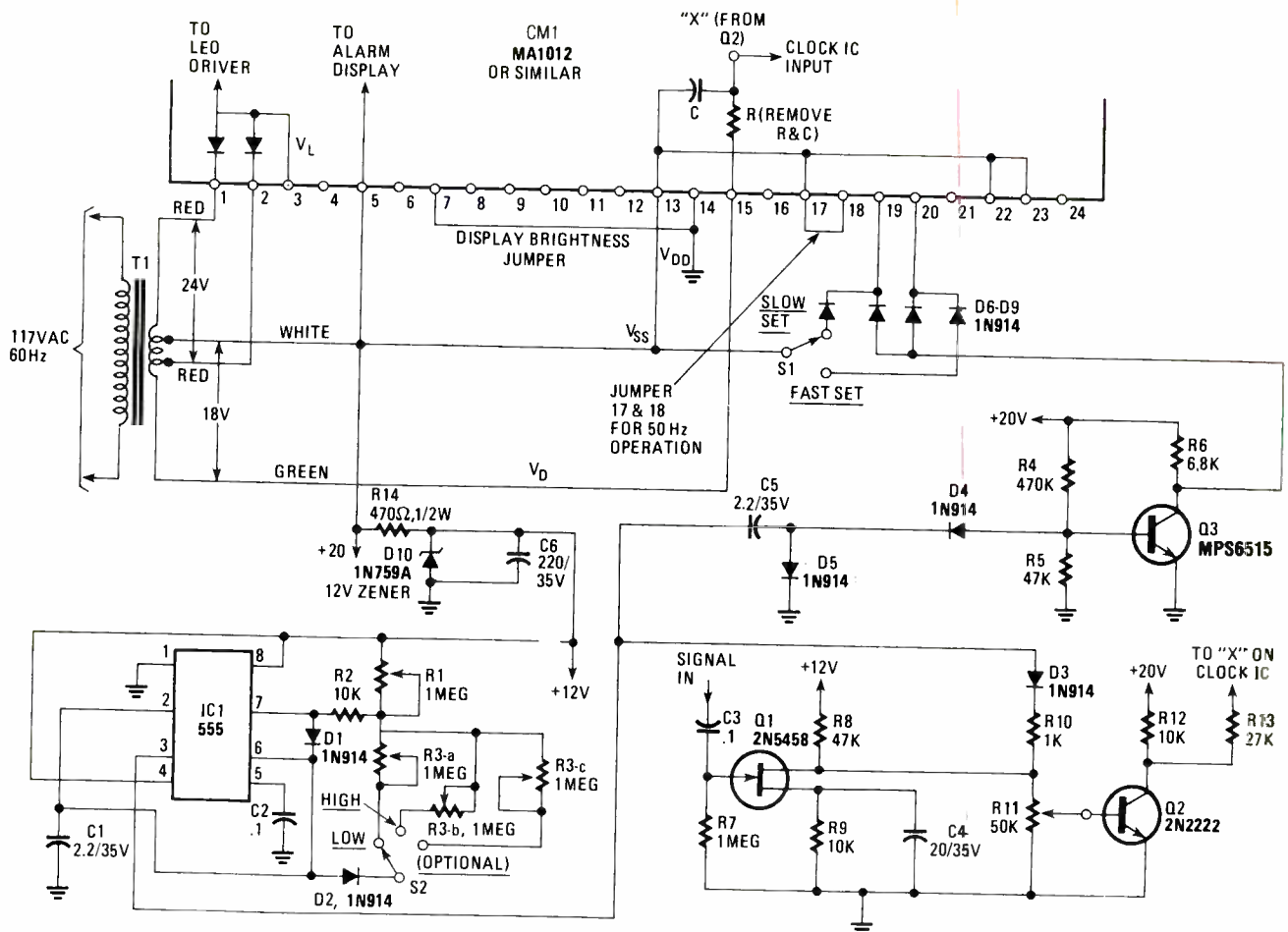


FIG. 3—SCHEMATIC DIAGRAM for the frequency counter. While the circuit is designed to use the National MA1012 clock module, it can be adapted to use the Texas Instruments TMS-1952NL module.

PARTS LIST

RESISTORS

All 1/4 watt, 5% unless noted

- R1, R3-a, R3-b, R3-c—1 megohm, potentiometer (miniature, trimpot suggested)
- R2, R9, R12—10,000 ohms
- R4—470,000 ohms
- R5, R8—47,000 ohms
- R6—6,800 ohms
- R7—1 megohm
- R10—1000 ohms
- R11—50,000 ohms, potentiometer
- R13—22,000 to 27,000 ohms (see text)
- R14—470 ohms

CAPACITORS

- C1, C5—2.2 μ F, 15 to 25 VDC
- C2—0.1 μ F, 50 VDC, ceramic
- C3—0.1 μ F, 100 VDC, Mylar
- C4—20 μ F, 15 to 25 VDC
- C6—100 μ F, 20 to 25 VDC

SEMICONDUCTORS

- D1—D9—1N4148 or 1N914
- D10—1N759A or 1N4742A, 12-volt Zener
- CM1—MA1012 National digital clock module (with LED readouts)
- IC2—555 timer
- Q1—2N5458 FET
- Q2—2N2222
- Q3—MPS6515

MISCELLANEOUS

- S1—SPST (optional for 100 - 1000-Hz counting range)
- S2—SP3T (third position for optional counting range above)
- T1—Primary 117 VAC; secondary 24-volt CT and 18 VAC, 100 mA
- Miscellaneous hardware

of the display interval, the figures be reset to 0:00 or 12:00 on the readout.

The best method is one that provides an easily-calculated bridge between actual input frequency and readout display.

How to do it

For a "pseudo-direct" time-to-frequency reading, covering from under 1 kHz to 120 kHz, the ALARM

DISPLAY and SET feature of the MA 1012 was used. I simply varied the "off-time" of the 55 timer IC with R3. The overall circuit is shown in Fig. 3. Note that the clock IC's input filter, R and C, is removed to accommodate the far higher input frequency.

Since I found that input signals of 10 to 15 volts peak are required for reliable clock operation, I added a FET-input preamplifier. It delivers adequate output pulses for input signals as low as 100 mV peak.

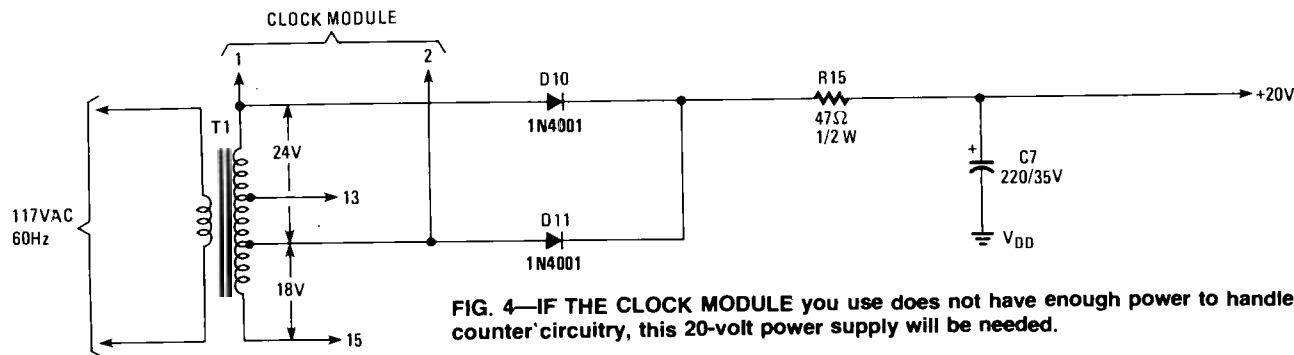


FIG. 4—IF THE CLOCK MODULE you use does not have enough power to handle the counter circuitry, this 20-volt power supply will be needed.

Notice, that when the 555 timer is in the ON or DISPLAY mode, the positive output is used to hold off the signal amplifier, via D3. Diodes D4 and D5, together with capacitor C5, form a gate to reset transistor Q3. It is normally biased into conduction, resulting in a low potential at its collector. When the display period ends and the timer shuts off, C5 charges through D4, making the bias on Q3's base fall and its collector potential rise suddenly. This reset pulse is applied via diode D6 and D7 to the SLOW and FAST SET terminals of the clock module, thereby resetting the display back to 12:00 when the module is in the ALARM SET mode, or 0:00 if it is in the SECONDS DISPLAY mode. When the 555 timer again turns on, C5 is discharged via diode D5.

Some clock modules may not have enough power to spare for the additional frequency counter circuitry. The +20 VDC supply shown in Fig. 4 will handle the added circuitry if needed.

Construction steps and hints

A small piece of perforated board, containing the components of the circuit shown in Fig. 3 can usually be fitted into a corner of the digital clock case. In soldering connections to the clock IC's terminals, use a minimum of heat and observe the usual precautions involving MOS-technology components. Potentiometer R11 can be replaced by two separate ¼-watt resistors, once the optimum setting for maximum output from Q2 has been determined, as discussed below.

Calibrate before using

For calibration purposes, a signal generator, standard frequency counter, and an oscilloscope are necessary. However, an oscilloscope with a well-calibrated horizontal sweep can be used when a regular frequency counter is not immediately available.

After checking out the completed circuitry, disconnect diode D3 temporarily and set potentiometers R1, R3-a, and R3-b at about mid-range. Apply a 10-kHz square wave of about 1-volt peak amplitude to the input and observe the output amplitude at the collector of Q2 with the oscilloscope set for an appropriate sweep rate. Adjust R11 for best output, reducing the input test signal if clipping occurs. Increase the test frequency up to 100 kHz or so, observing frequency effects, especially at the IC input end of filter resistor R13, reducing R13 somewhat, if necessary.

Reconnect D3 and make sure that the signal at the collector of Q2 is gated on and off at regular intervals. Set the RANGE switch to LOW. Adjust R1 for an OFF period of about one second. Now adjust R3-a so that, with an input frequency of 10 kHz, the clock displays

10:00. Reduce the frequency to 5 kHz and the display should read close to 5:00. At 1000 Hz, it should indicate 1:00. R1 can be varied for a "vernier adjustment" of R3-a, so long as the display is on long enough to give the observer a useful reading before resetting.

Return the test oscillator to 10 kHz and switch the RANGE switch to HIGH and adjust R3-b for a display reading of 1:00. At 50 kHz the indication should be 5:00, and at 100 kHz it should be about 10:00. It should be also possible to get a reading with an input frequency of 120 kHz, which would be indicated by a display of 12:00* (the asterisk indicates that the PM LED is now on).

For interpolations, remember that the clock is indicating at a 0 to 60 time base, while the frequency base is at 0 to 100. Thus, on the LOW range, a reading of 5:30 would correspond to a frequency of 5500 Hz. The following chart can easily be memorized for other readings:

FRE- QUENCY (kHz)	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.05
TIME	1:00	1:06	1:12	1:18	1:24	1:30	1:36	1:42	1:48	1:54	2:00	2:03

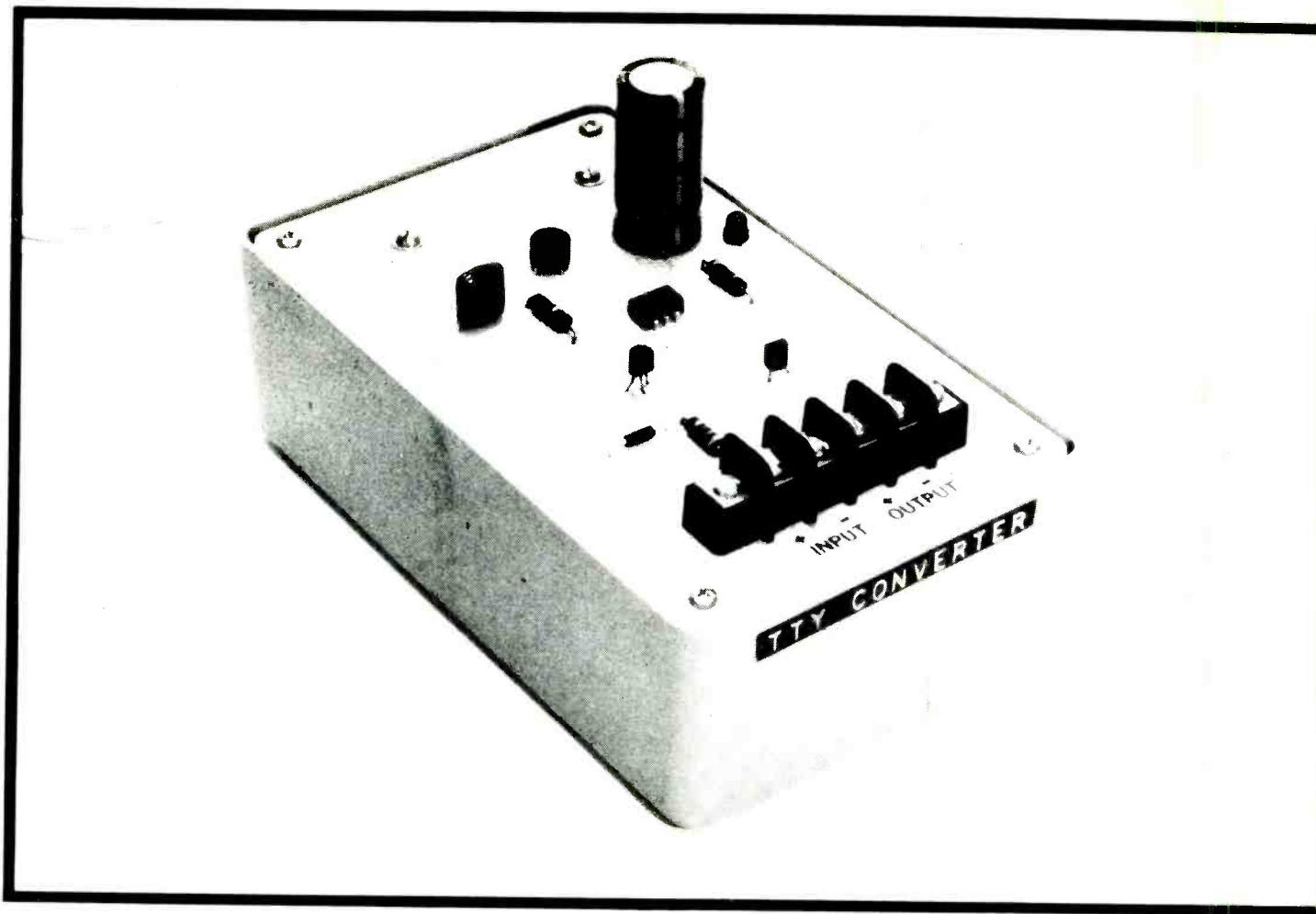
You can see that the following input frequencies are read as follows in the examples below.

RANGE	TIME DISPLAY	FREQUENCY
Low	1:12	1200 Hz
"	4:42	4700 Hz
"	6:54	6900 Hz
"	8:33	8550 Hz
High	2:18	23.0 kHz
"	5:15	52.5 kHz
"	7:37	75.2 kHz
"	11:51	118.5 kHz

You may want to extend the range of the basic instrument below 1 kHz, or above 100 kHz. For a range from 100 to 1000 Hz, simply switch the ALARM SET connection from SLOW to FAST and calibrate the new LOW range with another potentiometer (R3-c). For frequencies from 100 kHz to 1 MHz, a 4017 decade counter "pre-scaler" can be added, preferably with its own high-frequency pre-amplifier circuit.

In this way, the experimenter or student can build an inexpensive, reasonably accurate, and easy-to-use frequency counter, at little more than the cost of an average digital clock.

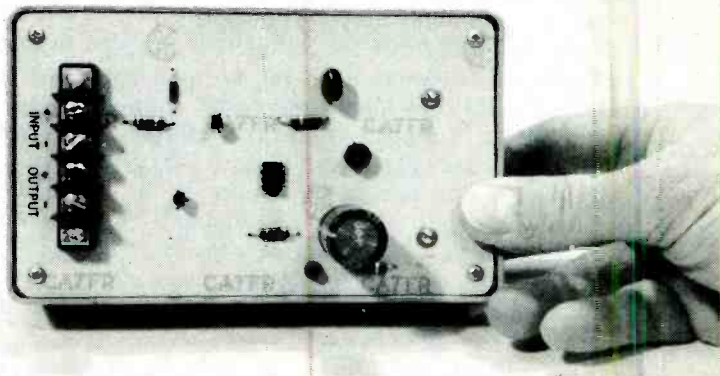
SP



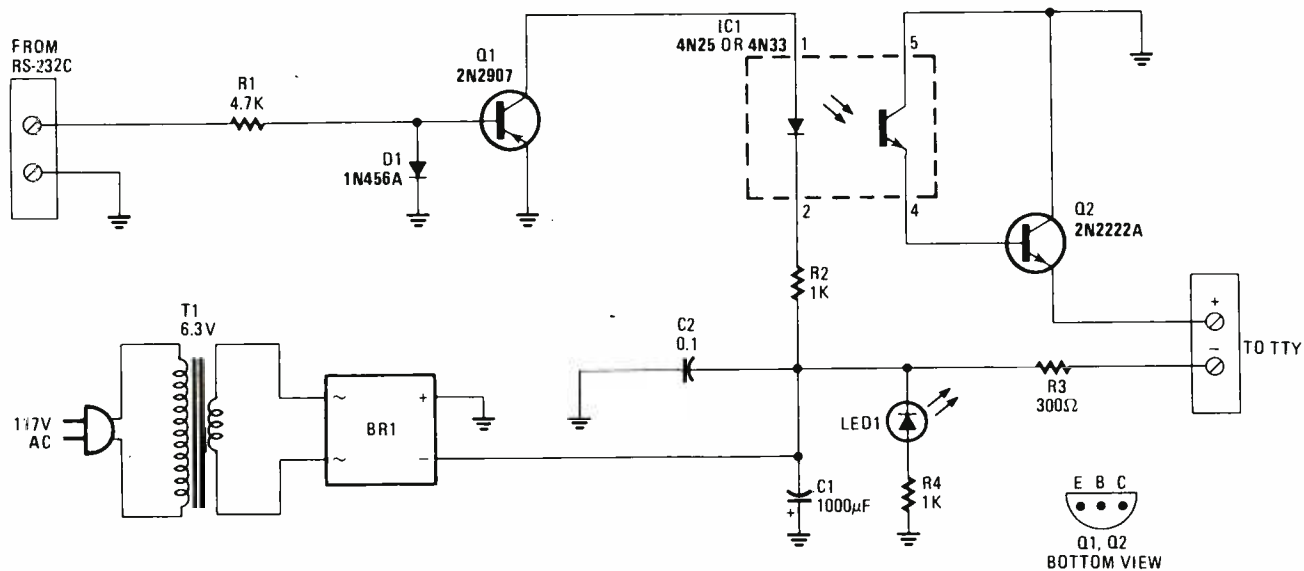
TTY PRINTER CONVERTER

PERSONAL COMPUTERS GET QUITE EXPENSIVE. WHILE a basic system is relatively cheap, little can really be done without a printer; and more often than not, even the least expensive line printer can almost equal the cost of the rest of the system. But there *is* a cheap way to get hard copy: it might be somewhat slow compared to the *zip-zip-zip* of a line printer, but what's a little loss in speed worth if you can wind up with a printer for less than \$150!

The key to budget printing is the Model 33 teletype printer, also known as an RO33 (RO means *Receive Only*). A combination printer and keyboard (a full terminal) is known as a KSR33 (KSR meaning *Keyboard Send and Receive*). Until a few years ago, the Model 33 was used almost universally as a terminal for time-share systems: there were thousands and thousands of them scattered across the U.S. in high schools, universities, business offices, and homes. Almost overnight they were made obsolete by high-speed terminals that could send and receive at least three times faster than the 110 wpm rate of the model 33 TTY. Today, those terminals are buried in school basements ready for



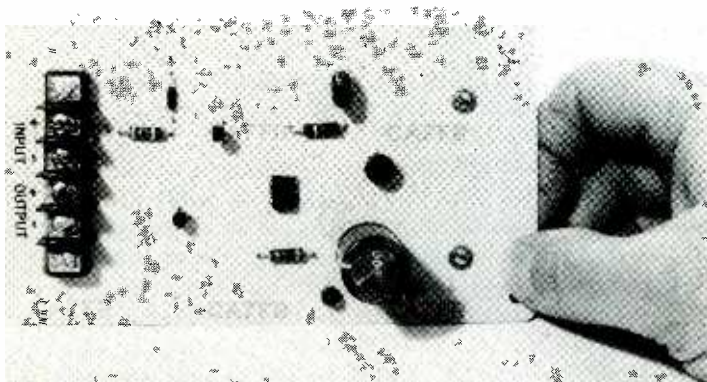
THIS TELETYPE CONVERTER lets you use a surplus teletype printer to get hard copy from your computer. The printer can be bought for as little as \$125; the converter should cost you less than \$25 to build.



IN THIS CIRCUIT, the positive side of the power supply is common; the negative side is 12 volts below ground.

Use an inexpensive, commonly available teletype terminal as a printer for your computer.

JOE SHANKER

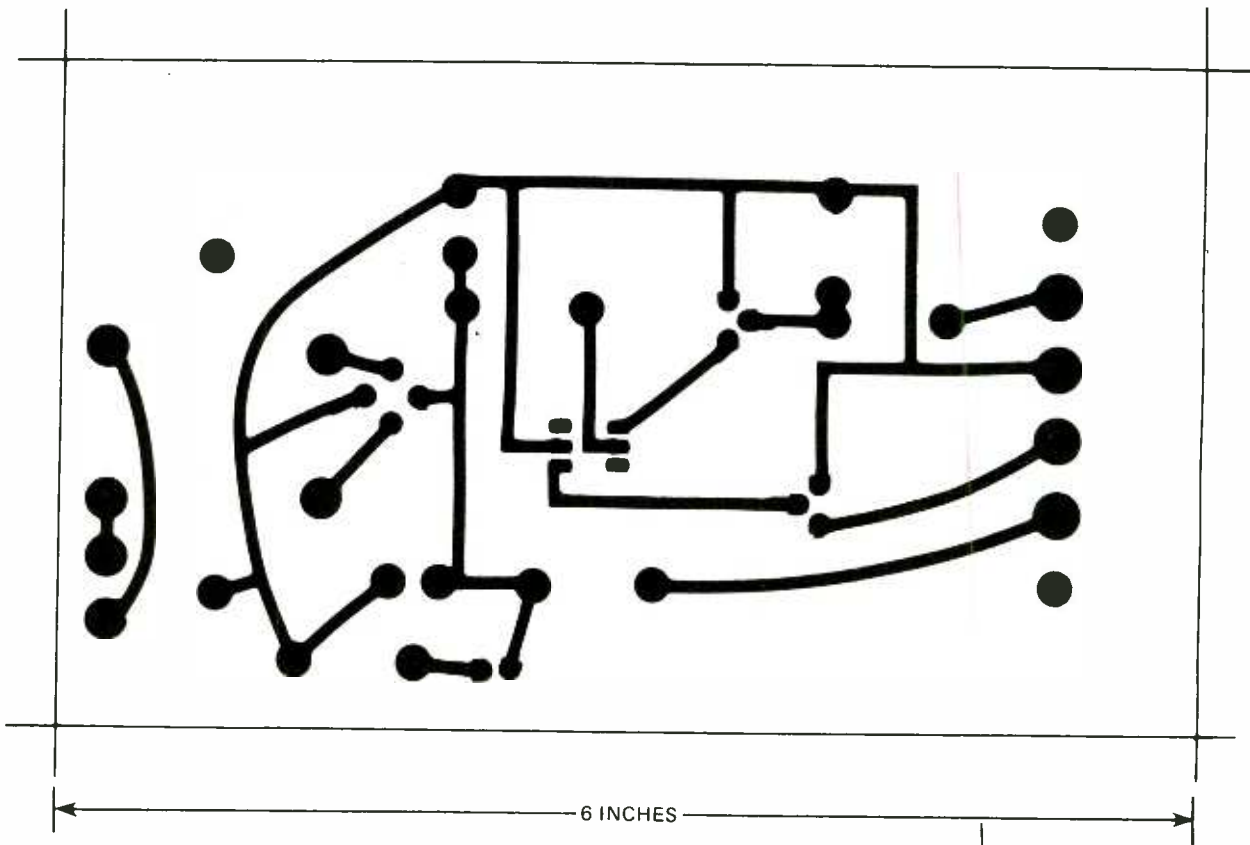


THE COMPONENT LAYOUT IS WIDE OPEN and should create no assembly problems, even for the beginner. Just make sure that transistors Q1 and Q2 "face" in opposite directions. Their leads are "in-line" and are fanned to the triangular configuration.

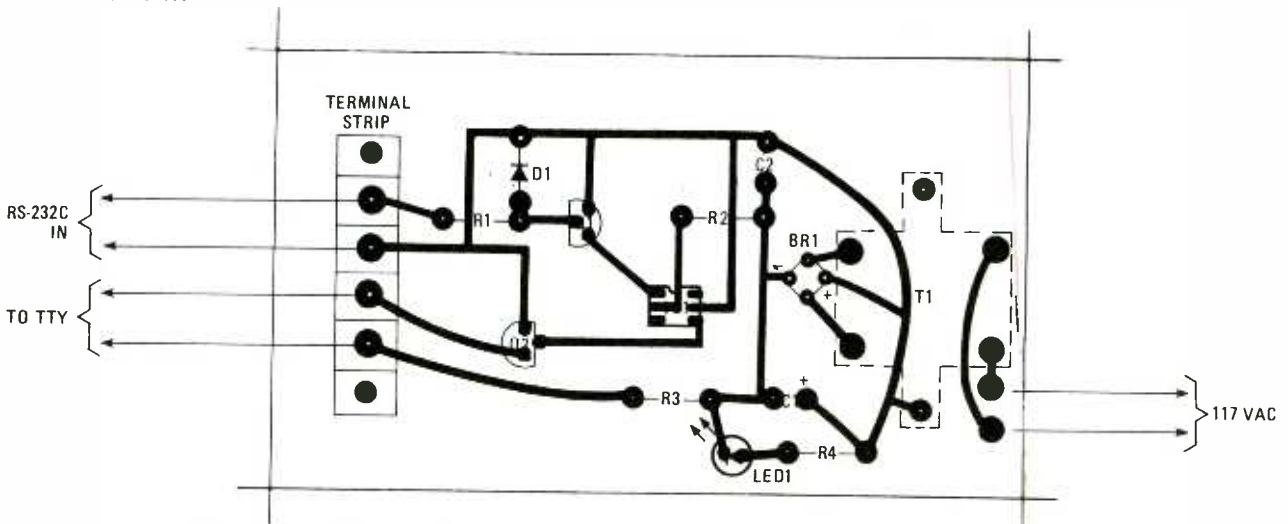
"junk" sale to surplus dealers, who sell refurbished Model 33 printers for as low as \$125.

Since the TTY is a *serial* device, it can be used with any personal computer that has a serial I/O or printer port that can be set for the 110 Baud rate of the TTY. The problem, however, is that the TTY receives and sends through a 20-mA current loop. While many early personal computers provided both an RS232C and 20-mA serial I/O, most modern personal computer serial ports are either RS232C, or eventually end up as RS232C through an adapter. Since RS232 is a voltage I/O, it cannot be used to directly drive a TTY.

That's where the TTY Converter comes in. The converter, which should cost well under \$25 to build—the exact price depending on how well your junk box is stocked—converts RS232C serial signals to 20-mA current loop. Connected between the computer and the TTY, it appears as an RS232C "load" to the computer, and as a 20-mA current source to the TTY. When you instruct your computer to PRINT, the computer outputs to the TTY just as it would to a serial printer.



THE PRINTED-CIRCUIT BOARD also serves as the case cover in this project. The foil pattern you should use is shown here full size.



TRANSFORMER T1 and the connections to the 117-volt power line are on the foil side of the board as indicated by the dashed lines in this parts-placement diagram.

How it works

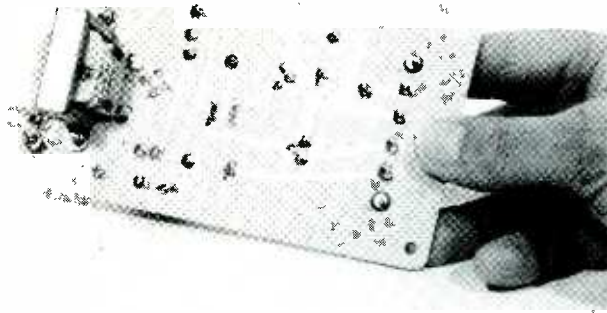
The TTY's "+" and "-" printer connections are connected to the corresponding "+" and "-" terminals on the converter. The computer's RS232C output is connected to the converter's input. Note that one RS232C connection is a true "ground." The TTY's "-" is *not* a ground; it simply indicates polarity to the printer: *Make certain that you don't ground the "-" TTY connection.*

RS232C outputs *mark* at nominally -12VDC. Character bits, or *spaces*, cause a rise to +12VDC. The TTY *marks* when current is *on*, it *spaces* when current is turned off. To convert RS232C to 20-mA current loop, we simply turn off the current loop when the RS232C signal goes through the transition from -12VDC to +12VDC. (Note: An RS232B I/O *marks* at +12VDC

and *spaces* at -12VDC. It is also used for personal computer equipment. The term "RS232" almost universally implies "RS232C".)

The RS232 output from the computer is applied to Q1. The -12VDC *marking* voltage causes Q1 to conduct, thereby illuminating the LED in opto-coupler IC1. The LED's illumination "excites" the base of the transistor within IC1, causing the transistor to conduct. Since the transistor in the opto-coupler is connected from Q2's *collector* to *base*, Q2 conducts, providing approximately 20-mA to the printer through Q2's *emitter* return. The TTY is receiving a 20-mA *marking* current.

When the RS232 signal goes positive, Q1 is cut off. (D1 protects the base by shorting the positive current



THE POWER TRANSFORMER IS MOUNTED on the foil side of the PCB and its connections are made to solder pads that are not drilled through. There must be no access whatsoever to the line voltage terminals from the top of the PCB.

to ground.) The LED is turned off, which causes the opto-coupler transistor to turn off also, thereby turning Q2, which interrupts the current flowing into the TTY printer. Since the current through the LED, opto-transistor and Q2 track the applied RS232 signal, the current through the TTY will also track, and the TTY is "fooled" into believing that the drive signal comes from a standard TTY current loop.

One note of caution

Generally, 110 Baud equipment, such as the TTY, requires two stop bits tacked on the end of the serial character. All other Baud rates (for personal computers) use one stop bit. You must program that RS232 I/O to provide two stop bits at 110 Baud. With Zenith/Heath-kit, and other computers having a SET command for the I/O, it's done through software with a command such as SET LP: (or AT:, whatever you use) 2SB (meaning 2 stop bits). With RS232's that are hardware-set, such as the TRS-80, simply set the appropriate switch for 2 stop bits.

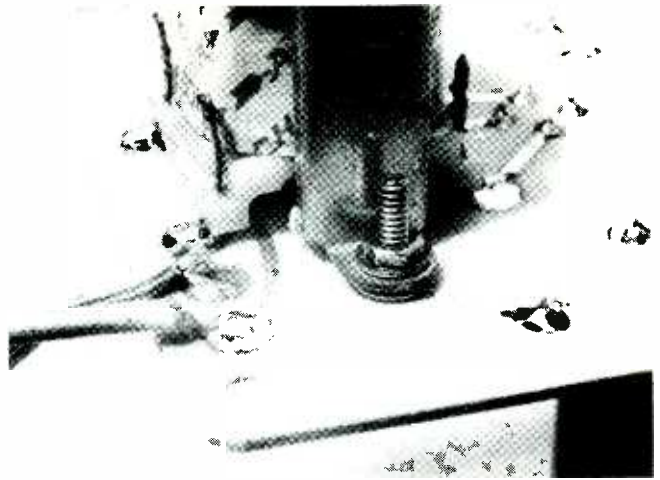
How to build your own

Almost anything goes, though the printed-circuit layout shown is the most convenient method because it substitutes directly as the cover for a standard plastic cabinet. To avoid being zapped by the 117-volt power line connections should you inadvertently touch the PCB components, power transformer T1 is mounted on the underside of the PCB using stand-offs (a stack of washers will do); and all connections to the transformer, as well as those from the linecord, are tack-soldered to oversize solder pads that are not drilled though. Follow these instructions and you'll find that it is impossible to contact the 117-volt connections.

Note that the positive power supply is common: the negative side of the power supply is below ground potential. Make certain you get the polarity of C1 correct: the positive lead must be "grounded."

Virtually any silicon switching transistor with an H_{FE} of 50 or more can be used for Q1 and Q2. Just make sure that Q1 is PNP and Q2 is NPN. Similarly, virtually any silicon diode rated 25 PIV or higher can be used for diode D1.

No power switch is provided because the converter



THIS PHOTO SHOWS how a small stack of washers can be used as a standoff when mounting transformer T1. The standoff is needed to prevent the transformer from shorting out the traces that run underneath it. Any other type of standoff can also be used.

PARTS LIST

RESISTORS

R1—4700 ohms, 1/2-watt, 10%
R2, R4—1000 ohms, 1/2-watt, 10%
R3—300 ohms, 1/2-watt, 10%

CAPACITORS

C1—1000- μ F/12VDC electrolytic
C2—0.1- μ F Mylar

SEMICONDUCTORS

Q1—PNP transistor, 2N2907 or equal
Q2—NPN transistor, 2N2222A or equal
IC1—Opto-coupler, 4N25 or 4N33 or equal
BR1—25 PIV diode bridge (non-DIP)
D1—Small signal diode, 1N456A or equal
LED1—Any small LED

OTHER COMPONENTS

T1—6.3 volt, 300-mA filament transformer, Radio Shack 273-1384 or equal
Terminal strip, cabinet, printed-circuit materials

should be switched on and off by the same switch that controls the line voltage to the TTY.

Using the converter

Once the converter is connected and the RS232 port is programmed for 110 Baud and 2 stop bits, you simply forget about the converter. Just use the computer normally, using the appropriate PRINT, LIST, or LPRINT, LLIST commands, and the TTY will do the rest with its familiar *ricky-ticky* sound. Though the TTY prints only in CAPS (no lower case), so do many other printers—even models priced from about \$1000 and up. In fact, though slow and noisy, the TTY has major advantage over most other all-caps printers, its characters are *fully formed*, as contrasted to matrix printer characters that are created by closely-spaced dots.



COMPRESSO-AMP

Maximize your modulation with this audio compression amplifier.

HERB FRIEDMAN

ALTHOUGH DYNAMIC RANGE IS A MAJOR ATTRIBUTE OF high fidelity sound, it is the last characteristic one wants for maximum recording or transmission of intelligence. For example, consider the tape recording of a conference: if one speaker shouts while another mumbles, much intelligence will be lost during playback if the recording is made with full dynamic range. If the playback volume is adjusted for a comfortable listening level for the speakers with loud voices, the *mumblers* will barely be heard. Conversely, if the playback volume is adjusted for comfortable hearing of the mumbler, the shouters will border on the threshold of

pain. What is really needed is something that equalizes the shouters and the mumbler so they are both recorded (and reproduced) at approximately the same volume level.

Another place we don't need wide dynamic range is public address (PA). If the microphone gain is already bordering on the edge of feedback (howling), a speaker simply raising his voice can push the system "over the edge" into howling (caused by voice peaks). On the other hand, if the speaker lowers his voice it can easily fall below the level of listener comprehension. Again, what is needed is not dynamic range but almost no

dynamic range; neither raising nor lowering the voice should have an appreciable effect on the volume level from the PA loud speakers or horns.

And, of course, let's not overlook radio communications: ham, CB, or commercial. Maximum intelligence is conveyed when the transmitter is 100% modulated. Unfortunately, because of the voice's normal characteristics "unprocessed" modulation has an *average modulation depth* of approximately 30% and less. But if the normal dynamic range is compressed so that both weak and loud voice levels are processed to a constant level the transmitter will be 100% modulated most of the time—thereby providing the maximum "talk power."

Note that in all of the preceding examples, what is needed is some form of compression device that establishes a "ceiling" or maximum-value audio level, and then automatically provides enough gain to amplify weak sounds to the ceiling level. At the same time, it must also automatically reduce gain so that loud sounds cannot exceed the ceiling. Either way, what comes out is a constant voice level that is all "talk power."

A device that provides the type of compression usually needed, and that can be built for a rather reasonable cost is the Compresso-Amp shown in Fig. 1. Though it uses only two active components—an operational amplifier IC and a somewhat unusual FET—it provides approximately 1.5 volts output from micro-



PENCIL POINTS TO THE SPACE available for two extra 500- μ F filter capacitors. They are used only if you cannot obtain 1000- μ F electrolytics.

phone level and has a tapered compression ratio that increases the gain quasi-logarithmically as the input level is reduced (voice is lowered). In practical terms this produces a 1.5-volt output from both a shout and a whisper. A fast attack time also provides moderate peak limiting (not clipping) that establishes an almost flat ceiling for the output level.

For maximum effectiveness in using the Compresso-Amp you must keep in mind certain characteristics of heavy compression that work at cross purposes. First

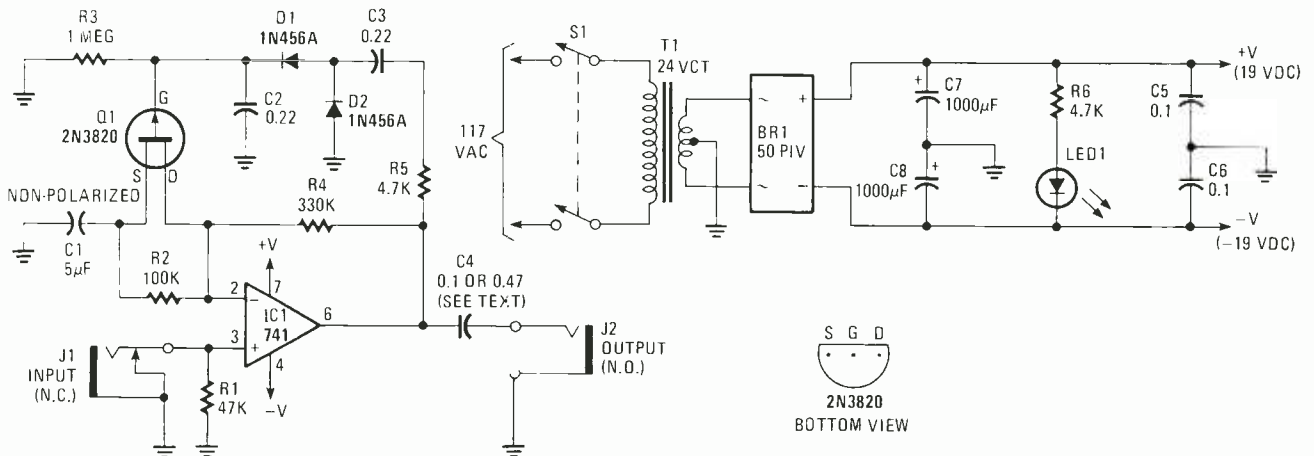


FIG. 1—COMPLETE SCHEMATIC OF THE COMPRESSO-AMP. The circuit is simple, but really does the job.

PARTS LIST

RESISTORS

- 1/4 or 1/2 watt, 10% or 5%
- R1—47,000 ohms
- R2—100,000 ohms
- R3—1 megohm
- R4—330,000 ohms
- R5, R6—4,700 ohms

CAPACITORS

- 20 volts or higher
- C1—4.7 or 5 μ F non-polarized
- C2, C3—0.22 μ F
- C4—0.1 or 0.47 μ F, see text
- C5, C6—0.1 μ F
- C7, C8—1000 μ F, see text

SEMICONDUCTORS

- IC1—741 op-amp
 - Q1—2N3820 FET
 - LED1—Any 20 mA LED
 - BR1—50 PIV bridge rectifier, DIP-type, Radio Shack 276-1161 or equal
 - D1, D2—Silicon diode 1N456A, see text
 - J1—Phone jack, closed circuit
 - J2—Phone jack, open circuit
 - S1—DPST or SPST switch
 - T1—24V. C.T./100 mA with PC leads
- Cabinet, printed circuit materials, etc.

(T1 (\$4.95) and Q1 (\$2) are available from Custom Components, Box 153, Malverne, NY 11565. Add \$2 postage and handling per total order. New York State residents must add sales tax. Canada add \$1.)

among them is that the amplifier cannot discriminate against unwanted sounds: when it amplifies weak sounds it amplifies all of them, whether desired or not. Among the weakest sounds are the higher voice frequencies that "hiss," and those that "pop:" so the compressor output will be excessively sibilant: The *hissy* voice sounds will literally scream.

Also, pops formed by the lips will sound like gunshots if the mike is too close; you can't make like a rock star and rest the mike on your tonsils when using a compressor.

Both problems are reduced simply by using an inexpensive mike at least one foot away from your mouth (the professional working distance). The inexpensive mike has reduced sensitivity to high frequencies so the hissy sibilant sounds will be attenuated before they get to the compressor. The "long" working distance to the mike reduces the sensitivity to "pop."

How it works

Resistor R1 sets the load impedance for the microphone, which can be any output impedance up to 50,000 ohms. If a crystal or ceramic mike is used the excessive loading caused by the 47,000-ohm resistance R1 will result in severe attenuation of the low (bass) frequencies. (Though it's possible someone will prefer, or have need for, an attenuated bass response.)

The gain of operational amplifier IC1 is determined by the ratio of R4 to the impedance represented by R2 in parallel with that of Q1. Q1 is a P-channel FET with a drain to source impedance of approximately 10K ohms when the gate voltage is zero. Q1's 10K impedance in parallel with the 100K or R2 is essentially 10K, hence, the amplifier gain "at rest" is 330K/10K, or approximately 30 dB. As the microphone's input level is increased, the op-amp's output at pin No. 6 reaches the "breakover" voltage of diodes D1 and D2. Part of the output signal is rectified by the diodes, filtered, and applied as a DC control voltage to Q1's gate.

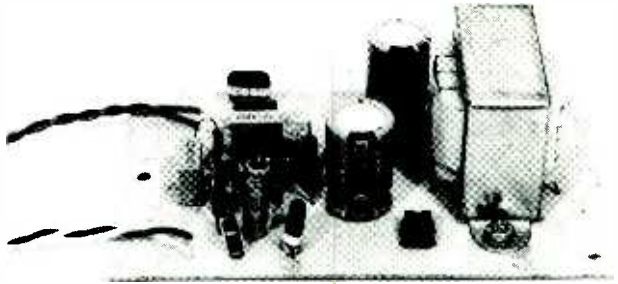
At higher volume levels the gate control voltage causes Q1 to appear as an impedance approaching 1 megohm. The impedance represented by R2/Q1 is now approximately 100K ohms, so the amplifier's gain is 330K/100K, or about 10 dB. (The greater the applied input signal the smaller the amplifier's gain.) The time constants of the control voltage circuit—R5, R3, C2, C3—are selected to give a fast attack and moderate release so the voice level does not pop up and down.

Because of the inherent frequency compensation characteristics of the 741 op-amp, the higher the gain the greater the high-frequency attenuation between approximately 8000 Hz and 20,000 Hz. At the very low voice levels the highs vanish, but so does any internal op-amp hiss, which more or less prevents the "pumping" background hiss characteristic of most heavy compressors. If, for some reason, you don't want the upper highs attenuated at low volume levels substitute a wideband (non-compensated) op-amp for IC1, but be certain to apply whatever external frequency compensation is specifically suggested for the op-amp used to prevent instability (high frequency oscillation).

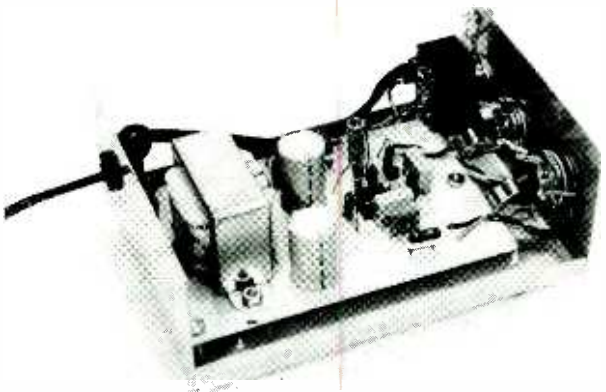
The entire circuit is assembled on a 3 × 4¼-inch printed-circuit board (PCB) that fits nicely into a vented 4 × 2¾ × 6-inch metal cabinet. All components are standard, though T1 and Q1 are not the easiest to lo-

cate. Though any 24-volt center-tapped transformer can be used for T1, most are rated more than 1 ampere, and are somewhat large. They will probably require modifying the layout of the PCB and might also require a larger cabinet. A 100-mA rated transformer with PCB leads will fit both the layout and the cabinet. If you can't locate one locally, or have trouble finding the specified transistor for Q1, they can be ordered from the source given in the parts list.

Be careful with Q1. There is no direct substitute regardless what any substitution manual might claim. *If you can't obtain the specified Q1 don't build the project; it probably won't work correctly with a substitute.*



THE COMPLETED PCB. Note that all resistors and capacitors are end mounted. The PCB foil layout will not accommodate components mounted "flat" on the board.



THE PCB FITS NICELY into the cabinet specified in the text. Its mounting holes clear the rubber feet of the cabinet. If you substitute a different cabinet make certain there is clearance from the top of T1 to the cabinet's cover.

Diodes D1 and D2 are silicon small-signal. Do not substitute germanium type diodes, though you can substitute small signal silicon diodes such as the 1N914 or equivalent. The variation in performance will be insignificant.

Any eight-pin 741 op-amp can be used for IC1. If you substitute an uncompensated op-amp for IC1 make certain you added the required connections for the external frequency compensation components to the PCB foil layout.

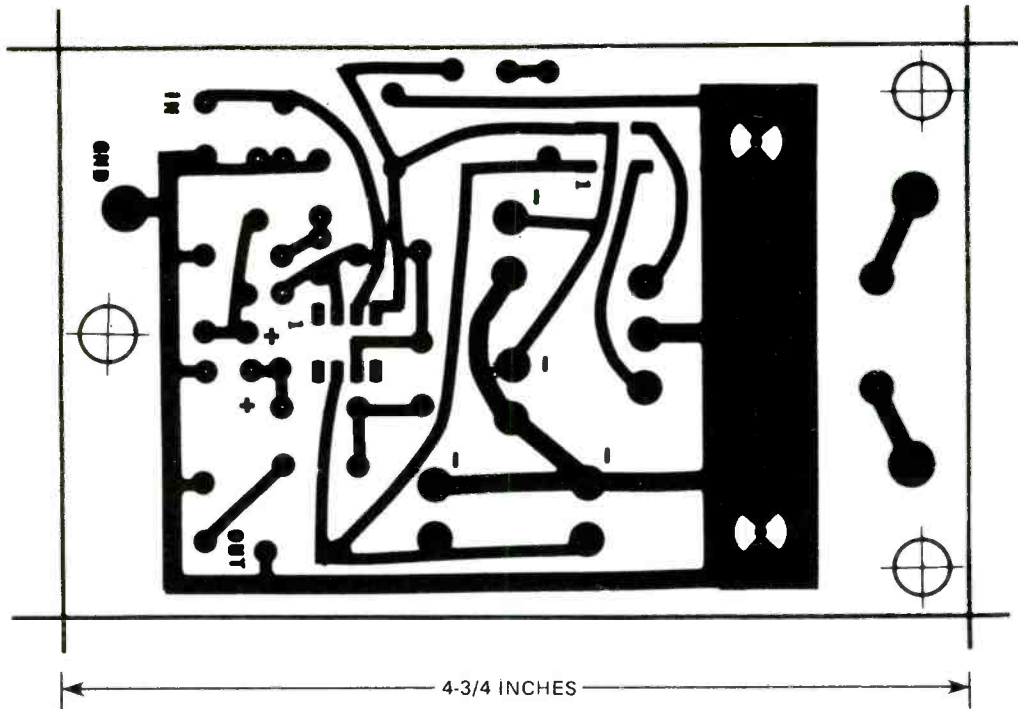


FIG. 2—FULL SIZE FOIL PATTERN makes the circuit board for this project a cinch to build.

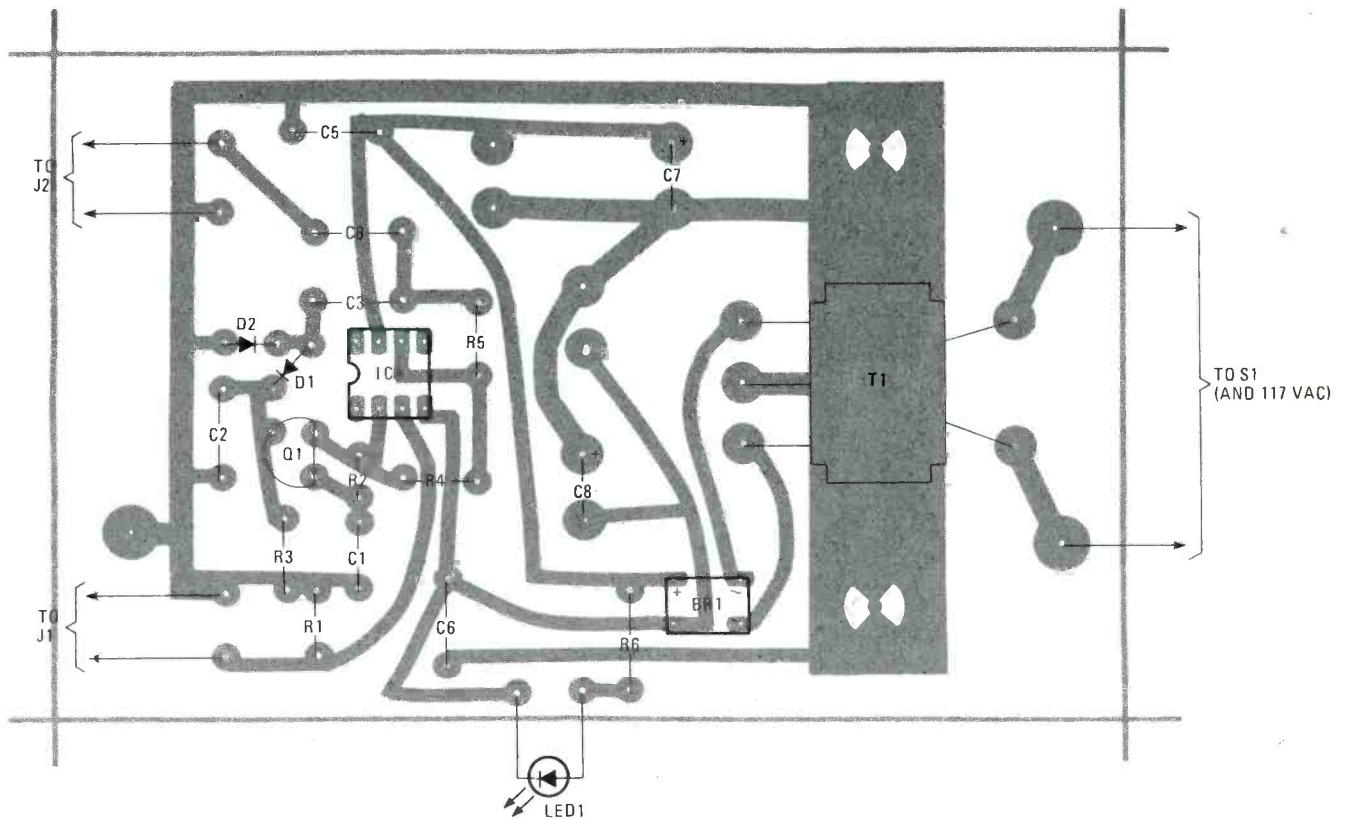


FIG. 3—PARTS LAYOUT DIAGRAM for the Compresso-Amp. Make sure you watch polarity of the electrolytics.

There are only two filter capacitors shown in the schematic even though there are mounting locations for four capacitors on the PCB. Filter capacitors C7 and C8 are rated at 1000 μF . Unfortunately, this value is not always available. The 500- μF electrolytic, however, is a more or less standard stock item so the PCB

layout provides for parallel-connected 500- μF capacitors. If you can locate 1000- μF capacitors, install only one for each side of the bi-polar power supply—make certain there is a capacitor for both the positive and negative "rails." If you can't get 1000- μF capacitors fill up all four positions with 500- μF capacitors.

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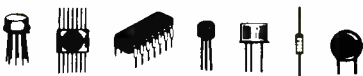
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All electrolytic filter capacitors face the same direction, that is, their negative leads all face the same edge of the PCB. If you look at the four capacitors and one or more negative lead marks aren't lined up you have made an error in installation: fix it before you apply power to T1.

Capacitor C1 must be a *non-polarized* electrolytic. Either a 4.7 or 5- μ F type can be used. Do not substitute an electrolytic, unless it's a pair connected "back-to-back."

Capacitor C4 should be 0.1- μ F if the Compresso-Amp will be connected to loads of 50K ohms or greater. Use a 0.47- μ F capacitor for C4 if the load will be less than 50K.

Any 20-mA LED can be used as the power indicator. But watch polarity when you hook it up.

Input jack J1 is a closed-circuit type that grounds the "tip" connection when the microphone plug is withdrawn. It prevents open-circuit "hum" from being fed through the system when the mike is disconnected. Output jack J2 is a conventional open circuit phone jack.

Normally, the volume level will be controlled by the equipment that follows the Compresso-Amp. If you want some form of gain control on the compressor itself, install a 10K to 50K audio-taper potentiometer after C4. Do not replace input load R1 with a volume



TOP VIEW of the completed circuit board. The circuit may be simple, but it gets the job done.

control: the mike must enter IC1 at maximum level.

To prevent the PCB's foils from shorting to the cabinet, place a 1/4-inch standoff, or a stack of washers, between the PCB and the cabinet at each mounting screw.

Special modification

An all *talk power* signal is good for brief transmissions. For extended periods of time, say for an address through a PA system, continuously high *average voice power* can tire the listener, much in the manner that TV commercials—which all use speech processing—get subconsciously tuned-out after two or more have assaulted the ear. Nature simply didn't intend the ear to experience continuous constant level (talk-powered) average signal power. You can take some of the compression off the lower volume levels by reducing the value of R4 to 100K ohms. This modification will generally not be required except when the Compresso-Amp is used for PA; and even then you should try both values to determine which is the most effective for your particular use.

SP

ELECTRONIC DRUMS



***Build this up-to-date version on one of
Man's first musical instruments.***

HERB FRIEDMAN

THERE WAS A TIME WHEN A DRUM WAS A HOLLOWED log, a tightly stretched skin, or even a 55-gallon steel drum. Today, many a rock band, or even a "one-man band," gets special drum effects the same way it makes musical sounds, with an electronic synthesizer—a device that uses electronics to create the sounds of real instruments, or "electronic sounds." It's not unusual to see a small "square" mounted on a stand adjacent to the keyboards; when struck with one or more fingers, it produces the sound of a bass, conga, or bongo drum through the keyboard amplifier or an auxillary amplifier.

Though the prices for many "single drum" synthesizers are based on the "all that the traffic will bear" school of marketing and carry price tags well in excess of \$100, you probably already have most of the components you need to build a drum synthesizer in your junk box. Even starting from scratch, an Electronic Drum such as the one in the photographs shouldn't cost you much more than \$10, with most of the cost going into the cabinet and power switch.

The Electronic Drums project described here provides one or two drum sounds when you touch a finger to a foil *touch plate*. To provide some dynamic range—thereby avoiding the boredom of a constant volume level—each touch plate is adjacent to a *muting pad*

that sharply reduces the sound of the drum if the muting pad is touched at the same time as the drum (or music) plate.

You determine the actual sound at the time of construction. You can build in the sound of bongo, conga, or even bass drums, though electronic bass usually needs a "music" or "bass" amplifier and a 15-inch *music instrument speaker*, or 15-inch music woofer.

How it works

The sound is generated by a "bridged-T" oscillator that is adjusted just below the threshold of oscillation. In this Electronic Drums project there are two sound generators, Q1 and Q2. Q3 is a straight amplifier.

Using Q1 as a guide, the sound effect, or quality, is determined by T-network R4/R5/C3, and T-network C1/C2/R8. Trimmer resistor R8 is adjusted so that the circuit is just on the verge of oscillation. Usually, R8 is advanced until the circuit oscillates and is then backed off slowly until oscillation ceases.

When your finger contacts the touch plate, the circuit is literally *kicked* into oscillation, producing a loud sound. If another finger is grounded, or touching a ground touch pad, body resistance is shunted across R8, pushing Q1 into oscillation. It's just at the threshold so the oscillations are of low level.

If your finger contacts the touch plate with no path to ground, the capacitive voltage of the body from the electric circuits of the home—the thing that causes "hum" when you touch an open microphone amplifier input—triggers the oscillations at full volume. If the finger simply strikes the touch plate and is instantly removed the circuit is triggered into oscillation and then immediately starts to decay, producing the "musical sound" shown in the scope photos.

The photographs of the oscilloscope screen show how the oscillator triggers at full volume when the touch plate is struck, and then decays at an almost fixed rate. To the ear this sounds as "bonk" or "boom," depending on the frequency.

The basic, or reference sound, is the "bonk" produced by the component values for Q1—it is the "bonk" of a small bongo drum. Q2's values can be modified for whatever relationship you want for the small drum. The values shown for Q2 produce the lower pitched bongo drum. For a deep bass, or conga drum, substitute 0.05 μF capacitors for C4 and C5, and a 0.1 μF capacitor for C6. To get intermediate tonal values use values for C4 and C5 that are between 0.005 μF and 0.05 μF .

PARTS LIST

RESISTORS

1/2 watt, 5%

R1, R2—100,000 ohms

R3—47,000 ohms

R4, R5—47,000 ohms, matched pair, see text

R6, R7—47,000 ohms, matched pair, see text

R8, R9—25,000 or 50,000 ohms, trimmer resistor

R10, R11—20,000 ohms

R12—470,000 ohms

CAPACITORS

rated at least 10 VDC

C1, C2—0.005 μF matched pair, see text

C3—0.01 μF , see text

C4, C5—0.01 μF matched pair, see text

C6—0.02 μF , see text

C7—1 μF non-polarized, see text

C8—0.1 to 2 μF depending on load, see schematic

SEMICONDUCTORS

Q1, Q2—NPN transistor, 2N5172 or equal, see text

Q3—NPN transistor, 2N3394 or equal, see text

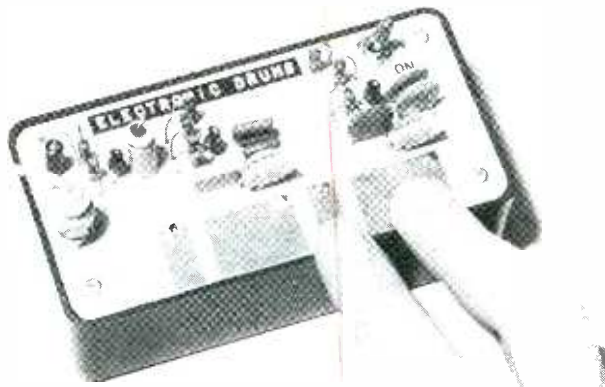
MISCELLANEOUS

B1—9-volt battery, type 216 or equal

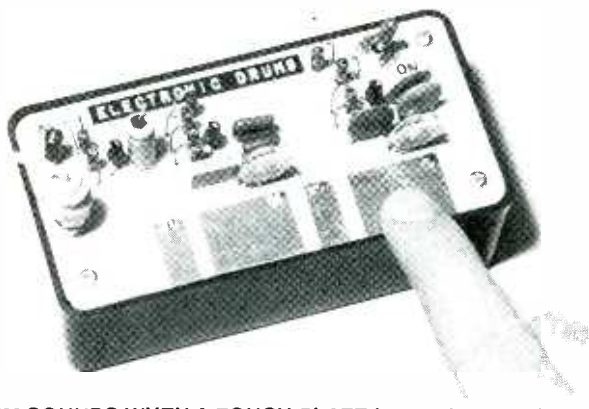
S1—SPST switch

J1—Phono jack

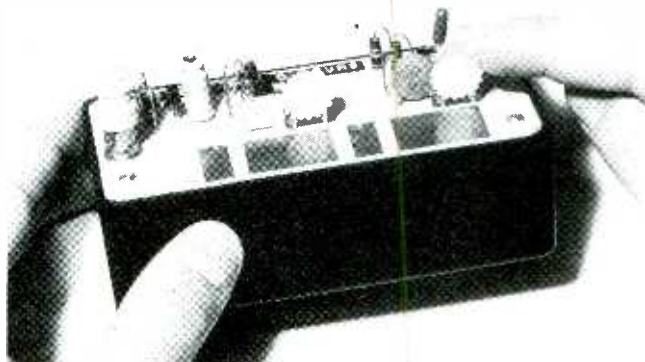
Printed circuit materials, cabinet, battery terminals



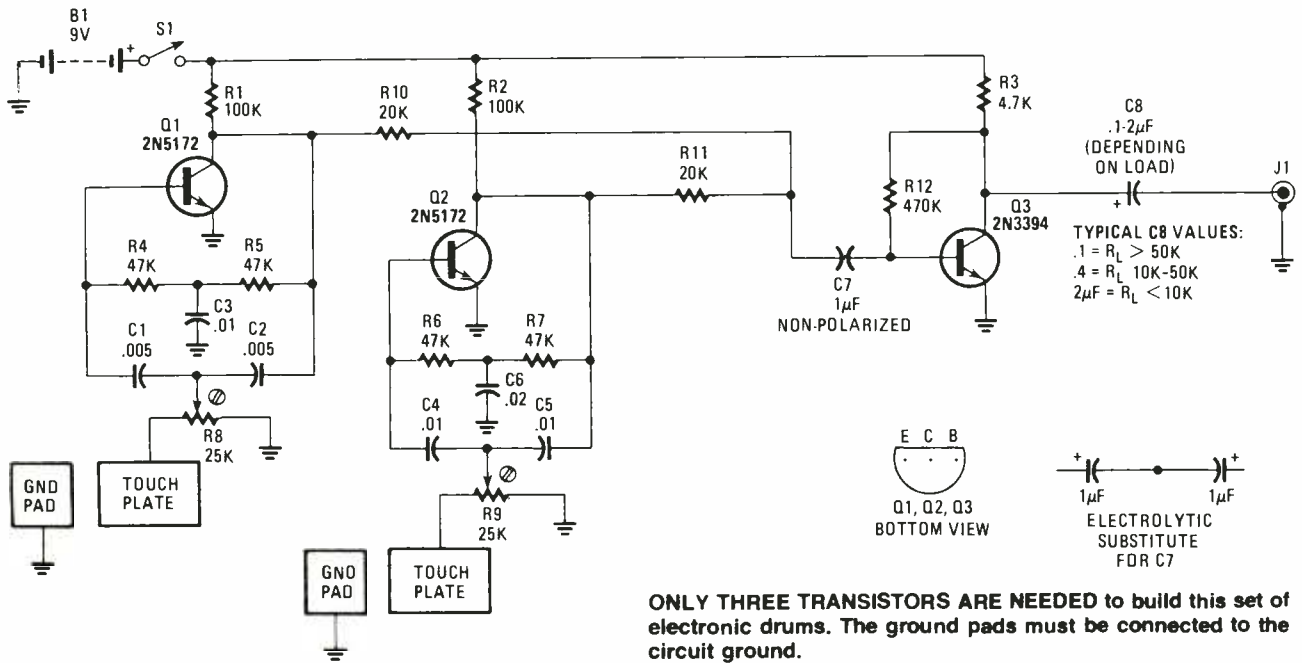
TOUCHING A GROUND PAD while striking a touch-plate produces a low-level sound. Sliding the finger rapidly on and off the ground pad while striking the touch-plate will create various slide effects. The effects depend on the setting of the oscillator adjustment.



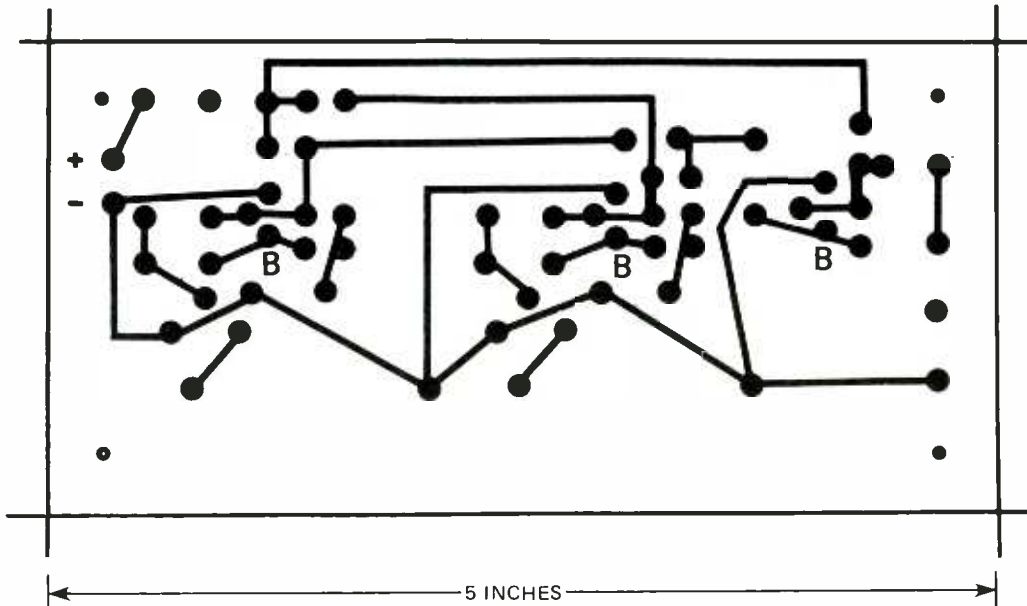
DRUM SOUNDS WHEN A TOUCH-PLATE is struck with a finger.



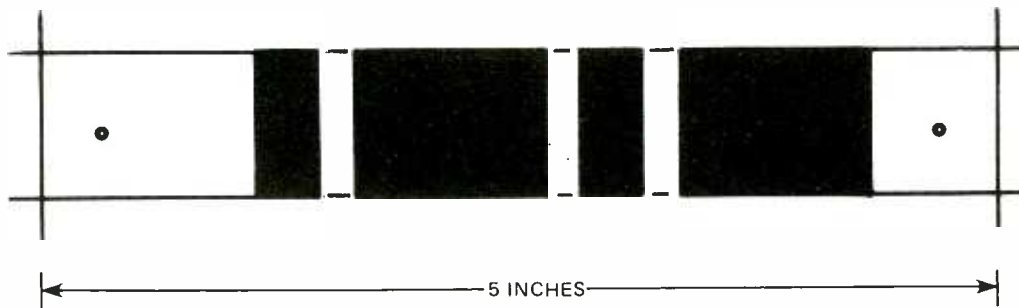
EACH OSCILLATOR IS ADJUSTED with its individual trimmer resistor. Advance the trimmer until the circuit oscillates; then back it off very slowly until the oscillation just ceases. If backed off too far the sound will not be triggered when the touch-plate is struck.



ONLY THREE TRANSISTORS ARE NEEDED to build this set of electronic drums. The ground pads must be connected to the circuit ground.



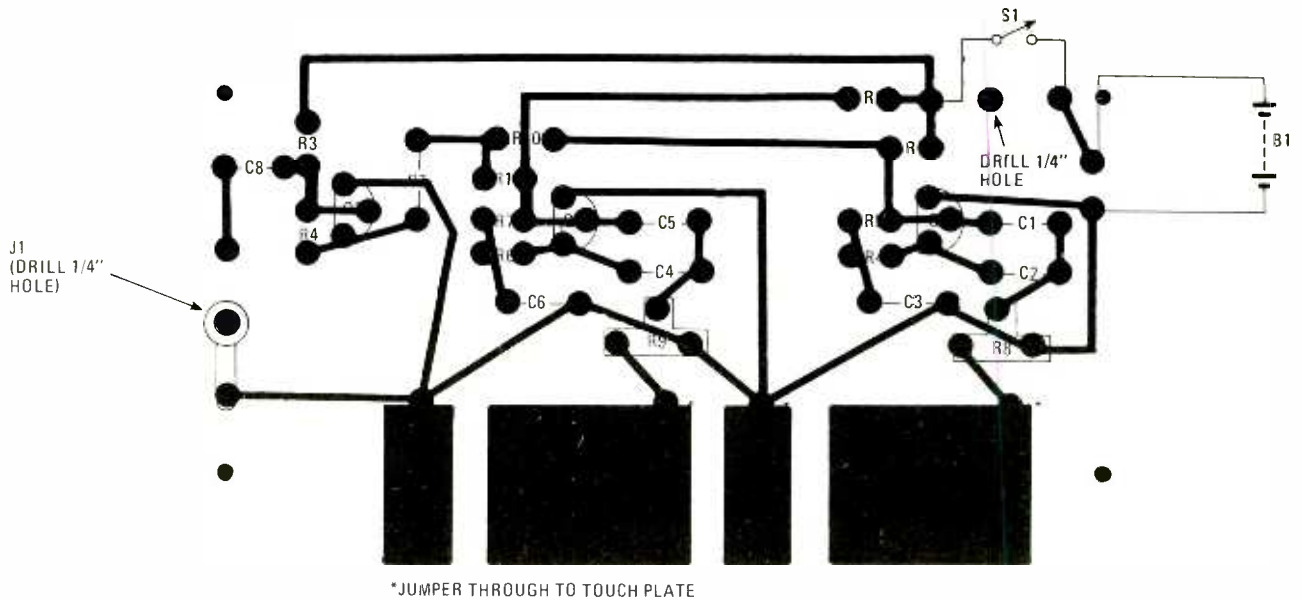
FOIL PATTERN OF THE MAIN CIRCUIT BOARD is shown full size.



FOIL PATTERN FOR THE TOUCH PLATES. You can vary this pattern as desired.

Do not use values larger than $0.05 \mu F$, because the bass will be so low that hardly anything will be heard, assuming you have an amplifier and speaker that can reproduce cellar sounds. In all instances, make the value of C6 twice the value of C4 or C5.

Any values within the indicated range can be used as long as individual pairs are matched to a reasonable degree—you don't need laboratory-standard tolerance. For example, R4 and R5 can be within 20% of 47K, but they must be almost equal in value. Taking a handful



PARTS LAYOUT DIAGRAM is a must for the constructor. Follow it closely.

of resistors and matching them using an ordinary shop ohmmeter is fine—you don't need 1% resistors.

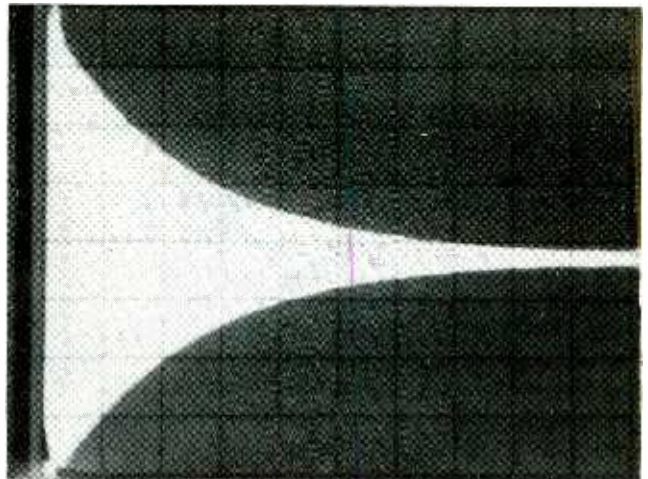
Similarly, C1 must be matched to C2—borrow a capacitance meter or bridge from someone. Sort out a handful of capacitors all with the same marked value and select any two that have the same measured value. For example, you might wind up with two capacitors marked $0.005 \mu\text{F}$ that are actually $0.007 \mu\text{F}$ or $0.004 \mu\text{F}$. You don't care what the exact values are, as long as they are the same. Whatever the value of C1 and C2, C3 must equal or be close to the combined value (straight addition) of C1 and C2.

What happens if the component-pairs don't match? Either the pair will be so far apart that the oscillator won't start when the touch plate is struck, or it will start but the adjustment of R8 will be so finicky as to be almost unusable. The more precise the match the greater the range of R8's adjustment, which has some control over the final sound quality.

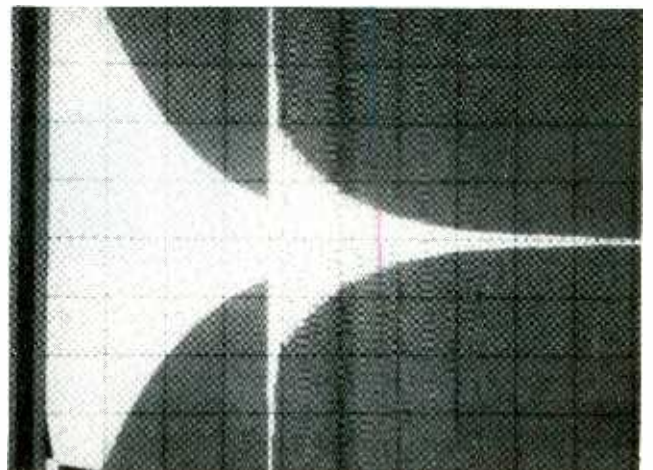
Construction isn't difficult.

The unit shown is built on a $27/16 \times 415/16$ -inch printed-circuit board (PCB) that also serves as the cover for a Radio Shack cabinet. The cabinets come with either square or rounded corners. If the box you obtain has rounded corners, simply file down the PCB corners to fit. The touch plates are made from a strip of the same PCB material. You can modify either PCB template to accommodate your selection of components or touch plate configuration.

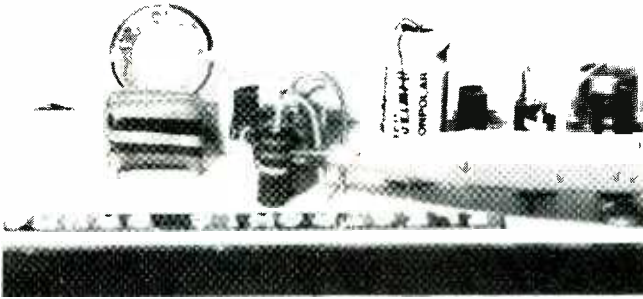
Connect the touch plate foils into the circuit with wires passing through both boards. Drill the necessary holes before installing any components. Line up the touch plate PCB with the main PCB and secure it in place with strips of tape. Then drill through from the foil side of the main PCB. Make all PCB holes, except those for power switch S1 and output jack J1, with a No. 55 or No. 56 drill bit. (Some of the trimmer resistors (R8/R9) on the surplus market may require a drill slightly larger than a No. 55. Test the trimmer mount-



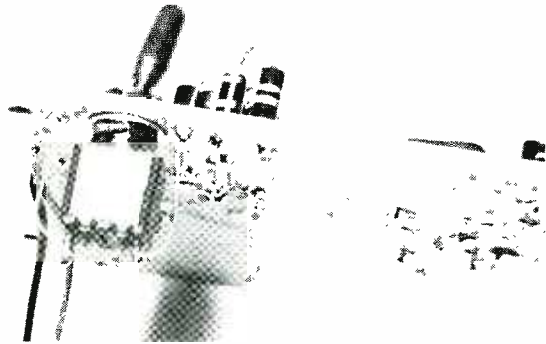
THE SOUND OF A DRUM is really a decaying oscillation, as shown by this scope picture. The maximum oscillation at the left occurs when the touch-plate is struck. Almost instantly the "tone" starts to decay. In both illustrations the horizontal "time" is 0.2 seconds/div.



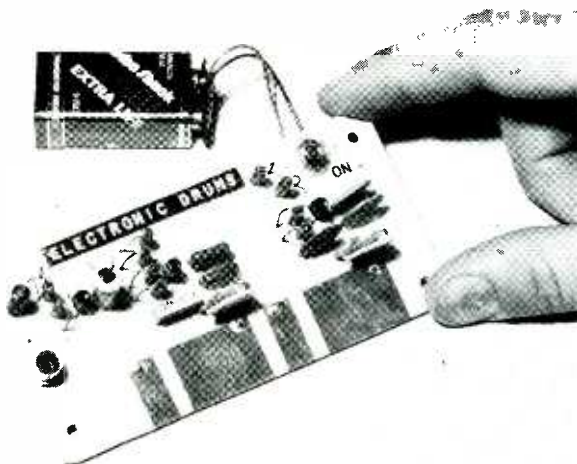
THIS IS HOW TWO OVERLAPPING DRUM SOUNDS APPEAR. The sharp rise approximately 0.8 second after the first drum sound is caused by striking the touch-plate for the second drum. The first drum is actually decaying behind the second drum.



THE RESISTORS MUST BE MOUNTED ON END because the foil layout won't accommodate a flat mounting. You can change the layout if desired.



THE POWER SWITCH IS CONNECTED THROUGH WIRES tack-soldered to the foils. An easy way to do it is to slide the wire through. Cut it off flush with the top of the board and then back it out very slightly below the top surface before soldering.



THE ENTIRE CIRCUIT IS ASSEMBLED ON A PCB that doubles as the cabinet cover. The touch plate is a separate PCB on top of the main PCB and connected by wires that run through both boards.

ing before you install any components on the PCB.)

Transistors Q1 and Q2 can be almost any small-signal NPN with an h_{FE} in the neighborhood of 200 to 300. On the other hand, the h_{FE} of Q3 should be 30 to 50; do not substitute a moderate or high gain transistor for Q3.

To avoid possible problems caused by component tolerances, capacitor C7 should be the non-polarized type specified in the parts list. You can, however, substitute two back-to-back electrolytics; that is, two 1- μ F capacitors with their negative leads connected together, and installed into the circuit by the two positive connections.

Can you add a third drum effect by expanding the PCB? YES! Connect its output through a 27K resistor to the R11/C7 junction, and change R10 and R11 to any value between 27K to 33K. You can use several drum oscillators as long as the parallel resistance of the output connection resistors—R10, R11, etc.—is approximately 10K to 12K.

Final adjustments

The output of the Electronic Drum is about 0.5 volt so connect J1 to a hi-fi amplifier's auxiliary (AUX) input, or the "line" or instrument input of an instrument amplifier. **Don't use the microphone input.** It will probably be overloaded by the drum signals.

Set trimmer resistors R8 and R9 full counter-clockwise when looking at the front of the adjusting "wheel." (The trimmer's wiper will be at "ground.") Turn the power *on* with S1 and slowly advance R8 until the circuit breaks into oscillation and you hear the tone from the speaker. Then back off the trimmer adjustment until the oscillation just ceases. Don't back off too far or the oscillator won't start when the touch plate is struck. Do the same with oscillator Q2.

The drums should sound cleanly when the touch plate is struck. If the sound "warbles", or is hard to set, there is probably a component-pair mismatch.

Generate the sound only by *striking* the touch plate. Don't maintain finger contact as this will produce a "hum" that is heard as the drum sound decays. A quick strike, as you would do when playing a real drum, is what's required.

To produce a lower volume level, keep one finger in contact with a ground pad, or strike both a ground and drum touch plate at the same time. An interesting *roll* effect can be generated by rapidly shifting the finger back and forth across the adjacent ground and drum pads. Slight overall sound "triggering" variations can be attained by making a small adjustment to the trimmer resistors. **SP**

MOTOR SPEED CONTROLLER

CONVENTION SHAFT-SPEED REGULATION OF SMALL- and medium-torque DC motors used in tape recorders, automotive and portable cassette players, movie projectors, phonographs, light electronic equipment, etc., is most often regulated by negative impedance control, or linear (DC) control of a tachometer feedback voltage. Both methods have relatively poor temperature stability and supply-voltage regulation. The $\mu A7391$ and $\mu A7392$ monolithic integrated motor-speed controllers, designed to overcome those problems, operate as closed loop, AC tachometer feedback, duty-cycle controlled switching regulators. These systems offer advantages that include:

1. Superior power-supply efficiency with increasing supply voltage, compared to equivalent DC-controlled systems. This results in longer battery life in portable equipment.
2. Speed regulation independent of tachometer signal shape and amplitude as long as the terminated tachometer voltage exceeds 100-mV peak to peak. Since the system depends only on tachometer frequency, this simplifies circuit design and lowers the cost of the tachometer generator.
3. Excellent speed stability over all combinations of specified supply voltages and ambient temperatures. Speed error is typically less than 1% for most applications.

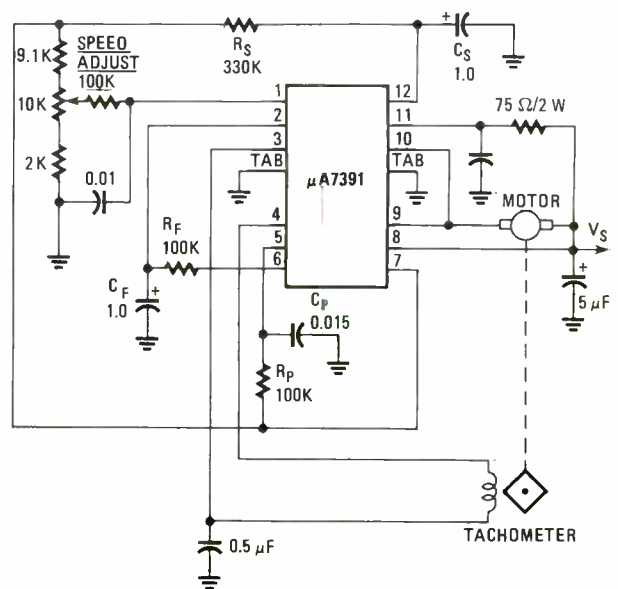
The basic difference between the two versions, as shown in Table 1, is the lower output current of the $\mu A7392$, the lower-cost model. Both regulators are versatile control elements, even in circuits that require

much greater drive currents and voltages than the $\mu A7391$ or $\mu A7392$ can provide. Additional power circuitry can be connected in order to act as the "muscle" with the regulators performing as the "brains" of the system.

Capstan drive motor control

One good use of the $\mu A7391/2$ is for capstan drive motor control in tape recorders. Figures 1 and 2 show two such applications, along with performance data.

Figure 1 is for an automobile cartridge tape recorder using a type 9100 Telex DC-motor or equivalent with a



PERFORMANCE WITH AN 8-TRACK CARTRIDGE AUTOMOBILE TAPE RECORDER, TYPE 9100 TELEX DC MOTOR OR EQUIVALENT WITH A 16-POLE TACHOMETER WINDING.

NOMINAL MOTOR SPEED	3300 RPM
TACHOMETER FREQUENCY	440 Hz
SUPPLY CURRENT - $V_S = 14$ V	200 mA
SPEED REGULATION (a) V_S 10-16 V	1%
(b) T_A 0-50° C	< 1%
(c) NO LOAD - 2 OZ.-IN.	2%
MIN. SUPPLY VOLTAGE OPERATION ($\mu A7391$)	7 V
STALL CURRENT @ $V_S = 14$ V	2.4 A

FIG. 1—MOTOR CONTROL CIRCUIT for an 8-track cartridge tape player.

TABLE 1—SUMMARY OF OUTPUT DRIVE SPECIFICATION

Controller	Max Motor Drive Output Saturation Voltage	Max Peak Motor Drive Output Current	Max Repetitive Motor Drive Current
$\mu A7391$	1.1 V (at motor current = 2 A)	3.5 A	2.0 A
$\mu A7392$	1.6 V (at motor current = 0.3 A)	1.0 A	0.3 A

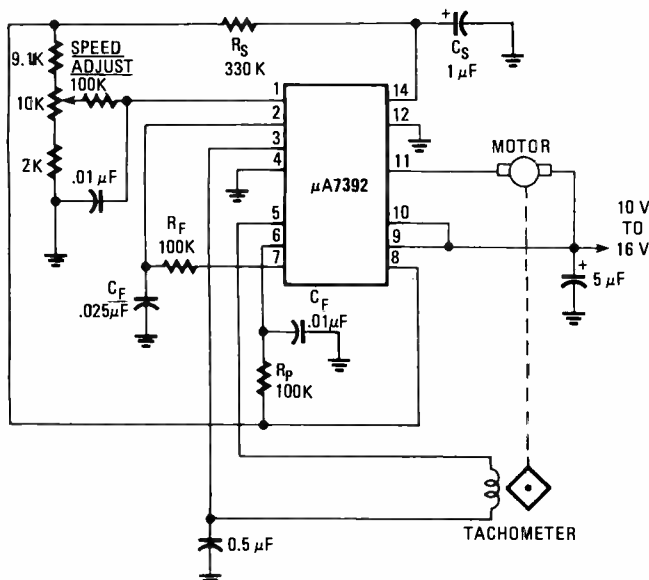
Reprinted from *Progress*, Jan/Feb 1979, with permission of Fairchild Camera & Instrument Corp., Mountain View, CA.

Here are two IC's designed to control small DC motors along with some circuit ideas for you to try.

J. D. FREEMAN

16-pole tachometer winding, that gives a control frequency of eight times the shaft speed. The $\mu A7391$ is preferred in this application because the required stall current is 2.4 amps. Performance data is shown with respect to a nominal load torque of 0.2 oz./in. This corresponds to a supply current of 200 mA. Control accuracy is 2% with an induced load-torque variation of no load to 2.0 oz./in. This is better than the worst-case torque required for this system.

The application in Fig. 2 is a cassette tape recorder using a Philips motor with an integral 72-pole tachometer winding. The stall current is 650 mA and running current is only 100 mA, making the $\mu A7392$ a more



PERFORMANCE USING A CASSETTE TAPE RECORDER. THE MOTOR IS A PHILIPS WITH A 72-POLE TACHOMETER.

NOMINAL MOTOR SPEED	2400 RPM
TACHOMETER FREQUENCY	1440 Hz
SUPPLY CURRENT $V_S = +14$ V	100 mA
SPEED REGULATION (a) V_S 10-16 V	0.6%
(b) T_A 0-50°C	< 1%
(c) NO LOAD - FULL LOAD	1%
MIN SUPPLY VOLTAGE OPERATION	6 V
STALL CURRENT, $V_S = 14$ V	650 mA

FIG. 2—MOTOR CONTROL CIRCUIT for a cassette tape recorder.

economical choice. Because of the lower t_m (mechanical time constant) of this motor, the recorder operating frequency was set at 1440 Hz, allowing an $R_F C_F$ (low-pass filter time constant) of only 2.5 RMS while delivering a control accuracy of 1% with load variations.

When an application requires a motor in the 18- to 24-V range, the $\mu A7392$ can be used as long as stall current and running current demands do not exceed 1 amp and 300 mA, respectively. Figure 3 shows the clamp diode and supply connections for operating 10- to 24-V motors. The on-chip overvoltage protection does not function in this application.

For motors requiring applied voltages greater than 24 V and/or currents larger than the $\mu A7391/2$ can accommodate, an external power transistor can be connected to the controller, as in Fig. 4. The lower-cost $\mu A7392$ is used for two reasons:

1. The full output capability of the $\mu A7391$ would not usually be needed, except in cases where the base drive to the external transistor exceeds the capabilities of the $\mu A7392$.
2. A power NPN transistor is used to supply-reference the motor and the $\mu A7392$ does not require an inverter stage following the output for this connection.

Here also, unless the motor supply is the same supply used for the rest of the regulator, the overvoltage protection will not protect the motor.

The peak current $I_{C(pk)}$ required for the external transistor is equal to the motor stall current. If a single transistor with the required capability is not available, several transistors can be paralleled, as shown in Fig. 4. Equalizing resistor R_S is connected to each

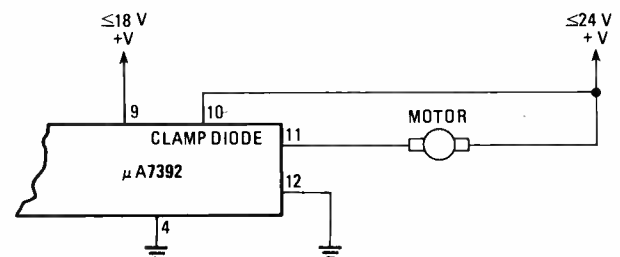


FIG. 3—IC OPERATION with a high-voltage (18 to 24 volt) motor.

emitter to insure equal sharing of motor current (I_M), and to current-limit protect the transistors under stall conditions. Under start conditions, power dissipation in the transistors decreases rapidly on an exponential decay vs. time curve, as the motor comes up to speed. The average dissipation in the transistors under steady-state conditions is $V_{CE(SAT)} \times I_C (T_{on}/T_{period})$.

Under normal (steady-state) conditions, peak current $I_{C(pk)}$ is not reached, since the motor time constant, t_m is greater than T_{on} . At very high frequencies, switching-time losses should be taken into account. An external free-wheeling diode (D1) must be included in the circuit.

Optical tachometer

Figure 5 shows a $\mu A7391/2$ used in an optical tachometer. The light transducer is the Fairchild FPA103, light-reflection emitter/sensor array, or equivalent, and consists of a gallium arsenide light-emitting diode, along with a silicon NPN transistor. The emitted light is in the infrared region, roughly at 900 angstroms. The phototransistor responds to the reflected radiation from the diode only when the reflective object (in this case, the light wheel in Fig. 5) is in the field of view of the transistor. Maximum output current occurs with a 90% white surface at a distance of 0.05 inch from the device. The current is reduced to 1/10 of maximum when the distance from the device increases to about 0.3 inch.

The light wheel can be silkscreened with as many alternate light and dark sections as desired. The wheel shown in Fig. 5 produces a frequency eight times the motor-shaft speed.

Motor start/stop control

In data-acquisition systems, it is desirable to be able to start and stop tape drive via digital enable/disable commands. Figure 6 shows a method for doing this with the $\mu A7391$.

The TTL-compatible inverters in the circuit phase the enable/disable commands so that when a stop command is received at the input command terminal, pin 12 is grounded and Q1 is turned off. Grounding pin 12 disables the stall timer so that even if the motor off-time extends beyond the stall-timer time-out, T_{SO} (determined by $R_S C_S$), the motor starts again as soon as an enable pulse is received. Since transistor Q1 provides base drive to the output transistor, via R11, a logic "1" disable command at the input turns off Q1 and thereby stops the motor. Additional standard circuitry for dynamic or mechanical braking can also be used if it is required in a particular application.

Bidirectional motor control

Figure 7 illustrates a method of reversing motor directions for bidirectional control using a bridge circuit driven by a $\mu A7392$. Output start-currents that are as high as several amperes are quite possible with that IC.

When the motor-drive switching transistors, Q8 and Q9, are switched on, the supply is placed across the motor, causing rotation. When Q10 and Q11 are on, direction of rotation reverses. Emitter followers Q7 and Q12 drive Q9 and Q10, respectively, while Q8 and Q11 are driven directly by Q6 and Q13. This eliminates the possibility that a large saturation voltage in one of

the lower transistors (Q9 or Q10) might turn the other one on.

Transistors Q6 and Q13 are driven by direction-control transistors Q3 and Q4, respectively. Switching-voltage from the $\mu A7392$ is coupled to the bridge via Q2 and either Q3 or Q4, depending on the respective conducting states. Transistor Q4 has a reference voltage, derived from the $\mu A7392$ regulator output (pin 8), of about 2.5 volts at the base. If Q1 is off, Q3 receives base drive from R2 and Q4 is off. Thus Q2 switch current is steered by Q3 to the left channel determined by Q8 and Q9. This situation corresponds to a logic "0" voltage at the direction-control input terminal. If a logic

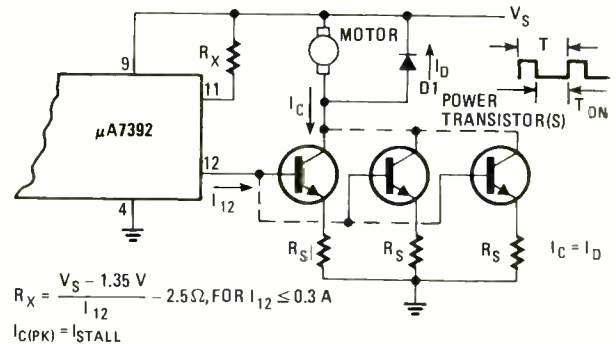


FIG. 4—AN EXTERNAL POWER TRANSISTOR is used with motors having a voltage rating greater than 24 volts.

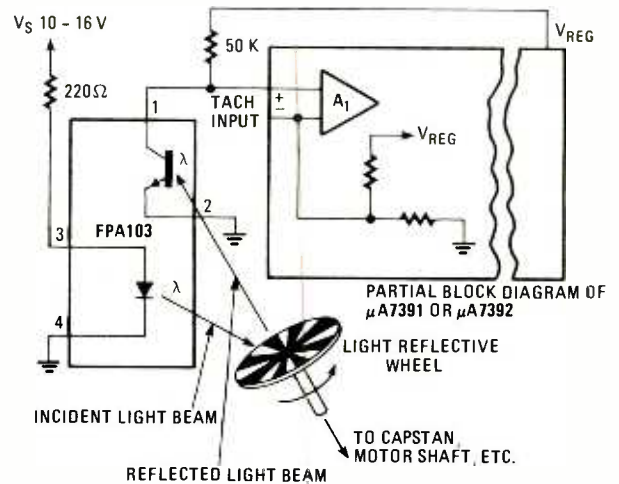


FIG. 5—AN OPTICAL TACHOMETER is another method of sensing motor speed.

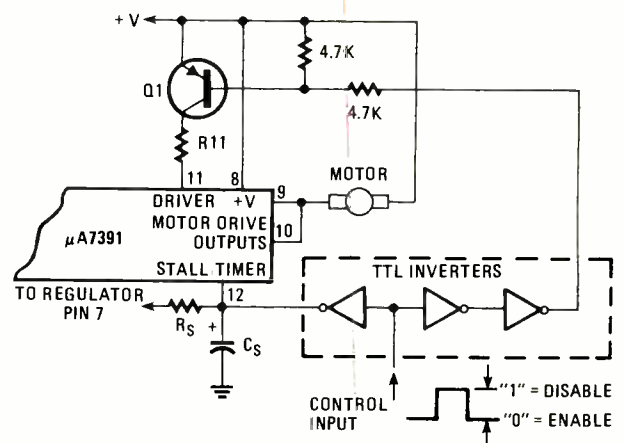


FIG. 6—MOTOR START/STOP control.

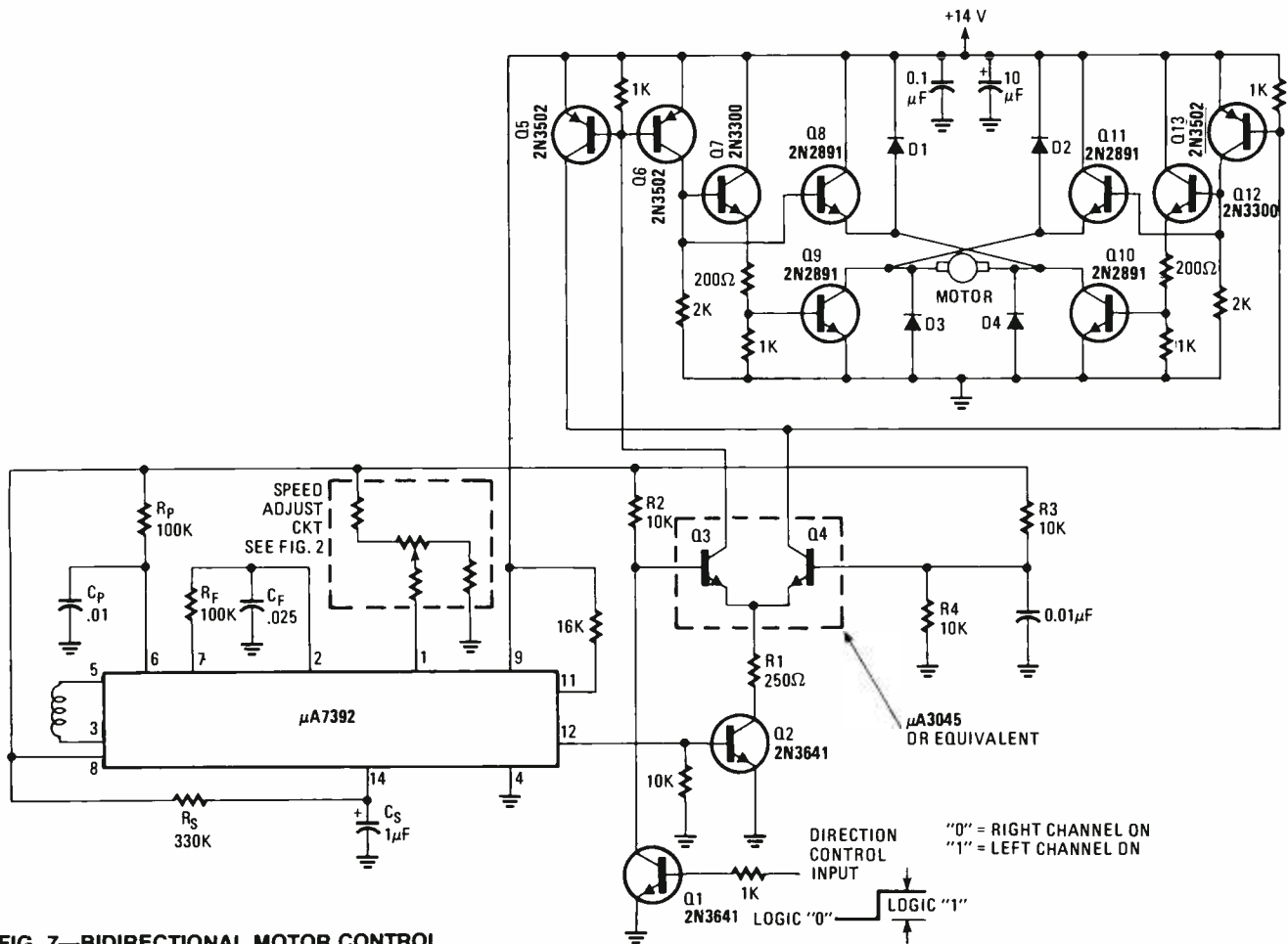


FIG. 7—BIDIRECTIONAL MOTOR CONTROL.

"1" appears at the terminal, Q4 will be turned on and Q3 off, causing rotation in the opposite direction with Q2 toggling Q10 and Q11. Transistor Q5, a PNP device, insures that both channels do not simultaneously turn on when power is first applied.

Diodes D1 through D4 are free-wheeling diodes clamping the kickback voltages at the collectors of Q9 and Q10. Transistors Q3 and Q4 are an integrated pair, constructed on a common substrate for good matching of base-emitter voltages and for temperature tracking.

Final notes

The μA7391 and μA7392 motor-speed controllers are high-performance, integrated circuits capable of providing 2 amps or 300 mA of running current, respectively, to a DC motor or some other inductive load.

Some guidelines to follow in the use of these regulators are:

1. Keep the tachometer frequency high compared to the inductive time constant of the load. This insures that the load "sees" substantially a DC current, i.e., the current does not go to zero.
2. For good stability, keep the filter-pole components R_FC_F at least 1/2 decade smaller than the mechanical time constant reflected to the motor shaft.

In addition to those presented, many other applications utilizing the A7391/2 as the "brains" of a control loop are possible, such as SCR or triac control of universal motors in AC or DC operation, solenoid position control in fluid pressure regulating systems, or pump control for blood recycling in medical apparatus. **SP**

more new products

MAIL-ORDER CATALOG, number 853, *Spring/Summer 1981*, is 104 pages describing electronic kits, educational courses, and computer software designed to appeal to homeowners, hobbyists, technicians, and engineers. There are products in amateur radio, stereo high fidelity, automotive test equipment, test instruments, microcomputers, marine instruments, and TV.



Some of the new kit products being introduced are a 2-meter amplifier, a deluxe antenna tuner, a cordless digital wall clock, and a speedometer/trip log for powerboats and sailboats.

In addition to the electronic kits, the catalog also spotlights an award-winning educational section of self-study courses. For the computer enthusiast, there are a variety of courses including new ones in BASIC and COBOL programming languages. For the engineer and technician, there are high-technology specialties such as microprocessors and opto-electronics. And for the hobbyist, courses are offered in hobby electronics, amateur radio licensing, automotive ignition and electrical repair certification, and weather prediction. The catalog is free on request. —**Heath Company**, Benton Harbor, MI 49022.

**CIRCLE 539 ON
FREE INFORMATION CARD**

DMM, model 3450, is "true hand-sized" and has a special ohms range with audible continuity tone. It displays immediate resistance reading with no range-change needed. The basic DC accuracy is 0.15%.

The special ohms range indicates continuity with a ½-second 80-dB musical note, and provides actual resistance measurement if the circuit under test is less than 1000 ohms. Because the tone is instantaneous, the model 3450 works as a quick continuity or intermittent checker. The tone can also be used to check diodes and transistors.

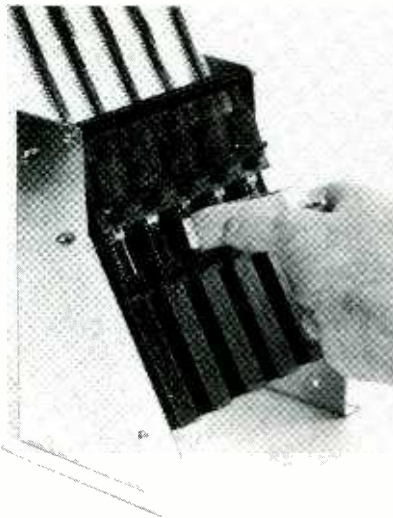
The 3½-digit DMM with a ½-inch LCD display also features both high and low power ohms, and overload protection up to 1000 volts, with special 2-ampere/250-volts fuse arrangement. Battery life is



500 hours (typical with the 9-volt battery), and the display has a low-battery indication when remaining battery life is down to eight hours.

The single color-coded range switch permits the model 3450 to be operated with only one hand; it selects 0-1000 VDC or VAC in five ranges, 0-20 megohms resistance in six ranges, and 0-2000 mA AC or DC current in four ranges. The model 3450 is priced at \$150.00—**Triplet Corporation**, One Triplet Drive, Bluffton, OH 45817.

**CIRCLE 533 ON
FREE INFORMATION CARD**



IC DISPENSERS, models MDD-1, MDD-2, and MDD-10, are 1-channel, 5-channel, and 10-channel versions of DIP IC dispensers for MOS and CMOS as well as standard devices. Each channel accepts any standard IC shipping tube easily, and can accommodate any standard IC from 2 to 42 pins on .300, .400, or .600 centers. Adjustable guides position each IC individually for easy extraction, and simple gravity feed insures reliable deposit of the next IC into extraction position after the

previous IC is removed. The dispensers are made of conductive carbon-filled thermoplastic with steel supports; the MDD design insures effective static dissipation (a grounding lug is included) as well as long and reliable performance.

The model MDD-1 (1 channel) is priced at \$21.85; the model MDD-5 (5-channels) costs \$83.43, and the model MDD-10 (10-channels) sells for \$160.45.—**OK Machine and Tool Corporation**, 3455 Conner Street, Bronx, NY 10475.

**CIRCLE 541 ON
FREE INFORMATION CARD**



MULTIMETER, model 945, is a full-function, hand-held multimeter in a "calculator-style case." It measures both DC and AC voltages with a resolution of 10 μ V up to 1000 VDC and up to 700 VAC in five ranges. Both plus and minus are displayed in DC measurements, so that there can be no ambiguity. Resistance is measured from 200 ohms at 10 milliohms resolution to 20 megohms in six ranges. There are five ranges of DC and AC current, measuring from 10 nA to 2 amps. Basic accuracy is $\pm .05\%$.

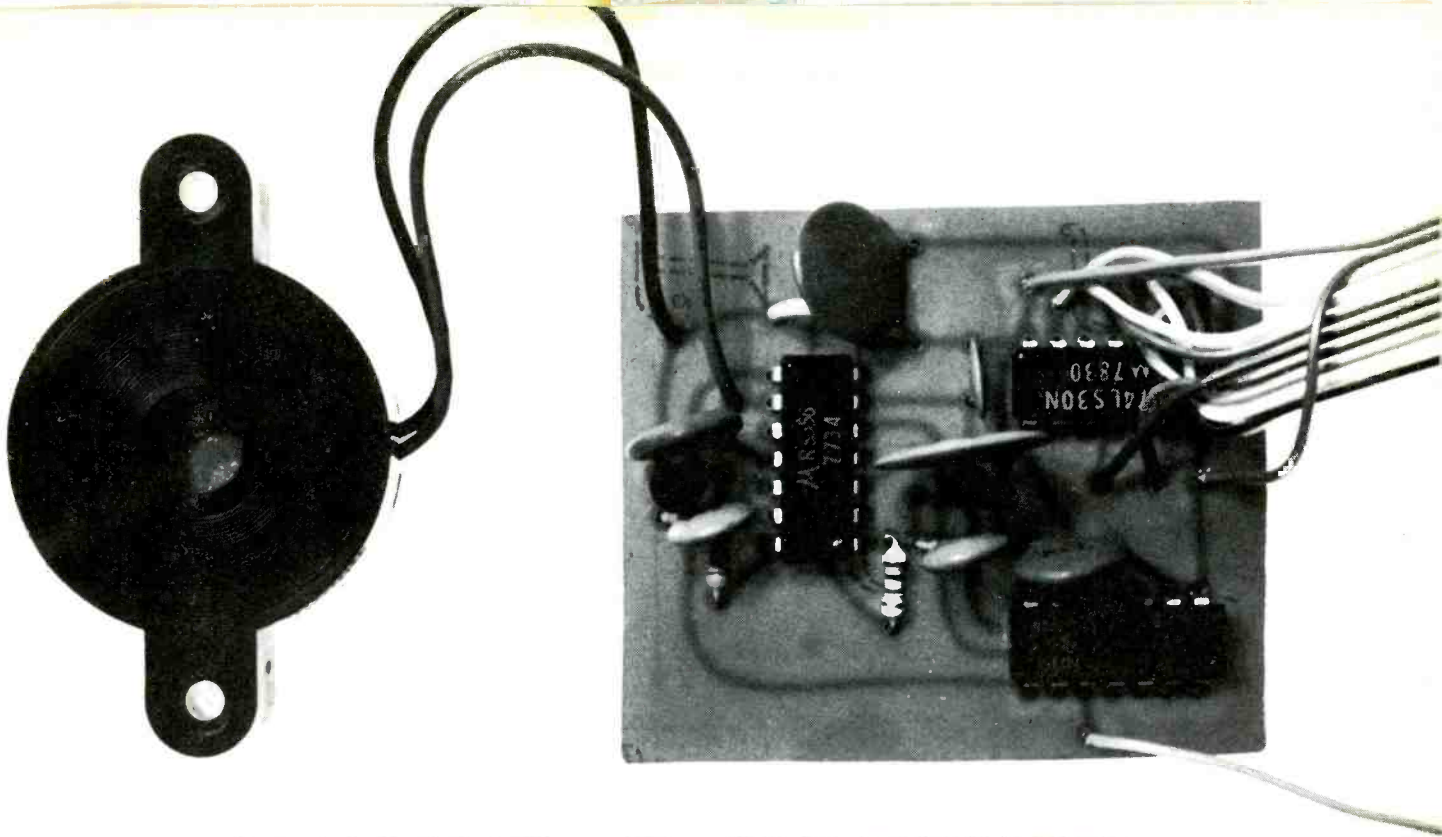
The unique feature of the model 945 is its ability to characterize diodes as well as to test them. Since the resistance measurement is made by constant-current sources, the multimeter displays the voltage drop directly across a diode each decade current step from 100 nA to 1 mA, yielding a 5-point curve.

It is powered by a 9-volt battery, and features a 0.43-inch-high liquid crystal display of the high-contrast type, easily viewed under most lighting conditions. AC voltage, average sensing with RMS calibration, has a basic accuracy of 0.5% over the full power-frequency range to 500 Hz. At reduced accuracy, the model 945 will measure from 30 Hz to 1 kHz.

The model 945 is rugged, difficult to damage in any way, and designed for truly portable use. The battery, designed to last 100 hours, has a "low-battery" indicator.

The model 945 is priced at \$265.00. —**Data Precision**, Electronics Avenue, Danvers, MA 01923.

**CIRCLE 536 ON
FREE INFORMATION CARD**



BUILD A BEEPER FOR YOUR TRS-80

**Typing can be a lot easier when your computer
"talks" back to you.**

LYNN R. ERICKSON, P.E.

FROM THE FIRST TIME I TURNED ON MY TRS-80*, I FOUND the lack of audible or tactile feedback a handicap when operating. Looking at the screen to make sure that a character is not double typed, or missed, slows data entry and leads to program errors. The circuit described in this article is an easy and inexpensive solution to this problem.

How it works

The TRS-80 keyboard is periodically scanned by the Z-80 microprocessor under control of the monitor/interpreter Read Only Memory (ROM) to see if a key has been pressed. The keyboard itself does not generate a key-pressed signal. (Refer to the *TRS-80 Micro Computer Technical Reference Handbook*, Radio Shack Catalog No. 26-2103, for a complete description of the keyboard logic.) However, the logic used for the keyboard scan holds all the keyboard column lines high until a key is pressed *and* the line is being scanned. By connecting the keyboard column lines to the 74LS30

eight-input NAND gate, IC1, (see Fig. 1, the complete schematic of the TRS-80 beeper) a keypressed (KP) signal is generated at the gate output anytime a column line goes low. Since the timers we are using are triggered by a signal that goes low, we invert the KP signal using IC2-a, one of the two-input NAND gates of IC-2, and the resulting \overline{KP} signal is used to trigger $\frac{1}{2}$ of IC3-a, a 556 dual timer connected as a retriggerable, negative recovery, monostable multivibrator, to give a KP pulse approximately 50-ms long.

This circuitry generates a KP pulse every time the keyboard is scanned, even though the character may be acknowledged only once for multiple scans. If the output from IC3-a were fed directly to the piezo buzzer, it would buzz as long as the key was pressed. But, after determining that a key is pressed and which key it is, the Z-80 always takes some action affecting the video display. This means that activity results on the \overline{VID} signal line of the TRS-80. We invert and buffer the \overline{VID} signal using the extra gate of IC Z37 on the computer circuit board and combine the resulting VID signal with the KP pulse from the timer using

*TRS-80 is a registered trademark of Radio Shack.

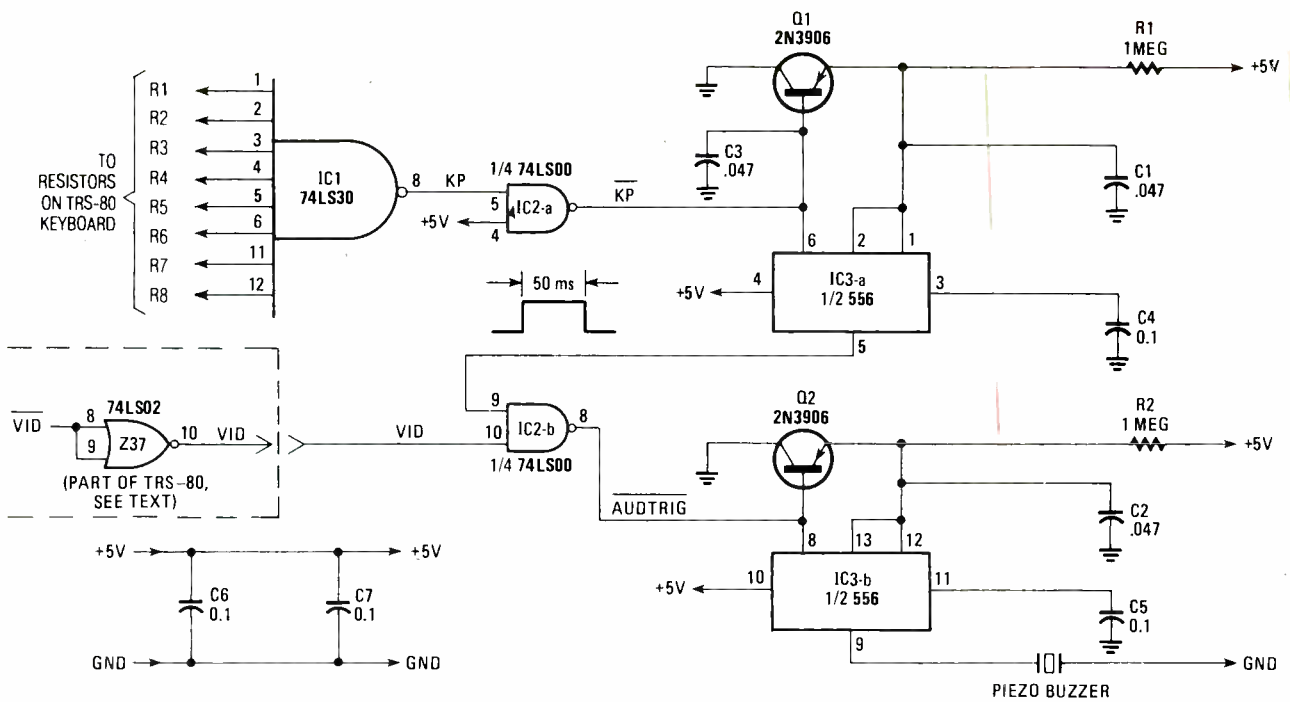


FIG. 1—SCHEMATIC DIAGRAM OF THE BEEPER showing connection to the TRS-80.

IC2-b. Now, when both signals are high, the gate output goes low. This AUDTRIG output from IC2-b triggers IC3-b, turning on the piezo buzzer for 50-ms.

Recap—we have created logic to sound the buzzer when all the following are true:

1. The keyboard is scanned by the Z-80 CPU.
2. A key is pressed.
3. The CPU acknowledges the key within 50 milliseconds by taking action affecting the video display.

Other components include the RC timing pairs, R1-C1 and R2-C2, that determine the time the buzzer is on and the length of the KP pulse. The values of the timing pairs can be adjusted to suit personal preference according to the formula: Time On = 1.1 RC. Transistors Q1 and Q2 are used to make the timers retriggerable. This means that the buzzer will continue to sound as long as the three enabling conditions are true, making multiple-character entry easy to detect. Capacitors C4 and C5 bypass spurious noise away from the 556 FM inputs. C6 and C7 are power bus despiking capacitors. C3 makes the circuit less susceptible to false triggering when programs output video without keyboard input. The piezo buzzer and the three IC's use minimal current, so the TRS-80 power supply will not be overloaded.

How to build it

To facilitate mounting the beeper inside the computer case, I built the unit onto a printed circuit board (PCB). Etch the board and mount the components as shown in Figs. 2 and 3. Use a cut-off component lead or other solid wire for the jumper, and make certain that all unused gate inputs of IC2 are connected to ground or +5 volts. Cut a piece of ribbon cable 13 inches long, split one end lengthwise to ten conductors, and connect it to the signal and power inputs at IC1 on the Beeper circuit board (see photos for details). Now

Parts List

RESISTORS

R1, R2—1 megohm, ¼ watt

CAPACITORS

C1, C2, C3—.047 μF, 50 VDC, disc

C4, C5, C6, C7—0.1 μF, 50 VDC, disc

SEMICONDUCTORS

IC1—74LS30 eight-input NAND gate

IC2—74LS00 quad NAND gate

IC3—556 dual timer

Q1, Q2—2N3906, PNP silicon

MISCELLANEOUS

Piezo Buzzer, Radio Shack No. 273-060 or equal

Printed circuit board

Foam mounting tape

Wire and ribbon cable

An etched and drilled circuit board is available for \$6.00 postpaid from: Lynn R. Erickson, P.E., 1432 Rockhaven Place, Manteca, CA 95336. California residents please include 6% sales tax.

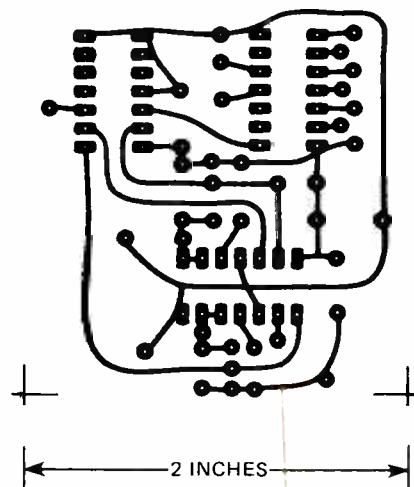


FIG. 2—FOIL SIDE CIRCUIT BOARD PATTERN. Pattern is shown actual size.

WARNING

Installing this beeper into your TRS-80 will void your warranty on the TRS-80. Be sure you realize that before you start this project.

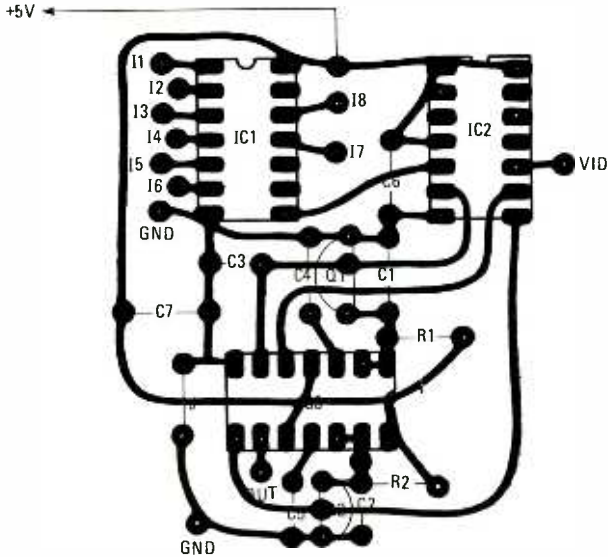


FIG. 3—COMPONENT LAYOUT ON CIRCUIT BOARD shows exact location of each component.

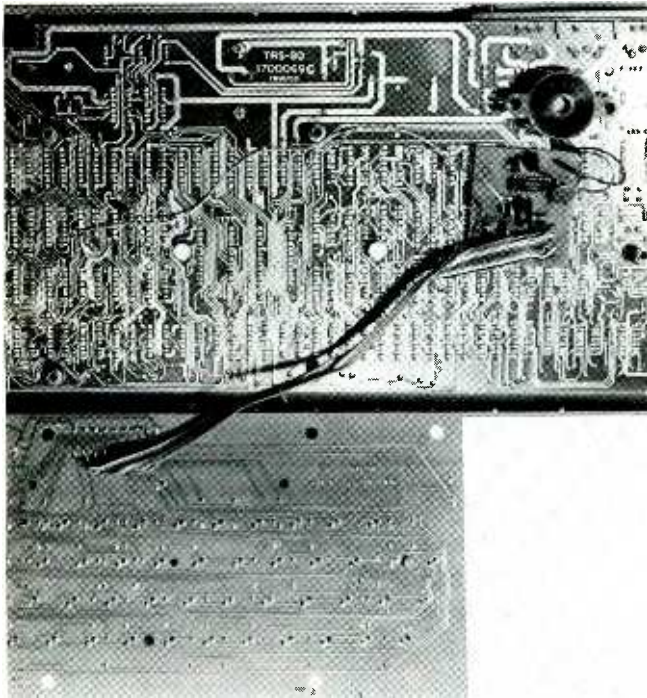


FIG. 4—INSTALLATION AND HOOKUP of beeper inside the TRS-80.

lay this assembly aside temporarily.

Remove the six screws holding the computer case halves together. Position the computer on a table facing you and remove the top-case half and set it aside. Gently lift the keyboard while rotating it toward yourself. Being very careful of the interboard connector, lay the keyboard on the table with the keys down, exposing the foil side of the circuit boards as shown in Fig. 4.

Carefully install a jumper from pin 8 of IC Z36 to

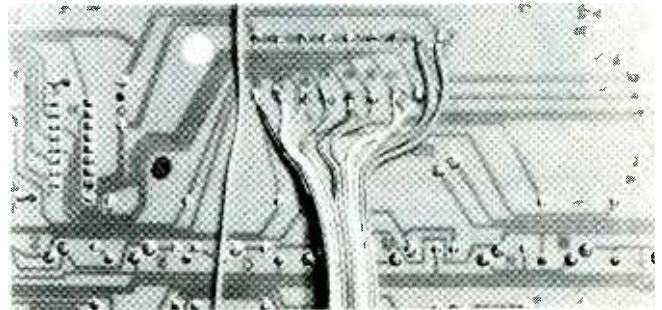
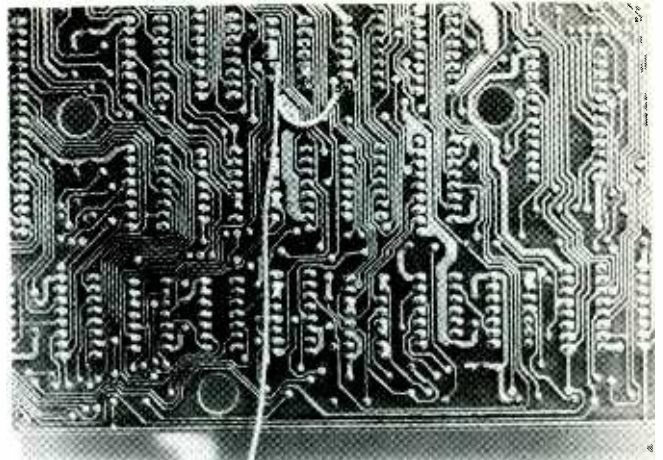


FIG. 5—CONNECTIONS TO THE TRS-80 KEYBOARD and computer circuit boards.

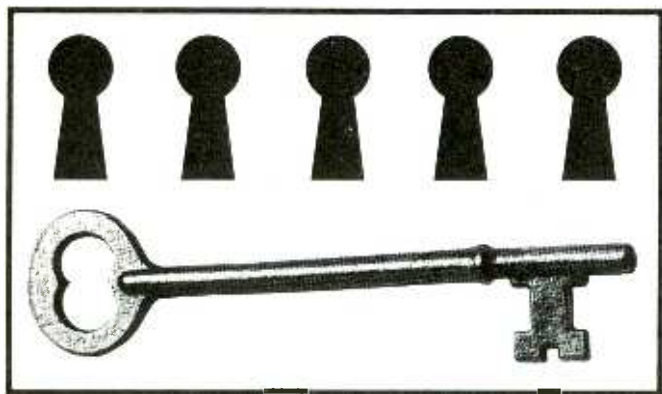
pins 8 and 9 of IC Z37 on the computer circuit board as shown in Fig. 5. Before completing this step, check pins 8 and 9 of IC Z37 with a multimeter or logic probe to see if they are connected to ground. On my TRS-80 those pins were floating, even though the Radio Shack schematic shows them connected to ground. If your computer does have those inputs tied to ground, cut the foil between pins 8 and 9 and connect the jumper to the pin that is left floating.

Next solder one end of a 12-inch piece of No. 28 stranded wire to pin 10 of IC Z37 as shown. Remember, you are working from the foil side of the board so pin 1 is at the upper right of the IC lead pattern, not the left. Connect the other end of this wire to the VID input of IC2. Observing polarity, connect the buzzer wires to the board. Now solder all eight gate-input conductors of the ribbon cable to the innermost ends of R1 through R8 on the foil side of the keyboard. The order of the column lines is unimportant, since any column line going low causes the output of IC1 to go high. Solder the positive power lead of the ribbon cable to the outer end of R7 and the negative lead to the outer end of R9 to complete the hookup to your TRS-80. Mount the Beeper board and the buzzer on the CPU printed circuit board using double sided foam mounting tape, and replace the top-case half.

Checkout and operation

Hook up your TRS-80 to the power supply and video display as you usually would, and power up. The only difference you will notice is the short "beep" as the computer acknowledges your input. If you should have difficulty, check for solder bridges or cold solder joints. Use a magnifying glass where the jumper and VID line have been connected to the CPU board. A less than hair-size bridge can foul up the works. **SP**

MAKING THE TOUGH DECISIONS



A budget-management report from United Way

By operating like any other modern, well-run business enterprise, United Way succeeds in delivering the maximum in human services for the dollars that are collected.

Volunteers carefully review the budgets, operating patterns and track record of agencies asking to become part of the United Way organization.

These volunteers scrutinize the various functions performed by the agency, look at the kinds of people it helps, and evaluate its success in delivering its services.

They look ahead, five or ten years down the road, and *plan* for what the community will need as people grow older, single parent families increase—as things change.

But there are some decisions that can't be made strictly on a dollars-and-cents basis.

For example, what happens when a

new service agency wants to become a United Way organization—especially when there may be two or more equally qualified organizations equally in need of United Way support? Who chooses? And on what basis?

The answer to this question is often complex. And sometimes it can be an agonizing decision to admit one agency instead of another, because the final choice means one agency gets the added help it needs and the other agency (and the people it serves) has to go without.

The people decide

But the bottom line is that volunteers do make the decisions after carefully weighing all the pros and cons. It's sometimes a hard process, but it's as fair as we know how to make it.

And these are *local* volunteers, deciding how local funds are distributed. The United Way philosophy is based on the belief that local volunteer groups are in the best position to judge their community needs, so they should make the financial decisions.

Because volunteers work free of charge doing everything from collecting money to deciding how it will be used, administrative costs are kept low, and more can be spent on needed services.

And that's how United Way works so well. And why.



United Way

Thanks to you, it works. For all of us.

PROJECTS FROM ENGLAND

A one-IC radio circuit and a disco light flasher are just two of the ideas from the other side of the Atlantic.

IT ISN'T EASY TO KEEP COMING UP WITH A WIDE SELECTION of interesting projects every issue. But it can be done and we intend to continue doing it. One way we are going to continue bringing you a variety of projects each month is by making a selection from a number of project-oriented books. This article, for example, brings you a group of projects selected from four separate construction books. We hope you like them. If you want to see more, please write and tell us so, and we will be sure to include similar articles in the issues to come.

Using Zener diodes

Three-terminal integrated-circuit voltage regulators are now readily available in a standard range of voltages—5, 12, 15, 18, and 24 volts. Those units provide a simple, reliable means of voltage regulation—but what if you need a non-standard voltage, say 27 volts as an example?

The solution is to float the regulator above ground by connecting a Zener diode with a suitable wattage rating in series with the regulator's ground lead. In Fig. 1, a 3-volt, 5-watt Zener is used. The voltage across the 24-volt regulator remains at 24 volts, but the voltage seen at the output is the regulator voltage plus the Zener diode voltage— $24 + 3$ volts = 27 volts.

The usefulness of this circuit can be extended by switching out the Zener diode as in Fig. 2. Now the circuit can deliver either 24 or 27 volts. Or, as shown in Fig. 3, we can add in a 6.3-volt Zener and now have a power supply that delivers 24, 27, or 30 volts at the turn of a switch.

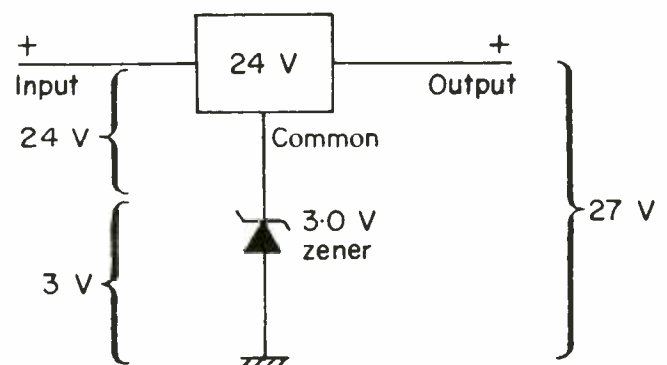


FIG. 1—A NON-STANDARD VOLTAGE can be obtained from a voltage regulator circuit if a Zener diode is connected as shown.

IC LED flasher

This circuit uses the logic gates of a 7400-type IC to form a low-frequency multivibrator that drives two red LED's, causing them to flash alternately. Each 7400 contains 4 gates, so each 7400 can drive 4 red LED's. Figure 4 shows the diagram for two gates connected as a multivibrator driving two LED's. The other two gates can also be connected in a similar fashion to form a second multivibrator. The pin numbers in the diagram are the connections to the 14-pin IC. The numbers shown in brackets are the connections to the other two gates.

This circuit should be powered by a 5-volt supply, although a 4.5-volt battery can be used. The time inter-

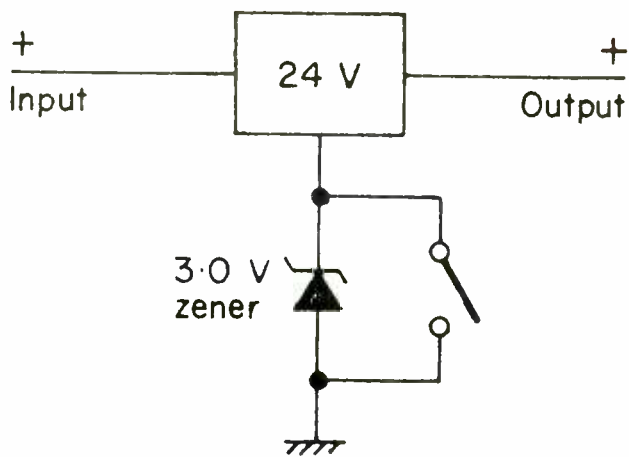


FIG. 2—A SIMPLE MODIFICATION of the circuit shown in Fig. 1 yields a voltage regulator circuit that delivers either 24 or 27 volts.

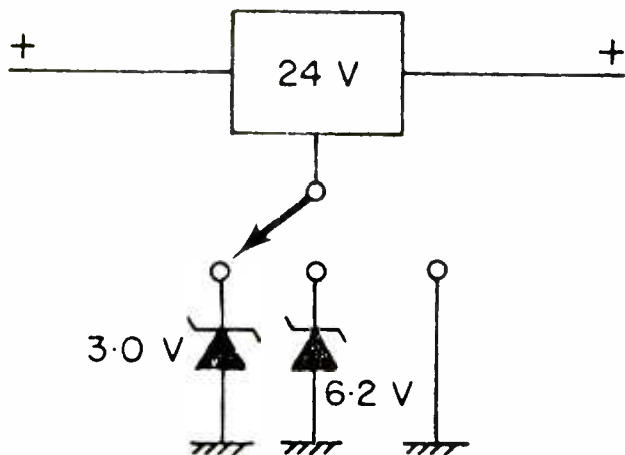


FIG. 3—A VOLTAGE REGULATOR CIRCUIT with many different outputs can be obtained by simply using Zener diodes with suitable voltages and a multiple position switch.

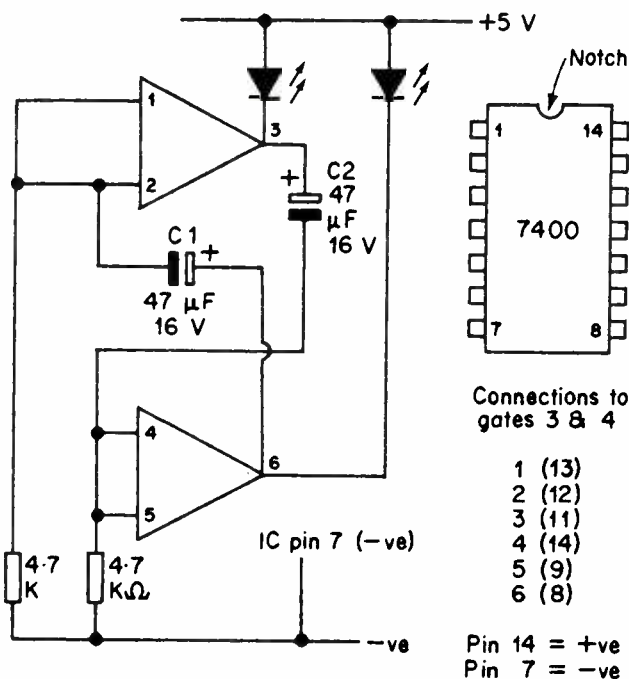


FIG. 4—A SIMPLE DO-NOTHING CIRCUIT, this low frequency multivibrator circuit alternately flashes two LED's. The time interval between flashes is determined by capacitors C1 and C2.

val between flashes is determined by the values of C1 and C2. For a longer time period (lower frequency) use a larger value electrolytic. Try 100 μF or 220 μF for a start.

If several 7400's, each one driving 4 LED's, are connected together, with different timing capacitor values to produce a variety of flash rates, a scintillating display can be produced.

Audio light modulator

A light modulator adds interest to a disco, or can be used at a party or for amusement at home. It can be single channel for treble, middle, and bass frequencies. Illumination can be of any chosen colors, such as blue, green, and yellow for bass, middle, treble, or red and green for bass and treble. For a single channel, the light could be any color you choose.

Line-voltage lamps of about 40 to 100 watts will generally work best, but there is no reason why low-voltage lamps could not be used if that is what you prefer.

The lamps flash on and off in time with the musical beat, or in following the peaks of volume at various frequencies. That is quite effective with even a single colored lamp, but it is much more entertaining with two or three lamps, and frequency-sensitive control circuits.

Figure 5 shows a single-lamp audio light modulator, and this is easily developed for one or two additional lamps. The audio driving power required for a single lamp is not very great, and could probably be taken off the power supply of almost any tape or record player (or radio) that has an output of 1 watt or so. The audio signal is taken from the loudspeaker circuit through isolating transformer T1. That results in a similar signal being generated in the secondary of this transformer.

Current for the lamp is obtained through the SCR. When low-level audio is present in T1, the SCR is not triggered into conduction. However, a loud beat, or sustained higher volume, drives the gate strongly enough for the SCR to conduct, so the lamp lights to follow the sounds. As the SCR circuit operates from AC, the SCR moves out of the avalanche condition whenever the gate current is low.

If this circuit is scaled down to use 12 volts or other low voltages, current must be derived from a line transformer. A DC supply is not suitable, as the lamp will remain fully lit, once the SCR has been triggered.

VR1 makes it possible to adjust the power reaching T1, and is set so that with normal volume the SCR is triggered repeatedly, except during quiet passages. The way in which performance changes with adjustment of this control will be clear when using the circuit.

The voltage obtained from the speaker circuit, for a given power, will depend on the impedance. Due to the presence of R1 (and VR1) the circuit is normally suitable for a 2-ohm to 16-ohm output, and has very little effect on results, when connected in parallel with the loudspeaker. Some equipment may have a spare output circuit, but such an extension or additional circuit does not exist in most transistor equipment. It is not likely that the amplifier can be damaged by connecting the audio light modulator, since R1 prevents any substantial overall reduction in impedance. Leads should be clear of any pick-up or input circuits, to avoid instability or feedback (in a similar manner to

Connections to gates 3 & 4

- 1 (13)
- 2 (12)
- 3 (11)
- 4 (14)
- 5 (9)
- 6 (8)

Pin 14 = +ve
Pin 7 = -ve

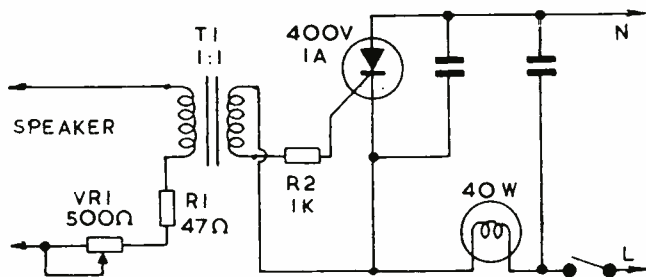


FIG. 5—FOR A DISCO EFFECT, try this single lamp modulator. It flashes a light bulb on and off to the beat of the music.

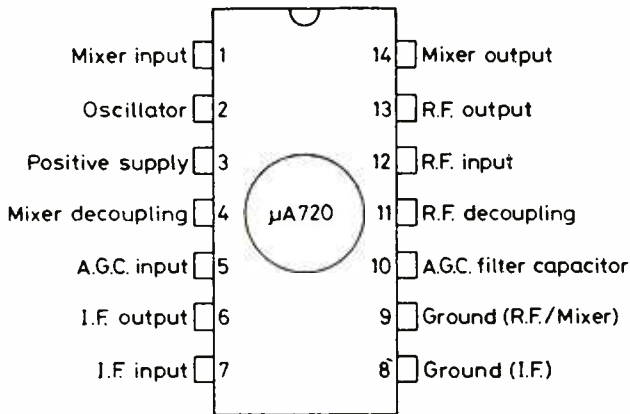


FIG. 6—THIS FAIRCHILD μ A720 IC can be used with a power amplifier to build a superheterodyne AM receiver.

wiring a loudspeaker). If necessary, R1 can be placed at the loudspeaker end of the circuit, or a similar resistor may be inserted here in both leads, so that actual connections to T1 are less prone to cause feedback.

It is not essential that T1 should have a 1:1 ratio. A suitable transformer here is the loudspeaker coupling type, and if that has two secondaries for 3 ohm or similar speakers, those will provide the 1:1 ratio shown. Where the ratio available is not 1:1, it will generally be necessary to connect it to step-up the primary signal voltage, unless the impedance of the speaker circuit is fairly high. A multi-range meter, suitable for audio frequencies and connected to the secondary, should kick up to several volts, with normal volume. If a transformer is to be wound, there is considerable latitude in the number of turns, and about 100 for the primary and a similar number for the secondary, will be satisfactory. The power-handling capacity need not be very great, so 18-gauge or heavier wire is convenient.

It is essential that the primary/secondary insulation of the component is adequate to isolate the line circuit, so small 1:3 and similar transistor coupling transformers are not suitable.

When building a circuit that incorporates both audio and line voltages in this way, safety must be one of your prime concerns. A breakdown in T1 could place line voltages on the audio and speaker circuit, but with many amplifiers the primary of T1 cannot be grounded for safety. A tube-type transformer will generally have insulation intended for several hundred volts, and its core can also be grounded. A low-amperage fuse should be wired into the line source. Maximum safety

is obtained when the amplifier is also line-operated, with one side of the speaker circuit grounded, so that T1's can also be grounded.

The alternative to those precautions, which are essential for safety in the event of component failure, is to use lower-wattage lamps and draw current for them from a 24-volt transformer or similar low-voltage source. One pole of the lamp supply, or a center-tap, can then be grounded for protection.

The capacitors are used to suppress interference produced by the SCR. Values here are not too critical, but for safety the components should be rated between 600 and 1000 volts.

Radio circuit using an IC

The Fairchild μ A720 is very similar to the National Semiconductor LM1820 and to the RCA CA3123 devices. Any one of those integrated circuits can be used with a power amplifier to construct a superheterodyne AM receiver. These devices are supplied in 14-pin dual-in-line packages with the connections shown in Fig. 6.

One of the devices can be used with appropriate tuned circuits as a medium-wave receiver, but if you include switches, you can extend the frequency range to include the long-wave band, the shipping bands, and any of the short-wave bands up to a maximum frequency of at least 30 MHz (corresponding to a wavelength of 10 meters). Tuning can be carried out by a ganged capacitor, but permeability tuning can be used in car radio receivers for optimum signal-to-noise ratio with a conventional car antenna.

Practical circuit

A typical circuit for the use of the μ A720 type of device is shown in Fig. 7. It is a conventional type of superheterodyne circuit with a radio-frequency amplifier stage for optimum signal-to-noise ratio and maximum rejection of the spurious-image frequency signals. The intermediate frequency can be the normal 465 kHz or any similar frequency; that intermediate frequency is set by the resonant frequency of the ceramic filter and the tuned circuits in T4 and T5. The circuit provides automatic gain control from the output to the earlier stages; that keeps the volume fairly constant because the signal being received fades due to interference wave effects. The biasing voltages in the integrated circuit are stabilized by an internal regulator. The output from the volume control is suitable for feeding directly to an integrated circuit audio amplifier (such as the National Semiconductor LM380, the Fairchild μ A706, etc.), but is equally suitable for feeding to a power amplifier made from discrete components.

In the circuit of Fig. 7, the signal from the aerial is coupled by the transformer T1 into the pin 12 of the device. The amplified input frequency appears at pin 13 of the device and is fed to the radio-frequency-stage output tuned circuit of T2. This circuit resonates at the same frequency as T1, both being tuned by the ganged capacitor.

The output from the tuned circuit of T2 is coupled to the input of the mixer stage at pin 1 of the device. The oscillator is tuned by the circuit coupled to pin 2 and the same ganged capacitor which tunes the circuits of T1 and T2. The sum and difference frequencies of the signal and oscillator frequencies appear at pin 14 (the

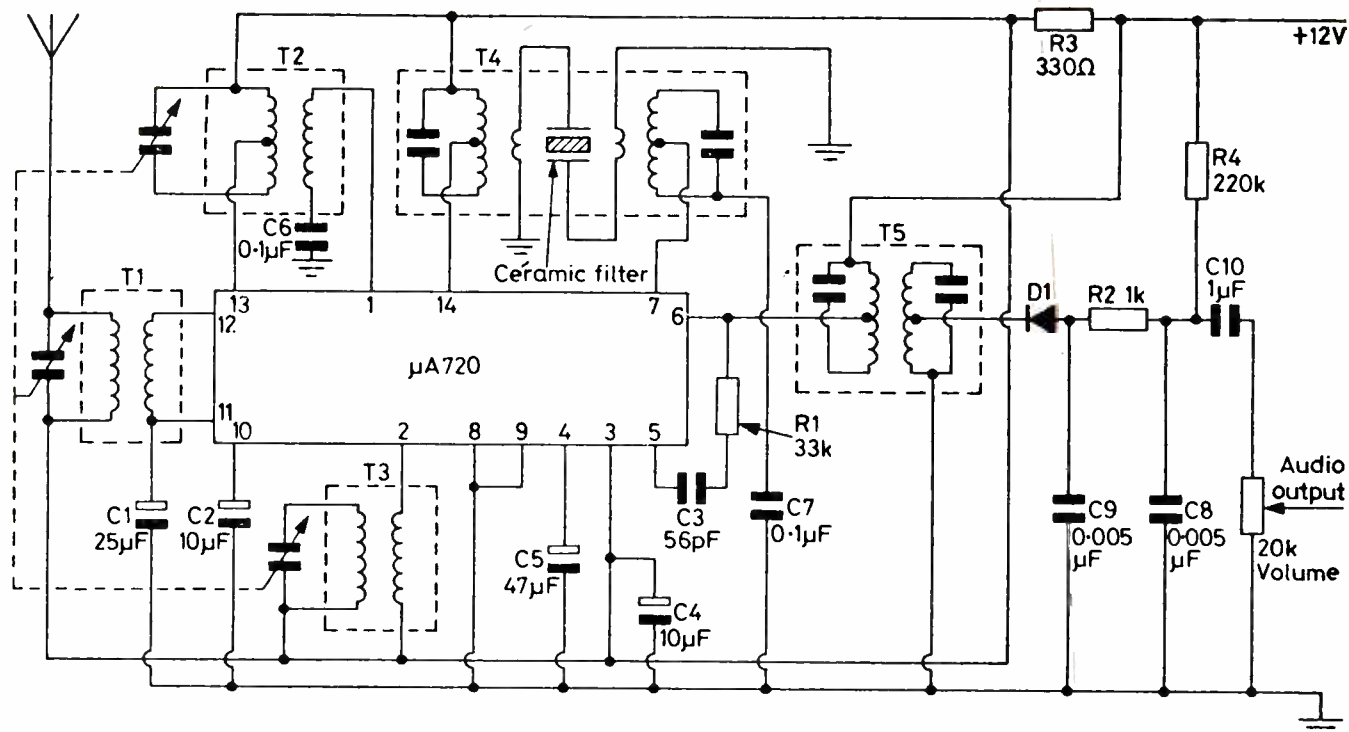


FIG. 7—A TYPICAL SUPERHETERODYNE RADIO circuit using the $\mu A720$ IC. The ceramic filters are used for good selectivity.

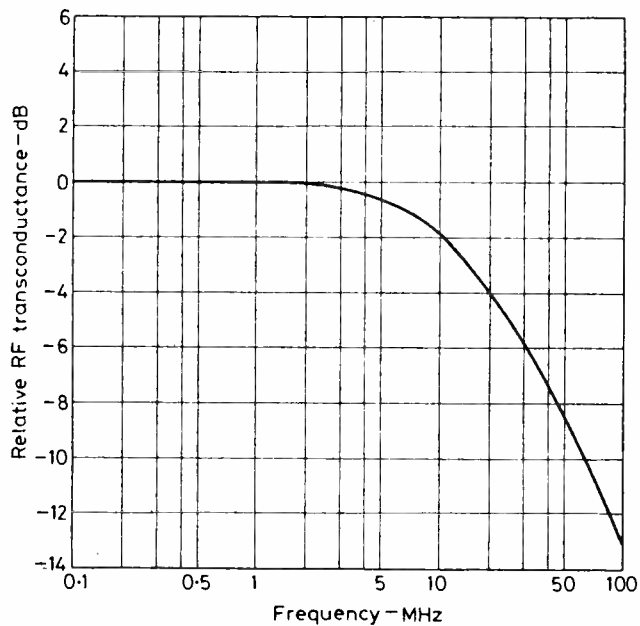


FIG. 8—THIS GRAPH ILLUSTRATES how the RF transconductance falls off with increasing frequency in the circuit of Fig. 7.

mixer-stage output). The difference frequency is selected by the tuned circuit of T4 and passed to the ceramic filter, which is also resonant at the difference

frequency before passing to the output tuned circuit of T4.

Ceramic filters can provide very good selectivity. That makes it possible to listen to a weak station which is close to a much more powerful station. Filters are available that have bandwidths of 8 kHz, 6 kHz, and 4.8 kHz at 6-dB down. They give a relatively flat band-pass characteristic with fairly steep sides and generally give a much better selectivity characteristic than can be obtained by using a few tuned circuits. Nevertheless, a simple double-tuned intermediate frequency transformer can be used instead of the ceramic filter shown for T4. Both the ceramic filters and the transformers are very small components.

The output from the ceramic filter unit is fed into the intermediate-frequency input at pin 7 of the device and the amplifier output appears at pin 6. That output at the intermediate frequency is fed into the double-tuned transformer T5. The audio-output signal is obtained by means of the demodulator diode D1 and the following filters which reduce the amplitude of the intermediate frequency in the audio signal.

The output signal is also fed through R1 and C3 into pin 5 of the device. It is then demodulated by internal diodes and is filtered by C2 so as to provide an automatic gain control voltage with a suitable time constant.

The transconductance (and therefore the gain) of the radio-frequency stage falls with increasing frequency as shown in Fig. 8. The gain is about 6-dB down at 30 MHz and about 9 dB at 50 MHz.

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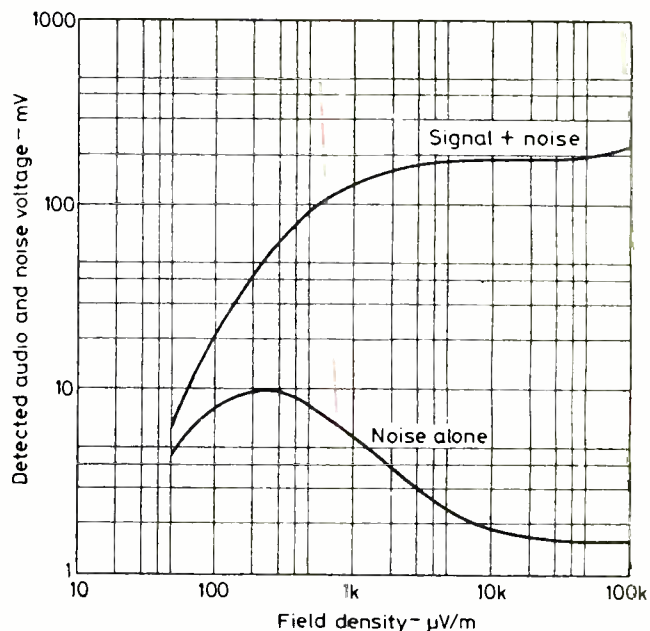


FIG. 9—THE NOISE PERFORMANCE of the one-IC radio circuit is shown here. The distance between the curves at any point is a measure of the signal-to-noise ratio at that point.

The noise performance is well illustrated in Fig. 9. The upper curve shows the value of the demodulated audio output plus noise for a 1-MHz input signal frequency modulated at the 30% level with a 400-Hz signal. The lower curve shows the noise output when no signal is applied at the input. The distance between the two curves at any point is a measure of the signal-to-noise ratio at the input level concerned. Both axes of this graph are plotted on logarithmic scales so that a very wide range of levels can be shown on a single graph.

The absolute maximum voltage that may be applied to a μ A720 device is 16 volts; voltages above that value are liable to damage the device, even if they are applied only for an instant. In order to allow an adequate margin of safety, it is wise to regard the upper limit as being about 14 volts, and to operate the device from a 12-volt supply.

The voltage at pin 3 is stabilized at a value between 6.6 and 7.5 volts, but the device will function at supply voltages below that value (even down to 3 volts at reduced gain). Pin 3 must never be connected directly to the positive power-supply line, but a current-limiting resistor (R3 in Fig. 9) must be used. The current required by the circuit of Fig. 9 is around 10 mA.

That's this issue's round of projects. We hope you like them. And we will try and bring you another selection each issue.

SP

The circuits in this article were extracted from the following books: 50 Circuits Using Germanium, Silicon & Zener Diodes by R.N. Soar, \$3.50. 50 Simple LED Circuits by R.N. Soar, \$3.50. 50 Projects Using Relays, SCR's & Triacs by F.G. Rayer, \$3.50. Radio Circuits Using IC's by J.B. Dance. All four books are published by Bernard Babani Ltd., London, England. They are available in the United States from Electronic Technology Today Inc., 17 Slate Lane, Central Islip, NY 11722 at the prices indicated.

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