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Hands-on Electronics

48784

#2

FALL 1984

THE MAGAZINE FOR THE ELECTRONICS ACTIVIST!

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650-MHz AMP-PRESCALER PROBE

AUTOMATIC DARKROOM TIMER

CAPACITANCE METER

- How your ears react to sounds!
- Voltage regulator design tips!
- Analog Anemometer measures the wind!

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Hands-on Electronics Volume 2, No. 2 Fall, 1984

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Hands-on Electronics

#2
FALL 1984

The Magazine for the Electronics Activist!

Calling all Hams, SWL'ers, Computer Buffs, Students, CB'ers, Antique Radio Collectors, BCB Listeners—Everybody!

There's a big world out there enjoying the various aspects of electronics hobbying. Those "aspects" divided themselves into special-interest groups and some almost never communicated with each other. That was often carried to extremes. For example: In the mid-1970's, an Amateur Radio Operator was expected to tear up his ticket should a member of his immediate family obtain a CB license. How many shortwave listeners (SWL's) do you know? They're all over, but you can't find them so how can another hobby group ignore them! And, did you ever try to hold a conversation with a computer buff? Yet, as alien as they may seem to each other, there is one common fiber (other than the electronics affiliation) that binds them into a brotherhood. That's project building! Yes, this hodge-podge group gathers unto itself as a dynamic group, because of its need to build, duplicate, repair, and modify electronic gadgetry.

That's why you can expect as many different hobby types in **Hands-on Electronics** as there are rock sizes in a quarry.

Never has one magazine meant so much to so many hobbyists with one editorial package.

Just gander at this issue's Table of Contents, and if you don't find one or more articles of interest to you, your hobby may be button-hole collecting or shining pennies. If you drive a car, the Pocket Safety Flare project is for you...or, if weather is your off-beat, the Dual Peak/Current Anemometer belongs on your roof....or, if you are the traveling kind, Panoply (our personal burglar alarm) belongs in your suitcase. I think I proved a point! It makes no matter what esoteric name you give to your hobby, if it requires negative electrons to make it go, we are all one and the same. So, enjoy this issue of **Hands-on Electronics**.

Julian S. Martin

Julian S. Martin, KA2GUN
Editor

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2.2k	271-1325
3.3k	271-1328
4.7k	271-1330
6.8k	271-1333

Ohms	Cat. No.
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15k	271-1337
22k	271-1339
27k	271-1340
33k	271-1341
47k	271-1342
68k	271-1345
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220k	271-1350
470k	271-1354
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MJE34	PNP	276-2027	1.49
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MPS3638	PNP	276-2032	.79
TIP120	NPN	276-2068	1.29
2N3055	NPN	276-2041	1.99
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MPSA06	NPN	276-2059	.59
MPSA13	NPN	276-2060	.59
MPSA42	NPN	276-2061	.69
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7805	+5 VDC	276-1770	1.59
7812	+12 VDC	276-1771	1.59
7815	+15 VDC	276-1772	1.59
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7912	−12 VDC	276-1774	1.59

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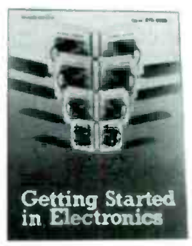
DPDT DIP Relay. Fits 16-pin DIP socket or PC boards. Contacts: 1 amp at 125 VAC. Coil: 5VDC, 50 ohms. 7/16 × 25/32 × 3/8". **275-215** . . . **3.99**

Getting Started In Electronics

2⁴⁹

By Forrest Mims III



Teaches basic electronics with an emphasis on ICs. Easy-to-read text and diagrams. 128 pages. Already a "classic." **276-5003** . . . **2.49**

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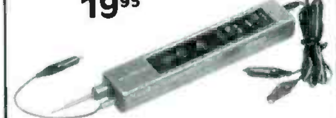
Digital Logic Probe

19⁹⁵



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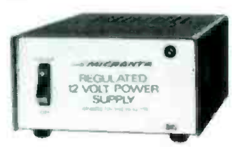

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NEW PRODUCTS SHOWCASE

DIGITAL VOM

The Triplett Model 3550-A hand-held, push-button operated, digital VOM offers ±.25% accuracy on all DC ranges, 10-A test capability, and audible continuing tone. Designed for 2000-hours battery life, the Model 3550-A is ideally suited for a myriad of in-field measurements on commercial or hobby electronic/electrical equipment. The unit features a new 2-A, 600-volt fuse arrangement, plus safety designed test leads for optimum user protection.

CIRCLE 829 ON FREE INFORMATION CARD

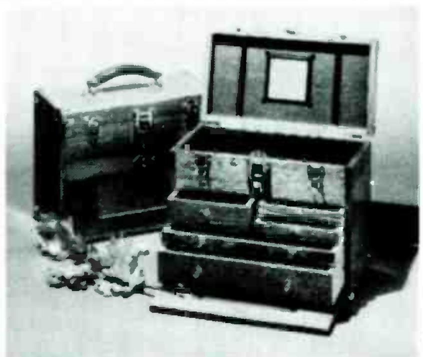
The Model 3550 has a .5-in., 3½-digit LCD with polarity and low battery indication. Overrange and auto-polarity are included. Handy pushbuttons permit rapid selection of 6 tester functions. Ranges include: 0-1000-volts DC in 5 ranges; 0-750-volts AC in 5 ranges; 0-10-A DC or AC in 6 ranges including a 200 μA range; 0-20 Megohms in 6 ranges. Pushbutton selectable, hi-low power ohms and resistance diode check is included. Audible continuity is available on the 200-ohm range.

The molded black, high-impact thermoplastic case has a sure-grip *finger tread* surface finish and has an optional tilt stand. Other optional accessories include vinyl carrying case, battery cover, high-voltage probe, external shunt, temperature probe, clamp-on AC ammeter and line separator.

Priced at only $85.00, the Model 3550-A is warranteed for a full year and is furnished completed with 9-volt battery, 42-in. test leads, screw-on alligator clips, and a comprehensive instruction manual. Literature is available from Triplett Corporation, One Triplett Drive, Bluffton, Ohio 45817. Telephone: 419/358-5015.

5-Drawer Oak Tool Chest

Jensen Tools and Alloys has introduced a wooden tool chest for the precision hobbyist. That 5-drawer handcrafted oak tool chest is ideal for safe-keeping of precision tools or for storage of parts, PC boards, bulbs, IC's, etc. Made of selected, thoroughly-seasoned, kiln-dried, dark oak, the cabinet-type drawers are of tongue and groove construction, and are cushioned with a green billiard-table felt. Drawer fronts, chest side and back are solid ½-inch oak. Center hasp, latches, drawer pulls and corner protectors are nickeled steel. Other features include a small triangular mirror mounted on the inside of the top lid, two elastic tool holders, a top till, a leatherette handle and two keys. The overall size is 14- (W) × 11- (H) × 7⅞-inch (D).



CIRCLE 826 ON FREE INFORMATION CARD

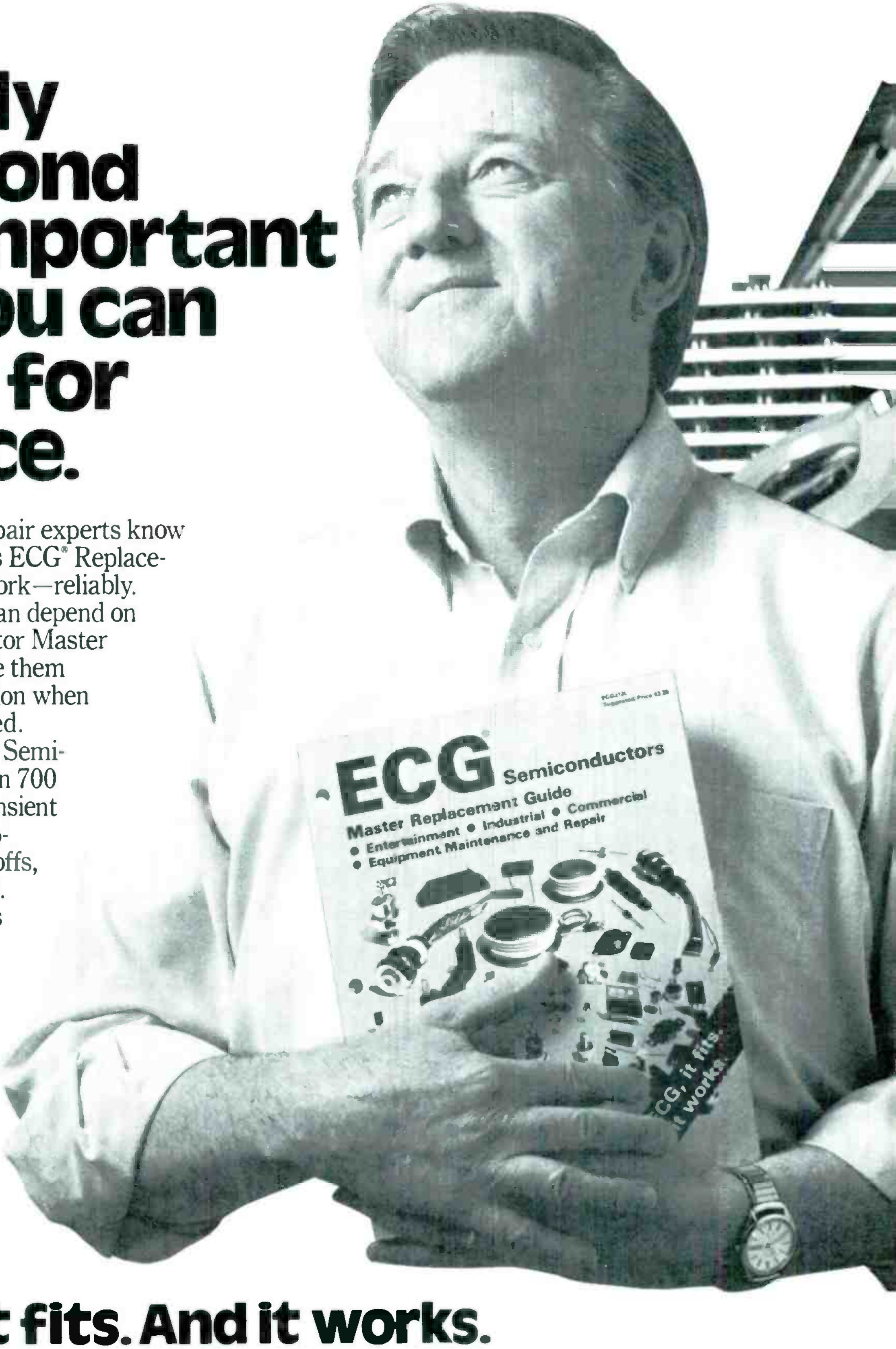
For a free catalog describing that and other tool chests, cases and tool kits write to Jensen Tools, Inc., 7815 S. 46th St., Phoenix, AZ 85040, or telephone 602/968-6231.

Cassette Deck

The new Denon DR-M11 two-head cassette deck offers many features found on the more expensive Denon cassette products currently in their line. Beginning with the transport, the new two-head cas-

(Continued on page 8)

Probably the second most important book you can turn to for guidance.



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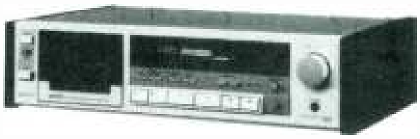
CIRCLE 824 ON FREE INFORMATION CARD

NEW PRODUCTS

(Continued from page 6)

sette deck uses the identical Denon computer-controlled *Silent Mechanism*. In addition to avoiding the annoying "clunk" sounds associated with conventional designs, Denon's *Silent Mechanism* uses a special computer-controlled circuit to check tape speed, as does a specially manufactured capstan which eliminates hub vibration, thereby reducing wow and flutter.

The DR-M11 uses Denon's non-slip, reel-drive motor system which guarantees even tape tension during playback. By



CIRCLE 827 ON FREE INFORMATION CARD

eliminating belts and clutches and controlling the motors electronically, Denon makes possible constant take-up torque, so that smooth and even tape tension is maintained throughout the play of each cassette. The result is minimization of wow and flutter, far fewer dropouts and vastly improved phase characteristics.

The new deck is equipped with Dolby B and C noise reduction as well as an MPX filter. Dolby C offers a 20-dB reduction in noise, while actually increasing dynamic-range capability in the mid- and high-frequencies.

The deck is equipped with fine adjustment capabilities for tape bias. At its center position, standard-level recording bias is assured. With either chrome or normal tapes, bias fine adjustment permits the user to extract maximum performance from various brands and formulations of tape.

Other operation and convenience features incorporated in the DR-M11 model includes: Timer record/play, one-touch record/pause, pause/record mute, output level control, and more. The DR-M11 adds Denon's convenient Program Music Search System, which permits the user to select up to 15 separate items on a single side of recorded tape. Used in conjunction with the four-digit counter, program and memory keys, that system greatly enhances the convenience of using this new deck.

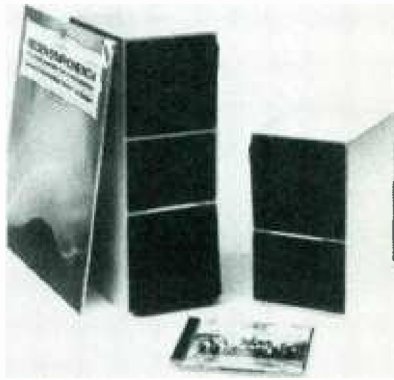
The Denon DR-M11 cassette deck is available at most audio dealers nationwide. Prices will vary.

Compact Speakers

Bang Olufsen's new Beovox CX-50 and CX-100 two-way systems provide excellent imaging and placement flexibility. The two speaker-systems share common elements. They both use a 4-inch woofer and 1-inch tweeter, and crossover at 2,500 Hz. Distortion for both is listed as less than 1 percent, and they both have a nominal 6-ohm impedance. In addition, the aluminum cabinet and distinctive Bang Olufsen style are part of both speaker systems.

The Beovox CX-50 measures 4⁵⁄₁₆- (W) × 7⅞- (H) × 7⅞-inch (D). It uses a single tweeter and woofer, can handle 50-watts RMS, weighs 7.8 lbs., and has a frequency range of 80 to 20,000 Hz. It has a black anodized aluminum finish. The CX-50 has a suggested retail price of $99 each.

The Beovox CX-100 uses a single tweeter, but two 4-inch woofers accounting for its larger (4⁵⁄₁₆-in × 12³⁄₁₆- × 7¹³⁄₁₆-inch) size. The second woofer, and



CIRCLE 828 ON FREE INFORMATION CARD

increased size, also enable the CX-100 to offer a 50- to 20,000-Hz frequency range and handle 100-watts RMS. The cabinet is finished in a choice of anodized black or brushed aluminum. The CX-100 weighs 11 lbs. and has a suggested retail price of $149 each.

For more information write to Bang Olufsen of America, 1150 Feehanville Dr., Mount Prospect, IL 60056.

Computer Prototyping Board

The *eZ* Board is a solderless experimenter system which provides a time-saving convenient method for building experimental add-ons to interface with personal computers. Features include a high-quality, glass-epoxy, printed-circuit board mounted with a set of solderless breadboarding units for building circuits. Four separate distribution buses with 50 tie-points each can be used for power ground, clock lines, reset commands and more. An array of the point blocks from which each pin of the computer's bus system (I/O channel) is clearly labelled for quick identification and is easily accessible. A four-position DIP switch is mounted on the board. Each switch position connects to a set of tie-point block

(Continued on page 10)

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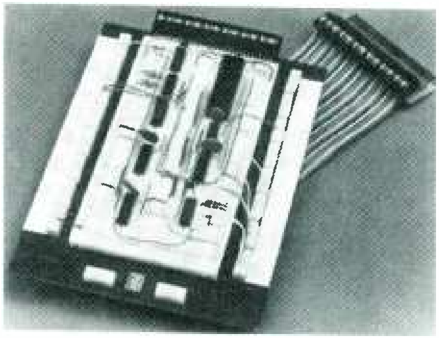
NEW PRODUCTS

(Continued from page 8)

sockets on either side to aid in the development and analysis of experimental circuits. A flat ribbon cable connects the board to the computer's bus expansion slot. The breadboarding area consists of 2090 tie-points with a capacity of 24 14-pin DIP's components with lead diameters up to .032-in. simply plug-in and are connected with ordinary solid hookup wire.



CIRCLE 832 ON FREE INFORMATION CARD

Models IPC, APC, and CPO are available for IBM-PC, Apple, and Commodore; and all other hardware-compatible computers of the same type. Models for other computers will be introduced soon. Retail price for the entire system, including cable and connectors is $174.95 each plus $5.00 shipping. For further information write to Sabadia Export Corporation, P.O. Box 1132, Yorba Linda, CA. 92686, or telephone 704/630-9335.

Hi-Fi Speakers

Jensen Audio's Concert Series home speakers bring superior sound quality to the music lover without great expense. With the Concert Series, only the sound is rich.

The top-of-the-line model 1230 is a three-way speaker that has a 12-inch low-frequency driver a 5-inch mid-range and a 3-inch tweeter. The 1230 combines high-

CIRCLE 830 ON FREE INFORMATION CARD

compliance speaker components and 140 watts of peak-power handling. The 1230 has a suggested retail price of $199 each.

Model 1030 is also a three-way speaker which uses a 10-inch, low-frequency driver with a 5-inch mid-range and 3-inch tweeter. Its peak power handling capability is rated at 120 watts. The 1030 carries a suggested retail price of $169 each.

Jensen's third Concert Series speaker is model 820 which is a two-way speaker that uses an 8-inch low-frequency driver and a 3-inch tweeter. The 820, rated at 100-watts peak, was designed for efficiency. Model 820 has a suggested retail price of $119 each.

Jensen's products are available at audio outlets nationwide.

Weather Chart Recorder Kit

Alden Electronics has a professional-quality, facsimile Weather Chart Recorder Kit designed for hobbyists, amateur meteorologists, radio hams, educators, students, pilots, or anyone else interested in receiving their own weather charts and weather satellite pictures at home or the office.

The easy-to-assemble kit provides a re-

CIRCLE 820 ON FREE INFORMATION CARD

NEW PRODUCTS

corder that, when connected to a stable high-frequency, general-coverage, SSB receiver and suitable antenna, can receive weather charts, satellite pictures, and oceanographic data from over 50 transmitter sites around the world.

Facsimile weather-chart transmissions are a free government service available to anyone with the means to receive them. Up to now, the cost of equipment has prohibited many people interested in

CIRCLE 833 ON FREE INFORMATION CARD

weather from taking advantage of that valuable service. The new recorder in kit form is affordable, so the hobbyist or home user can receive the same detailed weather charts currently used by government and professional forecasters. You can DX and receive weather charts from transmit sites in Italy, Japan, Russia, and many other countries throughout the world. Since all charts use the same symbols by international agreement, charts can be interpreted easily.

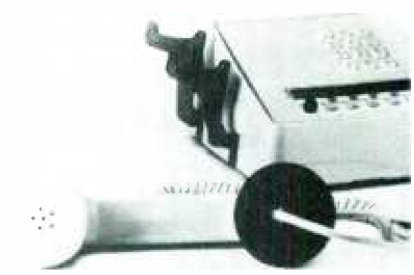
The kit can be completed in five to six hours. An illustrated, step-by-step assembly manual, with separate operator's manual and a worldwide radiofacsmile frequency guide and broadcast schedule are provided. All major components and circuit boards are preassembled and tested.

The recorder runs at 120 scans per minute on standard 117-volt, 60-Hz power and consumes 30 watts when printing and 10 watts in standby mode. Low-cost paper cassettes available from Alden provide approximately 50 charts, 11-inches wide. The Weather Chart Recorder Kit costs $995.00 plus $5.00 shipping and handling in the U.S. plus applicable state sales taxes. For additional information contact Alden Electronics, Washington Street, Westboro, MA 01581, or telephone 617/366-8851.

Telephone Modem Attachment

This innovative device called a Black Jack, increases the usefulness of portable computers. The Black Jack facilitates the use of a telephone modem for computer-to-computer access in hotels, offices, or other places on the road. It attaches to the telephone in seconds. Simply unscrew the telephone mouthpiece and microphone, and replace it with the Black Jack. Insert the RJ11C direct-connect line cord from the telephone itself. Black Jack sells for below $50.

More more information or for a free catalog of other unusual and special electronics tools and equipment, write or call Jensen Tools Inc., 7815 S. 46th Street, Phoenix, AZ 85040, or telephone 602/968-6241.



CIRCLE 831 ON FREE INFORMATION CARD

CIRCLE 821 ON FREE INFORMATION CARD

ON DX'ING

JENSEN

Tuning In English Language Broadcasts

"WHAT CAN I HEAR ON SHORTWAVE?" Newer shortwave listeners often ask that question. Actually it's not all that easy to give a short, snappy answer.

There are thousands of shortwave stations. They range all around the globe, with radio signals coming at us from more than 200 different countries.

Many are low-powered—one kilowatt, 100 watts, or even less. A station in Peru, whose signals sometimes are heard in the U.S. and Canada, runs a *measly* 12 watts! That power won't get an ordinary table lamp to glow!

Others, the big guys of international broadcasting, have transmitters each pumping out hundreds of thousands of watts of shortwave power.

Shortwave stations of the world are packed into a dozen broadcasting bands between 11 and 120 meters, with plenty of strays operating on out-of-the-way, out-of-band frequencies.

Some of those DX targets are a snap to hear, regardless of how much SWL'ing experience you have, or the receiver you use. Other stations seem to be sometime-things, audible when reception conditions are right, but then absent for weeks, or even months.

Still other outlets are so tough to hear, because of short schedules at impossible times of day. Also, because of low-powered transmitters or other factors, they are seldom, if ever, logged in North America.

When an SWL asks what he or she can hear, it usually means, "What can I hear regularly and easily?" For the beginning listener, it often means, also, "What can I hear in English?" If the question at the head of this column is narrowed to stations broadcasting in English, the answer is a bit easier. But it isn't necessarily a short answer.

There are more than 100 different countries with shortwave stations broadcasting (at least sometimes) in the English language. More than half of those stations could be considered reasonably good bets for most shortwave listeners.

Besides those, I'll have some suggestions for hearing some additional SW targets which broadcast in languages other than English. That's where the real DX'ing starts. Give 'em a try, guys!

In this, and coming columns, I'll take a continent-by-continent look at what you can hear, and when and where to tune. Let's start where most people do: with Europe. Here's a selection of European stations for you to try.

Netherlands— One of the most popular and widely heard of the European broadcasters is *Radio Nederland*. The station has several relay stations around the world, including one on the island of Madagascar, off the east coast of Africa, and on Bonaire, one of the Netherlands Antilles, just north of South America.

The latter relay beams strong signals into North America during the evening hours here, 0230-0325 Universal Coordinated Time (UCT)) to east coast North America: 0530-0625 UCT to west coast North America. The frequencies are 6,165 and 9,590 kHz.

To hear transmissions of the same programs directly from transmitters in Lopik, Netherlands, try tuning 9,895 kHz. And you'll find the *Radio Nederland* (remember, spell the name using *d* not *t*, and no *s*) *Happy Station* program, a listeners' favorite for simply decades, during the Sunday schedule.

Belgium—Just next door to Holland, the *Belgian Broadcasting Service, BRT*, can be heard 0030-0115 UCT on a pair of shortwave frequencies, 9,925 and 11,620 kHz, in the 31- and 25-meter bands, respectively. You'll find its DX program on Mondays.

Albania—The Soviet Union, and other eastern European broadcasters, are tame by comparison with the anti-U.S., anti-West broadcasts of Albania's *Radio*

THIS IS THE HOME of the *Voice of Hope*, a Gospel radio station in southern Lebanon which has been politically controversial at times in the past. The station has been on the air since January, 1981 in that strife-torn Middle East country. The shortwave signals of that station can be heard in the U.S. before 0100 UCT on 6,215 kHz.

JENSEN ON DX'ING

Tirana. *R. Tirana's* voice is a throwback to the vitriolic days of the Cold War of the '50's. While its subject matter may be something of a novelty, it gets boring fast.

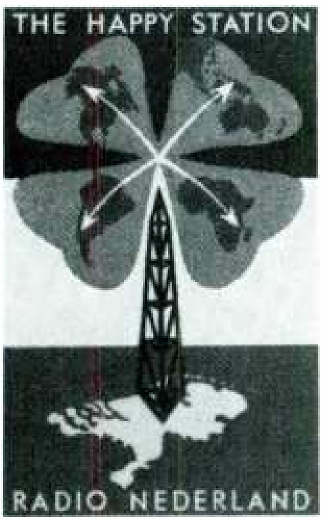
If you want to tune in, its easy to find *R. Tirana's* powerful signals. There are half-hour nightly segments in English, beginning at 0000, 0130, 0230, 0330 UCT. For the first segment, the frequencies are 7,060 and 9,760 kHz. For the second and third periods, 7,120 and 9,760 kHz. For the last, substitute 9,750 kHz for 9,760 kHz.

Norway—*Radio Norway* has a very limited English service. Other than mere identification announcements, English is heard only on Mondays, with the *Norway Today* program.

Here are some times and frequencies to try: 0400-0430 UCT on 9,570, 9,705 and 11,870 kHz, and 0500-0530 UCT on 6,015, 9,565, 11,865 and 15,165 kHz.

Ireland—Here's something of a toughy and a sometime operation. *Radio Dublin International* is an unlicensed station which can be heard at times on the out-of-band frequency of 6,909 kHz during the North American evening hours.

Ireland hasn't had its own government shortwave outlet for many years, and repeatedly denies that it has any interest in broadcasting to overseas audiences on shortwave. But *RDI*, essentially a *pirate* operation which, like others of its kind, has been more or less ignored by Irish officialdom—filled the vacuum. While there are other Irish pirates on the air, RDI, with an 800-watt transmitter, has enough power to leap the pond to North America under the right conditions.



A MINI-POSTER FROM *Radio Nederland*, called "The Happy Station" for more than a half century. The poster shows the worldwide scope of the station's shortwave broadcasts.

Radio Dublin International wants to become legal, however, and is lobbying the government to include shortwave stations of its type in enabling legislation expected to come before the Irish Parliament early in 1985. The station asks for letters supporting its efforts from listeners and shortwave fans. Send your letters to Mr. Jim Mitchell, Minister of Posts and Telegraph, Leinster House, Dublin 2, Ireland.

USSR—Remember the old *Chickenman* spoofs of radio-serial dramas? Well, *Radio Moscow* English programs, like the pseudo-super-hero Chickenman, are everywhere, everywhere! Soviet broadcasting is a subject in its own right,and I'll cover that more fully in a later column.

For now, suffice it to say that *World Service Broadcasts*, *Radio Moscow's* 24-hour-a-day English programming, is specifically beamed to North America for 14 hours a day, from 0300-03500 and 1000-2000 UCT. Additionally, regional English programs to North America's

(turn page)

JENSEN ON DX'ING

East Coast can be heard between 2200 and 0300 UCT, and to West Coast listeners from 0300 to 0700 UCT. There are many frequencies in the 21-, 17-, 15-, 11-, 9-, 7- and 6-MHz bands to try. Tune a bit; you can't miss *Radio Moscow*.

Poland—I get more request for schedule and frequency information for Polish and Greek shortwave broadcasts than for any other European outlets. Most of those requests are from expatriates, or from second-generation Polish and Greek Americans who want to hear broadcasts from the old country.

Radio Polonia has Polish-language broadcasts for its merchant seamen from 0000 to 0200 UCT, followed by English programming to 0355, directed to North America. The frequencies are 6,095, 6,135, 7,145, 7,270, 9,525, 11,815 and 15,120 kHz.

Greece—For the *Voice of Greece*, broadcasting from Athens, try 7,315 kHz from 0000 UCT. It has Greek programming to North America. For English/Greek transmission, also to our continent, tune 11,645 kHz, 0100-0145 UCT.

France—For a major western European country, France does surprisingly little English-language shortwave programming. But you can find *Radio France International* in English on 7,125 kHz at 0400 UCT.

Luxembourg—*Radio Luxembourg* was a pop music station years before the traditional and, let's admit it, conservatively hidebound government broadcasters of western Europe were forced to follow suit, at least in some services. Radio Luxembourg can be heard in English from 0000 UCT on 6,090 kHz, with *Earthling* news programs on the hour.

Denmark—Once one of the most popular of the European stations, with a much-listened-to evening transmission to North America. But the Danes gave up on English-speaking listeners long ago. Today Radio Denmark has only Danish programs, with an occasional English language identification announcement thrown in. But, it has a transmission beamed to Danes in the North American area at 1400, 1600 and 2000 UCT on 15,165 kHz.

Switzerland—*Swiss Radio International* is another listeners' favorite from Europe. English programming from Bern to North America can be heard at 0145-0215 and 0430-0500 UCT on 9,725 and 11,715 kHz, plus 6,135 and 9,635 kHz during the earlier period.

The *SRI* DX'ers program, *Swiss Shortwave Merry-Go-Round* is aired on the 2nd and 4th Saturdays of each month, and is hosted by the two Bobs, popular SW personalities.

You can hear me on the program too, on the second Saturday program, every other month, with a brief segment on shortwave domestic radio, presented in cooperation with the *Radio Database International* publications.

And, there are at least a dozen other European stations you can tune. It's random selection. Do some hunting on the SW bands, for that's what DX'ing is all about—the quest for what you've not yet heard! Good luck!

Mailbag, Grabbag

I'll wrap up this column with a couple of letters from you readers. By the way, I'm always glad to hear your comments and questions. Send them to me in care of **Hands-On Electronics**, 200 Park Avenue South, New York, NY 10003.

Tell me what you're hearing on shortwave. And let me see a photo of you and your DX-den, receivers and all. As space permits, I'll run your photos in this column.

First a question from Harold Martin, Spokane, WA, who is puzzled about a pair of similar sounding stations on the 49-meter band.

"I hear two stations that refer to Sandino, one on 6,2000 kHz, the other on 6,205 kHz. I suppose those Spanish-speaking stations are Nicaraguan, but what else can you tell me?"

On 6,200 kHz is *Radio Sandino*, a relayed shortwave version of the government medium-wave station in Managua. But the station on 6,205 kHz is called *La Voz de Sandino*, or more recently, the *Voice of Free Nicaragua*. It is a clandestine operation opposed to the Managua regime. Sometimes you'll hear English programming from the latter around 0000 UCT.

And from Bob Piencikowski in Miami: *"What's the relationship between frequency and meters/meter-band? I hear both announced by stations on the air."*

Radio frequency describes the number of times the length, in the metric system measure, of the radio-wave cycle.

In a practical sense, the information tells you where to tune your receiver. For decades, though, receivers have been calibrated by frequency, in kilohertz, rather than by wavelength, in meters, although either gives you the same basic information. Wavelength designations survive today mostly in references to shortwave bands.

The formulas for coverting frequency to wavelength (λ) and vice versa are:

$$\lambda \text{ (meters)} = 300{,}000/\text{Freq. (kHz)}$$
$$\text{Freq. (kHz)} = 300{,}000/\lambda$$

That brings us to the foot of another column. Until next time, good listening.

—*Don Jensen*

LETTERS

What's in a Name?

I just spent half the afternoon looking over the several newsstands in my neighborhood for my favorite magazine, **Special Projects**. When I couldn't find it anywhere, I settled for a copy of **Hands-On Electronics** only to find that it was my old friend. That convinced me, so enclosed please find my order for a subscription, and keep up the good work.
F.M., Danbury, CT

We keep telling you and telling you! Subscription is the only *way to go!*

BCB Booster

Where can I get the plans for a good broadcast-band booster?
H.T., Hutchinson, KA

Bet you missed our No. 10 issue of **Special Projects** *in which we ran a broadcast-band booster project that may be the hotest item in that issue. You can get a copy by requesting the issue and including a check to cover the cost of the issue ($3.00) and postage-handling ($1.00).*

Replacement Guide

Why can't the makers of semiconductors use one-tenth the number of items they now stock, and eliminate duplication between each other, and themselves?
D.D., Winnemucca, NV

Because they can't! However, there are several good semiconductor replacement guides on the market, and the one I saw just yesterday was published by Philips-ECG. To get your copy, call 1-800-225-6107 and you'll obtain the address of the nearest ECG distributor. Visit him and purchase your copy of the guide.

Position Counts

I'd like to take issue with the *Quick Code Practice Oscillator* article on page 43 of the last issue. The top photograph shows the telegraph key mounted on top of the cabinet. That is not a "natural" position for a key, as it is raised off the tabletop. The key should have been placed in front of the box, and at table level, so the operator could learn to use proper wrist action while sending.
P.R., San Mateo, CA

Correct! But the key isn't "mounted" on top of the cabinet. It was simply placed there to make a more-compact photograph. Us editor-types have to think in terms of space conservation! (Believe that one, and I'll slip you another line!)

Unscrambling

I have read about video scrambling, but much of the material was disjointed, that is, picked up from several magazines and books. Where can I get one good publication on video scrambling techniques?
B.M., Waco, TX

The title of the book you are seeking is Video Scrambling Techniques! *You can get your copy for only $12.95 plus $1.50 for first-class postage and handling from Randon Access, Box 41770-R, Phoenix, AZ 85080.*

Letter from Heaven

I don't expect you to publish this letter, but I had to pay you a compliment. Your last issue of **Hands-On Electronics** was a real winner. It was an excellent mix of articles with something for everybody, and I'm certain that it isn't an easy job to try to second-guess readers' wants and needs. You guys do a great job, and I wanted you to know how satisfied I was.
R.D., Durango, CO

Are you kidding? The boss reads this column too! Best way to see your letter in print is to pay us a compliment!

Sharpen Pencil

I have been reading all sorts of electronic magazines for many, many years, and would like to know how to go about writing an article for a magazine like **Hands-On Electronics**? Any tips?
S.T., Brooklyn, MD

We could fill books with writing tips. The best bet, if you've got a pet project that is really unusual and unique, with lots of appeal, is simply to write it up. Type it double spaced, lots of margin, provide good, clear diagrams and top-notch black-and-white photos (with the negatives, please). If we agree with your appraisal of your own work, we'll print it and you'll not only see your name in print, you'll get paid for it. But be warned! Most of our staff editors started that way.

Sudden Heat

I noticed something interesting that I thought I ought to report on. I built the *Auto-Temp* (Page 84—**Hands-On Electronics**) and was performing the assembly last steps, encapsulating the ends of the temperature-sensing probes in eopxy. While waiting for the epoxy to set, I tentatively turned on the unit, and noticed a marked increase in the temperature readings for both inside and outside. They continued to rise and then, after stabilizing, settled back to normal readings. How do you account for that phenomenon?
R.T., Kalispell, MT

Your experience was actually quite normal. Epoxy is an exothermic, in that it gives off heat as it sets. The probes were merely recording the increase in heat. ■

BOOKSHELF

Computer Crazy
by Daniel Le Noury

Are computers making you crazy? Or are you crazy about computers? Either way, SYBEX has just released a book that will make you laugh about them.

Computer Crazy is a book of hilarious cartoons drawn by Daniel Le Noury,

the French illustrator who has made SYBEX's book covers famous for eye-catching graphics. Uncannily on the mark or outrageously off the wall, those cartoons play on people's worst fears and wildest fantasies about computers.

SYBEX, Inc., 2344 Sixth Street, Berkeley, CA 94710. Paperback, 96 pages, $5.95.

The Complete Home Video Book
by Peter Utz

Here is a most comprehensive, up-to-date handbook of information on how to buy, connect, operate, maintain, and troubleshoot video equipment. Unlike most other books on that subject, which obscure important details with unnecessary technical jargon, *The Complete Home Video Book* provides you with a wealth of critical information in clear, simple terms. Everything is mapped out step by step, starting from basic concepts and building to more advanced elements of video use. Common video terms are highlighted, making it easier than ever before to remember the information. Best of all, the text is easy to understand and so thoroughly illustrated that no prior electronics or photographic knowledge is needed to understand and master the skills presented.

The Complete Home Video Book is a must for anyone involved in the home-video revolution. The appendixes list home-video books, periodicals, tapes, and manufacturer listings.

Dr. Peter Utz has produced and directed more than 500 instructional-TV productions for the City University of New York. He has also published *Video User's Handbook* and more than 35 articles in media and television journals, and presently supervises the media department at the County College of Morris in Randolph, New Jersey. He also teaches professional and home-video courses.

Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. Hardcover, 562 pages, $29.95.

Introduction to WordStar
by Arthur Naiman

There has long been a

(Continued on page 20)

Learn robotics and industrial control as you build this robot

New NRI home training prepares you for a rewarding career in America's newest high-technology field.

The wave of the future is here. Already, advanced robotic systems are producing everything from precision electronic circuits to automobiles and giant locomotives. By 1990, over 100,000 "smart" robots will be in use.

Over 25,000 New Jobs

Keeping this robot army running calls for well-trained technicians . . . people who understand advanced systems and controls. By the end of the decade, conservative estimates call for more than 25,000 new technical jobs. These are the kind of careers that pay $25,000 to $35,000 a year right now. And as demand continues to grow, salaries have no place to go but up!

Build Your Own Robot As You Train at Home

Now, you can train for an exciting, rewarding career in robotics and industrial control right at home in your spare time. NRI, with 70 years of experience in technology training, offers a new world of opportunity in one of the most fascinating growth fields since the computer.

You need no experience, no special education. NRI starts you at the beginning, takes you in easy-to-follow, bite-size lessons from basic electronics right on through key subjects like instrumentation, digital and computer controls, servomotors and feedback systems, fluidics, lasers, and optoelectronics. And it's all reinforced with practical, hands-on experience to give you a priceless confidence as you build a programmable, mobile robot.

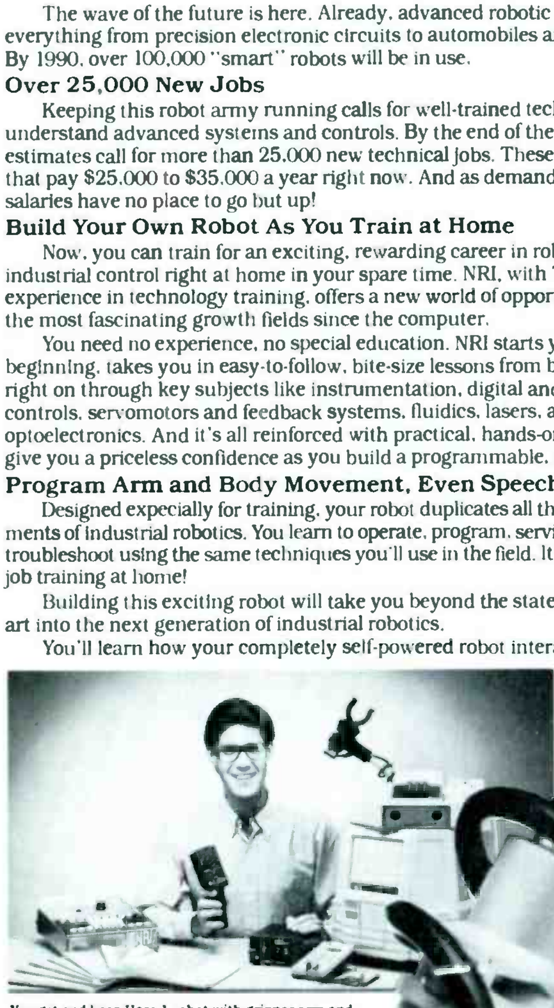
Program Arm and Body Movement, Even Speech

Designed expecially for training, your robot duplicates all the key elements of industrial robotics. You learn to operate, program, service, and troubleshoot using the same techniques you'll use in the field. It's on-the-job training at home!

Building this exciting robot will take you beyond the state of the art into the next generation of industrial robotics.

You'll learn how your completely self-powered robot interacts with its environment to sense light, sound, and motion.

You program it to travel over a set course, avoid obstacles using its sonar ranging capability. Program in complex arm and body movements using its special teaching pendant. Build a wireless remote control device demonstrating independent robot control in hazardous environments. You'll even learn to synthesize speech using the top-mounted hexadecimal keyboard.



You get and keep Hero 1 robot with gripper arm and speech synthesizer, NRI Discovery Lab for electronic experimentation, professional multimeter with 3½-digit LCD readout, 51 fast-track training lessons.

Training to Build a Career On

NRI training uniquely incorporates hands-on building experience to reinforce your learning on a real-world basis. You get professional instruments, including a digital multimeter you'll use in experiments and demonstrations, use later in your work. And you get the exclusive NRI Discovery Lab®, where you examine and prove out theory from basic electrical concepts to the most advanced solid-state digital electronics and microprocessor technology. Devised by an experienced team of engineers and educators, your experiments, demonstrations, and equipment are carefully integrated with 51 clear and concise lessons to give you complete confidence as you progress. Step-by-step, NRI takes you from the beginning, through today, and into an amazing tomorrow.

Send for Free Catalog Now

Send for NRI's big free catalog describing Robotics and Industrial Control plus over a dozen other high-technology courses. You'll see all the equipment you get in detail, get complete descriptions of every lesson, find out more about career opportunities for trained technicians. There's no cost or obligation, so send today. Your action today could mean your future tomorrow.

NRI SCHOOLS

McGraw-Hill Continuing Education Center
3939 Wisconsin Ave.
Washington, DC 20016

WE'LL GIVE YOU TOMORROW.

BOOKSHELF

(Continued from page 16)

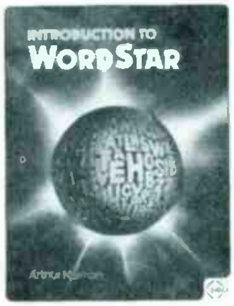
need for a well-organized, clearly written introduction to WordStar, MicroPro's popular word-processing program. Wordstar, like all of MicroPro's other software, is an impressive program; but the manuals that explain it tend to be intimidating, repetitive, and stuffy. Now we have a new training guide, which attempts to fill the gap.

Well-organized, well-written, and fun is exactly what this book aims to be. If you already own WordStar, it will clarify the workings of features that you only have a foggy comprehension of, or which you don't even know exist. (It is a rare WordStar owner who really understands what the program can do.)

If you've just bought WordStar, this book will quickly and easily teach you how it works, so you can use the program's own manuals to look things up in, rather than as primers. If you are considering buying WordStar, you will get an excellent sense of the program's capabilities, and of whether or not it can do what you need done.

If you just want a good idea of what a word-processing program can do, this book will give you one, using WordStar as an example.

What *Introduction to WordStar* won't do is replace WordStar's manuals. Its aim is to

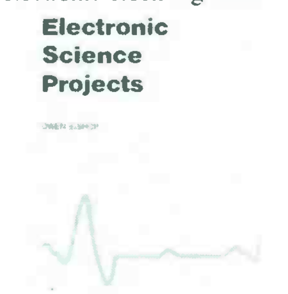


introduce subjects, not to describe them exhaustively.

SYBEX, Inc., 2344 Sixth Street, Berkeley, CA 94710. Paperback, 202 pages, $14.95.

Electronic Science Projects
by Owen Bishop

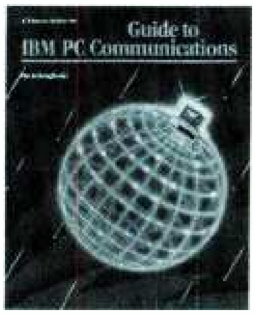
This fascinating book contains twelve electronics projects all having a strong scientific flavor. The way in which they work, and how to build and use them, is clearly explained. Those projects range in complexity from a simple color temperature meter to an infra-red laser. There are novelties such as an electronic clock regulated



by a resonating spring, and an oscilloscope with a solid-state display. Also included are scientific measuring instruments like a pH meter and an electrocardiograph.

That unusual collection of projects is strongly recommended to all hobbyists who are looking for something different to build.

Electronic Technology Today, Inc., P.O. Box 240, Massapequa, NY 11762. Paperback, 135 pages, $5.75 plus $.75 for postage and handling.



Guide to IBM PC Communications
by David Kruglinski

All IBM PC users will benefit from this invaluable resource to communication networks that shows how the IBM PC can communicate with mainframe and minicomputers as well as other IBM PC's. Readers will learn about a range of convenient applications from sending a telex to trading stocks. Combining product descriptions and practical examples, David Kruglinski highlights communication techniques available to all users.

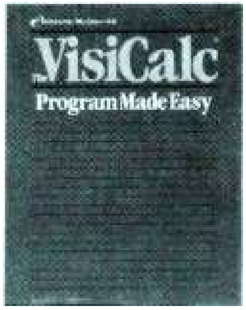
Detailed descriptions are provided for various information networks including, The Source, CompuServe, and Dow Jones/News Retrieval Service.

Osborne/McGraw-Hill, 2600 Tenth Street, Berkeley, CA 94710. Paperback, 250 pages, $15.95.

The VisiCalc Program Made Easy
by David M. Castlewitz

That text is a tutorial, a companion to other references you may have read about the VisiCalc program, and to what you may have learned from other users or in formal courses. However, the book is meant to be used, not just read. The lessons should be followed while you are at your computer. You are encouraged to try the formulas, commands, and functions as they are explained.

Some of what you will



learn from this book concerns basic skills. You need to master those rudimentary elements to become proficient in using the VisiCalc program. But the book also goes beyond the basics.

Osborne/Mcgraw-Hill, 2600 Tenth Street, Berkeley, CA 94710. Paperback, 195 pages, $12.95. ■

How to build a *1920's Style*

By David Whitby

Tubes are almost gone, but not forgotten. Now is the time to assemble this little gem, to bring an ancient circuit to life again and gain a valuable memento of the past "golden radio era."

Wireless Receiver!

AMID THE EVER INCREASING PACE AND ADVANCEMENT OF electronics technology there exists a growing interest in the history of radio or *wireless* as it was then known.

The collecting and restoration of vintage receivers components, and all manner of paraphernalia from the pioneering days has become an established hobby, with a growing number of clubs, societies, and publications being formed around the world to cater to the many enthusiasts of this relatively small area of antiquity.

The author was first bitten by the vintage radio bug whilst involved in designing vintage data communications equipment in the mid 1970's. Was it brought on by an overdose of plastic microchips, a touch of nostalgia for *the good old days*, or simply a desire to find out where all *this started*? Probably all three, but it wasn't long before all sorts of strange and dusty haunts were being explored in search of crystal sets, vacuum tubes, books, and innumerable other relics of the technological past.

The 1920's

The one-tube set described here* came about as the result of a desire to build a radio receiver from scratch, using the circuits and techniques of the 1920's. The wireless literature of the era shows the 1920's to have been a most active and interesting period with great technical improvements having been effected during and after World War I, and then the *coming of age* with the advent of broadcasting during the early 1920's.

There was phenomenal growth in the component and set manufacturing industry with large numbers of new firms springing up almost overnight, but with only a handful being destined to last out the decade. The surge of public interest and intrigue at *wireless*, the new wonder has possibly not been equaled since—even by video or computers. That was truly the era of the *home brew* set, a large proportion of receivers being made at home from plans published in the numerous wireless magazines of the time.

That set, while not intended to duplicate a particular design of the era, contains many early circuit and construction techniques, and has the appearance and feel of the genuine article. It has been named the Unidyne in keeping with the many other *dynes* of the era (Neutrodyne, Solidyne, Infradyne, etc.)—the name Unidyne was actually used on a British home-constructor's set of around 1924.

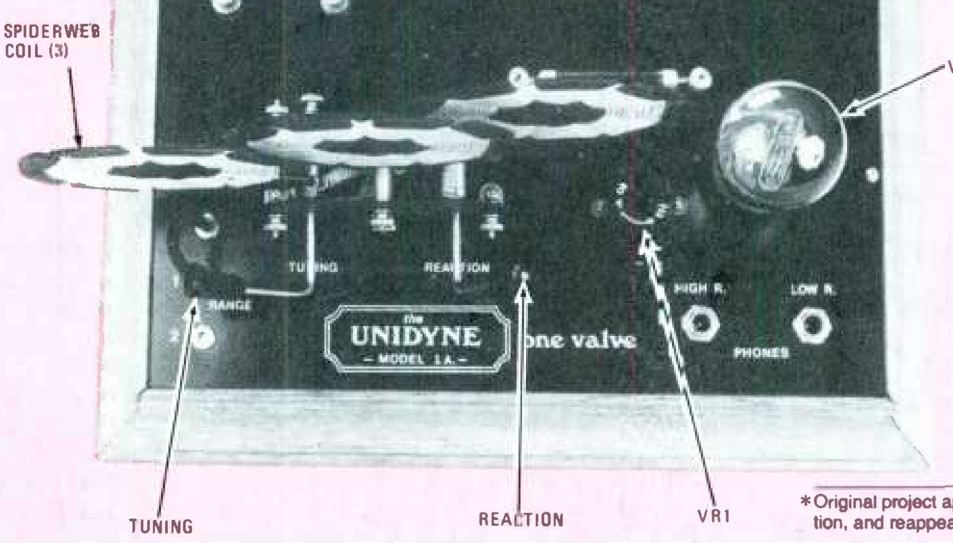
As much use as possible has been made of original type materials, such as a mahogany base, bakelite panel, cotton-covered wire, spiderweb coils, and early-type tubes.

For those who have an interest in the pioneering days, building the Unidyne wireless set will provide hands-on experience in such skills as the ancient art of spiderweb-coil winding, variometer tuning, leaky-grid detection, "A" and "B" batteries, and swinging coil-reaction control—all essential knowledge for the vintage radio builder.

Despite the antiquity of the design, the set is a surprising performer; and, at night—given a reasonable long wire antenna (and preferably a ground)—it will pull-in many country and interstate stations, once one has become adept at manipulating the tuning and reaction controls.

Circuit Details

The circuit is of the leaky-grid, regenerative-detector type (Fig. 1), built around a single battery-operated triode vacuum tube. The one pictured is a Marconi-type 210LF which has a British 4-pin base and a 2-volt filament. You don't have to use that triode tube, for just about any RF tube of the period will work as well. (The editor has used a 37 and 76 vacuum tubes in similar circuits. Other tube types you may want to try are the 24A, 26, 27, 40, 57, 75, 2A6, 6C5, UY227, and just about any other antique triode tube even though it was designed for audio work.)



WE CALL IT THE UNIDYNE! This simple one-tube device functions as a leaky-grid, regenerative-detector circuit that has surprisingly excellent *pull-in* power and sensitivity. Tuning is accomplished by actuating the tuning lever that in turn positions the left spiderweb coil closer to the center spiderweb coil, thereby increasing the combined inductance in the tuned-resonant circuit. Regenerative feedback is achieved by toying with the reaction lever that positions the right spiderweb coil.

*Original project appeared in Electronics Australia, November, 1983 edition, and reappears here by permission.

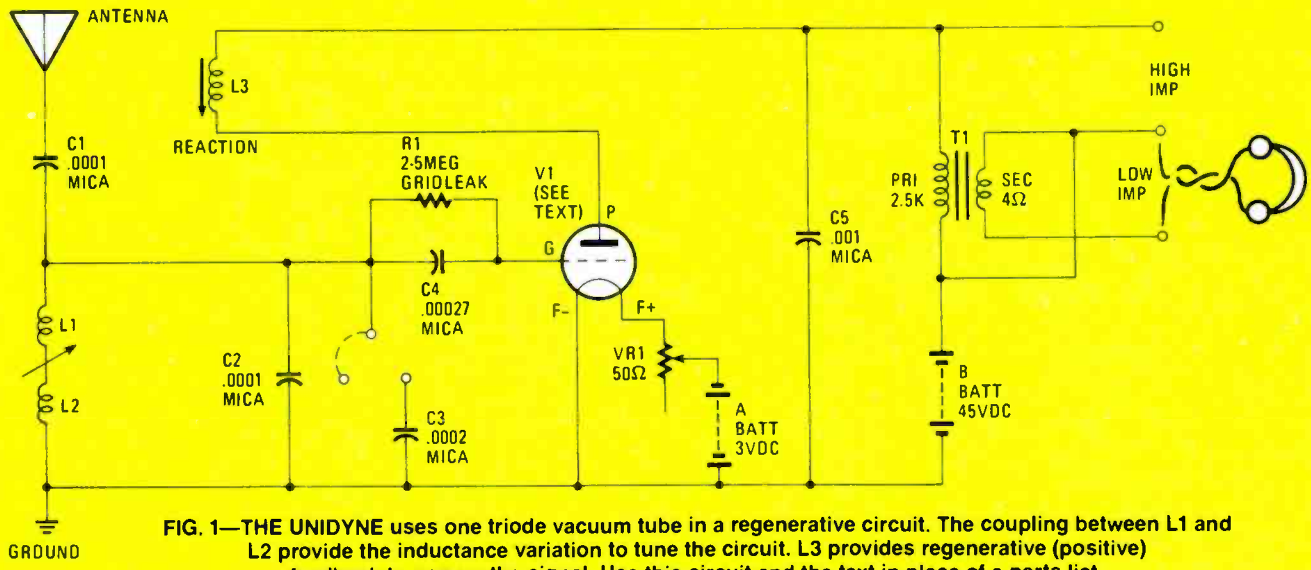


FIG. 1—THE UNIDYNE uses one triode vacuum tube in a regenerative circuit. The coupling between L1 and L2 provide the inductance variation to tune the circuit. L3 provides regenerative (positive) feedback to pep-up the signal. Use this circuit and the text in place of a parts list.

Filament current is supplied by two D-cells (for 2-volt filaments) mounted in holders under the panel. The tube plate supply (B battery) is 45-volts DC made up of five No. 216 (or P1) 9-volt DC batteries mounted in a specially made holder also under the panel. You can freely substitute battery types as requiredin your design.

For tube filaments and heaters requiring more than 2-volts DC you may have to add more batteries, or *cheat*! As the power requirements increase to the filaments, you may want to substitute a hidden step-down filament transformer for economy's sake. It all depends on the tube you use.

Audio is output into headphones, and the older the headphones appear, the more authentic in appearance will be the receiver in which they are plugged. An audio-output transformer T1 provides either high impedance (1000- to 4000-ohm) for the golden-oldie headsets, or low impedance for modern stereophones.

Signals picked up by the antenna are fed via C1 (Fig. 1) to the tuning circuit consisting of L1, L2, C2, and C3. Tuning is carried out by varying the inductance of the L1-L2 combination. Inductors L1 and L2 are identical flat radially wound *spiderweb coils* connected in opposition so that as their relative mechanical coupling is varied there is more (when close coupled) or less (when loosely coupled) cancellation of the equal and antiphase inductances. That sounds like mumbo-jumbo, but it means that the total inductance is varied over a range that will tune in AM broadcast stations. Known as *variometer* tuning, that system was popular in various forms in the early days; it soon gave way to the fixed inductance/variable capacitor system which is still used today, in order to cover the entire broadcast band two plug-selectable fixed capacitors (C2, C3) are used.

The RF signal selected by the tuning circuit is detected by the grid of the tube, the detection system being known as *leaky-grid* or *cumulative-grid* detection. In simple terms, the grid/filament combination of the tube may be looked upon as a diode, with the triode concept of the tube ignored for the moment. On positive half-cycles of the incoming signal, the diode conducts, current flows through R1, a voltage is developed across R1, and C4 is charged to that voltage. The polarity of the charge is negative toward the grid and positive towards the filament. On the following negative half-cycle the diode does not conduct, but the grid is held negative by the charge on C4. That charge, however, commences to *leak* (discharge) away through R1. If the next positive half cycle is weaker than the previous one, the voltage across C4 will continue to fall. If it is stronger, the C4 voltage will rise. The time constant for R1/C4 is so chosen that it is just short enough to allow the charge on C4 to follow the highest modulation frequency. Those grid variations are amplified by the tube's triode action, and appear as much stronger signals in the plate circuit.

Regeneration

At the same time, the RF signal applied to the grid is also amplified and appears as a stronger signal in the plate circuit. The secret of high amplification of those simple sets lies in the use of regeneration or *reaction* as it was often called. That involves the coupling back of some of the amplified RF signal into the tuning circuit in such a way as to add to or assist the original signal (positive feedback). That feedback increases the sensitivity and selectivity of the receiver and makes long-distance reception possible with simple circuitry.

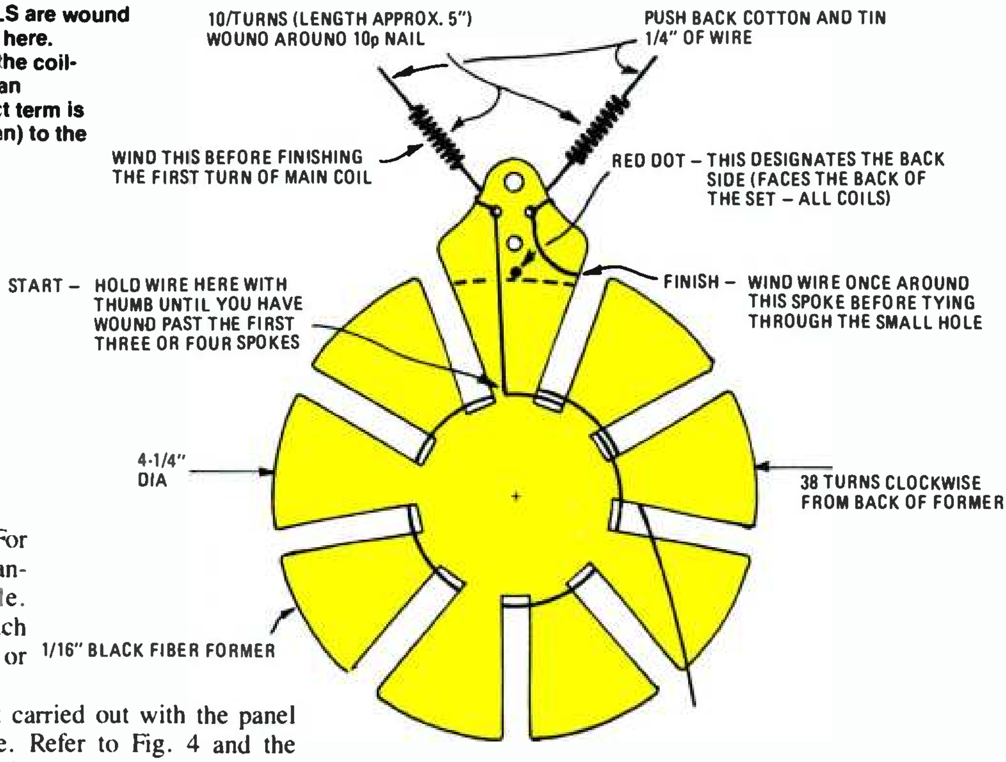
Regeneration is accomplished in this case by a third spiderweb coil connected in the plate circuit and arranged with variable mechanical coupling to the other coils to enable the amount of regeneration to be precisely controlled. In use, the reaction coupling is increased until the set is just short of the point of oscillation, or howling, and it is at that point that the receiver is in its most sensitive and selective condition.

Capacitor C5 serves to bypass the RF component, which would otherwise tend to be blocked by the impedance of the headphone circuit. Transformer T1 is a 2500-ohm:3.5-ohm vacuum-tube, audio-output transformer. On/Off control is provided by the filament rheostat VR1, which disconnects the filament supply in its anticlockwise position. That also cuts off the B battery current, which flows due to filament emission. Should you have trouble finding a control of that type, include an on/off toggle switch in the A supply circuit.

Construction

Exact details for the Unidyne cannot be given because the layout of parts depends so much on the parts you obtain, and those power-supply variations you use that differ with the

FIG. 2—THREE SPIDERWEB COILS are wound identically. The details are shown here. Should you be poor at sketching the coil-former to the correct size, obtain an enlarged photo copy (the incorrect term is Xerox, but you know what we mean) to the 4-1/4-in. diameter size indicated.



author's original conception. For the same reason, a Parts List cannot be supped with that article. However, read on! There is much you can do to make your own, or compromise.

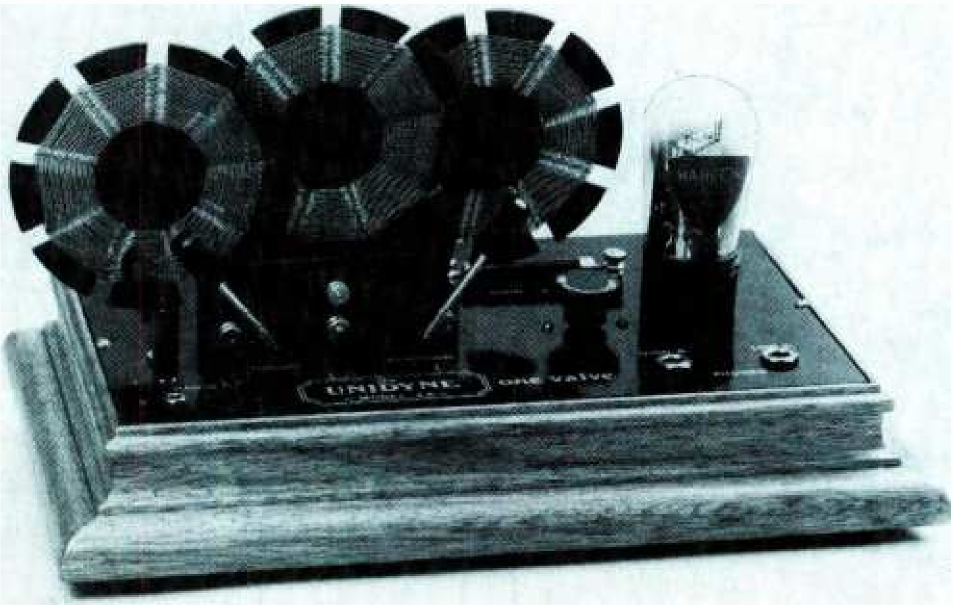
Assembly and wiring is best carried out with the panel mounted into the wooden base. Refer to Fig. 4 and the photos. The first job to be done is to prepare and finish the base. That is made from a mahogany molding (similar to a picture-frame molding) which is obtainable at lumber-supply centers and picture-frame outlets. Start by thoroughly sanding down the base with No. 100 sandpaper, taking care to always sand along the grain. Finish off by sanding super smooth with No. 280 paper observing the same precautions.

Dust down and apply one coat of satin (not gloss) clear polyurethane floor finish with a good-quality small brush, taking care to avoid runs and bubbles. Allow it to dry completely then sand lightly all over with fine paper. Apply a final even coat and leave to dry in a warm, dust-free place.

While the base is drying, the coils can be wound. The three coils are identical, consisting of 38 turns of No. 22-26 DCC (double-cotton covered) wire wound on a nine-spoke, black-fiber former as illustrated in Fig. 2. The former can be made from electrical fish paper, that stiff insulation material used to physically isolate electrical circuits. The odd number of spokes produces a coil with interleaved turns and resultant low distributed capacity and high Q. (Not bad for a 70-year-old design.)

Carefully observe the starting procedure, red dot toward the operator, and the interleaving as shown in Fig. 2. If a spoke is missed, it will be necessary to unwind and correct the error. In order to produce a neat finish, keep a firm but not too tight tension on the wire. Terminate the coil as shown. The little 10-turn coils at the start and finish are to provide flexible leads for the two coils, which are mechanically movable. Wind those coils around a 10-penny nail form, and then discard the nail.

Dip the finished coil into a solution of three parts methylated spirit to one part green drawing ink and then dry thoroughly. Repeat if the color is not vivid enough. The ink dyes only the cotton and is not easily visible on the black spider former.



THIS IS THE third of five photos of the completed Unidyne receiver described in this article. With the five photos and the drawings, you should be able to approximate the layout of parts for an effective reproduction. Position the tube socket so that the tube's label or type marking faces front.

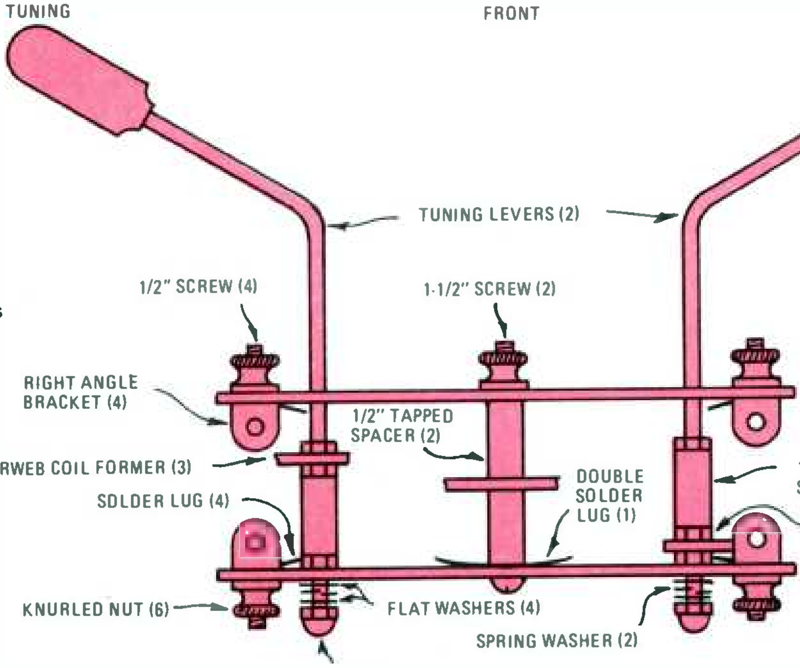


FIG. 3—THE ASSEMBLY that contains the three spiderweb coils is made and then secured to the surface of the Unidyne's breadboard. The outside coils should be mounted with some stiffness, so that when they are positioned they will remain in place. Use 1/2-inch, tapped spacers and same number of nuts as spacers to effect coil positioning as the author did.

The assembly of the complete tuning/reaction unit is next and is shown in Fig. 3. The coils and tuning levers are supported by front and back cheeks made of the same black fiber material as the coil formers. The tuning levers from 1/4-in. soft steel rods and tapped as required. Black plastic knobs or handles are expoxied to the ends. Follow the drawing in Fig. 3 and the photos to make two tuning levers. Attach the tuning and reaction levers to two of the coils, taking careful note of the difference in the arrangement of nuts and spacers between those two as shown in Fig. 3.

Tighten all nuts firmly with a nutdriver, ensuring that the levers are fixed close to the vertical center line of the coils and through the outermost hole on the long spoke of the former. The red dot on the coil former should face the back of the tuning unit on all three coils.

Attach the fixed coil to the back cheek, noting the arrangement in Fig. 3, and tighten the 1½-in. screws into the ½-in. tapped spacers at the front of that coil as shown.

Fit the threaded shafts of the tuning and reaction coils into the back cheek, turning coil to the left and reaction coil to the right and fasten loosely (do not tighten yet) with the flat washers, spring washer and dome nut as shown.

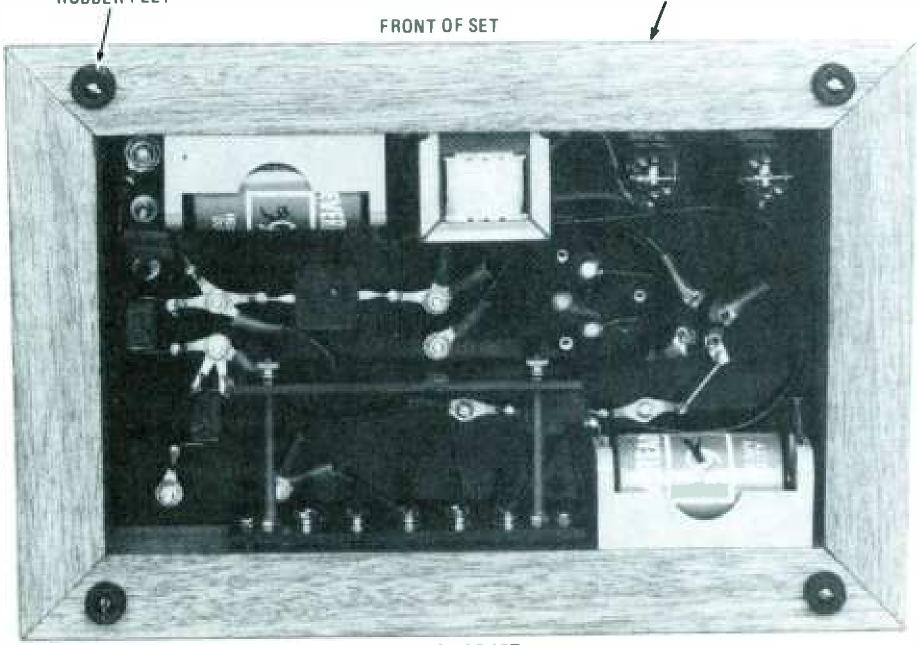
To fit the front cheek, move the levers to the vertical position, insert the ends of the lever into the appropriate holes in the cheek, and push the cheek down the levers, around the bends, and over the two central screws. Thread two knurled nuts onto those screws, and the assembly will now be mechanically stable.

Attach the right-angle brackets and solder lugs, using ½-in. × ⅛-in. screws and knurled nuts as shown, and solder the coil wires to the lugs as directed below.

From the front of the upright tuning unit:

1. Tuning coil—left wire to left rear lug. Right wire to central lug.
2. Fixed coil—left wire to left front lug. Right wire to central lug.
3. Reaction coil—left wire to right rear lug. Right wire to right front lug.

(Continues on page 98)



HERE'S THE UNIDYNE bottom-side up. Compare it to the drawing at right. Note that the author added modern-day rubber feet to the picture-frame cabinet.

FIG. 4—HERE IS a drawing of the underside of the Unidyne. Solder lugs are used to facilitate point-to-point wiring. Try to obtain old parts in as many instances as possible. The author could not find old phone jacks, so modern ones were used. In fact, if you can locate some pin jacks, that would be better. However, from the outside, no one could tell the age of the jacks. ▶

An exasperating human problem!

HI-FI SOUND... BUT

It is ironic that, at the very time when we are most excited about a new era of high-quality sound in the home, we are putting at risk the very organs we need to hear that sound. So look after your ears; they're the only ones you'll ever have!

☐IT HAS TAKEN ABOUT 100 YEARS OF THE ART OF AUDIO reproduction to progress from the primitive phonograph of Thomas Alva Edison to the cause of all the present excitement—the laser-read compact disc. But for all of that time—and longer—we have been working on the gradual destruction of our ears. Years ago, we blasted them with noisy machinery, pneumatic drills, and rivet guns. Now we have more fashionable methods.*

As if it isn't enough to have ears grow old and sluggish with age, we hasten the process with rock bands and hi-fi headphones—both capable of creating a sound-pressure level, where it matters, of 120 dB or more.

And, if ears have grown old and sluggish, whether naturally or prematurely, of what possible interest are those tiny whisps of sound, now exposed by the elimination of recording noise? Both may lie below the threshold of our hearing!

And what of the rich overtones on the strings and the oboe? Overtones? What overtones?

No Instant Cures

What makes the loss of hearing seem worse is that ears are not like eyes. One can suffer with hypermetropia (long sight), myopia (short sight), presbyopia (loss of lens flexibility), or astigmatism (misshapen lens); and yet retain virtually normal vision with the aid of contact lenses or spectacles.

But that very common effect—progressive loss of aural sensitivity—whether natural or aggravated, general or concentrated at the higher frequencies, is normally incurable and irreversible. Nor, can all or partial loss of hearing be compensated by artificial aids, at least not to high-fidelity listening standards.

The inherent limitations of diminished hearing and of practical electronic aids make it impossible to recover the frequency response, dynamic range, distortion levels, and directional perception of normal hearing. Artificial aids may restore communication, but that's about all. If and when implants are devised to bypass the faulty functions, the position may be more hopeful; but, in the meantime, guard the hearing you have as long as you can!

Inside the Ear

Figure 1 illustrates the physical structure of a human ear. It comprises three distinct sections; the *outer ear*, the *middle ear* and the *inner* ear.

The *outer ear* comprises three main components, of which the most obvious is the outer appendage, known as the *auricle* or *pinna*. Apart from its usefulness in supporting spectacles, the *auricle* or *pinna* modifies sound wavefronts entering the second component of the *outer ear*, the *ear canal*. The brain can ultimately interpret the modified sound wavefronts as supplementary clues to the source of individual sounds. (Some engineering types would refer to the *auricle* as a sound wave phase-shifter!)

The *ear canal* is a fleshy tube which attains dimensions giving it a broad resonance effect which more than doubles the subjective intensity of sounds in the region 2000 to 5500 Hz—the frequency range which we hear best. At the inner end of the *ear canal* is a tough, flexible membrane

*Original project appeared in Electronics Australia, June, 1983 Edition, and appears here by permission.

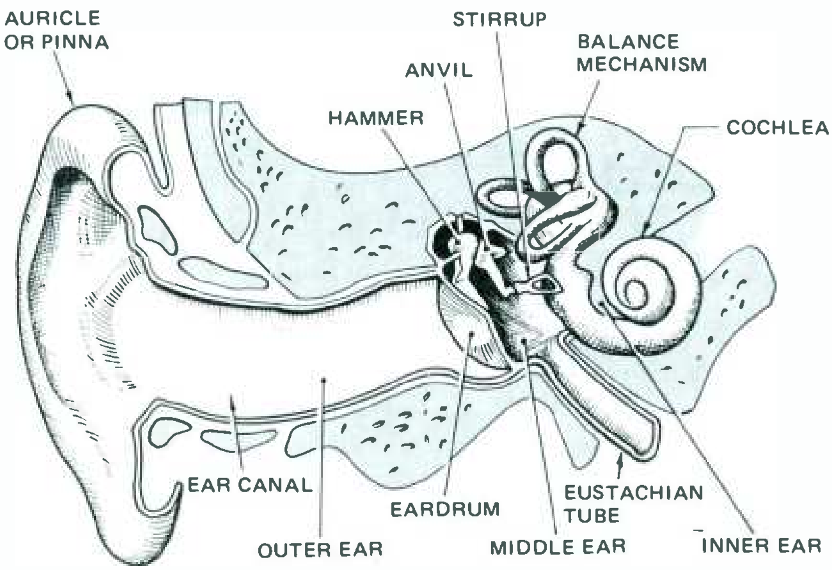


FIG. 1—ILLUSTRATING the structure of the human ear. While part of a remarkable human sense, it is nevertheless vulnerable to age, infection, and physical damage.

LO-FI EARS

By Neville Williams

called the *eardrum*, which seals off the *outer ear* from the *middle ear*. The *eardrum* vibrates in sympathy with the incident sound pressure waves and transfers the vibrations to the smallest bones in the body. The three bones, the *hammer*, *anvil* and *stirrup*, pass the vibrations on to the *inner ear*, an organ which has to do with both hearing and our sense of body balance.

As the ultimate destination of the sonic energy, the *cochlea* is nature's own microphone transducer, turning sonic information into nerve impulses. A tapered, convoluted, fluid-filled tube (Figs. 1 and 2), it is divided along its length into two compartments by the *basilar* membrane.

Sonic impulses are transferred from the *stirrup* (or *stapes*) to a small, bony, oval-shaped piston at the large end of the *cochlea*—the *oval window*. The impulses travel through the liquid in one compartment to the small end of the *cochlea*, then pass through a small aperture and back along the second compartment to the larger end. Here they encounter the so-called *round window*, which reflects the sonic energy back the way it came, much as an object will reflect wave energy in water or a radar waveguide.

Electrical Sensors

The interaction of the initial and reflected sonic wavefronts sets up standing-wave effects in the *cochlea* liquid, causing physical ripples in the central *basilar* membrane. Those ripples trigger responses from an array of something like 24,000 nerve ends distributed along and within the *cochlea*. In its own mysterious way, the human brain is able to translate the resulting electrical nerve signals—digital rather than analog in character—into separately identifiable signals, each with its own pitch, intensity, and phase.

It is, in fact, easy to become quite carried away when extolling the virtues of human ears in prime condition by stating that:

—Our ears are so discriminating that we need thousands of dollars worth of audio equipment to provide the same listening satisfaction as when hearing the real thing.

—The human hearing apparatus—the ear, auditory nerves, and hearing centers in the brain—make up one of the most discriminating mechanisms in the world of nature.

—Many people can detect changes in pitch of only one part in 1000, and even an untrained ear can tell the difference when the same note on the musical scale is played on two different kinds of instrument.

—We can hear a mosquito buzzing outside the window screen and the next instant listen to a jet aircraft roar overhead. The difference in intensity of those two sounds is a ratio of about 1 to 10,000,000,000. (Try that span of voltage on your multimeter.)

—The human ear is capable of hearing sounds within a frequency range of about 20 Hz to 20,000 Hz... and so on.

Our ear possesses an *automatic volume control* mechanism. A sudden loud bang causes a reflex action in two tiny muscles located in the *inner ear*. One—the *tensor tympani*—contracts and stiffens the *eardrum*, so that it cannot vibrate as freely as it would otherwise. The other—the *stapedius muscle*—immobilizes the *stirrup*-shaped *stapes*, preventing it from delivering excessive input to the *inner ear*.

Much has been written, too, about the ability of the human auditory system to concentrate on one particular sound source in a noisy environment, on one speaker in a restaurant, one instrument in a group. Indeed, there are occasions

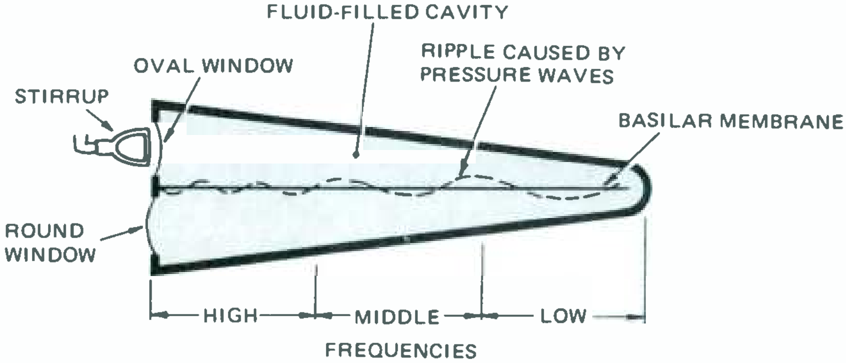


FIG. 2—FED with sonic impulses via the "*stirrup*', the *cochlea* is nature's counterpart of the microphone, transforming physical vibration into electro-chemical nerve impulses. Loss of aural acuity usually occurs first at the higher frequencies.

the auditory system may reject all sound, turning it into a sonic blur that does not disturb concentration—or something even more remote that does not disturb sleep.

And there's the matter of audio-signal phase—the subject of much discussion and argument in recent years. Human hearing is amazingly sensitive to phase, runs the argument, and much of that indefinable satisfaction which is either apparent or not apparent in hi-fi sound reproducion is traceable to phase discrepancies in the system. So we've had a spate of linear-phase loudspeakers and now, linear-phase phono cartridges.

There Are Problems

In truth, your ears may not perform as described above because the keen edge of your hearing has been perceptibly blunted—purely as a function of age. Also, if your ears have been subjected to protracted periods of very high-level sound, whether in the context of entertainment or employment, there is a strong chance that they will exhibit losses additional to those due to aging.

In respect to aging, a broad rule of thumb suggests that, if a young child is credited with the ability to hear sounds up to 20,000 Hz, the child will exhibit a loss of treble response at the rate of about 2000 Hz per decade. On that basis, one can draw up a table correlating age with the upper limit of hearing. The assumption is that the aural response will be rolling off through the nominated frequency with a fairly pronounced cutoff beyond it. (See Table 1.) There is a difference between the sexes. It is noted that females retained a generally better high-frequency response than males.

TABLE 2—NOISE LEVEL TABLE

Injurious Range	
140 dB	Jet engine at 25 yards
130 dB	Rivet gun—pain threshold
120 dB	Propeller airliner, 50 yards
Danger Zone	
110 dB	Pneumatic rock drill—non-OSHA approved
100 dB	Metalworking shop
90 dB	heavy transport truck
Normal Range	
60 dB	Ordinary conversation, 3 feet
50 dB	Low conversation, 3 feet
40 dB	Soft background music
30 dB	Whisper at 3 feet
20 dB	Quiet country dwelling
10 dB	Rustling leaf
0 dB	Threshold of hearing

TABLE 1—AGE TAKES ITS TOLL!

Age in Years	Upper Limit of Hearing
10	18,000 Hz
20	16,000 Hz
30	14,000 Hz
40	12,000 Hz
50	10,000 Hz
60	8,000 Hz
70	6,000 Hz
80	4,000 Hz

Familiar Format

Purely to present the information described in the previous paragraph in a more readily recognizable form, the usual frequency-response hearing format in Figs. 3 and 4 have been modified. The curves ignore the expectedly superior hearing of children and take, as reference, clinically normal 20-year-old female ears. The derived curves involve a certain amount of free-hand extrapolation, but they still can be taken as being well *in the ballpark* for typical age/hearing loss relationship.

Two points are obvious from the family of curves in Figs. 3 and 4. One is a ready explanation of why aging grandparents may frequently find it necessary *to beg your pardon*. To them, speech is quite muffled. The other is that, beyond about age 50, your audio amplifier system is beginning to sound

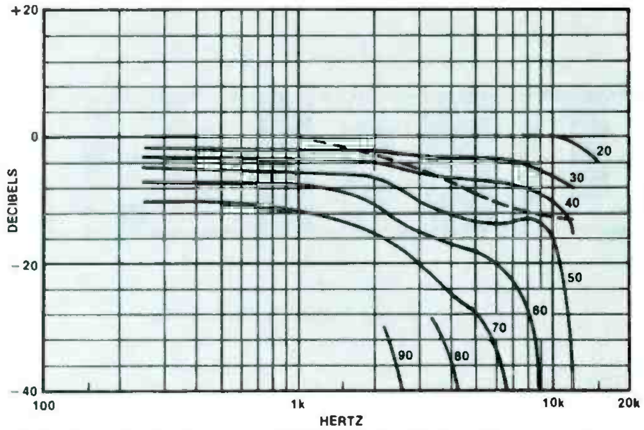


FIG. 3—WITH CLINICALLY-NORMAL HEARING of 20-year-old females referenced to 0 dB, those curves give some idea of the gradual loss of hearing acuity with advancing age, the loss being particularly apparent at high frequencies.

much as it would to a young person in his/her twenties, with the tone control turned to minimum treble. To a 70-year old, the tone control may not appear to have much effect at all.

Well then, does the compact disc, or any other improved audio system coming down the pike, represent a waste of time and money to the 50-and-over group—the people who can best afford the equipment?

Fortunately not, for reasons about which we still have to speculate.

A difference in frequency response, as such, may not be all that apparent to the 50-and-overs. But the clean, hard transients can still be obvious by contrast to what they have been accustomed to current audio systems.

And the reduction in harmonic distortion can certainly be evident as an uncanny clarity, which is missing in the audio program if the contact disc has been remastered from a tape.

As for background noise, the difference may not be as obvious as to a younger person but a difference there can be over the low and middle register, where rumble and acoustic feedback betray the mechanical nature of the conventional phono system. All is not lost, by any means!

(Continued on page 94)

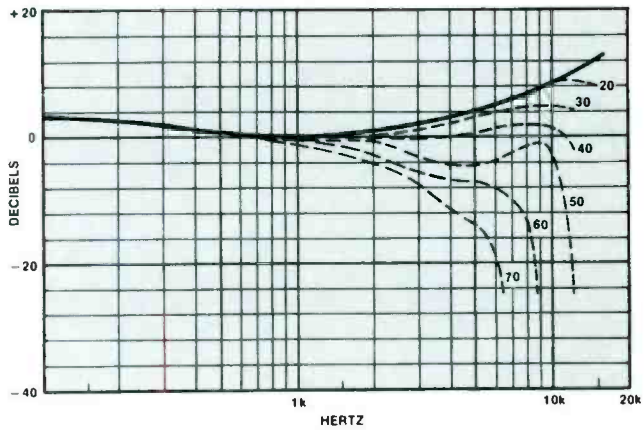
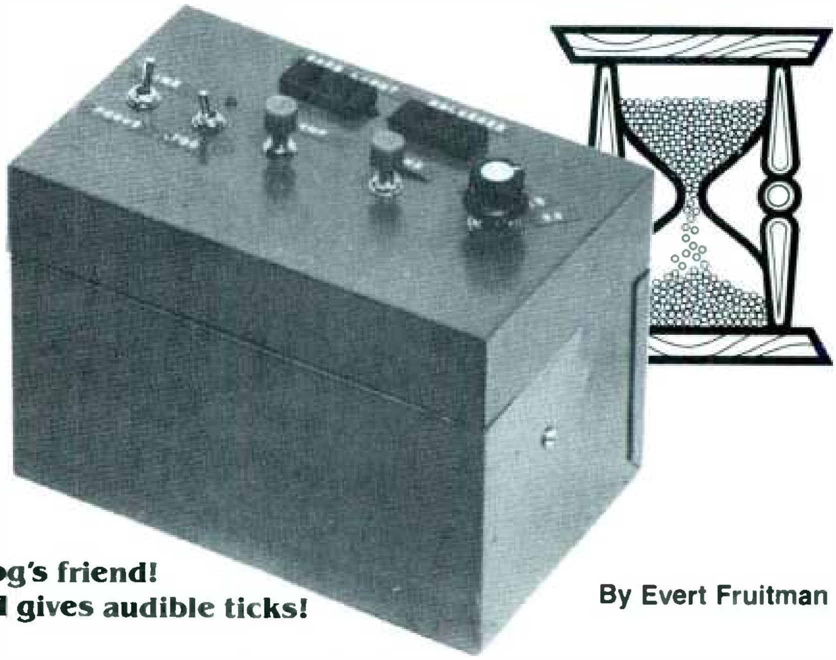


FIG. 4—TAKEN FROM BASF literature, the heavy curve shows the noise-energy distribution of a typically good quality compact cassette tape. High-frequency loss with advancing years renders the hiss level less obvious.

AUTOMATIC DARKROOM TIMER



This thrifty timer is a real phototog's friend!
It counts on its digital fingers and gives audible ticks!

By Evert Fruitman

IN THE EARLY DAYS OF PHOTOGRAPHY IT WAS NECESSARY to sensitize, then expose and process the glass-plate negatives while they were still wet. After a few advances in technology, all that had to be done to take a picture was to take the camera into the photo store. There they would remove the exposed film and put in a new roll—in the darkroom. Things have come a long way since that time. However, if you are an amateur photographer, you may be operating out of a closet that is pressed into service as a temporary darkroom.

The usual setup consists of a safelight, enlarger, tanks, trays, chemicals, etc. When the film is ready for printing, it is placed in the enlarger and the image focused on an easel. When the enlarger is turned on, the safelight is turned off. Usually the enlarger is on for 8-16 seconds, depending upon the negative and paper in use. It is more than a mere convenience if that sequence of events takes place after pushing just one button.

After several hectic darkroom sessions where I turned on the enlarger and stopwatch and dumped the safelight, I decided that there had to be a better way to do it. As always, I wanted the simplest possible circuit with minimum expense.

Although digital circuitry can give precise timing pulses, the circuits aren't all that simple, inexpensive, or required in this application. A simple analog timer consisting of a resistor and capacitor can give very repeatable timing cycles. Throw in a few transistors, a relay, and a pushbutton switch, and you can have an automatic timer.

The Automatic Darkroom Timer described here turns on the enlarger for a prescribed length of time, turns off the safelight, gives audible indication of elapsed time, and automatically resets everything at the end of the timing cycle. The sequence is started by merely pushing one button. *Fantastic*!

Basic Theory

The basic timing circuit of Fig. 1-A begins its timing sequence when switch S is closed. Capacitor C starts charging at an *exponential* rate until it reaches the voltage of battery B. Another circuit connected across capacitor C could be set to close a relay when the charge on the capacitor reaches a predetermined voltage. The higher the voltage setting, the longer the time delay.

The adjustable constant-current generator of Fig. 1-B supplies a steady current to capacitor C. In so doing, it straightens out the *voltage vs. time* charging curve. The smaller the current, the longer the time required for a given capacitor charge.

Resistor R_a provides current to Zener diode D, which breaks down and starts conducting at about 9 volts. That voltage, minus 0.6 volts, is applied to the two resistors (R_b, R_c) in the Q's emitter circuit. Nine volts, (8.4-volts DC) divided by the value of the emitter resistors (R_b and R_c) gives the value of the current in the emitter-collector circuit of Q. (The emitter-base current is usually small enough to be ignored.) That small, but steady current, is used to charge the timing capacitor, C.

The transistor's collector (Fig. 1-B) resistance is effectively changing value while the voltage across capacitor C is increasing. The action maintains a constant current flow. That action continues up to the point where the voltage across the

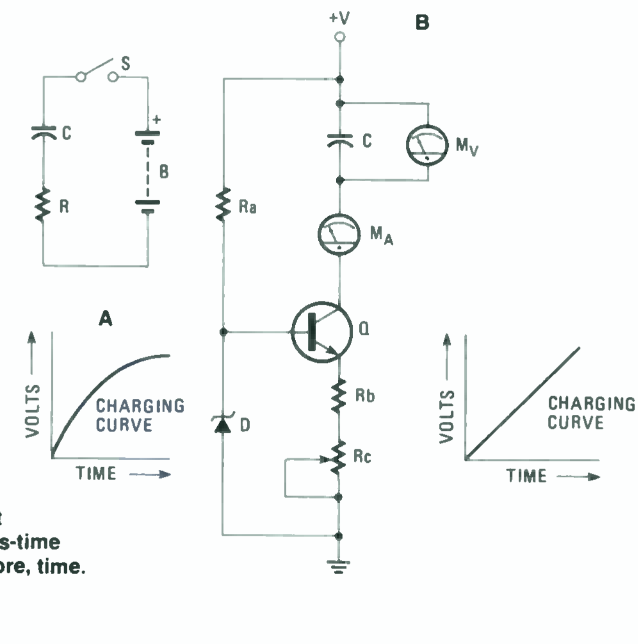


FIG. 1—THE BASIC TIMING CIRCUIT is seen at A. The constant-current generator is added at B. The voltmeter would show the linear charge-vs-time for the capacitor. The control in the emitter adjusts current, and therefore, time.

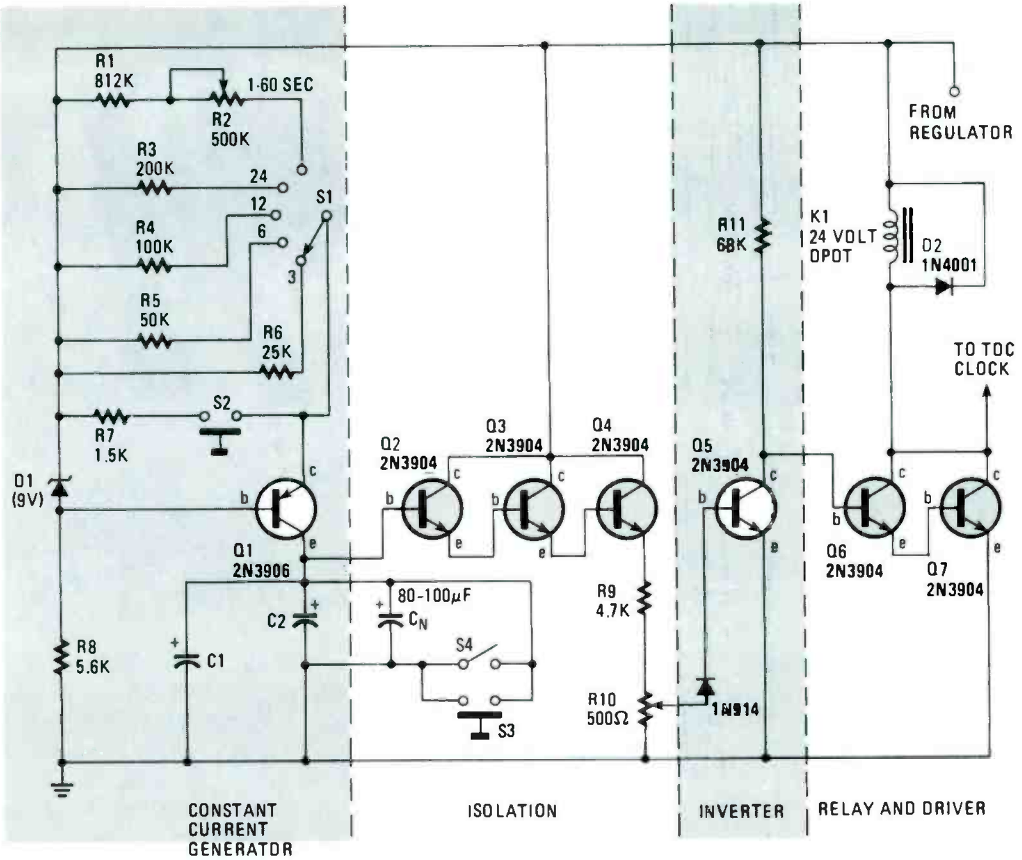


FIG. 2—SCHEMATIC DIAGRAM for the automatic darkroom timer is shown minus the power supply (Fig. 5) and relay connections (Fig. 4), and audible elapsed-time indicator (Fig. 3) circuits.

capacitor, plus the voltage across the emitter resistors, equals the applied voltage. At that time the milliammeter's (M_A) reading very suddenly drops to zero, and the voltmeter's (M_V) reading stops increasing.

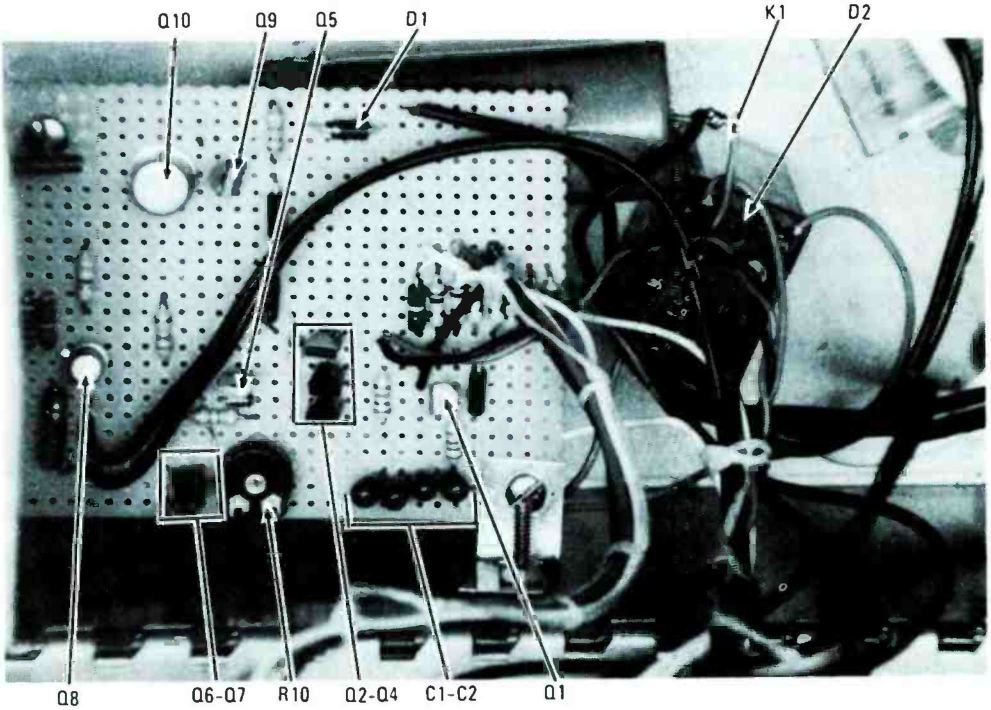
Potentiometer R_c allows the current, and therefore the time, to be varied as needed for a given application. In that case, that amounts to 1 to 60 seconds for just under full charge on the capacitor.

Inside the Circuit

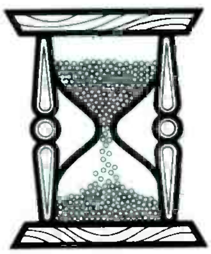
Adding a rotary switch, S1, and several range resistors, R1-R6 gives us preset time periods (see Fig. 2). The detents on the rotary switch act like click-stops. I find that very handy in the darkroom. The times I selected are one printing-stop apart: 3, 6, 12, 24 seconds. The 12-second time gets the most use, which is why I went to fixed times. Potentiometer R2 was added for variable timing.

The 1500-ohm resistor and pushbutton will end the timing cycle a fraction of a second after it is pushed. That function is used after the time/focus switch is returned to the time position. It may be used if you feel that an exposure is too long.

A PNP transistor is used in the final version of the timer



THERE'S LOTS of real estate available on the perf-board chassis, so parts do not have to be crowded. You may want to secure an old transformer, or other useless heavy weight, to the bottom of the card-file box to give it *Heftability*!



PARTS LIST FOR AUTOMATIC DARKROOM TIMER

SEMICONDUCTORS
D1—9.0-volt, 1/2-watt Zener diode
D2—1N4001-1N4004 silicon diode
D3—1N4003-1N4004 silicon diode
D4-D5—total series Zener voltage to be 26-VDC, 1/2-watt diode
LED1—red light-emitting diode
Q1—2N3906 PNP silicon transistor
Q2-Q7, Q9—2N3904 NPN silicon transistor
Q8—2N2646 field-effect transistor
Q10—2N3053 NPN silicon transistor

RESISTORS
(All fixed resistors are ¼-watt, 5% units)
R1—8200-ohm
R2—500,000-ohm, ¼-watt, linear-taper potentiometer
R3—200,000-ohm (make from two 100,000-ohm resistors in series)
R4—100,000-ohm
R5—50,000-ohm (make from two 100,000-ohm resistors in parallel)
R6—25,000-ohm (make from four 100,000-ohm resistors in parallel)
R7—1500-ohm
R8—5600-ohm
R9, R15—4700-ohm
R10—500-ohm, ¼-watt, PC-mount potentiometer
R11—68,000-ohm
R12—116,000-ohm (see text)
R13—390-ohm
R14—27-33-Ohm

CAPACITORS
C1, C2, C_N—total parallel value equals 80-100-µF, 20-WVDC electrolytic capacitors
C3—4.7-µF, 16-20-WVDC, electrolytic capacitor
C4—1000-µF, 50-WVDC electrolytic capacitor

ADDITIONAL PARTS AND MATERIALS
F1—.5-A, 3AG fuse and holder
J1, J2—2-prong AC outlet
K1—24-volt, DPDT relay with contacts rated at 3-5 A
S1—5-position, single-pole rotary switch, non-shorting or shorting types (use standard 6PST switches)
S2, S3—SPST, normally-open pushbutton switch
S4-S6—SPST toggle switch
SPKR1—4-8-ohm miniature loudspeaker
T1—Power step-down transformer: 117-VAC pri.; 22-26-VAC sec.

because that allows the voltage across the capacitor to be measured against ground. That makes the rest of the circuit simpler.

Transistors Q2 through Q4 (Fig. 2) provide isolation for the timing capacitor (C1-C2, one or more capacitors in parallel). Transistors Q2 and Q3 form a Darlington pair as do Q3 and Q4. That makes the input resistance at the base of Q2 very high and, therefore, the loading effect on the timing capacitor very small.

The voltage at the base of Q2 must exceed 1.8 volts before the triple-transistor Darlington starts conducting. After that, the input voltage appears across the emitter resistors, R9-R10. They are relatively low-value resistances, and may be used to drive another stage. The 500-ohm potentiometer, R10 takes a small sample of the input voltage and applies it to the next stage.

Only 1.2 volts of the 15 volts on the timing capacitor are needed to turn on the inverter stage. With the inverter stage, relay K1 is turned on only during a timing cycle. That means that when the timer is first plugged into the wall, it starts a timing cycle. The QUICK-DUMP pushbutton switch S2 will end that easily enough.

Toc Clock

When the timing capacitors, (C1-C2) are discharged, the inverter is off; therefore, the Darlington pair, Q6-Q7, driving relay K1 (see Fig. 2) is on, and the relay is in the energized position. The timing cycle is started by momentarily pushing the TIME pushbutton switch S3, which dumps the charge on the timing capacitors (C1-C2). Every time the enlarger turns on, as a matter of habit, I start counting seconds. In order to make that a little easier, and somewhat more accurate, the UJT

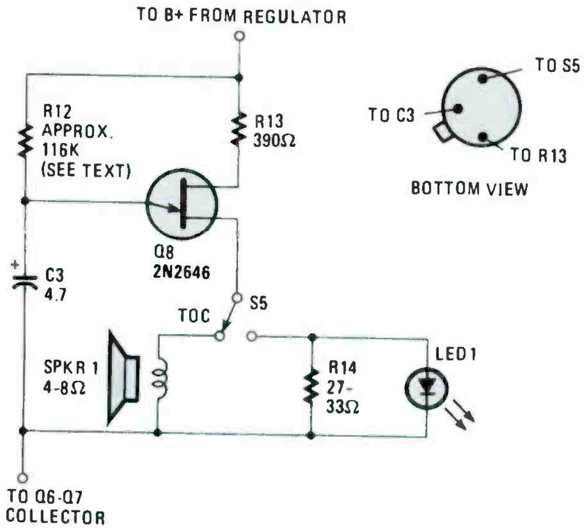


FIG. 3—SCHEMATIC DIAGRAM for the audible elapsed-time indicator circuit. Note that switch S5 offers a choice of audible signals or complete silence, using an LED for low-level visual time signals.

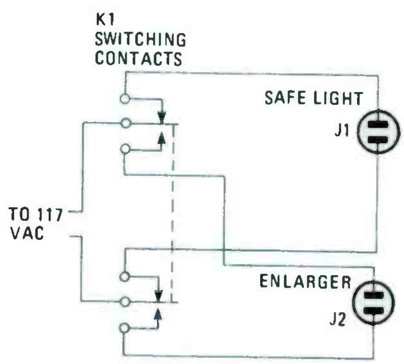


FIG. 4—WIRING OF RELAY contacts and sockets for enlarger and safelight. The center contacts of both halves of the relay connect to the primary side of the power transformer in the power supply. Be sure that they are connected *upstream* of the on-off switch and fuse.

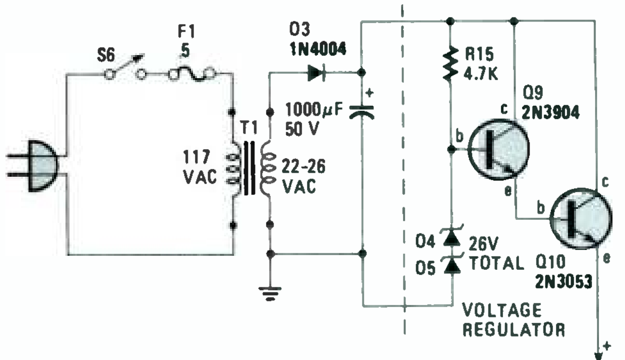


FIG. 5—CIRCUIT for the Automatic Darkroom Timer power supply. Note the vertical dotted line preceding the regulator circuit. If transformer T1 selected has a secondary voltage rating of 16 to 18 volts, the regulator circuits, to the right of that dotted line, can be deleted.

oscillator was added. See Fig. 3. The *toc* clock, as that's what it sounds like, or LED1, give an indication of when the enlarger is supposed to be lit. The power for the clock is taken directly across the relay coil, sharing the power from the external power supply. The relay's contacts (Fig. 4) connect the 117-VAC line to either the SAFE LIGHT or ENLARGER AC outlets.

The overall power requirements are so light that a simple halfwave rectifier and one filter capacitor is all that is needed. See Fig. 5. If your power transformer delivers 16-18 volts, the regulator circuit elements won't be needed. Timing accuracy is insured by Zener diode D1 (Fig. 1) connected to Q1. With the 22-volt transformer (T1 in Fig. 5) that I used, the voltage out of the filter is more than 33 volts. That would put more than 20 volts across the timing capacitors with possibly unpleasant results.

Resistor R15 (Fig. 5) supplies current to the 26-volt Zener diodes (D4 and D5). That reference voltage, after losses in the two transistors (Q9-Q10), comes out close to 24 volts at the emitter of the 2N3053. That is the power source for the timer (Fig. 2) and the toc clock (Fig. 3).

Construction Tips

Most of the circuit parts go on a piece of perf-board. The sockets and switches mount on the panel. I found a 4 x 6-inch plastic card-file box an inexpensive and convenient way to package the Automatic Darkroom Timer. The small speaker is cemented to the inside of the cover. The sound is loud enough, even with the cover closed, so that extra holes were not needed. The main board is held in place with a couple of L brackets.

The main board is laid out just about the way the circuit is drawn. The tantalum timing capacitors (C1 and C2) are at the top of the board, next to the mounting bracket. Below that is the Zener diode (D1) and the PNP transistor (Q1). The preset time resistors (R1-R7) complete the left side of the board. The three Darlington transistors Q2-Q4 are in the middle and connect to the potentiometer (R10) at the top of the board. The inverter (Q5) is below it. The relay drivers (Q6-Q7) are next to it. The UJT oscillator and associated parts are on the right side, down from the top. You may want to leave enough room in that area for a small 50,000-ohm potentiometer and 82,000-ohm fixed resistor (that is resistor R12 in Fig. 3) help set the toc clock for one-second ticks. I used fixed resistors and trimmed it until the value for R12 was close enough.

There is plenty of room for the relay and transformer in the bottom of the box. Use a grommet where the power cord passes through the metal box. Press-on decals look nicer than the label tape, but are harder to see in the darkroom.

Checkout Time

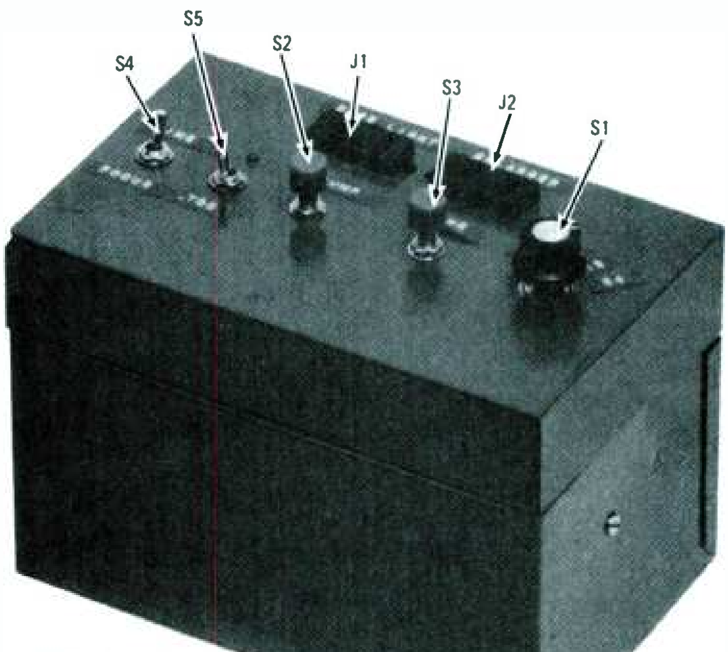
Initial setup is rather straightforward. When the line cord is plugged in, the timing capacitors will start charging. That action may be followed with a voltmeter connected from Q4 emitter to B-minus. After a fraction of a second or a few seconds, depending upon the setting of the time switch, the voltage across the resistors will start rising. It should go up to about 15 volts. The potentiometer R10 is adjusted to trip the relay at the desired time interval. Use a stopwatch or sweep second hand to gauge the time and set the longest time first; the others should fall into place. If they don't, you may trim the timing resistors as needed.

If you choose to skip the preset feature and use just the variable times, then suitable marks may be made on the panel as the various times are measured.

After the Adjustable Darkroom Timer is calibrated, a couple of lamps may be plugged into it and the action observed.

In actual use I find the preset times handy. My typical exposure runs close to 12 seconds. If the exposure needs to be lengthened out a bit, the TIME pushbutton switch is held down for an extra toc or two. If the exposure should be shortened a bit then the QUICK-DUMP button is used.

The Automatic Darkroom Timer has helped increase the enjoyment of one of my hobbies by taking some of the hassle out of the darkroom work. Since the timer is portable, it has been used for short-term timing around the house. ■



EVERYTHING you need to operate or interconnect to the Automatic Darkroom Timer can be found on top of the unit's box. AC power cord is hidden behind unit. You may reposition controls during construction to your liking—location of parts is not critical.

Dual Peak / Current Anemometer

BY DONALD BRUNS

Know at a glance what's happening with the wind through this easy-to-build project. Obtain current wind speeds and previous wind-gust high!

□EVERYONE WANTS TO KNOW, "HOW HARD DID THE WIND blow last night?" That is especially true when lots of terrible noises have kept one up all night long! The present windspeed is easy to measure while one is looking at one of a number of inexpensive and simple wind gauges or anemometers. But a first-class weather-station setup with a 24-hour recorder chart is prohibitively expensive. For about $40, you can build the Dual Peak/Current Anemometer that will provide you with not only the current windspeed on an analog meter, but also a digital reading of the highest gust measured.

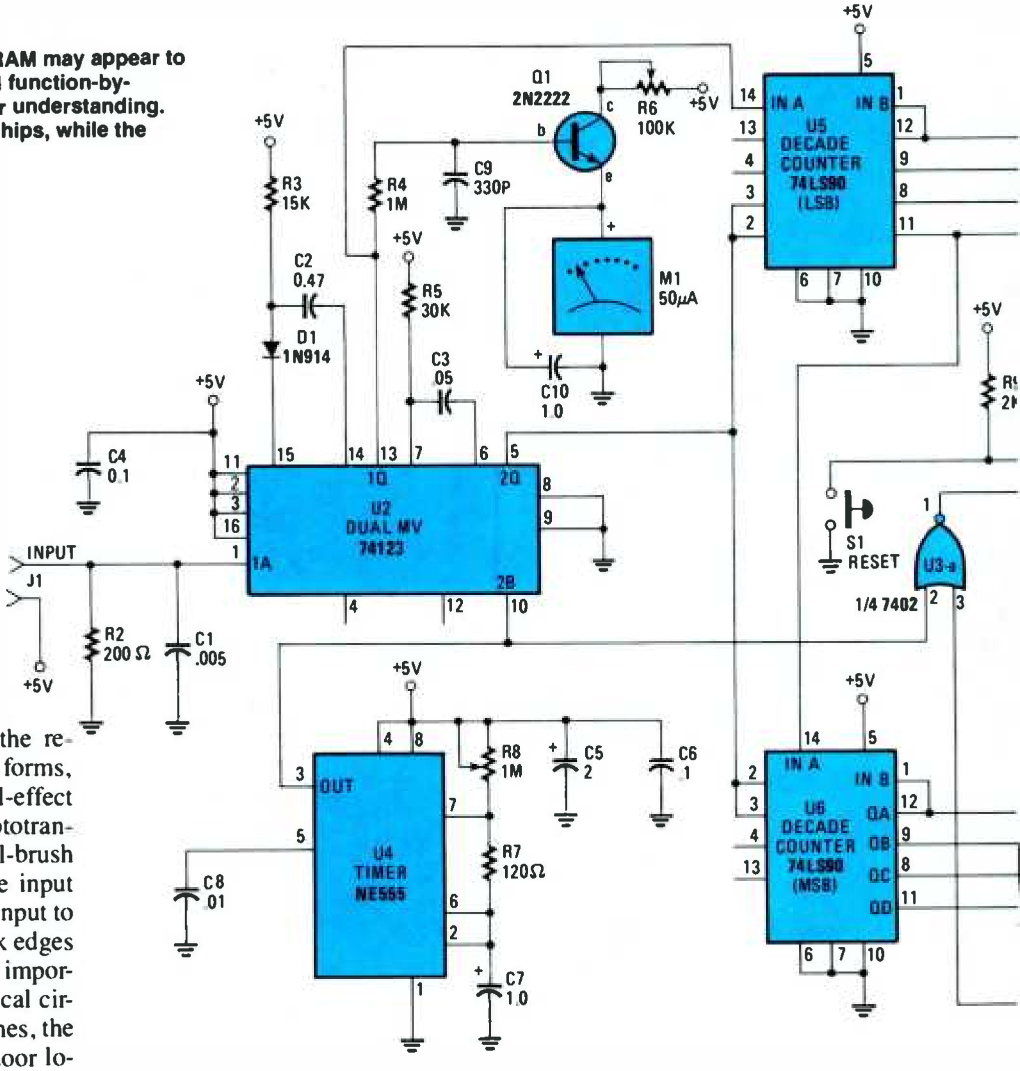
The panel-meter on the Dual Peak/Current Anemometer allows the observer to follow the windspeed as the wind blows, and gives a better feeling for gusts and average windspeed than a single digital display. The digital display, however, keeps a record of the highest windspeed measured since the display was last reset, so constant observation is not required. The anemometer can also be used as a peak-reading speedometer or tachometer if an appropriate input is supplied, and is easily calibrated. The anemometer is all TTL based so it can operate from a car battery as well as from a charger-type wall transformer for continuous operation.

Circuit Description

The entire Dual Peak/Current Anemometer electronic circuit consists of four sections: The remote transducer or anemometer head, the analog display, the digital display, and the power supply. Each of those sections will be discussed separately, since almost any combination of circuits can be used in order to modify the project to the builder's own desires.

The input circuit of the main circuit board, shown in Fig. 1,

FIG.1—MAIN BOARD SCHEMATIC DIAGRAM may appear to be complex; however, follow the detailed function-by-function discussion in the text for a clear understanding. The units count (LSB) is the top row of chips, while the tens count (MSB) is the bottom row.



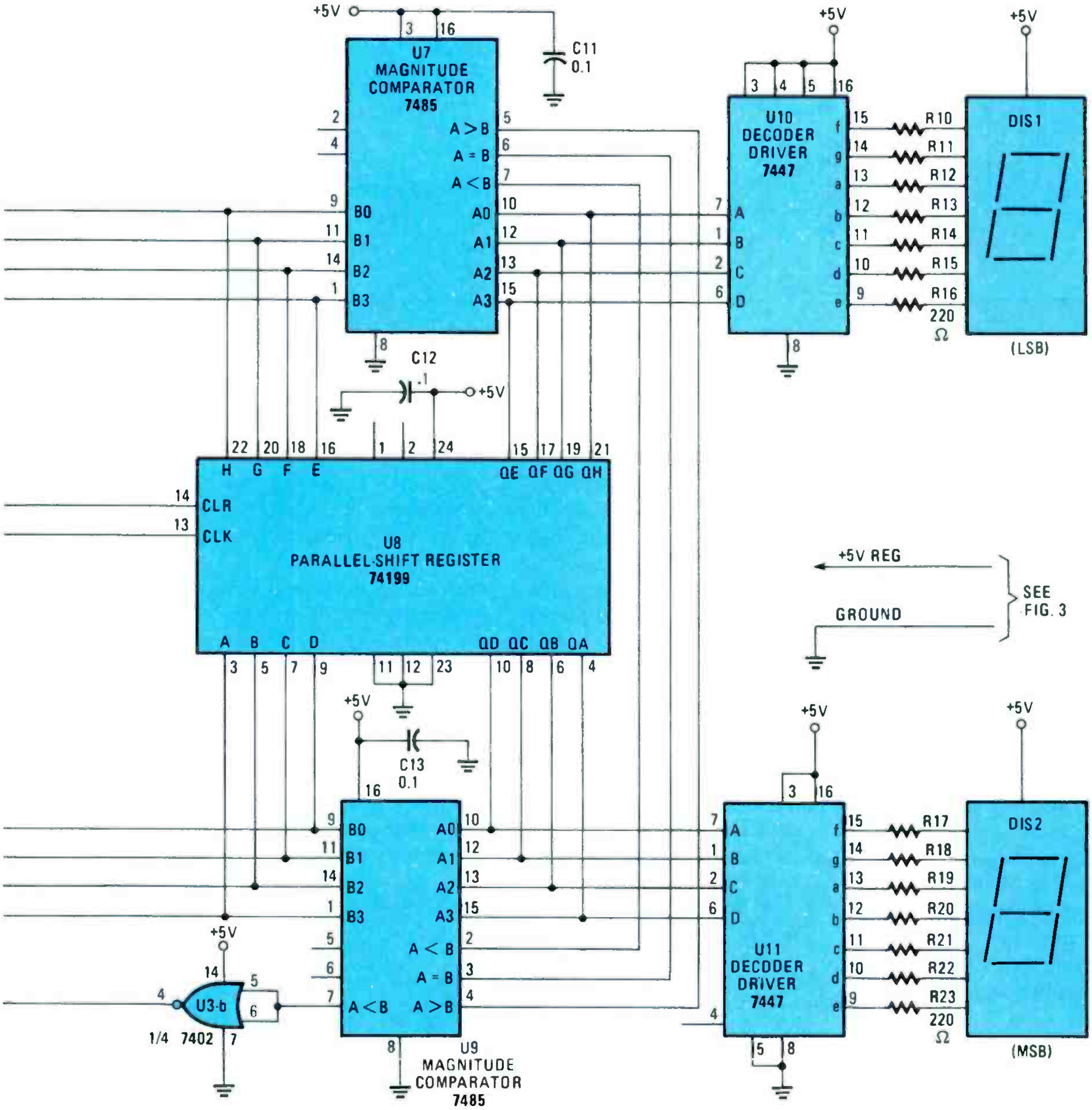
requires TTL-compatible pulses, so the remote transducer can take a number of forms, some of which are shown in Fig. 2. Hall-effect switches, magnetic reed switches, phototransistors, or diodes, or even mechanical-brush contacts are all permitted because the input effectively debounces and buffers the input to the rest of the circuit. Only falling-lock edges are counted, so pulse widths are not important. For indoor applications, the optical circuits may be best; or mechanical switches, the easiest and cheapest. For remote outdoor locations, magnetic devices are required. Because anemometers work best when made as light in weight as possible, the Hall-effect switch with lightweight magnets is the best choice.

The circuit shown in Fig. 2-B shows how to connect the Hall-effect switch with only two wires, rather than requiring three. When no magnet is nearby, the integrated circuit in the Hall-effect switch takes only a small amount of supply current. When the proper magnetic pole is nearby, however, the device must also supply the load resistor R1. While that extra current causes a larger drop across R2 in Fig. 1, and thus triggers the A section of the 74123 dual monostable multivibrator U2, it also reduces the supply voltage across the Hall-effect switch U1 to about 2½ volts. Although that is actually below the recommended operating voltage for the chip, the circuit still works, and saves sending a third wire to the remote transducer.

The analog and digital portions of the main circuit board (Fig. 1) share the same input circuit. The A section of the U2 (pin 1 input) is set to give one pulse for every input TTL transition, and the input pulse width is not critical. At the highest input pulse rates, U2 is triggered almost immediately after the previous pulse is gone, giving a high average-output voltage. At the lowest pulse rate the average-output voltage is nearly zero. The relationship is linear between those extremes. Those pulses (Q from pin 13, U2) are current-amplified by Q1 and drive the panel meter M1 directly, using trimpot R6 to calibrate the full-scale reading.

The pulse-count averaging is done by the slow mechanical response and damping of panel meter M1 directly. The averaging is done by the slow mechanical response of the panel meter, and is noticeably of a pulsed character only for the very lowest output rates, below a few per second. At that speed, the wind is so mild that it really doesn't make any sense to measure it.

The same pulses from pin 13 of U2 are sent to 74LS90 decade counters U5 and U6, which count up for a time period set by the NE555 timer U4, before being reset by the pulse from the B section of U2. That counting period is determined by capacitor C7 and the trimpot R6, which is varied to allow the digital side to be calibrated to the analog side. Before the decade counters are reset, their values are continually fed to the inputs of a 74199 (U8), an 8-bit parallel-shift register, and the B inputs of two 7485 magnitude comparators U7 and U9. The A inputs of U7 and U9 are connected to the outputs of U8



and to the digital displays, consisting of a pair of 7447 BCD-to-7 segment decoder/drivers U10 and U11 and a double-digit, 7-segment LED (DIS1 and DIS2). When the present count in U5 and U6 are smaller than the values in the display, then the outputs of U7 and U9 stay low and keep the shift pulse from U4 from turning on gate U3, and nothing else happens during the counting period. Decade counters U5 and U6, however, are reset every time. As soon as they record a larger value than that in the LED display, the outputs of U7 and U9 turn on U3 and allow the reset pulse from U4 to clock U8, and the new, higher value appears in the LED display. When the RESET switch S1 is pushed, all of the output lines of U8 are cleared; so the peak reading will disappear, to be filled with the next digital count. The comparison process is repeated every clock cycle.

Power

The current requirements are rather large, due to the standard TTL circuits and two large LED displays, DIS1 and DIS2. With all 14 LED segments in the two displays lit up, 300 mA of current is drawn from the 5-volt DC power supply,

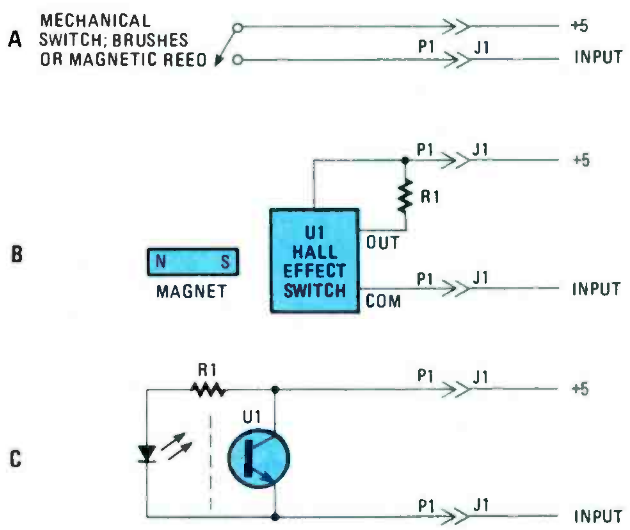


FIG. 2—SCHEMATIC DIAGRAMS of typical remote transducers or pickups that sense the rotational movement of the anemometer arms (see text).

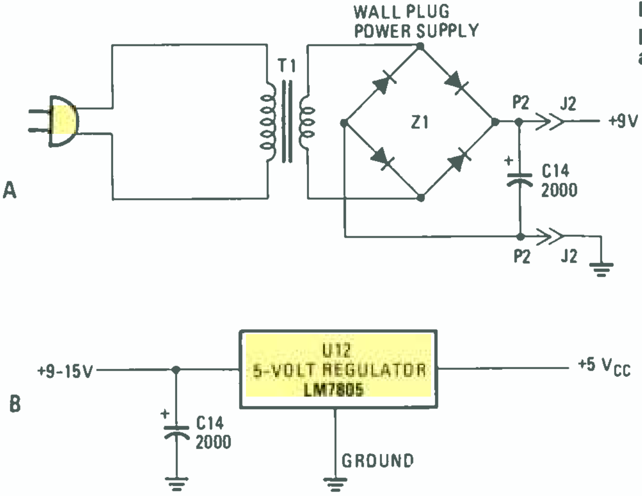


FIG. 3—SCHEMATIC DIAGRAM for bridge-rectifier power supply and five-volt regulator that powers the anemometer's electronic circuits.

so standard batteries would not last long. Either a large battery, or wall transformer—or the small power supply shown in Fig. 3, supplying at least that current at 7 to 18 volts—can be used with the 7805 regulator U12 to supply the only voltage needed for this project.

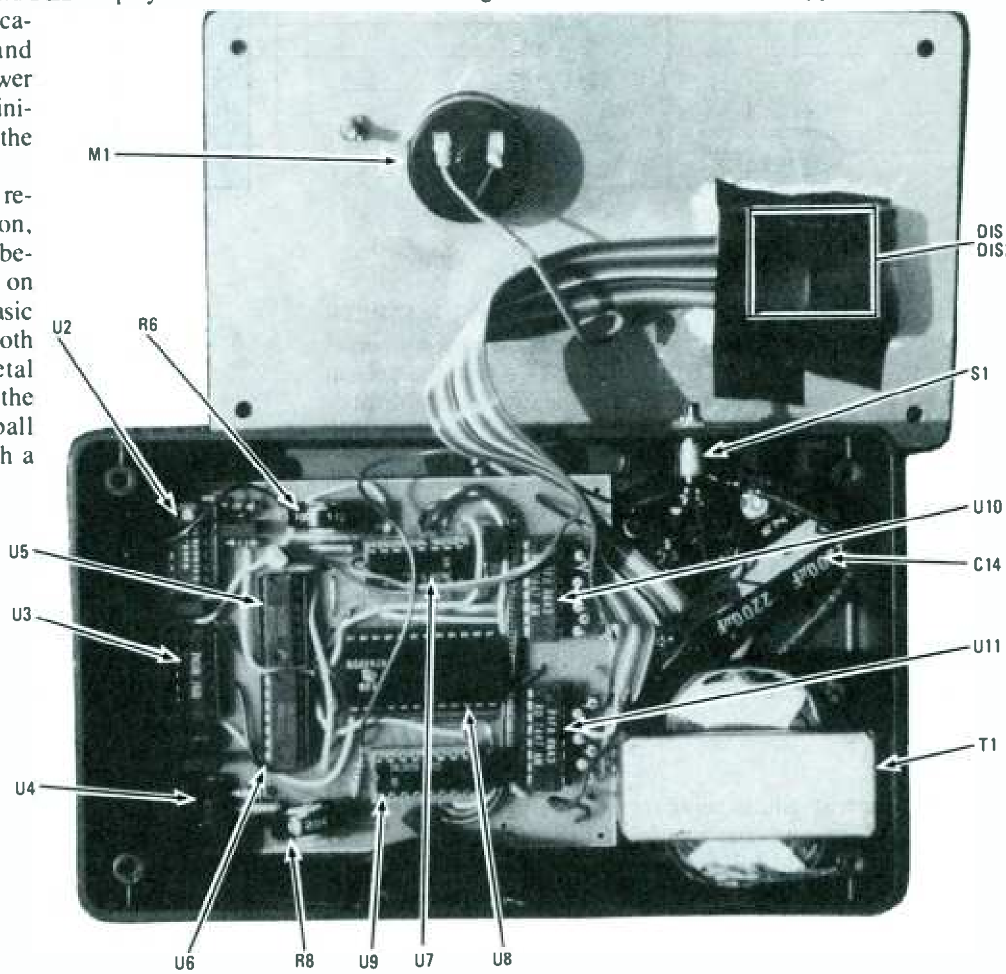
Construction

The construction of the circuit board is not critical, since only low frequencies are involved. The many parallel wires suggest the chip layout; wire-wrapping is probably the most convenient technique, although any other method should work. A metal case may also be used as the power-supply heat sink, so that might be more convenient than a case made entirely of plastic. The panel meter and LED displays are best connected with color-coded ribbon cable. Miniature polarized plugs and jacks were used to connect the power supply and remote sensor, and a miniature reset switch, S1, is placed near the digital LED displays.

The anemometer's remote sensor requires some mechanical construction, but the details are not given here, because they would depend too much on the scrap materials available. The basic design is shown in Fig. 4. Three smooth cups are rigidly attached to a metal shell, which in turn is epoxied to the outer race of a small, unsealed ball bearing. The inner race is held with a $3/8$-inch bolt, which then mounts to a fixture on a fence or rooftop. Three magnets are also epoxied to the inside of the shell, with a Hall-effect switch U1 and R1 epoxied to the nut holding the bearing.

Construction materials, for the most part, are scrap items. The only guiding features are that the parts be weatherproof and lightweight. Plastic eggshells, either from a toy store or from pantyhose containers, seem fairly indestructable and very lightweight, and are preferred over ping-pong balls or aluminum funnels or spoons. The spherical shape is preferred, giving a better peak reading than cone-shaped cups, because they have a tendency to not slow down after a gust of wind dies down. That allows the digital counter to record a slightly higher average windspeed, closer to the peak gust velocity.

The ball bearings used in the prototype models were not sealed; to keep the starting friction very low, allowing very small windspeeds to start the anemometer cups rotating. The bearings were obtained for $1 from a local surplus house. The ratio of outside radius R, as shown in Fig. 4, to cup radius r is not too critical, but should be about 2 to 1. The overall length of R should be between 1½ and 2½ inches for best linearity and minimum response time. The smaller the arms, the faster the anemometer will spin, and the faster the digital display may be updated. In the interest of low weight, the prototypes used three magnets made of the rubberized type of material



THE BULK of the electronics for the Dual Peak/Current Anemometer is located in a plastic case with aluminum cover. The LED indicators, DIS1 and DIS2, and the meter, M1, mount on the cover. A ribbon cable provides the connection between the circuit and the LED indicators. The case may be replaced with a fancy cabinet or wall-mounted plate.

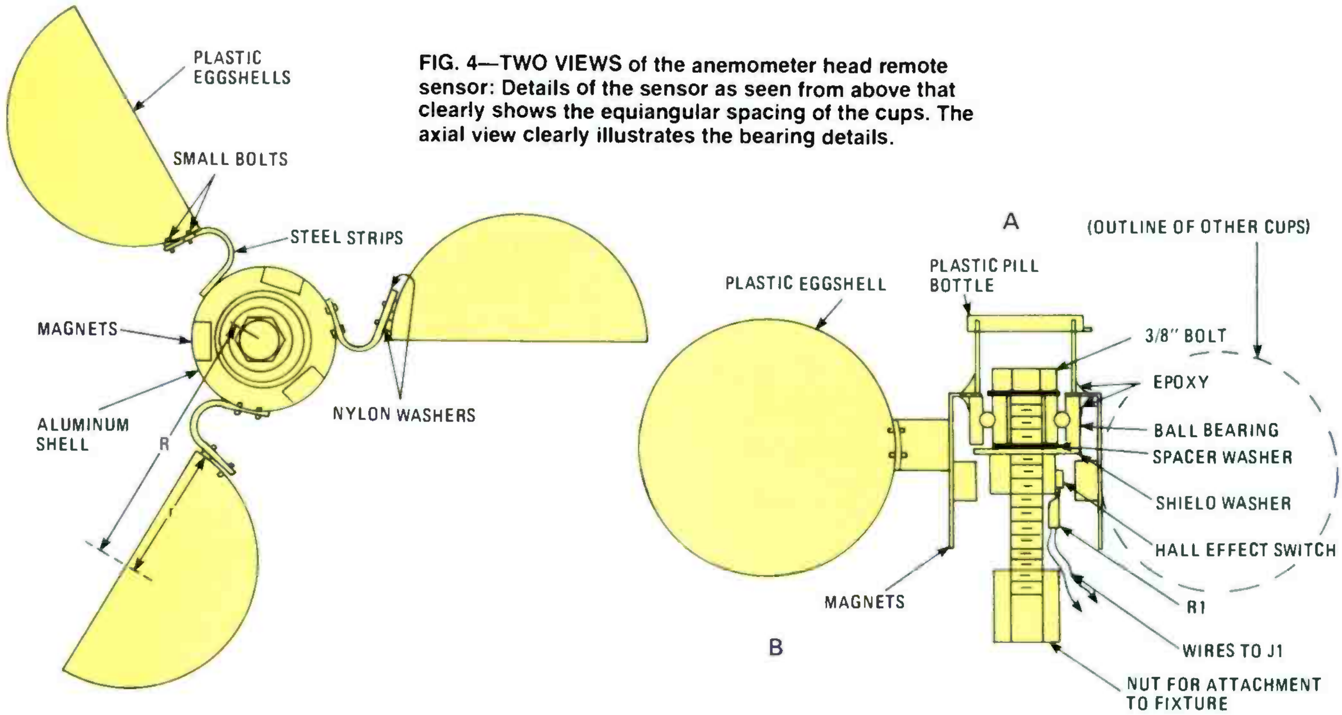
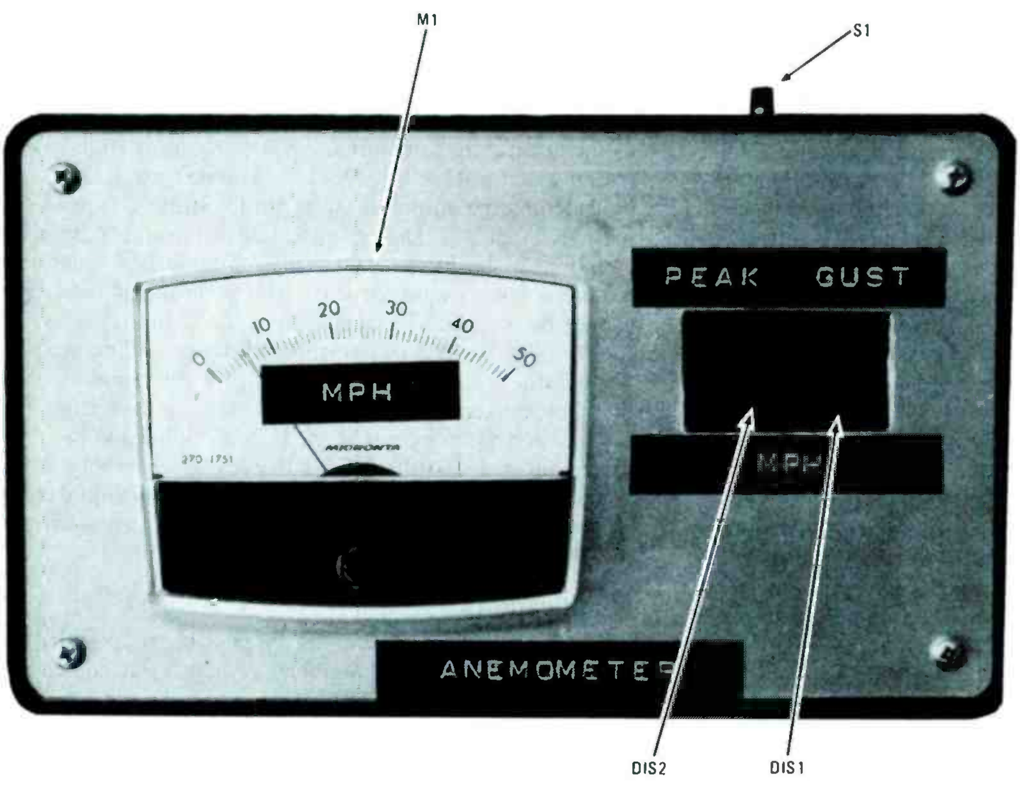


FIG. 4—TWO VIEWS of the anemometer head remote sensor: Details of the sensor as seen from above that clearly shows the equiangular spacing of the cups. The axial view clearly illustrates the bearing details.

used for magnetic bulletin boards, so that the head sent three pulses for every rotation. That technique permits the display to be updated frequently, so that short gusts will be captured. The rest of the parts were truly scrap items. The aluminum shell is actually the top cut off an old electrolytic capacitor, and the plastic eggs were bolted on with strips of 1/4-inch wide thin steel strips from a junkbox, using the smallest bolts available, cushioned with nylon washers. The top cover is made from a plastic pill bottle, cut in half and epoxied onto the aluminum shell.

Calibration

The calibration of the Dual Peak/Current Anemometer is most easily done by actually using a calibrated wind. The most convenient source is a car with the sensor attached to the front bumper. If the anemometer sensor is placed on a bracket in front of the car, and the tests are performed on a calm day with no other traffic, the calibration should be adequate for home use. The test is best performed with a helper. First connect the anemometer sensor to the display units, and either tap off the car battery or use a 9-volt alkaline battery



ALL INDICATIONS displayed on the front panel of the Dual Peak/Current Anemometer read in miles per hour. The meter, M1, indicates current wind speeds, and as the wind varies in speed, the meter pointer will be seen to drop and kick up. RESET switch S1 clears the peak reading of the display LED's, DIS1 and DIS2. The next clock cycle will provide an indication, and this indication will increase should the wind increase always indicating the highest gust since the RESET switch was last depressed.

PARTS LIST FOR DUAL PEAK/CURRENT ANEMOMETER

SEMICONDUCTORS

D1—1N914 rectifier diode
DIS1, DIS2—Seven-segment light-emitting-diode display
Q1—2N2222 NPN transistor
U1—Hall Effect Switch—see text (Radio Shack 276-1646)
U2—74123 dual retriggerable monostable multivibrator integrated circuit
U3—7402 quad 2-input NOR integrated circuit
U4—NE555 timer integrated circuit
U5, U6—74LS90 BCD decade counter integrated circuit
U7, U9—7485 magnitude comparator integrated circuit
U8—74199 8-bit shift register integrated circuit
U10, U11—7447 BCD-seven-segment decoder/driver integrated circuit
U12—LM7805 5-volt, 1-A, positive voltage-regulator integrated circuit
Z1—Full-wave, 50-PIV, 1-A, bridge-type rectifier (see text)

RESISTORS

(All fixed resistors are ¼-watt, 20% rated)
R1—120-ohm (see text)
R2—200-ohm
R3–15,000-ohm
R4—1-Megohm
R5—30,000-ohm
R6—100,000-ohm, trimpot
R7—120-ohm
R8—1 Megohm, trimpot
R9—2000-ohm
R10-R23—220-ohm

CAPACITORS

C1—.005-µF, ceramic or mylar
C2—.47-µF, mylar
C3—.05-µF, mylar or ceramic
C4, C6, C11, C12, C13—0.1-µF, mylar or ceramic
C5—2-µF, electrolytic
C7, C10—1-µF, tantalum
C8—.01-µF, ceramic or mylar
C9—330-pF, ceramic
C14—2000-µF, electrolytic

ADDITIONAL PARTS AND MATERIALS

M1—0-50-uA, DC panel meter
T1—6.3-volt, 1-A line step-down transformer (see text)
P1, P2—Miniature 2-conductor plug
J1, J2—Miniature 2-conductor jack
S1—SPST, normally-open, momentary-contact, push-button switch
Printed-circuit or perforated-circuit board, IC sockets, chassis box or plastic case with metal cover, ribbon cable, steel strips, magnets, aluminum shell, wire, solder, hardware, nylon washers, epoxy cement, decals, etc. Refer to text for materials obtained from surplus sources.

wired to the input power jack. Have the driver of the car maintain a constant velocity of 50 mph, and adjust both trimpots so the displays read 50. (It takes 1.2 minutes—1 minute, 12 seconds—to travel a measured mile on a highway at 50 mph.) Then the digital display reads miles-per-hour directly, while the meter reads 1 mph per 1 microamp. The reset switch S1 will have to be pressed every second or so to read the digital speed, and whenever trimpot R8 is adjusted.

Although that completes the calibration, here's a caveat about the variablity of the wind. Wind velocity on a small scale is very turbulent and variable, so while a tree's branches may be wildly waving at one place, an anemometer placed only 20 feet away may be practically stationary. The effect of roof lines, trees, and other obstacles will cause variations in recorded windspeed, so that peak just recorded on your anemometer is not necessarily the same-speed gust that blew over your trash cans. The average over many gusts or many days, however, should be accurate, and the relative values from day to day are always interesting.

All that remains is to install the anemometer sensor at the remote site. Two-conductor wire is all that is required; but remember that neither is grounded, so proper insulation should be used. If the 5-volt line is accidentally grounded, the voltage regulator U12 will shut off, so that no permanent harm is done. Although rooftop installation will generally give the highest readings, the hazard of lightning strikes may exist if too high a pole is selected.

Troubleshooting

Although the circuit assembly and construction are straightforward, there are several easy tests which can be done if, because of the possible modifications, the circuit does not work properly. First of course, the power-supply voltage should be checked at each of the IC pins that require the 5 volts. To check the input circuit, measure the voltage on pin 1 of U2—it should oscillate between about 0.7 volts and 2.5 volts when the magnets are moved near and away from the U1. If nothing happens, the magnets may be reversed, or not strong enough. If the voltage does change, but not enough to trigger the U2, then the Hall-effect switch is working; but due to manufacturing tolerances, it may require a slightly different value for R1 or R2. That can be done by trial and error, by watching the output of U2 at pin 13. If those parts check out OK, then the analog meter should work. Individual variations in the current gain of different transistors may also require a lower value for R4 if full-scale meter indication cannot be reached. To troubleshoot the digital circuits, an oscilloscope is needed, but standard digital techniques will again suffice. Check the various pulse widths, making sure that they are near the expected RC values for each chip. The reset switch S1, when not pushed, should allow pin 14 of U8 to remain near 5-volts DC, and goes to zero only when contact is made, zeroing the display. Those hints should cover most of the probable difficulties; if all else fails, try substituting chips one at a time.

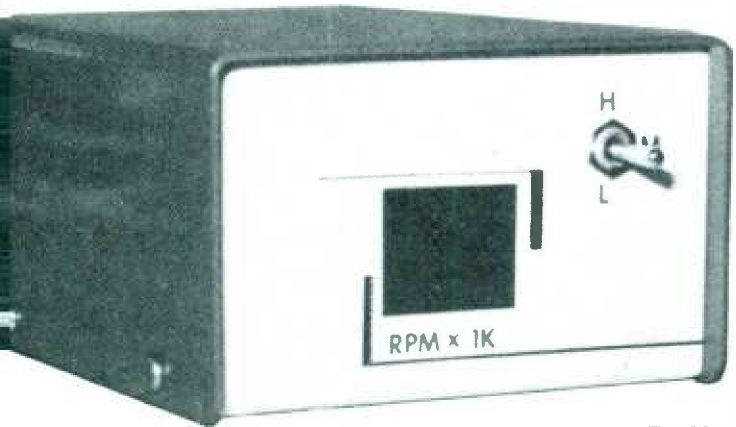
Modifications

Several circuit modifications are possible to alter the device to the particular requirements or parts on hand.

The panel meter can be 100-microamp full scale instead of 50 microamp, for a 0-to-100 range on the analog scale.

(Continued on page 94)

Keep your set of wheels ahead of the pack by building....



DIGI-TACH

A solid-state readout device that lets you check your car's engine performance during tune-ups and on the road!

By Mark C. Worley

MOST AFTER-MARKET TACHOMETERS ARE EITHER EXPENsive, inaccurate, or both. With the all-CMOS, digital tachometer (we call it Digi-Tach) described in this article, you can have reliability, accuracy, an easily read display, and freedom from mechanical damage due to shock and vibration. Digi-Tach will work with any car with a conventional ignition system.

A 2-digit tachometer may seem to lack resolution, but the primary application for this circuit is for use while driving. When fine-tuning an engine, you can't beat a quality, expanded-range analog tachometer, but for use in the car, a digital tachometer should be your choice.

How it works

A digital tachometer is actually a low-frequency counter with a readout calibrated in *rpm*'s instead of Hertz. Much like a frequency counter, the Digi-Tach (Fig. 1) contains a master-clock circuit (U6), latch and reset pulse generators (U2-b–U2-d), input signal conditioner (U1, U2-a), pulse counter (U3), display and display drivers (DIS1, DIS2, U4, and U5), and a voltage regulator (U7). As an added feature, Digi-Tach contains a dimmer circuit (U2-e) as an added feature.

Since we're counting *rpm*'s, we have to scale the counting period via the master-clock generator, U6, to display a pulse rate as something other than pulses-per-second. A 4-cylinder car idling at 1000 *rpm* has its engine *turning over* one-thousand times a minute. So how does that equate to a pulse frequency? If we assume that each cylinder will fire once per revolution, there would be 4 × 1000, or 4000 pulses per minute from the ignition coil, so, 4000 divided by 60 equals 66.66 pulses per second. However, only half the spark plugs fire each revolution, so there's really only 33.33 pulses per second in this case. An 8-cylinder engine has twice as many spark plugs, so 1000 *rpm* equals 66.66 pulses per second, and a 6-cylinder engine generates 50.00 pulses per second. All that refers to 4-cycle (Otto) engines; 2-cycle (diesel) engines operate differently.

Now that we know the pulse rate we're going to measure, we need to figure out how to display that rate in *rpm*. Since, again, a 4-cylinder engine generates 33.33 Hz at 1000 *rpm*, we can count the pulses for 300 milliseconds, which will be ten pulses. If we now display that count of 10 with a decimal point between the two digits, we can read it as 1.0 x 1000 *rpm*. For 6-cylinder engines, we need to count the pulses for 200 milliseconds, and for 8-cylinder engines we only need to count the pulses for 150 milliseconds, to convert from Hz to *rpm*.

For those that still insist on more than two digits, consider that for a 4-cylinder engine we'd have to count pulses for 3 seconds to be able to display three digits. For 8-cylinder engines we could cut that time in half, to 1.5 seconds, but that would still give us a pretty unresponsive display. An alternative would be to use a frequency-multiplier circuit, but the added expense and trouble isn't worth it. With that behind us, let's look at each part of the circuit in detail.

Master Clock

The master-clock generator, which sets the time-period during which the ignition pulses are counted, is a 4060 CMOS oscillator/divider set to run at 424 Hz when used for 4 or 8-cylinders. That frequency is divided down to the clock frequency of 3.3 Hz at pin 6, and 6.6 Hz at pin 4. For 6-cylinder engines, the oscillator frequency is set to 320 Hz and is divided down to a clock frequency of 5.0 Hz at pin 4; the resistor and capacitor values that are used allow the oscillator to be tuned through both frequencies.

The oscillator frequencies are somewhat arbitrary, being determined in part by the values of the components that were

PARTS LIST FOR DIGI-TACH DIGITAL TACHOMETER

SEMICONDUCTORS
D1—1N4004 silicon diode
D2, D3—1N914, 1N4148, or equivalent silicon diode
U1—MCT2 optoisolator
U2—4584 or 74C14 hex Schmitt trigger integrated circuit
U3—4518 dual BCD counter integrated circuit
U4, U5—4511 BCD-to-7-segment decoder/driver integrated circuit
U6—4060 binary counter integrated circuit
U7—7805 5-volt regulator

CAPACITORS
C1,C2—0.1-µF, ceramic disc
C3—.047-µF, Mylar
C4, C5—.001-µF, ceramic disc
C6—.01-µF, ceramic disc
C7—1000-µF, 16-WVDC, electrolytic
C8—100-µF, 16-WVDC, electrolytic
C9—10-µF, 16-WVDC, electrolytic

RESISTORS
(All fixed resistors are 1/4-watt, 5%, units unless otherwise specified)
R1—10-ohm
R2—2200-ohm
R3—27,000-ohm
R4—10,000-ohm
R5—20,000-ohm, miniature trimmer potentiometer
R6, R25—4700-ohm
R7, R8, R24—47,000-ohm
R9-R22—150-ohm
R23—620-ohm

ADDITIONAL PARTS AND MATERIALS
DIS1, DIS2—5082-7740 LED displays (Hewlett-Packard), or equivalent
S1—SPDT, center-off, toggle switch
Metal box, perfboard, wire, solder, Bishop Graphics *E-Z Circuit* part number EZ1206, display sockets (see below), etc.
The display sockets used in the project are Aries Electronics part number 14-810-90T, 14-pin, 90-degree, tin-plated, vertical-mount sockets. Check with your local wholesale electronics distributors or contact Aries Electronics, Inc., PO Box 130, Frenchtown, NJ 08825, (201) 996-6841, for their nearest distributor.

on hand. In addition, we wanted to keep the frequency low and use moderate component values for R4–R6 and C3 to maximize the frequency stability. Large-valued resistors and capacitors tend to be less temperature-stable than smaller valued components. In any case, the master clock must be available from some one of the divider outputs regardless of the oscillator frequency used.

Latch and Reset

The latch and reset pulses are generated by three of U2's inverters. The rising edge of the pulse from U6 is coupled into U2-b through an R-C network made up of C4 and R7. That spike causes the normally-high (5-volts) output of U2-b to go low (0-volts) for about 50 microseconds, which is used to latch the updated count into the display. The rising edge of that latch pulse also causes the output of U2-c to pulse low for about 50 microseconds in an identical manner. Since the reset pulse has to be positive, U2-d inverts it to the proper polarity.

You can see the relationship between the master-clock pulses and the latch & reset pulses if you refer to the timing diagram shown in Fig. 2. As with most frequency counters, the gating or counting period is not synchronized to the incoming frequency and sometimes causes the last digit to vary by ±1 count.

Counting Pulses

The input circuit uses an optoisolator and a Schmitt trigger to make the noisy, high-voltage ignition pulses suitable for the pulse counter. The optoisolator was chosen as the input device because it is a current operated device that ignores voltage transients. Only when a few milliamps of current flow through the internal light-emitting diode (LED), will the signal be coupled to its phototransistor and be recognized by the circuit as an ignition pulse. Resistor R1 is used as a fuse and is mounted at the coil-end of the pickup wire. Diodes D1 and D2 protect the LED from high reverse voltages caused by ringing in the ignition coil. Capacitors C1 and C2 further help to immunize the circuit from extraneous noise pulses. Before the ignition points close, the LED in U1 is drawing about 6 mA through the primary winding of the ignition coil. That keeps pin 5 of U1 low. When the points close, current is cut off from the LED and pin 5 goes high because of pull-up resistor R3. The inverter, U2-a, squares-up the pulses before they're fed to U3.

Schmitt triggers have the unique ability to take a noisy signal, or one with a slow rise time and shape it into a straight-sided, clean signal suitable for digital use. Their outputs switch from high-to-low or low-to-high as the input signal passes through a point equal to about 50 percent of the supply voltage. In the pulse generator, the pulse-shaping of inverters U2-b–U2-d is used create clean pulses from narrow, rounded spikes. In the signal conditioner, inverter U2-a shapes the output pulses from U1, while the dimmer circuit finds another use for Schmitt triggers.

Getting a Display

The ignition pulses from U2-a clock the dual divide-by-ten, BCD counter, U3, whose two counters are ripple-cascaded. The reset pins, pins 7 and 15, are tied together and are normally low, allowing the counters to advance on each clock pulse. When a reset pulse is received, the internal counters are reset to zero to clear the counters before they count the new *rpm* rate. The output data from U3 is in BCD (*B*inary *C*oded *D*ecimal), which is required by the display drivers.

The data from pins 3 through 6 are the least significant digit (LSD) bits and should drive the right-most digit, while the data from pins 11 through 14 should drive the most significant digit (MSD), the left one. If you wire those backwards, it takes a lot of rewiring to turn things around, so be careful.

The display drivers, U4 and U5, convert the BCD data into 7-segment display code for the two displays. The latch signal, which is normally high, keeps the previous *rpm* value latched

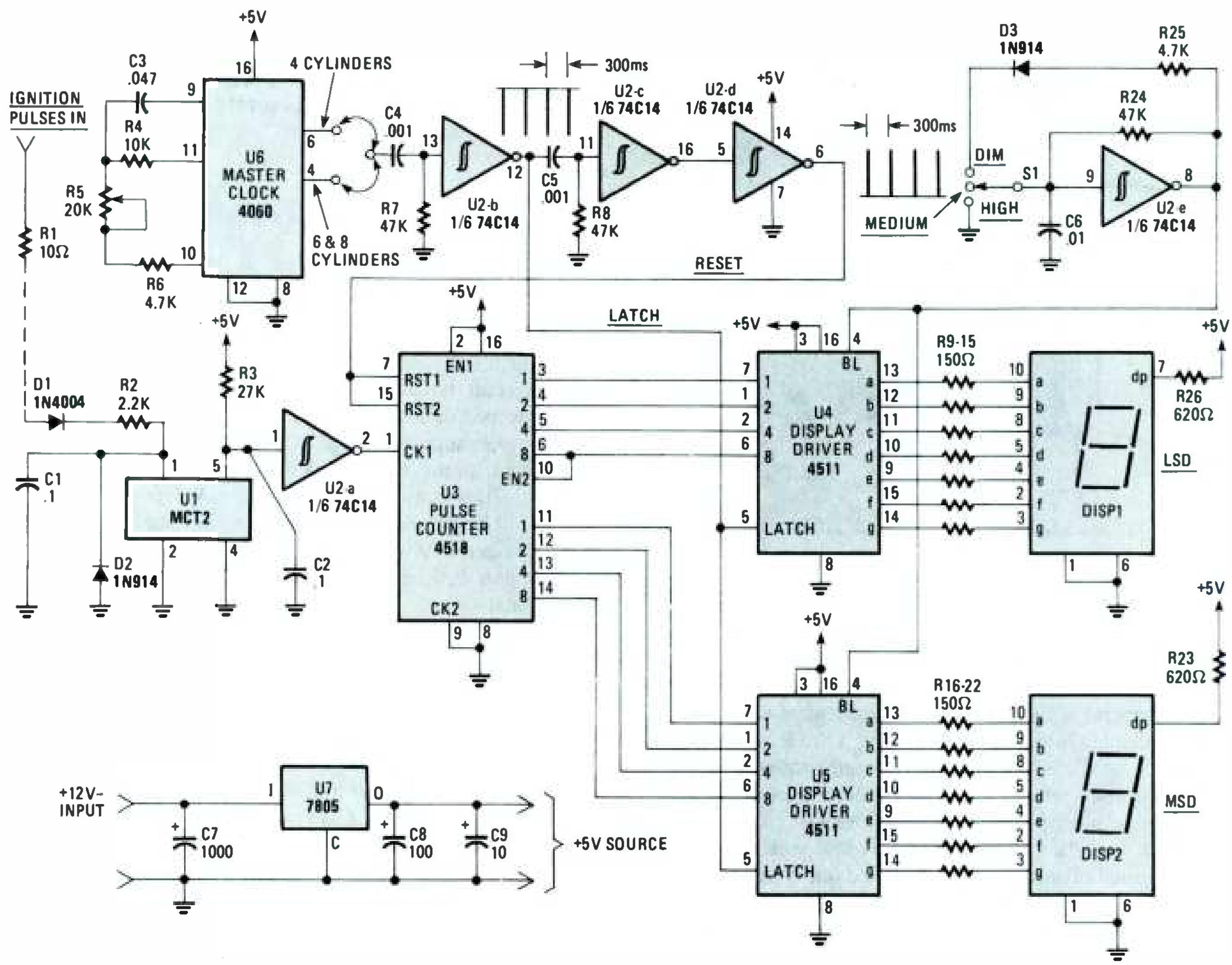
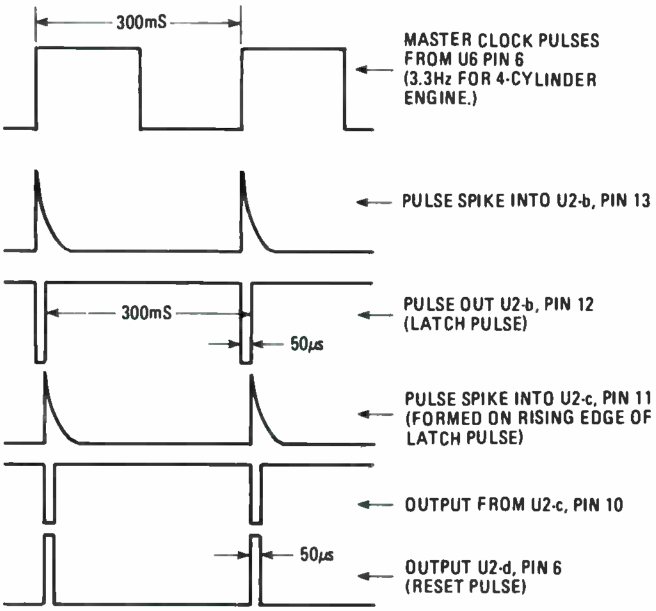


FIG. 1—THE SCHEMATIC DIAGRAM of Digi-Tach circuit. Since this device is to be mainly used while driving, two-digit resolution was used to keep response time short. An optoisolator is used to render the noisy, high-voltage ignition pulses suitable for input to the circuit.

into the displays until the master-clock generates another timing pulse. At that time, the latch pulse locks in a new display count, then the reset pulse clears the counters to zero.



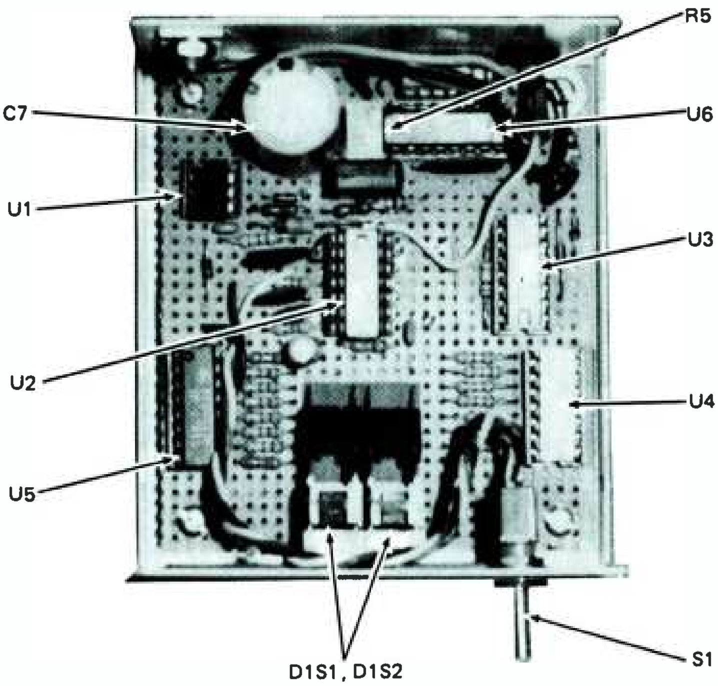
The 100 μs that latch and reset operation takes is a very small portion of the 150–300 ms used to count the ignition pulses, so it can be ignored.

Since a car's interior has widely varying lighting levels from bright sunlight to midnight blackness, the display should be capable of being adjusted to those conditions. A display with sufficient brightness to be viewed in sunlight is usually too bright and blurry in darkness, while one suitable for viewing in darkness is too dim to be seen in sunlight. Using an SPDT, center-off, toggle switch (S1), we can have a brightness control with HIGH, MEDIUM, and LOW positions.

The blanking input of the display drivers, pin 4, will turn the displays on or off if it is taken high or low respectively. If we modulate the blanking input with a variable duty-cycle signal, we can control the brightness of the display by varying the ratio of the on and off times.

The versatile Schmitt trigger can become a simple oscillator with a duty-cycle of about 50 percent by adding only a

FIG. 2—THE RELATIONSHIP between the master-clock pulses from U6 pin 6 and the latch and reset pulses are shown here. The example illustrated is for a 4-cylinder engine, hence the master-clock frequency is 3.3 Hz. As with most frequency counters, the gating or counting period is not synchronized to the incoming signal, which sometimes causes the last digit to vary by one count. Note: waveforms are not drawn to scale.



PEEKING INSIDE THE CASE you find the author's neatly assembled perfboard circuit. Author used point-to-point wiring; however, you could use the wire-wrap technique. Approximate location of parts on your layout to take advantage of author's successful planning.

capacitor and a resistor. That is done with the U2-e circuit. If the output of that circuit is fed to the blanking input of the display drivers, it dims the display somewhat to give us a medium display brightness. By adding a diode and resistor, the duty-cycle of the oscillator can be made controllable, and, depending upon which direction the diode faces, the duty-cycle can be mostly high or mostly low. For a dim display (LOW), we want the pulses to be mostly low, which keeps the display turned off more than it is turned on. Note that we're not particularly interested in the oscillator's frequency, as long as it is sufficiently high to avoid flickering the display; we need to vary the duty-cycle to control the brightness.

The value of resistor R25 can be changed to whatever gives you the desired low illumination level. Reducing the value dims the display even more. It would even be possible to replace R24 with a photosensitive resistor mounted on the front panel to make a display that automatically adjusts to ambient lighting. Just eliminate the switch and permanently connect the cathode of D3 to ground. If the dark resistance of the photo resistor is too high, the oscillator frequency may drop top low and cause a flickering display, so you'll have to experiment a bit. If you replace R25 with the photoresistor (instead of R24), the dimming action will be in reverse because its resistance decreases with an increase in light.

When the input to the oscillator is grounded by the switch, the output goes high, which turns the displays on to their brightest for the HIGH setting. Since the 4511 display drivers have a maximum safe-current capacity of 25-mA-per-segment, 150-ohm limiting resistors are used to limit the current in each segment to about 23 mA with a 5-volt DC supply. The decimal point is driven directly from the supply, instead of from the decoder/drivers, so a 620-ohm resistor is used to limit the brightness to a suitable compromise between the LOW and HIGH settings. Figure 3 compares the outputs from U2-e for the three brightness settings.

Power-Supply Details

The 7805 voltage regulator is used primarily for circuit protection and to stabilize the master oscillator frequency. The typical +12-volt system in most cars generates about 13.8-volts, which is safe for the CMOS IC's in this circuit, but a voltage spike of only a couple volts would exceed their safe ratings. Additionally, changes in the power-supply voltage affect the oscillator frequency, which must be kept stable for accurate *rpm* readings.

The circuit draws about 200 mA with the displays at full brightness, so the 7805 voltage regulator will get moderately warm. The voltage regulator, U7, will remain well within its safe limits as long as it's properly heat-sinked.

Construction

Digi-Tach is built on a 2⅝ × 2⅜-inch perfboard, which fits into an aluminum box that measures about 3⅛ × 3½ × 2 inches. Power, ground, and the ignition pickup wire come in through a 3-wire cable in the back. The voltage regulator, U7, is mounted in the left, rear corner of the box, which acts as a heatsink for it. The LCD's and dimmer switch, S1, are mounted up front.

Use sockets for all the IC's except U7. Mount the decoder/drivers near the two displays. The other IC's can be installed where convenient since the layout isn't critical.

The prototype was hand-wired with the help of Bishop Graphics *E-Z Circuit*, which is a stick-on type of instant printed-circuit pattern. The author prefers to use just the dual-in-line pattern to hold the IC sockets in place, then use wire-wrapping wire to interconnect the pads and parts. We don't wirewrap with the wire—we solder it. (The part number for the DIP pattern is EZ1206.) Route your wires directly between the two points they solder to instead of cabling them all together. That *rat's nest* method doesn't look as pretty, but it is easier to troubleshoot and usually results in less noise being coupled between wires.

No doubt you've noticed the vertical sockets used to hold the displays in place (see photo). They're amazingly convenient since they eliminate the need for a second board to mount the displays on. That way, the whole circuit is built as one modular piece. Check the parts list for the part number and source for those. We also used the *EZ Circuit* pattern to hold the sockets in place. Be careful when wiring the sockets—it is especially easy to get "turned around" and misidentify the pins since they make a 90 degree bend. The displays have ten pins, so each socket will have four unused pins, one at each corner, which can be conveniently used for tie-points.

Small-gauge wire will handle the power, ground, and interconnections for the complete circuit except for the power and ground leads for U4 and U5. Run a separate 20-gauge wire from the 5-volt output of U7 to the supply pins of the display drivers, and a separate ground lead, too. If any of the other IC's tie into those leads, the current surges that occur as the displays update can cause erratic circuit behavior. Feel free to add extra 10-µF electrolytic or 0.1-µF disc capacitors between power and ground at various spots on the board to eliminate noise. Capacitor C9 in the schematic is one such added capacitor. Also be sure to tie the circuit common to the metal box. A terminal-lug under a screw in the right, rear corner of the box was used for that.

After wiring the board and checking for incorrect wiring, shorts, etc., use a power supply capable of at least 200 mA with an output between 9- and 15-volts DC, and apply power without any of the CMOS IC's or displays installed. Check for 5 volts on the proper pins of each IC and correct any problems you may find. Now plug in the IC's and the displays and fire it up again; you should have two random numbers (or zeros) and a decimal point displayed. Try the 3-position dimmer switch but don't try changing R26 until you've had a chance to view the display at night in your car.

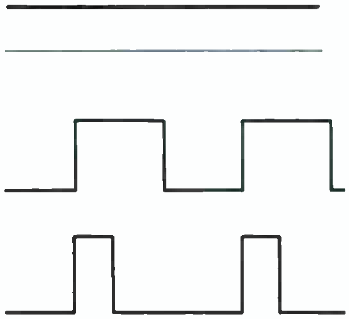


FIG. 3—A FRONT-PANEL SWITCH allows the brightness of the display to vary. These waveforms, which are output by U2-e and fed to the blanking input of the display drivers, are used to set that brightness. The waveform in *a* is the output when the brightness switch is in its HIGH position. The waveform in *b* is the output when the switch is in its MEDIUM position. The waveform in *c* is the output when the switch is in its LOW position.

Calibration

Determine whether Digi-Tach will be used with a 4-, 6-, or 8-cylinder car and jumper C4 to either pin 4 or pin 6 of U6 accordingly. (Pin 6 is used only for 4-cylinder cars, while pin 4 is used for both 6- and 8-cylinder cars.) Apply power, then set a stable audio-frequency generator to about 60 Hz (sinewave or squarewave) at maximum output and connect it to the pickup wire. If you get any kind of a steady display that varies only when the frequency is changed, then set the generator to a frequency that should equal 5000 *rpm*, and adjust R5 until the display shows "5.0." Note, 166.66 Hz = 5000 *rpm* on a 4-cylinder engine, 250.0 Hz = 5000 *rpm* on a 6-cylinder engine, and 333.33 Hz = 5000 *rpm* on an 8-cylinder engine. Use a frequency counter, if available, to get the most accurate calibration by setting the main oscillator to either 424 Hz or 320 Hz on pin 11 of U6, or by accurately measuring the audio frequency used to calibrate the tach.

If the signal generator doesn't have the power to drive U1, check to make sure that there aren't any circuit problems causing that, then remove U1 from its socket. Next insert a 10,000-ohm resistor into pin 5 of U1's socket, turn the generator's output to minimum and connect it to the free end of the resistor. Slowly increase the generator's output to somewhat above where the display has a steady reading, and adjust R5 until the display shows the proper *rpm*. Remove the 10,000-ohm resistor and replace U1.

Installation

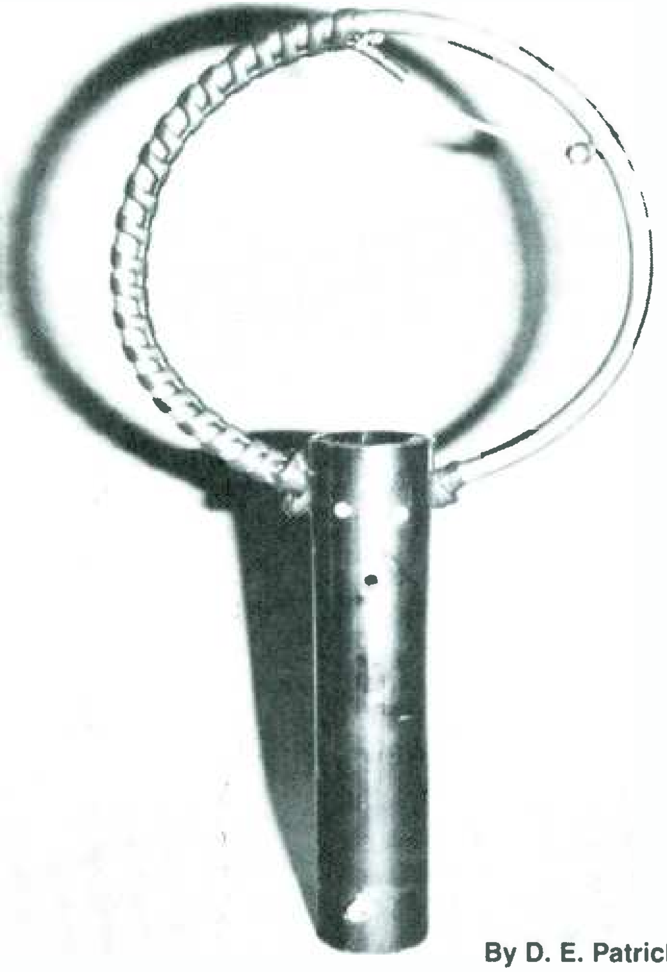
Installation of Digi-Tach is a matter of personal preference and convenience, but mount it where it's easily viewed and doesn't interfere with your driving. The power lead should go to a terminal on the fuse block that is powered only when the ignition is on. Better yet, include a ½-amp fuse in series with the Digi-Tach's power lead. Route the ground lead via the shortest path to a good chassis ground and make a proper connection.

The pickup wire should have a heavy, insulating jacket to protect it against abrasion and possible shorts to the car chassis. Avoid routing the ignition pickup wire near the radio since it may radiate some noise into the radio. The pickup wire should go to the ignition-coil terminal marked with a "–." That is the terminal that the car's points (part of the ignition system) connect to. Connect the pickup wire to the terminal through a 10-ohm resistor (R1 in Fig. 1) to isolate the terminal in case the pickup wire shorts to the chassis. Solder the resistor to the end of the wire, put sleeving over the resistor, and solder a spade lug to the other end of the resistor for connection to the coil. In the event that the wire shorts to the chassis, the resistor will safely burn open like a fuse. If you prefer, a ¹⁄₁₀-amperefuse could be used in place of R1.

Do not connect the pick-up lead to the heavy, high-voltage lead coming out of the top of the coil, or to the spark plugs. You shouldn't have any problems making Digi-Tach work if you have a conventional ignition system or a capacitive-discharge ignition system. Digi-Tach isn't intended for use on the newer "breakerless" and "high-energy" systems and may not work on them, however, with an inductive pickup coil and a few additional parts you could probably convert Digi-Tach to work on those types of ignition systems.

With proper usage, Digi-Tach should help improve the performance and gas mileage of your vehicle. ■

THE AUTHOR'S completed Digi-Tach was designed to match the interior style and color of his car. Dashboard mounting was used; however, the unit was so position that a sudden stop would not make it a hazzard to the driver. The front panel switch presets the light intensity of the display taking into account daylight and night-time driving.



Add a Directional Loop Antenna to your CB or Ham Rig

Here's a useful project to help find a CB'er or Ham who is causing TVI, or one who is lost or otherwise in need of help!

By D. E. Patrick

YOU'RE SITTING AT HOME WATCHING YOUR FAVORITE TV show. Suddenly, the picture is enveloped in snow and the sound becomes distorted. What's happened is that some CB'er or ham is victimizing you with a spitting, spattering, over-powered, over-modulated, and/or off-frequency transmission. If you're lucky, he'll go away—but more than likely he won't.

Now, you don't have to just sit there and take it. Using your CB or ham transceiver's S-meter and a loop antenna, you can locate him, take away his anonymity, and a discuss the matter up-close and personal.

On a more pleasant note, the Directional Loop Antenna described here can be invaluable when searching for a CB'er who's lost or in need of help.

Going Further

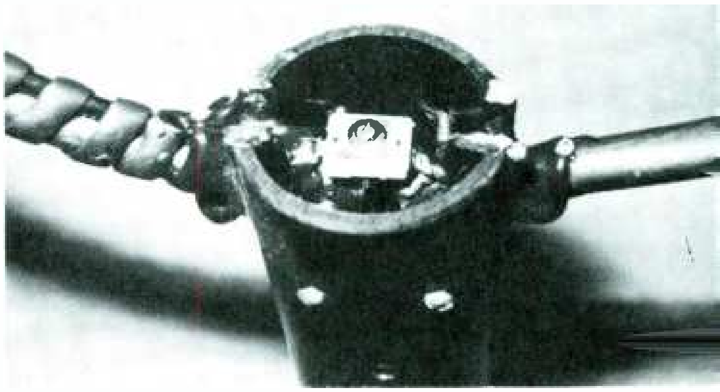
A direction-finding loop antenna is a tried and proven method of finding a transmitter. The unit described here can be built with, or without, an optional preamp, depending upon the sensitivity of your receiver. It is designed for direction-finding only—not for transmission. In fact, should you desire to blow away your final amp's chips, press the talk button when the loop is connected.

As shown in Fig. 1, the antenna proper is a loop of copper tubing. It is mounted to a larger piece of PVC or ABS plastic tubing, used as a mast, and tuned with trimmer capacitors and an adjustable slider. The antenna is attached to a ham or CB receiver or transceiver. The receiver (or transceiver's) S-meter is used as an indicator of received signal strength. When the flat surface of the loop is aimed (broadside) in the direction of a transmitter, the S-meter will provide a null indication. In other words, the direction of the flat side of the loop will indicate a line along which the transmitter is located. Adding a pointer to the unit, perpendicular to the flat side of the loop, can be a help.

Of course, if you rotate the loop 180°, you will get a second null. Therefore, at least two readings—and a map—are required, as shown in Fig. 2. With two readings, the position indicated by the intersection of the two lines is the location of the transmitter. Thus, with the aid of a map (oil company and auto-club maps are the best), you should be able to track down your quarry. However, the more readings you take, the sharper an indication of the location you can obtain.

Loop Antenna Construction

To build the loop proper, take a 30-inch length of copper tubing and start bending it into a loop around a 5-gallon paint can, or a thin telephone pole, or similar form to give you the basic shape; you can finish it up by hand (of course, a pipe bender or former is the ideal way to go). At the two open ends solder a 5- to 50-pF trimmer capacitor (C1) so it can be



30-IN. LENGTH of copper-tubing loop is cemented in place with epoxy. Trimmer capacitor C1 is soldered to bridge the loop's ends. Note coax cable taped to loop at left.

adjusted from the top side. Drill two holes through the tubing for two #6 screws that are used to mount the loop to the mast.

Attach the braid of a piece of RG-58/U or equivalent coax to the top center of the loop, with the center conductor going to a copper slider. Four inches minimum of the braid should be attached to the slider. The slider can be cut from a piece of 1/64-inch thick copper or brass sheet to approximately 7/8 × 1/4 × 1/64-inch, with a 1/8-inch screw hole, and a 3-32 × 1/2-inch screw/nut combination used as a tightener.

Preparing the Mast

The copper loop is mounted on a piece of 2-inch diameter ABS tubing or equivalent. The tubing, which is used as a mast, should be a least one-foot long. Two 7/16- × 1-inch slots are cut in the top side of the mast to receive the copper loop. A 3/8- × 3/8-inch slot is cut in the bottom side of the mast for the output coax line. Two 11/64-inch holes were drilled to hold the loop to the mast with #6 2½-inch screw/nut combinations. The actual length of the screws will be dictated by the diameter of the mast tubing used. Another 1/8-inch hole is drilled in the bottom of the mast to hold a line restraint for the output coax.

Also, two 1/8-inch holes were drilled to hold a small circuit board upon which C2, C3, and L1 are mounted; another 1/4-inch hole is drilled to allow adjustment of C2 if no preamp is used. On the other hand, an additional 1/4-inch adjustment hole is required for a third trimmer capacitor if a preamp is used.

If no preamp is required, C2, C3, and L1 are mounted on a piece of perforated construction board, with the loop coaxial cable attached to the center tap of L1 and ground, and the output coaxial cable attached to C3 and ground (see Fig. 3). Inductor L1 consists of 25 turns of #24 magnet wire on a 1/4-inch coil form, tapped 6 turns from the lower end. That is, wind 6 turns, make a 1/2-inch diameter loop, twist the loop and wind another 19 turns. Capacitor C2 is wired in parallel with L1 and C3 goes to the tap. The low end (end with smallest number of turns) goes to ground. The inner lead of coax from the loop is soldered to the tap and the inner lead of the output coax is soldered to the other end of C3.

Generally, well-designed receivers with at least one RF preamp stage and a good signal-to-noise ratio won't require a preamp. Further, too much gain can have the net effect of

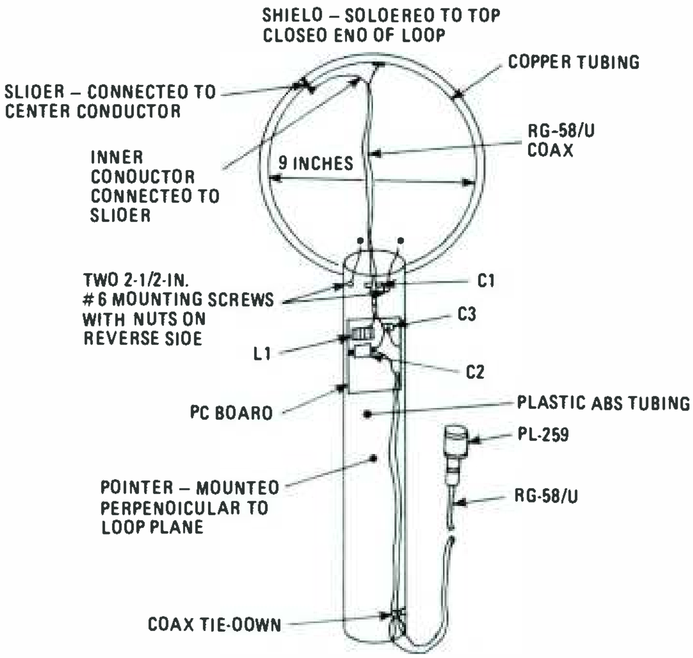


FIG 1—A LOOP ANTENNA can easily be built using some copper tubing, some plastic tubing for the mast, and a few components. It can help you locate the source of troublesome TVI, or find the position of someone who is in need of help.

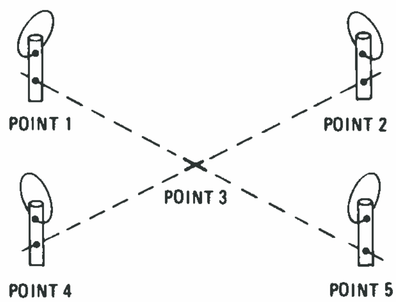
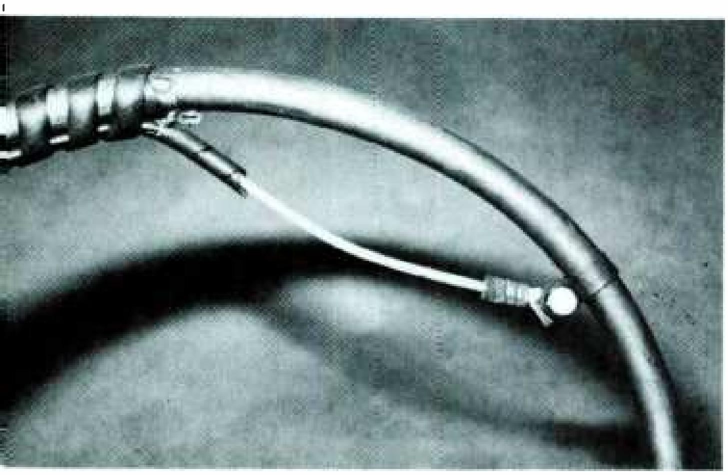


FIG. 2—TO PINPOINT a location, at least two readings should be taken. The point where the lines determined by those readings intersect is the general location of the transmitter. The more readings that are taken, the more precisely a location can be found.



END OF COAX BRAID is soldered to the top-center of the copper loop and the center conductor of the cable is connected to the slider that is made from a piece of copper.

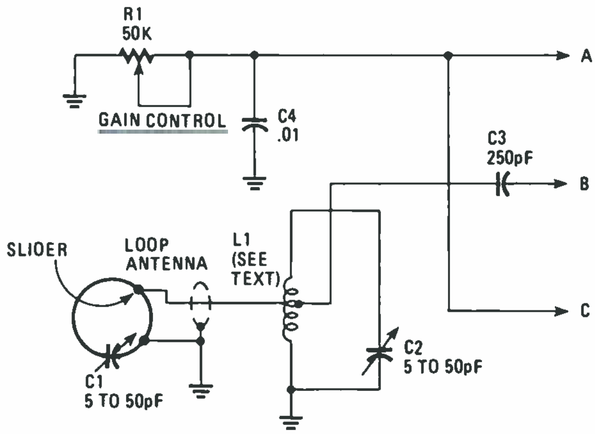


FIG. 3—THE BASIC circuit to tune the loop antenna. Coil L1 consists of 25 turns of #24 magnet wire, tapped at 6 turns from the low end, on a 1/4-inch form.

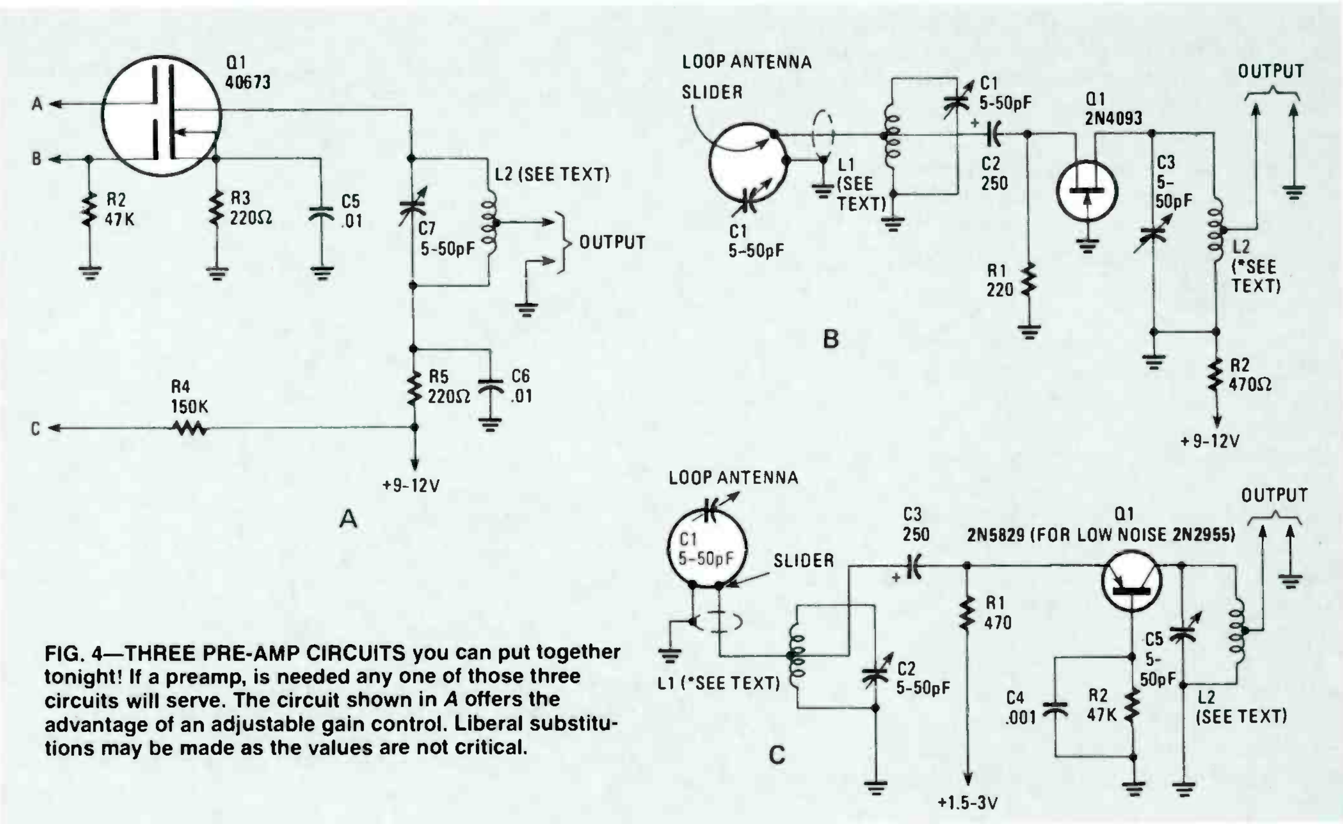


FIG. 4—THREE PRE-AMP CIRCUITS you can put together tonight! If a preamp, is needed any one of those three circuits will serve. The circuit shown in *A* offers the advantage of an adjustable gain control. Liberal substitutions may be made as the values are not critical.

overloading some receivers. Therefore, the loop antenna should be tried out first on your particular receiver without a preamp. If a preamp is used, some type of provision to bypass the preamp in strong-signal areas should be included.

In any case, all the preamps in Fig. 4 are similar. The protected dual gate MOSFET circuit in Fig. 4A is a common-source type with gain control provided by R1. The circuit in Fig. 4B is a common-gate JFET type, and the circuit in Fig. 4C is a common-base transistor type.

Coils L1 and L2 are wound the same as described earlier. The circuits of Figs. 4A and 4B require 9 to 12 volts, while the circuit in Fig. 4C runs on only 1.5 to 3 volts. All three can be built out of junkbox parts, with pretty loose substitution of parts allowed. The values shown in the circuits are not at all critical. Note that one advantage of the circuit in Fig. 4A is that it offers the convenience of gain control, which can come in handy.

Adjusting the Loop

First, let's look at the Directional Loop Antenna adjustments if no preamp is used. Connect the antenna to one receiver (or transceiver), and key a transmitter on the same frequency (not the same transceiver) using a light bulb as a dummy-load for 5-watt CB rigs. With the two units some distance apart, adjust C1, C2, and the slider on the loop with an alignment tool for a peak indication on your S-meter. The adjustments will interact, and if one or more adjustments won't peak the S-meter, try adding a 10- to 20-pF capacitor across C1.

If each adjustment still doesn't give you a peaking-type indication, perform the same procedure to C2. And if all the above doesn't work, add a few turns to L1's long side. When everything is right, C1 should be able to make the S-meter rise toward a peak and fall toward a null, then C1's adjustment range will cover the entire CB band—the source of most TVI. However, the loop can be also used to find a ham transmitter (usually less of a problem) with a little adjustment or by changing capacitor and/or inductor values.

Adjusting the unit with the preamp is about the same, except for the additional trimmer that is adjusted in the same manner as C2. However, you'll typically need a greater distance between test receiver and transmitter to avoid overloading Q1. Generally, the preamp is not required for strong signals and should be switched out of circuit or bypassed when not in use.

Use

Tune your transmitter to the frequency of interest. Tweak up the loop antenna by adjusting C1. Rotate the loop for a null on your receiver's S-meter. That will provide you with a line along which the transmitter lies. Using a map and a compass, find your location. Draw a line on the map as indicated by the loop antenna. Drive or walk some distance away and take another reading as previously described. Draw another line on the map. The transmitter is located where the lines intersect. For greater accuracy, take some additional readings. The point where all the lines intersect is the location of the transmitter. Now, go get him! ■

PARTS LIST FOR DIRECTIONAL LOOP ANTENNA

C1, C2—5–50-pF, trimmer capacitor
C3—250-pF, ceramic disk capacitor
L1—Tuning coil (see text)
Copper tubing (3/8-inch O.D., 30-inches long), ABS plastic tubing (2-inch O.D., 12-inches long or greater), RG/58-U coax, miscellaneous hardware, sheet copper for slider, etc.

ELECTRONIC COIN TOSS

We call upon fate to make those fair decisions we cannot make ourselves

By Bob Scott

☐MANY AFFAIRS OF THE HEART, ATHLETIC EVENTS, AND business deals have been decided by the flip of a coin. Often, when we cannot come to an immediate decision on a question, we'll toss a coin to decide the issue. The simple electronic device decribed here can be used as an electronic *coin toss* game to decide such *important* issues as who pays for the coffee, or who takes the lunch break first. When properly adjusted to provide a 50-50 chance of heads and tails, the Electronic Coin Toss Game can be used to demonstrate and study the laws of probability.

Inside the Circuit

The circuit diagrammed in Fig. 1 was developed from a heads-or-tails game circuit that is seen often in hobby magazines in one form or another. Two general-purpose NPN silicon transistors are connected in an Eccles-Jordan flip-flop circuit that has two steady states of equilibrium. One is when Q1 is conducting and Q2 is cut off; the other is when Q1 is cut off and Q2 is conducting. The circuit remains in a given state until some outside influence causes the conducting transistor to cut off and the non-conducting transistor to turn on. The transistors have light-emitting diodes (LED's) in their collector circuits to show which transistor section is conducting at a given instant. The conducting transistor causes its corresponding LED to glow. One LED is marked HEADS and the other TAILS.

When the ON-OFF switch is first closed, pure chance causes one transistor to be turned on and the other turned off, thereby lighting either the HEADS or TAILS indicator. When we press the FLIP switch, S1, the circuit is converted into a free-running multivibrator oscillating at approximately 700 Hz. The LED's are alternately on and off but the switching is so rapid that both LED's appear to glow continuously. As soon as flip switch S1 is released, the circuit stops oscillating and remains in the state it was in at the very instant that S2 opened. (*Continued on page 95*)

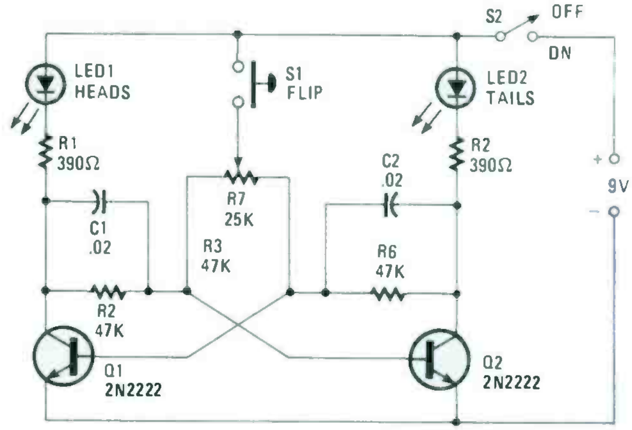


FIG. 1—BALANCE is the theme of this schematic diagram so that the coin flips fall equally heads as well as tails.

PARTS LIST FOR ELECTRONIC COIN TOSS

SEMICONDUCTORS

LED1, LED2—Light-emitting diode (Both red, or one red and one green)

Q1, Q2—2N2222 general purpose NPN silicon transistor

RESISTORS

R1, R5—390-ohm, 1/4-watt resistor

R2, R3, R4, R6—47,000-ohm, 1/2-watt resistor

R7—25,000-ohm, subminiature potentiometer, printed-circuit mount

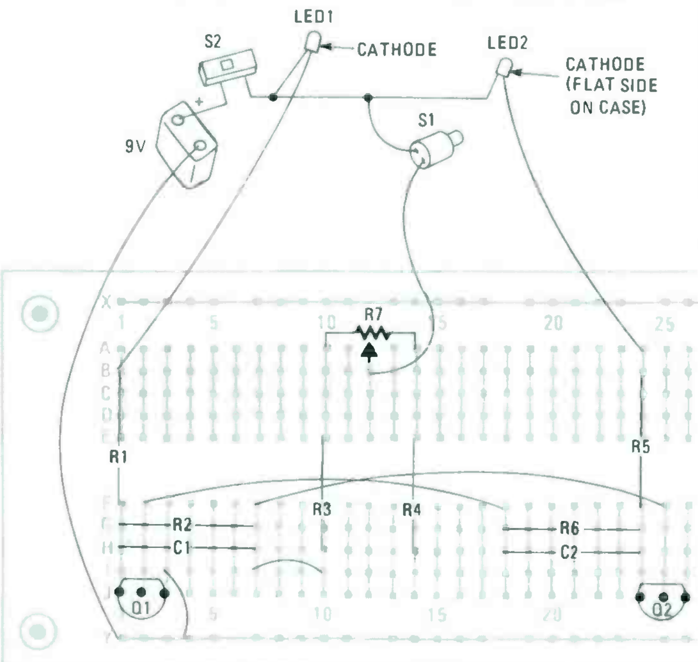
ADDITIONAL PARTS AND MATERIALS

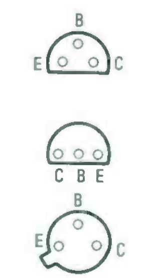
C1, C2—.02-μF, ceramic trimmer

S1—SPST, subminiature, normally-open, push-button switch

S2—Miniature slide switch

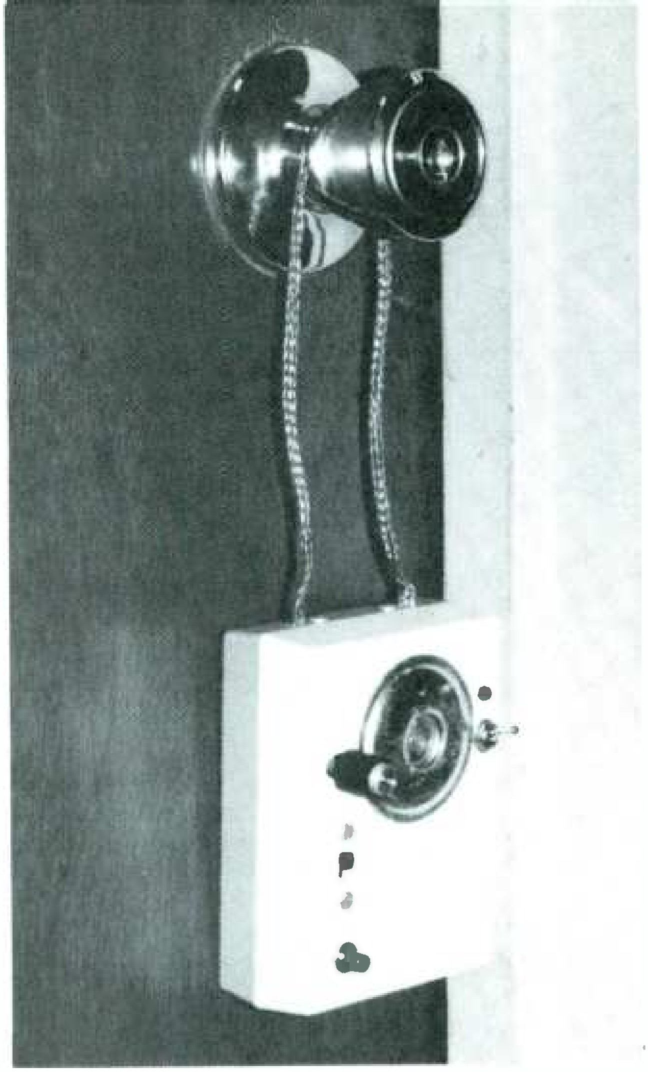
9-volt transistor battery and terminal clips, pre-drilled printed-circuit board or printed-circuit board material, wire, solder, etc.





2N2222 TYPE BASE PINS (BOTTOM VIEWS)

FIG. 2—USING A STANDARD solderless breadboard, your wired version of the Electronic Coin Toss should look like the diagram shown at left.



Build....
PANOPLY

Protect your person and your property with this unique device. To trigger it, all an intruder need do is touch a doorknob.

By Richard Erickson and Arthur Sheiman

HERE'S A DEVICE THAT CAN BE USED TO PROTECT BOTH your person and your privacy. Called the Panoply (after a medieval suit of armor or protective covering), the device is really a sonic panoply. It protects via an alarming panoply of sound that is emitted even before an intruder can fully penetrate the room, area, or premises. It does that by electronically sensing the presence of an intruder as he barely touches a doorknob, even if he is wearing insulating material such as gloves or boots. The Panoply is highly portable. In addition to providing protection at home, it can be transported and used on trips or at the office. Best of all, the Panoply is inexpensive; its cost to make is only about $30.

Theory of Operation

The schematic diagram of the Panoply is shown in Fig. 1. The circuit is powered by two nickel-cadmium C cells, B1 and B2, connected in series to yield about 2.5-volts. A battery charger is an important part of the device (for reasons that are described later in this article). For the values shown in the schematic diagram (Fig. 1), a suitable unit is listed in the Parts List. The recharging circuit consisting of B1, B2, R9, and jack J1 can be modified to accept chargers of different output voltages and currents.

The heart of the Panoply is the oscillator consisting of R3, R4, C3, C4, Q1, and T1 (see Fig. 1). Diodes D1 and D2 conduct on alternate half cycles. No matter which diode is conducting, C4 is effectively in parallel with C3. Capacitors C3 and C4 form a resonant circuit with the transformer T1's F3-F4 winding; the resonant frequency of the circuit is roughly 1 to 2 MHz.

Transformer T1, which is wound on a toroid, has a 3-turn primary and three secondary windings of 17 turns each. About ⅙ of the signal at the collector of Q1 is fed back to its base via the transformer coupling between the primary and the first secondary winding. The secondary of T1 works as an impedance transformer.

The signal at the collector of Q1 (Fig. 1) appears across one of the secondary windings to B+. Any impedance on the far end of the secondary appears across all three windings to B+. This results in a 9-to-1 impedance reduction; any impedance on the far end of the secondary winding appears nine times smaller to the oscillator. Resistor R4, the sensitivity-adjustment potentiometer, controls the loop gain of the oscillator circuit by controlling the gain of the transistor amplifier. The oscillator is set so that it just begins to oscillate by adjusting R4. That's the key to how the circuit works.

The door you wish to protect against intruders is connected via a copper braid to the transformer secondary. When an intruder touches the door, his capacitance to ground appears in parallel with C3 and C4, which puts the oscillator out of resonance, causing the circuit to stop oscillating.

The circuit made up of D1, D2, C5, and R5 (Fig. 1) rectifies the oscillator signal. When the unit is oscillating, the rectified signal on the base of Q2 keeps Q2 on, which keeps SCR1 from conducting. When the oscillation ceases, and after C5 discharges through R5, Q2 turns off and SCR1 conducts, turning either buzzer BZ1 or light-emitting diode LED1 on. (That depends upon the setting of S3, the mode-control switch.) The SCR1 continues to conduct until the reset switch, S2, is closed.

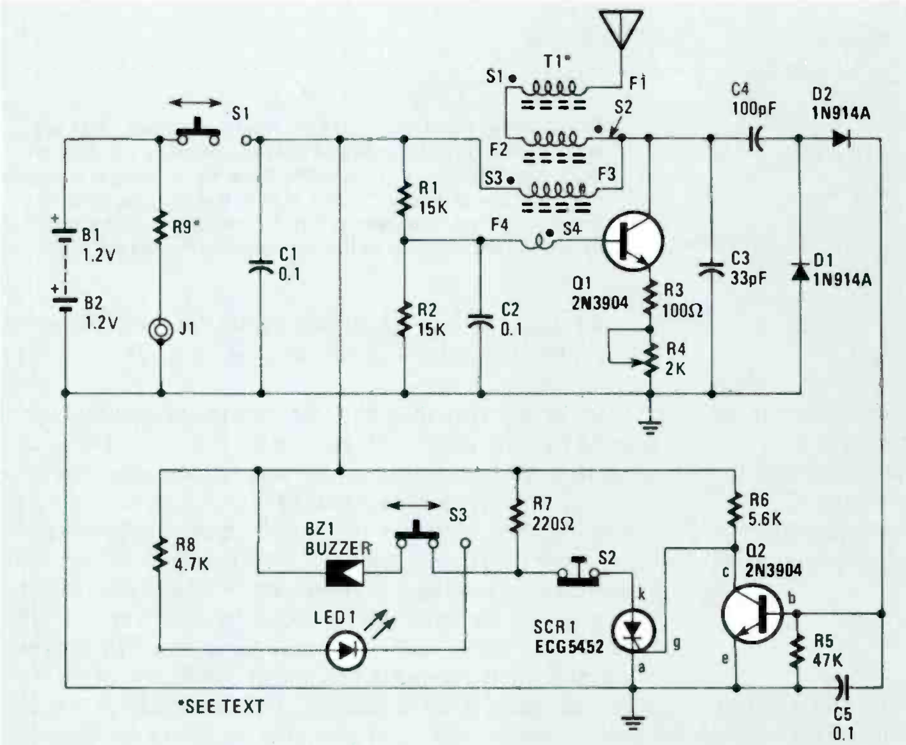


FIG. 1—SCHEMATIC DIAGRAM of the Panoply. Transformer T1 is hand wound on a toroid as described in the text. One of the three secondary windings of that transformer connects to a copper braid that is looped around a doorknob.

PARTS LIST FOR PANOPLY

SEMICONDUCTORS

D1, D2—1N914 silicon diode
LED1—Red, light-emitting diode
Q1, Q2—2N3904 transistors
SCR1—ECG 5254 silicon controlled rectifier (Sylvania)

RESISTORS

(All fixed resistors ¼-watt, 5%, units unless otherwise specified)
R1, R2—15,000-ohm
R3—100-ohm
R4—2000 to 5000-ohm, linear-taper potentiometer (Radio-Shack 271-217, or equivalent)
R5—47,000-ohm
R6—5600-ohm
R7—220-ohm
R8—4.7-ohm
R9—See text for computation details

CAPACITORS

C1, C2, C5—0.1-µF, ceramic disc
C3—33-pF, ceramic disc
C4—100-pF, ceramic disc

ADDITIONAL PARTS AND MATERIALS

B1, B2—Ni-Cd C-type rechargeable cell
BZ1—1.5-volt buzzer (Radio-Shack 273-0004, or equivalent)
J1—miniature phone jack
S1—SPST, slide switch
S2—SPST, normally-closed, momentary push-button switch
S3—SPDT, slide switch
T1—see text
Case (see text), perforated construction-board or printed-circuit materials, RG-8/U coax braid, battery recharger (Radio-Shack 273-1651, or equivalent), toroid (see text and ordering information below), magnet wire, wire, solder, etc.

If you can not obtain the toroid form it is available from the authors. Send a check for $2.00, payable to either author, and a stamped, self-addressed envelope to ERS Industries, 45-38 220 Place, Bayside, NY 11361. A completely wound T1 is also available from the authors for $5.00.

Of the remaining components in Fig. 1, C1 and C2 bypass the power supply. Switch S1 is the power switch. Resistors R1 and R2 develop the bias for Q1. Resistor R8 limits the current through the LED1. Resistor R3 limits the current through Q1. Resistor R6 limits the current through Q2 and the gate of SCR1. Resistor R7 keeps the SCR on; it is necessary if the current through the LED1 is less than the holding current of SCR1. It is also necessary if a mechanical buzzer is used, as was the case in the units the authors constructed. Mechanical buzzers interrupt themselves by repeatedly opening and closing the circuit. When closed they conduct about twice as much as their nominal current rating. When open, of course, they conduct no current at all. The buzzer used in the Panoply circuit is rated at 1.5-volts, 300 mA.

Charging Current

The standard charging current for Ni-Cd cells is about 1/10 their ampere-hour rating. In the five units the authors have built, 1.2-AH cells were used. That implies a charging current of of 120 mA. That current times the value of R9 must equal the charger output voltage minus the 2.5-volts (the battery voltage). If the Ni-Cd cells were 100 percent efficient,

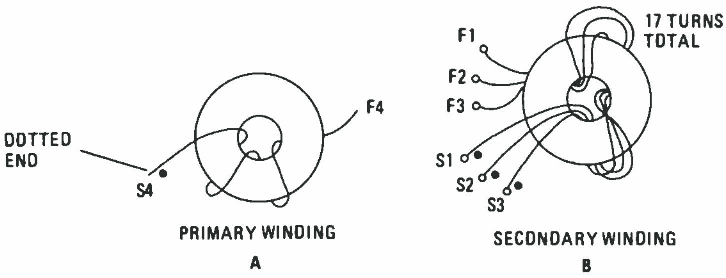


FIG. 2—THE PRIMARY and secondary windings of T1 are wound on a toroid. Details of how the primary winding is done are shown in A, of how the three secondary windings are done are shown in B, and of how the windings are interconnected is shown in Fig. 1. Ordering information for the toroid is given in the text and the Parts List.

charging time would be 10 hours (120 mA × 10 hours = 1.2 AH). However, nothing is 100 percent efficient.

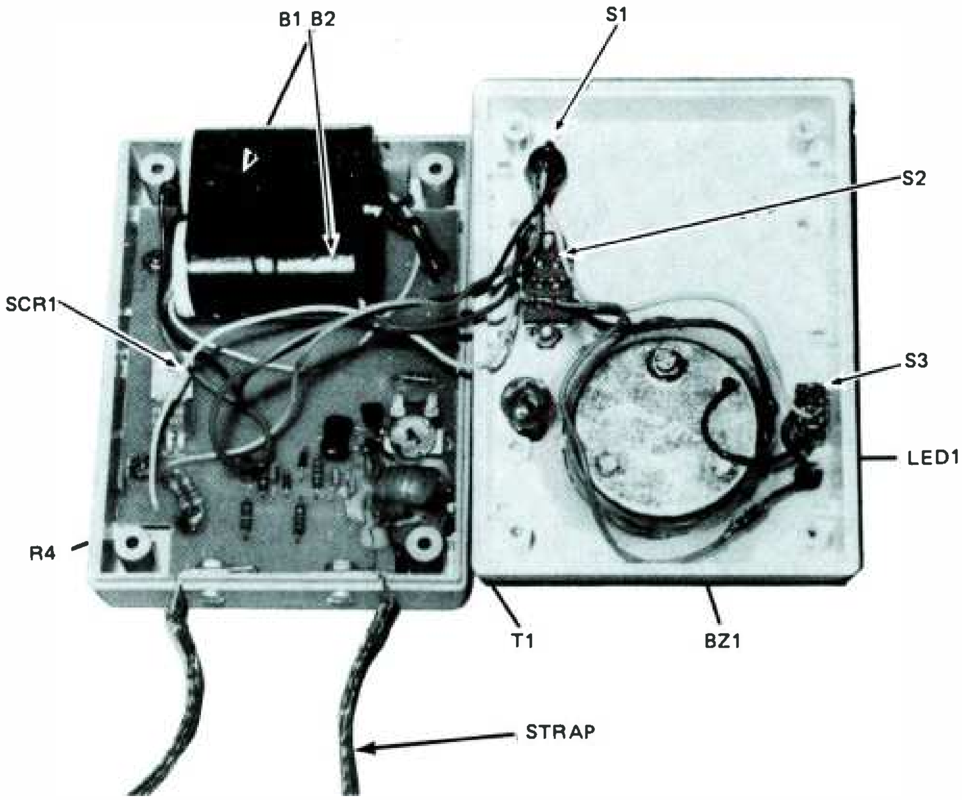
The standard *fudge factor* is 20 percent to 40 percent yielding a charging time of 12 to 14 hours. Of course, if the charger cannot output 120 mA, or if the circuit draws more than 120 mA, the charge time will vary inversely with the factor by which the charging current differs from 120 mA. Bear in mind that higher charging rates lower battery life. For that reason, charging currents are almost always kept below 33% of the ampere-hour rating.

Construction

Five Panoply's have been successfully built and installed into a Unibox 130 (GC Electronics) enclosure. That sturdy plastic case comes in five two-tone color options and measures 4.38 × 3.25 × 1.5 inches. If you use a different case, be sure that it is no smaller than the above dimensions.

The toroid for T1 is the most unusual item required. It is manufactured by Indiana General (part number F627-8-Q1) and is distributed by Permag Corporation (400 Karin Lane, Hicksville, NY 11801). If you can not obtain that item or a suitable substitute, the authors would be happy to supply it (see Parts List for ordering information). Any substitute toroid should have an initial permeability of about 100 and a maximum permeability of 400, or more, at frequencies up to at least 10 MHz.

The primary winding of T1 is wound with 24-AWG wire, while the secondary windings are wound with 28-AWG magnet wire. (If using Radio Shack magnet wire, use 26-AWG for the primary winding and 30 AWG for the secondary windings.) As shown in Fig. 2A, 3 turns are wound on the toroid for the primary winding. Note that the winding starts with the wire entering one side of the toroid and ends with the wire leaving the other side. As those familiar with the right-hand rule will realize, flux will be induced in opposite directions in the toroid depending on which end of the wire has the more positive voltage. To keep track of that difference, one of the ends is arbitrarily declared to be the *dotted end* (see Fig. 2). Next, three equal lengths of 28 AWG wire are wound side-by-side, as a group over the primary winding turns, to form 17 turns. As with the primary, the secondary-winding wires enter the toroid on one side and leave on the other (see Fig. 2-b). The side of the toroid declared the dotted end for the primary is also the dotted end for all the secondary windings. Finally, the ends of the magnet wire are carefully stripped and connected together, resulting in the transformer configuration shown in the schematic diagram in Fig. 1.

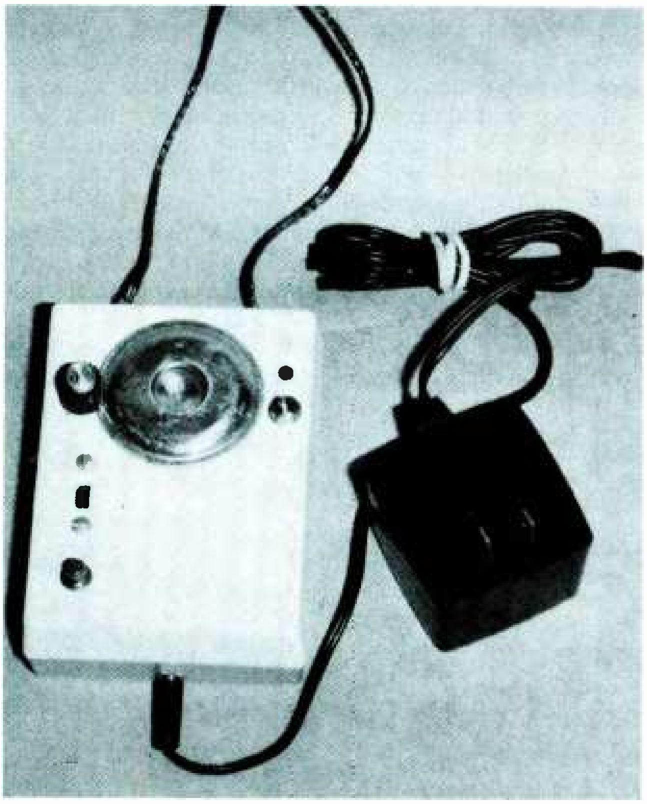


INTERIOR VIEW of the Panoply highlights the neat con struction technique of the authors. Note that the circuit is mounted on a printed-circuit board. However, perforated-construction board is perhaps more suitable for a circuit of this type and that construction technique is recommended.

It doesn't matter which of the secondary-winding wires is chosen to correspond to a particular secondary winding. When connecting the secondaries, be sure to pay careful attention to the dot convention that you have established.

If you wish to substitute for the SCR specified in the Parts List, any substitute you select should have gate threshold currents of 200 μA or less, gate turn-on voltages of 0.8 volts or less, and on-state current ratings of 4 amperes *rms*, or more.

The layout of the Panoply circuit is not critical, and because the wiring is not extensive, perforated construction-board can be used to build the circuit; that construction technique is quite reliable and even recommended for this small circuit. PC-board construction is another alternative, although the design of a suitable pattern is left to the reader's own talents and imagination. The author's unit, shown in the photos used a printed-circuit board.



THE PANOPLY and battery charging unit ready to go. The holes required to mount all cabinet-mounted components were cut in the plastic case with a hot soldering-iron tip and awl. Note the coaxial-cable braid at the top of the unit; it is looped around a doorknob to link the knob with the Panoply.

On the front panel of the completed unit (see photos) the author mounted a large buzzer BC1, LED1, reset switch S2, power switch S1, and mode-control switch S3. A sensitivity-adjustment potentiometer, R4, is also mounted on the front panel. On the bottom is jack J1. Finally, on the top is an 8-inch length of copper braid which loops around the doorknob to sense intruders.

Mounting of all the cabinet-mounted components is easiest if you own the appropriate drilling and punching tools. But even if you do not own such tools, with improvisation, the construction is still not too difficult. All holes can be made using a soldering iron and an awl. The soldering iron is used to melt large cuts and holes in the plastic; the awl is used to punch and bore smaller holes (for screws). Before melting any plastic, be sure that the work area is well ventilated, because potentially dangerous fumes may be released. Also, be aware that after the soldering iron cools, some plastic residue will be left on the tip. Either use a spare tip or be prepared to scrape the residue off with a file or sand paper.

When melting holes in the plastic with the soldering iron, a rim of hot plastic will form around the hole. If quick action is taken, that rim can be cleanly removed with needlenose pliers. Otherwise it will be necessary to file or cut away the rim when it hardens.

Holes made too large can be salvaged by mounting the component with some five-minute epoxy. Epoxy should be used in any case to bond the buzzer, BZ1, and light-emitting diode, LED1 securely to the case, and to mount the thumbwheel potentiometer, R4.

The copper braid, which is looped around a doorknob when the unit is in use, is the shield of RG-8/U coaxial cable. The braid should be separated from the rest of the coax, cut to about 10 inches, and inserted through two small slits in the top of the enclosure. If the slits are small enough, tinning the last inch of each end of the braid will be enough to prevent it from being pulled back out of the enclosure. Otherwise the braid will have to be punched and screwed into place.

Operation

To use the unit, with the door open, the Panoply is hung on the inner doorknob of the home or room to be protected. Set the mode-control switch to select the LED1 and then turn the device on. Adjust the sensitivity-adjustment potentiometer until the slightest touch on the outer doorknob will set of the unit. Note that in this procedure, each time the unit is set off the LED1 will light and remain lit until the reset switch is pressed. Once the unit is properly adjusted, the door should be closed and the mode-control switch flipped to select the buzzer. Now, when the outer doorknob is touched, a very loud alarm will sound, alerting you to an intruder's presence.

To improve the sensitivity of the device, leave the battery recharger connected to the unit; doing that will extend the groundplane of the Panoply. It is not necessary to have the charger plugged-in to a wall outlet.

The Ni-Cd batteries that power the unit normally last about two months before requiring a recharge. To fully recharge dead batteries requires about 12 to 14 hours. The unit may be operated while the batteries are recharging.

The Panoply will function without any problems on nonmetallic doors with nonmetallic doorframes. Operation is not possible on all-metal doors, because the loading of the metallic door on the Panoply circuit completely overwhelms any loading an intruder might cause. Operation is possible with nonmetalic doors mounted in metal doorframes, although the door will require a minor modification: The plunger of the doorknob (the bolt) must be insulated from the metal doorframe. That can be done by placing a single layer of electrical tape in the cavity in the doorframe into which the bolt is inserted when the door is closed. Once that is done, the doorframe can be used as a convenient ground plane for the device. Attaching a short clip-lead from J1 to the doorframe will result in incredible sensitivity.

Construction of the Panoply is one way the electronics hobbyist can apply his unique skills to the problem of providing security in this security-conscious world. Despite the simplicity of the device it can be remarkably comforting that it is *standing guard* on trips and lonely nights! ■

MUSICAL RINGER

Add a novel touch to your telephone with music. This project will let your telephone play any one of 26 popular tunes.

By Alan Capesius

☐ARE YOU BORED WITH YOUR TELEPHONE? HERE'S A PROJect that will make even wrong numbers an event to look forward to. It is a musical telephone ringer (we call it (Musical Ringer) that replaces the standard ringer sound with your choice (switch selectable) of 26 popular melodies. Let's take a closer look at the circuit.

How It Works

The heart of the circuit, shown in Fig. 1, is the General Instrument AY-3-1350 melody synthesizer integrated-circuit chip. That device generates one of 25 different available tunes (or one of three chimes) when triggered. It provides a low-level audio signal suitable for driving a small amplifier circuit. The choice of melodies offered by that integrated circuit is shown in Table 1.

A TIL111 optoisolator, U2, is used to isolate the circuit from the telephone line. When the telephone ring-signal is received, The R3–D1 circuit limits current flow and passes a small portion of the signal to the optoisolator, U2. Upon receiving the signal, the optoisolator provides a trigger signal to the 7555 timer (U3), initiating the timing cycle. The timer controls Q1, which, when it conducts, supplies power to the melody synthesizer, U1. That switching scheme reduces power consumption because, in the standby state (when Q1 is off), the timer is the only device drawing power—it draws only about 100 μA (typical). As a result, the Musical Ringer can be battery-powered, although use of a well-filtered, low-power AC wall-pack adaptor is recommended. If the power supply is insufficiently filtered, the Musical Ringer may trigger falsely. If that happens, try placing a 10-μF electrolytic capacitor across the power connections to filter the power supply further.

Once power is applied to U1, it will output one of 26 melodies. Which of those melodies that is output is deter-

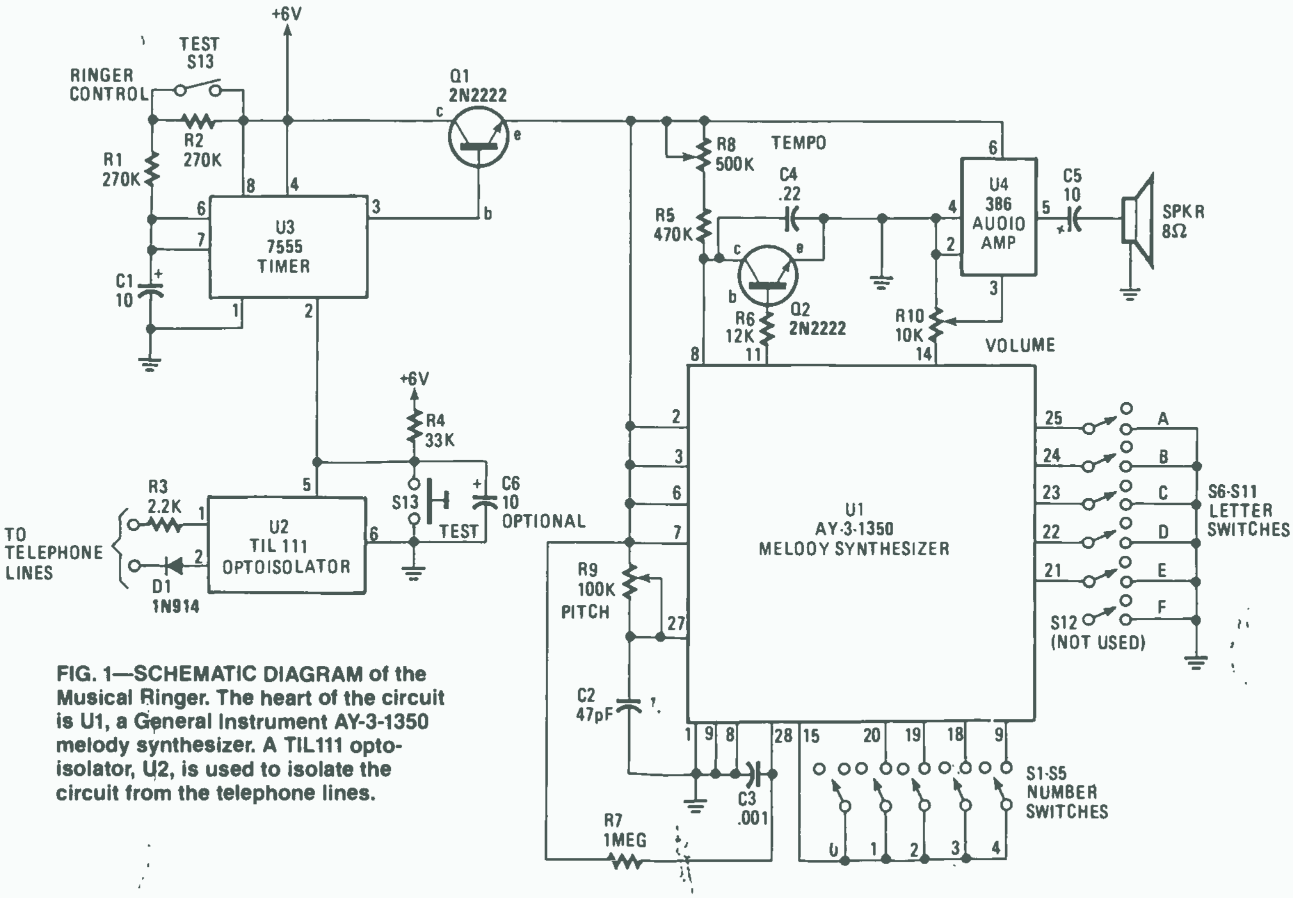


FIG. 1—SCHEMATIC DIAGRAM of the Musical Ringer. The heart of the circuit is U1, a General Instrument AY-3-1350 melody synthesizer. A TIL111 opto-isolator, U2, is used to isolate the circuit from the telephone lines.

mined by the settings of S1 through S11. (Note that in the author's prototype, quad DIP switches were used). Table 1 shows the switch settings for the various melodies. Finally, U4, a 386 audio amplifier, serves to amplify the audio output of U1 to a usable level.

Any construction method is suitable and parts placement is not critical. As shown in Fig. 2, the author's prototype was built on perforated construction board. When you have finished construction, set switches S1—S11 to the tune you desire, and apply power. The ringer may play when power is first connected; do not worry, that is normal.

To test the ringer at any time, simply press the TEST switch, S13. If the ringer does not operate correctly, recheck all connections and resolve the problem before connecting the circuit to the telephone lines. If you wish to leave the ringer permanently selected to one tune, you can replace S1–S11 with wire jumpers.

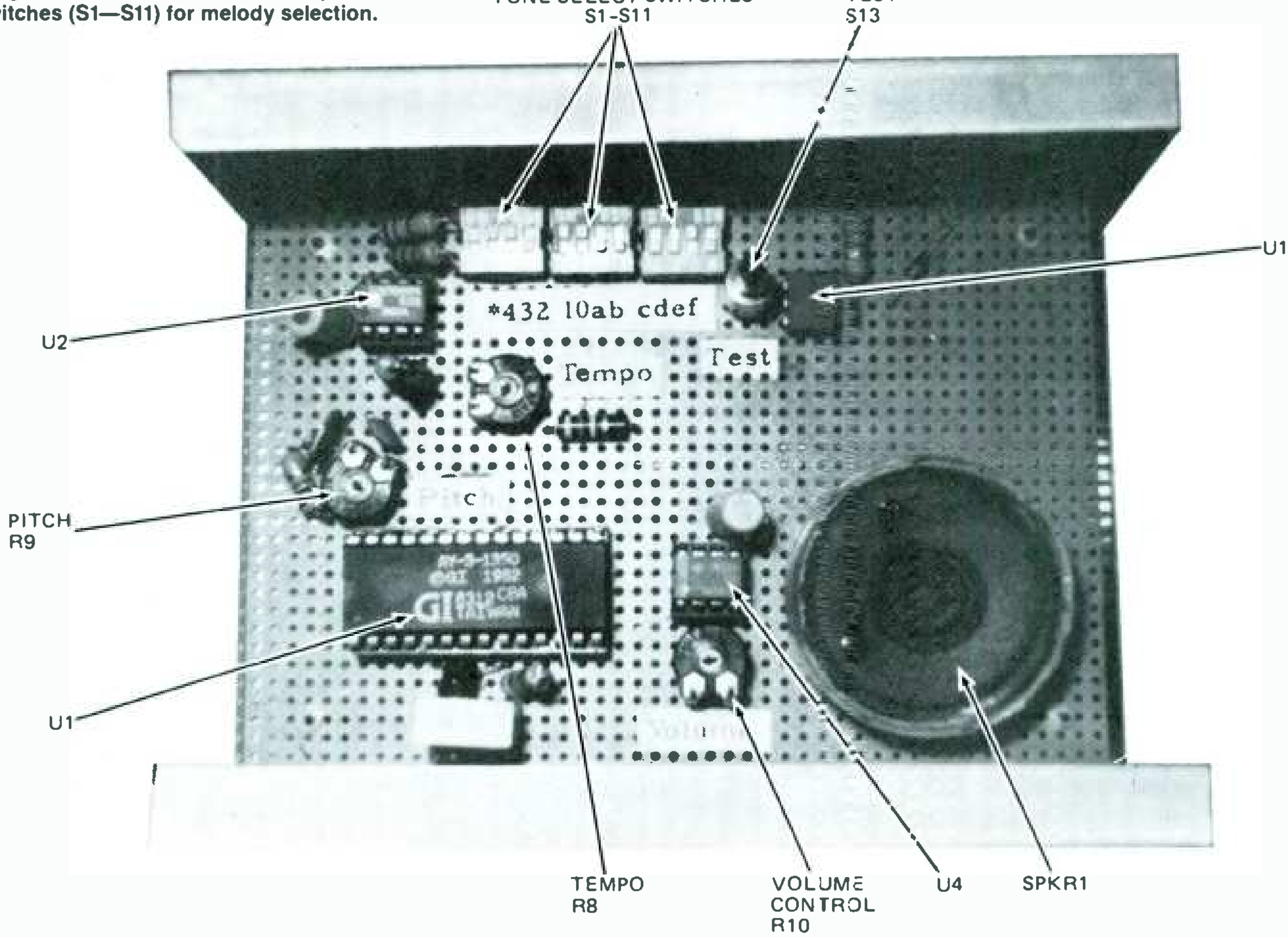
Ringer operation is determined by four controls: PITCH, TEMPO, VOLUME, and RINGER CONTROL. The first three of those are used to control the quality of the audio output. The RINGER CONTROL switch is used to select the ring rate of the Musical Ringer. Closing that switch, S12, sets the ringer to sound once for every ring of the telephone. Opening S12 sets the ringer to sound on every other ring of the telephone.

(Continued on page 96)

TABLE 1
Tunes and Switch Settings

Tune	Switch Settings
Toreador	A0
John Brown's Body	A1
America, America	A2
O Sole Mio	A3
Hell's Bells	A4
William Tell	B0
Clementine	B1
Deutschland Lied	B2
Santa Luca	B3
Jingle Bells	B4
Hallelujah Chorus	C0
God Save The Queen	C1
Wedding March	C2
The End	C3
La Vie en Rose	C4
Star Spangled Banner	D0
Colonel Bogey	D1
Bethoven's 5th	D2
Blue Danube	D3
Star Wars	D4
Yankee Doodle	E0
Marseillaise	E1
Augustine	E2
Brahms Lullaby	E3
Bethoven's 9th	E4
Westminster Chime	F0-F4

CONSTRUCTION IS NOT CRITICAL, so use any method you prefer to package the Musical Ringer. Note that the author used quad DIP switches (S1—S11) for melody selection.



ON COMPUTERS

FRIEDMAN

"Interchange" means you can read and sometimes run!

THERE IS NO SUCH THING AS A *FREE* lunch! The legendary free lunch of the saloons with sawdust on the floor was pickled in brine: It raised a fierce thirst that could only be relieved by a pitcher of beer. The cost of the beer was far in excess of what the *free lunch* would have cost.

The free lunch of personal computing often turns out to be programs whose claim(s) to fame is that they permit the interchange of software between what are normally incompatible computers. Theoretically, using an *interchange* program will allow you to *read the programs* from your computer class' Zenith computer on your home TRS-80.

Notice I say "...*read the programs*." Not "...*run the programs*," or, even "....*use* the *programs*;" only "...*read the programs*."

To *read* a program means that the characters can be transferred from one storage medium to another, say from a TRS-80 Model 4 disk to an Osborne or Kaypro disk. The user then often assumes that since all three computers use a Z80 microprocessor, the programs of computer will run on the others. With rare exceptions, that isn't true. For starters, the Osborne video display is memory-mapped differently from that of the Radio Shack Model 4. If the software was specifically written to use a particular computer's memory-mapped video display for faster display response, it can't be moved from one computer to another.

SuperCalc is a good example of memory-mapping. The version supplied with the Osborne cannot run on a Kaypro, while the regular universal *for-any-CP/M-computer* version of SuperCalc will run on any CP/M Z80 machine, because it isn't memory-mapped. So even though you might be able to *read* a program, it's more than likely you won't be able to *run* it.

If the program you want to run is a universal version—meaning it's not specifically written for a particular computer—you can interchange computers if you have interchange software that really works. For example, the *Interchange* program supplied with the Montezuma 2.2 CP/M for the Radio Shack Model 4 and 4/P computers can program one of the computer's disk drives to both read and run software from the disks of other computers. For example: I have run universal *WordStar* directly from an Osborne disk on a Model 4/P (portable) computer, just as I have run *SeekEasy* from a Kaypro disk on the Model 4/P. Conversely, I have formatted my *Word Plus* spelling checker, which was originally supplied on Osborne disk, to run on the Model 4/P. Then I've used the 4/P to create a Kaypro disk of *Word Plus* to check the spelling of documents created on the Kaypro (which was used to write this article with *WordStar*). If that sounds complicated, read it through again—because it's a perfect illustration of one of the rare instances when you actually can get a *free lunch* in personal computing.

Unfortunately, little software is the equal of *Montezuma's Interchange*, which can run directly from the disk of many different computer formats. Most interchange software will permit you to copy and read software of other computers to the disk format of the host computer, and a few will work the other way—but both kinds of software usually *read* but won't *run*.

Now you might think that BASIC programs would be a different case, because virtually all popular computers use *Microsoft* BASIC: If you can read the BASIC of one computer on another you should be able to run it. Sometimes, yes—sometimes, no. There are minor differences in syntax and commands that often get in the way. For example, Radio Shack's BASIC was intended to provide very compacted code; you can often cram more BASIC statements into a TRS-80's RAM. One reason for that is that the TRS-80's use space compression; they will accept the statement: **50 GOTO325**, or **70 FOR X=1TO99**. Standard *Microsoft* BASIC will produce a syntax error on those statements because it requires a <SP>ace between **GOTO** and **325**, and between **1**, **TO**, and **99**. In *Microsoft* BASIC, the statements would read: **50 GOTO 325**, and **70 FOR X=1 TO 99**. So even if you can *read* the BASIC program from another computer there's no guarantee you can run it.

The clear-screen command is another

(Continued on page 96)

HERE'S THE MENU for the Montezuma 2.2 Interchange Program for the Radio Shack Model 4 and 4/P computers. You can *read* almost every program—maybe *run* some!

ELECTRONIC LIGHT FLASHER

Do visitors have trouble finding your house at night? Here's a project for you.

By Robert F. Scott

☐ARE EVENING VISITORS TO YOUR HOME OFTEN DELAYED because they cannot read your house number from the street? If so, you need some kind of identifier that can't be missed by someone in a passing vehicle. One such highly visible attention-getter is a flashing porch- or yard-light, or an illuminated house number that blinks. (If you have sensitive neighbors, the latter is preferable.) The electronic light-flasher described here is ideal for use in such an application.

Light Flasher

The circuit we've developed is shown in Fig. 1. The blinking or flashing rate is determined by U1, a 555 timer integrated circuit. Its output, at pin 3, feeds U2, a H11J triac driver. That driver consists of an infrared LED that is coupled internally to a light-activated silicon bilateral switch (DIAC). When the LED internal to U2 is turned on by the timer, U1, its light triggers the DIAC; effectively closing the circuit between pins 4 and 6, and fires the Triac, TR1, (a Radio-Shack 276-1001, or equivalent) through its gate circuit. When the Triac is firing, it acts as a closed circuit that turns on the light (or other device it may be controlling via SO1). When the timer turns off, the LED, the DIAC and Triac stop conducting and the light turns off. The sequence then repeats. The flashing rate can be varied by means of R1, a 500,000-ohm potentiometer.

Figure 2 shows how the flasher's components can be mounted on a simple experimenter's prototyping board. Bear

(Continued on page 102)

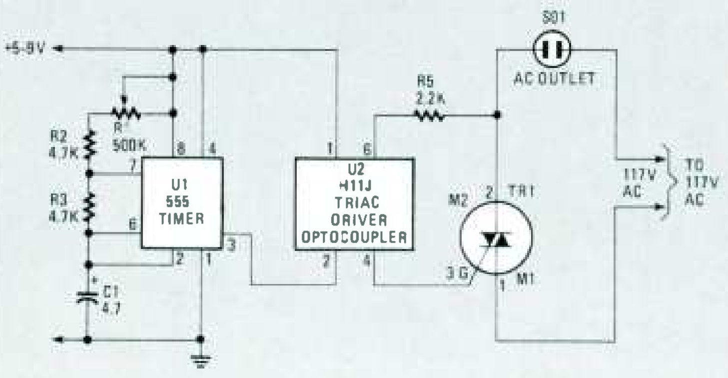


FIG. 1—SCHEMATIC DIAGRAM of the Electronic Light Flasher circuit. Although the device is primarily designed to flash a light on and off, the device can be used to turn any resistive device plugged into SO1 on and off rapidly.

PARTS LIST FOR ELECTRONIC LIGHT FLASHER

SEMICONDUCTORS

U1—555 timer integrater circuit
U2—H11J Triac-driver/optocoupler (GE), or equivalent (Radio-Shack's 276-134 appears suitable but it has not been tried)
Q1—Triac, 200-volts, 6-A (Radio-Shack 276-1001, or equivalent)

RESISTORS

(All fixed resistors are ½-watt, 5% units unless otherwise specified)
R1—500,000-ohm, linear-taper potentiometer
R2, R3—4700-ohm
R4—390-ohm
R5—2200-ohm, 1-watt

ADDITIONAL PARTS AND MATERIALS

C1—4.7-µF, 50-WVDC, electrolytic
SO1—AC receptacle
Line cord, circuit board, hook-up wire, suitable case or enclosure, etc.

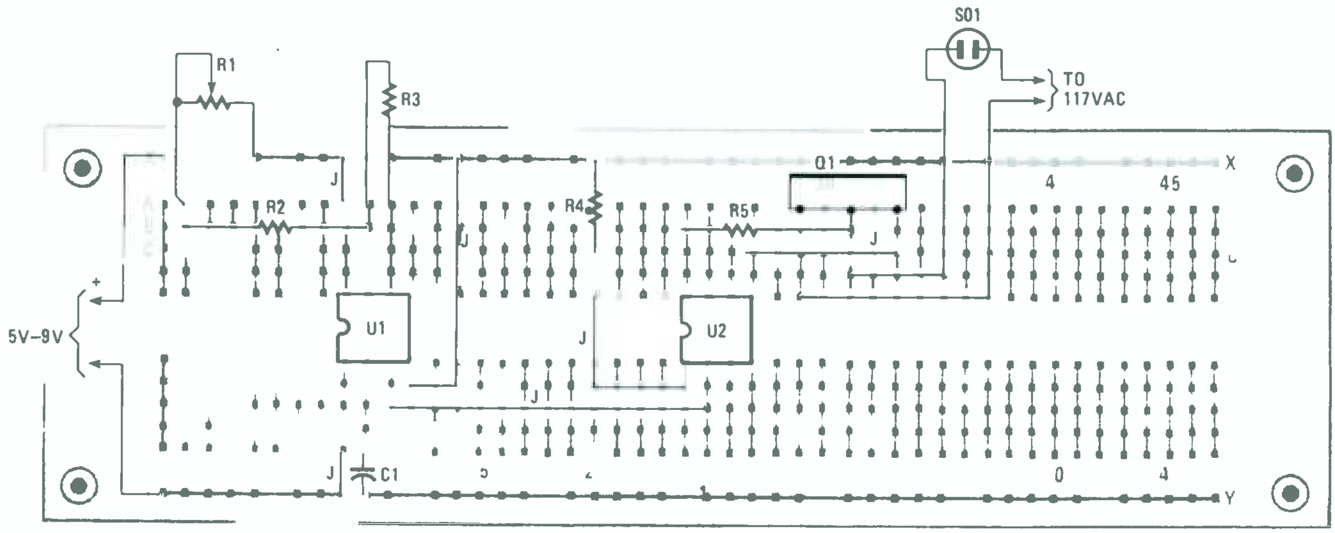


FIG. 2—ONE SUGGESTED LAYOUT for the Electronic Light Flasher is shown here. Once the circuit is built on an prototyping board, it is recommended that it be housed in a suitable enclosure.

SAXON ON SCANNERS

They've added in the missing Aero Band!

ONE OF THE MORE INTERESTING AREAS of the UHF-frequency spectrum has long been the so-called UHF-aero band, which runs between 225 and 400 MHz. Here's the band used for military aeronautical communications: everything from mid-air refueling to training flights, military control towers to GCA (ground controlled approach) systems. Most people don't realize that a great many civilian control towers can also operate on frequencies within that special frequency band. All fine and well with the exception of one stickler of a problem—scanners have never covered that band. Crazy? They just skipped right over it as if it didn't exist, even though scanners have been made to cover the standard VHF-aero band (118 to 136 MHz) used by all private and commercial aircraft.

The missing band, for years, has been heard only by those monitors who were able to convert military surplus equipment, or to build their own equipment. Everybody else just sat around and grumbled. Some wrote pleading letters to manufacturers of scanners. Regency, a leading manufacturer, got the message recently and brought out a new scanner that covers the almost-forgotten band.

The new scanner is called the MX-5000 and frequency coverage ranges from 25 to 550 MHz, straight through without a gap. That is to say that it starts out lower in frequency than CB, then goes up in frequency through the VHF-low band, all VHF-TV channels, the FM broadcast band, the 2-meter ham band, the 220-MHz ham band, the 70-cm ham band, the VHF-high band, the UHF-public-safety band, the UHF-T band, the UHF-aero band, and a portion of the UHF-TV band.

Of course you can't see TV pictures on the Regency MX-5000, but you can hear the audio portions of the broadcasts.

The scanner will search out frequencies at 5-, 12.5-, or 50-kHz increments and it will scan on any 20 frequencies you enter into its microprocessor. A built-in telescoping whip is supplied with the MX-5000. We found it to offer decent reception for strong local signals; however, for hearing anything other than such signals, you're going to want to use a good outside-mounted antenna located as high as possible. In fact, reception can be given an extra boost by adding a scanner preamplifer to the antenna system. That is a device similar in function to a TV-set booster and it can be obtained from many better-stocked scanner dealers. If your nearest scanner dealer doesn't carry those units, write to Hamtronics, 65 Moul Road, Hilton NY 14468; they make a nice unit which can be used to soup-up the sensitivity of any scanner.

THE Regency MX-5000 scanner covers all frequencies between 25 and 550 MHz, and that includes many channels never before included in a consumer scanner.

CIRCLE 825 ON FREE INFORMATION CARD

The Regency MX-5000 can be operated from a 12-volt power supply or (with the external adaptor that comes with the scanner) from any 117-volt AC household power source. Regency scanners are sold nationally and you might wish to check out the MX-5000 at your nearest dealer. If you wish to contact Regency Electronics, Inc. for more information or the name of your nearest dealer, their address is 7707 Records Street, Indianapolis IN 46226. Always say you saw it in **Hands-on Electronics**.

Some of the frequencies in nationwide use in the UHF-aero band include 241 MHz used by many National Guard helicopters; 243 MHz is a military aero-emergency channel, 381.8 for Coast Guard aircraft, 255 MHz for FAA flight-service stations, 311 MHz for the USAF Strategic Air Command, and 381.3 MHz for the USAF Tactical Air Command. USAF dispatchers use 372.8, 342.5, 344.6, and 375.2 MHz. Some monitors with special antennas aimed skyward have reported hearing the Space Shuttle on 296.8 MHz on those orbits which take the craft overhead. Those are only a few of the many frequencies one can monitor in UHF-aero band. A complete listing of ground stations and other frequencies that are active in the band is included in the Top Secret Registry of U.S. Government Radio Frequencies, a 168-page book available from CRB Research, P.O. Box 56, Commack NY 11725. The book is $14.95 plus $1 postage to the USA/Canada, plus APO/FPO addresses.

More UHF

Let's stick with UHF monitoring for a

while. On any scanner you can tune some especially interesting frequencies that don't seem to be very well known. For instance, frequencies 400.90, 460.925, 460.95, and 460.975 MHz are especially established for the exclusive use of central alarm companies. Such companies exist in many areas of the nation and provide an interesting service. The central alarm companies install break-in/flood/fire sensors in homes and offices—such devices being connected by landline telephone to a central alarm console that is monitored around the clock. When a panel light flashes, that indicates trouble; a patrol car is dispatched to investigate. Those frequencies are used for all of the companies' internal communications and very often get to sounding much like police frequencies. The central alarm companies are, in fact, very much like private police services, and they can offer some exciting monitoring for those who know about them.

If you're located within the vicinity of any larger airport serving any of the major airlines, you're probably going to be interested in checking out the happenings in the band which runs from 460.65 to 460.875 MHz. Frequencies here are spaced at 25-kHz intervals (460.65, 460.675, 460.70, etc.—10 channels in all). They are used by airlines for all sorts of airport operations activities, including security, passenger service, cargo and baggage handling, maintenance crews, and other similar functions. Generally speaking, the range of those stations is limited to the environs of the airport itself; the transmitters are low-powered and the antennas are mounted relatively low to the ground.

There's all sorts of interesting chatter taking place on these frequencies if you're within range of the stations. Take a listen! Put your scanner into search mode between 460.65 and 460.875 MHz and if you're near any passenger airport you'll find it worthwhile! It's extra interesting when a VIP is using a particular airline's services at your local airport; the red carpet is rolled out and the company's 460 MHz goes absolutely wild with special arrangements.

Into the Mailbag

Reader Pete Ryerson of Opportunity, WA took time to ask where he might obtain a copy of the police *10 Codes* which he hears being used via his scanner. Well, Pete, there are 10 codes and there are 10 codes. That is to say, while many police departments use the basic or standard 10 code, which has been promulgated by the Associated Public Safety Communications Officers (APCO), there are those agencies which use their own variations of that code, incorporating special localized codes for their own purposes.

You can, however, get a free copy of the basic standard 10 Code if you send a postcard or letter requesting the code. That is available from CRB Research, P.O. Box 56, Commack NY 11725. Be sure to say that you read about it in this column! The code is available to all readers in the USA and Canada.

Next, an inquiry popped in from Manny Rodriguez of Houston, TX.

Manny asks for operating hints on using the *search* feature of his scanner since the set's instruction manual tells how to program it in, but doesn't seem to go into details and techniques.

Essentially, that gives you the chance to search out new (to you) and unknown stations and frequencies on your programmable scanner. You punch up a lower-limit frequency, then a higher-limit frequency, and the scanner samples all frequencies within those limits. One common mistake that scanner owners make is by trying to search too large a swath of spectrum. It takes so long between the time the scanner gets back to rechecking a given frequency that you've missed all or part of a series of communications. In other words, don't set the search limits more than 500 kHz apart from one another at any time, and let the scanner explore that stretch of frequencies for no less than an hour or two, no matter how dead it may sound to you at first. Furthermore, if your scanner has a fast/slow, scan/search spread rate, always use the faster rate. Start out at the scanner's lowest frequency and search out every 500-kHz frequency segment right on through to the highest frequency that it will cover. You say that the operation could well take weeks? Yes, it could—so what? It's enjoyable and interesting—and what's the hurry?

Alice Brannigan of Boston, MA sends a note to say that sometimes when ionospheric *skip* conditions are right for long-range reception, it's worth taking a listen on 34.81 MHz since that's the frequency used by the United States Fish & Wildlife Service. The F&WS has many stations operating here, Alice reports, and if you're interested in hearing the operations of that federal agency, you'll get your fill on 34.81 MHz. Righto, Alice, and may we add that that agency also uses 34.83 MHz in addition to the channel you noted in use.

Let's hear from you—our readers! Why not send along a photo of your own monitoring station, or tell us what you're hearing, or want to know how to hear. Just write to me in care of this magazine. We'll talk some more next time!

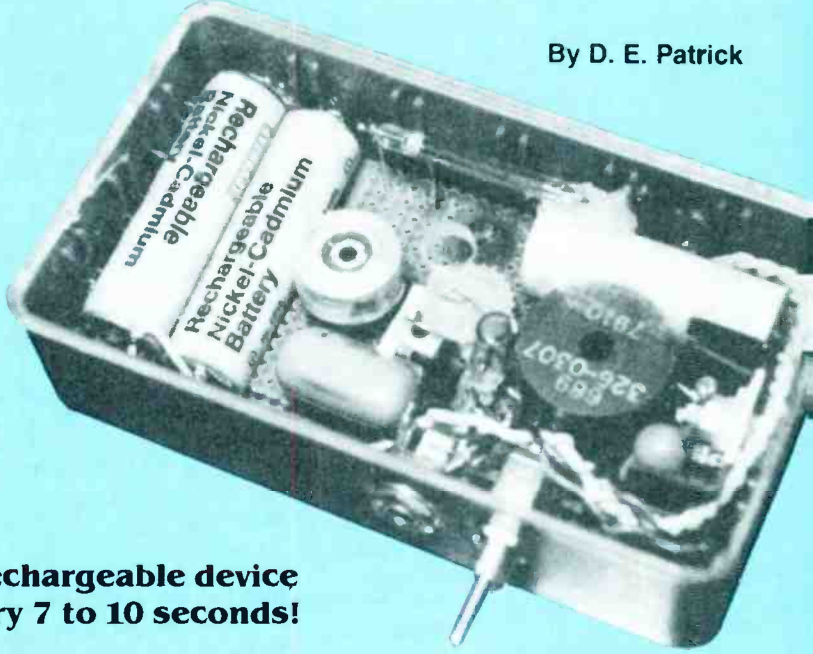
—Mark Saxon

I'd like to hear your comments about this column. Your input ends up as output on these pages. Address your cards to Mark Saxon, Hands-on-Electronics, 200 Park Ave. So., New York, New York 10003. Thanks!

THE ELUSIVE UHF-AERO BAND (225 to 400 MHz) contains all sorts of fascinating and exciting military aeronautical communications from Strategic Air Command bombers to National Guard helicopters. Scanner operators can now monitor these active frequencies for the very first time. (*U.S. Army photo*)

POCKET SAFETY FLARE

By D. E. Patrick



Powered by two AA cells, this rechargeable device fires off a xenon flash tube every 7 to 10 seconds!

IMAGINE YOURSELF DRIVING DOWN A BUSY HIGHWAY IN the middle of a dark, dreary, rainy night. Suddenly your car gives up the ghost! A tire blows, water hose splits, fan belt breaks, or the motor just sputters to a quiet death—just about any fault will end you on the shoulder; or worse, on the highway! Now, turn on the flashers or blinkers (if your battery will let you), and step out into no man's land with other cars whizzing by.

How safe do you feel?

Well, maybe you're better prepared than most. You get out the old strike-type flares and reflective triangles, placing them so another vehicle won't slam into either you or your car. But if you're not that well prepared, a slow creeping fear grips your guts, when the flash of a too close truck's headlights blind you for a second, disappearing into the night.

Now how do you feel?

Then again, maybe the horrifying thought of one of those high-speed, gas or diesel projectiles scattering what's left of you and your car all over the concrete slab you're standing on hasn't hit home. Who's to say? Some idiots have run right up the rear end of a parked police car, *whirling cherries* and all, at full tilt! Will it be your turn next?

So, you start around the car, lift the hood and stare into even more darkness, as the cars going by seem to be getting closer and closer with each pass.

Where's that flashlight? You fumble with it, fight with it, and finally slap it around till it lights up. If it lights at all, maybe you'll start to feel a little better. If it doesn't light, you feel instantly worse. But no matter what, the thought of a high-flyer slamming into your car's rear never leaves your mind.

Now snap out of it—it doesn't *have* to be that way. Consider building the battery-powered Pocket Safety Flare, which you can place on top of your car when you get out. It provides a bright flash that can be seen at great distances, while not so bright it destroys another driver's night vision. The bright flashes emitted will illuminate both you and your car and all of a sudden you won't be in the dark any more. You'll have a

PARTS LIST FOR POCKET SAFETY FLARE

SEMICONDUCTORS

D1—1N4002 rectifying diode
D2—1N4005 rectifying diode
LED1—20-mA light-emitting diode with maximum current of 50 mA
Q1—TCG-152 NPN silicon transistor (SK-3041 or equivalent)
SCR1—Silicon controlled rectifier (GE C106D1 or GE C107D1)

RESISTORS

R1—100-ohm, ½-watt
R2—330-ohm, ½-watt
R3—1.2-Megohm, ¼-watt
R4—5-Megohm, linear-taper, trimmer potentiometer

CAPACITORS

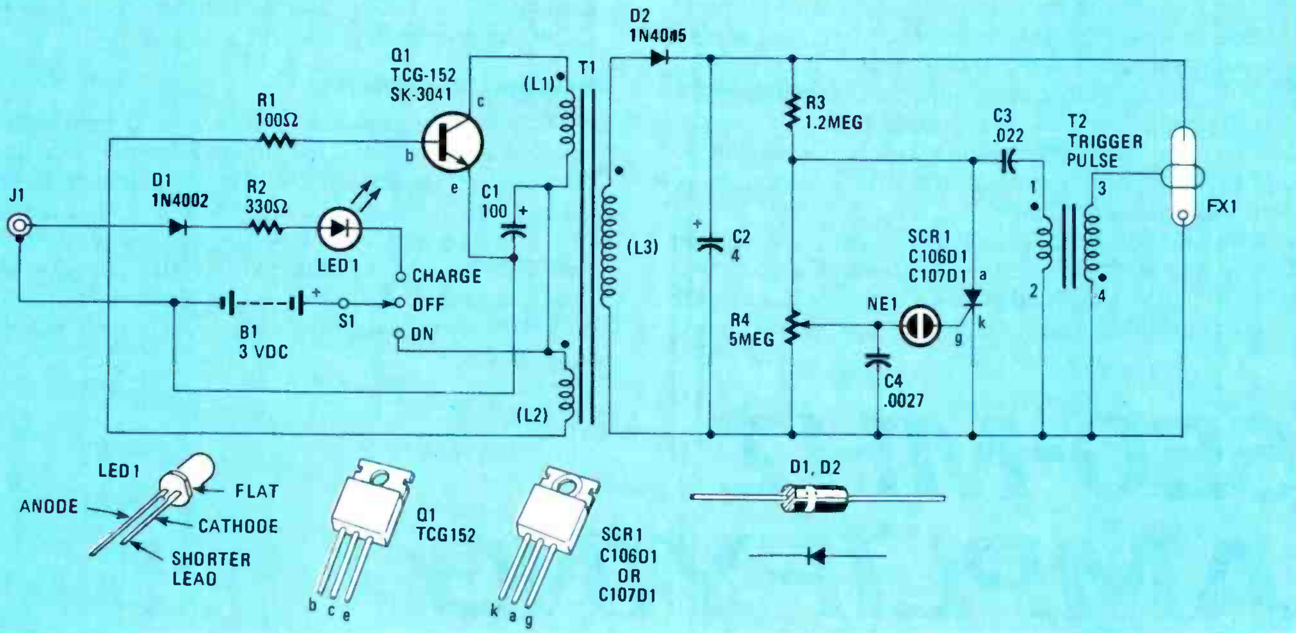
C1—100-µF, 10-WVDC tantalum
C2—4-µF, 250- to 400-WVDC, electrolytic or film
C3—.022-µF, 500- to 600-WVDC, mylar, disc, or ceramic
C4—.0027-µF, 200-WVDC, disc, mylar, or film

ADDITIONAL PARTS AND MATERIALS

B1—AA Ni-Cd cells—2 required
FX1—Xenon flash tube (ETC 11510 or any 5-watt flash tube)
J1—Phono jack
NE1—Neon lamp (NE2 or equivalent)
S1—SPDT toggle switch with center-off position
T1—Potted ferrite transformer (ETC 11516)
T2—Trigger-pulse transformer (ETC 11501 or Radio Shack 272-1146)
Plastic case, clear plastic cover, perfboard or printed-circuit materials, RV cement, wire, solder, hardware, etc.

KIT OF PARTS

A complete set of parts is available from Electronic Technical Consultants, PO Box 29278, Denver, CO 90229 for $35.00 postpaid.



safety flasher that illuminates, attracts attention, and wards off bad spirits, especially those drivers with lots of bad spirits sloshing around inside.

Instead of red blinkers, flashers, or whirling gumballs which seem to have the nasty habit of attracting drunks like flies to sour mash. Light-sensitive night drivers will avoid flashing strobes as a vampire would avoid sunlight. Thus, while not a 100% sure thing, the Pocket Safety Flare beats standing around in the dark, wishing for the best and fearing the worst. Further, the Pocket Safety Flare can be used by bikers, pedestrians, et al. Use of the the Pocket Safety Flare is better than cursing the darkness.

How the Circuit Works

In Fig. 1, two Ni-Cd AA cells provides about 3-volts DC to the circuitry when S1 is in the ON position and the optional trickle charger LED1, R2, and D1 are not in circuit. The AA cells will provide over two hours of continuous operation, albeit that time may be increased by using C or D cells.

In any case, when S1 is on, power is applied to an oscillator composed of Q1, R1, C1, L1, and L2. Coil L1 is the primary winding of T1, and L2 is the feedback winding. When Q1 turns on, its collector current saturates T1's ferrite core. That, in turn, removes the base drive to Q1 through L2. Transistor Q1 then turns off. As the field around L1 and L2 decays, Q1 will eventually turn on again, and the cycle repeats over, and over.

Transformer T1 is a step-up, ferrite-core, potted-type unit (see the Parts List), whose secondary-winding (L3) output is rectified by D2 and filtered by C2. That capacitor charges up to around 250 to 300 volts, which is applied to the resistor divider composed of R3 and R4, along with the flash tube FX1. Capacitors C3 and C4 will charge up to around 200 and 100 volts, respectively, through R3 and R4, respectively. Flash rate is adjustable via R4.

When the charge on C4 gets to around 100 volts, neon lamp NE1 fires discharging C4 into the gate circuit of silicon control rectifier SCR1. Then SCR1 turns on discharging C3 into the primary winding of trigger-pulse transformer T2. Transformer T2 is another step-up, pulse-type unit (see the Parts List) providing an output of around 4 kW across transformer T2's secondary winding. The xenon gas inside FX1 is ionized and a bright flash is emitted. Finally, C3 quickly discharges through L4, and the cycle repeats over, and over.

The trickle charger can be plugged into the car's cigarette lighter, or wall outlet at home, via a 12-volt DC battery eliminator. Twelve volts is applied through D1 to prevent polarity reversal to R2, a current limiter, and LED1. The function of LED1 is to indicate when the Pocket Safety Flare is charging. That circuit should have a maximum charging current of around 50 mA. It will also act as a fast-acting fuse if large currents are pulled thru it. Thus, if R2 shorted in the charger circuit, LED1 would open. In any case, R2 will determine the current applied, which in this case is around 20 to 30 mA.

Another possible configuration is to run the Pocket Safety Flare directly off the car's battery. But that defeats the stand-alone portability inherent in the unit's design. It may, however, be added as another optional feature with suitable dropping resistors and another switch position, if desired.

(Continued on page 102)

CONSTRUCTION of the Pocket Safety Flare is in a flat plastic chassis case with a clear plastic cover. Hole in plastic cover permits adjustment of flash-rate potentiometer R4.

IF YOU OWN A NEW, OR OLD, FREQUENCY COUNTER THAT will operate up to 50 MHz, but not 650 MHz, then here's a project for you! For under $50.00 in parts, which includes two IC's, you can add a battery-operated, amplifying 650-MHz Prescaler Probe to your existing frequency counter. Now, compare that to purchasing 500-MHz counters in the $200 to $250 price range, and 650-MHz counters in the $400, and better, price range.

Further, the 650-MHz Prescaler Probe isn't just a prescaler IC with about 800-mV of sensitivity. No way! Our probe uses a Plessey SL952 wide-bandwidth RF amplifier that's usable to 1 GHz, providing a typical sensitivity around 4 to 20 mV, fronting an old-reliable Fairchild divide-by-10, 650-MHz 11C90 chip to get the job done.

How the Circuit Works

The 650-MHz Prescaler Probe's input is terminated by resistor R1 (Fig. 1) and is fed through C1 to the diode limiter composed of D1 through D4. Those diodes are forward-biased by the +5-volt supply for small-input signals and, in turn, feed the signal to U1. However, for larger input signals, diodes D1 through D4 will start to turn off, passing less of the signal, and, thus, attenuating it. But even in a full-off state, the FH1100-type diodes will always pass a small part of the

650-MHZ AMPLIFYING

PRESCALER PROBE

By D.E. Patrick

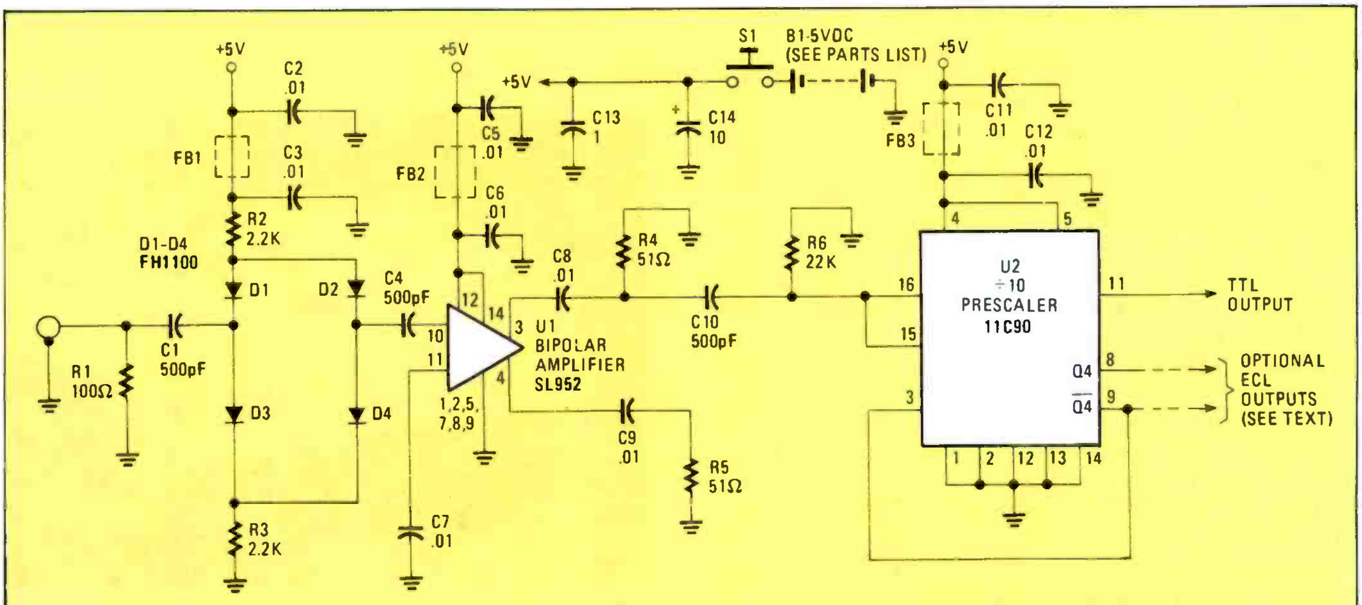


FIG. 1—IT TAKES more space to draw the probe's diagram than it does to lay it out on a perf-board.

input to U1 because of capacitive leakage within the diodes.

Integrated circuit U1, a Plessey SL952 bipolar amplifier, capable of 1-GHz operation, provides 20 to 30 dB of gain. The input signal is supplied to pin 10, U1 with the other input (pin 11) bypassed to ground. The output signal is taken at pin 3 and pin 4, with pin 3 loaded by R4 and pin 4 by R5.

Integrated circuit 11C90, U2, is a high-speed prescaler capable of 650-MHz operation configured for a divide-by-10 format. A reference voltage internally generated appears at pin 15 and is tied to pin 16, the clock input. That centers the capacitive-coupled input voltage from U1 around the switching threshold-voltage level. An ECL-to-TTL converter in U1 provides level conversion to drive TTL input counters by tying pin 13 low. Therefore, no external ECL to TTL converter is required at the pin-11 output.

On the other hand, ECL outputs are available at U2, pin 8 (Q4) and at pin 9 (Q4), if desired. In that circuit configuration, pin 13 is left open, and U2 will use less power.

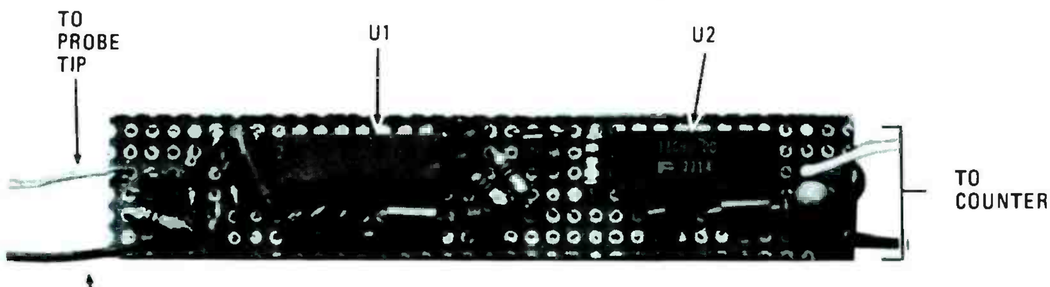
Construction Hints

Layout and shielding at proper points are critical, because of the high gain and small size of the probe. To eliminate problems, use the parts layout provided. Further, a shield should be placed between U1 and U2, and the entire probe circuitry encapsulated in a metal inner-case, albeit a plastic outer-case may be used to prevent any possible shock.

Some final notes

It should be pointed out that at frequencies from 50 MHz to 650 MHz, frequency counters and prescaler front-ends are much more sensitive to misuse. For example, you might get away with coupling a transmitter into the front end of a 10- to 50-MHz counter with a high-impedance front end having protection diodes going to ground, although even that's pushing things. But trying the same thing with the typical bridge used in this project will lead to disaster. If you need to couple the counter to a transmitter, try loosely coupling it with a coil of wire.

And a good rule of thumb at such high frequencies is not to push more than a volt, or so, at most high-frequency counters or scope-sampling units. For example, you can blow some 1- to 10-GHz scope samplers costing over $3000 by just over-driving the beasts with 1 volt; the same thing applies here and with most prescalers and counters. ■



THE PROBE'S PARTS are small enough to mount on a perfboard that is 7/10-inch wide. The board's length is not critical. There's sufficient space inside most probes to permit mounting of parts. Refer to text for shielding information.

PARTS LIST FOR 650-MHz AMPLIFYING PRESCALER PROBE

SEMICONDUCTORS
D1-D4—FH1100 diodes
U1—SL952, Plessey bipolar-amplifier integrated circuit
U2—11C90 Fairchild prescaler integrated circuit

RESISTORS
(All fixed resistors are 1/4-watt, 5% carbon-film types, or equivalent)
R1—100-ohm
R2, R3—2200-ohm
R4, R5—51-ohm
R6—22,000-ohm

CAPACITORS
(All capacitors are monolithic, or small disc types except when indicated otherwise)
C1, C4, C10—500-pF
C2, C3, C5-C9, C11, C12—.1-µF to .01µF
C13—1-µF
C14—10-µF, 10-WVDC tantalum

ADDITIONAL PARTS AND MATERIALS
FB1, FB2, FB3—ferrite beads (ETC FBS100, or equivalent)
S1—Momentary pushbutton switch
B1—5-volt mercury or lithium battery
Printed-circuit board or perfboard, probe with internal shield, wire, solder, mounting hardware, etc.

A complete set of parts is available from Electronic Technical Consultants (ETC), P.O. Box 29278, Denver, CO 80229 for $50.00 plus $10.00 for postage and handling.

CAPACITANCE METER

Now you can identify the rating of those unmarked capacitors in the bottom of your junkbox that you could never use before!

By Joe Horner

NEARLY EVERY HOBBYIST HAS A BOX-FULL OF UNUSED capacitors which sit there, year after year, because he doesn't know what value of capacity they have. Color codes have faded or worn off. Even when they are marked, you can't always be sure—for instance, does "510J" mean 51.0-picoFarads or 510-picoFarads? From the capacitor's physical size you can usually tell if it is pico- or microfarads, but that's about all.

Here is an easy-to-understand, easy-to-build project using one integrated-circuit chip that can measure about 95 percent of the capacitors you will ever use in projects and servicing of consumer-electronics devices. It measures full scale from 500-pF to 500-μF in six decades, requires no calibration, or no zeroing—just a full-scale potentiometer adjustment. On the lowest scale (500-pF) you can measure down to about 10-pF, giving the instrument a *dynamic range* (ratio of highest to lowest value) of nearly 8 powers or 100 million). Not bad for a one-chip gadget that we call the Capacitance Meter.

How it Works

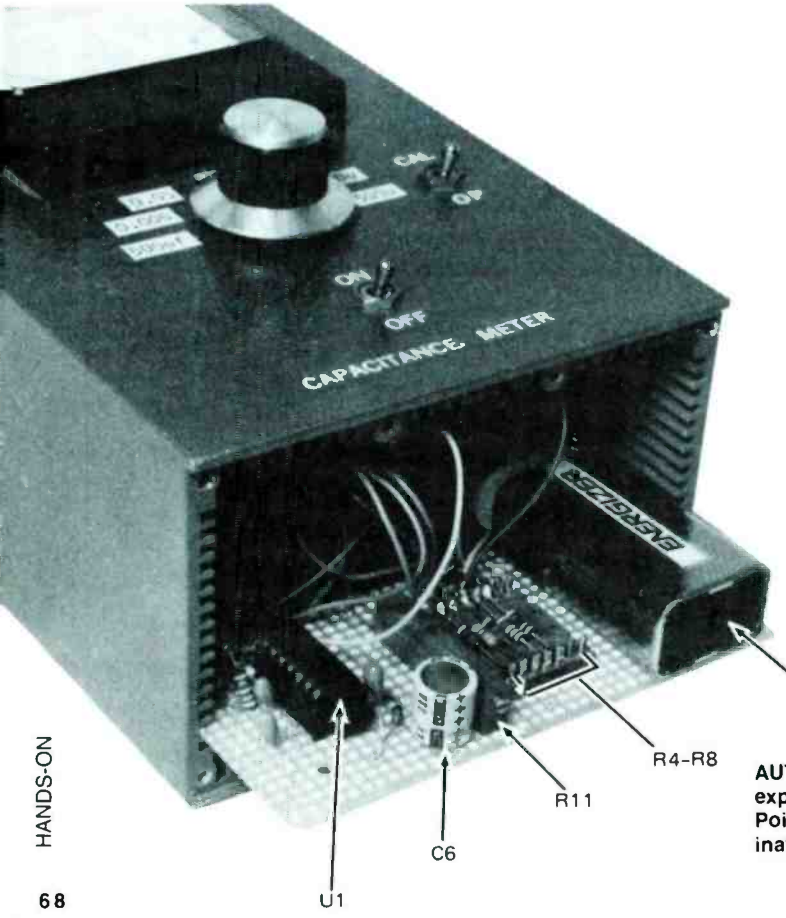
The heart of the unit is the popular 555 timer integrated-circuit, in its dual-package version, the 556. The first stage, U1-a, is an oscillator, and the second, U1-b, the measurement part of the circuit. It converts unknown capacity into a pulse-width modulated signal the same way an automotive dwell meter works. It does that in a very linear fashion, so that the fraction or percent of the time that the output is high is directly proportional to the unknown capacitance (C_x in the schematic). Meter M1 effectively reads the average voltage of those pulses since its mechanical frequency response is low compared to the oscillator frequency of U1-a. See Fig. 1.

Oscillator U1-a's frequency is determined by C1 and R1, R2, or R3 selected by range switch S1-a. Use a high-quality capacitor for C1 such as a mylar or polystyrene type. The oscillator frequency of U1-a is either 5.5, 55 or 550 Hz depending on the setting of S1. The output, at pin 5, is normally positive, and very briefly goes low, triggering U1-b via capacitor C5. Chip U1-b is wired as a non-stable multivibrator. When triggered, its output (pin 9) goes high, and the unknown capacitor starts charging up. It takes a period of time

$$t = 1.1RC_X$$

for C_X to charge up. Pin 9 then goes low until the next trigger pulse from the oscillator, and the whole cycle repeats. If T is the time between the drive pulses out of U1-a, that portion of the on time at the output is

$$t/T = 1.1RC_X f.$$



AUTHOR'S CONSTRUCTION TECHNIQUE is a bit classier and expensive than that required for home-workshop purposes. Point-to-point, wire-wrap, wiring on the perfboard eliminated the need for a printed-circuit board.

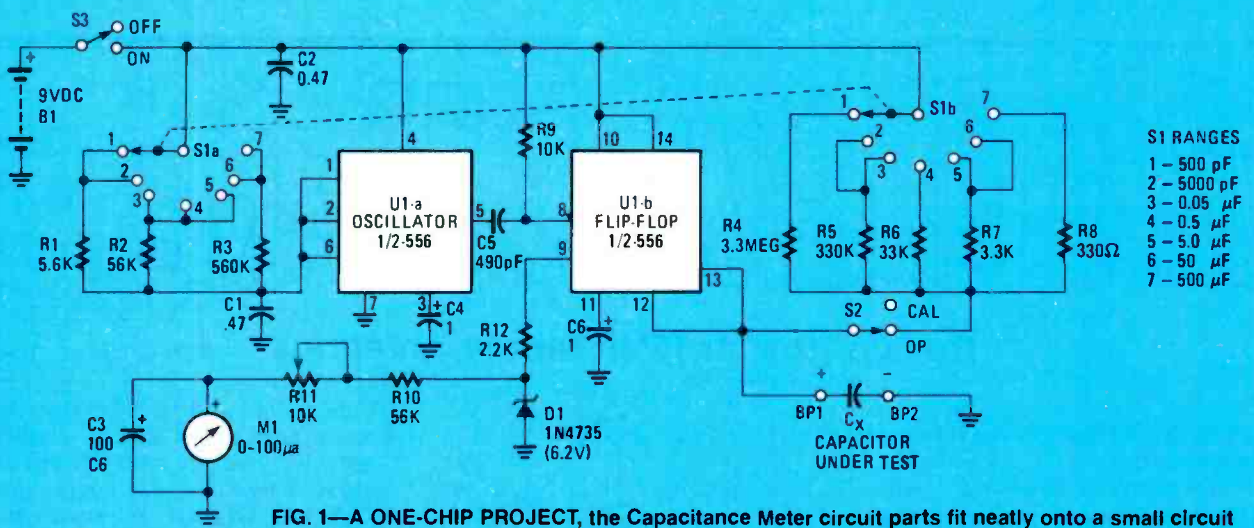


FIG. 1—A ONE-CHIP PROJECT, the Capacitance Meter circuit parts fit neatly onto a small circuit board. Switches S1, S2, and S3, meter M1, and binding posts BP1 and BP2 mount on the chassis box.

PARTS LIST FOR CAPACITANCE METER

SEMICONDUCTORS
D1—1N4733 Zener diode, 6.2-volt
U1—556 dual timer integrated circuit

CAPACITORS
—.47-μF, mylar or polystyrene
C2—.47-μF, disk
C3—100-μF, 15-WVDC, electrolytic
C4, C6—1-μF, 15-WVDC, electrolytic
C5—490-pF, disk

RESISTORS
(All fixed resistors are ¼-watt, 5% units unless otherwise noted)
R1—5600-ohm
R2, R10—56,000-ohm
R3—560,000-ohm
R4—3.3-Megohm
R5—330,000-ohm
R6—33,000-ohm
R7—3300-ohm
R8—330-ohm
R9—10,000-ohm
R11—10,000-ohm, linear-taper, trimmer potentiometer
R12—2200-ohm

ADDITIONAL PARTS AND MATERIALS
B1—9-volt DC transistor-radio battery
BP1, BP2—Multi-way binding post; one red, one black
M1—0-100-μA, 2- to 3-in., DC meter
S1—2-pole, 8-position or 2-pole, 12-position, non-shorting, rotary switch, use only 7 positions
S2, S3—SPDT, miniature, toggle switch
Perfboard, IC socket (optional), flea clips, knob with index, stranded wire, decals, solder, battery holder (optional), hardware, etc.

where f is the frequency (f = 1/T). Full-scale reading occurs for t/T = 1.00, so the design equation becomes

$$C_X \text{ (full scale)} = 1/1.1Rf.$$

For example, to measure an unknown capacitor of 500 μF (full scale) with a trigger frequency of 5.5 Hz requires a charging resistor of:

$$R = 1 \div [1.1 \times .0005(f) \times 5.5 \text{ Hz}] = 330 \text{ ohms}$$

That points out why the upper range of the instrument is 500μF. We can't go lower with the oscillator frequency, or the meter needle visibly vibrates and is hard to read. Applying Ohm's law, with 330 ohms being the resistance, the peak charging and discharging currents is approximately

$$V \div R = A$$
$$9 \div 330 = 27 \text{ mA}.$$

To increase the Capacitance Meter range another decade (5000 μF and 33 ohms) would result in charging current of 270 mA—far too much for the battery and the internal transistor in U1-b which discharges the capacitor.

The output voltage is held constant at 6.2 volts by the Zener diode D1. Resistors R10 and R11, and capacitor C2 form a low-pass filter to smooth out the low frequency ripple, slightly visible at the highest full-scale range.

Construction

The circuit shown in Fig. 1 is all that there is to wire. Layout and placement of parts is not critical, because of the low frequencies used. I built mine in a 2½- × 4- × 6-inch aluminum box with lots of room to spare. You could fit the Capacitance Meter into a smaller enclosure for a more compact unit—that's up to you.

The integrated circuit and various components are mounted on a perfboard as shown in the photo. Be sure to use multi-way, color-coded binding posts for the terminals BP1, BP2) of the test capacitor, C_X, since one side is ground and one side is positive. Trimmer potentiometer R11 is so infrequently adjusted that I mounted it on the circuit board. It is accessible through a small hole in the bottom of the case.

After wiring is completed and checked, turn the unit on. With no unknown capacitor connected, switch S2 to the CAL

(Continued on page 102)

CALLING ALL HAMS

Design Tips for 15/40 Dipole Antennas

THE PVC PIPING MOUNT STRUCTURE, described in a previous issue of **Hands-on Electronics** (See Fig. 1), can be the foundation for several additional antenna types. In a similar manner as the inverted-V dipole, the legs of a 3/2-wavelength antenna can also be attached and erected. A 3/2-wavelength antenna has two 3/4-wavelength segments which can be attached to the terminals at the top of the PVC mast.

A 15/40-dipole combination is convenient because the frequencies of the 15-meter band are approximately three times higher than the frequencies of the 40-meter band. In fact a half-wavelength dipole on the 40-meter band has segment lengths that correspond to approximately 3/4 wavelength on the 15-meter band. The center feedpoint of a 3/2-wavelength antenna also has a low impedance that can be matched to a coaxial transmission line. Details on that arrangement follow.

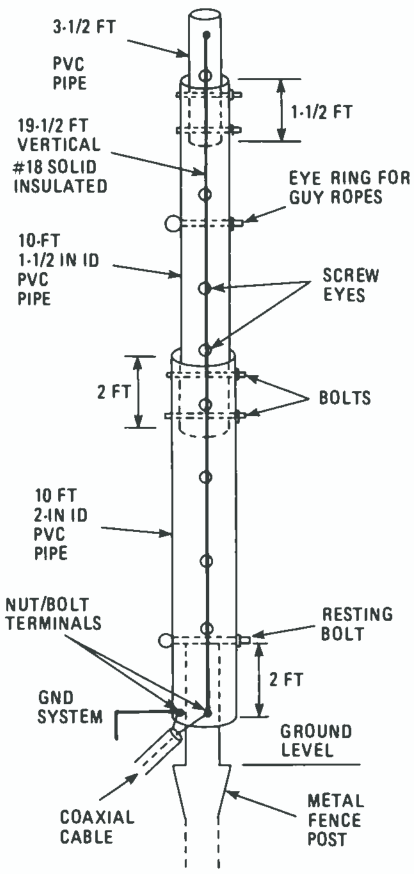


FIG. 1—PVC mast construction needs eyelets at the top for dipole use.

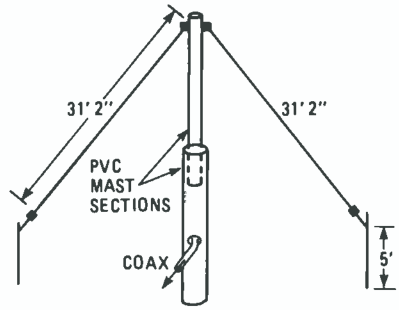


FIG. 2—40-meter inverted dipole.

Inverted-V Dipolers

The basic inverted-V dipole structure is shown in Fig. 2. Each of the two antenna segments are supported by two metal or wooden fence posts about 5 to 6 feet above ground. This will make the ends accessible from the ground.

Antenna leg lengths are such that resonance is obtained in the single sideband section of the 40-meter band. It is a simple matter to operate the antenna on the CW low-frequency portion of the band by clipping on two short lengths of wire to the ends of the antenna segments. Refer to Fig. 3. Note that the antenna legs are made of insulated wires. Wire is bared at the ends and then looped. As a result a good-quality clip will make a sound grab to the bare wire. CW operation is now possible with a low SWR ratio.

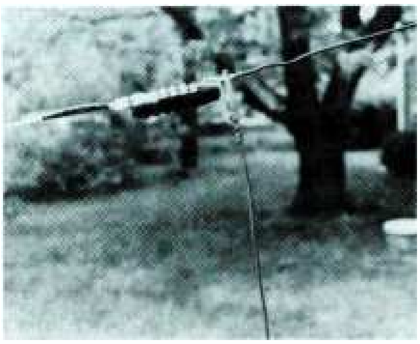


FIG. 3—Clipped on frequency-shift segments (2 required) lowers antenna resonance to CW frequencies.

In my installation, it was only necessary to add a 12-inch length to obtain very low SWR readings at the CW end of the band. Resonance was approximately 7050 kHz. Of course you could obtain a low SWR reading at the CW end by using a tuner. However, two pieces of wire and two clips is an easy, inexpensive way. An SWR meter will help you find the exact add-on length you require.

Resonance on the 15-meter band as a 3/4-wavelength antenna element requires some additional length. The add-on lengths I wanted also require additional length. The needed add-on lengths are given in Fig. 4. Clip on a 22-inch length for 15-meter sideband operation and a 27-inch length for 15-meter CW operation. Lengths given will bring you into the ball park for your installation. You may wish to do a bit more trimming if you wish to center on one specific frequency.

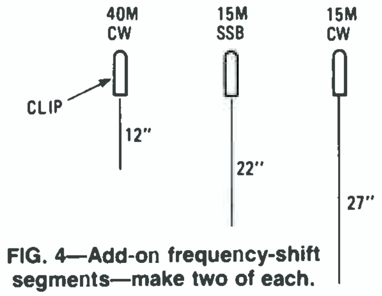


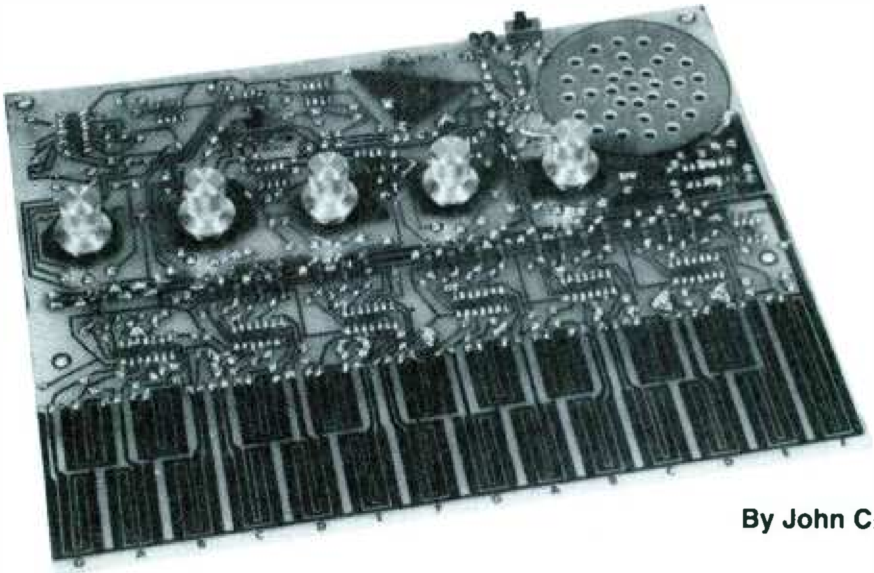
FIG. 4—Add-on frequency-shift segments—make two of each.

My three sets of add-ons are stored near the back door. They can be clipped in place quickly when operation on other than the 40-meter sideband is desired. Once the add-ons have been prepared, frequency-changing becomes less troublesome and perhaps even faster than retuning a tuner. In that procedure you choose a better plan by tuning the antenna rather than the line. Also you get out of your operating chair and gain a little exercise as a side benefit.

The alternative plan of Fig. 5 shows how the clips can be installed permanently, along with three separate insulators. When insulator A is open the antenna installation is ready for 40-meter sideband operation. Closing A and opening B places the antenna in the 40-meter CW section. Closing A and B and open-

(Continued on page 101)

Electrochune



By John Clarke

A 23-note organ—two full octaves including sharps and flats—with special effects, the Electrochune is capable of a surprising variety of harmonious sounds.

☐WHY THE NAME *ELECTROCHUNE*? BECAUSE IT'S MEANT TO be a fun name for a fun project. We think that readers will really enjoy it, both in the building and in making music. Electrochune is easy to put together, with no expensive hardware, and is capable of a surprising variety of harmonious sounds. Electrochune has a range of almost two octaves, together with sharps and flats, and has six controls for varying its sound output.

Electrochune* is a complete self-contained keyless organ with all components mounted on a medium-size printed-circuit board measuring 8-in. × 10-in. It can be built in the bare-bones form shown in the photographs or dressed up with a cabinet, if you wish.

Electrochune can be played with your finger. Merely touching the *key* areas on the printed-circuit board brings each note into action.

Much of the circuitry in the Electrochune is similar to that used in modern synthesizers and so it has some features similar to those popular instruments. For example, like most synthesizers, Electrochune is monophonic. That means that it cannot play chords and is meant to be played one-handed or, really, in that case, one-fingered.

Electrochune is also similar to many synthesizers in that it uses voltage-controlled amplifiers, a sample-and-hold circuit and a voltage-controlled oscillator. As a result, it has such features as adjustable attack and decay for envelope control and tremolo. It also has voice mixing and its own built-in amplifier and loudspeaker.

Unlike earlier keyless instruments, the Electrochune can be tuned very precisely over its almost two-octave range, because each key can be tuned exactly and individually, without affecting any other key. That means that if you want to use the Electrochune seriously, in spite of our remarks at the beginning of this article, you can do so and set up each key so that it is exactly on pitch. It is also possible to tune the Electrochune to match other instruments. The mind boggles at the possible ramifications of that—you could even have "Electrochune in Concert".

Even though the Electrochune can be tuned very precisely, it is not necessary to go to any special bother if you are just building the unit for casual use. Just install the resistor values we have specified.

Electrochune is powered by an AC plugpack. While that will make it initially a little more expensive, it will soon pay for itself by eliminating the cost of batteries.

How It Works

While the complete circuit is fairly complicated, the Electrochune is easy to understand if the circuit is broken down into sections which can be examined one at a time.

Look at Fig. 1 which explains the broad principles of the circuit. The heart of the circuit is a voltage-controlled oscillator (VCO). As the name implies, that has a frequency output which is proportional to a voltage applied to its input. The input voltage for each note is fed to the VCO from its indivual voltage divider via an individual switch. Since there are 23 notes, there are 23 separate voltage dividers and 23 switches, each of which is actually a switch element in a CMOS quad bilateral switch package.

Following the VCO are the envelope-shaping and tremolo

*Original project appeared in *Electronics Australia*, July, 1981, and appears here by permission.

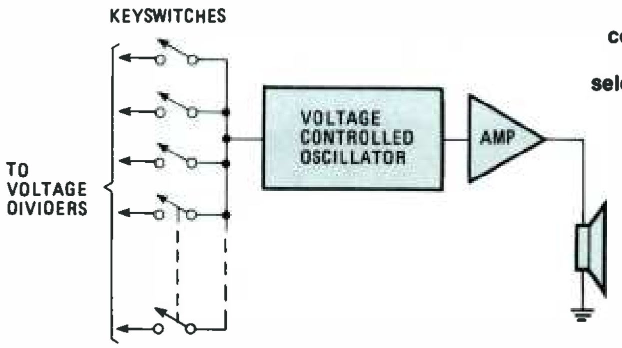


FIG. 1—THE HEART of the Electrochune is a voltage-controlled oscillator (VCO) that provides a cycled output proportional to the voltage applied to its input. By selecting proper voltages in sequence, a tune can be heard.

circuits and the audio amplifier and loudspeaker. Now if it were not for the fact that we wish to provide envelope shaping, the simple principle embodied in Fig. 1 would be adequate and the complete circuit diagram would be quite a lot simpler than it is.

By *envelope shaping* we mean giving a precise and defined value to the attack and decay of each note. Thus, for a given setting of the controls for attack and decay, each note will sound roughly the same in initial intensity, in duration and in the way it fades into silence. Thus, the envelope of each note will be same regardless of whether the player hits the notes in staccato or slower fashion. That is quite a refinement compared to previous keyless organs which provided very little facility for expression.

Okay. Now remember that the VCO requires a defined input voltage to produce a given frequency and that it is only while the particular keyswitches are closed that they connect the particular note voltage divider to the VCO. So what happens when the player takes his big greasy finger off the particular key and expects the note to fade away? It doesn't. Because when the input voltage is removed from the VCO its frequency immediately rises to a very high value, which is its free-running frequency. Since that would lead to a very unmusical and totally unsatisfactory instrument, we need to provide some means for the circuit to *remember* the VCO input voltage after the key is pressed. That is done with a sample-and-hold circuit and that is incorporated as shown in Fig. 2.

That diagram shows an array of switches for the various notes, each with its own voltage divider. When a key is touched, the appropriate CMOS switch (U11-U16) is closed, feeding the note voltage through to a FET-input op amp, (U10) which operates as a buffer stage. The output from that buffer is fed to a conventional op amp (U8) functioning as a Schmitt trigger and to a sample-and-hold circuit. The Schmitt trigger controls the sample-and-hold circuit as well as the envelope-shaping circuitry (for attack and decay) following the VCO. After the envelope shaper, a similar circuit provides further signal processing in the form of tremolo (amplitude modulation). Finally, the signal is amplified and fed to a loudspeaker.

Fig. 3 shows the different functions possible with the envelope shaping and tremolo circuits.

With Fig. 1 and Fig. 2 in mind, we can consider the complete circuit diagram as seen in Fig. 4. The heart of the circuit, the VCO, is U4, which is an Exar XR2206 function-generator integrated circuit. That is connected to provide simultaneous sinewave and squarewave outputs, which are mixed across a 5000-ohm potentiometer, R33, providing the necessary range of sinewave and squarewave.

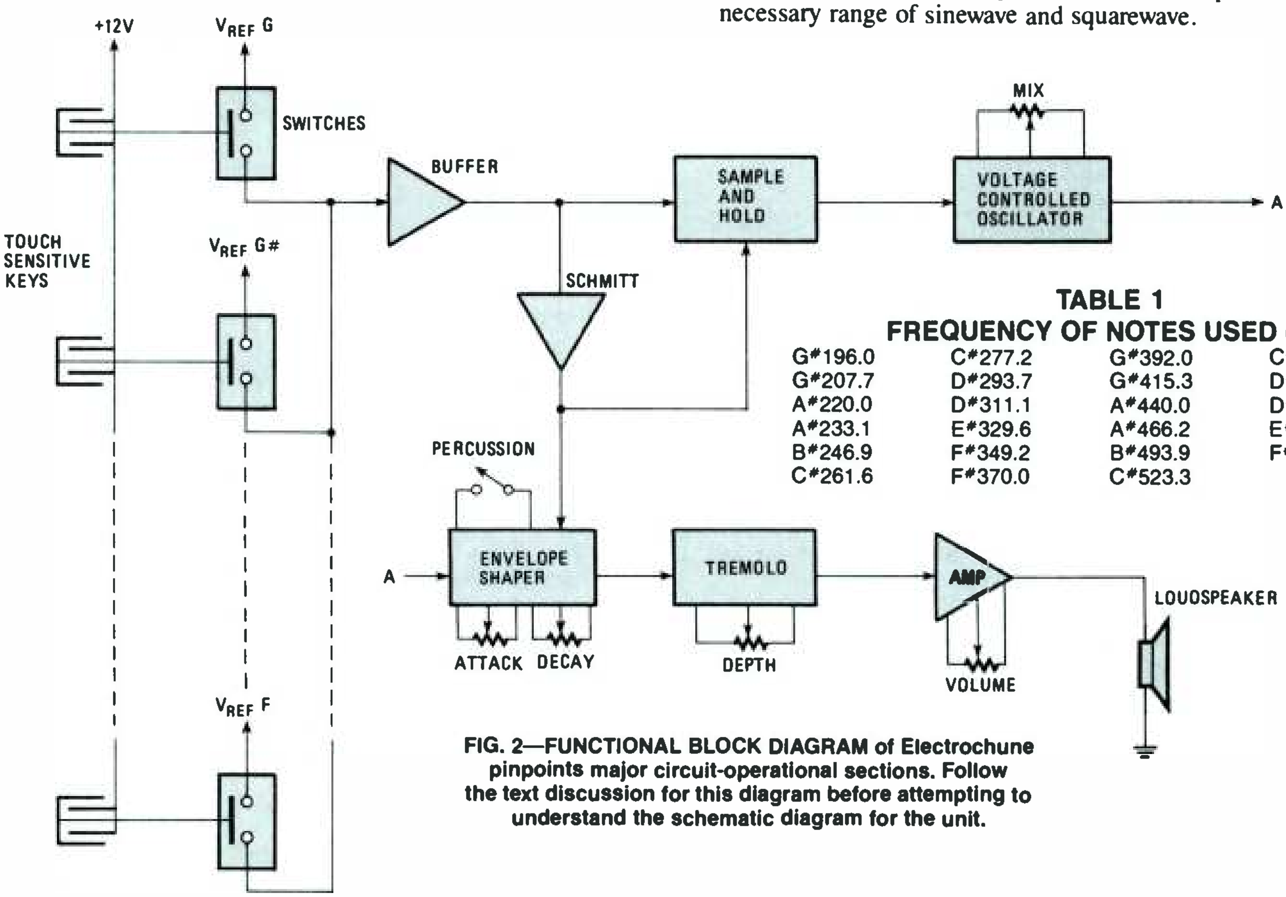


FIG. 2—FUNCTIONAL BLOCK DIAGRAM of Electrochune pinpoints major circuit-operational sections. Follow the text discussion for this diagram before attempting to understand the schematic diagram for the unit.

TABLE 1
FREQUENCY OF NOTES USED (Hz)

G#196.0	C#277.2	G#392.0	C#554.4
G#207.7	D#293.7	G#415.3	D#587.3
A#220.0	D#311.1	A#440.0	D#622.3
A#233.1	E#329.6	A#466.2	E#659.3
B#246.9	F#349.2	B#493.9	F#698.5
C#261.6	F#370.0	C#523.3	

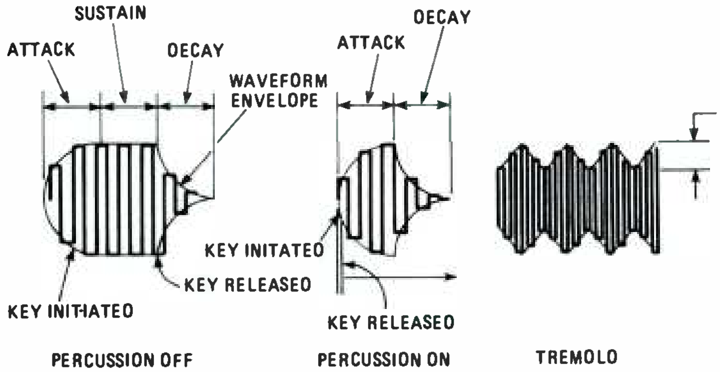


FIG. 3—A PICTURE IS WORTH a thousand words, and a diagrammed waveform is worth even more! Here, the attack, sustain, and decay effects on a waveform are seen in the two waveforms at left and center. Percussion on/off pertains to the setting of switch S1. The right diagram of a waveform illustrates the tremolo effect superimposed on a continuous wave; however, the effect will function on random-frequency waveforms (like music) as well.

Looking back to the key inputs, U11, U12, U13, U14, U15, and U16 are quad CMOS bilateral switches which provide the input from the note-voltage dividers. The CMOS switches are switched by skin resistance of the finger placed across the appropriate key pattern.

The selected note voltage is fed to a FET-input operational amplifier, U10, operating as a buffer stage. The input of U10 is normally held high by a 10-Megohm resistor, R24, when all CMOS switches are closed. Resistor R24 has a negligible loading effect on the note voltage.

The output of U10 is fed to U8, the Schmitt trigger, and also to the sample-and-hold circuitry. That consists of a single CMOS switch (U14d) and U3, another FET-input operational amplifier connected as a voltage-follower which monitors the voltage across a .047-µF capacitor, C27.

Sample and Hold

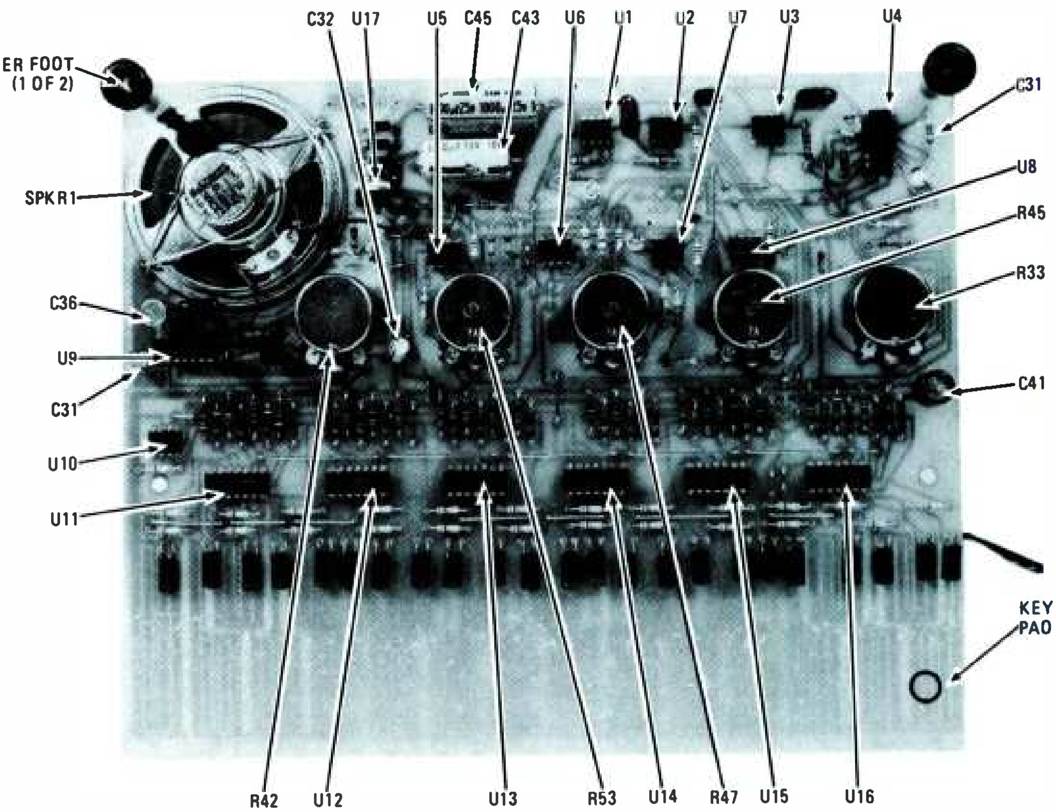
As soon as a selected voltage appears at the output of buffer U10, it drives the output of Schmitt trigger U8 low, initiating the 555 monostable timer, U2, which delivers a short turn-on pulse to U14d in the sample-and-hold circuit. That allows the .047-µF capacitor, C27, to charge to the full value of the note voltage—a value which it will hold, by virtue of being in a very-high impedance circuit, until the next note is struck. Voltage-follower U3 then feeds the capacitor voltage value to the VCO to determine the frequency.

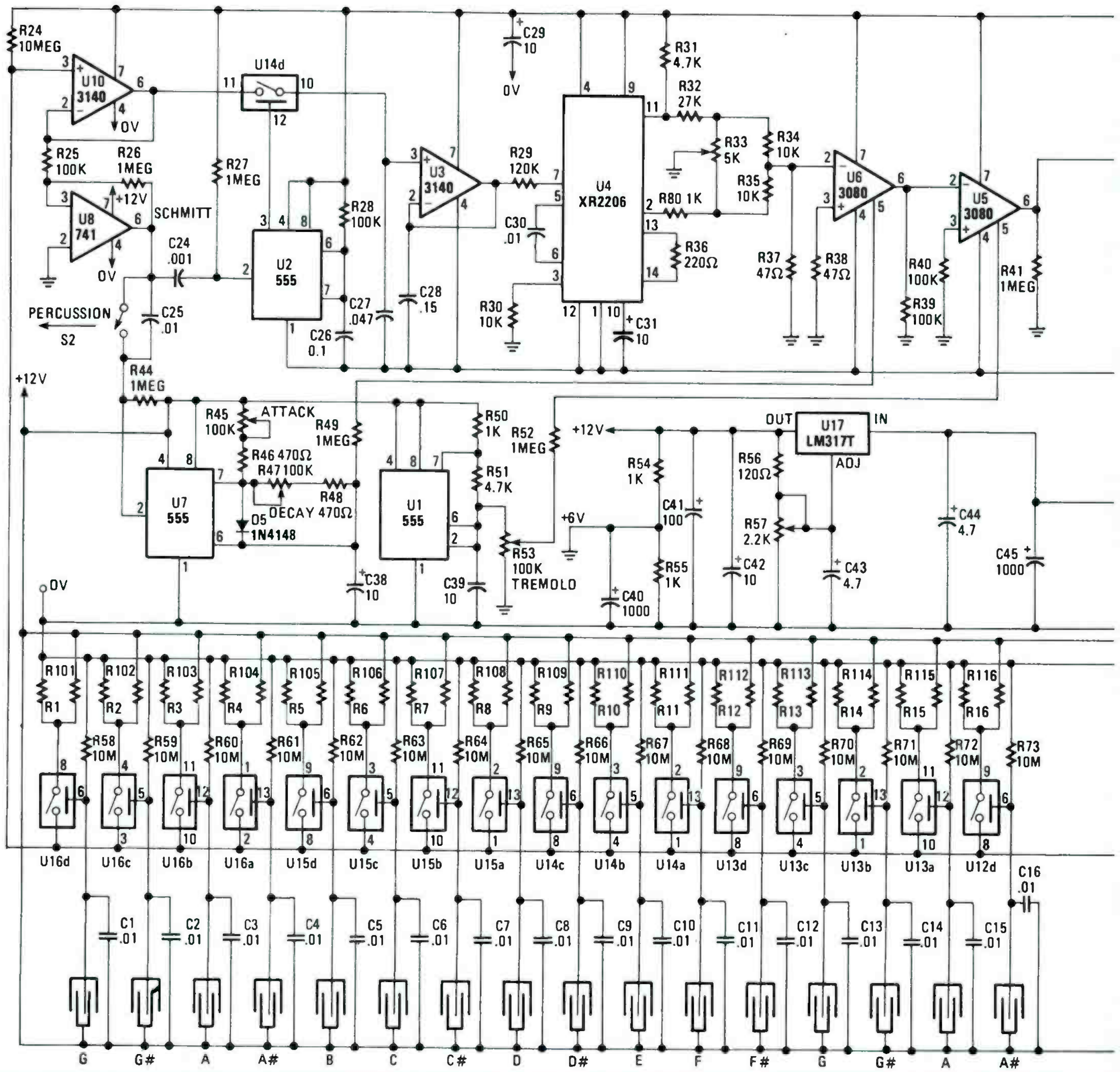
At the same time as the Schmitt trigger initiates the monostable to operate the sample-and-hold, it also initiates the envelope-shaping circuitry. Thus, at the same time as the note frequency is determined, its envelope is also controlled. Logical, isn't it?

So the Schmitt trigger also initiates 555 monostable timer U7 for a set period. Here, the ramp voltage at pin 6 is used to control a CA3080 transconductance amplifier (read: variable-gain amplifier) U6. The ramp voltage goes up for attack and down for decay, and is separately controlled for those two parameters by 100,000-ohm potentiometers, R45 and R47.

The percussion switch associated with U7 works in the following way: A 1-Megohm resistor, R44, normally holds the trigger input, pin 2, high and triggering is either done through the .01-µF capacitor, C25, or directly, via the percussion switch contact, S2. When the percussion switch is in the

PARTS LOCATION for key components located on the printed-circuit board. This project requires an etched circuit board. Using other wiring techniques will only prove to make the project more difficult to assemble and operate.





PARTS LIST FOR ELECTROCHUNE KEYLESS ORGAN

SEMICONDUCTORS

D1-D4—1N4002 1A rectifier diode
D5—1N4148 small-signal switching diode
U1, U2, U7—555 timer integrated circuit
U3, U10—CA3140 BiMOS operational amplifier
U4—XR2206 monolithic function generator integrated circuit
U5, U6—CA3080 operational amplifier
U8—741 operational amplifier
U9—LM380 audio power amplifier (14 pin DIP) integrated circuit
U11-U16—4066 CMOS quad bilateral switches integrated circuit
U17—LM317 three-terminal regulator

RESISTORS

(All fixed units are 5% tolerance, ¼-watt. Refer to Table 2 for additional information)
R1-R4—22,000-ohm
R5-R7—20,000-ohm
R8-R10—18,000-ohm
R11-R12—16,000-ohm
R13—15,000-ohm
R14-R15—13,000-ohm
R16—12,000-ohm
R17—11,000-ohm
R18-R21, R30, R34, R35—10,000-ohm
R22-R23—9100-ohm
R24, R58-R79—10-Megohm
R25, R28, R39, R40, R104—100,000-ohm
R26, R27, R41, R44, R49, R52—1-Megohm
R29—120,000-ohm
R31, R51—4700-ohm
R32—27,000-ohm

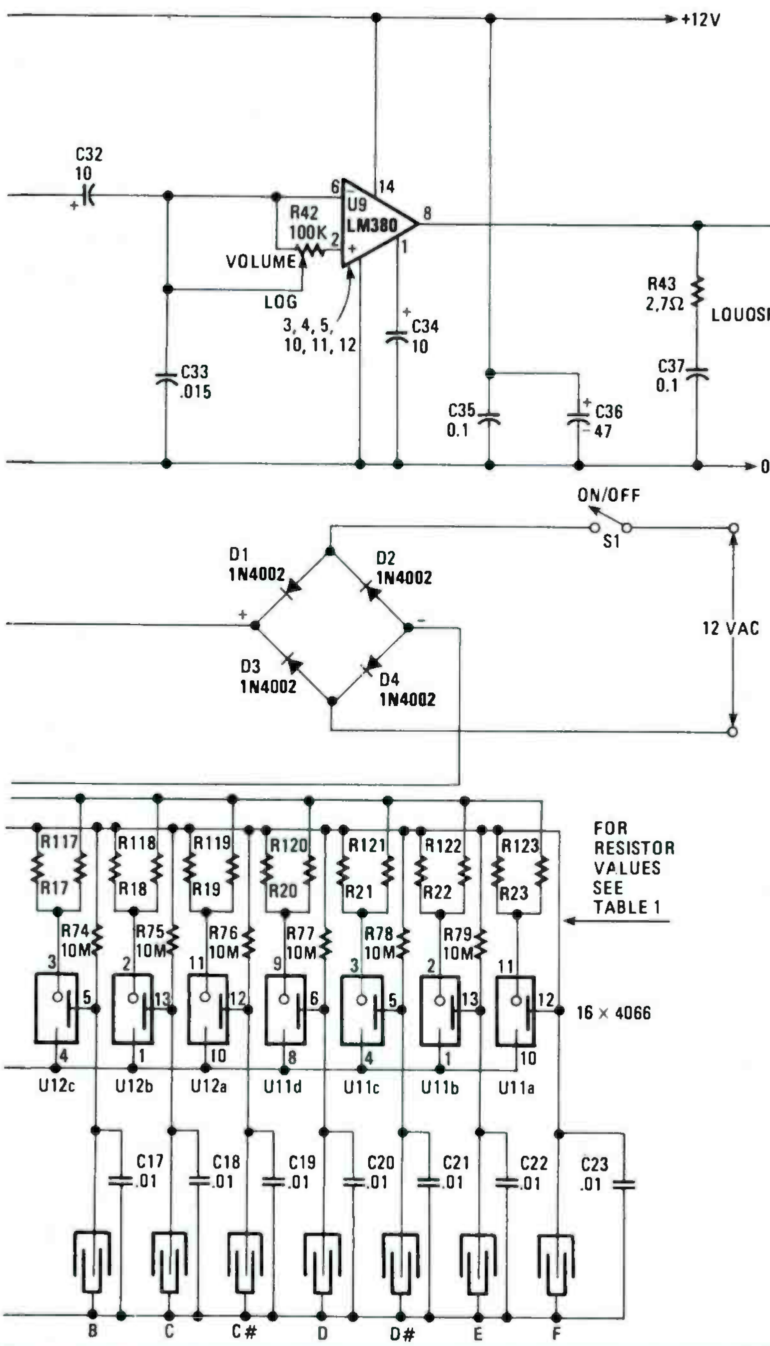
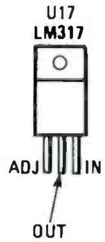


FIG. 4—COMPLETE SCHEMATIC DIAGRAM for the Electrochune is given on this page. Power supply is a 12-volt DC plug pack.



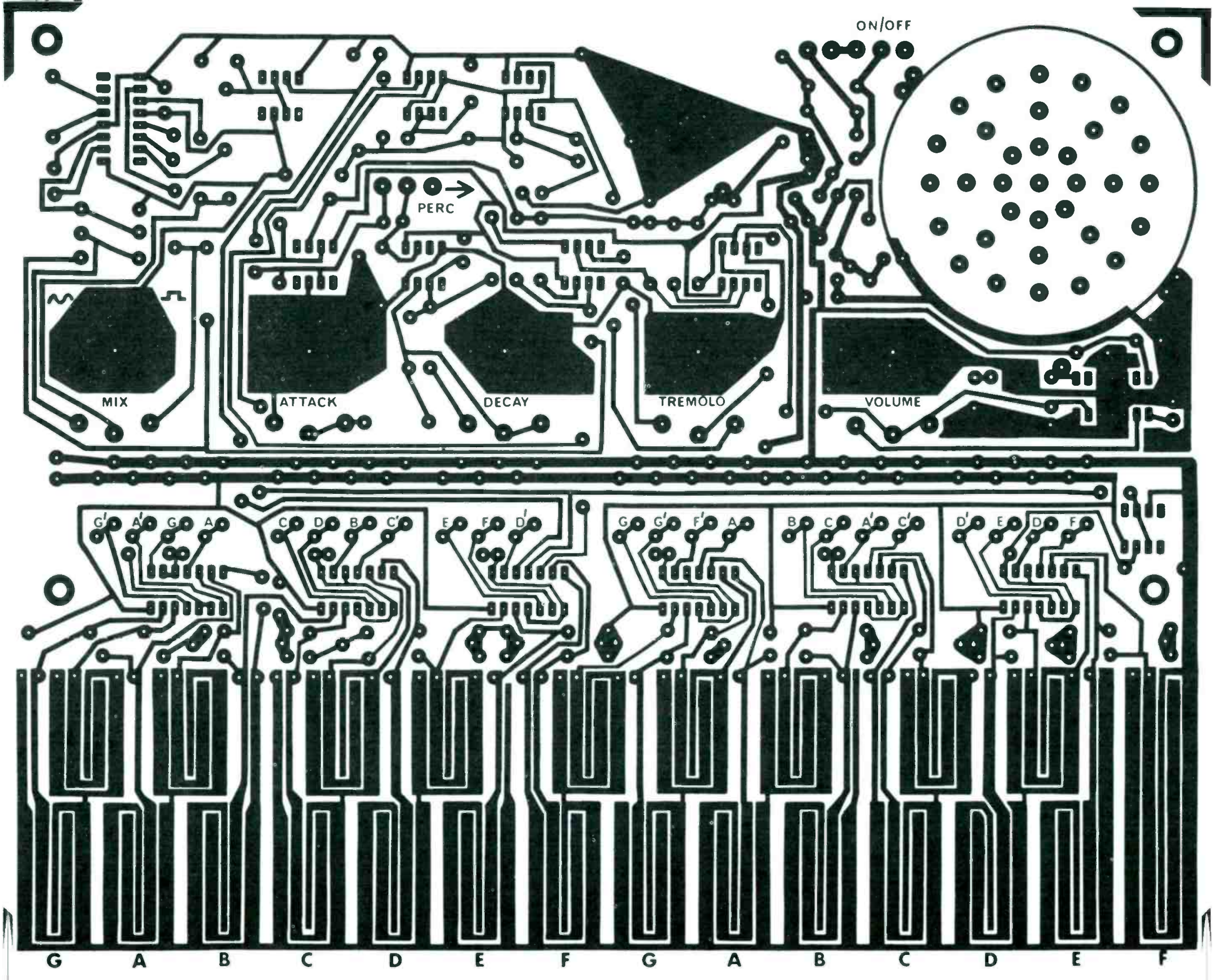
R33—5000-ohm, linear-taper potentiometer
R36—220-ohm
R37, R38—47-ohm
R42—100,000-ohm, logarithmic-taper potentiometer
R43—2.7-ohm
R45, R47, R53—100,000-ohm, linear-taper potentiometer
R46, R48—470-ohm
R50, R54, R55, R80—1000-ohm
R56—120-ohm
R57—2200-ohm, miniature, vertical trimpot
R101—91,000-ohm
R102, R105, R114—110,000- and 680,000-ohm in parallel
R103, R111—110,000- and 750,000-ohm in parallel
R106—110,000- and 820,000-ohm in parallel
R107—120,000- and 620,000-ohms in parallel
R108—110,000- and 620,000-ohm in parallel
R109—110,000- and 910,000-ohm in parallel
R110—120,000- and 750,000-ohm in parallel
R112, R113, R115—120,000- and 680,000-ohm in parallel
R116—120,000- and 820,000-ohm in parallel
R117—130,000- and 560,000-ohm in parallel
R118—130,000- and 620,000-ohm in parallel
R119—150,000- and 750,000-ohm in parallel
R120—180,000- and 820,000-ohm in parallel
R121—240,000- and 680,000-ohm in parallel
R122—360,000- and 560,000-ohm in parallel
R123—330,000-ohm

CAPACITORS

C1-C23, C25, C30—.01-μF, metallized polyester
C24—.001-μF, metallized polyester
C26, C35, C37—0.1-μF, metallized polyester
C27—.047-μF, metallized polyester
C28—0.15-μF, metallized polyester
C29, C31, C32, C34, C38, C39—10-μF, 16-WVDC, electrolytic
C33—.015-μF, metallized polyester
C36—47-μF, 16-WVDC, printed-circuit mount, electrolytic
C40—1000-μF, 16-WVDC, axial-lead, electrolytic
C41—100-μF, 16-WVDC, printed-circuit mount, electrolytic
C42—10-μF, 16-WVDC, tantalum
C43—4.7-μF, 16-WVDC, tantalum
C44—4.7-μF, 25-WVDC, tantalum
C45—1000-μF, 25-WVDC, axial-lead, electrolytic

ADDITIONAL PARTS AND MATERIALS

S1, S2—SPDT slide switch
SPKR1—2-1/2-in., PM loudspeaker
AC plug pack 12-Volts AC at 500 mA, IC sockets optional, decals, cabinet material, printed-circuit material, knobs, tinned copper wire, solder, hook-up wire, etc.


ON/OFF
PERC
MIX
ATTACK
DECAY
TREMOLO
VOLUME
G A B C D E F G A B C D E F

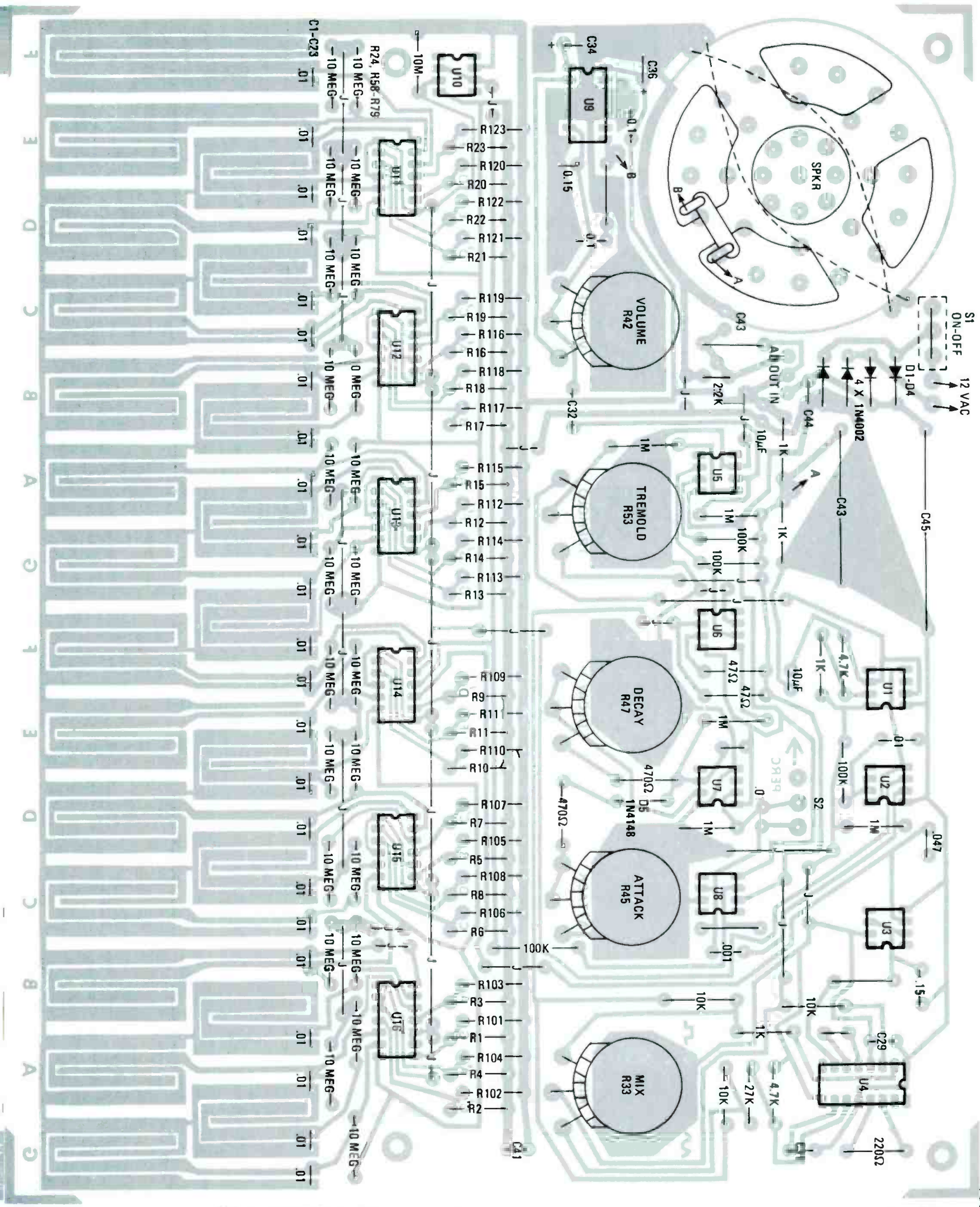
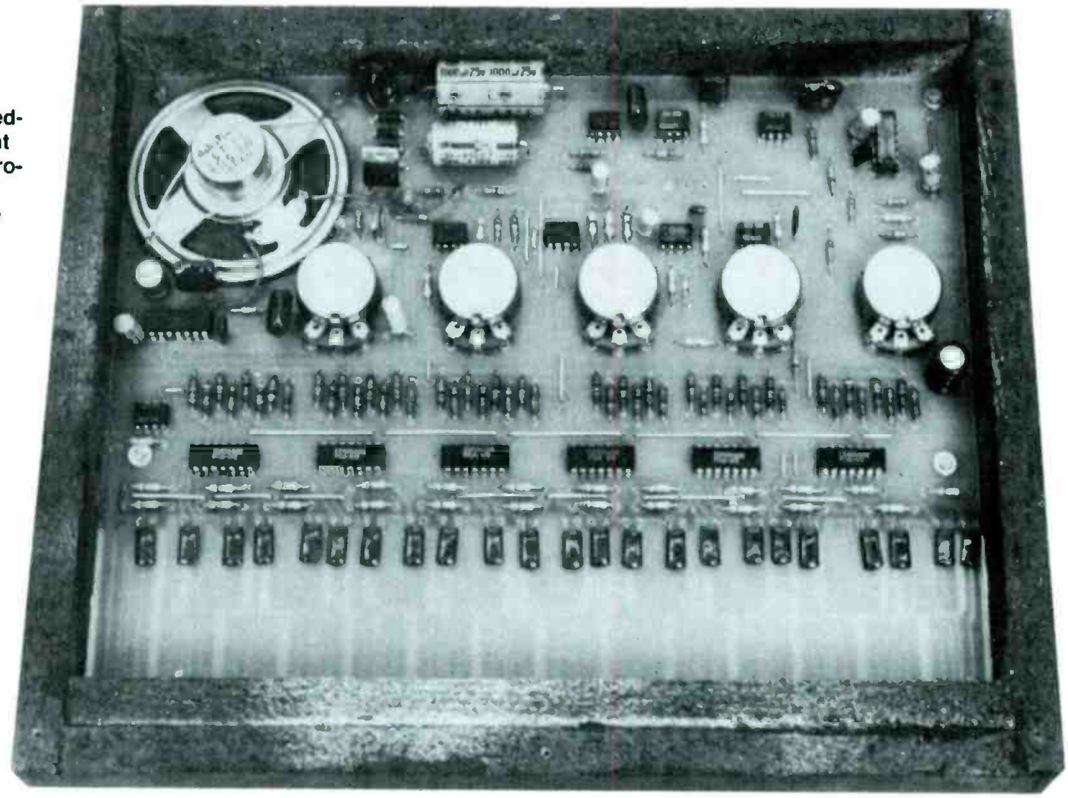


FIG. 6—PUTTING the Electrochune together is easy once you have made the printed-circuit board—just follow the wiring diagram above. Note that S1 and S2 slide switches are mounted on the copper-foil side of the board. Also, some of the paralleled resistors are located there. IC sockets may be used if desired.

FIG. 5—SAME-SIZE template of the printed circuit used to mount the parts on the original Electrochune.



YOU CAN SEE WHY a printed-circuit board is so important to the construction of Electrochune. The parts are lined up like soldiers on a parade field displaying their colors and markings clearly for inspection. Wood base surrounds the board providing some cosmetic effect and protection.

direct-coupled position, after the Schmitt goes low, the voltage at pin 6 rises at the attack-rate setting and is held at the maximum rise voltage until the Schmitt goes high. The voltage then falls at the decay rate setting. When the percussion switch is in the capacitive-coupled position, the voltage at pin 6 rises to the maximum level and then immediately falls regardless of the Schmitt output.

Following transconductance amplifier U6 is another of the same type, U5, which provides the tremolo function. That is controlled by the sawtooth output of the 555 timer, U1. U1 oscillates at about 7 Hz and it has a 100,000-ohm potentiometer, R53, across its sawtooth output to vary the tremolo effect between about 30-percent modulation and zero.

Incidentally, in case the IC numbers seem to have no particular order in this theory discussion, just take a quick look at the printed-circuit board overlay. There you will see that the numbering refers to a sequence on the PC board, making the particular IC easy to find.

Finally, the signal is capacitive-coupled to amplifier, U9, which provides about 1 watt of power—enough to give a substantial volume from the speaker. The volume control operates on the common-mode principle, whereby the input signal is applied to both inverting and non-inverting inputs. The greater resistance between the input at pin 6, and the non-inverting input, pin 2, the greater the volume. If both inputs were tied together, then the output volume would be zero.

To reduce the possibility of instability of the amplifier, the input signal is bypassed with a .015-µF capacitor, C33. A Zobel network at the output of the amplifier helps prevent instability caused by the loudspeaker load.

The power supply is derived from a 12-volt AC plugpack which is full-wave rectified, filtered with a 1000-µF capacitor, C45, and regulated with an adjustable three-terminal regulator, U17, set to 12-volts DC. The supply is center-tapped by a resistive voltage divider (two 1000-ohm resistors, R54 and R55) to provide decoupled reference voltage for the various op amps. Decoupling is provided by a 1000-µF capacitor, C40, which also carries the loudspeaker return current.

Construction

All the components are accommodated on a large PC board. A same-size diagram of the printed-circuit board is provided in Fig. 5, and a top (foil-side) view of the printed-circuit board with components in place is shown in Fig. 6. We suggest that the printed-circuit board you use be tin-plated, providing the same corrosion protection and also making it easier to solder.

Start assembly by making sure that the holes are drilled to suit the potentiometers and slide switches used. Solder in all the links (use tinned, copper wire) keeping them straight and tight between the mounting holes. Next, all the resistors can be soldered in place. Note that R1/R101 to R23/R123, whose values are shown in Table 1, have some parallel resistor combinations. Those are mounted on both sides of the PC board. The resistors on the copper side are soldered directly over the opposing resistor and to the same mounting holes. Those specified resistors make possible the frequencies that make the musical notes from Electrochune.

Now the IC's can be soldered in place, making sure the orientation is correct. Note that not all the IC's are oriented in the same direction. The CMOS IC's should be soldered in place last. Be sure that the supply pins (pins 7 and 14) are soldered first; use a grounded soldering iron.

The capacitors can then be connected in place. The 23 .01-µF capacitors were soldered to the keyboard ¼-inch above the printed-circuit board so that they could be bent over flush to the board's surface. That prevents them from being broken off and gives a neater appearance.

The potentiometers are bolted to the printed-circuit board in their respective holes, and the terminals of those soldered directly to the board. The solder lug eyelet of each terminal will need to be cut off and the whole terminal bent through 180° in order for that to be achieved.

The loudspeaker is mounted face down on the fiberglass side of the printed-circuit board. Two lengths of stiff tinned copper wire are then soldered across the back of the loudspeaker from one side to the other and hold it tightly to the printed-circuit board.

Finally, the wires can be brought to the loudspeaker and the slide switches soldered to the printed-circuit board. Note that the switches are soldered on the copper side of the board—and not the fiberglass side, as would usually be the case. ¢We have attempted to make tuning as simple as possible. By using the values specified, the organ should be in reasonable tune. However, the overall tune would depend upon the voltage provided by the regulator being set close to 12 volts and the capacitor used for the oscillator on U2.

For critical tune applications, the organ can be adjusted with the aid of a frequency meter or organ-tuning standard. The frequencies for each note are given in the accompanying table for frequency meter use, but for the tuning reference method, beats can be listened for, or Lissajous figures set up on an oscilloscope. Various parallel resistors can be placed across the reference resistors, R1/R101 to R23/R123, until the instrument is in tune.

Note that the order of tuning resistors does not exactly follow the keyboard musical-note order, but the relevant resistors for each note are labelled on the printed-circuit board overlay diagram for easy identification.

If you wish to make the Electrochune tunable to match other instruments, it will be necessary to have a variable capacitor in parallel with C1, which is connected between pins 5 and 6 of U4, the VCO. The largest suitable variable capacitor we know of is the solid dielectric type used in most portable AM radios. Those normally have a range of several hundred picofarads, giving a useful tuning range.

To make use of that option, you will have to make sure that, when the variable capacitor is in circuit, the Electrochune can be brought to standard tune, i.e. A at 440 Hz. The same remark applies if you wish to tune the whole instrument precisely, as described above: First make sure that you have a precise 12 volts from the regulator and then set A440 by suitable adjustment (i.e., padding with small parallel capacitors if necessary) of C1.

TABLE 2
TABLE OF TUNING RESISTOR VALUES

R1	22K	R112	120K//680K
R101	91K	R13	15K
R2	22K	R113	120K//680K
R102	110K//680K	R14	13K
R3	22K	R114	110K//680K
R103	110K//750K	R15	13K
R4	22K	R115	120K//680K
R104	100K	R16	12K
R5	20K	R116	120K//820K
R105	110K//680K	R17	11K
R6	20K	R117	130K//560K
R106	110K//820K	R18	10K
R7	20K	R118	130K//620K
R107	120K//620K	R19	10K
R8	18K	R119	150K//750K
R108	110K//620K	R20	10K
R9	18K	R120	180K//820K
R109	110K//910K	R21	10K
R10	18K	R121	240K//680K
R110	120K//750K	R22	9.1K
R11	16K	R122	360K//560K
R111	110K//750K	R23	9.1K
R12	16K	R123	330K

Resistors are 5% units unless 2% or 1% units are available in the junkbox, or at a low cost.

Making Music

Playing the Electrochune involves the use of one finger only. If a second finger contacts another note while the first finger remains on a key the same note will still play. It is not until all fingers are released from the keyboard that another note can be played.

From time to time it will be necessary to clean off the keyboard (with a weak detergent solution) so that any build-up of grease and dirt does not prejudice operation by tending to turn on the CMOS keys. Do not use abrasive cleaners for that job.

The Attack and Decay controls are adjustable from about .005 second to about one second, giving rise and fall envelope times varying from almost instant to a slow-rise time. If the percussion is on with maximum attack and decay times, then just a "plop" will be heard. With the percussion off, the musical note will appear to respond only when the key is pressed.

The Electrochune is a bare-bones project without a cabinet. That construction aspect is left to the builder to work out to fit his needs. However, rather than let the matter drop cold, a photo of a dressed-up unit illustrates what can be done to make the unit eye-appealing. ■

DRESSING UP Electrochune adds spice to something that sounds nice and makes it look good, too! The printed-circuit board can do with some support. Wipe the key pads with a dry tissue from time to time, removing the accumulation of skin oils on the copper foil.

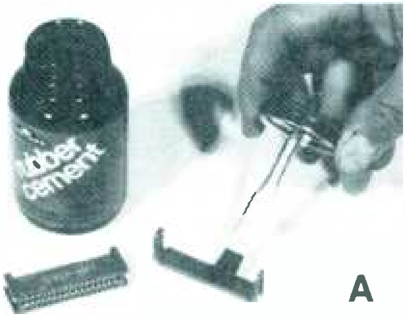
YOU EARN $20 FOR EACH TIP

TESTBENCH TIPS

The very next time you come up with a simple, but clever, idea that helps you build a better project, or do a better job of installing, or testing, a project, let us know about it. Put your idea on paper (typewrite it), spelling out the details on one sheet. Take a black-and-white photo of the idea in action and send it to the Editor. (Color photos lose too much contrast.) If your tip is used in this column, you will receive a check for $20. Sorry, we will be unable to return your tip or photo, and all entries become the property of **Hands-on Electronics.** Send all mail to **Hands-on Electronics** Testbench Tips, Room 1101, 200 Park Avenue South, New York, New York 10003.

Hold That Cable

Ribbon cable becomes very slippery stuff when I try to hold it in position as I squeeze the parts of an insulation displacement connector in a vise. Often, the wire slips just a smidgen and the contacts pierce through the insulation to the wrong wire. I discovered that if I coat the connector's pressure bar (A) and the



A

edge of the ribbon cable (B) with ordinary rubber cement, and press them together when the cement is dry to the touch, the wire stays in position and

B

doesn't budge when the connector is squeezed together. Every connector becomes a perfect installation (C). The rubber cement residue has no effect on the cable's insulation. *—H.F., Hewlett, NY*


C

Feed Fixing

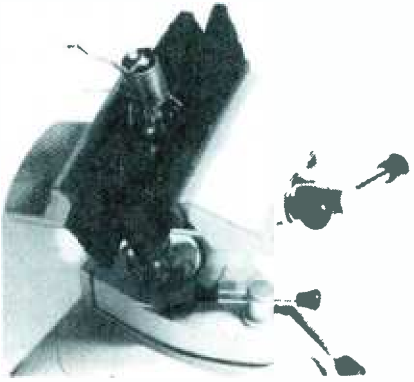
My single-sheet printer becomes a nightmare when I need to print a long list of names, files, or a BASICII program. I found that a small roll of paper from an inexpensive printer will sit on top of the printer in the groove formed by the platten and the paper rest. With the paper roll pushed against the left paper stop, a dowel is cut to the exact fit between the roll of paper and the right side of the printer—just loose enough for the paper

to feed freely. You can count on the paper roll to remain in perfect alignment for a l-o-n-g listing. Like the paper, the dowel fits in the platten groove.

—K.J., Medicine Hat, Sask.

Still Another Use!

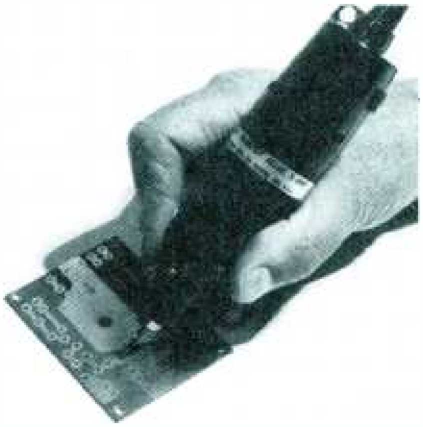
The conductive foam used to pack static-sensitive components is a perfect vise-jaw gripper when I have to hold delicate parts in a vise. The foam surface is unusually coarse, providing suitable gripping action to hold a fragile part in position even if the vise isn't tight. The



foam's extra firmness prevents it from deforming and releasing the pressure on the part. Also, since it conducts electricity, should you mount a static-sensitive component or board in the vise, provide a good electrical ground to the vise's frame to avoid static-charge buildup. *—A.W., Kansas City, KA*

New Tool

The extra fine dental burrs sold at flea markets are great for modifying homebrew printed-circuit boards. Their extra small footprint and high sharpness lets me slice through unwanted foils leaving barely a mark on the plastic substrate. The only problem I had was with the chuck size required to hold the burrs.



Dental burr shafts are very thin and require a chuck smaller than the standard size that comes with a hobby grinder. Go to your local hobby-supply store and pick up a copper or brass metal tubing that snug fits over the burr's shaft. Now the expanded shaft is of a suitable thickness for most hobby-type drills.

—W.T., Indianapolis, IN

Designing Practical DC Power Supplies

Once you know all about rectifiers, filters, and basic regulators you are ready for three-terminal regulators, current regulators, output-current limiting, over-voltage protection, heat sinks, switching regulators, and inverter circuits

By Joseph J. Carr

IF YOU ARE CONFIDENT THAT YOU KNOW ALL THERE IS TO know about designing the basic rectifying and filtering circuits for a power supply, you can dig into this article that begins with voltage-regulator circuits. Covered here are not only the standard three-terminal devices, but also certain special applications of three-terminal, integrated-circuit voltage regulators and adjustable integrated-circuit voltage regulators. You can also obtain information on switching voltage regulators— and we have even gone into the discussion of protection devices that every project builder should know about. Should you desire to beef-up your knowledge on power supply circuit design before getting into this article, we suggest that you look through the Summer, 1984 issue of **Hands-On Electronics** and read the first part of this feature article.

Three-Terminal Regulators

Three-terminal, integrated-circuit voltage regulators are a family of devices that provide fixed-output voltages, and are packaged in (usually) standard power-transistor cases (TO-3, TO-39, TO-92, TO-5 and TO-220). Rated output currents range from 100 mA in the TO-5 (and TO-39, TO-92) package up to 10 amperes in certain TO-3 types; most TO-3 and TO-220 devices are rated 750 mA to 1 ampere.

Figure 1 shows package outlines for the most common forms of three-terminal, integrated-circuit voltage regulator. Note that all use standard transistor packages. Other packages are used, but most are special house-brand types and are, therefore, unique to a company.

An all but *universal* circuit for using three-terminal integrated-circuit voltage regulators is shown in Fig. 2. Some elements of that circuit are optional, while others are found all of the time. Not shown in Fig. 2 is the transformer and AC-line input circuitry, which are unchanged regardless of whether or not a regulator is used.

Bridge rectifier BR1 and capacitor C1 (Fig. 2) are the same for any power supply. Selection of those components was covered in the previous installment. A rule-of-thumb for ripple filter capacitor C1 is not less than 1000-µF per ampere maximum load current. Thus, for a 3-ampere power supply, use 3000 µF (or more) of filter capacitance.

Capacitors C2 and C3 (Fig. 2) are used to improve the noise immunity of the circuit, and will have values between 0.1 µF and 0.47 µF. The actual value selected is optional, except that (generally) higher load current designs prefer higher capacitances. We can use 0.1 µF for all 1-ampere supplies and either 0.33 µF or 0.47 µF for 3- and 5-ampere designs. Those values are guidelines, and are suitable for

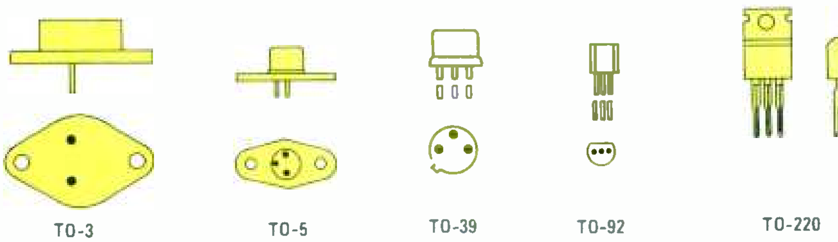


FIG. 1—MANY 3-TERMINAL voltage regulators are compacted into packages common to transistors and integrated circuits. The most common are illustrated in outline form and identified by their universal package number. The TO-3 type relies on its case as one electrical circuit termination. The TO-220 type has the mounting bracket and center terminal electrically connected.

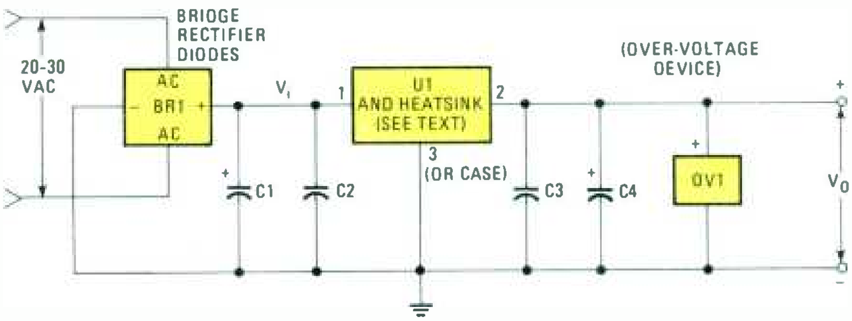


FIG. 2—CIRCUIT DRAWING of a typical voltage regulator circuit using a 3-terminal device. Capacitors C2 and C3 are used to suppress transient impulse noise common to voltage-regulator devices. Over-voltage protection circuit (OV1) prevents voltages in excess of the predetermined amount from reaching the output terminal.

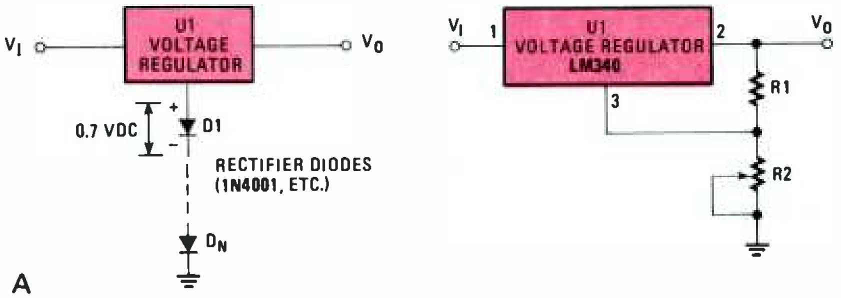


FIG. 3—NON-STANDARD VOLTAGES can be obtained from voltage regulators that were designed to produce one fixed regulated voltage. In A, one, or more diodes raise the device's V_O output by .7-volt DC for each diode connected in series. A resistance divided in B is used to provide an offseting voltage that is variable.

most applications.

The location of C2 and C3 is critical. Those capacitors are used to suppress transient impulse noise, which implies high-frequency content pulses. Therefore, C2 and C3 must be mounted as close as possible to the body of the voltage regulator integrated-circuit (i.e. U1). Many projects call for mounting C2 and C3 on the body of U1! If those capacitors are mounted too far from U1, or if their leads are too long, then the function of the capacitors is compromised.

Capacitor C4 (Fig. 2) is optional but highly recommended, except in circuits that experience wide shifts in load current over short durations; digital circuits are examples. In those cases, C4 is mandatory.

The function of C4 is to improve the transient response of the voltage regulator. The capacitor serves as a local reservoir to supply current to the load for a brief instant while the regulator readjusts itself to the new, higher, level of current demand.

The device marked *OV1* is an over-voltage protection circuit, sometimes called an *SCR-crowbar*. The function of OV1 is to protect the external circuitry served by the voltage regulator in the event of a catastrophic failure of U1. Keep in mind that input voltage V1 is at least 2-3 volts higher than regulated output voltage V_O, and may be much higher than V_O. If U1 fails to the point that V1 appears on the V_O line (a frequent failure mode), then failure of the devices receiving V_O is likely. In a TTL circuit, for example, a U1 failure would place +8 volts on the +5 volt line—and that will burn out TTL chips!

The heatsink for U1 is sometimes pronounced *optional* by manufacturers and authors. I personally prefer heatsinking of all voltage regulators, contrary advice notwithstanding. Voltage regulators are power-dissipating semiconductor devices and, as such, their reliability is directly affected by temperature. For 1-ampere and under models, the metal chassis (if any) may be sufficient. Otherwise use a finned heatsink on U1.

Changing Output Voltage

Three-terminal integrated-circuit voltage regulators come in fixed voltages such as 2.0, 5.0, 10.0, 12.0, 15.0. 18.0, and 24.0 volts. If we need voltage values between the *standard* voltages, then some other tactic is necessary. Figure 3 shows two methods for changing V_O on fixed-voltage three-terminal integrated-circuit voltage regulators.

Figure 3A shows the use of rectifier diodes (e.g. 1N4001-1N4007, or equivalent) in the common lead of the voltage regulator to increase V_O. The value of V_O changes about 0.7 volt for each diode connected in series. Although that method works, it is not recommended because of the temperature dependence of the 0.7-volt drop across the rectifier's PN junction! In most cases, the method of Fig. 3B is preferable.

The circuit of Fig. 3B places the common terminal of the regulator at a potential that is a fraction of the desired V_O, rather than ground.

Perhaps the best solution to the variable voltage problem is the use of a regulator designed for such operation. Common voltage-regulator types available are the LM317 (1.5 ampere), LM338 (5-ampere) and Lambda Electronics' LAS*XX*U devices.

The LM338 is a 5-ampere horse of a regulator in a TO-3 case. It must be heatsinked at that current level, especially in situations where the input voltage (V_I) is much larger than V_O. That situation occurs in variable supplies when V_O is at its minimum value. In the LM338 circuit of Fig. 4, for example, a 28-volt V_I will permit an adjustible V_O of 1.2 volts to 25 volts. At the low voltage, therefore, power dissipation P_D at 5 amperes load current will be:

$$P_D = (28\text{-}1.2 \text{ V}) \times (5 \text{ A}) = 134 \text{ watts!}$$

The problem is less acute at the maximum value of V_O where:

$$P_D = (V_I - V_O) \times (I_{Load}) = (28\text{-}25 \text{ volts}) \times (5 \text{ A})$$
$$P_D = (3 \text{ V}) \times (5 \text{ A}) = 15 \text{ watts.}$$

The LM338 output voltage V_O is set by a voltage-divider network (R1 and R2) that may be either a single potentiomenter, or a combination of a fixed resistor and a potentiometer. If a fixed output voltage is desired, then both R1 and R2 can be fixed. The output voltage is determined by:

$$V_O = (1.25 \text{ V}) \times (R2/R1 + 1).$$

In most cases, the value of R1 will be 120 ohms to 250

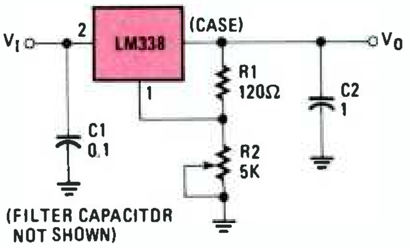
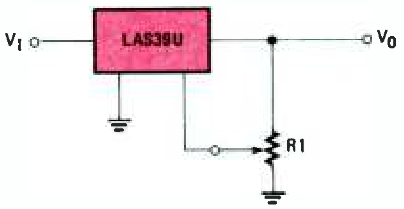


FIG. 4—THE LM338 voltage regulator must be mounted on a heat sink when a large internal voltage drop is expected. As the text details, a V_I of 28 volts and a V_O output of 1.2 volts will burn up about 134 watts at a load current of 5 amperes. Under the same conditions, except V_O is 25 volts, the power dissipated is only 15 watts.



ohms, and R2 is set to produce the desired voltage. The above equation can be rewritten in more practical form as follows:

$$R2 = (V_O/1.25 - 1) \times R1$$

Example

Design an LM338 regulator to produce an 13.8 VDC output so that CB radios can be bench-tested. Assume that R1 = 120 ohms.

$$R2 = (V_O/1.25 - 1) \times R1$$
$$R2 = (13.8/1.25 - 1) \times 120$$
$$R2 = (11.04 - 1) \times 120$$
$$R2 = 10.04 \times 120$$
$$R2 = 1205 \text{ ohms}$$

Of course, one would not try to find a 1205-ohm resistor, but would make R2 a series combination of a fixed resistor and a potentiometer. For example, a 1000-ohm fixed resistor and a 500-ohm linear-taper potentiometer to precisely set V_O.

Keep in mind that the LM338 is a 5-ampere voltage regulator. As such, it should be heatsinked with a finned heatsink, and silicone heat-transfer grease should be applied to touching surfaces. In the the TO-3 package, the case is the output terminal so it must be isolated from the chassis ground. That requirement means either insulating the heatsink assembly, or using a mica insulator under the LM338 TO-3 package.

Figure 5 shows another variable regulator, Lambda Electronics' LAS-39U. That device is similar to LM338, but will pass 8 amperes. The value of the adjustment potentiometer in ohms is:

$$R1 = V_O/10A$$

Higher-Current Regulators

Voltage regulators capable of *higher currents* are sometimes needed for digital projects, amateur transmitters, and audio power amplifiers. We will define *higher current* to be over 5-8 amperes. One of the easiest ways to accomplish that job is to use one or more high-current transistors as a series-pass element. Figures 6 and 7 show how that is done. The advantages of those circuits are that design is simplified immensely, and we can use power transistors with lower beta ratings, because of the higher current availability of the integrated-circuit regulator.

In both circuits, the output voltage V_O is approximately 0.6 to 0.7 volt lower than the rated output voltage of the three-terminal integrated-circuit regulator. Thus, using an LM340T-12 regulator will produce an output voltage of about 11.4 volts.

The version of Fig. 6 uses a plastic PNP power transistor such as the popular TIP-34 for the series-pass element. That circuit will handle 5-6 amperes.

Somewhat higher currents can be accommodated by the circuit of Fig. 7. That circuit also provides a means for adjusting the actual output voltage to a precise value.

The heart of the circuit is an LM317 integrated-circuit adjustable voltage regulator (U1). That device will set the reference voltage at the base of the series-pass transistors (hence, also V_O), and can supply up to 1.5 amperes of base current to those transistors. If more base current is needed, then use an LM338 device (which produces up to 5 amperes) instead of LM317.

The output voltage V_O will be 0.7 volt less than the voltage produced by U1. The U1 voltage will be set in a manner that is similar to the LM338 discussed earlier. In that case, however, R2 is represented by two resistors, R2a and R2b. The overall equation is:

$$V_O = 1.25V\ (R2a - R2b)/R1 + 1 - 0.7.$$

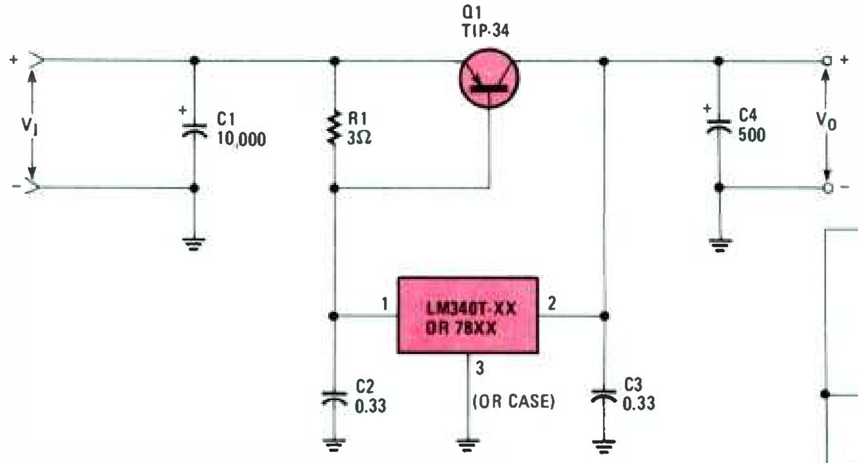


FIG. 6—THIS CIRCUIT will deliver up to 6-7 amperes using a voltage regulator to drive a plastic-case, PNP "series-pass" transistor.

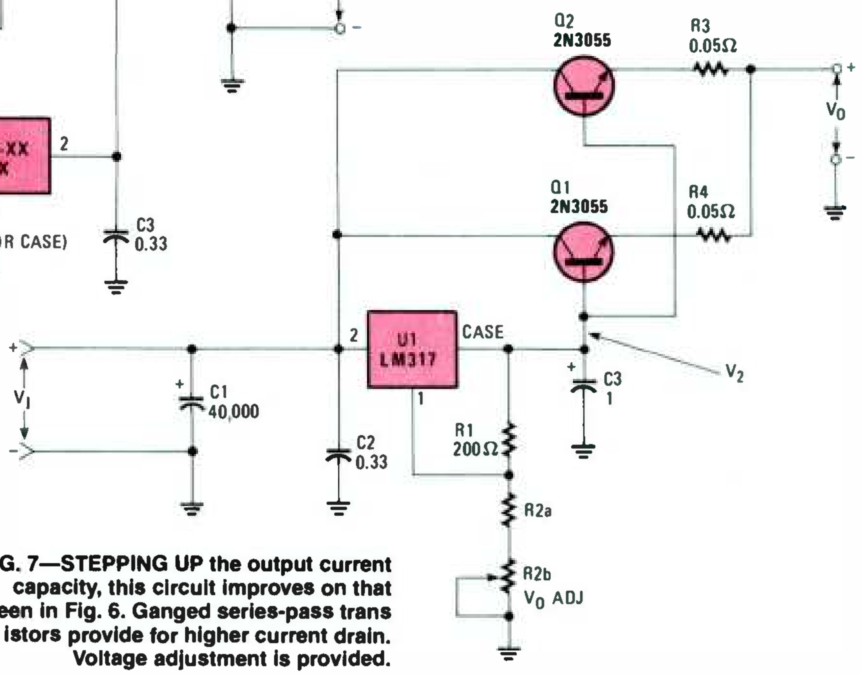
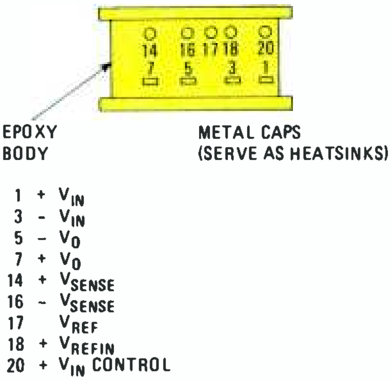


FIG. 5—The LAS39U adjustable voltage regulator is an improved variation ◀ of the LM338 in Fig. 4. The LAS39U requires only one circuit element, an output voltage-setting potentiometer.

FIG. 7—STEPPING UP the output current capacity, this circuit improves on that seen in Fig. 6. Ganged series-pass transistors provide for higher current drain. Voltage adjustment is provided.



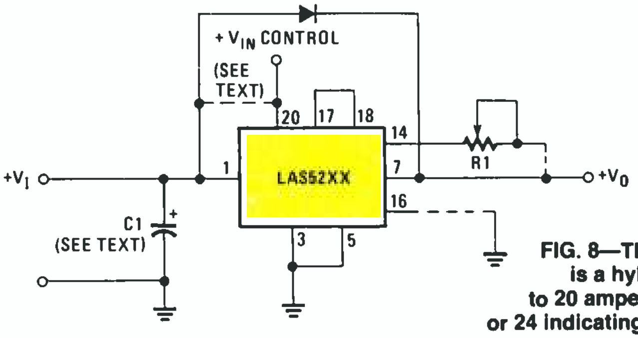


FIG. 8—THE LAS52XX voltage regulator is a hybrid device that can deliver up to 20 amperes. The XX could be either 05 or 24 indicating the regulated-voltage output.

You should recognize that equation as being a modified version of the LM338 equation. Normally, potentiometer R2b will be from 10 to 50 percent of the total (R2a + R2b). The precise ratio of R2a to R2b depends upon the degree of control (i.e. resolution) and range (maximum to minimum values of V_O) desired.

The high current is handled by one or more series-pass transistors. Two ratings are of primary consideration when selecting transistors: collector power dissipation and collector current. In addition, we must also be certain that each transistor has a V_{CC} rating high enough to accommodate all reasonable excursions of input voltage V_I.

The power dissipated in the collector of the series-pass transistor is the product of the collector current (maximum) and the C-E voltage drop which, in that case, is the difference (V_I-V_O). For adjustable regulators, then, the actual maximum power dissipation that the transistors must sustain is:

$$P_{d(mam)} = I_{C(max)}(V_{I(max)} - V_{O(min)}).$$

When two or more transistors are connected in parallel to increase the current capacity of the regulator, we must use emitter ballast resistors R3 and R4 (Fig 7) in series with each emitter. Also, if there are wide differences in the beta gain of the transistors, then the load division may not be even. Under that circumstance, it may happen that the current handled by one transistor exceeds its rated I_C. For that reason, rough matching of the power transistors may be desirable.

With the circuit shown in Fig. 7, using 2N3055 transistors for Q1 and Q2 will yield a power supply of 15 to 20 amperes ICAS rating.

Another alternative for high-current regulators are the hybrid units made by Lambda Electronics Inc. (121 International Dr., Corpus Christi, TX 78410). Lambda has long been recognized as a leading manufacturer of O.E.M. and workbench power supplies, but also sells power-supply components. Figure 8 shows one of the Lambda hybrid regulators, the 20 ampere LAS-52XX devices. The XX denotes the voltage output, and may be 5, or 24. The package for those regulators is shown in Fig. 8A, while the application circuit is shown in Fig. 8B.

The package for the LAS-52XX (Fig. 8A) is a special design of epoxy, with heatsink surfaces top and bottom. The main heatsink surface is the bottom plate, and that should be attached to a metal heatsink surface.

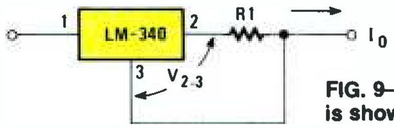


FIG. 9—A VOLTAGE REGULATOR is shown connected into a constant-current configuration.

The usual circuit for the LAS-52XX is shown in Fig. 8B. Capacitor C1 is the regular ripple-filter at the output of the rectifier. The value of that capacitor is 2000-µF/ampere, so for a 20-ampere power supply a 40,000 µF capacitor is required.

There are two V+ terminals on that device. Pin no. 1 is the main V+ terminal (high current) and is designated $+V_I$. That terminal is connected to the internal series-pass transistors. Pin No. 20 is designated $+V_{IN}$ (control), and is used to supply power to the internal control amplifiers. The voltage applied to pin No. 20 must be at least +7.5 volts DC. That requirement can be met on the LAS 5212 and LAS-5224 by connecting pins 1 and 20 together. On the LAS-5205, however, it may happen that $+V_{IN}$ is between 7 and 8 VDC, so may occasionally fall below the +7.5 VDC minimum. That situation occurred in one of my own products where the unregulated $+V_{IN}$ for a +5 VDC supply was derived from a 6.3 VAC transformer. The solution in that case was to connect Pin No. 20 to the +12-VDC supply used in the same microcomputer.

Pin Nos. 14 and 16 (Fig. 8) are sense lines, and are used to tell the internal reference amplifiers what voltage is being produced for V_O. If the wires connecting the regulator output to the load are short and heavy, then pin 14 can be connected via R1 directly to pin No. 7 (main = V_O), and pin 16 can be either grounded, or connected to pins 3 and 5. In many cases, however, we will connect the sense lines to $+V_O$ and $-V_O$ at the load. That connection permits them to be used to measure V_O where it is needed; and therefore, cancels the sometimes substantial effect of IR drop in the main current-carrying conductors.

Potentiometer R1 is used to set V_O to an exact value close to the nominal value specified by XX in the device type number. The resistance of R1 is given by:

$$R1 = .25V_O(1000\text{-ohms/volt}).$$

For a 5-volt LAS-5205, therefore, we need a resistance greater than

$$R1 = (.25 \times 5 \text{ volts})(1000\text{-ohms/volt})$$
$$R1 = (1.25)(1000) = 1250 \text{ ohms.}$$

Current Regulators

Figure 9 shows a three-terminal integrated-circuit regulator used as a current source. The output current is given approximately by:

$$I = V_{2\text{-}3}/R1 + I_Q$$

where I_O is the output current, V_{2-3} is the output voltage, V_O, R1 is the resistance in ohms, and I_Q is the quiescent current of U1 (typically 1-5 mA).

Diode Protection

Rectifiers in modern DC power supplies are solid-state PN-junction diodes. The advantage of those diodes is that they pack a lot of *rectification* into a small (in fact, tiny) package. On the disadvantage side, however, those diodes tend to be sensitive to high-voltage transients and to damage caused by excessive current surges.

Figure 10 shows a diode with added components that are used to protect the diode. Note: Not all of those measures will be used in all cases, but they are seen occasionally.

Series resistor R1 is used to limit surge currents. Normally, a diode will have a large surge-current rating that is defined as the one-cycle overload. On U.S. systems (i.e. 60 Hz), that means the overload for 1/60 second or less. Longer-duration overloads must be derated. Perhaps the biggest overload seen by most rectifiers is the initial charging of the filter capacitor. At turn-on, the filter capacitor is discharged, so the current rate of charge is very high. In most low-current supplies there is no problem, because the value of the filter capacitor is low enough so that it charges rapidly. If a large filter capacitor is used, however, the high-current portion of the changing cycle is prolonged enough to damage the rectifiers. The purpose of resistor R1 is to limit the current to a safe value during that portion of the changing cycle. Depending upon voltage and current levels, the value of R1 will be (usually) 5 to 100 ohms. The appropriate value is found by applying Ohm's law (E/I), using the applied voltage and maximum safe current.

Another tactic for preventing rectifier damage is to raise the power-supply AC voltage to the diodes slowly—but more on that topic later.

The parallel resistor across the diode (R2 in Fig. 10) is used when two or more diodes are connected in series. That tactic is used to increase the PIV rating of the rectifier. Because of differences between diodes, however, the voltage drop across each may be different. Shunting equal-valued resistors across the diodes tends to equalize the voltage drop across each diode. The usual value is 1000 ohms per volts.

Capacitor C1 is parallel with D1 (Fig. 10) and is used to suppress high-voltage transients from the power line. Those transients can reach 2000 volts, and may occur several times per day. Such transients can blow a PN junction diode.

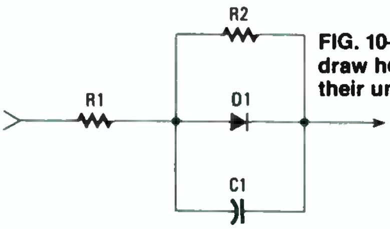


FIG. 10—AT TURN ON, rectifiers draw heavy currents because their uncharged filter capacitor appears as a short circuit for the first half cycle, or more.

Connecting .001-μF capacitor in parallel with the rectifier will eliminate many such transients (because of their high-frequency content) without passing any appreciable amount of 60-Hz current.

Figure 11 shows on form of *soft turn-on* circuit. The intent of that circuit application is to limit current flow for a few seconds, until the filter capacitor charges to a certain voltage. Various methods are used for that job. In Fig. 11, slow turn-on is accomplished by placing a resistor in series with the transformer primary winding. After a few seconds of *slow operating*, switch S2 is closed, and the power supply now operates at full capacity.

Other schemes involve substituting either lamps or *ballast* tubes for R1. Note that there is a fuse, F1, in the primary winding of transformer T1 (Fig. 11). Always fuse your power-supply circuits! The fuse should be the device that is closest to the power line's hot lead-point of entry, so that no fault can occur that will cause damage *without* blowing the fuse.

High-frequency interference signals on power lines, including those transients discussed above, can disrupt the operation of electronic equipment. A surprising amount of hash comes down the AC power lines. One way to eliminate many such signals is to place an LC filter in the power-line circuit between the point of entry into the equipment and the transformer primary winding. Figure 12 shows such a filter. Each line from the AC power mains has its own L-section lowpass filter that will pass 60-Hz power but not other frequencies and transients.

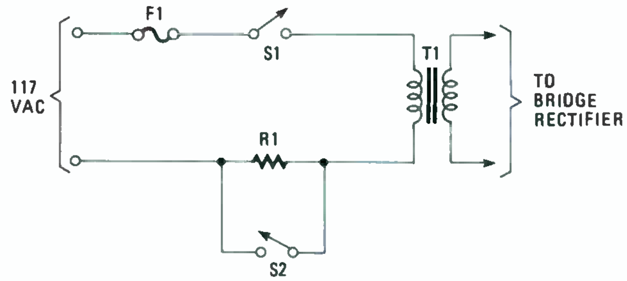


FIG. 11—ONE WAY to eliminate the heavy current through a diode during the first few moments when AC power comes on is to reduce the AC, to be rectified to a lower level.

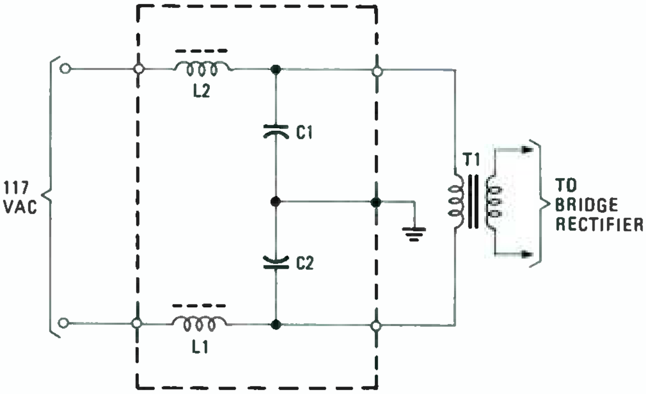


FIG. 12—WHAT APPEARS to be a safe power-line filter can kill you at the next visit to the doctor's office. Unequal capacitors and interactive inductors may produce a hot ground.

Filters such as diagrammed in Figure 12 are available ready-made, and are even available to chassis-mounted AC power receptacles. If you build your own, be sure that the capacitors are rated for use across AC power lines. Generally speaking, filters should be located as close as possible to the power-line point of entry into the equipment. That tactic prevents coupling to other conductors within the cabinet from the unfiltered section of line. If possible, the fuse should be located with the filter shield, and should be in the circuit ahead of the filter. That arrangement will prevent a catastrophe in the event of a short to chassis by a filter component.

Using an AC line filter such as Figure 12 automatically increases the current flowing in the power line ground (i.e. the *third wire*). In certain applications, that current is intolerable—medical equipment is an example. The amount of added ground current is proportional to the values of C1 and C2, and to some extent, mutual coupling between inductors L1/L2 and chassis. For those cases, that type of an AC line filter may not be applicable.

As mentioned above, high-voltage power-line transients cause problems in electronic equipment. Besides damaging diodes, they are also known to interfere with the operation of equipment. Digital computers seem especially prone to transient problems. Any computer that seems to "bomb" spontaneously, is probably experiencing alteration of the data due to transients. What is needed is some means for eradicating transients before they can do harm.

Figure 13 shows two methods for clipping AC line transients before they get into the power supply. In Fig. 13A we see two Zener diodes connected back to back. The breakover voltage (V_Z) of those diodes should be greater than the maximum peak AC voltage expected. Most equipment is specified to operate on 125 VAC (rms), so the maximum peak voltage will be (1.414) (125), or 177 volts. For a margin of safety, select V_Z to be 200 volts for both D1 and D2.

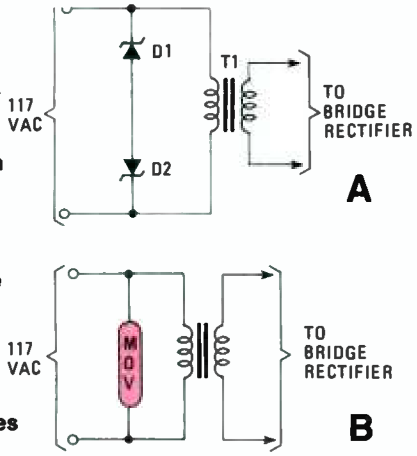


FIG. 13—TWO WAYS to reduce the possibility of damage to circuits due to transient high-voltage spikes on the AC line to the power supply. In A, back-to-back Zener diodes, rated large enough for the AC line used, lop off the excess-voltage spikes. In B, a metal-oxide varistor, a voltage-sensitive resistor element, also eliminates the high spikes.

A second popular alternative is the metal-oxide varister (MOV) device shown in Fig. 13B. General Electric makes MOV devices for that application. The MOV can be modelled as a pair of Zener diodes (per 4A), but it is actually a type of voltage-senstitive resistor. It will have a high resistance at all potentials below a certain threshold, but breaks down to a low resistance above that potential. Thus, high-voltage transcients are chipped away by the MOV, while the AC line voltage is not affected.

Output Current Limiting

If the output of an unprotected DC power supply is accidentally shorted, then immediate destruction of the power supply will result. Power supplies do not like to see direct short circuits across their outputs.

Figure 14 shows a simple overcurrent, or short-circuit, protection circuit. Transistor Q1 is the regular series-pass element found on many regulated supplies. The output voltage is set by V_Z of diode D1, and will be approximately 0.6 to 0.7 volt less than V_Z.

The overcurrent protection circuit consists of Q2 and R2. Resistor R2 is in series with the output current line, so it will develop a voltage drop of $I_O \times$ R2. That voltage becomes the base-emitter bias for Q2. When I_O µlt R2 reaches 0.6 volt, the junction potential for silicon transistors, Q2 will turn on hard and effectively shorts out series-pass transistor Q1 from base-to-emitter. Under that conditions, Q1 is cut off.

Some power supplies are designed to permit variation of the current limiting point. The quick and dirty way to do that job is to make R2 a variable resistor.

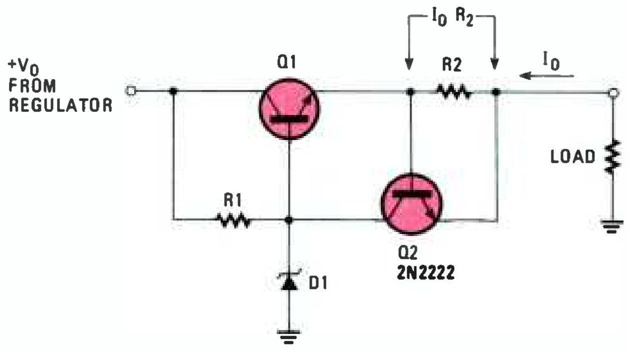


FIG. 14—A SERIES SENSING RESISTOR develops a voltage drop that triggers Q2 into action at a selected current drain. Transistor Q2 restricts the passage of current through Q1.

Regardless of whether variable- or fixed-resistor configuration is used, the value of R2 is found from Ohm's law in which the voltage value used is 0.6 volt:

$$R2 = 0.6/I_{O(max)},$$

Where: R2 is in ohms and I_O is in amperes.

For most DC power supplies, the value of R2 is very low, often a fraction of an ohm. A 10-ampere power supply, for example, requires a .06-ohm resistor. Such resistors can be made either by paralleling higher fractional value resistors (e.g. five 0.33 ohm), or, from custom-winding resistive wire over a form such as a high-valued 1 or 2 watt resistor.

Over Voltage Protection

There is always a differential between input and output voltage on a regulated power supply. Typically, there will be at least 2-volts differential, and possibly as much as 35 volts. If something happens to cause the input voltage to appear on the output, then it is likely that circuitry served by the power supply will be damaged. Standard TTL digital circuits, for example, operate from +5 VDC regulated supplies that, in turn, operate from +8 VDC unregulated supplies. If either the series-pass transistor shorts, or, the Zener diode opens, then +8 VDC will appear at the regulator output; that potential will burn out TTL chips. Obviously, single-point failure in the power supply can wipe out massive amounts of digital logical!

The solution to that problem is the so-called *SCR crowbar* overvoltage protection circuit, an example of which is shown in Fig. 15. An SCR crowbar is a hard-fisted, brute-force method of dealing with the problem. When the circuit senses an overvoltage condition it shorts the output of power supply, blowing the fuse in the process.

An SCR (silicon controlled rectifier) exhibits a high impedance between the cathode and anode terminals until a

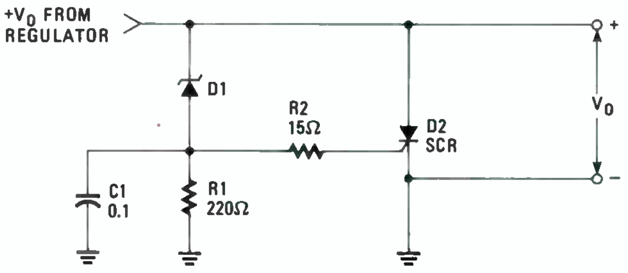


FIG. 15—FORCED SHUTDOWN! That's what happens when the overvoltage occurs. The SCR fires, and the circuit's fuse blows!

current is injected into the gate terminal. When that happens, the SCR becomes like any other PN junction diode. Only a brief pulse is required on the gate terminal to make the SCR turn on and stay on. The SCR will remain on until the cathode-anode current drops below a *hold* value.

In Fig. 15, the SCR is D2, and it is connected directly across the power supply V_O output. The SCR will remain dormant until Zener diode D1 breaks over and causes a gate current to develop in R2. The Zener voltage of D1 is selected to be higher than V_O, but less than the V_I applied to the regulator input. For a +5 VDC power supply, either 6.2 volts or 6.8 volts is typically chosen for V_Z of D1.

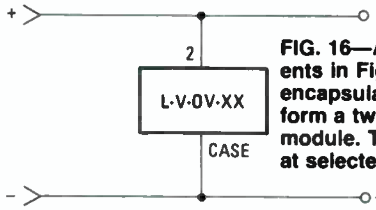


FIG. 16—ALL of the components in Fig. 15 are effectively encapsulated in one module to form a two-terminal over-voltage module. These modules are available at selected voltage levels.

Lambda Electronics, Inc. makes a line of overvoltage-protection modules that are essentially SCR crowbar circuits in two-terminal packages (Fig. 16). Those OV modules are packaged in TO-66 and TO-3 transistor packages (low- to medium-current modles) and special packages (high-current models)—various models are available in popular voltages, at currents from 2 amperes to 35 amperes.

A method for making a low-current (2 ampere) Lambda OV module operate a high current is possible. The low-current OV module is used to sense the overvoltage condition and then supply gate current to the SCR. That method is very much like Fig. 15, but with an OV module replacing the Zener diode, and that circuit could be used with SCR's in the 50 to 100 ampere range.

Heat

The single, largest cause of failure in electronic equipment is *heat*. Studies of failure records on electronic equipment indicate a seemingly inordinate number of failures among power transistors, voltage regulators, rectifiers and power amplifiers, and integrated circuits.

When the microcomputer rage hit several years ago, I built a Digital Group Z80-based machine that required a central regulated +5 VDC, 10-ampere power supply. I used a Motorla MC-1569R and HEP-57000 transistor in the power supply. Even on a finned heatsink, that series-pass transistor grew too hot to touch after a few seconds of operation. That condition is a recipe for a premature failure that could have disastrous effect!

The solution to the heat problem was a 40 cubic-feet-per-minute (cfm) muffin fan mounted so that it blew air over the heatsink. After the fan was added, the series-pass regulator cooled off to the point where you could hold a finger on it.

When my homebrew microcomputer was finally mounted inside a Vector Electronics Cabinet (modified by me from S-100 to DG configuration), I used two fans. The small 40 cfm fan blew across the power-supply components, while a 110 cfm fan ventilated the circuit cards. Added one-inch holes were drilled along the top edge of the cabinet sides to allow air to escape—and carry off heat.

No power-supply voltage regulator should be operated without a heatsink. If you use an H-package (TO-5) device, then use a *hat* type transistor heatsink. Where TO-66, TO-220 or TO-3 packages are used, mount them on a finned heatsink if at all possible. For regulators pulling more than 5 amperes, blow air across the heatsink (even where the regulator is rated for use without forced air!). Taking a few precautions about heat buildup will more than repay you in added reliability.

High-Voltage Power Supplies

In this current age of solid-state integrated-circuit chips and modules, it is difficult to find theory discussions on power supplies and regulated supplies rated above 30 volts DC. Those supplies we tag as *high-voltage* with the understanding that the range is anywhere from 30-volts to many kilovolts. While the techniques used at the extreme ends of that voltage span are a bit different, it is reasonable to lump them together in the same category.

At its lower end, the high-voltage range can be further subdivided into "under 100-volts" and "over 100-volts." In the under 100-volts range we can use techniques identical to the low-voltage supplies discussed in earlier parts of this series. All we need to do is substitute transformers, rectifiers, and filter capacitors of suitable ratings. For regulated supplies, we need to obtain series-pass power transistors with adequate collector power dissipation at the collector-emitter potentials (V_{CE}) expected. Zener diodes of correct rating need to be obtained either singly (ratings to over 200-volts DC are available), or, by series-connecting lower-voltage Zener diodes.

FIG. 17—ZENER DIODES can be stacked to effect higher Zener voltages; but power ratings must be considered.

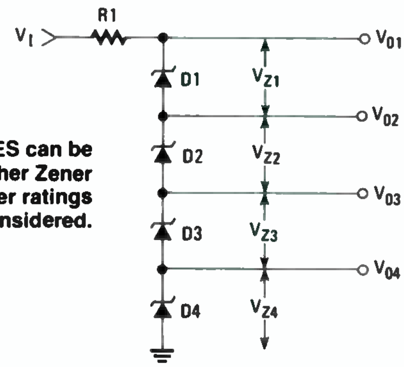


Figure 1 shows a stack of four Zener diodes connected in series to provide a high voltage V_{OI}. The total voltage from that stack will be:

$$V_{OI} = Z_{Z1} + V_{Z2} + V_{Z3} + V_{Z4}.$$

An added benefit of that circuit is that we can tap off at any of the diodes to also produce certain lower voltages. That latter tactic, however, should be limited to cases where the lower voltages only lightly load the supply.

The diodes used in Fig. 17 will have to be selected with a power rating that takes into account each V_Z rating. If Zener diodes with vastly different V_Z ratings are used for D1 through D4, then it is possible that the power rating for one or more diodes will be exceeded, even though some will operate within rating. Some people prefer using diodes with equal (or nearly equal) V_Z ratings and the same wattage rating.

Transformerless Power Supplies

Many consumer products use transformerless power supplies in order to reduce cost (transformers are relatively

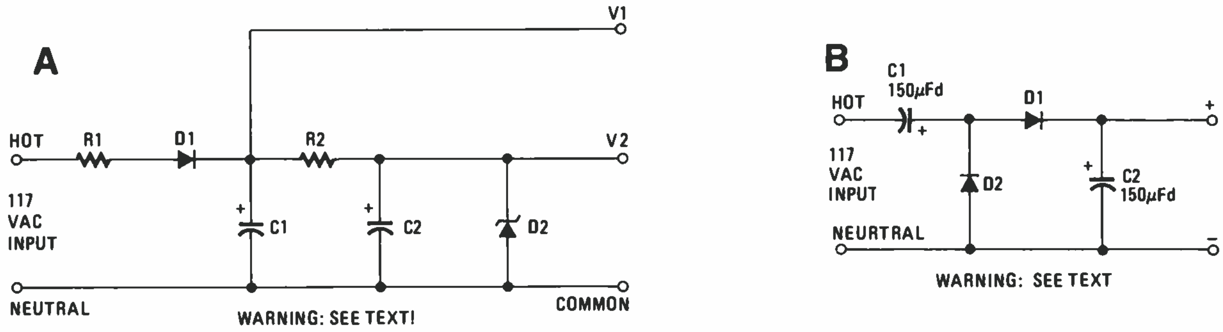


FIG. 18—TRANSFORMERLESS POWER SUPPLIES are quite common. In A, this halfwave rectifier circuit is common to the vacuum-tube radios for several decades. In B, the voltage doubler uses two identical capacitors to provide twice the voltage normally pssible in A.

expensive). Figure 18 shows two different versions of transformerless supplies.

The version of the transformerless power supply shown in Fig. 18A is a simple halfwave rectifier supply that is operated directly from the 117-volts AC power line. The rectifier is in series with the hot side of the AC line, while the common is the neutral side. The high-output voltage, V_1, will be approximately equal to the peak AC voltage. Since the AC *rms* voltage may vary between 105 and 125 volts, V_1 may vary from 148 to 178 volts DC. A lower voltage, V_2, may be provided by a series-dropping resistor (R2) and, in that case, a Zener diode (D2). Resistor R1 is not always used, and serves both as a current-limiter, and fuse to protect the rectifier (D1).

Figure 18B shows a voltage-doubler power supply; also half-wave rectified. The output of that supply will be slightly less than twice the output voltage of Fig. 18A. It is advisable to have C1 and C2 of equal value and rating.

Warning

Transformerless power supplies contain an inherent danger that is potentially lethal! If used incorrectly, or carelessly, those supplies can kill you. If, for any reason, the hot and neutral become reversed (and it does happen), then the power supply will continue to work but the common will be the lethal hot side of the AC power line. Touching the normally cold common line (negative side in Figs. 18A and 18B) is extremely dangerous in that case. If such a supply is used so that common is chassis, then the entire chassis must be insulated from the outside of the cabinet. That is the way TV and radio sets are designed. In that situation, beware of *sneak circuits* that lend to the lethal chassis via mounting screws, knobs with metallic paint, signal commons, or antenna return paths. Transformerless power supplies should always be operated using a polarized AC line cord; that is, one that fits into the AC outlet only one way. Whenever possible, transformerless power supplies, commonly called AC/DC supplies, **are not recommended** for project construction.

High-Voltage, High-Power

The classic high-voltage power supply for 500-watt (and over) audio and RF vacuum-tube applications provides from +800-volts DC to +5000-volts DC at currents up to 1 ampere. A typical high-voltage power supply for a linear RF 1-kW amplifier might be 2700-volts DC at 500 mA.

The transformer used in the high-power, high-voltage supply will often have two primary windings (see Fig. 19A). That arrangement allows you to use either 117-volts AC or 220-volts AC. Most users prefer 220-volts AC for high-power applications because of the lower current requirements. A 2-kW PEP SSB linear amplifier might draw 10 amperes on 220-volts AC, and 20 amperes on 117-volts AC. The connections for 220-volts AC and 117-volts AC are shown in Figs. 19B and 19C, respectively.

Most designers do not even try finding multi-kilovolt diodes for use as rectifiers in high-voltage high-power supplies. A usual trick is to connect several diodes in series to form each rectifier (see Fig. 20). Recall that the rectifier I_V rating must be 2.82 times the applied *rms* AC voltage. If our transformer delivers 2000-volts AC *rms* (a common value), then the IV rating of the rectifiers must be (2000-volts AC) x (2.82), or 5640 volts. A reasonable margin for error would be realized by making the actual PIV rating 6 kV or 7 kV. A 7-kV rectifier is realized by connecting seven 1000-volt PIV

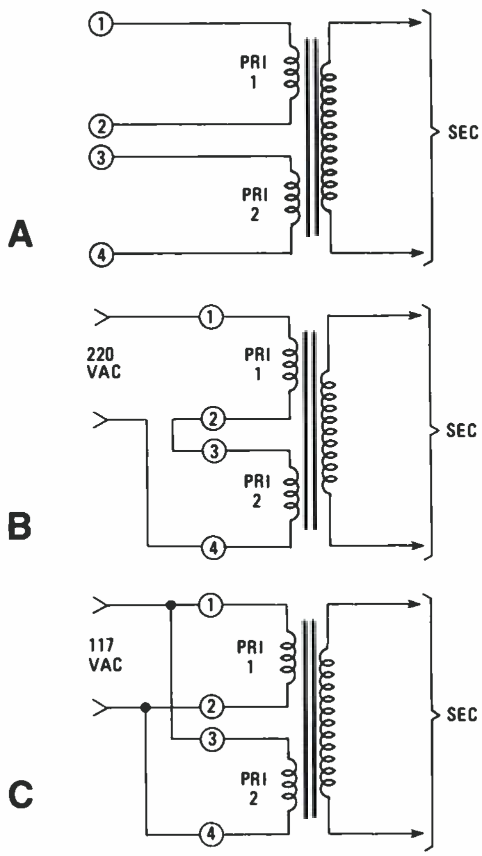


FIG. 19—TWO PRIMARY WINDINGS in a power transformer offer the opportunity to double the voltage of the secondary.

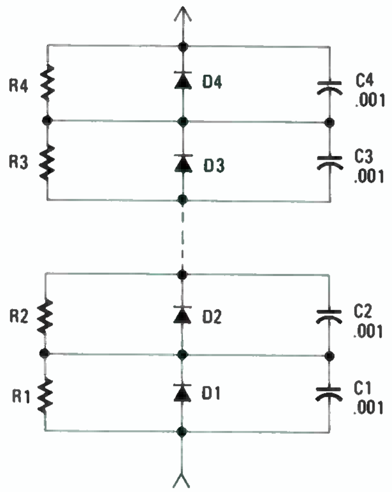


FIG. 20—HINTS on how to overcome the problems of connecting many diodes in series are revealed in the drawing.

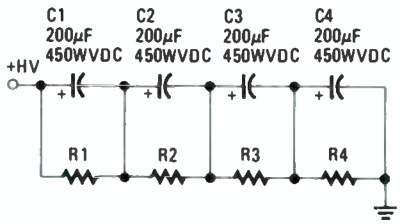


FIG. 21—A USEFUL TECHNIQUE to fabricate an inexpensive high-voltage filter capacitor of common workbench service parts. In practice, all parts should be of equal values and ratings.

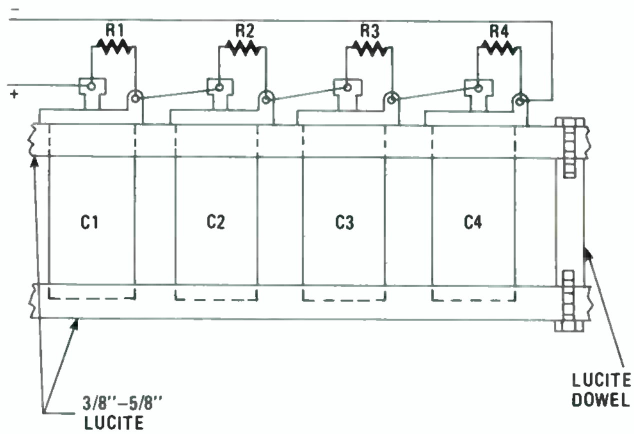


FIG. 22—THIS IS HOW the diagram in Fig. 21 is fabricated for project use—remember, you are dealing with high-voltages!

diodes in series per Fig. 20. The total PIV rating is the sum of the individual PIV ratings.

A problem with connecting diodes in series is that, unless the diodes are truly identical (not just the same type number), there will be a difference in voltage drops among the diodes. That difference could prove disastrous. The solution is to connect equalization resistors in parallel with the diodes (R1-R4 in Fig. 20). Those resistors are usually rated at 1-watt, and have a value of 50 to 100 ohms per volt PIV. Thus, for 1000 volt PIV diodes, the value of the resistors will be 500,000 to 1 Megohm, at 1 watt. It is important that the values of those resistors be equal to each other, otherwise the purpose of an equalization resistor will be lost. Should one resistor discolor quickly during the first few minutes of operation of the power supply, the chances are that the resistor, or the diode it shunts, is out of specification.

The capacitors are used to protect the diode rectifiers against high-voltage transients arriving on the AC power lines. For most applications, each capacitor will have a value of 0.001 µF, and they will be a disc ceramic type. The voltage rating of the capacitor is at least the PIV rating of the diodes, and preferably higher. It would not be inappropriate to use 3-kV disc capacitors with 1-kV PIV, rectifier diodes.

The diodes and other components of the rectifier of Fig. 20 must be mounted so that the high voltage is well insulated from chassis or common. The usual procedure is to construct the rectifier on a wiring board of bakelite, phenolic, or fiberglass. That board is then mounted on ceramic or lucite stand-off insulators that are 2-3 inches thick.

Connections made in high-voltage power supplies must be rounded and smooth. No sharp points can be allowed to stick out of the solder joints, nor can sharp points be allowed elsewhere. High voltage into sharp points produces high-voltage corona discharge—a phenomenon familiar to TV service technicians.

The filter section of a high-voltage power supply can be any of several types, but we will consider only the *brute-force* filter. Such a filter, which we have used before, consists of a single capacitor across the output of the rectifer.

There are at least two options for filter capacitors in high-voltage power supplies. We can, for example, use a high-voltage capacitor with a capacitance demanded by the desired ripple factor. Such capacitors are oil-filled, and very expensive—also sometimes difficult to obtain. The other alternative is to use several lower-voltage capacitors (the type used by servicemen since they are easy to find) in series (Fig. 21).

Each capacitor in the series stack of Fig. 21 is a 450-WVDC (working-Volts DC) electrolytic capacitor. Although not required, it is highly advisable to make all of the capacitors in the stack equal in both capacitance and WVDC rating.

The resistors in parallel with the capacitors are used to equalize the voltage drop across the capacitors. In most cases, the resistors will have a value of 50,000 to 150,000 ohms. The wattage rating should be:

(WVDC)2/R.

For 150,000-ohm resistors and a WVDC of 450 volts, 2-watt rated resistors are sufficient; for 50,000-ohm resistor, a 7.5-watt rating should be used.

The electrolytic capacitors used in Fig. 21 are constructed in metal cans. The outer metal case of each can is the negative electrode of the capacitor. The insulated connector on the capacitor is the positive terminal. Normally, the metal can is grounded and poses no danger. But in that arrangement, the cases of all but one of the capacitors are above ground and could be lethal if touched. Because the cases are electrically hot, special care must be taken in the assembly of the filter stack. Figure 22 shows a typical set-up.

Two sheets of 3/8- to 5/8-inch Lucite are used to hold the filter capacitors. Holes are drilled in the top sheet large enough to admit the body of the capacitors, but not the mounting collar. The bottom sheet is inset with shallow holes just deep enough to allow the bottom of the filter cans to seat firmly. Of course, the holes in both top and bottom must line up with each other. The sheets are held apart by Lucite dowels at the four corners of the sheets. Note: the thickness of the lower Lucite sheet must be great enough to withstand the high voltage. That thickness is measured from the bottom of the sheet to the bottom of the hole inlet for the capacitors.

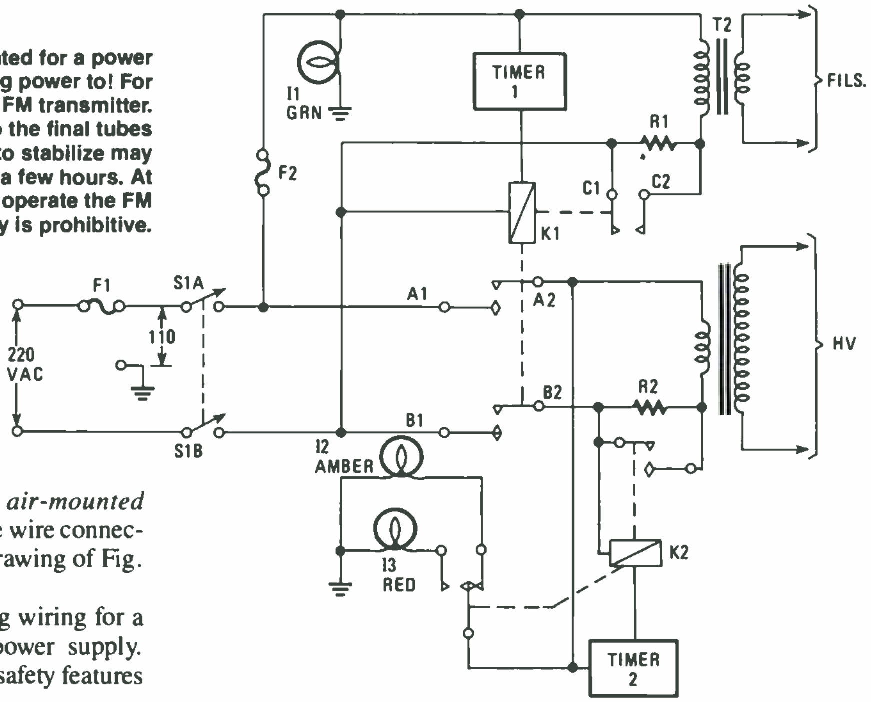


FIG.23—THIS MAY LOOK overly complicated for a power supply, but consider the circuit it is supplying power to! For example, the supply may be feeding a 5000-watt FM transmitter. The sudden application of high-voltage to the final tubes before the oscillator has an opportunity to stabilize may reduce the life of the final amplifiers to a few hours. At $130 per tube, 4-tubes total, the cost to operate the FM transmitter without this power supply is prohibitive.

The voltage-equalization resistors can be *air-mounted* from the tabs on the electrolytic capacitors. The wire connections between capacitors are as shown in the drawing of Fig. 22.

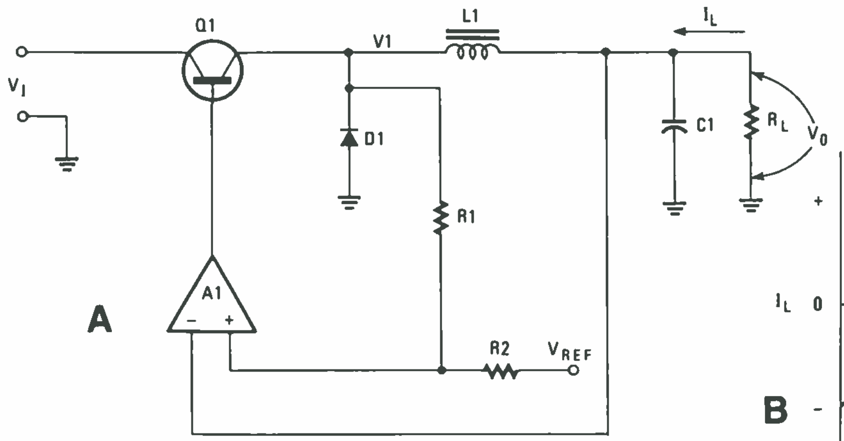
Figure 23 shows the typical primary winding wiring for a high-voltage, high-power AC-operated DC power supply. Besides the two transformers, there are several safety features to that circuit.

Two transformers are used if the power supply is used for RF linear-amplifier service. Such amplifiers most often are vacuum tubes which require a low-voltage, high-current filament supply (T2).

Vacuum tubes must be brought to operating temperature before high voltage is applied. That requirement means that the filament must be turned on before you turn on the high-voltage DC supply. That job is accomplished by the switching arrangement of Fig. 23. Switch S1 is the main power-on switch, and will turn on the filament transformer. That switch must be a heavy type that can pass the primary currents of the two transformers. The main current will be that of the high-voltage transformer. That current can be 20-amperes on a kilowatt linear operated from 117-volts AC.

The primary winding of high-voltage transformer T1 is controlled by the A1/A2 and B1/B2 contacts of relay K1. Those contacts close (A1-A2 and B1-B2) when the coil of K1 is energized. The coil is energized when Timer-1 *times out.* The duration of the timer is set to a value that will permit the tubes to heat up. In some cases, the timer will be electronic, but most are electro-mechanical.

The cold filaments of a high-power vacuum tube draw a tremendous amount of current. As the filament heats up, however, the current drops to the operating level. That *in-rush* current can reduce the life of a vacuum tube. In order to reduce that in-rush current, a resistor is placed in series with the filament transformer primary winding. That resistor generally has a value that will reduce the current to about one-half its normal value. When Timer-1 *times out,* contacts C1-C2 of K1 close and short out the resistor. With R1 shorted, the primary of T2 receives its full voltage.



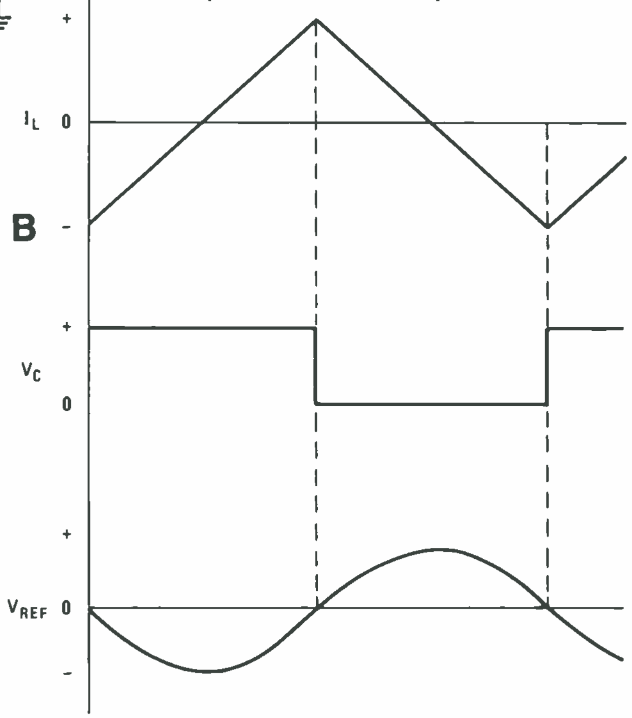


FIG. 24—TRANSISTOR Q1 is not operating as a series-pass transistor. It is functioning as an electronic switch, alternately opening and closing—depending upon the control and reference voltages fed to amplifier A1. Text describes circuit and relationship of curves to circuit operation.

A similar problem exists on the high-voltage side of the power supply. The charging current of the filter capacitors at turn-on is very high. That current can damage the rectifier diodes. Resistor R2 performs the same current-limiting function as R1. Another timer, Timer 2, is used to energize relay K2 at a time that will permit the filter capacitors time to charge enough to reduce the current flow. Generally, the duration of Timer-2 is much shorter than that of Timer-1.

The lamps are an optional –nice touch. Lamp T1 is green, and comes on as soon as S1 is closed; I2 is amber and comes on when Timer-1 is energized; lamp I3 is red and comes on when the high-voltage finally comes on.

The power supply in Fig. 23 must use two fuses. That scheme is necessary, because of the vastly different power levels of the two transformers. If we have just one fuse, it would have to pass a high enough current to power the high-voltage side. Should a catastrophe occur on the filament side of the supply, it might be severe enough to burn out T2. By placing two fuses in the circuit, however, we overcome that problem and fully protect the circuit.

Cutting Down the Heat

All of the voltage regulators presented thus far suffer from a major defect. The active element, the series-pass transistor, dissipates substantial amounts of power. All of those previous circuits required an input-output differential ($V_I - V_O$) across a resistive element that is a source of wasted power. The power dissipated by the series-pass transistor is given by the expression:

$$P = I_O(V_I - V_O),$$

where P is the power dissipated in watts, I_O is the output current in amperes V_I is the input voltage in volts, and V_O is the output voltage in volts.

If the input-output voltage differential ($V_I - V_O$) is large, then the power dissipation is large. At a current of 1 ampere, the standard +5-volt regulator will dissipate only 3 watts at the minimum value of ($V_I - V_O$). But those voltage regulators can work at potentials (V_I) up to +40 volts, at which the power dissipation would be (40 volts −5 volts) time 1 ampere, or 35 watts.

Along with the wasted power comes heat, and heat is the great *killer* of electronics equipment. All of that power which is dissipated becomes heat, so we may conclude that the voltage regulator contributes substantially to the heat build-up in equipment. A solution to that problem is the switching voltage regulator.

Figure 24A shows a simple block diagram of a switching regulator, while Fig. 24B shows the waveforms. Transistor Q1 is not a series-pass transistor, as in ordinary voltage regulators, but rather is an electronic switch. When the base of Q1 is made positive, the collector-emitter resistance drops to a very low value. The voltage drop across Q1 under that circumstance is also low, $V_{CE(SAT)}$. When the base of Q1 is zero, or negative, it is cut off so the collector-emitter resistance is very high.

Amplifier A1 in Fig. 24A is used as a voltage comparator. There are two inputs to the comparator. If the voltages applied to those inputs are equal, then the output voltage is zero. If the voltage to the negative (−) input is larger than the voltage at the positive (+) input, then the output will be negative. But if the negative (−) input is at a lower voltage then the positive (+) input, then the output is high positive. The

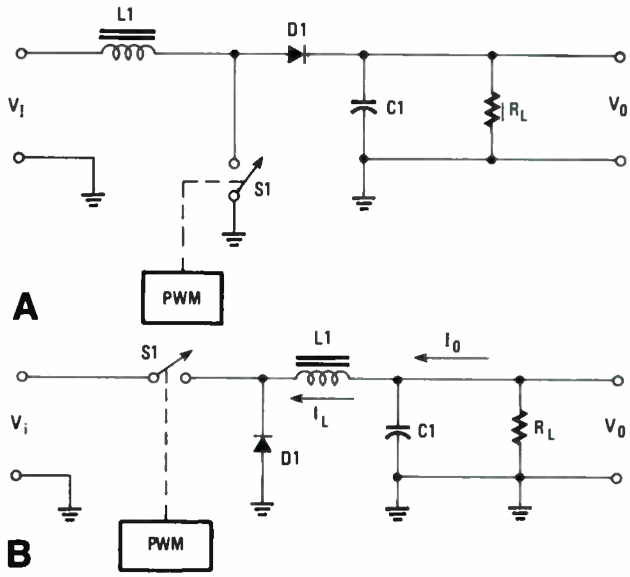


FIG. 25—THE TWO SWITCHING power supplies shown here provide for a step-up voltage (A) and step-down voltage (B). Switch S1 is actually transistor Q1 shown in Fig. 24A.

output of the voltage comparator, A1, drives the base of switching transistor Q1.

When the base of Q1 is *high*, current I_L will flow in inductor L1 and also in load resistor R_L. The voltage appearing across the differential inputs of the comparator A1 is the voltage across inductor L1, which is given by the equation

$$V = L1 \times \Delta I_L/\Delta t$$

That circuit will oscillate at a frequency between 2 and 20 kHz, which is given by

$$F = [V_O(V_I - V_O)] \div [(L1)(V1)(I_{MAX} - I_{MIN})$$

There are two basic configurations for the switching power supply (See Fig. 25:), step-up (Fig. 25A) and step-down (Fig. 25B). The step-up version provides an output voltage that is greater than the input voltage, while the step-down version produces an output voltage that is lower than the input voltage. The main differences between those two configurations is the relative positions of the inductor (L1) and switch S1 (which corresponds to transistor Q1 in Fig. 24A). In the step-up version, the inductor is between V_I and the switch. The switch is connected in shunt across the line so that, when S1 closes, the inductor is across the V_I power supply. The counter-electromotive force (CEMF) generated by collapse of the magnetic field around L1 produces the increased voltage that sums with V_I.

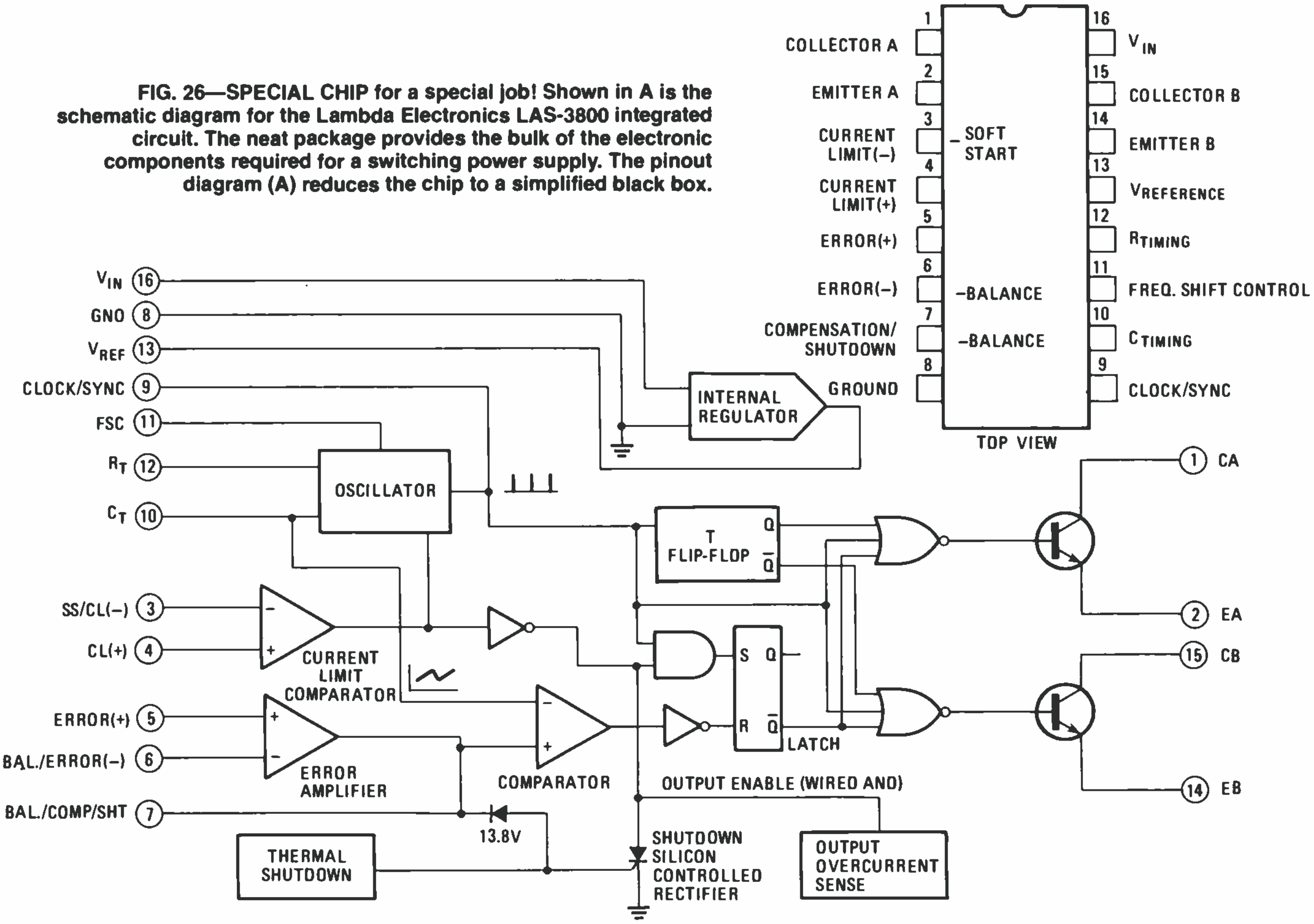
The step-down version is shown in Fig. 25B. In that circuit, the switch is between V_I and the inductor, and is in series with the line rather than shunted across it.

Both versions of the circuit shown in Fig. 25 use a pulse-width modulator (PWM) to drive the switch. The PWM produces a variable-width drive pulse whose duration is determined by the discrepancy between the desired output voltage and the actual output voltage.

IC Switching Regulators

Several semiconductor manufacturers now make integrated circuits perform most (or all) of the functions of a

FIG. 26—SPECIAL CHIP for a special job! Shown in A is the schematic diagram for the Lambda Electronics LAS-3800 integrated circuit. The neat package provides the bulk of the electronic components required for a switching power supply. The pinout diagram (A) reduces the chip to a simplified black box.



switching regulator. Figure 26A shows the block diagram of the Lambda Electronics LAS-3800 device; Fig. 26B shows the package pin-outs.

The 16-pin DIP integrated-circuit package contains a temperature-compensated reference voltage source, a sawtooth oscillator (with overcurrent frequency shift), pulse-width modulator, error amplifier, current limit comparator and a pair of 500-mA, NPN output transistors (with overcurrent protection). The LAS-3800 is designed as a fixed-frequency regulator for both power supply and DC motor-control applications. The LAS-3800 will operate over an input voltage (VI) range of 12 to 40 volts, with a fixed frequency up to 500 kHz. The timing resistor connected between pin 12 and ground must have a minimum value of 5000 ohms. Figures 27A and 27B show step-up and step-down voltage-regulator circuits using the Lambda LAS-3800 IC switching regulator.

The step-up version (Fig. 27A) oscillates at a frequency of approximately 58 kHz, and provides an output of 48-volts DC at a current of 0.25 ampere. The unregulated input voltage is 12-volts DC. Line regulation is 10-millivolts for input shifts over the range 10-14 volts; load regulation is 13 millivolts. Note that the E_A and E_B outputs are tied together on the LAS-3800. Those outputs combine to drive the switching transistor, Q1.

The step-down version is shown in Fig. 27B. That power supply will produce a regulated output voltage that is lower than the line voltage. That is the generic type of power supply used in many microcomputers. Notice that the configuration is similar to that shown earlier for that class of switching voltage regulator. In that case, the LAS-3800 internal transistors are used as the electronic switches. The E_A and E_B outputs are tied together to increase the current capability of the chip. Diodes D1 and D2 are used to isolate the chip's outputs from each other.

The circuit of Fig. 27B oscillates at 90 kHz, and will produce +5-volts DC output from a 12- to 24-volts DC input. The full output load current is 500 mA, so the power available is 2.5 watts. Regulation levels are similar to Fig. 27A.

The step-down version contains a component not used in the step-up version. The device marked L2-OV6 is an IC over-voltage protection module. The L2-OV6 is a 2-ampere, 6-volt SCR crowbar. If the switching regulator fails, and permits V_I to get onto the V_O line, the L2-OV6 breaks down and shorts the output line. In both cases, the actual output voltage can be adjusted by a sample of the output voltage selected by a potentiometer across the output line.

Inverter Circuits

An inverter is a special kind of switching power supply that produces an AC output. The actual output is more like a squarewave than a sinewave, but it can be used to power lights and other devices which represent non-reactive loads (i.e. small inductance or capacitance). The inverter also forms the basis for DC-to-DC converter circuits. Such circuits are sometimes used to provide DC voltages of a different level than the power-supply voltage, while in other cases their function is to provide isolation between the two DC power supplies. That latter application is used in medical instruments for patient safety reasons.

The Lambda LAS-3800 can be used in an inverter circuit such as Fig. 28. That circuit is similar to the old *vibrator power supply* used in pre-transistor auto radios. The inset in

Fig. 28 shows how both circuits work. The switch, whether vibrator or solid-state, is essentially an SPDT switch (S1). Power is applied to the center-tap of the primary winding on transformer T1. The switching action causes the current to flow in first one half the primary winding then the other. The switch will ground first side A and then side B of the transformer. The result is a constantly charging near-squarewave applied to the transformer.

In the solid-state version of Fig. 28, transistors Q1 and Q2 form the switch. In analogy with the mechanical switch, we find the common emitters form the single-pole switch sections, while the two collectors are the *throw* terminals. Like the vibrator version, the action of the transistor *switch* is to ground first side A then side B of transformer T1. As in the previous case, the DC input power is applied to the primary-winding center-tap. LAS-3800 outputs E_A and E_B are used to drive transistors Q1 and Q2 out of phase with each other. The current-sense resistor, R_S, is connected to the current-limit and frequency-shift inputs of the LAS-3800.

The transistors are power types. They should have a high enough collector power dissipation, and voltage and current ratings high enough to carry the load. The current and power dissipation ratings are easy enough to see, but the voltage rating may be a problem. The switches essentially place a squarewave across the primary of the transformer, which is an inductive load. Since the transformer current has a high rate of change, and the load is inductive, the voltage spike will be high. The CEMF produced will be:

$$V = L(\Delta I/\Delta t).$$

(Continued on page 95)

A

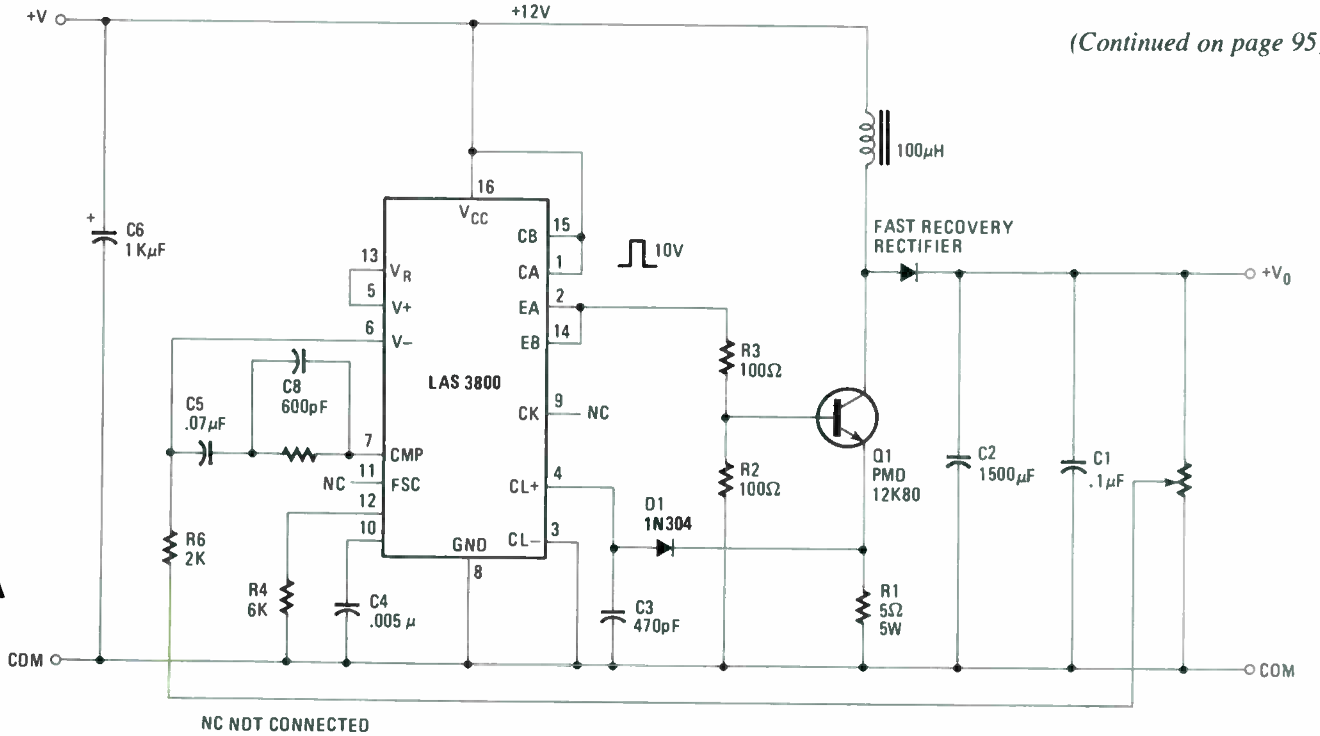
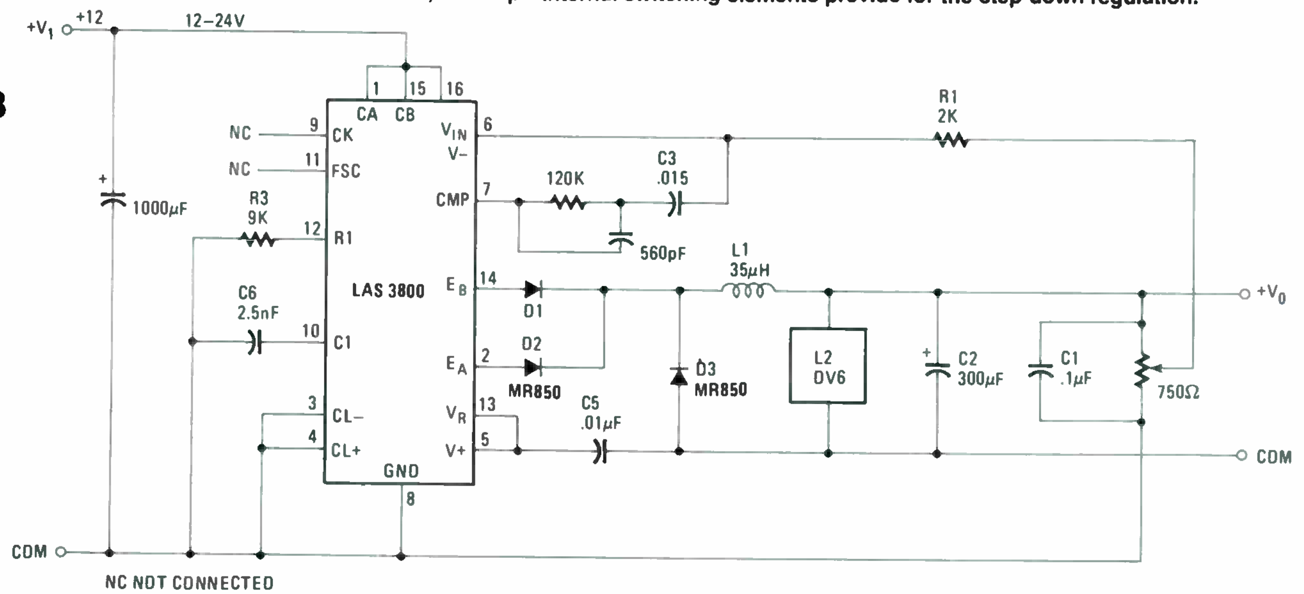


FIG. 27—EITHER STEP-UP OR STEP-DOWN voltages are possible from the Lambda LAS3800 integrated circuit. In A above, a step-up circuit alternately switches coil L1 from a short-circuit to ground via R1 to the rectifier/filter network. In B below, the chip's internal switching elements provide for the step-down regulation.

B



DUAL PEAK/CURRENT ANEMOMETER

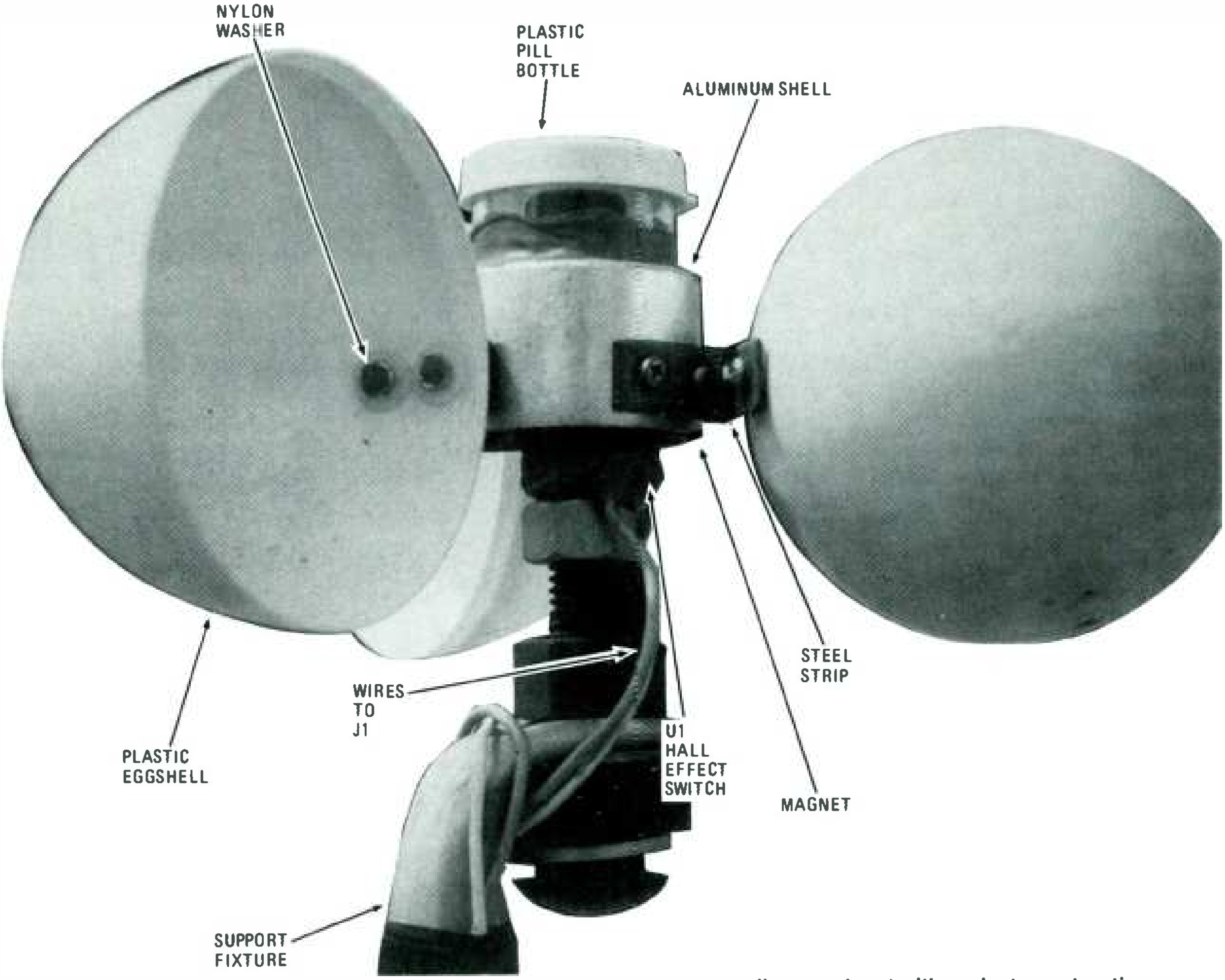
(Continued from page 44)

without relabeling the face. Low-power CMOS chips can be substituted for some of the chips directly, but extensive redesign must be done to replace the 8-bit shift register with two 4-bit CMOS chips. LCD displays can also be substituted for lower-power consumption and portable battery operation. Three or more of each of the decade counters, comparators, registers, and displays can be wired together to increase the dynamic range of the digital peak detector, although the analog portion will not be improved. Similarly, range switches may be incorporated, if the timing components of the input U2 are also adjusted accordingly. The update time of the digital display is set at about 2/3 second with the present component selection and that matches the response time of the anemometer head, but the different applications may require slight redesign.

Conclusion

The combination of both analog and peak reading digital readouts on the Dual Peak/Current Anemometer make it a most interesting and convenient instrument to use. It doesn't have to be watched continuously, nor is an expensive chart recorder necessary. Power consumption is less than an incandescent night light, so no on-off switch is even included, and it is on for 24 hours every day.

Once the anemometer is mounted, however, be prepared for friends to call up and ask, "Wow, the wind really blew hard tonight! What did your anemometer record?" But, if they are really friends, they will wait until the next morning to call you up! ■



THE ANEMOMETER REMOTE SENSOR requires parts that are not usually associated with project construction; nevertheless, acquisition of those materials should not be difficult. The most important aspects of the sensor's construction is balance and symmetry—both of which go hand in hand.

HI-FI SOUNDS, BUT LO-FI EARS

(Contnued from page 32)

Hearing Problems

But—and it is a very significant but—the foregoing figures and remarks apply to people with what has been described as *clinically normal* hearing. While that term has to be very broad in its interpretation, there can be little doubt that a significant number of people suffer from clinically sub-normal hearing.

In some cases, the problem is congenital, in others traceable to trauma of one kind and another. Such problems should logically be referred to a specialist for whatever treatment may be available.

Of more concern, in the context of the present article, is the kind of hearing loss brought about by avoidable situations, of which by far the most important is exposure to prolonged and excessive sound-pressure levels.

The Noise Hazard

The accompanying noise-level figures in Table 2 may prompt the question, "What happened to the automatic-volume-control function," mentioned earlier, and reputed to protect our hearing against exposure to loud noise? The explanation, it would appear, is that the spontaneous tensioning mechanism in the ear can cope with sound-level variations within the *safe* range and perhaps somewhat beyond it; and it can cope with very loud sounds, provided they are infrequent and of short duration. However, when faced with very loud, *sustained* sound, the muscles gradually let go, allowing the high-level impulses to reach the *cochlea*. It is then that the damage occurs, with the hair-like nerve ends for the higher frequencies being particularly vulnerable. Once destroyed, they can never regenerate.

In practical terms, males were at one time more at risk than females, because of their likely exposure to factory noise for much of their adult lives and their possible involvement in noisy activities at other times.

Nowadays, we seem to have learned some lessons in those areas, with noise-abatement programs operating in factories and the more frequent wearing of earmuffs where high noise-level cannot be avoided.

The trouble is that modern technology has now put powerful amplifier systems into everything from rock-music reviews to theaters, cars, and homes. And, with them has come the cult belief that, for sound to turn you on, it has to be at deafening level. How else can it shut out every other stimulus? What's more, if you don't like it that way you must be a bit odd—or old!

As if that's not enough, modern technology has provided us with personal cassette/radio players, and with miniature hi-fi stereo headphones which, if driven hard enough, can deliver sound-pressure levels of 120 dB or more—and that is also in the injurious range (see Table 2).

So, if you really want to add further "decibels down" to the inevitable effects of aging, it is not necessary to take up the trade of a boilermaker or a riveter. Anyone can achieve the same result by spending a few hours a week at a disco, or playing super-loud music at home, or cultivating high-frequency deafness in comparitive isolation with the aid of a powerful headphone stereo system.

What's more, the new deafen-yourself-with-music syndrome is appropriately non-sexist; male and female have equal access to the method. In fact, they often tend to do it in mixed pairs!

Is that all? No, not quite!

According to our medical source, another effective way of turning down your biological tone control is to swim frequently and dive deeply in polluted water. Entering the body through the mouth and nose, bacteria from polluted water can travel up the *eustachian tube* and set up infection in the middle ear. Too many episodes like that can take their own special toll.

And that brings us right back to where we started!

If the blush of youth in your cheeks has given way to the mantle of maturity, you can still anticipate a pleasurable listening experience from quality audio systems—provided you've taken reasonable care of the two bits of audio equipment for which no replacements are available—your ears! But, if you're fortunate enough to be still young, and look forward to the day when even the compact audio disc will be primitive and obsolete, spare a thought for those tiny nerve ends in your ear which dislike loud sound so much that rather than listen, they lie down quietly and die! ■

DESIGNING POWER SUPPLIES

(Continued from page 93)

The inductor, in that case the inductance of the transformer's primary winding, need not have a large value to generate a high voltage, because the current pulse rate of change ($\Delta I/\Delta t$).

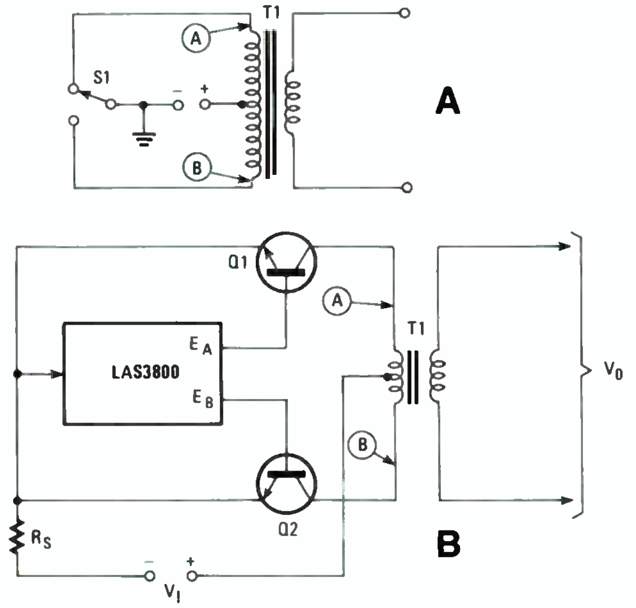


FIG. 28—OLD TIMERS will recall the circuit in A that is similar to the vibrator power supplies common to automobile radios that used vacuum tubes for many years. The LAS3800 chip B provides the same function by driving two switching transistors in an almost identical switching circuit.

Sometimes, designers place an RC *snubber* network across the primary winding from collector-to-collector (Q1 to Q2). Typically, such a *snubber* consists of a series combination of 0.001-µF capacitor (at 1000-volts or more) and 100-

ELECTRONIC COIN TOSS

(Continued from page 53)

If all components in the circuit could be exactly matched, the chances of either transistor being on at the instant S2 is released would be exactly even—a 50:50 chance. However, the adjustable trimmer potentiometer, R7, is included so that you can compensate for variances in the components' values. If you have access to a oscilloscope, check the waveform at either collector while S2 is held closed. Adjust the trimmer for equal on and off periods.

Putting It Together

The circuit layout is shown in the photo and in Fig. 2. Most of the components are on a small piece of printed-circuit board (half of a 300 PC Experimenters board from Global Specialties Corp. or Radio Shack Experimenters PC board No. 276-174). The switches and LED's are mounted on a 2 × 4½-inch piece of blank PC board. The LED anodes, and all + 9-volt DC connections, are soldered to the copper foil.

Run off 100 tosses and record the fall of the coin. The count should be no further than 52:48 from a 50:50 expectation. If the gap is larger, reset S1 slightly, and do it again. After all, give the suckers a break! ■

ohm resistor rated at 5 to 10 watts.

Switching-type voltage regulators provide a means for designing a power supply that has a very low heat-dissipation factor. Unlike some of the other voltage regulators available, the switching type has a low input-output voltage differential. An implication of low-heat production is the ability to produce a power supply with much smaller volume than similarly-rated voltage regulators that use the series-pass transistor method.

We have gone quite a distance into the theory of power supplies and regulated power supplies in these two articles. In fact, the editors believe that once you have mastered the discussions up to that point, you, the reader, are thoroughly prepared to design almost all the power supplies you'll ever need for your home-brew projects. Beyond that point in knowledge, any additional information would of necessity be specialized to a high degree such that we could not hope to cover it in these pages. The editors suggest that you reread the two articles carefully, again! There is much to learn, and even more to commit to memory. ■

MUSICAL RINGER

(Continued from page 59)

Installation is fairly easy. Simply locate the lines that normally control the bell in your phone and connect them to U2 as shown. Note that before making any connections to the telephone lines it is advisable to contact your phone company regarding their policy toward private installations. ■

PARTS LIST FOR MUSICAL RINGER

SEMICONDUCTORS
D1—1N914 diode
Q1, Q2—2N2222 NPN transistor, or equivalent
U1—AY-3-1350 melody synthesizer integrated circuit
U2—TIL111 optoisolator module
U3—7555 dual timer integrated circuit
U4—386 audio amplifier integrated circuit

RESISTORS
(All fixed resistors ½-watt, 5% units unless noted otherwise)
R1, R2—270,000-ohm
R3—2200-ohm
R4—33,000-ohm
R5—470,000-ohm
R6—12,000-ohm
R7—1-Megohm
R8—500,000-ohm, linear-taper, PC-mount potentiometer
R9—100,000-ohm, linear-taper, PC-mount potentiometer
R10—10,000-ohm, linear-taper, PC-mount potentiometer

CAPACITORS
C1, C5, C6—10-μF, 10-WVDC, electrolytic
C2—47-pF
C3—.001-μF
C4—0.22-μF

ADDITIONAL PARTS AND MATERIALS
S1–S11—SPST slide switches (quad DIP switches, such as Radio-Shack 275-1304 or equivalent are recommended)
S13—SPST momentary pushbutton switch
SPKR1—8-ohm speaker
Batteries (6-volts) or AC adaptor (see text), power supply jack, decals, hardware, aluminum case with slotted openings, rubber feet, wire, solder, perfboard, telepone cable, etc.
Note: S12 is not used but may be physically present when quad DIP switches are used.

FRIEDMAN ON COMPUTERS

(Continued from page 60)

sticking point (one of several). Some computers use a **CLS** command to clear the screen, others use ASCII code 26 [**CHR$** (26) in BASIC]. If you exchange BASIC programs that don't use the same clear-screen command the program might run, but continuously overprint the screen.

If you exchange BASIC programs, be prepared to go over the program line by line to clean up the syntax.

Because the IBM-compatible computer is so popular, some of the most recent interchange software intended to exchange disk files between the IBM-compatible and other computers automatically correct the differences in the BASIC statements. By the time you read this issue of **Hands-on Electronics**, the automatic correction might be written into all interchange software. Either way, at the very least you now know what to look for if you plan on exchanging BASIC programs.

There is one exception of note: Interchange software can't work between different microprocessors because of differences in the op-code. You can not run software written for the 8080 or Z80 on an 8088 computer, and vice versa. The fact that interchange software for your Z80 computer will *read* an IBM disk means absolutely nothing if you can't run it. The exception is software, presently being tested, that converts the op-code of CP/M-80 to IB PC-DOS.

Interchanging software between different CPU's requires a hardware modification to the computer. For example: There is the Microsoft Z80 card for the Apple computer, which permits the Apple to run CP/M-80 software from an Apple-formatted disk (you can't use the disk from any other computer).

Another kind of hardware modification is Quadram's *Quadlink* for the IBM PC—actually a plug-in adapter with 64K of RAM that emulates the Apple computer— that uses a 6502 CPU. The Quadlink not only emulates the Apple, but it uses the PC's own disk drive(s) to read/run the original Apple-formatted disks. (The Quadlink is supplied with Apple DOS 3.3 and Applesoft BASIC.) But even here there's a limitation on interchange, because the IBM drives will create and read/run only from standard Apple-format disks for the Apple, Apple I, and Apple II+ computers. The PC can neither read nor run from Apple IIe or IIc disks, because they are half-tracked (every other track). Nor can the IBM read/run disks for the Apple, Apple II, and Apple II+ computers which have been half-tracked for copy protection. (The older Apple disk systems will run the copy protection half-tracked software.) If you have Apple software you need to run on a PC, phone Quadram's technical service and ask if it will run the specific item of software.

If you need to interchange software between different computers, make certain that the software you intend to purchase really does what you think it can do. Some of the descriptions for interchange software are as slippery as Jello—you can't quite get a hand on it and pin down what it's supposed to do. —*Herb Friedman*

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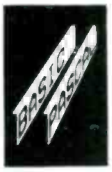

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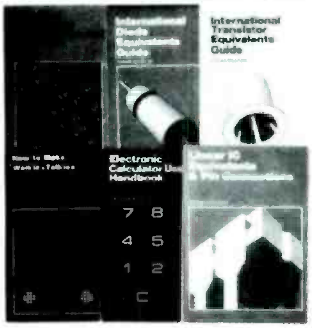

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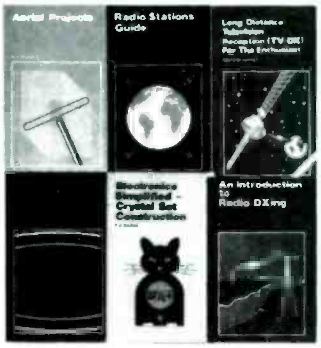

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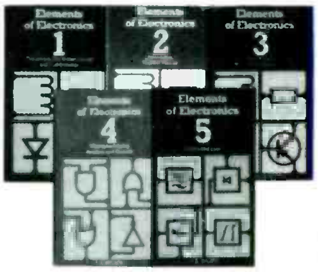

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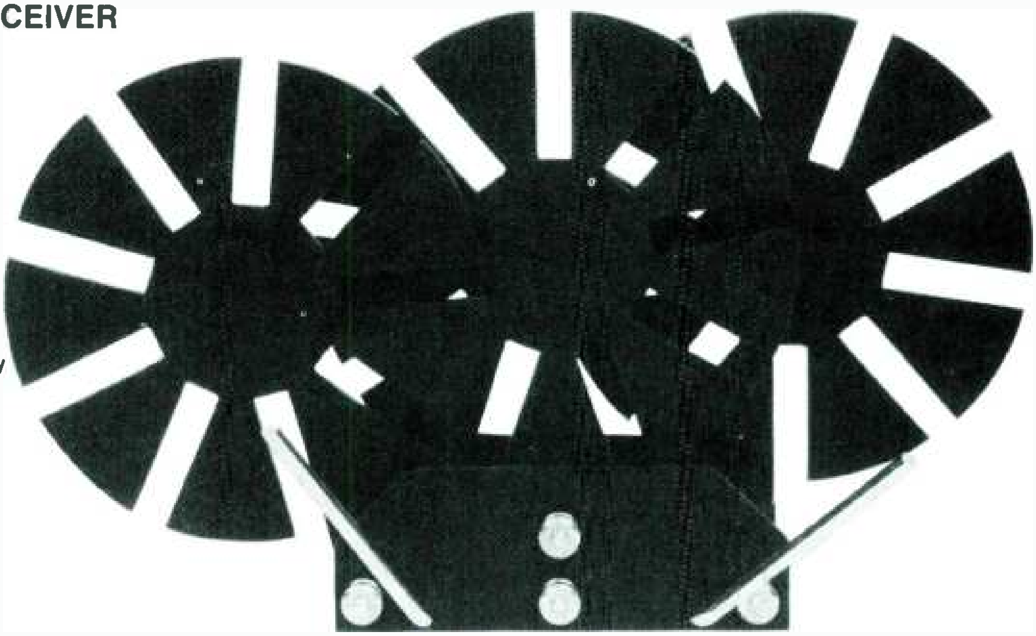
1920's WIRELESS RECEIVER

(Continued from page 26)



THE SPIDERWEB coil assembly is shown here for illustrative purposes so that you would be able to duplicate it. Actually, the coils should be wound prior to assembly. Fabricate some type of insulating knob material to fit over the levers. That would greatly reduce the effect of body capacitance while tuning.

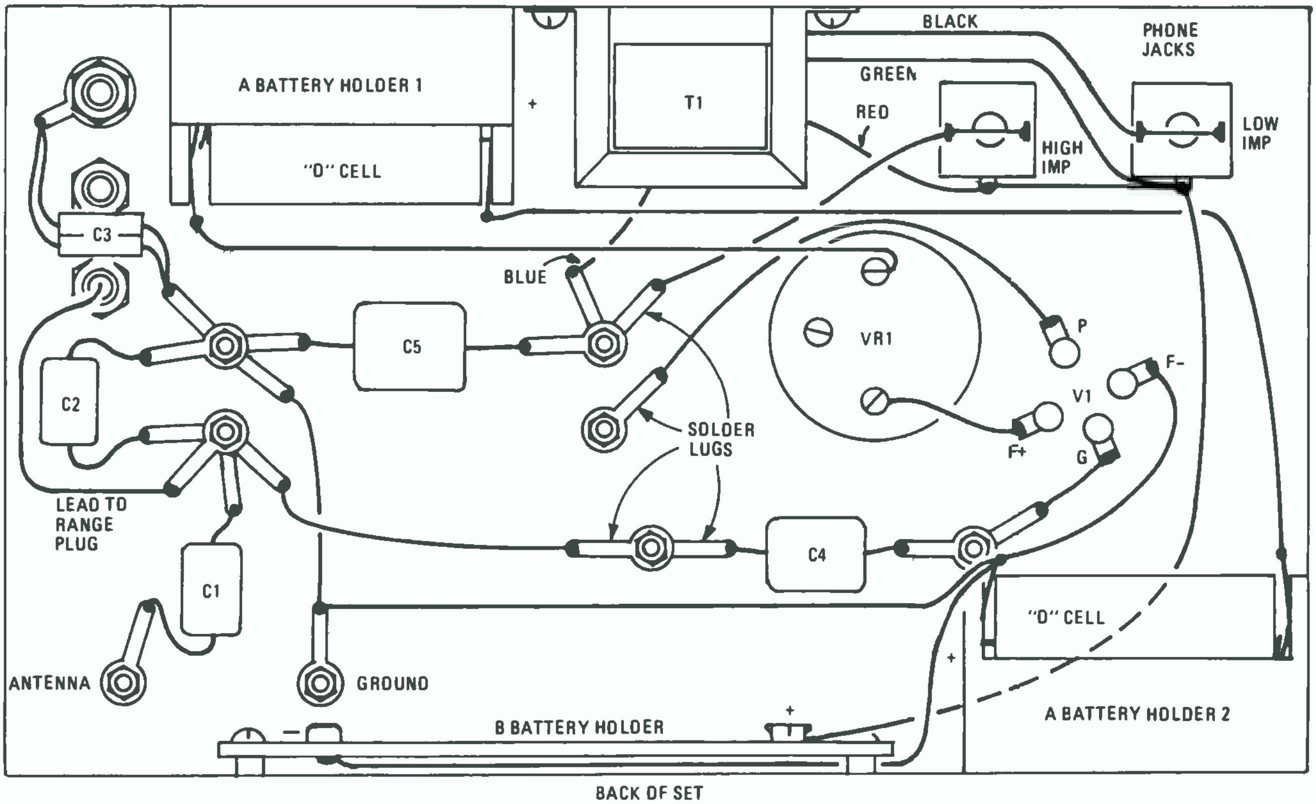
The dome nuts on the end of the lever shafts can now be tightened just enough to allow easy, smooth movement of the coil levers. In some cases it may be necessary to add one or two flat washers under the dome nuts to produce enough friction with the nuts fully tightened. The small knobs on the end of the tuning and reaction levers are pushed on with a twisting action and the tuning unit is now ready to be fitted to the panel.

Assuming the base is completely dry the three battery holders and T1 can be screwed to the inside of it before the panel is attached. Those are fitted with the brass roundhead screws, into drilled pilot holes in the wood, taking care to note the relative polarities of the battery holders and the orientation of T1 from Fig. 4.

The two D-cell holders are standard modern components and the B battery holder (supplied complete) is fabricated from a bakelite strip with five sets of battery clips rivetted to it and a clamp to hold the batteries in position.

Next fit the bakelite panel into the base with reference to Fig. 4 and fasten it with the two screws provided. The panel is pre-loaded with the tube socket pins, with VR1, and the antenna and ground terminals.

Fit the tuning reaction unit to the panel using the ⅝-in. long, round-head screws and tighten the nuts under the panel firmly using a nut driver. Fit all the solder lugs as shown in Fig. 4 using a flat washer under the nut in each case and then fit the phone jacks. The grid leak, and C4 combination is mounted using ⅝-in. long screws with the nuts on top of the panel. The grid leak is held between those nuts and two knurled nuts, as seen in the photograph.



A HEADSET, or *cans* as they were called, will dress up the Unidyne should they happen to be of ancient vintage. Connection to the cord was made to terminals on the earpieces.

Wiring

Arrange to support the set upside down and begin wiring by trimming and fitting the mica capacitors to the lugs as shown in Fig. 4. The main wiring is carried out with the black cloth or rubber covered wire supplied and a spaghetti sleeve is fitted over each lug after soldering. The wiring is fairly straightforward, and should present no problems if Fig. 4 is followed carefully.

When finished double check the wiring to avoid the possibility of 45 volts appearing on the tube filament (a lot of vintage tubes went that way in days of old) or of the B-battery being shorted (they give a very short life that way).

If all is well you can install the batteries and the tube, connect the phones, and hear what 1983 programs sound like on a 1925 radio set. If the set does not operate, check with a multimeter that the filament voltage is reaching the filament and that the B battery voltage is reaching the plate. With the filament lit up (just visible) and VR1 full on there should be just under 2 volts across the filament due to the residual resistance of VR1. Of course, the prior statement depends on the tube type you use.

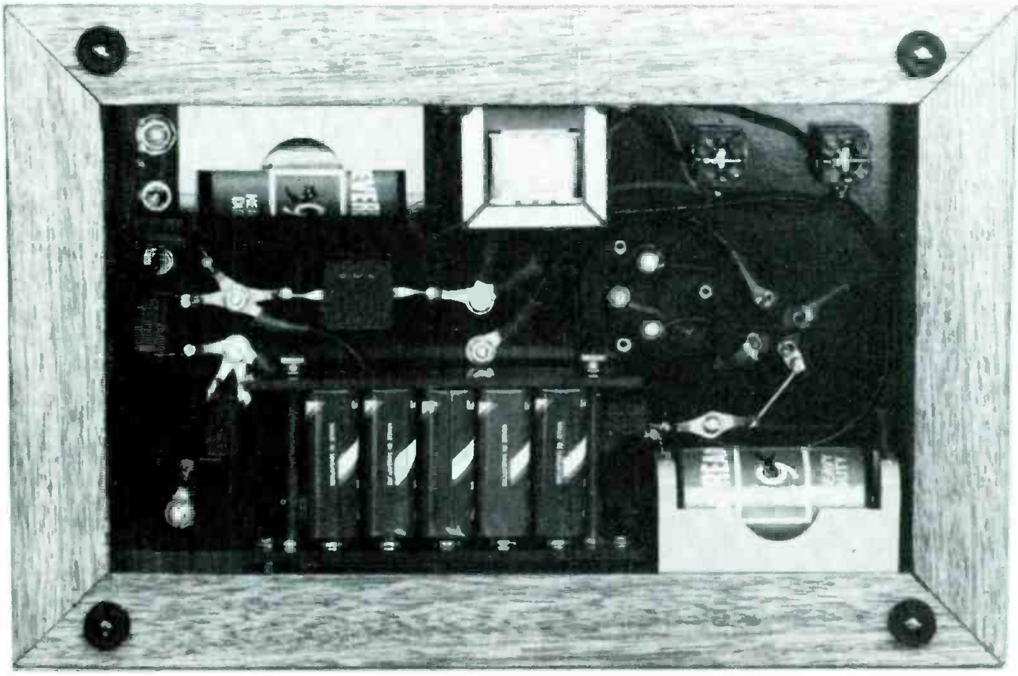
The filament current is 90-110 mA with fresh batteries and the B battery current varies from 0.4 mA to 1.5 mA depending on the signal strength and the tube type. The B batteries will have a very long life (almost shelf life) and it should only be necessary to replace the two D cells from time to time if the set is used fairly frequently (those are not very expensive).

The set works quite well, in most locations, with an indoor antenna of ten to twenty feet but an outdoor antenna and an ground will boost reception remarkably, especially in country areas. Any ground will also almost completely remove the effects of hand or body capacity on the tuning of the set.

The set attracts attention wherever it is seen; and while the great enjoyment is in building and operating it, there is also much pleasure in explaining and demonstrating it.

You may have trouble finding all the parts you need to assemble the Unidyne, as the author did; however, continue to scrounge the flea markets in your area and you'll be surprised to discover how rewarding that search can be. In fact, you may very well be on your way to setting up a small radio museum.

Overall, the project will have served its purpose if it stimulates an interest in the origins of our particular branch of technology, with the knowledge that knowing where we have come from can often help us see more clearly where we are going. Happy vintage listening! ■



THE COMPLETED UNIDYNE with batteries in place is ready for its first DX. Except for the modern-day batteries, you are looking back over 60 years of radio history. The author scrounged some old mica capacitors. If you are unable to obtain "micas,' look for tubular types that hint of days gone by. Neatness counts, so dress up the leads.

CALLING ALL HAMS

(Continued from page 70)

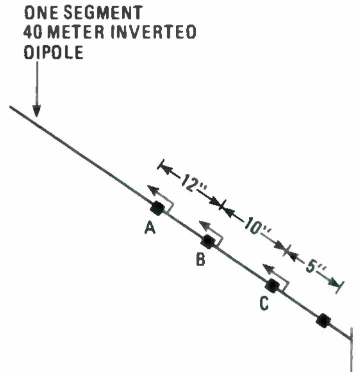


FIG. 5—Alternative jumper plan.

ing C arranges things for operation on 15-meter sideband. All three jumpers closed sets up operation on 15-meter CW.

Horizontal Directivity Change

The simple arrangement of Fig. 6 demonstrates a way of changing the horizontal directivity of the antenna. In that plan the antenna is made more directive by raising the height of the tie-down mast or post in such a manner that the antenna leg ends do not come as near to ground. In addition to the main mast, you would require two 10-to-15 feet of PVC piping. Those set over metal fence posts. There are three

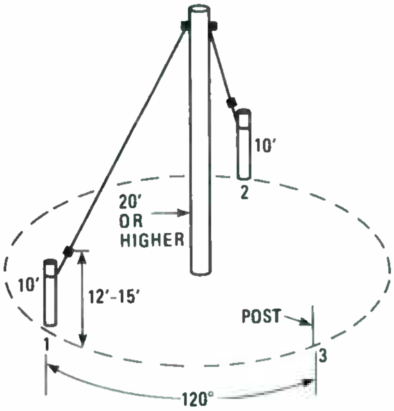


FIG. 6—Manual direction change by shifting posts.

such posts spaced equidistantly in a circle about the main mast. You change direction by lifting one of the masts off its post and moving it to the unused post. That plan provides an easy method of manually rotating a long dipole. Provide the necessary rope slack for each antenna segment that permits you to lift the mast off and move it to another post. You can use nylon rope and a flag-pole cleat attached to the PVC piping at chest level, Fig. 7.

If you want to obtain maximum broadside directivity from the antenna, you can use PVC mast all the same height. Some guying might be required and it would be a bit more trouble to make an exchange.

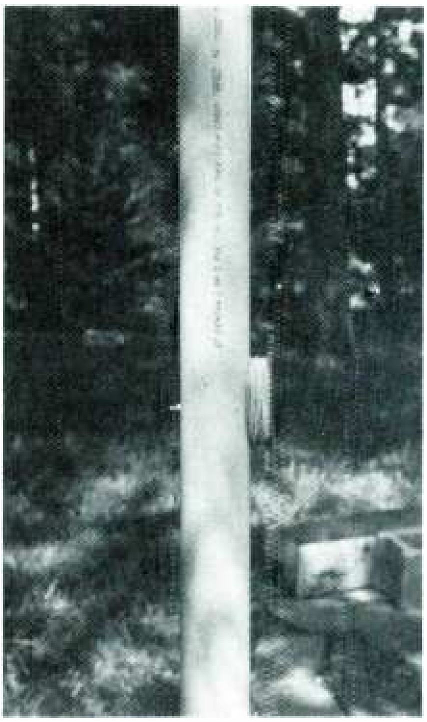


FIG. 7—Using a flag-pole cleat.

However, getting the end of each antenna segment 12 to 15 feet above ground provides acceptable directivity. You can obtain that height with the proper adjustment of your rope slack and the physical distance of the ten-foot PVC pipe from the main mast.

How the directivity changes is demonstrated in Fig. 8. In the examples, the orientation of the short PVC pipe 2 is such that the line between the main mast and the pipe 2 is directly north. Two other pipes are located at positions 120° on either side of pipe 2. Therefore, in Fig. 8A, the approximate figure-eight pattern on 40-meters is NW/SE. There is a 120° rotation of pattern for Figs. 8A and 8C depending upon which pair of short masts support the antenna. The three possible positions provide a maximum each 60° around the 360° circumference.

The directivity is similar for 15-meter operation. However, the dipole segments do tilt. Hence, the antenna operates as a 3/2-wavelength type, the maximum directivity is at an angle the bisects the direction of tilt. In Fig. 8A maximum directivity would be northwest. However,

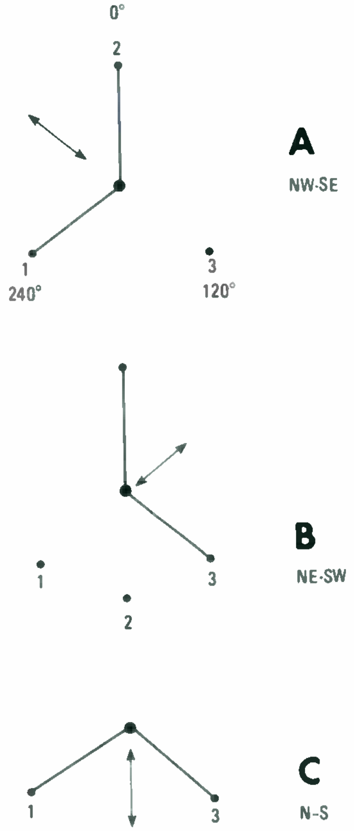


FIG. 8—Shifting directivity of a dipole.

there are significant lobes in other directions, too, because that configuration is not highly directional. Fig. 8B favors the northeast; Fig. 8C favors the south.

Of course the short-mast positions need not be specifically on 0°, 120°, and 240°. You can arrange them in your mounting site to place maximums in the directions you prefer. In my own location, the ideal positions for the three short masts are 90°, 210°, and 330°. —Ed Noll, W3FQ3

POCKET SAFETY FLARE

(Continued from page 65)

There's nothing critical about construction of the Pocket Safety Flare. The circuit can easily be breadboarded or circuit-board layout developed. Also, a complete set of parts is available (see the Parts List).

The author's prototype was built into a box with a clear plastic frontplate. That provides a good looking unit. The front of the case is, in effect, a window; but other construction configurations are possible. Another point worth noting is that T2, C4, SCR1, and associated high-voltage circuitry should be located as close to FX1 as possible, with xenon flash tube (FX1) shock mounted to a capacitor (C2) with a few drops of silicon rubber cement.

When operated properly, potentiometer R4 should be adjusted for a flash every second or so. That can also be changed by altering the time constants associated with C3 and C4, where higher values for C3 will also increase intensity. Higher flash rates will increase the drain on batteries while slower flash rates have the opposite effect. In any case, a high-frequency oscillation will be heard to come from T1, when the unit is operating properly. That sound is normal and there's nothing to be alarmed about. While currents are quite low, the 250- to 300-volts DC potential on C2 and 3- to 4-kV potential produced by T2 can still provide some noxious stimuli to the uninitiated. Therefore, exercise some restraint and *caution* when playing around inside the plastic case. ■

ELECTRONIC LIGHT FLASHER

(Continued from page 61)

in mind that you will be working with AC line-voltage here, so extra care should be taken (use insulated wire of appropriate gauge, etc.). We also strongly recommend that the circuit board and AC receptacle be placed in an chassis box.

The DC voltage required by the circuit can be obtained from batteries or from an AC-to-DC adapter wired into the 117-volt AC side of the circuit.

OK, you are all set to connect the Electronic Light Flasher to a resistive load. Try not to exceed the current rating of the Triac you use. Also, inductive loads play havoc with circuits of this type, so avoid their use. The inductive kick during "switch-off" produces current spikes way in excess of the device's current and voltage safe ranges. ■

CAPACITANCE METER

(Continued from page 69)

position, turn R11 until the meter pointer indicates full scale. Return switch S2 to the OP position. Precaution: Always start with the range switch, S1, in the highest position and work your way down range until you obtain a reasonable reading. The reason for that is that if the unknown capacitor is larger than the meter's full-scale value, a mid-scale value on the meter will be observed. That is because the charging cycle of C_x doesn't finish before the next trigger pulse, and runs into the next cycle.

Here's a trick you can use to extend the meter's range effectively. If you have two identical capacitors (or any number N for that matter) put them in series (observing polarity, plus to minus) and connect them to the C_x terminals, BP1 and BP2. An individual capacitor will be N times the measured value.

The number of otherwise useless capacitors in your junkbox will now be able identified and usable—that will more than make up for the few dollars you may have to spend for parts. ■

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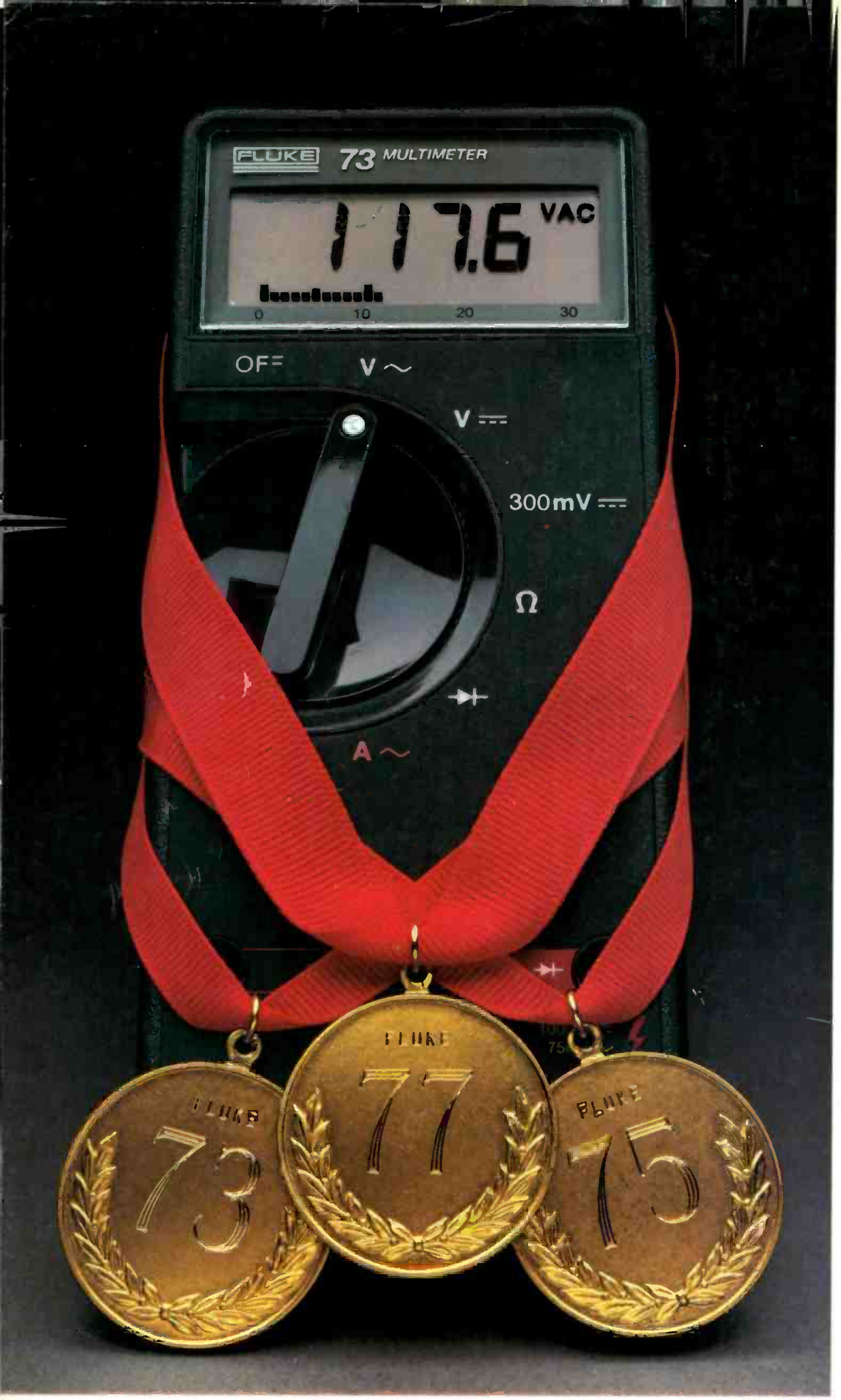

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