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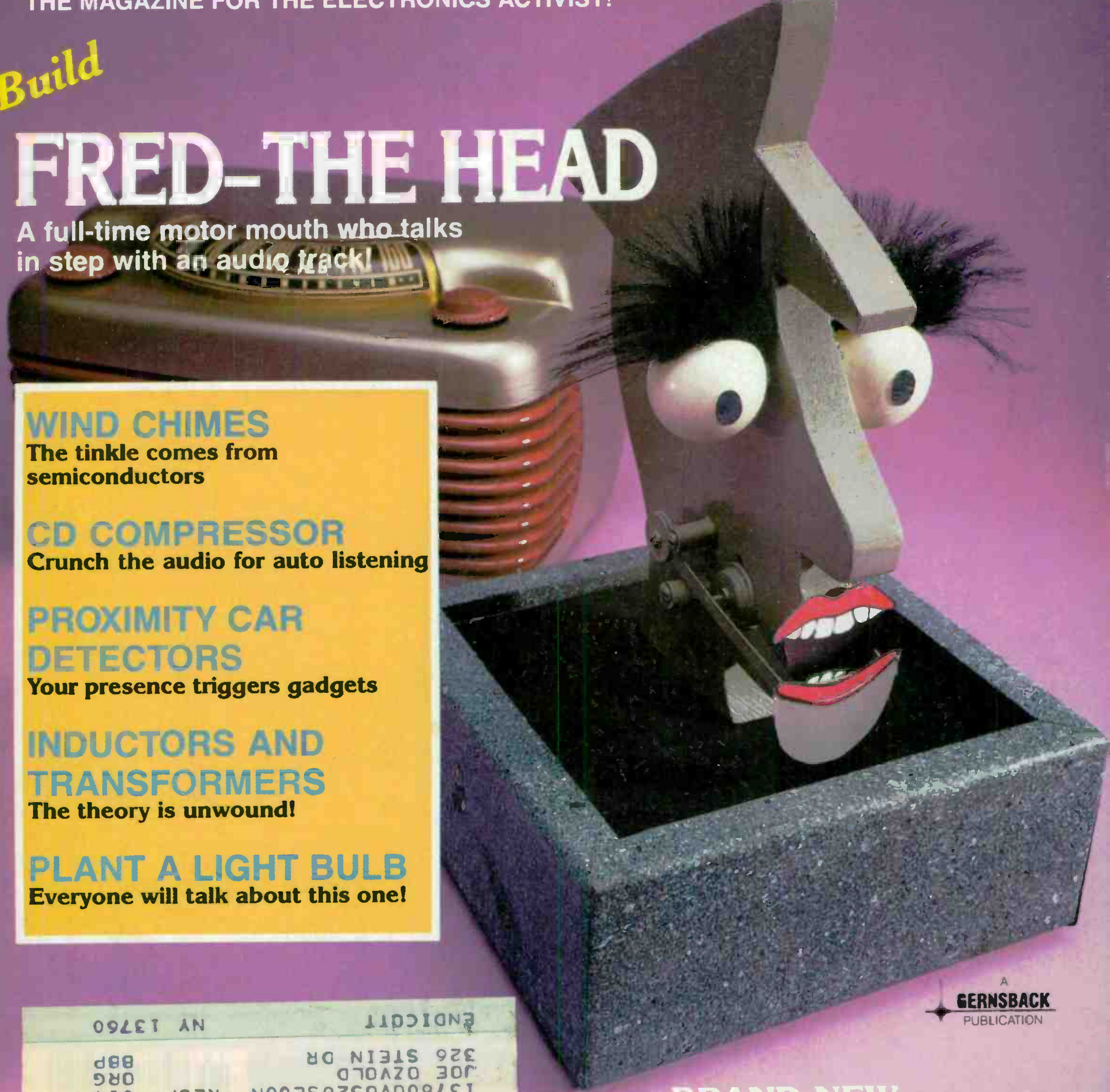
From the Publishers of Radio-Electronics

Hands-on Electronics®

THE MAGAZINE FOR THE ELECTRONICS ACTIVIST!

INCLUDING 12-PAGE GADGET



Build

FRED–THE HEAD

A full-time motor mouth who talks in step with an audio track!

WIND CHIMES
The tinkle comes from semiconductors

CD COMPRESSOR
Crunch the audio for auto listening

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Your presence triggers gadgets

INDUCTORS AND TRANSFORMERS
The theory is unwound!

PLANT A LIGHT BULB
Everyone will talk about this one!

A GERNSBACK PUBLICATION

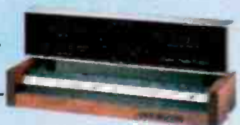
BRAND NEW— HAM RADIO COLUMN!

This Issue

Make your home into something special!

That's exactly what your home will be when you fill it with Heathkit electronic products – products that make your life easier and more enjoyable. Within our diverse line are kit and assembled products sure to enhance each room in your home.

1. Make your entryway more secure and easy to use with the Keyless Doorlock. You'll never again be locked out because of lost or forgotten keys. All it takes is a simple fingertip entry of a four-digit code, and the Keyless Doorlock unlocks your door.



2. Add a new dimension to your living room with your own Computerized Weather Station. This Digital Weather Station displays up-to-the-minute temperature, wind, and barometric pressure readings, along with time and date.

3. Give your kitchen a unique blend of style and efficiency with our Digital Wall Clock. This easy-to-build kit keeps time with quartz-crystal accuracy. And with its simulated oak wood-grain finish cabinet, you'll have a timepiece that fits into almost any decor.

4. Put your den to greater use with this IBM PC AT Compatible Computer. Do word processing, personal accounting and more when you run exciting IBM-compatible software on your fast and powerful HS-241. And you can build it yourself in just a few hours.

5. Bring the latest in digital technology to your bathroom. This Digital Scale lets you closely monitor your weight with electronic precision. And, it's battery operated so it's safe to use right out of the shower.

6. Add a video entertainment center to your bedroom. Our 19"-diagonal stereo TV kit gives you an extra-sharp color-corrected picture with full stereo sound, and convenient viewing that you can control from your bed. Comes in a simulated walnut cabinet that complements your room.

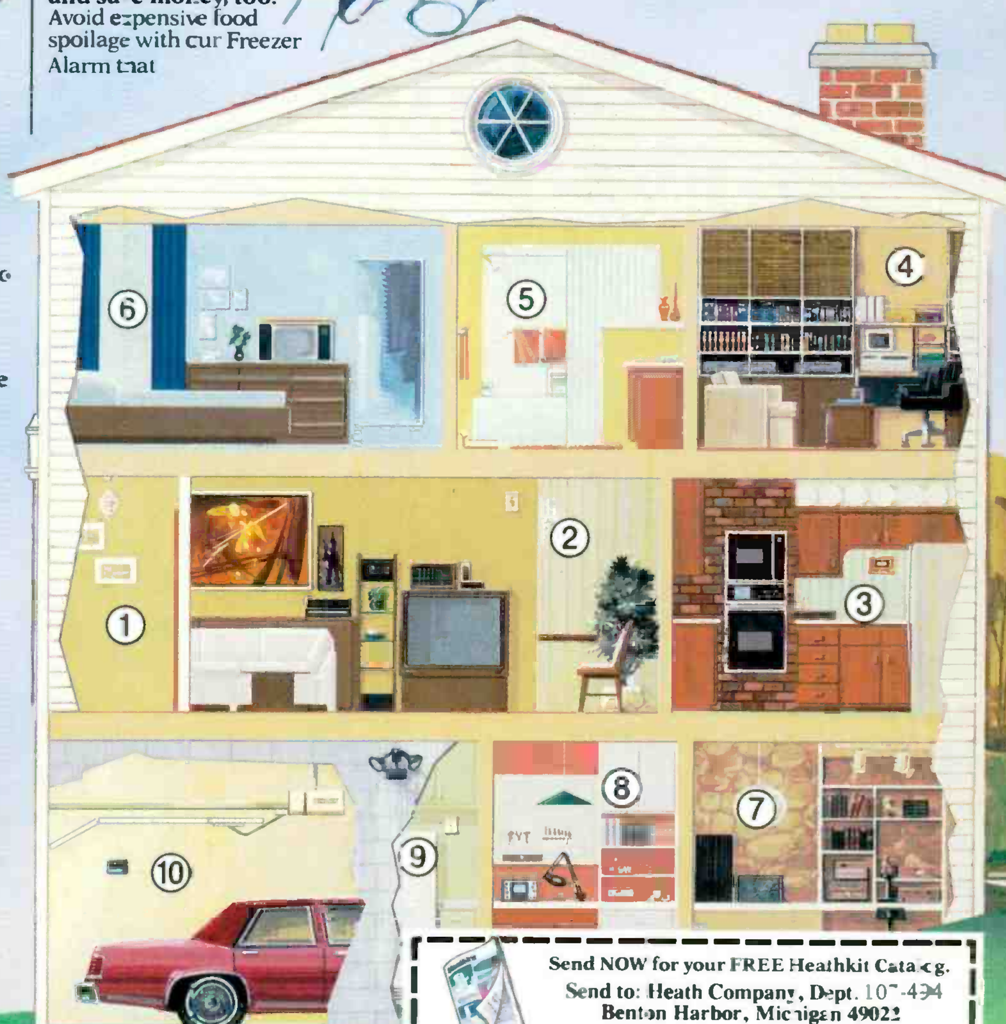
7. Transform your rec room into a haven for hobby fun. Put our Deluxe QRP CW Transceiver in this room and enjoy superb HAM radio operation that excells in performance and features. It offers expandable transmission and reception capabilities.

8. Give your workbench a touch of professionalism with this oscilloscope. Whether you're a service technician or a hobbyist, you'll love the wide range of measurement capability our laboratory-grade Dual Trace 10 MHz Oscilloscope gives you.

9. Add practicality to the utility room and save money, too. Avoid expensive food spoilage with our Freezer Alarm that warns you when the inside temperature of your freezer rises too high. Prevent water damage with our Food Alarm that warns you of water that's where it shouldn't be.

10. Make your coming and going easier than ever. Your garage door will open with incredible ease and dependability with our Deluxe Garage Door Opener. Easy to install, this opener is durable and includes a handy security light.

You'll find fun and excitement with every Heathkit product. Whether they're in kit form or already assembled, our products will help you enjoy your home more than you ever dreamed possible.



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Hands-on Electronics
Volume 4, No. 1 January 1987

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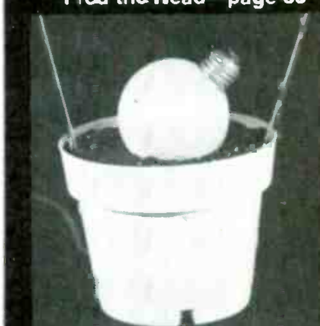

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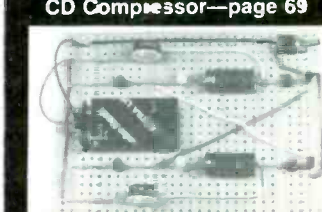

Astable Multivibrator—page 105

Hands-on Electronics

The Magazine for the Electronics Activist!

EDITORIAL PAGE

INCLUDING 12-PAGE GADGET

Volume 4, No. 1

January 1987

Fun is fun—so lets keep having more of the same!

Have you ever noticed that you are happy when you *play* at your hobby? Most people don't realize that. Doctors will agree hobby activity is relaxing even though you don't smile or laugh aloud. That was not the case with our editorial staff as they prepared this issue.

Fred-the-Head is probably the funniest device I ever put on a printed page. When the package containing Fred first arrived at the office the chuckles began, quietly at first, then then developed into outright roars during the day. We couldn't believe our own behavior—grown men and women laughing like children, dragging visitors over to chattering Fred. This was the project of projects—all our readers had to read about it and we hope that many of you will build it. So, if you have been enjoying your hobby, but not laughing aloud, my advice to you is build Fred-the-Head!

We did have one problem this past month. The December, 1986 issue offered a coupon allowing readers to obtain a free copy of the 1986 Index of Articles for **Hands-on Electronics**. I could not foresee the gigantic response—we ran out of copies and had to print a batch more. A few readers may have had to wait a bit longer than they should have, but we are all caught up now. If you missed the free coupon in the last issue, it's not too late to retrieve it and write for your free index. Otherwise, without the coupon, the Index sells for $1.00. See the Electronics Bookstore advertisement in the back of this issue.

Julian Martin

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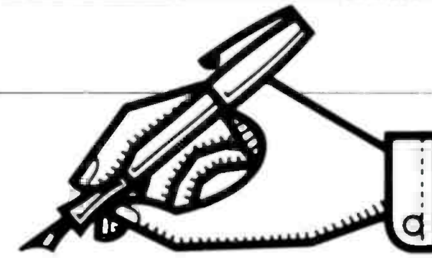

Letters! We get letters.

Capacitive Captive

I'm writing to ask about a part for the BC Magnum Booster described in the September/October, 1986 issue. In the Parts List, capacitor C1 is listed as a 365-pF variable capacitor. Looking through my mail order catalogs and calling local electronics parts stores has turned up nothing. Where can I locate one; is there a place that hobbyists, technicians, and engineers purchase their parts? R. A., Austin, MN

Try Custom Components, Box 153, Malverne, NY 11565. Capacitors of the type you've mentioned are $5.00 each, plus $2.00 shipping and handling per order.

Quick Directory

Now that button-type batteries are common, how does a guy go about buying one brand when the device lists the battery type for another brand? My supermarket doesn't carry a cross directory. What to do?
Z.F., Baltimore, MD

Well, the supermarkets should carry cross directories so that they can sell more batteries. But you need more than that! Use the Radio Shack catalog as a directory. They list the popular types and sell them, too. So do better camera outlets. Buy where the directories are available and let the supermarkets stick to milk and cheese.

Hung-up

I'm hung-up on the telephone project on page 60 of the September/October, 1986 issue of **Hands-on Electronics**. Figure 1 shows no pin number for the LM741 output, and the parts list for the circuit shows R3 as fixed, and doesn't even list Q1.

In Fig. 2 on page 62 you don't show the emitter, base, or collector locations for SCR1, so please help me.
E. C. M.,
Elmendorf AFB, AK

Let's do a quick fix on this one. With regard to the op-amp output; if you're using the 8-pin package, the output is at pin 6, but if the 14-pin unit is used pin-10 is the output.

Resistor R3 is a 100,000-ohm potentiometer. You are right about the transistor; it was accidentally left out.

As to Fig. 2, SCR's don't have base, collector, or emitter connections, but instead have anode, cathode and gate connections. The anode and cathode connections on SCR's are the same as those for a diode; that is, the cathode is that end of the symbol at which the bar appears.

Temperature's Rising

I'm having trouble with the electronic thermometer described on page 96 of the July/August issue. Is R4 really supposed to be 861 ohms or the more common 581 ohms? Either way I get -14 volts between pins 6 and 2 on IC2, but I don't know why. Could you give me some reference voltages to help me out?
K.H., Newport
News, VA

Getting right to the heart of the matter, let's first deal with R4: Its value is indeed 861 ohms (a rather uncommon value).

As to the reason that you're getting 14-volts at the output of U2, I suspect that the problem was caused by the rather confusing way in which the schematic drawing was shown. You'll note that one power connection (pin 4 for U1 and pin 7 for U2) for each IC has been omitted. Those two pins should be connected to the effective ground. In this case, the effective ground is the junction formed by connecting B1 to B2 (which is indicated by a ground symbol at that point). Redoing the circuit as outlined should enable you to zero the output by adjusting R6 as described in the text.

There are no reference voltages for the circuit that I can track down. However, that should get you going in the right direction. Have fun.

Tunes on the Go

I'm looking for either a bass/treble or equalizer circuit for my Sony Walkman, but I haven't been able to find a schematic diagram for one. The sound is good as is, but I want more bass for drums and treble for cymbals. Could you please help me find either of the two circuits. A. G. P., San Diego, CA

Have you read the November, 1986 issue? Look at page 59; there you'll find a circuit that would lend itself very nicely to portability. You'll have to design a small cabinet for it and work out parts placement, but that's the fun of building your own!

Speaker to Me

I've recently bought my first copy of **Hands-on Electronics** and found it to be a very good magazine (I've learned a lot from it already), and was hoping you could help me with a problem I have.

I'm building my own stereo system and am now trying to design my speakers. I need a schematic diagram for a subwoofer crossover. It should have a 120-Hz crosspoint and a 6-db-per-octave drop, what can you suggest?
T. C. Y.,
Yorba Linda, CA

We're always glad to hear from anyone interested in electronics; either a hobbyist or professional. I don't know if this will help you very much, but here goes. While thumbing through the MCM Electronics parts catalogue #13, I came across an offering that might be of interest to you. On page 95 they have a subwoofer crossover with the crossover point at 100 Hz, but I realize that the $29.95 price tag may fall somewhere outside of your budget; however, you might come out better in the long run.

If you really want to design your own crossover, I suggest that you check Radio Shack's "Building Speaker Enclosures." I seem to recall a crossover schematic diagram in there. Also check out the electronics section of your local library. There are sure to be one or two references that cover the subject. Let me know how things work out for you. Good luck.

Start the Music

Could you please tell me where I could get an AY-3-1350 melody synthesizer chip featured in the November, 1986 issue on page 82? Radio Shack doesn't stock them any more.
J. C. Shepard,
Richardson TX

The chip is made by General Instrument, which has a sales office at 5520 LBJ Freeway, Suite 330, Dallas, TX 75240. They should be able to steer you to a distributor. ■

Regency "Scanner Answer" Giveaway

Here's your chance to win a complete monitoring package from Regency Electronics and Lunar Antennas. 18 scanners in all will be awarded, including a grand prize of the set-up you see above: the Regency HX1500 handheld, the Z60 base station scanner, the R806 mobile unit, and a Lunar GDX-4 Broadband monitoring/reference antenna.

55 Channels to go!

When you're on the go, and you need to stay tuned into the action, take along the Regency HX1500. It's got 55 channels, 4 independent scan banks, a top mounted auxilliary scan control, liquid crystal display, rugged die-cast aluminum chassis, covers ten public service bands including aircraft, and, it's keyboard programmable.

Compact Mobile

With today's smaller cars and limited installation space in mind, Regency has developed a new compact mobile scanner, the R806. It's the world's first microprocessor controlled crystal scanner. In addition, the R806 features 8 channels, programmable priority, dual scan speed, and bright LED channel indicators.

Base Station Plus!

Besides covering all the standard public service bands, the Regency Z60 scanner receives FM broadcast, aircraft transmissions, and has a built-in digital quartz clock with an alarm. Other Z60 features include 60 channels, keyboard programming, priority control, digital display and permanent memory.

Send in a photo (like this one of Mike Nikolich and his Regency monitoring station) and receive a free gift from Regency. Be sure to include your name, address and phone number.

Lunar Antenna

Also included in the grand prize is a broadband monitoring/reference antenna from Lunar Electronics. The GDX-4 covers 25 to 1300 MHz, and includes a 6 foot tower.

Regency ELECTRONICS INC.
7707 Records Street
Indianapolis, IN 46226

Grand Prize (1 awarded)
1—Regency Z60 Base station scanner
1—Regency HX1500 Handheld scanner
1—Regency R806 Mobile scanner
1—Lunar GDX-4 Antenna

First Prize (5 awarded)
1—Regency Z60 Base station scanner
1—Regency R806 Mobile scanner

Second Prize (5 awarded)
1—Regency HX1500 scanner

Contest rules: Just answer the questions on the coupon, (all answers are in the ad copy) fill in your name and address and send the coupon to Regency Electronics, Inc., 7707 Records Street, Indianapolis, IN 46226. Winners will be selected from all correct entries. One entry per person. No purchase necessary. Void where prohibited by law. Contest ends June 30, 1987.

1. The Regency Z60 is
   - ☐ a digital alarm clock ☐ an FM radio
   - ☐ a scanner ☐ all of the above
2. The Regency R806 is the world's first ________ controlled crystal scanner.
3. The Regency HX1500 features
   - ☐ 55 channels ☐ Bank scanning
   - ☐ Liquid crystal display ☐ all of the above
4. The Lunar GDX-4 antenna covers ____ to ____ MHz.

Name: ________

Address: ________

City: ________ State: ________ Zipcode: ________

I currently own ________ scanners.

Brands owned: ________

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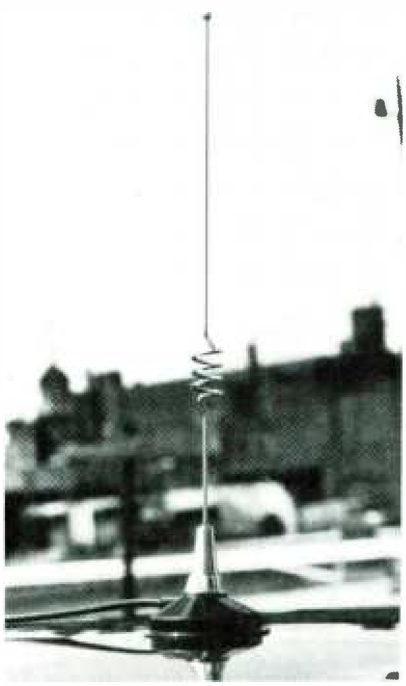
NEW PRODUCTS

800-MHz Mag Mount

The Antenna Specialists Co. series of 3-dB-gain, magnet-mount, low-profile mobile antennas for 800-MHz trunking and cellular applications are designed for optimum electrical performance while providing the convenience of storability for both demonstration and permanent operations where desired. Durability as well as electrical efficiency are insured through application of A/S' plating of the whip.



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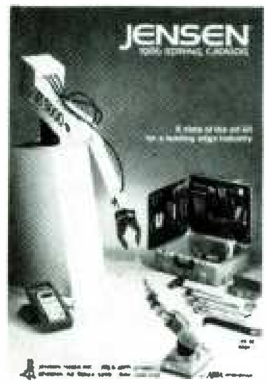
The antennas are rated at 50-watts continuous power with VSWR less than 1.9:1 over the specified ranges. Models ASPA1874N (type N male connector) and ASPA1874P (UHF male connector) cover the 806-866 MHz trunking frequency range.

Suggested list prices are $39.50 and $37.50 respectively. Models ASPD1874T (TNC male connector) and ASPD1874M (mini-UHF male connector) are provided for 821-896 MHz cellular telephone applications. All four models are furnished with 12 feet of RG-58A/U cable.

For complete specifications, write to The Antenna Specialists Co., P.O. Box 12370, Cleveland, OH 44112-0370.



CIRCLE 62 ON FREE INFORMATION CARD

Tools and Test Equipment Catalog

A new 144-page catalog of precision tools and test equipment is being offered free by Jensen Tools Inc. Illustrated in full color, the catalog contains more than 1,000 items of interest to field engineers, technicians, computer and telecommunications service personnel, and the robotics industry.

The catalog introduces economical telecom and PC service kits, specialty tools, soldering/desoldering devices, line aids, handsets, and logic monitors and other test equipment. Other categories include shipping containers, tool cases, computer/power equipment, lighting, optical and drafting equipment, power tools, measuring devices, and full lines of pliers, screwdrivers, wire wrapping/unwrapping tools, tweezers, and more.

For a free copy, write or call: Jensen Tools Inc., 7815 S. 46th Street, Phoenix, AZ 85044; Tel. 602/968-6231.

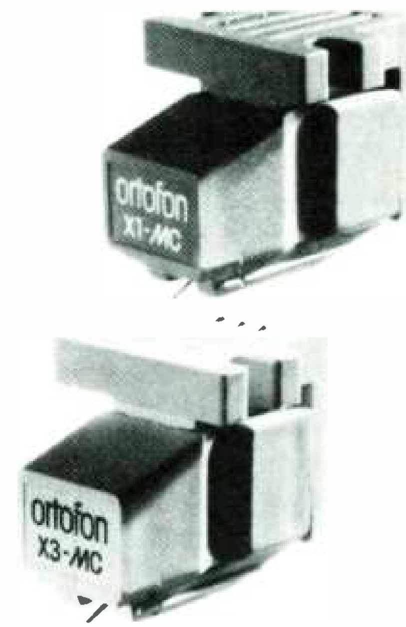
Phono Cartridge with Guaranteed Satisfaction

Ortofon's X1-MC and X3-MC moving-coil phono cartridges offer all the sound quality advantages of moving coil design, while overcoming the two most significant disadvantages: high-cost and low-output levels.

Ortofon's high-output levels result from a unique magnet structure that achieves a high-output level with fewer coil windings. Ortofon's proprietary coil-winding machines allow the use of extremely fine wire for lower moving mass, wider frequency response, improved tracking, and lower prices.

Ortofon is so confident of the sound quality of their new X1-MC and X3-MC moving-coil phono cartridges, that any consumer who doesn't prefer an X1-MC or X3-MC to his present cartridge can return it to his dealer within 30 days for a full, on-the-spot cash refund.

The Ortofon X1-MC has an elliptical stylus and has a suggested retail price of $75. The X3-MC has a Nude Fine Line stylus and a suggested retail price of $140.



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15-Channel Programmable Scanner

Automatic search, scan delay, and a priority channel are features that are normally reserved for expensive, top-of-the-line scanners. But one modestly-priced programmable scanner that has those features—and more—is the Regency R1075. Fully programmable, the 15-channel scanner can receive more than 15,000 frequencies from six of the most popular public service bands.

Designed for the beginning scanning enthusiast, as well as the veteran who is looking for a reliable back-up unit, the scanner can be programmed to search a frequency range for active frequencies.

With its priority channel and scan delay functions, the scanner keeps listeners from missing important transmissions. When it is activated, the priority channel automatically overrides all other calls so

CIRCLE 64 ON FREE INFORMATION CARD

that broadcasts from a favorite channel are never missed. Scan delay puts a two-second pause at the end of a transmission so that "calls" and "answers" can be heard before the scanner resumes its scanning cycle.

The scanner covers six full bands, including VHF-low (30-50 MHz), VHF-amateur (144-148 MHz), VHF-high (148-174 MHz), UHF-amateur (440-450 MHz), UHF (450-470 MHz) and UHF-T (470-512 MHz). A dual scan-speed control allows the scanning cycle to be set to fast or slow speeds.

The scanner is simple to program, with a numbered keyboard and a dual-level vacuum fluorescent display that flashes visual messages to aid in programming.

Other important features include channel lockout, for skipping channels not of current interest, plus sliding volume and squelch controls. In the event of a power failure, a built-in capacitor will save frequencies in memory for several hours, without requiring batteries. All electronics are housed in an attractive woodgrain case that features a top-mounted, built-in speaker.

The Regency R1075 has a suggested retail price of $179.95 and is backed by a full one-year warranty. The basic package includes an AC power-supply cord, telescoping antenna, and an easy-to-follow instruction manual.

Complete details are available from Regency scanner suppliers or by writing directly to Regency Electronics Inc., 7707 Records Street, Indianapolis, IN 46226.

Portable Oscilloscope

Tektronix has broken the $1,000 price barrier with the newest member of the popular 2200 Series of portable oscilloscopes. The dual-channel 2225 portable oscilloscope offers features including a 50-MHz bandwidth, alternate magnification, 500-mV sensitivity, peak-to-peak auto-trigger mode, and high-frequency/low-frequency trigger filtering. TV trigger also comes standard with the capability of selective triggering on TV lines or TV fields, making the 2225 well suited for a variety of television and video applications.

Alternate magnification provides many of the benefits of a dual-timebase scope in a single-timebase instrument. With that feature, users can view both the magnified and unmagnified sweep on the screen, simultaneously. The magnified sweep also can be independently positioned in reference to the unmagnified sweep. Alternate magnification gives a simple, easy-to-operate method of waveform expansion and is selectable in three levels: 5×, 10×, and 50×.

The scope's 500-μV sensitivity is four times more sensitive than previous 2200 scopes. The higher sensitivity opens up a new range of applications involving very low-level signal measurements. Those include such applications as amplifier noise, power-supply ripple, transducer, and tape-head signal measurements. In addition, the highly sensitive vertical channels can also be used in a differential mode for signal comparisons, or in an add mode.

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Also new to the 2225 is the trigger-filter capability. With that feature, users can selectively filter out unwanted low- or high-frequency components from the trigger signal. For example, a user can filter out the low-frequency component of a high-frequency signal that often causes instability.

To provide improved low-cost performance with the 2225, Tektronix offers the P6103—a 50-MHz, 10× passive probe—for under $50.00. The P6103 has compensation built into the probe head and a more durable probe tip. To change the probe tip, a new one is simply screwed into place.

The 2225 portable oscilloscope is priced at $995. The P6103 probe is priced at under $50.00.

For further information on the 2225 oscilloscope or to place an order, call the Tektronix National Marketing Center: Tel. 800/426-2200. In Oregon, call 503/627-9000.

Electro-Probe Digital Multimeter

The digital multimeter model DM-6593 Electro-Probe from A.W. Sperry Instruments is both small and convenient. Its features include autoranging, a unique interchangeable probe tip, electronic overload protection on all ranges,

CIRCLE 6 ON FREE INFORMATION CARD

CIRCLE 66 ON FREE INFORMATION CARD

instant continuity buzzer, data-hold button, and one-hand operation. It's the perfect instrument for taking readings easily and accurately in hard to reach areas.

Ranges are as follows: DC Volts—200 mV to 500 V; AC Volts—2 to 500 V; Resistance—200 ohms to 20 megohms; Continuity—buzzer sounds at approximately less than 150 ohms.

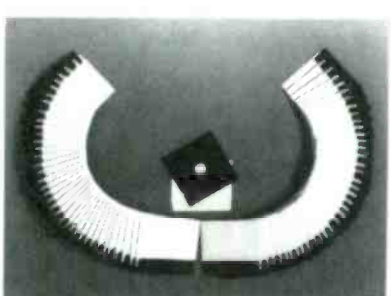
The DM-6593 comes complete with a TL-49 test lead, AG-940 detachable alligator clip, two B-6 batteries, Tip-1 short (0.5") probe tip, Tip-2 long (2.8") insulated probe tip, C-49 carrying case, one-year warranty and is economically priced at $55.00.

For more information, write to A.W. Sperry Instruments, Inc., 245 Marcus Boulevard, Hauppauge, NY 11788; tel. 516/231-7050.

29-cent Computer Diskettes

Micro Center/MEI, a personal computer direct marketer in Columbus, Ohio has lowered the price of quality diskettes. Consumers can now purchase floppy 5¼" diskettes—single- or double-sided—for just 29 cents when purchased in lots of 50. Each diskette, protected in a soft paper sleeve, is 100% certified at the manufacturer and is guaranteed for life—or your money back. Micro Center/MEI has sold over 21 million of these quality diskettes to thousands of customers all over the country. Only 29 cents for lifetime warranty 5¼" single-sided, double-density or double-sided, double-density quality diskettes.

Write or call Micro Electronics, Inc. 1555 West Lane Avenue, Columbus, OH 43221; Tel. 800/634-3478, or in Ohio 614/481-4417.



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Message Mike

Marshall Electronics' easy-to-use Message Recorder (shaped like a broadcast studio microphone from the early years of radio and TV) remembers important notes without you writing them down. It's the fun way to leave messages just about anywhere. The battery-operated unit records 20-second messages on a tape loop by simply holding down the record button and plays your message or instructions back every time it's picked up.

The Message Mike is available in two colors—#7020 Black or #7050 Red. It measures 9-in. × 3¼-in. × 3¼-in. and is powered by three AA batteries (included). The list price is $29.95 each. It is available from Marshall electronics, Inc., P.O. Box 2027, Culver City, CA 90230.

CIRCLE 68 ON FREE INFORMATION CARD

Don't Get Burned

Soldering temperature is set digitally in one-degree increments on a new temperature-controlled soldering iron introduced by Wellman Thermal Systems Corp. A solid-state controller assures tight tolerance temperature control.

It has easy-to-read digital set-point and indicator lamps. The special tip design allows 135-watts of power to be put into a 25-watt size without danger of overheating. The result is very fast initial heat-up and minimal temperature drop at the workpiece, even when used for prolonged periods.

CIRCLE 69 ON FREE INFORMATION CARD

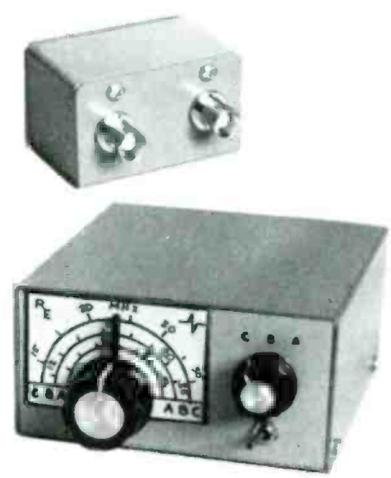
The sturdy compact industrial enclosure occupies only about 70 square inches of bench space but is heavy enough to resist accidental movement.

Available accessories include a tip-wiping sponge and soldering iron holder.

For more information, contact: Wellman Thermal Systems Corp., One Progress Road, Shelbyville, IN 46176; Tel. 317/398-4411.

New Radio Stuff

Radio Engineers has two products of interest to the radio enthusiast. For the home builder with an oscilloscope that can only "see" up to 5 MHz, two models of frequency extenders are available. Designated the Type HFX-1 and HFX-2 Oscilloscope Frequency Extenders, those units allow 5 MHz or 10 MHz bandwidth oscilloscopes to see RF signals as high as 55 MHz. The Type HFX-1 model contains an RF-signal source and a broadband mixing circuit that converts the high-frequency signal to an intermediate frequency within the oscilloscope's range. The Type HFX-2 is designed to be used with an external signal generator, but it still gives the same frequency coverage. Both units have 50-ohm input impedances and use BNC connectors to interface to the circuit under test and the oscilloscope.



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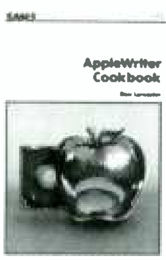
Also available is the Type DBX-30, a fixed 30-dB attenuator, which allows the extenders to sample higher power levels.

Data sheets are available on those and other products that the company manufactures by writing to Radio Engineers, 3941 Mt. Brundage Ave., San Diego, CA 92111; Tel. 619/268-7988.

BOOKSHELF

AppleWriter Cookbook
By Don Lancaster

AppleWriter Cookbook covers a wide range of topics giving thorough and extensive coverage of the five different versions of the AppleWriter program, including the new ProDOS 2.0. *AppleWriter Cookbook's* first two



CIRCLE 71 ON FREE INFORMATION CARD

chapters respond to the questions of actual AppleWriter users. The chapters that follow provide additional information on many areas such as: patches for NULL, shortline, Grappler, and other codes, self-prompting glossaries, microjustification, proportional spacing routines, WPL routines for columns, and source-code capturing instructions.

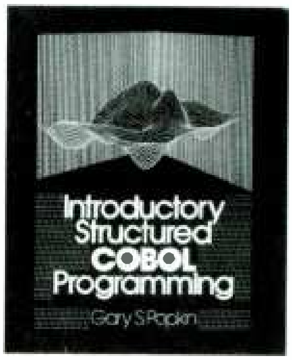
The cookbook has appendices full of WPL programs, AppleWriter patches, machine-language patches, and internal ProDOS AppleWriter 2.0 program details. *AppleWriter Cookbook's* 352 pages answer users questions; from the bare-bone beginner through the full source-code capturing, go-for-broke hacker.

Retailing for $19.95, the book is available directly from Sams by writing to Howard W. Sams and Co., Dept. R10, 4300 W. 62nd St., Indianapolis, IN 46268; Tel. 317/298-5409 or 800-428-SAMS.

Introductory Structured COBOL Programming
By Gary S. Popkin

Designed for readers with little or no knowledge of computers, as well as those who already know one or two programming languages, *Introductory Structured COBOL Programming* includes many examples emphasizing programming techniques and COBOL applications found in the business world.

The book begins with an elementary program in the opening chapter, and then introduces additional COBOL features of increasing complexity in succeeding chapters. To avoid unnecessary complications and facilitate understanding, only those COBOL features needed for a particular program are discussed at each step. Thirty-six complete, working COBOL programs—and part of a thirty-seventh—are shown.



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The book contains: an informal writing style, which is highly instructive; a gradual increase in the level of difficulty that allows the reader to master the material before proceeding; program-design techniques including flow charts, control charts, pseudo code, hierarchy diagrams, and top-down design; thorough definitions of all key words and concepts as they are introduced; a detailed explanation of the Report Writer and SORT features, and coverage of advanced topics for further study.

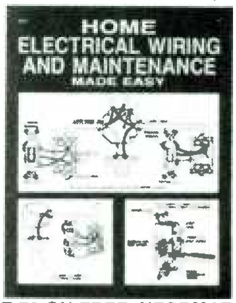
The book contains 471 pages; retails for $25.75 and is available from Wadsworth International, 7625 Empire Dr., Florence, KY 41042; Tel. 800/354-9706, or 606/525-2230

Home Electrical Wiring and Maintenance Made Easy
By The American Association for Vocational Instructional Materials

With *Home Electrical Wiring Made Easy* as a guide, even the beginner will see how simple it is to learn professional wiring techniques—whether replacing a faulty switch, installing a light dimmer, inspecting a home's wiring system for safety hazards, or installing a complete wiring system. Every procedure recommended in this wiring guide is in compliance with the most recent National Electrical Code requirements and every possible safety precaution has been observed.

The section on wiring homes, utility buildings, and service areas provides hands-on, step-by-step instructions for reading and interpreting wiring plans, selecting tools and materials, estimating wiring costs, installing switch and outlet boxes, grounding the electrical system and equipment, connecting receptacles, switches, and fixtures for each circuit, and more.

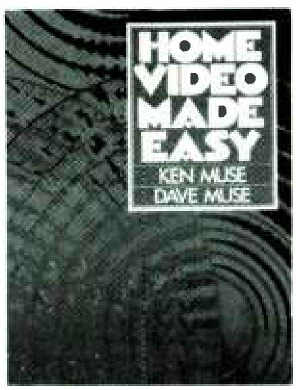
The reader will learn how to decide if a 120-volt, 120/240-volt, or 240-volt system is needed, and how to install the proper circuits and to service entrance equipment using a cable or conduit with overhead or underground conductors, how to install ground fault circuit interrupters and conduits, even the procedures for installing wiring for agricultural and other utility buildings.



CIRCLE 73 ON FREE INFORMATION CARD

And even if the reader plans to install an electric system from scratch, this book will more than pay for itself with advice on simple maintenance and repair of home electrical systems. Which tools should be used for doing each job, proper safety precautions to take when working with electrical wiring, how to recognize faulty wiring, lighting fixtures, and switches, and how to remove and replace worn or broken parts are just some of the subjects covered. And it doesn't take an accomplished handyman to appreciate the preventative maintenance tips included here—how to's for replacement of attachment plugs, lamp sockets, and service cords, fuses and resetting or changing circuit breakers, single pole 3-way and 4-way switches, inspection and repair of dryer, range, and other appliance outlets, replacement of incandescent and fluorescent lighting fixtures, and of ground fault circuit interrupters.

It is 272 pages long, and retails for $19.45 as a paperback and $28.95 as a hardbound book from TAB Book Inc., Blue Ridge Summit, PA. 17214; Tel. 717/794-2191.



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Home Video Made Easy
By Ken and Dave Muse

Home Video Made Easy is filled with cartoons and photos, and offers clearly written, simple explanations that assist you in the use of light, sound, and microphones. It shows you how to patch-in, edit, transition, jumpcut, or superimpose; and how to connect anything to anything. This book is packed with ideas, giving amateur home video efforts the polished look of professional TV.

Home Video Made Easy is 240 pages long, and the paperback costs $17.95. It is available from Prentice-Hall, Englewood Cliffs, NJ 07632; Tel. 201/592-5000

Introduction to Digital Communication Switching
By John R. Ronayne

Progression into the modern technical telecommunications field is simplified with *Introduction to Digital Communication Switching*. This reference guide will expose the reader to the concepts of digital communication switching—efficient channeling of incoming and outgoing telephone signals.

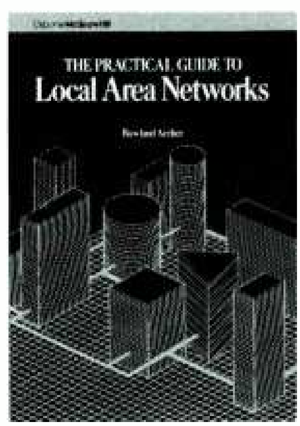
The book covers pulse-code modulation (PCM), error sources and

CIRCLE 71 ON FREE INFORMATION CARD

prevention, digital exchanges and control, all-digital networks, and the open System interconnection (OSI) model.

This is a complete reference aid for telecommunications professionals who will need to understand current transmission and switching techniques, and for students with a technical background in telecommunications.

A 200 page, softbound book retailing for $23.95, it is available from Sams by writing to Howard W. Sams and Co., Dept. R50 4300 W. 62nd St., Indianpolis, IN 46268; Tel. 800/428-SAMS.



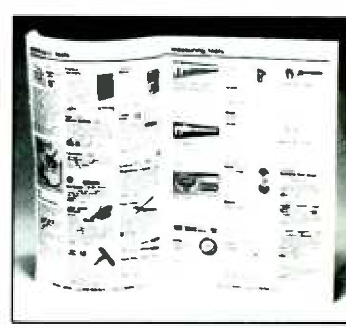
CIRCLE 75 ON FREE INFORMATION CARD

Local Area Networks
By Rowland Archer

Local Area Networks treats the subject of networks at the levels of potential purchaser, installer, manager, and user. It assumes that you are reasonably familiar with the setup and use of IBM PC's, but do not necessarily know programming.

Chapter 1 explains what a network is and gives a brief history of personal-computer networks. In chapter 2, the benefits and costs of LAN's are explored to help you decide whether to purchase one. Chapter 3 outlines the factors that should influence your selection, should you decide that a PC network is appropriate for you. Chapter 4 examines in detail the planning and installation of a network.

CIRCLE 5 ON FREE INFORMATION CARD

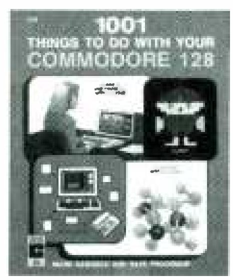


CIRCLE 11 ON FREE INFORMATION CARD

and includes a discussion of how much hardware and software to buy. Chapter 5, which closes the first half of the book, tells you how to use a network to run both existing and new applications that take advantage of the special features a network offers.

The second half of the book is devoted to detailed discussions of five popular networks. Those chapters give a clear picture of what it is like to install and use each system. The contrasts between the different networks reveal the variety of features available, so that you can decide which are important to you.

The book is available at bookstores throughout North America, or directly from McGraw-Hill, 2600 Tenth St., Berkeley, CA 94710; Tel. 800/227-0900, or 800/772-2531



CIRCLE 73 ON FREE INFORMATION CARD

1001 Things to Do with Your Commodore 128
By Mark Sawusch and Dave Prochnow

In *1001 Things to Do With Your Commodore 128* are ways to use your C-128 for applications ranging from household recordkeeping and budgeting, to investment analysis and business management—from game playing and hobby use, to scientific and educational applications. This book includes ideas for getting more from the C-128: to forecast weather, help youngsters make better grades, calculate camera settings, keep any business on the road to better profits, for technical applications, and to play games.

Packed with ideas for putting the C-128 computer to work it's a book that's sure to inspire computer users to come up with still more ideas of their own. The authors have provided all-new, commercial-quality programs for sound and graphics, financial, business, educational, and high-tech applications. Plus unique games and puzzles, as well as an invaluable library of computer specific utilities and subroutines. Printouts, flowcharts, diagrams, step-by-step instructions, and a wealth of illustrations, are all featured in this programming book.

A 208 page book, it costs $12.45 in paperback, and $18.95 hardbound, available from TAB Books Inc., Blue Ridge Summit, PA 17214; Tel. 717/794-2191.

CIRCLE 76 ON FREE INFORMATION CARD

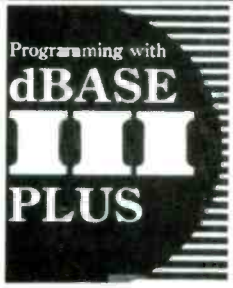
Satellite and Cable TV Scrambling and Descrambling
By Brent Gayle and Frank Baylin

Satellite and Cable TV Scrambling and Descrambling is organized so that the material in each chapter builds upon that explored in previous ones. The concepts underlying modern communications are outlined in Chapter 1. In the next chapter, the operation of both black-and-white and color TV is comprehensively explained. Chapter 4 is an in-depth study of the scrambling techniques which underlie all encryption systems in use today. The innovative MAC broadcast system is also outlined here. In chapters 5 and 6, the discussion turns practical as commercially available scramblers and descramblers for both cable and satellite TV systems are presented. The study includes an explanation of both the technical parameters of each system as well as its operational features.

The book, 280 page softbound retailing for $19.95, is available from Baylin/Gale Productions, 1905 Mariposa, Suite 101, Boulder, CO 80302; Tel. 303/449-4551

Programming with dBASE III Plus
By Cary N. Praque and James E. Hammitt

Programming with dBASE III Plus is a guide to Ashton Tate's newest version of its dBASE relational database manager for the IBM PC. It includes all the practical, use-it-now advice and guidance beginning PC users are looking for, as well as power programming techniques that will allow more advanced users to increase productivity, while sharply reducing application development time. The programming example alone will make the book worthwhile.

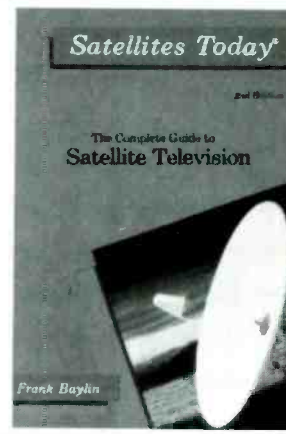


CIRCLE 73 ON FREE INFORMATION CARD

Drawing on their expertise in the use of dBASE II and dBASE III, the authors highlight the new generation enhancements that make dBASE III Plus one of the most sophisticated and versatile integrated software packages available on today's market. Just some of the areas explored include the more than 50 new commands and functions, new utilities such as an applications generator and an advanced query system, faster sorting speed and indexing capabilities up to 10 times faster than dBASE III, greatly expanded file capacity, and built-in networking capability.

Exceptionally well documented and packed with program examples—including a sophisticated payroll and inventory system—this is a sourcebook that goes beyond the material covered in most user's manuals. It provides the in-depth information needed to decide whether or not to upgrade techniques needed to tap the maximum productivity potential offered by this state-of-the-art software package, and details on how to use dBASE III Plus as a powerful, stand-alone programming language.

The book is 384 pages long and comes in papaerback for $21.45, and hardcover for $29.95. It's available from TAB Book Inc., Blue Ridge Summit, PA 17214; Tel. 717/794-2191.



CIRCLE 77 ON FREE INFORMATION CARD

Satellites Today
By Frank Baylin

Satillites Today explains, in a clear and readable fashion, the technology underlying the transmission of information to and from satellites, and describes satellites—the innovative and critical link in the communication revolution.

Written for both the non-technical beginner and the professional who wants to know more about that fascinating new television-viewing mode, it clearly explains the history of communications and satellite transmission; how TV and radio messages are transmitted to and from satellites; how home satellite systems work; what types of satellite-TV programs you can receive at home; why home satellite-receiving stations are legal; the full range of domestic satellites you can receive, and how to buy and operate a home satellite system. Plus the future of satellite systems, direct broadcasting, satellite spacing, and more.

It is a softbound book of 157 pages, costing $12.95, available from Universal Electronics, Inc., 4555 Groves Rd., Suite 13, Columbus, OH 43232; Tel. 614/866-4605

CIRCLE 73 ON FREE INFORMATION CARD

Lotus 1-2-3 Simplified—2nd Edition Including Version 2.0
By David Bolocan

Regardless of your programming experience, *Lotus 1-2-3 Simplified* is a must-have supplement to the standard user's manual. It provides secrets to taking maximum advantages of 1-2-3's highly-sophisticated features and capabilities, including Version 2.0's larger and faster spreadsheet operations, its macro and file compatibility with Symphony database software, and its larger memory capacity. Included are twenty different spreadsheet applications that can be put to immediate use handling the reader's business and financial needs.

The book is 272 pages long and costs $14.45 in paperback and $21.95 in hardbound. It is available from TAB Books Inc., Blue Ridge Summit, PA 17214; Tel. 717/794-2191.

CIRCLE 78 ON FREE INFORMATION CARD

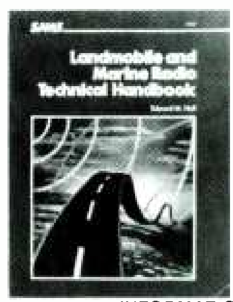
Electronic Synthesiser Construction
By R. A. Penfold

With *Electronic Synthesiser Construction* a relative beginner should be able to build, with a minimum of difficulty and at a reasonably low cost, a worthwhile monophonic synthesiser, and also learn a great deal about electronic music synthesis in the process.

It considers the various individual parts of the circuit that comprise a complete instrument and details the practical construction of those as separate units which can then be combined together to form the final synthesiser. Printed-circuit designs are provided for those main modules. Later chapters deal with sequencing and some effects units.

The book will also be useful to the more experienced users who, for instance, might like to add some of the designs to an existing system to increase its capabilities and versatility.

It is a paperback selling for $5.95 (plus $1.00 shipping and handling), available from Electronic Technology Today, Inc., POB 240, Massapequa Park, NY 11762.



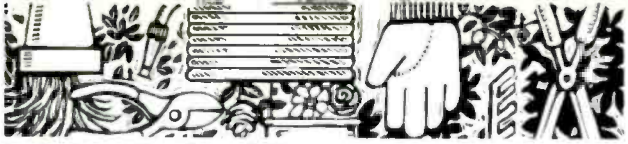
CIRCLE 71 ON FREE INFORMATION CARD

Landmobile and Marine Radio Handbook
By Edward C. Noll

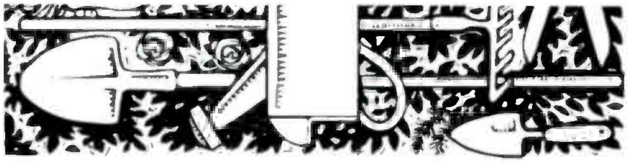
Landmobile and Marine Radio Technical Handbook is a good book for anyone interested in radio communications. The book is a useful learning tool for two-way radio communications and a complete reference source for experienced users.

Beginning with coverage of fundamental topics and working through to advanced subjects the book covers such topics as, two-way radio services and their frequency bands, transmission characteristics and modulation systems, basic solid-state theory for radiocommunications, digital and microprocessor electronics, antenna systems for mobile, fixed-station, and marine applications, test equipment types and usage, equipment testing and servicing procedures, two-way radio equipment and circuit descriptions, repeater stations and cellular radio, and radar equipment, and satellite communications. Two-way field communications are discussed, including private landmobile services, marine radiotelephone and radiotelegraph, marine navigation, citizens band, and FCC licensing.

It is a softbound book retailing for $24.95, available directly from Sams by by writing to Howard W. Sams and



PLANT A BULB



Imagine how much money could be made if you could really grow lightbulbs in your garden!

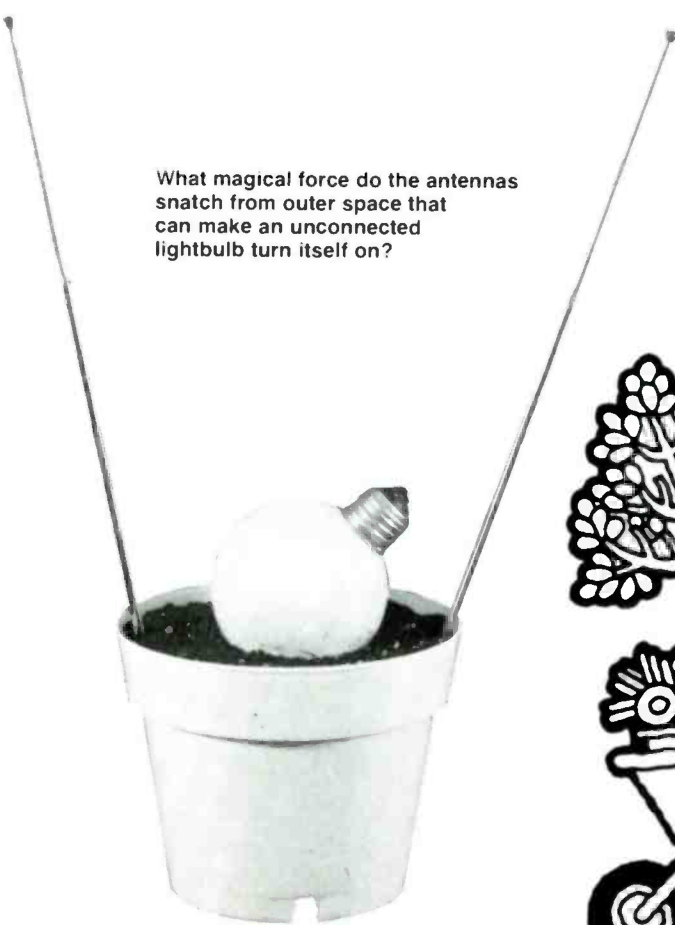
By Byron G. Wels

NO, THE THE LIGHTBULB GROWING IN A FLOWER POT ISN'T a photographic trick: We've got a real 40-watt bulb and two antennas in a pot of potting soil, and the bulb *really* lights!

Some bright and knowledgeable people have been tripped up by this project. One looked at it and said, "Chemical reaction in the soil, right?" Wrong! Another suggested we had an induction coil in the bottom of the pot. Wrong again! A young lady in the office said "I didn't know dirt could hold electricity!" And another chap was certain it was battery-powered because he had seen it lit in the morning, and then dark at noon: He said, "I was sure that the battery wouldn't last that long!"

Not Really Planted

In actual fact, the planted lightbulb is neither planted, nor battery-powered, nor possessed of some magical power: it's powered directly by the powerline, like all other conventional lightbulbs.



What magical force do the antennas snatch from outer space that can make an unconnected lightbulb turn itself on?

Here's how it's done. Get a ball-shaped lightbulb: We obtained the one used for the photograph at a local supermarket. Also get a bulb that's burned out. Carefully wrap the old, burned-out bulb in a cloth—an old towel does fine—and strike the glass smartly with a hammer to break the glass. Now carefully (very carefully) remove the splintered glass from around the remaining base, and then cement the base to the *top* of the ball-shaped lightbulb—offset to one side. (Any good five-minute-cure epoxy will do well.) Orient the added base with the bulb's filament so you're looking at it end-on when the lamp is lit.

Drill a small hole through the bottom of a flower pot, near what will be the back. Bring an AC linecord through the hole, and then connect the linecord's terminals to a lamp socket. (It's a good idea at this point to carefully coat the socket's screw terminals with some epoxy to keep moisture out.) Screw the bulb into the socket with the false screw-base at the top, and add some ordinary potting soil to a point about half-way up the socket. Carefully orient the socket so the lightbulb "sits" the way you want it, and then add the rest of the potting soil to a point where the curvature of the bulb stops.

To heighten the "magical" effect, you can install a disc-type flasher unit in the socket so the light pulses on and off.

Oh yes—the two antennas. They're just stuck into the soil. It's "smoke-screen," what magicians call "misdirection." All they add is curiosity.

Practical uses? Sure there are. Your local florist would be delighted to place this in his store window with a sign saying "Have you purchased your bulbs yet?" Or you can offer it to a hardware store owner, with a sign saying "Had any bright ideas lately?" They'll probably pay you ten times what you paid for the parts. That's pretty practical! ■

JENSEN ON DX'ING

You can learn almost any language from shortwave radio

I'VE ALWAYS THOUGHT THAT MANY high school and college foreign-language instructors were missing a bet by not recommending to their students that they listen to shortwave broadcasts for practice.

Except by actually traveling abroad, how else can you get so much listening exposure to the language that you're trying to learn?

Maybe some of you students in Spanish-, French-, or German-language classes will slip a tip to the prof to let him know the practice material that's there for the tuning every day.

Better yet, why not tape record some of the programming? Newscasts are great material for the novice linguist. Take your cassette to class so others can benefit, too. It's a better gift for *teach'* than a polished red apple!

Even if you're not in school, there are still some good ways to learn a lingo.

Some of the major international broadcasters offer special lessons—classes by radio—that will get you started learning their native languages. In some cases, the stations offer no-cost supplemental text materials through the mail to help you with the courses.

Recently, Alex Batman, editor of a fine column called "Easy Listening" which appears monthly in FRENDX, the bulletin of the North American Shortwave Association, reviewed the learn-a-language programs.

In addition to Spanish and German, Batman noted, there are language programs that can help you learn Dutch, Hebrew, Chinese, Japanese, Korean, and Russian. Radio classes in other languages have been offered, too; and perhaps will be again in the future, especially if listeners request such programming.

Here is what is available, according to Batman.

Takayuki Inoue Nozaki of Hachioji-city, Tokyo, is one of the top DX'ers in the world when it comes to logging stations in Latin America. Last year, Takayuki had the rare opportunity of traveling through South America, actually visiting many of the shortwave stations he had previously heard and verified.

Language Broadcasts

Spanish—*Spanish Foreign Radio*, Madrid, offers a program called "Learn Spanish: A Language Without Bounds." The programs are offered Monday through Friday at 0050 UTC, repeated at 0150 UTC on 6055 and 9630 kHz. The series includes both practice dialogue and grammar lessons.

German—"Auf Deutsch Gegast," or "Say it in German," is a weekly program broadcast on Saturdays by *Deutsche Welle*, the *Voice of Germany*. The broadcasts, supported by an available textbook, are broken down into sentences and are translated, with the dialogue read straight through in German at the end of each program. It is scheduled for 0135 UTC, and again at 0335 UTC, on a number of DW frequencies, including 6145, 9545, and 9565 kHz; and 0535 UTC on 5960, 6120, 6130 and 9690 kHz.

Hebrew—"Easy Hebrew," offered daily at 2300 UTC on 5885, 7410 and 9435 kHz by *Kol Israel*, is not a Hebrew language course for beginners. It is, simply, a program in Hebrew, spoken slowly and carefully pronounced, for those who have some background in the language.

Russian—"Russian by Radio" is presented by *Radio Moscow*'s World Service at 1930 UTC Saturday, and 0030, 0330, 0930, and 1630 UTC Sundays, on the many shortwave frequencies used by the Soviets. There is a textbook that you can obtain, which contains written lessons that you can send in for correction, if you wish.

Chinese—There are two ways to begin to learn this difficult language by shortwave radio. Programs are offered both by *Radio Beijing* and by Taiwan's *Voice of Free China*.

The former's program, "Learn Chinese" is aired by *Radio Beijing* at 1145 UTC on 9820 kHz, 1245 UTC on 9820, and 9640 kHz, and 0045 UTC on 9820 and 11685 kHz, on Mondays and repeated on Wednesdays. A text is available from *Radio Beijing* and it should be helpful to beginning students.

"Let's Learn Chinese" is the name of the *Voice of Free China*'s lesson program. Batman suggests that this program is presented so clearly and carefully that texts are not even essential; and, unlike most other language programs, it is offered at three different levels: for beginners, intermediate learners and advanced students, with printed course material for each student group.

The program is broadcast daily at 0245 and 0345 UTC on 5985 and 6065 kHz, and 0745 UTC on 5985 kHz. Signals, relayed by a private religious station, WYFR in Florida, are strong and clear here in North America.

The 0345 UTC program, however, is a relay of the previous day's 0245 and 0745 UTC airings. The beginner's course is presented on Wednesday (and 0345 UTC Thursday); the intermediate level on Mondays and Thursdays (plus 0345 UTC on Tuesdays and Fridays), and the advanced classes on Tuesdays and Fridays (with an 0345 UTC repeat on Wednesday and Saturday). And, to complete the somewhat complicated schedule, Saturday night programs are devoted to learning your

Chinese pronunciation.

Japanese—*Radio Japan* has two language lesson courses, "Let's Learn Japanese" on Tuesdays and "Let's Practice Japanese" on Fridays. Programs are broadcast on 5,990 kHz at 1335 UTC. Batman says that the programs seem similar, but have separate texts, obtainable from the station.

Dialogues are read in both Japanese and English, then are broken down by sentences. It's a bit tough for a beginner.

Korean—*Radio Korea*'s language lesson program has the almost generic name, "Let's Learn Korean." Apparently a text is available by writing to the station in Seoul. Sentences are read several times in Korean, and then in English. There's not much help with grammar or explanation. It is broadcast Monday through Friday at 1440 UTC on 9,750 kHz; 0240 UTC on 11,818 and 15,575 kHz, and 0440 UTC on 9,570 kHz.

With some dedication and work, those programs should help you to speak and understand some of the foreign languages that you hear on shortwave radio.

New Publications

If you understand enough Spanish to make out the identifications announced by some of the Latin American stations, but not enough to be able to sit down and write a reception report to them in their own language, a new book called "Language Lab" might be just what the doctor ordered.

"Language Lab" is the first of a series of do-it-yourself volumes from Tiare Publications (P.O. Box 493, Lake Geneva, WI 53147) that should help you write reception reports. It consists of 50 pages of phrases and sentences—in Spanish with English equivalents—appropriate for a reception-report letter.

Similar coil-bound books in French and Portuguese are scheduled for later publication by Tiare.

The cost is $12.95, plus shipping—$1 in the U.S. and Canada; $2, abroad.

If you're into broadcasting history—or, considering it from a different perspective: medium and shortwave trivia—chances are that you will enjoy author-editor Tom Kneitel's new book, *Radio Station Treasury, 1900-1946*.

Kneitel has collected in this 176-page book a wealth of broadcasting-station data from the earliest days of radio. It includes reproduced lists of stations worldwide from old printed log books. There are reprinted features from early radio magazines, plus some fascinating old-time ads!

For example, "A 5-foot wire thrown over a desk, my wife and I listened to a concert from Portland, Oregon, over 600 miles distant," reads one from a 1920's publication.

One of a number of reproduced articles from the past covers the origin and history of call letters of U.S. radio stations. Why, you may wonder, do eastern stations use "W" calls, while most of those west of the Mississippi start with "K?"

The book is available from CRB Research, P.O. Box 56, Commack, NY 11725, for $12.95, plus $1 postage in North America. Mention that you heard about Tom's book in **Hands-on Electronics.**

ABBREVIATIONS

DW	Deutsche Welle, the Voice of Germany
DX'ing	listening to shortwave broadcasts
kHz	kiloHertz (1000 Hertz or cycles)
SW	shortwave
SWL'ing	shortwave listening
U.S., USA	United States of America
UTC	Universal Time Code (old Greenwich Mean Time)

Down the Dial

Here are some of the shortwave loggings reported by some of our DX'ing friends. Join them in this column by letting me know what SW stations you're hearing. Drop me a line. If you have any questions about SWL'ing, include them in your letter too. The address is Jensen on DX'ing, **Hands-on-Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. In the loggings below, the times are given in UTC (Universal Coordinated Time, equivalent to Greenwich Mean Time). The frequencies are listed in kHz (kilohertz):

Alaska—6095, KNLS is a religious broadcaster owned and operated by the World Christian Broadcasting Corporation. This 100-kilowatt SW outlet is located at Anchor Point in our northernmost state. Its programming is directed mostly to China and the Soviet Union, across the pole. Look for this one around 0800.

Greece—7430, *Voice of Greece*, Athens, often can be heard with some terrific Greek music on this frequency, during the evening hours in the U.S. and Canada. You'll find English programming from 0130.

Mongolia—12,015, Ulan Bator's radio offers English-language programming here around 1200. You may well find interference, but it is an interesting catch nonetheless.

USA—15,295, not the best known of the private shortwave broadcasters in the U.S., WINB in Red Lion, PA, has been around for a few years and can be heard around 1600. (Credits: Bob Palmer, WA; Raymond Slagt, Aruba, Netherlands Antilles; Theo Bemis, Pittsburgh; North American SW Association, 45 Wildflower Road, Levittown, PA 19057.) ■

By Herb Friedman

FRIEDMAN ON COMPUTERS

—Computer control of the entire world—

ONE POSSIBILITY OF PERSONAL COMPUTing that hasn't gotten off the ground, moved from square one, or even started to run up the flagpole, is computer-control of the routine appliances used in daily life. Back in the ancient days of personal computing—1980 to 1984—it was one of the hottest "high-tech" subjects in the popular press. From national magazines to your local hometown newspaper, when a managing editor ran out of ideas he assigned someone a story on how computers will *soon* be used to start the morning coffee, turn on the oven to preheat so it will be ready to cook the *roast beast* for Mom, control the home's security system, and announce when baby falls out of the crib.

As you well know, except for a handful of hobbyists, personal computer control of appliances has gone off like a wet firecracker—and for good reason: It's more trouble than it's worth because it ties up a very expensive piece of hardware to do something that's done more efficiently and conveniently by dedicated gizmos.

Forget for a moment whether you would care to drink coffee made with water that's stood all night in an electric *perk* waiting for a computer to turn on the power, or whether Mom needs a $2500 computer to tell her how to whip up a bucket of *grits* or a platter of *chicken francesa*. Consider, instead, only the inconveniences—in particular, the need to interface the computer to the appliance(s).

Low Voltage Is Limiting

With very rare exceptions, a personal computer cannot directly control a household appliance, because under the best of circumstances the typical home-and-family computer accommodates only low-current digital signals of 5-VDC, or the ±25-VDC of the RS-232 I/O (input/output) port. In no way can those low-voltage circuits directly control a 117-VAC line-powered appliance, or even a telephone circuit (which uses 50-VDC and 90-VAC). Just to have the computer turn on a 117-volt light bulb requires an *interface*, a gadget that allows the computer to control an appliance even though the two are electrically isolated from each other.

The few interfaces available for consumer-appliance applications have been variations on the BSR controller. In general, there is no low-cost interface available for common home appliances—though it is easy enough for a hobbyist to build one.

Interface Circuits

Simplified—but working—interface circuits for computer to appliance interfacing are shown in Figs. 1 and 2. Both circuits accomplish the same thing. When the computer outputs a "high" of +5-VDC, the associated appliance—lamp I1—is turned on. When the computer's output is driven "low" (0-volts), the appliance is turned off.

Resistor R1 limits the drive to Q1's base to 5-mA (0.005-A), which allows just about any kind of small signal or switching transistor to be used for Q1. Relay K1 should have the same voltage rating as its source voltage, V_{DD}. If the source voltage comes from the computer's 5-volt power source K1 must have a 5-VDC coil. K1's maximum sensitivity is determined by Q1's β (gain). The maximum sensitivity of K1 (in mA) is:

$$K1_{sens} = 0.005 \times \beta$$

For example, if Q1's β is 100, then K1's sensitivity is:

$$.005 \times 100 = 500\text{-mA}$$

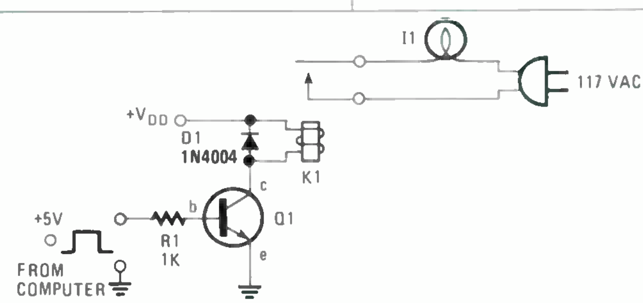


Fig. 1—A 5-volt "high" from the computer will cause K1 to pull-in and close its contacts, which completes the 117-volt powerline circuit for lamp I1. K1's voltage rating must equal VsbD_D. Thus, the coil rating in this case must be 5-VDC

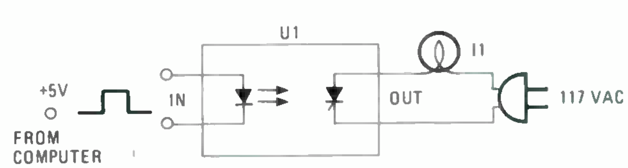


Fig. 2—An opto-coupler can really simplify the circuit, because among other features, it is powered directly from the computer—the "high" causes the diode to illuminate. Depending on how the circuit connects to the computer, a resistor in series with the diode might be needed.

Although the two interfaces do the same thing, Fig. 1 is the way an experimenter might do it using components from the almighty junkbox.

The signal input to Fig. 1 connects to one terminal of the computer's parallel-printer port. When the computer outputs a digital "high" to the port, transistor Q1 is driven to saturation: it conducts, causing relay K1 to pull in and close the contacts that applies 117-VAC to lamp I1.

Most likely, any relay with a coil rating up to 500-mA will work. In fact, most low-cost DC relays will fall in that sensitivity range.

Diode D1 can be any silicon rectifier of the 1N4004 type. It serves to squash the "kickback" voltage developed by K1's coil when current flow is interrupted—thereby keeping the transient "pulse" out of the computer.

(Continued on next page)

Sometimes it's just impossible to get a relay with the proper current rating. If so, use a more sensitive relay, e.g., 250-mA when 500-mA is calculated.

Opto-Coupling

Figure 2 is also an experimenter's kind of circuit, only it is all solid-state: using a Triac-output opto-coupler as a substitute for both Q1 and K1.

Opto-coupler U1 contains two devices in a light-tight housing the size of a small integrated circuit (it even looks like a DIP IC). One element is an infrared-emitting diode, the other is an optically-sensitive Triac whose gate is triggered when exposed to light from the diode.

The diode "glows" when the computer outputs 5-VDC. The glow from the diode triggers the Triac, which conducts, thereby turning on lamp I1. When the computer output goes "low," the diode turns off, causing the Triac to turn off, which in turn extinguishes the lamp.

But It Works

Although the circuits are very simple, they do work; and they do make it easy to experiment with computer-control of external appliances.

If you want to do extensive experimentation with remote control, you'll probably find that some form of multi-port/multi-function peripheral is available for your computer. As a general rule, they are plug-in *boards*—at least for the Apple and IBM clones—which are software addressable. In plain terms, that means you can turn one or more appliance controllers on and off simultaneously: the computer might control your burglar alarm through one port while keeping tabs on a bubbling pot of stew through another port. It might even keep track of the mash in the family still while it's protecting your home against fire, wind, and termites (it senses them gnawing away).

Let Us Know About It

As I said earlier, I can see no good reason to tie up several thousand dollars worth of hardware to do things that are done better with cheap timers, but we all have our own likes and dislikes. If you've done any unusual work interfacing your computer to appliances, we'd like to hear about it—maybe we can share it with the other readers. But keep in mind that we're talking about controlling appliances. Don't give us four pages of details on a laboratory application: that's what computers are really for.

When it comes to Robotics, and laboratory and industrial processes, computer interfacing certainly has proven itself to have great value because it allows us to do things more conveniently and cheaply. My complaint is using $2500 worth of equipment to do a 50-cent task. ■

By Byron G. Wels

WELS' THINK TANK

If you need a circuit, check out these pages

WHEN I FIRST UNDERTOOK TO WRITE this column, I expected it to be a monthly chore. But now that I'm into it, it has become totally absorbing and fascinating. In searching out the circuits that you're looking for, I come across others that are gripping. It's hard to believe that this sort of work can get so involving. It's like reading some kind of detective novel with the solution missing, and trying to figure out who the culprits are!

If you'll recall the first of these columns, written a couple of months ago, I mentioned that we had access to some of the top electronics writers in the world. Just to qualify that, I took a quick survey around the office, and counting *only* those writers in the office, eliminating freelance contributors or other columnists (who are but a phone call away), we have a total of over 500 years of electronics experience working right here! I don't know about you, but those numbers sure impressed me! That's a whole bunch of talent packed into one office.

Power Control

Among the more-interesting requests this month, was one from R.B., of Portland, OR. Like most other computer users, he's been turning everything on and off with a switched outlet strip. His complaint is that he has to turn everything on even if he doesn't plan to use everything.

Well, here's a better way, R.B. Take a *gander* at the schematic diagram in Fig. 1. That control unit, which is fused according to your power requirements, has surge protection in the form of a metal-oxide varistor (MOV); a reset circuit so that if the power drops out, power is not restored to the equipment until the reset switch is pressed; and it's loaded with indicator lamps to tell you what's on and what's not. And you can extend that circuit to add as many additional switched outlets as you need provided you do not exceed the current-carrying capability of the wires and AC outlet.

Phoney Beeper

We received an unusual request from L.M., of Niagara Falls, NY. He has a pompous friend who recently got a telephone beeper and whenever they go out with their friends, the unit on his friend's belt always beeps a few times during dinner. When that happens, he jumps up and runs to the phone. He thinks it makes him look important. One evening, he stopped to pick his friend up, and as they left the house, his friend said to his wife, "Now remember to beep me at eight o'clock and again at eight-thirty!" That did it. Now L.M. wants a beeper so that whenever his friend's beeper goes off, his can, too.

The schematic diagram, Fig. 2, should work well for you, L.M. We found an excellent solid-state buzzer at Radio Shack that provides a nice, loud, pulsing or continuous beep and it can be driven by a nine-volt transistor-radio type battery. We're using a 555 timer IC to provide a ten-second delay, and a push-to-make, push-to-break SPST switch.

What happens is simple. When you're ready—or more accurately put, when your friend's beeper goes off—press switch S1 and immediately place your hands on the table, where it can be plainly seen that you haven't flipped any switches. Within ten seconds or so, your own unit will start to beep and continue to do so until you press S1 again to turn it off, which also resets the unit. Your friend will soon get the idea. House your unit in a nice plastic cabinet with a belt harness.

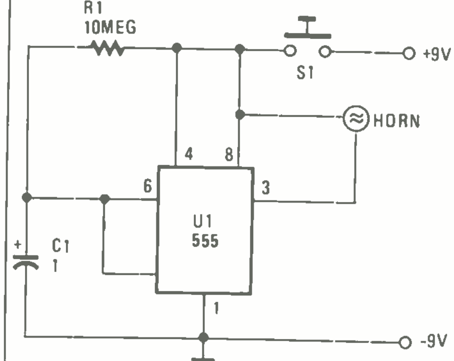


Fig. 2

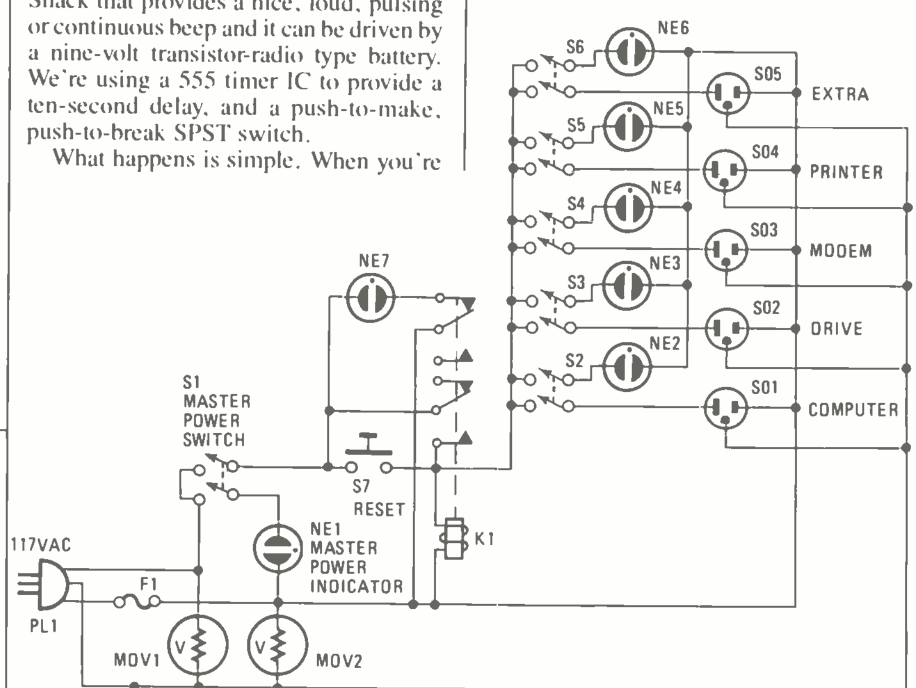


Fig. 1

SOURCE MATERIAL

This month's schematic diagrams were taken from the Application Notes of: Teledyne Semiconductor, 1300 Terra Bella Ave, Mountain View, CA 94039-7267; Solid State Micro Technology for Music, Inc., 20768 Walsh Ave., Santa Clara, CA 95050, and General Electric, Power Electronics Semiconductor Dept., Auburn, NY 13021. ■

Motor Controller

We got a letter from B.R., of Silver Springs, MD. He's looking for a simple circuit to control the speed of a small motor. I must point out that we can usually provide better service to you if you tell us more about the intended application instead of the specific need. Rest assured, we have no intention of stealing your idea! We just want to be of better service to you.

In any event, take a look at Fig. 3. We're using a Teledyne Semiconductor TSC429 as a small, closed-loop motor controller. Chip U1 is used both as a driver and comparator in the control circuit. The back EMF of the motor is used as a feedback signal to detect motor speed. Sure hope this circuit works for you!

Voltage Doubler

R.P., of Dallas, TX, writes to ask if we can provide a schematic diagram for a voltage-doubler circuit. Now voltage doublers are not unusual circuits, and electronics reference books are full of them. We interpret this inquiry to mean that R.P. has a good deal of faith in us; we certainly don't want to let him down, so here goes.

You'll find that the schematic diagram in Fig. 4 is unusual, to say the least. Again, we went to Teledyne Semiconductor for the information, and the circuit is built around their TSC429. Make certain that you use Schottky diodes in the output for maximum efficiency.

Controlled Light Flasher

M.V., of Salt Lake City, UT, wants a controlled light flasher. No problem at all, M.V. Just take a look at Fig. 5. You should have no problem with that circuit; but be aware that the circuit requires two separate voltage sources to make it work. It's a simple, straightforward circuit that needs no explanation.

Headlight Dimmer

We received an interesting letter from P.J. of Washington, DC. It seems that one of the options offered on his new car was an automatic headlight dimmer, and he refused it. Now he has decided that he'd like to have such an option, but the dealer wants too much money to install it. "Can I build my own?" he asks.

Of course, you can. Check out the schematic diagram in Fig. 6. When the lights of an on-coming car are sensed by photo-transistor Q1, things get going. Sensitivity is set by the 22-megohm resistor, R5, to about half a foot-candle. The relay used has a 12-volt, 0.3A coil. (The car's battery can handle that.) The L14C1 is complete with a lens that has a diameter of one inch for a 10° viewing angle.

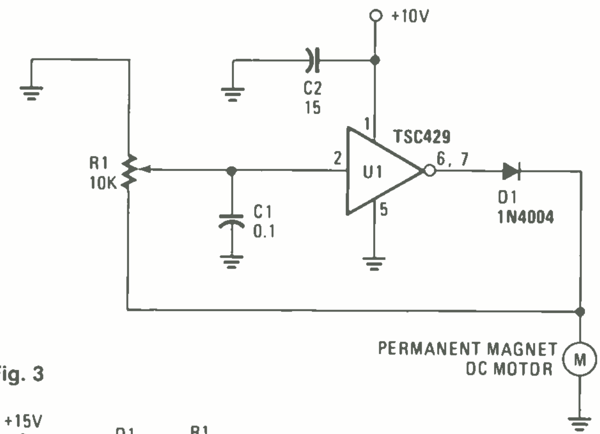


Fig. 3

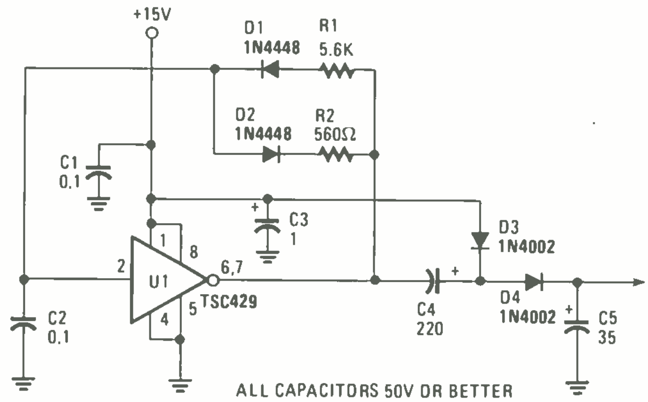


Fig. 4

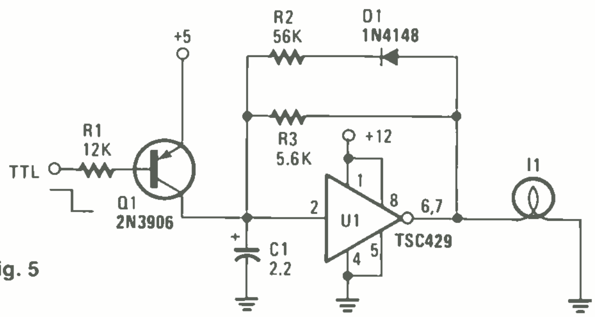


Fig. 5

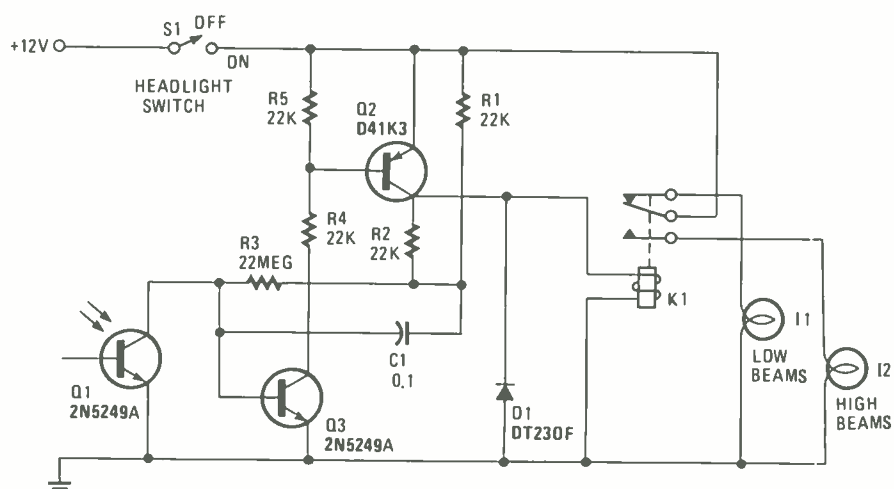


Fig. 6

Slave Trigger

Professional photographers don't depend on long cords between the camera and the remote (*slave*) flash. While that answers the question from T.L., of Lubbock, TX, the schematic shown in Fig. 7 will serve even better.

When the flash—connected to the PC connector or hot shoe on the camera—is

(Continued on page 110)

FRED-THE-HEAD

Here's a wooden head that can talk, sing, and yodel.

Richard L. Pearson

□FRED-THE-HEAD IS A UNIQUE WOODEN TALKING HEAD that's meant to be driven by any audio source, such as a radio, an amplifier, or a tape player. Although Fred is a true "blockhead," his mouth is articulated and will "speak" in synchronization with any audio signal that's coupled to an electronic circuit concealed within the base that supports Fred's head. If the audio signal is speech, Fred will appear to speak. If the signal is music Fred will appear to hum or whistle in time with the beat. One person even used Fred to reproduce the speech-synthesized voice of his computer.

Fred has served every purpose, from an extension speaker for a police-band monitor to an attention-getter for flea-market merchants.

Fred is powered from the 117-volt powerline. The audio input can be any suitable source having an output impedance in the range of 4 to 16 ohms. (The unit shown uses an 8-ohm speaker for Fred's "voice.") Full deflection of Fred's mouth requires a signal of .2Vp-p to be applied to the audio input—a level easily provided by even a small portable radio. Since the mouth's preamplifier has a high input impedance, it has no noticeable effect upon the signal source.

Electronic Assembly

Fred's electronics are assembled on a standard Radio Shack *Protoboard*, which has a coordinated system of holes consisting of horizontal rows designated by letters and vertical columns designated by numbers. In most instances the component leads themselves will form the circuit runs. When needed, short, non-crossing jumpers are formed from #22 solid bare hookup wire. Long runs or jumpers that *do* cross should be made from #22 solid insulated hookup wire.

Circuit Description and Operation

Take note that Fred's electronics provide no power boost or filtering to the audio delivered to his speaker. The circuitry (Fig. 1) is used simply to drive his mouth.

The input audio is applied to the speaker and across level control R6. The speaker's volume is determined by the audio-output level of the amplifier being used as the signal source. R6 provides a means of adjusting the input level to the mouth-driving circuitry for the correct "jaw" action.

U1 is a 741 op-amp; it is used as an inverting amplifier, having a gain of less than 100 at lower audio frequencies. R1, C2, R2, and the setting of R6 determine the overall gain of the stage. Capacitor C1 serves to maintain the DC bias at pin 2. Resistors R5 and R2 establish the desired bias at pin 3 (the non-inverting input of U1). The amplified audio is taken from U1, pin 6 and coupled via C3 to the gate of SCR1.

The jaw motor (MOT1), SCR1 and the secondary of T2 are connected in series. When there is no audio applied, the current path is blocked by the non-conduction of SCR1. As audio of varying frequency and amplitude is applied to the gate of SCR1, conduction begins at varying points in the positive half-cycle; that produces a half-wave rectifier with a duty-cycle that varies at an audio rate. The varying current through the circuit causes the DC motor to actuate the jaw in time to the input audio.

The power supply consists of T1, T2, D1, U2, and capacitors C4, C5, and C6. D1 and C5 provide an unregulated 17-VDC to U2, a 7812 voltage regulator. U2 and capacitors C4 and C6 provide a low-ripple source of 12-VDC for U1. T2 can have a 6.3 volt secondary, or a 12.6 volt secondary with the connection for MOT1 taken from the center-tap.

Electronic Assembly Tips and Procedures

This one paragraph cannot hope to include all the possible bits of information you would use to assemble the project.

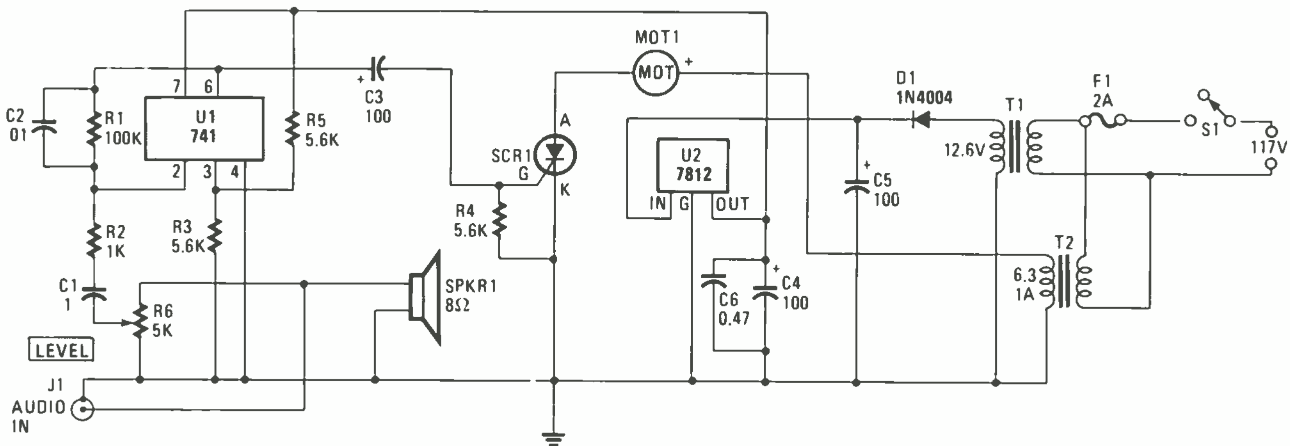


Fig. 1—The audio signal from the sound source is reproduced by speaker SPKR1. The signal across the speaker's terminals provide the sampling voltage that eventually drives Fred-the-Head.

Here are just a few: Become familiar with the parts layout, lead routing, and assembly procedures before beginning. Perform all circuit-board modifications before mounting any components. Use good soldering techniques and equipment. A low-wattage *pencil iron* is recommended for the board connections. Check for shorted runs before applying power. Use a heat sink on the motor shaft between the "jaw" and the motor when soldering the jaw to the shaft. Follow the general parts and lead placement shown. Note that jumpers must be installed before capacitors C4 and C5. Use insulation on all runs that are at powerline potential. The order of board assembly is up to you; but the jumpers covered by components should be installed first, and all foil carrying 117-VAC should be covered with RTV silicone rubber sealer at final assembly.

Making the Head

Fred's head is cut from a piece of 1-in. × 12-in. white pine, for which we provide a 50%-reduced template. (Fig. 2) For a full-size template, have a local photocopy shop make you a 2X enlargement. Suggested colors are shown on the template. The template also shows the required hole centers.

The large motor mounting hole is 15/16-in. Before cutting this hole, check the diameter of the motor's case. We have found that in some instances different motors are sold under the same stock number. (The size of the required hole may differ from our template.)

It is important for proper mouth action that the motor hole be perpendicular to the surfaces. The small 3/16-in. hole intersecting with the motor and wire holes is needed to provide clearance for the motor's wires. The 3/16-in. hole must be drilled first, followed by the 15/16-in. hole and finally, the 1/4-in. hole angle-drilled from the bottom—centered between the flat sides of the wood and angled as shown to match the mounting holes in the base.

The 1/16-in. diameter hole and countersink is a pilot hole needed for a #6 × 1/2-in. blunted sheet metal screw that is used to retain the motor. Its location is not critical other than it should be centered between the flat wood sides, angled approximately as shown. The 3/32-in. eye-mounting hole and the 1/16-in. jaw-stop holes aren't dimensioned.

After the holes are drilled, the head should be sanded and prepared for painting. If necessary, prepare individual templates so you can mark the color boundaries. (A suggested color scheme is shown. The flesh portion may be any color that you choose. Clear varnish for the base is recommended.) The head should be painted and allowed to dry before installing the jaw, mouth, and eyeballs.

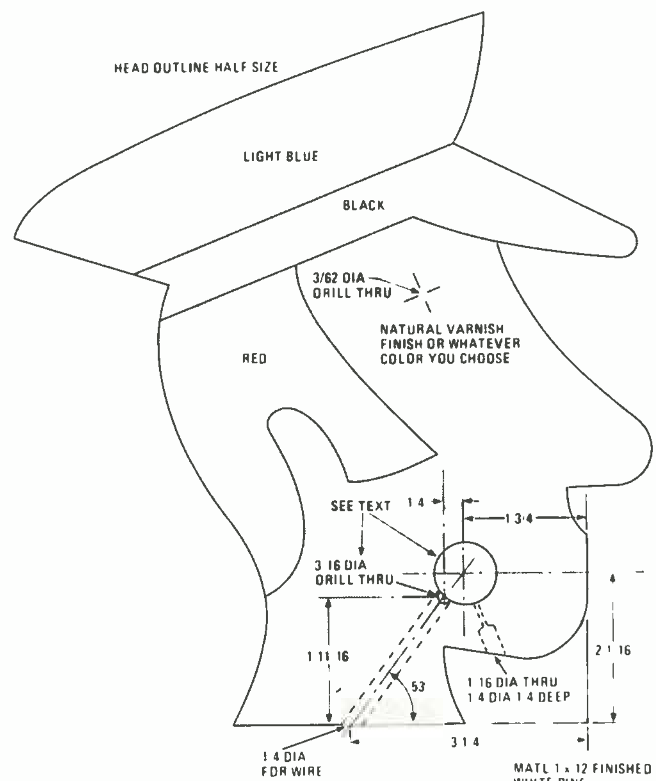


Fig. 2—This is a 50% reduction. A 2X enlargement (full size) can be obtained at your local photocopy shop.

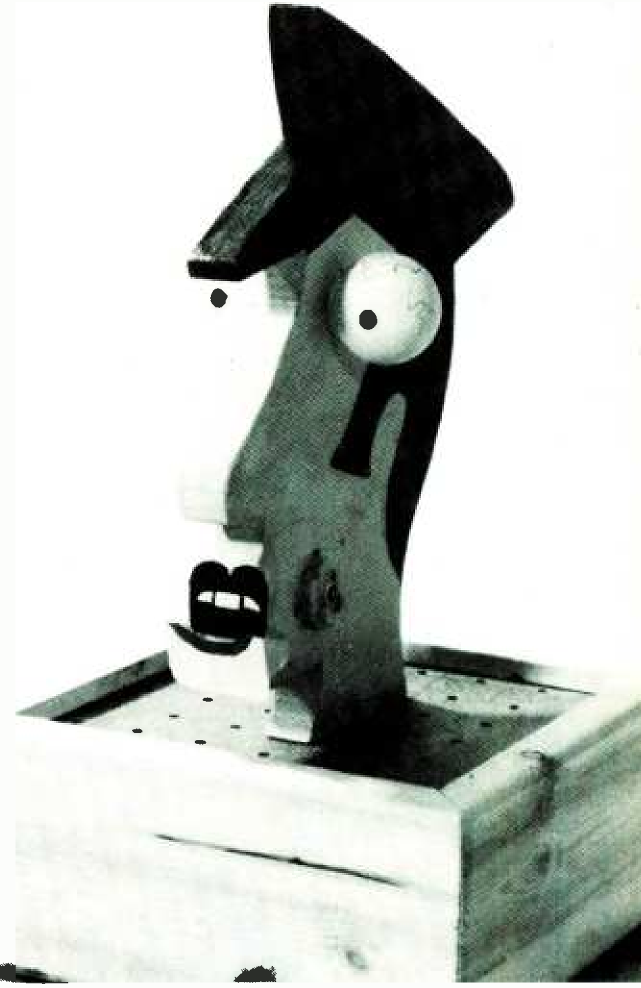
Base Assembly

The following procedures are suggested as a logical way of completing the base (Fig. 4) and head assembly. Those with woodworking experience may choose to proceed along other paths.

Our assembly was done using a glue gun and hot-melt adhesive. That method is fast, but it requires that you work quickly to prevent the cooling, thickening glue from interfering with the correct alignment of the parts. A more compliant adhesive (*Liquid Nails*, for one) can be substituted by those that tend toward panic when under pressure. The use of a

PARTS LIST FOR FRED THE HEAD

SEMICONDUCTORS
D1—1N4004 silicon rectifier diode
SCR1—200V, 6A silicon-controlled rectifier
U1—741 op-amp
U2—7812 12 volt regulator
CAPACITORS
C1—.1-µF, 35-WVDC, ceramic disc
C2—.01-µF, 35-WVDC ceramic disc
C3, C4, C5—100-µF, 35-WVDC, electrolytic
C6—.047-µF, 35-WVDC, ceramic disc
RESISTORS
(1/4-watt, 10% unless otherwise specified)
R1—100,000-ohms
R2—1000-ohms
R3, R4, R5—5600-ohms
R6—5000-ohm potentiometer with switch S1
ADDITIONAL PARTS AND MATERIALS
F1—2A fuse
J1—Phono jack
MOT1— 3-6-VDC motor, Radio Shack 273-228
S1—SPST switch, part of R6
SPKR1—Speaker, 8-ohms
T1—Transformer, AC line, step-down, power; 12.6-volt, 300-mA
T2—Transformer, AC line, step down, power; 6.3-volt, 1-A
Misc:—Protoboard, predrilled, Radio Shack 276-170, wire, insulating Vinyl Sleeving, ping-pong balls (2), hot melt glue, RTV silicon rubber and household cements, toothpick, 1/4-in. wide x 1/32-in. TK brass 5 1/2-in. long, (Available at model and hobby shops), screws, wood, Masonite pegboard, rubber feet, etc.
Kits Available
A kit containing the wooden parts for Fred-the-Head is available for $15.95 plus $3 shipping and handling. A kit containing the wooden parts and detailed plans of the electronics, wood, and metal fabrications is available for $19.95 plus $4 shipping and handling. From Dirijo Corp., P.O. Box 212, Lowell, NC 28098



Although Fred is a true woodenhead like Pinocchio, he can also talk, sing, whistle, hum, and yodel. Although you know for certain that Fred's mouth can only open and close, when moving in synchronization with an audio signal the effect is so good you'll bet that Fred is really talking.

corner clamp is recommended to ensure a professional appearance.

Referring to the illustration, assemble the front of the base and one side, then slide the top piece into the upper grooves of the assembled parts: make sure that the head mounting holes are positioned correctly. If they are satisfactory, remove the top, coat the edges of the upper grooves with adhesive, and then slide the top into place—firmly positioned against the grooves.

Check the fit of the other side piece. If it's good, coat the "active" surfaces with adhesive and assemble it to the top and front. Allow the glue to set.

> **Caution!** Take note that in the following steps the lower grooves of the front and sides aren't glued to the bottom of the base. They serve as slides, which allow the base bottom and back pieces to be removed.

Slide the bottom into the lower side grooves. Make sure that the mounting holes for the circuit board and the speaker are positioned correctly. Position the back on the assembly to check for a proper fit: The top and bottom should fit into all grooves.

Remove only the back. Coat only the lower slot of the back with adhesive. Replace and and center the back. The resulting bottom and back assembly serves as a removable tray for the electronic components.

Head Assembly

The motor should be a good fit to the hole. Before installing it in the head, solder the motor leads to the motor terminals using #22 stranded, insulated hookup wire or its equivalent. Allow at least 16 inches to extend from the head. From the left side of the head, insert the wires into the ¼-in. angled hole, route them along to the motor via the 5/16-in. hole. Insert the motor—shaft first—from the left side. Center it in the head. Secure the motor in place by inserting the #6 × ½-in. sheet metal screw from under the chin. CAUTION!! Do not overtighten and crush the motor!

Jaw Fabrication

The jaw is fabricated from 1/32-in. brass. Before drilling the hole for the motor shaft, check the diameter of the shaft because they do vary in size. A different-size hole may be required. Templates (Fig. 3) are provided for the mouth and lower lip: make "working" copies. Using a suitable adhesive, those should be mounted on a 3-in. × 5-in. white file card. The lip portions are then painted red. Nail polish works

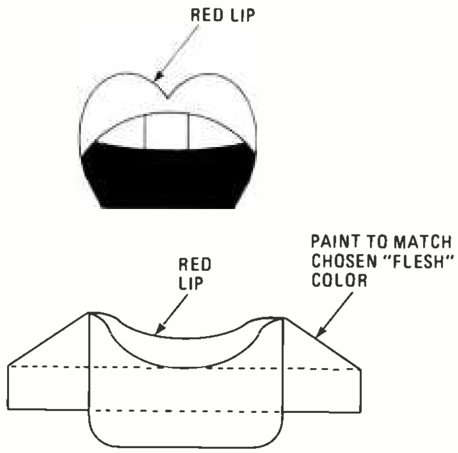


Fig. 3—Make 1.5X photocopies to use as a template when making Fred's mouth

well. After drying, carefully cut them out.

The lower lip/chin mounts on the front of the jaw and is bent around on each side: The dotted lines should be aligned with the jaw. Using a suitable household cement, align and glue the lip/chin to the jaw.

Jaw and Mouth Installation

Obtain two $\frac{3}{8}$-in. thick spacers. With the head laid flat, right side up, place the spacers in front of and behind the motor. Position the jaw on the motor shaft and resting on the spacers. Using a heat sink on the motor shaft and a 60-watt (or greater) soldering iron, solder the jaw to the shaft. Remove any flux residue and the spacers.

Swing the jaw down. Use a silicone-rubber adhesive or household cement. Apply the adhesive to head, and position the mouth as shown.

Eyeballs

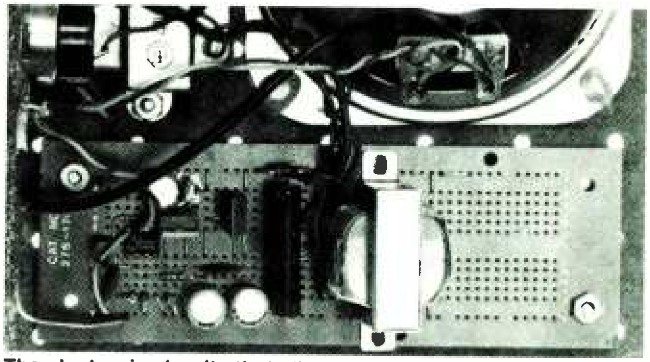
The eyeballs are ping-pong balls. Use an awl, or some other pointed object, to pierce an eyeball-mounting hole at the point where the ball trademark appears. Insert and center a pointed party toothpick through the head's eyeball mounting hole. Place a daub of suitable adhesive on each eyeball at the pierced hole and slide the eyeballs on the toothpick and into contact with the head. When dry, use a black magic-marker to form the pupils.

Jaw-Stops

The jaw-stops should now be positioned and installed. Use this procedure. The mouth-closed stop is the *lower*, the mouth-open stop is the *upper* (Fig. 5).

Position the mouth "closed." The lower lip should fully cover the teeth when viewed from the mouth level. Secure a hollow rubber bumper of some kind—like a rubber "spacer"—below the jaw and in contact with it in the approximate location shown. Mark the position on the head where the $\frac{1}{16}$-in. pilot hole will be drilled.

Position the mouth open. The lower lip should be at the



The electronic circuits that allow Fred to speak and sing are assembled on a piece of Protoboard, or any other kind of wiring board. Use whatever works best for you.

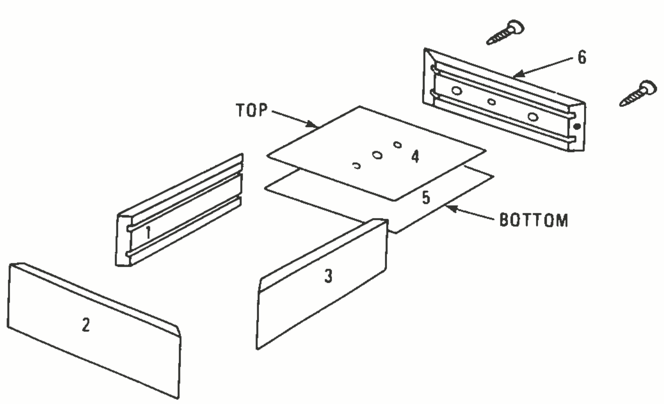


Fig. 4—If you slot the frame of the base the top and bottom can be easily secured during final assembly. Each section of the frame is 8-in. long by 3-1/2-in. high.

DID YOU SEE THE REAL FRED?

Which is the real Fred-the-Head: The one on the cover or the one on this page? Actually it's neither, because you can make Fred into whatever you want. The model we gave the photographer who snapped the cover is the one on this page. The photographer, however, saw Fred differently. He gave Fred the look of "another world" by painting him gray. Then he added "Groucho glasses"; but thought that made Fred look comedic, so he removed the glasses and simply pasted Groucho's eyebrows on Fred.

What do you think Fred should look like. Send us a sharp black-and-white photo of your working model. We'll print the "real winner" for everyone to enjoy. And remember, your Fred can be ugly, beautiful, comedic, tragic, ethereal, anything. Any kind of Fred-the-Head can be a "real winner."

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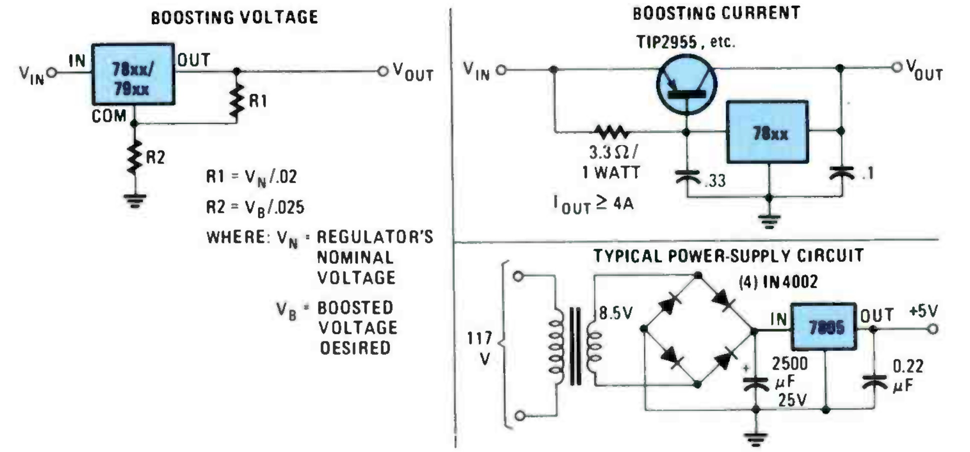
Hands-on Electronics

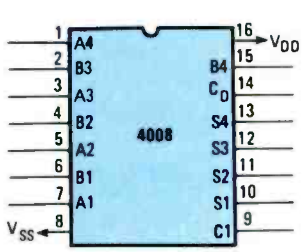
22 Hands-on Electronics FactCard — Using Voltage Regulators



23 Hands-on Electronics FactCard — Zener Diode Selection Guide

Type Number	Power Dissipation Rating at 50°C (Amps)	V_Z (Volts)	I_Z(T) (mA)	Type Number	Power Dissipation Rating at 50°C (Amps)	V_Z (Volts)	I_Z(T) (mA)	Type Number	Power Dissipation Rating at 50°C (Amps)	V_Z (Volts)	I_Z(T) (mA)
1N746	.4	3.3	20	1N963	.4	12	11.5	1N4735	1	6.2	41
1N747	.4	3.6	20	1N964	.4	13	10.5	1N4736	1	6.8	37
1N748	.4	3.9	20	1N965	.4	15	9.5	1N4737	1	7.5	34
1N750	.4	4.7	20	1N966	.4	16	8.5	1N4738	1	8.2	31
1N751	.4	5.1	20	1N967	.4	18	7.8	1N4739	1	9.1	28
1N752	.4	5.6	20	1N968	.4	20	7	1N4740	1	10	25
1N753	.4	6.2	20	1N969	.4	22	6.2	1N4741	1	11	23
1N754	.4	6.8	18.5	1N970	.4	24	5.6	1N4742	1	12	21
1N755	.4	7.5	16.5	1N971	.4	27	5.3	1N4743	1	13	19
1N756	.4	8.2	15	1N972	.4	30	5.3	1N4744	1	15	17
1N757	.4	9.1	14	1N973	.4	33	5.2	1N4745	1	16	15.5
1N758	.4	10	14	1N4112	.4	18	7.8	1N4746	1	18	14
1N759	.4	12	12	1N4728	1	3.3	76	1N4747	1	20	12.5
1N957	.4	6.8	18.5	1N4729	1	3.6	69	1N4748	1	22	11.5
1N958	.4	7.5	16.5	1N4730	1	3.9	64	1N4749	1	24	10.5
1N959	.4	8.2	15	1N4732	1	4.7	53	1N4750	1	27	9.5
1N960	.4	9.1	14	1N4733	1	5.1	49	1N4751	1	30	8.5
1N961	.4	10	14	1N4734	1	5.6	45	1N4752	1	33	7.5
1N962	.4	11	12.5								

24 Hands-on Electronics FactCard — CMOS IC's: 4008



MAXIMUM RATINGS *(Absolute-Maximum Values)*

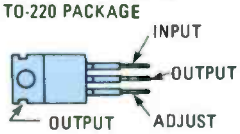
DC SUPPLY-VOLTAGE RANGE, (V_{DD})
(Voltages referenced to V_{SS} Terminal) .... −0.5 to +20V
INPUT VOLTAGE RANGE, ALL INPUTS .... −0.5 to V_{DD} +0.5V
DC INPUT CURRENT, ANY ONE INPUT .... +10 mA
POWER DISSIPATION PER PACKAGE (P_D):
For T_A = −40 to +60°C (PACKAGE TYPE E) .... 500 mW
For T_A = +60 to +85°C (PACKAGE TYPE E) Derate Linearly at 12 mW/°C to 200 mW
For T_A = −55 to +100°C (PACKAGE TYPES D,F) .... 500 mW
For T_A = +100 to +125°C (PACKAGE TYPES D,F) Derate Linearly at 12 mW/°C to 200 mW
DEVICE DISSIPATION PER OUTPUT TRANSISTOR
FOR T_A = FULL PACKAGE-TEMPERATURE RANGE (All Package Types) 100 mW
OPERATING-TEMPERATURE RANGE (T_A):
PACKAGE TYPES D,F,H .... −55 to +125°C
PACKAGE TYPE E .... −40 to +85°C
STORAGE TEMPERATURE RANGE (T_{stg}) .... −65 to +150°C
LEAD TEMPERATURE (DURING SOLDERING):
At distance 1/16 ± 1/32 inch (1.59 ± 0.79 mm) from case for 10s max .... +265°C

RECOMMENDED OPERATING CONDITIONS

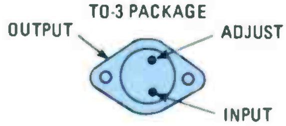
CHARACTERISTIC	LIMITS MIN.	LIMITS MAX.	UNITS
Supply-Voltage Range (For T_A = Full Package Temperature Range)	3	18	V

22 Hands-on Electronics FactCard — Regulator Packages

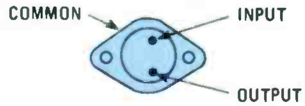
LM317T/LM350T
(POSITIVE REGULATOR)
TO-220 PACKAGE



LM317K/LM350K
(POSITIVE REGULATOR)
TO-3 PACKAGE

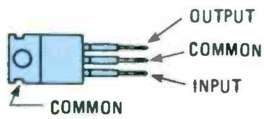


78H05
(POSITIVE REGULATOR)
TO-3 PACKAGE

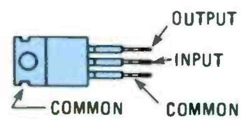


78Lxx
(POSITIVE REGULATOR)
TO-92 PACKAGE

78xx
(POSITIVE REGULATOR)
TO-220 PACKAGE



79xx
(NEGATIVE REGULATOR)
TO-220 PACKAGE



23 Hands-on Electronics FactCard — Voltage Regulator Selection Guide

Three Terminal Regulators

Type	Polarity	Case	V_{OUT} min	V_{OUT} typ	V_{OUT} max	I_{OUT} (nom)	Dropout Voltage
78L05	positive	TO-92	4.8	5	5.2	100mA	1.7
78L62	positive	TO-92	5.95	6.2	6.45	100mA	1.7
78L09	positive	TO-92	8.64	9	9.36	100mA	1.7
78L12	positive	TO-92	11.5	12	12.5	100mA	1.7
78L15	positive	TO-92	14.4	15	15.6	100mA	1.7
7805	positive	TO-220	4.8	5	5.2	1A	2
7806	positive	TO-220	5.75	6	6.25	1A	2
7809	positive	TO-220	8.64	9	9.36	1A	2
7812	positive	TO-220	11.5	12	12.5	1A	2
7815	positive	TO-220	14.4	15	15.6	1A	2
7824	positive	TO-220	23	24	25	1A	2
7905	negative	TO-220	−4.8	−6	−5.2	1A	1.1
7912	negative	TO-220	−11.5	−12	−12.5	1A	1.1
7915	negative	TO-220	−14.4	−15	−15.6	1A	1.1
LM317K	positive	TO-3		adj. 1.2 to 37		1.5A(min)	
LM317T	positive	TO-220		adj. 1.2 to 37		1.5A(min)	
LM350K	positive	TO-3		adj. 1.2 to 33		3A	
LM350T	positive	TO-220		adj. 1.2 to 33		3A	
78H06	positive	TO-3	4.85	5	5.25	5A	2.5

24 Hands-on Electronics FactCard — CMOS IC's: 4008

STATIC ELECTRICAL CHARACTERISTICS

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMIT at 25°C (TYP)	UNITS
Quiescent Device Current I_{DD} Max.	—	0,5	5	0.04	μA
	—	0,10	10	0.04	
	—	0,15	15	0.04	
	—	0,20	20	0.08	
Output Low (Sink) Current, I_{OL} Min.	0.4	0,5	5	1	mA
	0.5	0,10	10	2.6	
	1.5	0,15	15	6.8	
Output High (Source) Current, I_{OH} Min.	4.6	0,5	5	−1	
	2.5	0,5	5	−3.2	
	9.5	0,10	10	−2.6	
	13.5	0,15	15	−6.8	
Input Current, I_{IN} Max.	—	0,18	18	$\pm 10^{-5}$	μA

CHARACTERISTIC	CONDITIONS V_O (V)	V_{IN} (V)	V_{DD} (V)	LIMIT at 25°C (TYP)	UNITS
Output Voltage: Low Level, V_{OL} Max.	—	0,5	5	0	V
	—	0,10	10	0	
	—	0,15	15	0	
Output Voltage: High-Level, V_{OH} Min.	—	0,5	5	5	
	—	0,10	10	10	
	—	0,15	15	15	
Input Low Voltage, V_{IL} Max.	0.5,4.5	—	5	1.5	V
	1,9	—	10	3	
	1.5,13.5	—	15	4	
Input High Voltage, V_{IH} Min.	0.5,4.5	—	5	3.7	
	1,9	—EP	10	7	
	1.5,13.5	—	15	11	

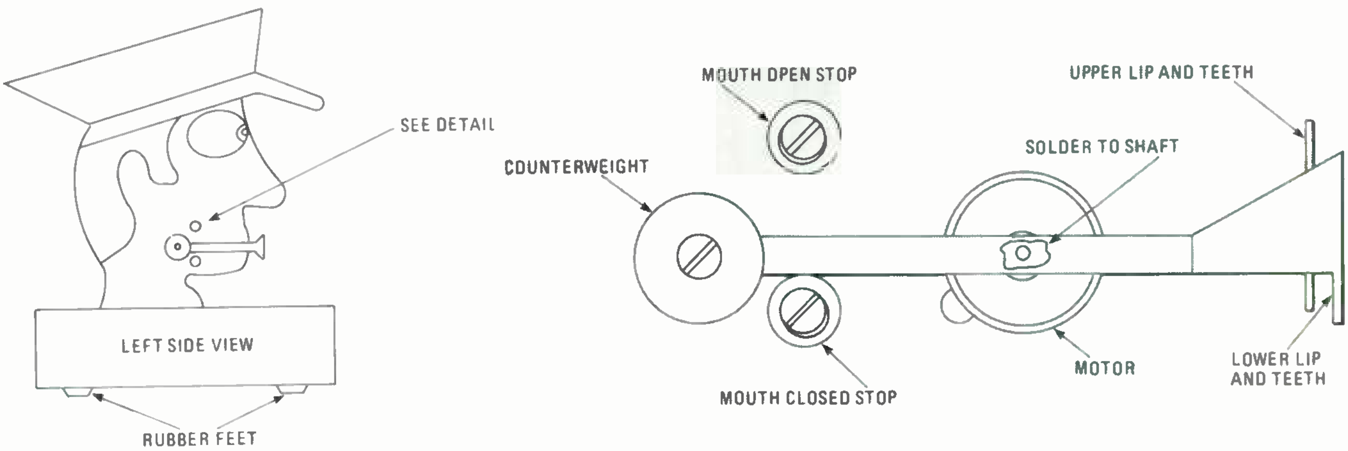
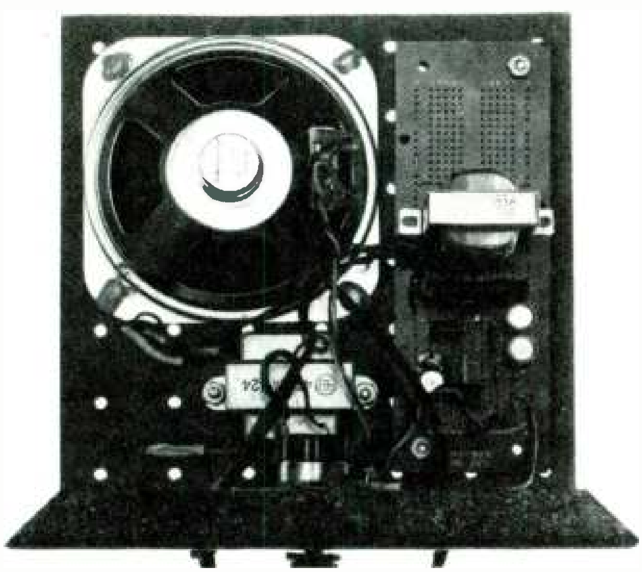


Fig. 5—The mouth mechanism should be counterweighted so that only a small torque from the motor is needed to move Fred's mouth. Two penny-size copper discs will work.



All the electronic hardware, except for the motor that drives Fred's mouth is assembled on a piece of *pegboard* 7-in. × 7-in. The holes provide the ventilation. Keep in mind that the larger the speaker the better Fred will sound.

lower edge of the black mouth area. Position and mark the location of the upper jaw stop. After drilling the holes, install the stops using #6 × 1-in. large panhead screws. Note that the rubber tubes should be loose and free to rotate.

Head to Base

Thread the motor wires through the ⅛-in. hole in the base. Position the head correctly and mark the location where the two holes fall on the bottom of the neck. Remove the head and drill two ³⁄₃₂-in. × 1-in. deep pilot holes in the neck at those points. Install the head with screws and washers.

Testing and Troubleshooting

Before final assembly or applying power for the first time, doublecheck all point-to-point wiring and check the board assembly carefully for shorted runs or unsoldered joints. Also check for proper polarity of C3, C4, C5, and D1.

Connect the audio input to an appropriate source and adjust the source for a normal listening level from Fred's speaker. Connect the linecord to 117-VAC and turn Fred on. Then advance the sensitivity control until the jaw action follows the speech or music being reproduced.

5. Do not adjust the control so that Fred's mouth yawns or opens on a continuous basis. To do so for long periods could cause failure of the DC jaw motor.

If the jaw fails to actuate, check for binding. Also check to make sure that the motor's polarity is correct: Incorrect polarity will only force the jaw more tightly closed.

Check for the presence of 12-VDC on pin 7 of U1.

With no audio input, also check for the presence of 6.3-VAC at SCR1's anode. At the correct audio setting there should be a varying negative DC level present.

Final Installation and Wiring

Using appropriate hardware and adhesive as required, assemble T2, the level control, the speaker, and the audio and power cords on the bottom of the base and the back assembly. Leave approximately 10 inches of free wire. Do not attach the circuit board yet. Connect all jumpers and the motor wires. Use twisted pairs for AC wiring runs and dress them away from the audio input.

Temporarily position the circuit board for testing. After successful testing and/or debuging, remove the board from the bottom of the base, cover the 117-VAC points with RTV rubber, and install the circuit board to the base. The base back assembly may now be slid into place and secured with two #6 × 1-in. cabinet screws. Install four rubber feet on the bottom of the cabinet sides: These are necessary to allow cooling air flow and adequate sound. To prevent possible electrical shock, do not eliminate any insulation features, and do not operate Fred around water or allow him to get wet.

Operation and Level Adjustment

Turn the level control and its power switch to *off*. Provide Fred with 117-VAC and a suitable source of audio. Adjust the audio source to a comfortable listening level from Fred's speaker. Turn Fred's power on and adjust the level control for proper mouth action with voice present. When the level is properly set, the mouth's action will closely follow the spoken or sung words. Do not adjust the level so that the mouth stays open. Turn Fred off when you are done with him.

Although our test and adjustment procedures have been in terms of Fred's "lip-sync'ing" to voice, keep in mind that by careful *tweaking* of level control (R1) Fred can be made to hum, sing, or whistle—at least it will appear that way. ■

PROXIMITY DETECTORS get close to your work

Shouldn't your presence be enough to power-up gadgets? Then let proximity detectors push those pushbuttons!

By Joseph J. Carr

☐THE DIRECTOR OF PLANT OPERATIONS IN A BUILDING where I once worked was a veteran practical joker. He loved gadgets that could be used to set traps for co-workers and any other poor soul who got lost wandering within the bowels of the building. One such toy was a lamp that turned on and off simply by touching the shade, or the body, or the potted plant that formed its base. What it wouldn't do, however, was turn on and off by the switch. He challenged me to tell him how it worked. At first mystified, I soon found out that the gag lamp worked using a capacitive proximity detector.

In addition to toys for gagsters, proximity-detector circuits are widely used in electronic security systems and other applications. For example, one automatic-door design uses a capacitive proximity detector to sense the approach of a pedestrian who wants to pass through the door.

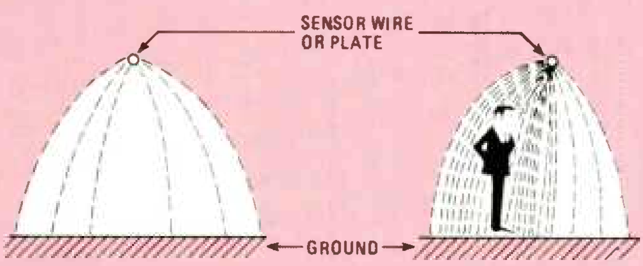


Fig. 1—Anyone walking in the electric field across the capacitor in the proximity detector, will change the field, and thus the capacitance. That appears as a voltage drop within the detection circuitry, which is then triggered.

Capacitance is an electrical property that exists between any two conductors. The classical "textbook" capacitor is a pair of parallel metallic plates separated by a *dielectric* consisting of a tiny air gap or other insulating material. The capacitance (specified in farads, or, more often, the smaller microfarads, nanofarads, or picofarads) is a function of the area of the plates, the spacing between them, and the nature of the dielectric material. The capacitance for several different geometries of plates (including those most useful in proximity detectors) are as follows: Parallel plate:

$$C = 0.2244A/d \text{ pF}$$

Where C is the capacitance in picofarads, A is the area between the plates, and d is the distance between the plates.

Long parallel strips:

$$C = 0.006949d/W \text{ pF/inch}$$

Where C is the capacitance per unit length of the strips in picofarads per inch, D is the separation between the strips in inches, and W is the width of the strips in inches.

Single wire and ground:

$$C = 7.354/\log(4H/D)$$

Where C is the capacitance per unit length of the wire in picofarads per inch, H is the height of the wire above ground in inches, and D is the diameter of the wire in inches.

Because most of the proximity-detector sensors discussed will have single wires and a ground, take a look at the last expression. The two factors that seem most important (and flexible to the designer) are the diameter of the wire used, and its height above the ground. Also affecting the capacitance (but not accounted for in the simplified equation) is the humidity and temperature of the air (dielectric) between the wire and ground.

How Do Proximity Detectors Work?

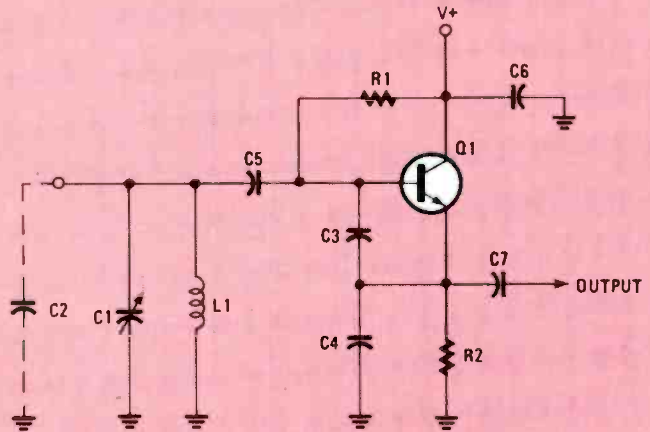
All sensors rely on what the experts call a *transducible property*. In other words, some physical parameter that can be converted into a voltage or current. In capacitive proximity detectors we rely on the fact that the capacitance is dependent upon the dielectric of the capacitor. Dry air is said to have a *dielectric constant* of 1, while the human body has a dielectric constant of about 80. Thus, when someone enters the field of a capacitor (see Fig. 1), the capacitance will increase by up to 80 times the former value. The electrical flux between the sense wire and ground increases dramatically because of that. There are several methods for using the capacitance for detection: oscillator, electrometer, and bridge circuits.

Oscillator Circuits

An LC oscillator (see Fig. 2) produces an output that is determined by the inductance and capacitance of the resonant tank circuit. The inductance is L1, while the capacitance is the variable capacitor C1 and the sensor capacitance C2. There will also be stray capacitance and inductance in the circuit, but they are not shown as discrete components. The circuit shown here will oscillate at frequencies from about 20 kHz to 10 MHz, depending upon the LC tank-circuit components, and the particular values of the feedback capacitors (C3/C4) that are selected.

Figure 3 shows a method by which two oscillators can be used in a proximity-detector circuit. Two sense wires are used in the circuit (Fig. 3A). The reason for that is that changes in temperature and/or humidity will easily change the oscilla-

Fig. 2—Oscillator circuits make very sensitive proximity detectors. The frequency of the actual tank circuit is dependent upon the variable capacitance used as the sensor.



tion frequency because they change the capacitance. Each sense wire is a length of #12 or #14 insulated wire mounted on insulated supports such as fence posts.

Figure 3B shows a block diagram of a detector that uses the capacitances in a heterodyned *beat-frequency* circuit. There are two oscillators selected so that the third harmonic of oscillator 1 will be close to the fourth harmonic of oscillator 2. For example, a common scheme sets oscillator 1 to a frequency of 100 kHz, while oscillator 2 is set to 74.875 kHz. The third harmonic of oscillator 1 is therefore 300 kHz, while that of oscillator 2 is 299.5 kHz. Therefore, the beat note at the output of the mixer stage will be the difference in frequency, or 500 Hz. By using that seemingly complicated method, we obtain a very large percentage change of beat frequency for relatively small changes in operating frequency. For example, causing oscillator 1 to shift to 100.010 kHz causes the beat-note frequency to shift to 530 Hz. The difference between the *same frequency* method and the harmonics method is that a 10-Hz change represents a 0.01-percent change in operating frequency, and a 6-percent change in harmonic beat frequency.

The filter circuit in Fig. 3B is a sharply tuned operational-amplifier passband filter centered on the normal beat frequency (500 Hz in our example). As long as the output of the filter sees a signal the trigger circuit will not be alarmed. But if the operating frequencies of the oscillators changes, the beat frequency is not longer within the filter passband, so the trigger circuit sounds the alarm.

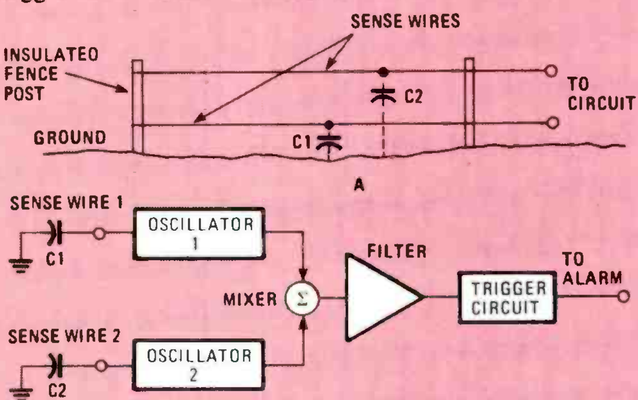


Fig. 3—Long sense wires can be used to protect an entire perimeter such as the fence-post design in A. The wires are connected to oscillators that are precisely tuned.

Electrometer Circuits

An electrometer is an amplifier with an extremely high input impedance. Traditionally, electrometers have been used to measure the outputs of devices such as very high impedance transducers and charged capacitors. The high input impedance does not bleed the charge off a capacitor as it measures the charge voltage.

Figure 4A shows the basic circuit for an electrometer proximity detector. The sense wire produces a capacitance (C1) at the input of the electrometer amplifier (A1). The capacitor is charged from a DC power supply through a high-value resistor. The value of the voltage across the charged capacitor is given by the expression Q/C, where Q is the charge in Coulombs and C is the capacitance in farads. When someone enters the field of the protected area, the capacitance increases tremendously, so the voltage across the capacitor will take a dip. That change of voltage is amplified by the electrometer and used to indicate intrusion.

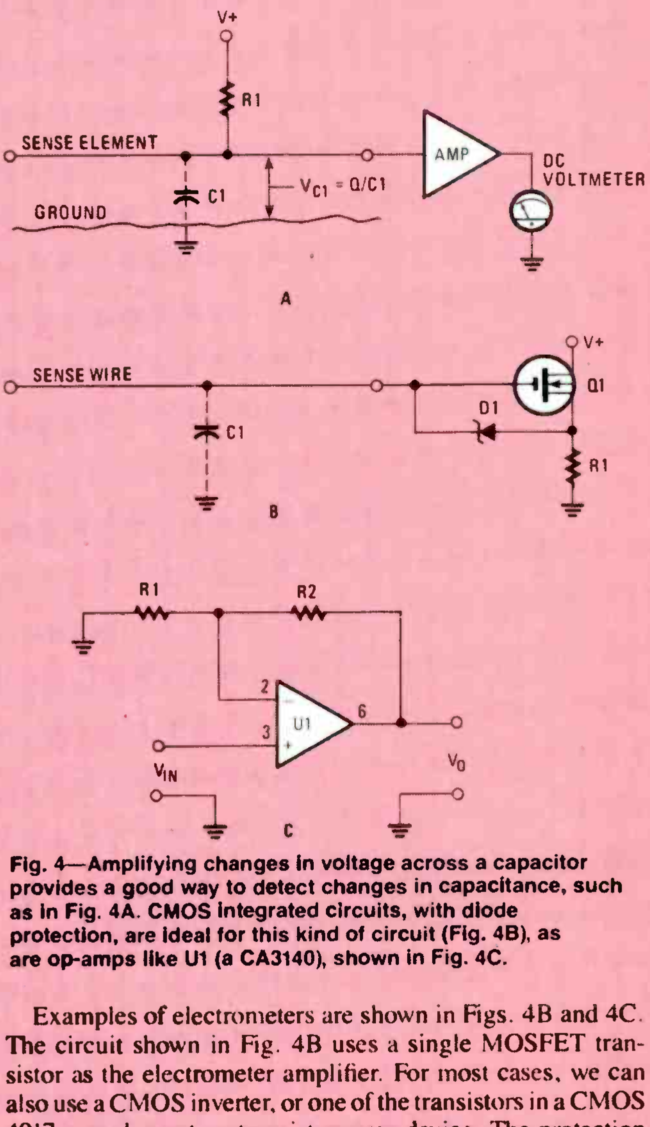


Fig. 4—Amplifying changes in voltage across a capacitor provides a good way to detect changes in capacitance, such as in Fig. 4A. CMOS integrated circuits, with diode protection, are ideal for this kind of circuit (Fig. 4B), as are op-amps like U1 (a CA3140), shown in Fig. 4C.

Examples of electrometers are shown in Figs. 4B and 4C. The circuit shown in Fig. 4B uses a single MOSFET transistor as the electrometer amplifier. For most cases, we can also use a CMOS inverter, or one of the transistors in a CMOS 4017 complementary transistor-array device. The protection diode shown in Fig. 4B is inherent in B-series CMOS devices, but for other MOSFET's it must be provided. The purpose of the diode is to shunt harmful high voltage from electrostatic potentials harmlessly around the delicate gate structure.

The unit's sensitivity—a measure of the device's input impedance, which indicates the degree of load placed on the circuit-under-test by the meter itself—is a prime factor in selecting the instrument that best serves your needs. The VIZ unit (shown in the photos) has a sensitivity of 20,000 ohms/volt. Multiplying the full-scale voltage on any given range by the sensitivity (in this case 20,000 ohms/volt) gives the input impedance. For example, if the meter is placed on the 50-volt scale, the input impedance is:

$$Z_{in} = 50 \times 20{,}000 = 1{,}000{,}000 = 1 \text{ Megohm}$$

In most cases, the VOM is fine for vacuum-tube circuits, but when it comes to solid-state circuits, they often load the circuit too much for practical use. For example, when measuring the base voltage of an NPN common-emitter transistor amplifier (see Fig. 1), you would expect to find a base-to-emitter voltage of between 0.2 and 0.3 volt for germanium or 0.6–0.7 volt for silicon transistors.

However, when the analog meter is placed on the 1.5-volt DC scale, it has an input impedance of 1.5 × 20,000, or 30,000 ohms. Unfortunately, that resistance is extremely close to the value of the bias resistors used in transistor circuits; therefore, the application of the meter probes changes the circuit's bias condition, rendering the measurement invalid. But the VOM is not without virtues: It is truly a minimum-hassle instrument to keep, store, and use; and it is very portable—factors that make the VOM popular with people who work for long periods in remote areas without the possibility of easy resupply.

Another plus is the VOM's usefulness when working around radio transmitters and other high-power RF amplifiers. That's because they are without any active devices to be misbiased by strong RF fields; thus, they'll work around transmitters where other (more expensive) instruments fail.

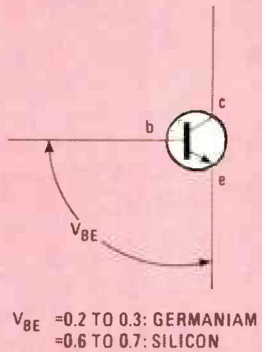


Fig. 1—VOM's are fine for vacuum-tube circuits, but when checking solid-state devices—say, the base volt age of NPN common-emitter amplifiers—the VOM often loads the circuit too much for practical use.

Electronic Multimeters

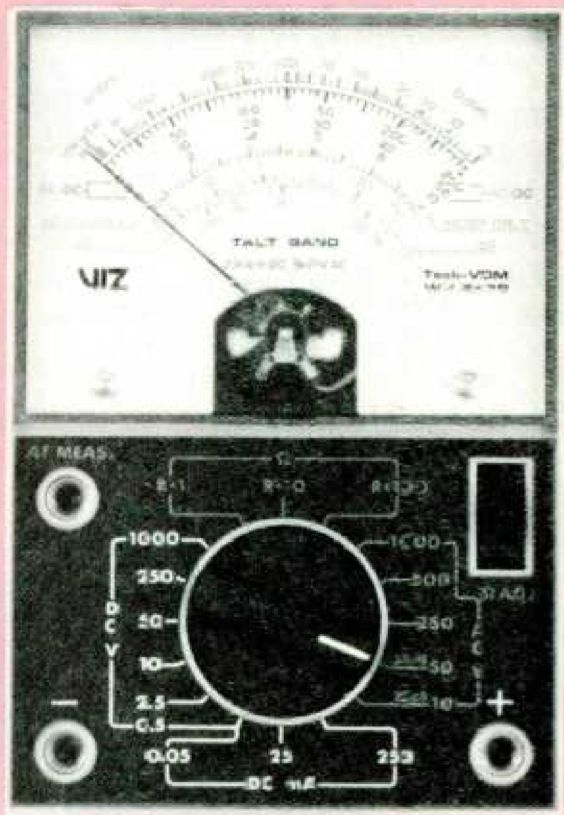
Another class of meters, which are collectively called electronic voltmeters (EVM), derive their names from their active input-circuit device: vacuum tubes, transistors, or field-effect transistors. The purpose of the input device is to increase the input impedance; thereby, reducing the loading effect of the meter on the circuit under test. Members of this class include everything from the early vacuum-tube voltmeters (VTVM) to transistor voltmeters (TVM) to field-effect-transistor multimeter—FETVM or FETMM—(see photos) to digital meters (DMM).

The old VTVM (see photos) had a typical input-impedance specification of 10 megohms, with an additional 1 megohm in the probe, for a total of 11 megohms. Additionally, there was usually 50-pF of capacitance shunting the input resistance. Modern FETVM and other EVM types often sport input impedances much higher than 11 megohms. (I can recall seeing 100 megohms advertised.) Like the VOM, the FETVM is a multi-range meter that uses front-panel switching to select both range and function (DC volts, AC volts, ohms, etc.). But, unlike the VOM, the FETVM and all other electronic voltmeters require a DC supply to power the active devices, before any measurements can be made.

In most cases, DC power is supplied by a battery, although some 117-volt AC-operated models are available. And unlike the VOM, electronic voltmeters are somewhat sensitive to RF fields; thus, they are not well suited for work around high-power transmitters and other RF generators (electro-surgery machines, diathermy, inductive heaters, etc.). Although both the FETVM and VOM have an AC-volts scale, their very low AC ranges are no substitute for the dedicated AC voltmeter required for measurement or alignment of audio circuits. That because the AC scales of VOM's and EVM's, typically, have limited frequency response. While they are accurate when used on 50 to 400 Hz AC power, their accuracy drops off sharply as frequency increases.

Digital Multimeters

The more-modern version of the electronic multimeter is the digital type (several units are shown in the photos). Those instruments use internal analog-to-digital (A/D) converters to transform the input voltage to a binary code that is displayed on a seven-segment readout. The digital type represents a large majority of multimeters sold today. Like EVM's and



This VIZ multimeter, which contains no active components, is a modern-day version of what is probably the oldest form of VOM. It requires no power other than a battery, which is used for resistance measurements.

VOM's, digital multimeters (DMM) measure DC volts, AC volts, milliamperes, and ohms.

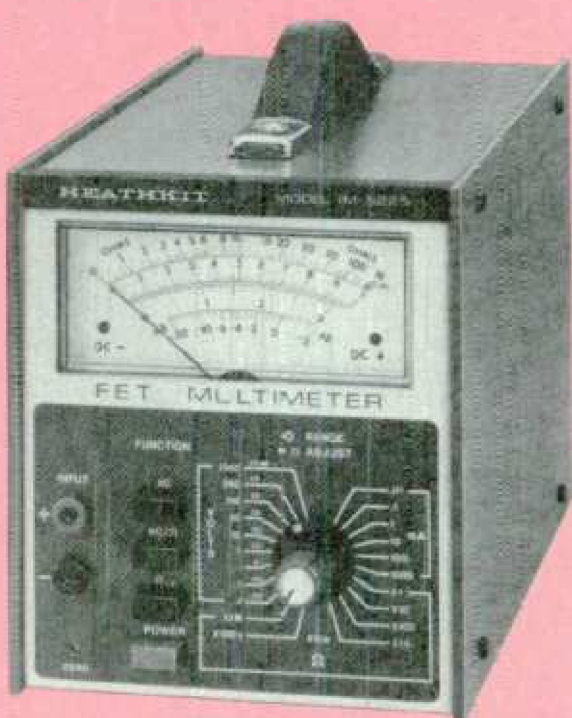
The DMM is often advertised as having 3½-digit or 4½-digit readouts. The *half digit* refers to the *most-significant-digit* or MSD (the one to the far left of the display), which can only display a 0 or 1. While the number of digits can be regarded as a rough measure of precision, it is no guarantee of greater accuracy: Nor is a DMM necessarily more accurate than a VOM, in certain applications. For instance, noisy signals tend to be integrated (low-pass filtered) by the inertia of an analog meter pointer, but can play tricks on some DMM's.

While it's true that DMM's have the potential for more initial and long-term accuracy than VOM's and other EVM's, the accuracy of all meters depends on the quality of internal circuits and other factors; thus, the size of the display cannot be taken to be an absolute indicator of quality.

Which One to Buy?

The type of meter needed and the number of features incorporated into it depends on what kind of work you intend to do and, to some extent, what you can afford. For instance, because I have a ham radio set with 1-kilowatt linear amplifier, my meter may have to work in high RF environments. As a result, a classic VOM (that's darn near as old as I am!) with a 25-kilowatt high-voltage probe is a part of my testbench setup. I also have a handheld Beckman DMM that measures the normal parameters as well as capacitance from 2000-pF (with 1-pF resolution) to 2000-µF full-scale. That last feature turns out to be of immeasurable benefit to anyone who develops circuits for amateur radio, SWL, and general-electronic hobbyists who are workbench oriented.

Digital multimeters are most often advertised as having 3½-digits or 4½-digits, which refers to the fact that the most-significant-digit (far left) can display a 1 or 0 only.



Early FET multimeters—a great improvement over VOM's—were large, bench-top instruments, which required a DC supply to produce a reading on the unit's resistance scale, as well as to power the active devices.

Other useful features to look for in a DMM are *diode* and/or aural *continuity* test capabilities. The diode-test mode is used to check-out diodes and the PN-junction of both PNP and NPN bipolar transistors. The normal ohmmeter function of a DMM's uses a very-low voltage, too low to forward-bias PN junctions. The diode mode (usually indicated by a diode symbol on the meter's front panel) is actually a resistance mode with a voltage that's high enough to forward bias the PN junction.

The aural continuity tester is basically a resistance scale that *beeps* when the probes see a low resistance. Why, you may be wondering, is that important? Try ringing out a multi-conductor cable, say for a computer printer or modem; or worse yet, an intercom cable while standing on a ladder. You simply cannot watch both probe tips and the meter at the same time—at least not easily. The beep of the meter tells you when the connection is made, and its absence indicates an open circuit.

Proper Multimeter Use

The way in which the meter is connected to the circuit is critical; failure to use it correctly can (and will!) result in catastrophe. Current, voltage, and resistance are measured in different ways. Figure 2 illustrates the methods for connecting a multimeter to read current (I) and voltage (V). Although the illustration indicates separate meters for voltage and current measurements, a multimeter should be connected the same way depending on which parameter you are reading.

It's all too easy to misconnect a multimeter by switching the function without first repositioning the probes. There are two rules for connecting ammeters and voltmeters (which also applies to the equivalent multimeter functions): Voltmeters are always connected in parallel with the load; and current meters are always connected in series—*never* in parallel—with the load.

The current rule is especially important. If an ammeter is connected in parallel with the load, its low internal resistance will draw large amounts of current (much greater than the meter's full-scale range) from the power supply of the circuit under test. In the case of an analog meter, the pointer will peg (bend). Those higher currents could also cause the meter's internal workings to open up, short out, or change in value. The problem is lessened with some DMM's (some manufacturers place fuses in series with the meter probes), but the problem is still present.

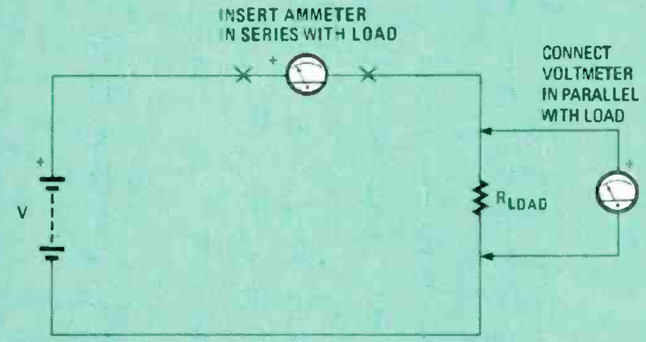
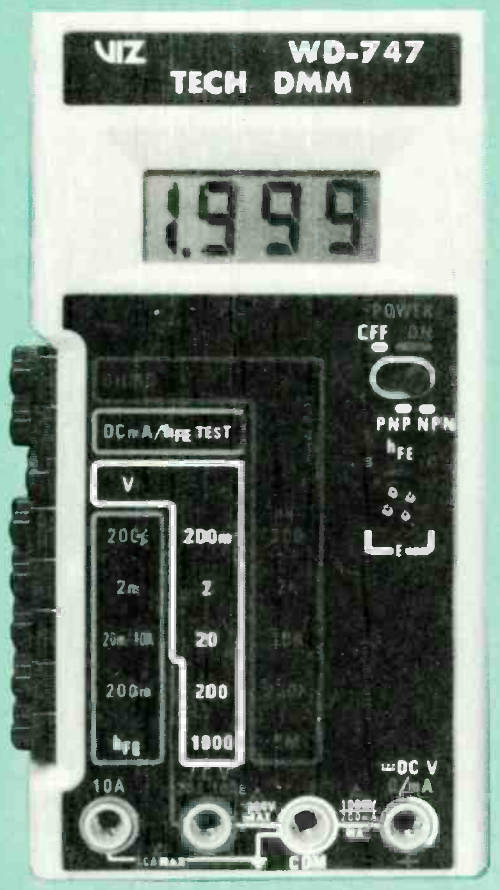


Fig. 2—When using a multimeter to read current (I), always connect the instrument in series —*never* in parallel—with the load. For voltage (V), the meter should be connected in parallel with the load.



The latest generation of digital multimeters, aside from reading the usual parameters, may be capable of testing transistor h_{FE} (gain), checking diodes, and some may even include a capacitance meter. And really sophisticated DMM's may include a bargraph display to emulate analog instruments.

The procedure for reading resistance is illustrated in Fig. 3. It is essential in making resistance measurements that power be removed from the circuit under test, and that at least one leg of the unit being checked is disconnected from the circuit. There are two reasons for that procedure: First, there may be

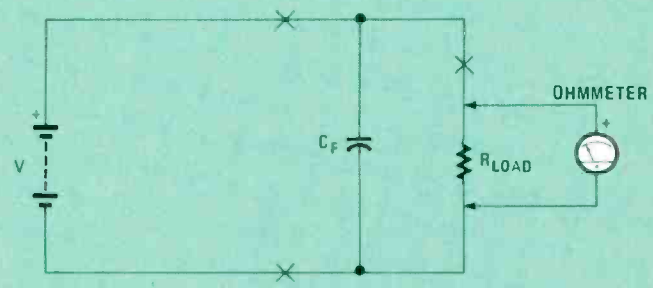


Fig. 3—It is essential in making resistance measurements that power be removed from the circuit under test, and that at least one leg of the unit being checked is disconnected from the circuit.

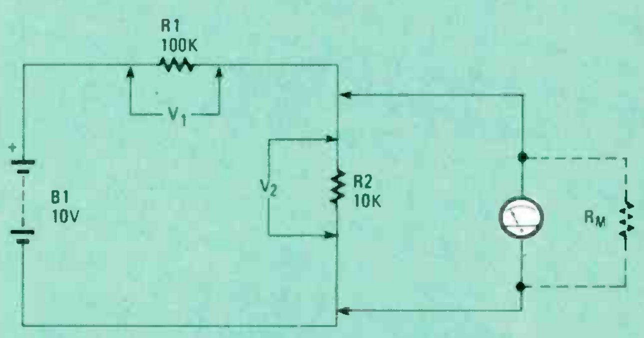


Fig. 4—The problem of loading comes about as a result of the meter's internal resistance being too close in value to that of the component or branch across which voltage is being measured.

current stored in capacitors in the circuit, which can zap certain meters. Power-supply filter capacitors are particularly notorious in that respect. It is a good habit to get into, even though disconnecting components can be a bit annoying. Second, there may be parallel alternate paths for current that can cause erroneously low readings.

Voltmeter Errors

Errors in reading voltage are often caused by misconnecting the test instrument. For instance, I can recall an electrical-engineering professor (actually a graduate teaching assistant) who could not tell a certain student why the voltages read in a lab experiment were considerably lower than those called for in the lab manual. As it turned out, the erroneous reading was caused by the loading affect of the voltmeter on the circuit.

To understand the problem, you must first realize that the voltmeter has a certain input impedance. For a VOM, the input impedance can be determined by multiplying the sensitivity (ohms/volt rating) by the full-scale range setting. Most good meters have a sensitivity of 20,000 ohms/volt, and some especially fine meters are rated at 100,000 ohms/volt. But there are a lot of very cheap imports rated at 1000 ohms/

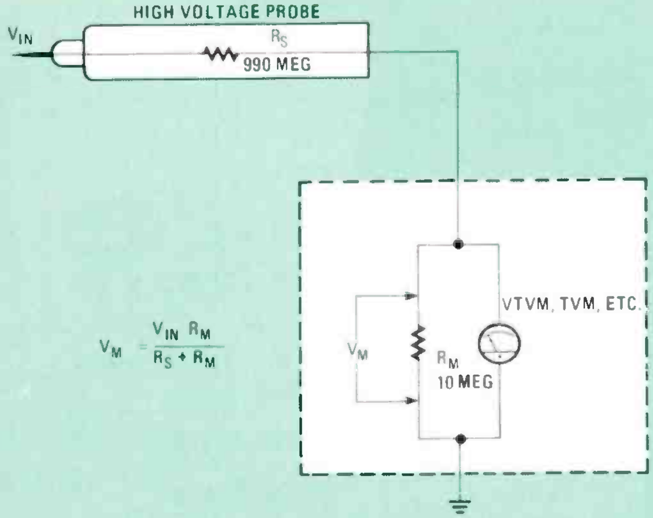


Fig. 5—High-voltage capabilities can be added to an electronic voltmeter, through the use of an attenuator probe, which can be a simple series resistor (R_S). In this illustration, the meter would only read 1/10th of the actual input voltage.

Somewhat unusual, this digital multimeter features both a digital readout and an analog scale, which is particulary useful when you need to track a constantly varying value.

volt, which is extremely poor. The 20,000 ohm/volt uses a 50-μA meter movement, while the 1000 ohm/volt uses a 1-mA meter movement! (The sensitivity reflects the natural full-scale range of the meter movement used in the VOM.)

Figure 4 shows a sample circuit—consisting of a 10-volt power source and two series-connected resistors, R1 and R2—which can be used to illustrate the problem of loading. Now, let's assume that what we want to know is the voltage across resistor R2 (V_2). The correct voltage can be calculated:

$$V_2 = (V_{in})(R2)/(R1 + R2)$$
$$V_2 = (10)(100,000)/(10,000 + 100,000)$$
$$V_2 = .909$$

That value, .909 volt, is proportional to the resistor value. Note that the resistors have a 10:1 ratio, which is reflected in the amount of voltage dropped across each resistor. Now, consider what happens when we connect the voltmeter across resistor R2. The total resistance in the R2 branch of the circuit becomes the parallel combination of R2 and the meter's input resistance. With a 1.5-volt full-scale setting using a meter with a 20,000-ohm/volt sensitivity, the resulting input impedance is 30,000 ohms; and for a 1000 ohms/volt model set to that same range, the input impedance is 1500 ohms. So, we can see that when a meter is connected in parallel with R2, the combination of R2 and the input impedance forces new values of R2 of 7500 ohms and 13000 ohms. Those heavily loaded resistances reduce the measured voltage from 0.909 to 0.697 and 0.128 volts, respectively, for the 20,000 and 1000 ohm/volt units. Those are substantial errors, which show the reason for using a voltmeter with a high internal impedance.

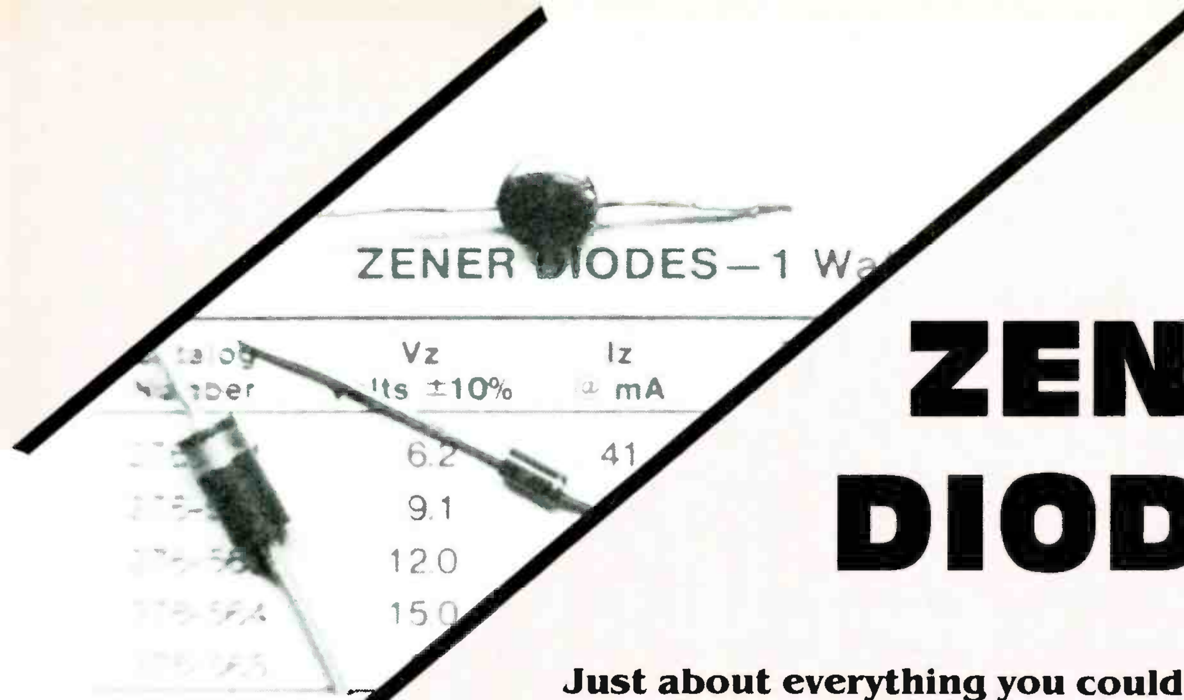
High-Voltage Probes

Most high-voltage meters are really ordinary voltmeters with a multiplier resistor or voltage-divider network added. Figure 5 shows a simple method of adding high-voltage capability to standard multimeters. By replacing the meter's normal probe with an attenuator probe, the meter can be made to read much higher voltages. Such probes, incidentally, are widely available from electronics supply stores that do lots of business with television technicians. TV service technicians often use them in conjunction with a regular voltmeter to measure the anode potential of color TV sets.

The meter in Fig. 5 has a specified input impedance of 10 megohms, while the probe's resistance (R_S) is 990 megohms; thus, their combined series resistance is 100,000 ohms.

(Continued on page 116)

The Simpson 260-type VOM is probably the most famous of all, having served as the archtypical design for many others, both more and less expensive. It is the "reference standard" VOM



ZENER DIODES

Just about everything you could possibly want to know about Zener diodes except why they're round and smell funny when they get hot!

By Bob Grossblatt

THERE ARE LOTS OF PLACES TO MAKE A MISTAKE WHEN you're going from a good idea to a working circuit. One way to keep the mistakes to an absolute minimum is to have a practical understanding of all the components that you intend to use. Once you know what a part does when it works, you automatically know what to look for when it doesn't.

One of the most commonly misunderstood components is the *Zener* diode. It's a pretty safe bet that, next to transistors, more Zener diodes have been destroyed through misunderstanding than any other active component. By the time you reach the end of this article, you'll not only know how to keep them from blowing up, you'll also see how they work and understand what they can do to solve problems in your designs.

Before we look at Zener's in particular, we have to talk about diodes in general. There are a lot of interesting things to say about diodes on the theoretical level but, practically speaking, the most important characteristic is that they only allow current to flow in one direction. As a result, the two main applications for diodes are switching and rectifying, both of which depend on that ability to one extent or another.

If you look at diode specifications in a data book, you'll be overwhelmed by the mass of data for each individual part. For most uses, only a few of the numbers are important. The others, such as the operating temperature and frequency, are less frequently given and have less of an affect on diode performance. If the characteristics described here aren't exactly the same as the ones in your data book, the blame lies with the industry. It's sad, but true, that there's no ANSI-type standard for diode ratings. Fortunately, however, most of the names chosen for the various diode characteristics are close enough so that you can figure out what the manufacturer is talking about. We'll briefly discuss how diodes are formed; cover some important Zener-diode specifications, and take a quick look at Zener applications.

Diode Formation

Diodes are formed by connecting some P-type material and N-type material. Without going into the nitty gritty, when the N-type material (cathode) is made more negative than the P-type material (anode), the diode is *forward-biased* and current begins to flow. If the P-half is made more negative, the diode is *reverse-biased* and no current will flow.

With those basics in mind, it's obvious that there are limits involved. Diodes need a certain amount of voltage to conduct—too little and they'll do nothing; too much and they're history. And that's what all the data-sheet numbers (operating parameters) are about.

The minimum voltage needed to turn on a diode depends on its physical make-up: germanium or silicon—the former needs .25 volt and the latter needs .65 volt. Since germanium diodes can turn on with a much smaller voltage, they're most often used in the front ends of radios, small-signal switching, and similar low-voltage applications.

Silicon diodes, besides having a higher turn-on voltage, are generally able to handle more power. That's why you'll find them in rectifier circuits—half-wave, full-wave, and full-wave bridge—and other circuits that have to handle large amounts of current.

There are two important diode specifications that relate specifically to the turn-on voltage: *maximum forward voltage*, (V_{fm}) and *maximum forward current* (I_{fm}). Both of those parameters are a measure of how much power a forward-biased diode can handle before it goes up in smoke. Some data books also list the *maximum peak* (V_{fp} and I_{fp}) figures, as well.

The difference between the two specifications is that while you can continuously subject the diode to the maximum values, you can only hit the peak numbers in short bursts. In practice, if your circuit puts spikes across a diode that are anywhere near the rated peak figures, you're really asking for trouble. It's a good idea to go back to the data book and choose a better diode.

Just as a diode has limits when forward-biased, there are maximum ratings for the reverse-biased condition, as well. Diodes are designed to prevent current flow if the voltage at its cathode is more positive than that at its anode. That's exactly what happens as long as you pay attention to the *breakdown voltage*, also referred to as *Peak-Inverse-Voltage* (PIV) or *Peak-Reverse-Voltage* (PRV). That's voltage at which the diode will throw in the towel and start conducting; it's an important number because a diode isn't a linear device.

When a diode is reverse-biased, theoretically no current flows through it—although in practice, all diodes leak to some extent. That's the *Reverse Current* (I_r) rating given in the data sheet. For most diodes, the I_r rating is constant at all reverse-voltage levels until you reach the PIV. As soon as you pass that point, the diode breaks down and reverse current starts to flow. What's important here, and also interesting, is that the amount of breakdown current is orders of magnitude greater than the leakage current. The moral is that a diode driven into breakdown can take a lot of other components with it when it dies.

The behavior of a diode when the PIV is exceeded is interesting because the voltage across the diode will stay the same, even when you increase the applied reverse voltage. A simple application of Ohm's Law indicates that more and more current has to pass through the diode. That translates into heat, smoke, and a trip to your local diode store for a replacement.

Taking Advantage

That characteristic of diodes, however, didn't go unnoticed by the manufacturers. Since diodes operating under breakdown or avalanche conditions can swallow any increase in voltage, several semiconductor designers realized that they had the beginnings of a very-useful, special-purpose diode. And so the Zener diode was born.

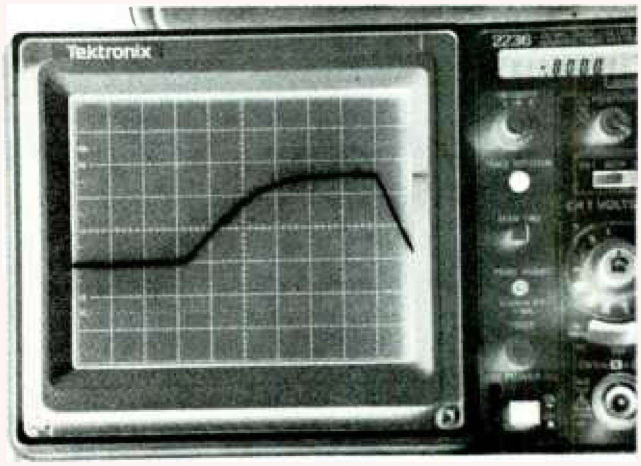
Zener diodes are regular diodes specially designed to operate under avalanche conditions. They have a specifically-defined breakdown voltage and can safely pass a predetermined amount of current. Now that you know that, you should realize that any diode can be used as a Zener diode.

That's not such a "hot" idea, because pushing a standard diode into breakdown usually destroys it. The only way to find the diode's exact breakdown voltage is to use a variable power supply and a voltmeter. However difficult that may be, it's a lot easier than finding the maximum value of the reverse current; and exceeding *that* value will definitely destroy the diode, damage your circuit, and ruin your day.

Since the unusual characteristic of a Zener diode is its ability to maintain constant voltages, most applications for them have to do with either voltage regulation or generating reference voltages. As with most other things, the best way to understand how a Zener behaves is to put one in a circuit and do some simple experimenting.

The Heart of the Matter

Figure 1 is the schematic of a Zener-diode circuit. Even though the circuit is somewhat bare, it's a typical layout for using a Zener diode. By placing the two meters in the circuit (as shown), we can watch the way the diode works. Once you have the circuit assembled, slowly increase the voltage from the variable power supply. The voltmeter reading on the output will continue to climb and the ammeter will stay at



Zeners pass only leakage current until the applied voltage reaches its breakdown value, then V_{out} rises rapidly.

zero. Once you reach the avalanche voltage of the Zener, (called the Zener voltage or V_z), the Zener goes into breakdown and starts to do some work. Cranking the voltage past the V_z point will demonstrate what the Zener is doing in the circuit. As the input voltage increases, the output voltage remains constant, while the ammeter indicates a rising current through the Zener.

You can up the input voltage as much as you want, but the output voltage will remain within a few volts of V_z. Of course, there are limits to that. The Zener doesn't have the same internal protection you'll find in the 7800 series of voltage regulators. If too much current flows through the Zener, it will blow up. Each Zener has two important ratings; the Zener voltage V_z, and current I_z. It's a good idea to keep those numbers in mind if you're going to put a Zener diode in a circuit. V_z specifies the output voltage and I_z helps you to calculate the value of R_z.

Even though the Zener is a specially designed diode, it still has all the other standard diode characteristics. Among them is that there's no limit to the amount of current it will try to conduct. Just as with LED's, using a Zener successfully means putting a resistor in the circuit to limit the current flow. Calculating the value of the resistor is a straight application of Ohm's law.

If you're into circuit analysis, you can go through the math yourself; but if you're practical minded, you can use the formula $R_z = (V_{in} - V_z)/1.1\,(I_{maxload})$ to calculate the value

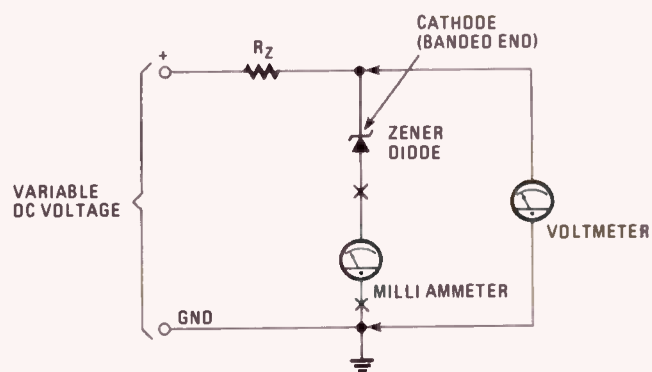


Fig. 1—This circuit illustrates a typical application of Zener diodes. Because of the characteristics, Zeners are often used to generate reference voltages or as voltage regulators.

of the resistor in ohms and the formula $P_r = (I_z + I_{maxload})2 (R_z)$ to calculate the resistor's wattage.

It's so simple to put a Zener to work that it often becomes easy to forget that they don't have any internal protection. Using a Zener with too small a resistor is a sure way to blow it up so be sure to use the formulas before you power-up your circuit.

We've already seen that any diode can work as a Zener. A regular diode won't behave as *well* as a Zener, but it can be used by thinking of the PIV as V_z and I_r as I_z. The value of the resistor will be more critical in that case, since I_r is usually in the microampere (μA) range as compared with I_z, which is usually in the milliampere (mA) range.

If you have a drawer full of diodes, the circuit in Fig. 2 can be used to test their Zener action. Once you've got the polarity of the diode straight (the banded end is the cathode), put it in the circuit and start slowly increasing the voltage. When you reach V_z, the ammeter will start to show current flow and the voltage will remain constant as you continue to increase the input voltage. Don't let more than 5 mA flow through the diode; too much current will blow it up.

Finding V_z is, as you've seen, pretty straightforward. Determining I_z, however, is something else. There's no way to find I_z (and consequently the diode's power rating), without destroying the diode in the process. All you can do is to make an intelligent guess based on its size and construction. Physically larger diodes and those that come in metal cases are better than plain diodes. Just about the only way to make a reasonable estimate is to compare the size of the unknown diode to one with known specifications—and then divide by two.

If you use unmarked diodes in a circuit, don't push them to the wall. Under-rate them and, if possible, put a heatsink on them. A much better idea is to go out and buy a new one with known specifications. A Zener diode is a cheap component but you would feel silly if you blew one up. ■

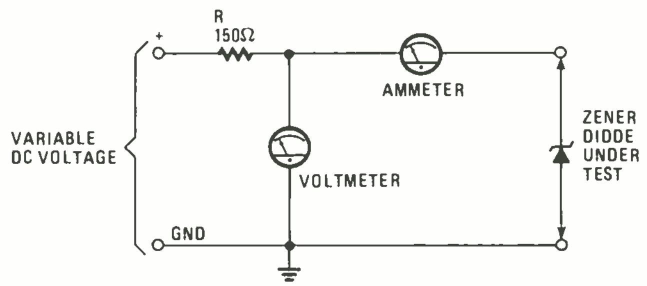


Fig. 2—This circuit can be used to test Zener-diode action. By placing the two meters in a Zener diode circuit (as shown) and slowly increasing the voltage using a variable power supply, you'll find that the voltage reading continues to climb and the current reading stays at zero until the avalanche voltage (V_z) is reached. However, upon reaching V_z the voltage stabilizes, as current rises through the Zener.

EXTEND YOUR MONITOR CONTROLS—BUT NOT YOUR BUDGET

By Herb Friedman

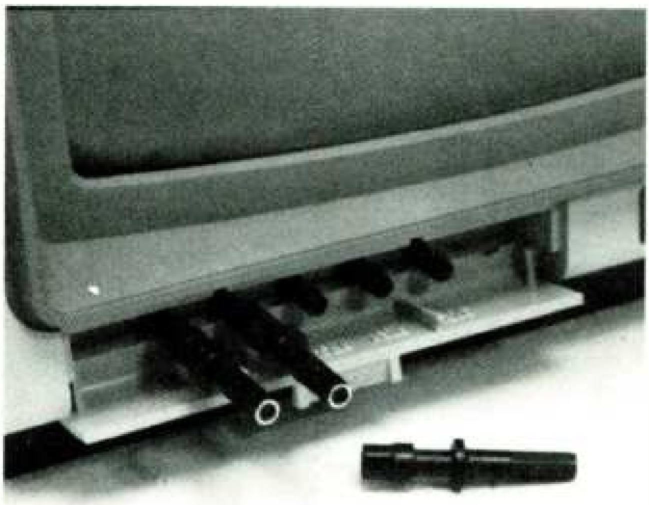
I FOUND I HAD TROUBLE GETTING MY FINGERS TO OPERATE my computer monitor's recessed contrast and brightness controls. The access space for the adjustment controls on some monitors is irritatingly small for all but a small child (there's hardly enough room to *fit* your fingers, let alone move them). If you work (or play) with your computer in an environment with changing light conditions you know that the controls can save you from having to endure a headache. Anti-glare screens are a possibility, but if you or your company has beer pockets it does no good for you to have champagne taste; and besides, these screens are not available for all monitors.

One day I came across the standard TV volume-control replacement knobs like the one shown in the photo. They are usually used if junior has gulped down the volume- or brightness-control knob off a radio or TV and, instead of slicing the tyke up, you go out and buy another. It looked as if it would fit over the mini-shafts on my computer, so I threw care to the wind, dug deep (about 50 cents each at a surplus supplier), and bought a few knobs.

Sure enough, as shown in the photo the knob slips right on the shaft and locks tight, with the new shaft extending well in front of the monitor. And it takes just a moderate pull to get it off.

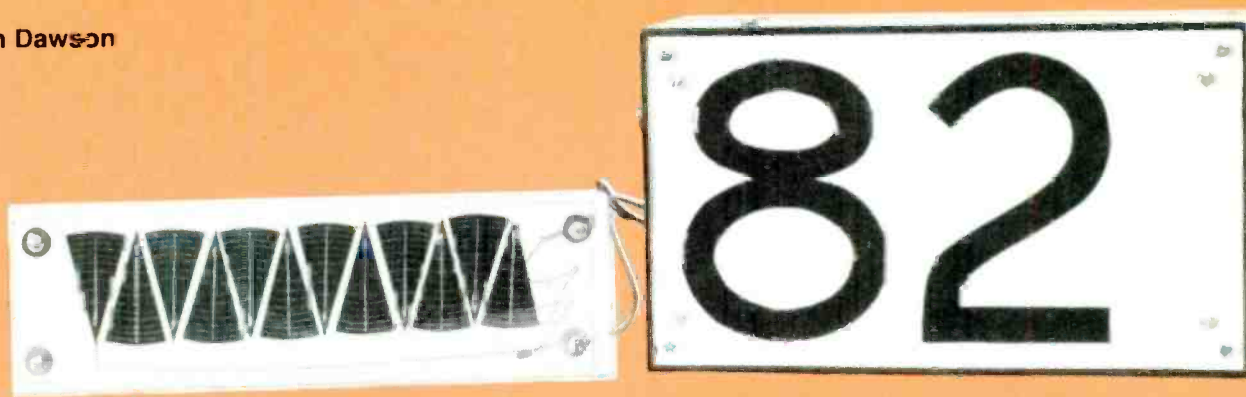
If you fear your co-workers might like them *too* much, or if junior's appetite is out of control, use a little Super Glue to hold them in place. However, I would advise against gluing them if it would impede the repair of the unit. ■

The use of the replacement knobs will mean leaving the access door open (if your computer has one), but if you use the controls a lot it is probably open most of the time, anyway.



Replacement control knobs are easily found in surplus, TV repair and electronics stores. They are easily put in place requiring no extra parts, tools, nor skill.

By Colin Dawson



SOLAR POWERED HOUSE NUMBER

This solar-powered project acts like a lighthouse to nighttime visitors who may be unfamiliar with your area!

☐SEARCHING FOR A PARTICULAR HOUSE ON A DARK, UNfamiliar street can be a frustrating business to your guests. Besides the embarrassment of ringing or knocking at the wrong door, the home owner may panic at the sight of an unfamiliar face—the next thing you know the *boys in blue* could be breathing down your guest's neck. However, you can nip that little problem in the bud by installing a *Solar-Powered House Number* (see photos), which is nothing more than an illuminated house-number that switches itself on at dusk and switches off six hours later.

Illuminated house numbers are a great idea but they invariably have one drawback—you have to remember to switch them on at dusk and off again before you retire. They also tend to be expensive. By contrast, the operation of our circuit is completely automatic and its illumination is independent of the main supply.

Two rechargeable batteries, which are topped off (charged up) during the day by a solar-cell array, provide power for up to 30 high-intensity LED's that backlight a number mask attached to a tinted plastic backing. The solar cells are wired in series and sandwiched between two sheets of acrylic plastic to protect them from the weather. The use of a solar-cell array dictated that the circuit be carefully designed to minimize power consumption.

The project is controlled by a light-dependent resistor (LDR), which is used to monitor the ambient light level. As dusk falls, the LDR's resistance increases to a certain critical level, at which the circuit triggers and illuminates the LED's. The LED's are driven in series pairs, a technique that enables two LED's to be driven with the same current as a single unit. A multiplexer ensures that no more than three LED pairs (out of a possible total of 19) are turned on at any given time.

Finally, we have the automatic dimmer (controlled by a second LDR) to gradually reduce the drive current to the display as it gets darker, while a timer switches the display off after six hours to minimize battery drain. An optional *retrigger* switch can be included in the circuit to reset the timer circuit for six additional hours of operation if required.

Most of the components are mounted on two printed-circuit boards and housed in a plastic case that can be waterproofed.

Batteries

Initially, we had proposed a simple solar-charged battery circuit consisting of three or four small nickel-cadmium (Ni-Cd) cells and a preassembled solar panel costing about $30. Unfortunately, both of those choices proved unsuitable. The solar panel simply lacked capacity and a Ni-Cd battery of suitable capacity turned out to be more expensive than we had anticipated.

The alternative was a sealed lead-acid battery (manufactured by Gates Energy Products). Such batteries are available in several sizes, with the smallest (see photo) equivalent in size to the familiar "D" cell. Strictly speaking, the battery is larger than necessary for this project—two such cells wired in series could run the circuit for at least a week without recharging. While that in itself is desirable, it also means that the preassembled solar-cell package lacks sufficient capacity to take full advantage of the batteries.

Another impressive specification of the Gates cells is their low internal resistance and consequent high discharge capability. The application manual lists the D cell as providing a maximum power transfer of 130W at 130 amperes! While that's of no particular advantage to the Solar-Powered Street Number, there are other situations where it could be used to advantage.

Solar-Cell Array

Having settled on the batteries, the next task was to devise a suitable solar-cell array. Preliminary tests had already shown that the preassembled array lacked sufficient capacity and, in any case, was not really waterproof. Eventually, we decided that a more suitable unit could be built *from the ground up*.

What we wanted was an array that was completely sealed against the weather and capable of supplying at least 20 mA at 5 volts in indifferent sunlight. Most of the cells we tested had a useful output in bright sunlight toward the middle of the day. It's outside of those circumstances that the cell's performance is critical.

We eventually chose cells rated 78 mA at 0.45 volts. Twelve such cells are required in all, to provide a nominal voltage of 5.4 volts when connected in series. That may seem excessive for a battery voltage of 4.2 volts, but remember that's only the *strong* sunlight rating. It will be somewhat less during the early morning and late afternoon.

The actual charging rate will vary from about 20 mA up to a maximum of 50 mA in reasonably bright sunlight, with an average somewhere around the 30-mA region. Assuming that the average rate is available for six hours, a daily charge of 180 mAh (milli-ampere hours) would be accumulated.

In calculating the necessary solar-panel capacity, we have assumed that the circuit will operate for six hours per night, although the time can easily be altered. The circuit draws only about 80 µA in the standby mode, increasing to a maximum of 60 mA just after sunset (LED's at maximum brightness), and then reducing to about 8 mA in total darkness due to the action of the dimmer circuit.

The total amount of power consumed during the six hours of operation depends upon the length and brightness of the twilight period. Generally, 110 mAh will be the greatest demand.

With charging losses generally accepted as 10% of the total charge, a typical daily demand on the solar cells would be about 120 mAh. The difference between that figure and the actual capacity of the solar cells (180 mAh) is important for two reasons: First, it ensures that the batteries will eventually be restored to full charge when the sun does shine after several overcast days. Second, the number of days on which a full charge can be acquired is greatly increased because less than six hours of sunlight is needed for the charge.

Circuit Operation

Figure 1 is a schematic diagram of the Solar-Powered House Number. The circuit can be divided into five sections: a light detector/switch (LDR1 and U2a); a timer (U1); a multiplexer (U3); a LED driver stage (Q2 to Q6); and a dimmer-control circuit (LDR2 and Q1). Let's see how it all works.

LDR1 is the circuit-enable switch. Together with a fixed 47,000-ohm resistor it forms a voltage divider, the output of which varies according to the amount of light falling on LDR1. At sunset, LDR1's resistance (and hence the voltage drop across it) increases until the voltage at pin 12 of U2a causes the gate to toggle, switching its output from high-to-low.

The output of U2a at pin 11 is connected to pin 12 (reset) of U1, a 4060 14-stage binary counter. As soon as the high-to-low transition occurs, the reset of U1 is released and it begins to count.

Clock pulses are provided by U1's internal oscillator, the frequency of which is set by external components R1 and C1. With the values shown for R1 and C1, the clock operates at only one cycle per 1.3's. Since the 4060 divides by 2^{14}, or 16,384, it takes about six hours for its Q14 output to go high (the other outputs are not connected). By altering the value of either R1 or C1, the six-hour time period can be varied as required.

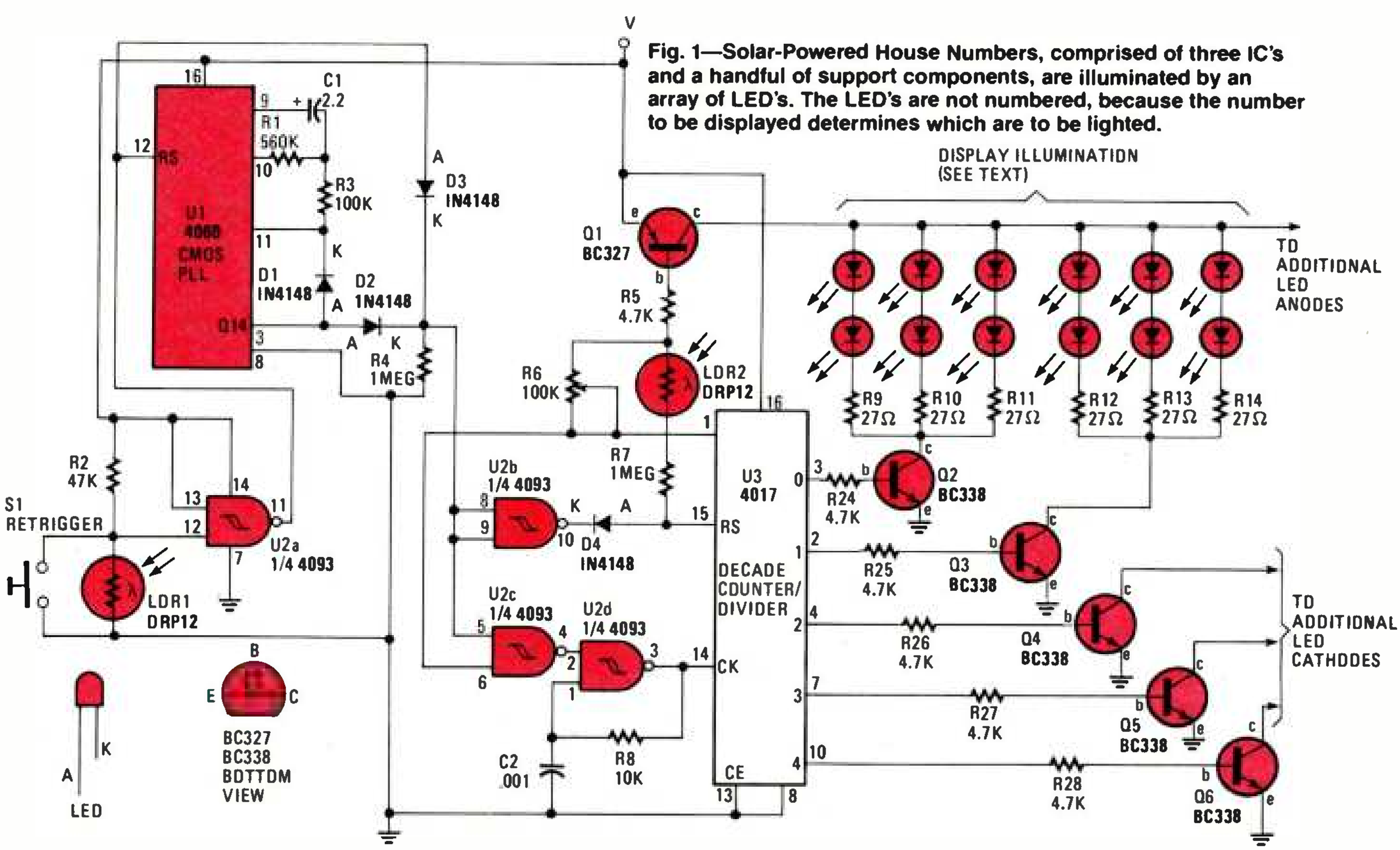


Fig. 1—Solar-Powered House Numbers, comprised of three IC's and a handful of support components, are illuminated by an array of LED's. The LED's are not numbered, because the number to be displayed determines which are to be lighted.

The optional retrigger switch (S1) allows the timer to be manually reset for an additional six hours of operation at any point in the cycle. Diode D1 stops the clock at the end of the six-hour period by pulling pin 11 of U1 high, preventing U1 from commencing a second six-hour period at the end of the first. That's due to the fact that it will still be dark after the first six hours, which means that pin 12 (reset) of U1 will still be low.

The output of U2a also connects to the anode diode D3. Another diode (D2) is connected in series with pin 3 of U1, while the cathodes of D2 and D3 connect to a common control point. The polarities of D2 and D3 are such that whenever either of their inputs (anodes) is high, the control point is also high. At other times, the control point is held low by pull-down resistor R4. In order for the multiplexing and LED drive circuitry to be enabled, the control point must be low. It follows, therefore, that in the period between U2a being triggered (sunset) and U1 completing its count (Q14 high), the display is operating.

U3 (a 4017 decade counter) is used to multiplex the display. Because our circuit only calls for a five-way multiplexer, the pin-1 output of U3 is connected to pin 15 (reset) via R7. When pin 1 goes high, U3 resets almost immediately, so one of its five output lines (0 to 4) is high at any given time, while the circuit is operating.

U3 pin 15 (reset) is also connected to the anode of diode D4, which means that normal resetting can only occur when D4 is reverse-biased. At other times, the reset pin will be held low and U3 prevented from resetting. To appreciate the significance of that, it's necessary to consider the circumstances whereby D4 will be forward-biased.

The cathode of D4 is connected to pin 10 of U2b, whose inputs are connected back to the D3/D4 junction. Recall that when that control point is high, the multiplexing circuitry is disabled. Because U2b is connected as an inverter, a logic high at the control point is translated into a low on the cathode of D4. The diode is thus forward-biased, inhibiting the reset function of U3.

Clock pulses for U3 are supplied by U2d, a simple Schmitt oscillator with a nominal output frequency of 110 Hz. The oscillator is enabled when pin 4 of U2c, which has one of its inputs connected to the D2/D3 control point and the other to the pin-1 output of U3, goes high. Thus, the clock will be inhibited when both inputs to U2c are high, (i.e., when the D2/D3 junction is high and the number-5 count has been reached).

Normally, a number-5 count will reset the multiplexer. However, at the completion of the six hours, pin 3 of U1 goes high and prevents U3 from resetting. At the same time, the multiplexer clock is stopped (due to the multiplex inhibit and number-5 count), and so the 4017 stops counting. The pin 1 output of U3 remains high while all other outputs remain low, keeping all display drivers turned off.

The display drivers (Q2–Q6) are driven by the 0–4 outputs of U3 via 4700-ohm current-limiting resistors. Up to three LED chains—consisting of two LED's wired in series with a 27-ohm limiting resistor—can be driven by each transistor. The chains are connected between the collectors of their respective driver transistors and the collector of Q1, which forms part of the dimmer circuit.

Note that the LED's are purposely not numbered. That's because some will be omitted or included, depending on the number to be illuminated. Also, note that there is a jump in numbers from the display's limiting resistors to the biasing resistors for the display drivers—a portion of the circuit has been omitted to save space.

The solar array uses two lead-acid rechargeable D-cell batteries, which have a capacity of 2.5 Ah. Then as day fades to night, the batteries are called on to provide power to the circuit.

The dimmer circuit consists of PNP transistor Q1, LDR2, R5, R6, and Q1. Q1 has its emitter connected to the positive supply rail and its collector to all of the LED anodes. The LDR simply provides base current for the transistor. During twilight, more base current is provided for the transistor so that the LED's operate at maximum brightness. As the level of ambient light falls, less base current is provided for Q1 and the LED's dim. R6 is adjusted after installation to provide a suitable minimum level of brightness, according to the installation.

Note that the drive current for Q1 is not derived from the negative supply rail, because that would result in a wasteful base current flowing during the day, when the LED's are not operating. Instead, the base current is derived from the pin-1 output of U3. When U3's operation is inhibited, pin 1 remains high and thus no current flows to the base of Q1. (Remember, for a PNP transistor to turn on, its collector must be more negative than its base, and its base more negative than its emitter.)

Construction

Construction can be divided into four main areas: the solar panel; the display; control electronics, and the preparation of the enclosure. Because the solar panel must be sealed after assembly and then left to dry, it should be attended to first. You should have the following parts handy before beginning: two pieces of acrylic plastic (about 195 x 60mm); 12 solar cells; 300mm of enamelled copper wire; four machine screws and nuts; eight washers; four solder lugs, and a 1N4001 diode (which is not included in the layout).

Having trimmed the two pieces of acrylic to size, clamp them together and drill a hole in each corner to accept the machine screws. That done, drill two smaller holes at one end of one sheet to provide access for the output wires.

The solar cells should now be connected in series using small lengths of the tinned copper wire. Two longer lengths (about 200mm and 40mm) are used for the output connections. Note: The cells are extremely brittle and will crack if mishandled. They can also be damaged by excessive heat, so treat them gently.

Once the cells are all interconnected, smear a dab of silicone rubber compound on the back of each and lay them out on the lower piece of acrylic sheet, as shown in Fig. 2. Feed the output wires through their respective holes in the lower acrylic sheet and connect the positive lead to the anode of the 1N4001 diode. Next terminate the cathode and negative leads with solder lugs.

Construction of the solar-panel array can now be completed by running a fillet of silicone rubber compound around the edge of one of the acrylic sheets, inserting spacers—two small washers at each screw should do the trick—between the two sheets to avoid crushing the cells, and then fastening the two sheets together using machine screws and nuts.

We also used solder lugs to terminate the external leads, which should be added during the final assembly. Don't forget to seal the holes for the output wires from the cells.

The circuit itself is built on two printed-circuit boards: the control board measuring 73 × 44mm; and a display board, measuring 180 × 95mm, templates for which are shown Fig. 3 and Fig 4, respectively.

Begin by assembling the control board according to the layout diagram shown in Fig. 5. Note that the IC's are CMOS devices and therefore static and thermal sensitive, so be sure to solder their supply pins first to enable the internal static protection diodes. We used printed-circuit stakes (nine in all) to terminate the external wiring connections.

The display board has been designed to accommodate various LED combinations to form any one or two digit number. If you require a three-digit number, then you will have to wire the display using matrix board or Veroboard.

Because the number required will vary, the LED locations are represented by numbers on the parts layout diagram (see Fig. 6). To select a certain number, all you have to do is install LED's and wire links (jumper connections) at the locations indicated in Table 1.

For example, to make up the number 5, install high-efficiency LED's at locations 1, 2, 3, 4, 7, 9, 10, 14, 15, 16, and 18; dummy LED's at 2, 6, and 17; and links at L2 and L4 (which is also the location of LED 19). The dummy LED's, by the way, are low-efficiency types. In use, they are simply blocked from view by the number mask on the display panel. Do not omit the dummy LED's. They are necessary because all LED's must be connected in series pairs to avoid variations in brightness.

All that remains now is to mount the various parts into the plastic zippy case. First, cut a piece of acrylic plastic to replace the original aluminium lid and attach to it a cardboard number mask representing your street number. The display board can then be mounted behind the number mask using 25mm screws as stand-offs. If you like, you can use a colored filter behind the mask to improve daytime visibility.

The control board is mounted to the base at one end of the case (see photos), and secured using machine screws and nuts. The two LDR's are mounted on the end of the case,

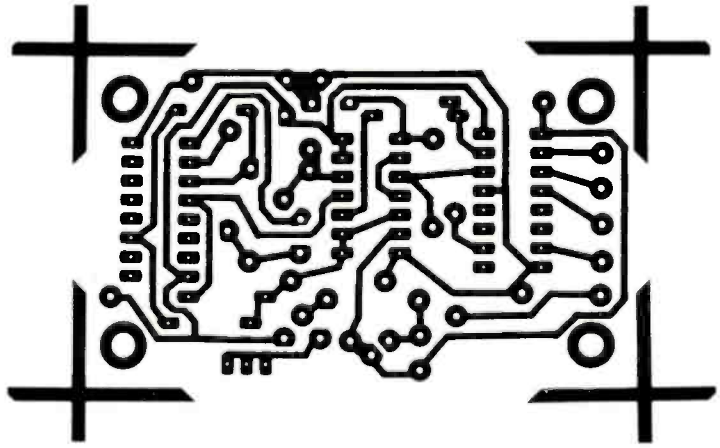
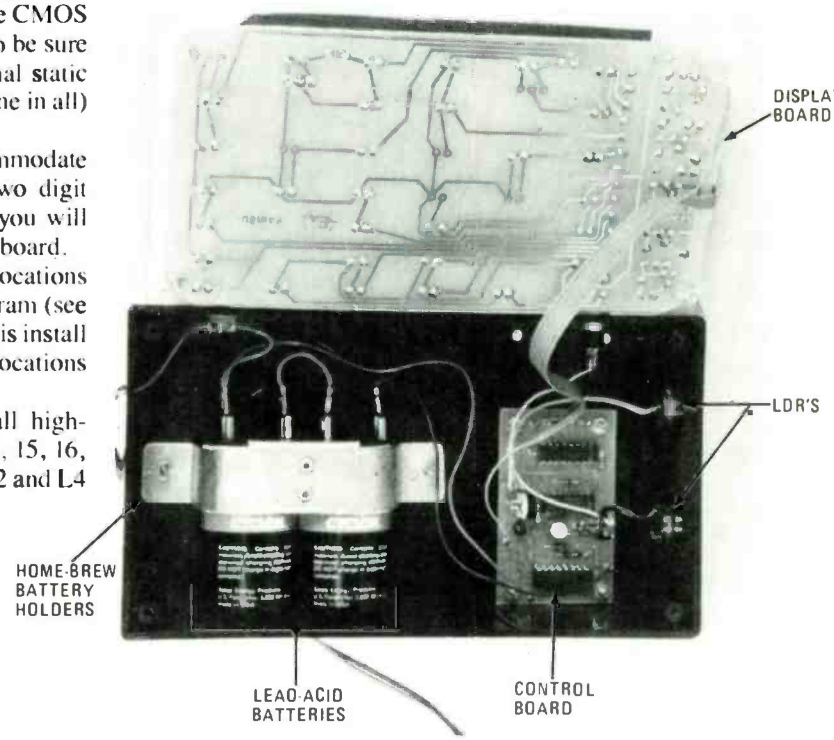


Fig. 3—This full-scale template of Solar-Powered House Number's control board (measuring 3 × 1⅞ inches) can be copied from the page and used to etch your own printed-circuit board.



All the electronics (except for the solar-cell array) are mounted in a plastic project box. The solar array should be mounted away from obstructions.

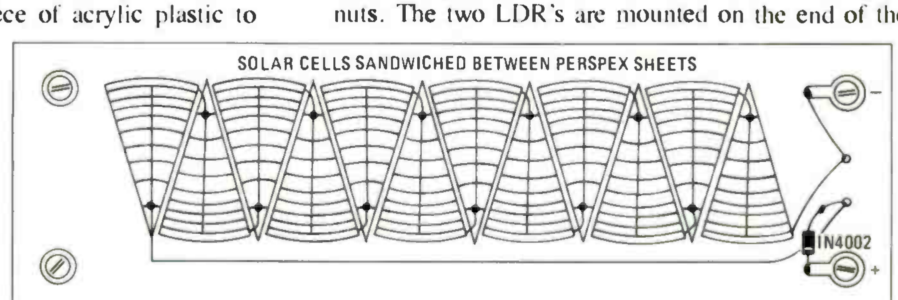


Fig. 2—The photocell array for the project is made from 12 photocell sections sandwiched between two pieces of clear acrylic plastic.

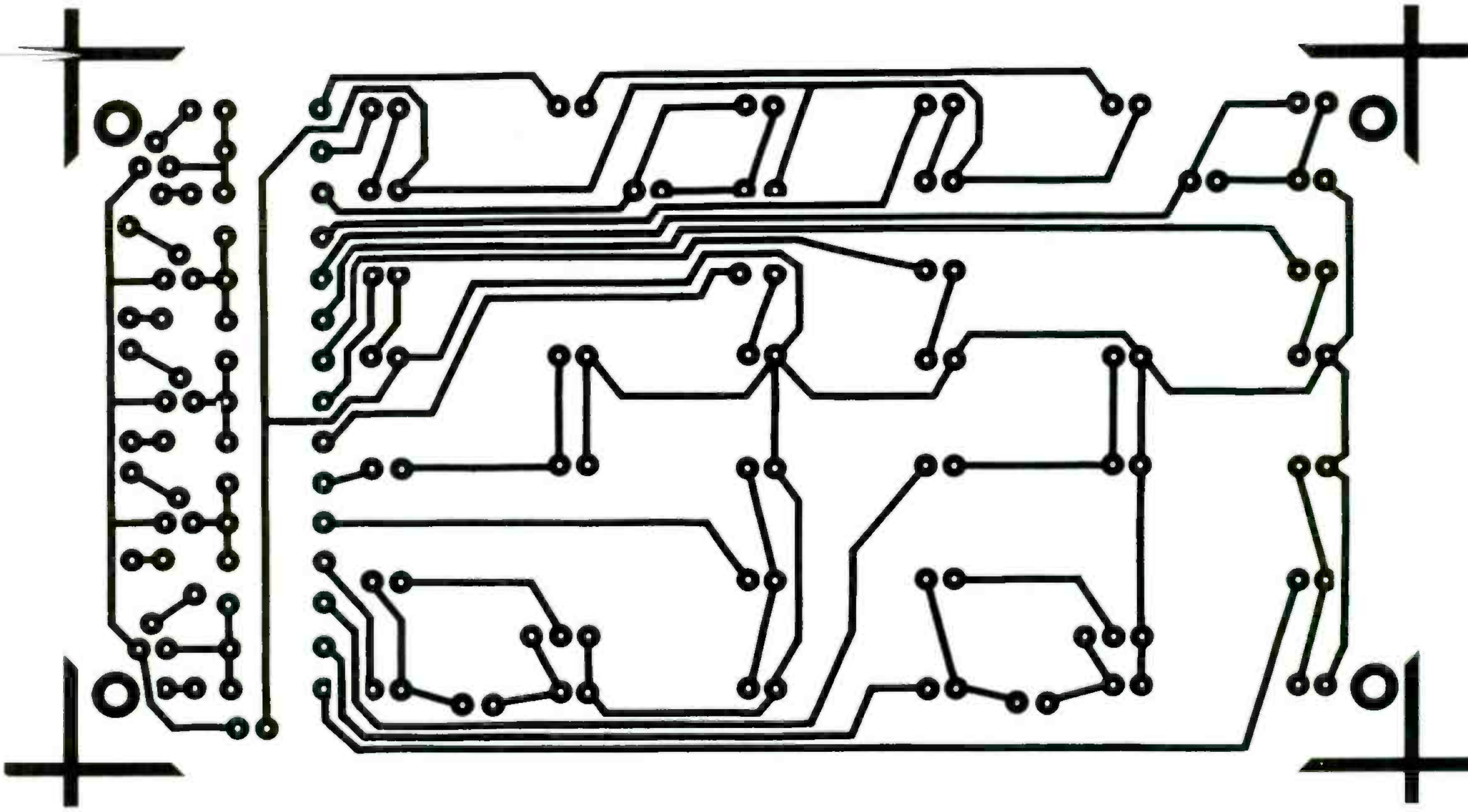


Fig. 4—The 7⅛ × 3⅞ inch template of Solar-Powered House Number's display board is easily copied to a printed-circuit blank using the photo-resist method of printed-circuit preparation. But feel free to use the method that is easiest for you.

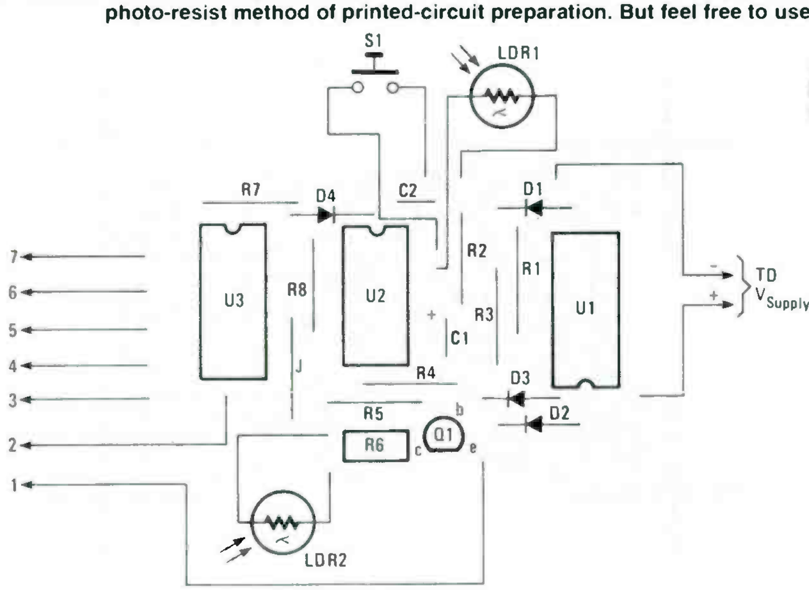


Fig. 5—The layout diagram of the project's control board leaves nothing to the imagination. Follow it and you should have no trouble.

ADDITIONAL PARTS AND MATERIALS

C1—2.2-µF, bipolar electrolytic
C2—0.001 ceramic disc
S1—SPST normally-open pushbutton switch
Printed-circuit materials, 12 solar cells (rated 0.45V/78-mA), 2 D-cell lead-acid batteries, silicone rubber sealant, scrap aluminum, enclosure, tinted plastic or bezel material, clear acrylic plastic, rainbow ribbon cable, hook-up wire, solder, hardware, etc.

PARTS LISTFOR SOLAR-POWERED HOUSE NUMBER

SEMICONDUCTORS

D1–D4—1N4148 small signal silicon diode
LED1–LED19—High-efficiency/low-efficiency light-emitting diode (see text)
LDR1, LDR2—ORP12 (resistance: dark, 10-megohm; light, 300-ohm) light-dependent resistor
Q1—BC327 (or SK3200, ECG298) PNP silicon medium-power transistor
Q2–Q6—BC338 (SK3854 or ECG293) NPN silicon medium-power transistor
U1—4060 CMOS 14-stage, ripple-carry binary counter, integrated circuit
U2—4093 quad, two-input NAND Schmitt trigger
U3—4017 decade counter/divider, integrated circuit

RESISTORS

(All resistors ¼-watt, 5% fixed units unless otherwise noted.)
R1—560,000-ohm
R2—47,000-ohm
R3—100,000-ohm
R4, R7—1-megohm
R5, R24–R28—4700-ohm
R6—100,000-ohm trimmer potentiometer
R8—10,000-ohm
R9–R23—27-ohm

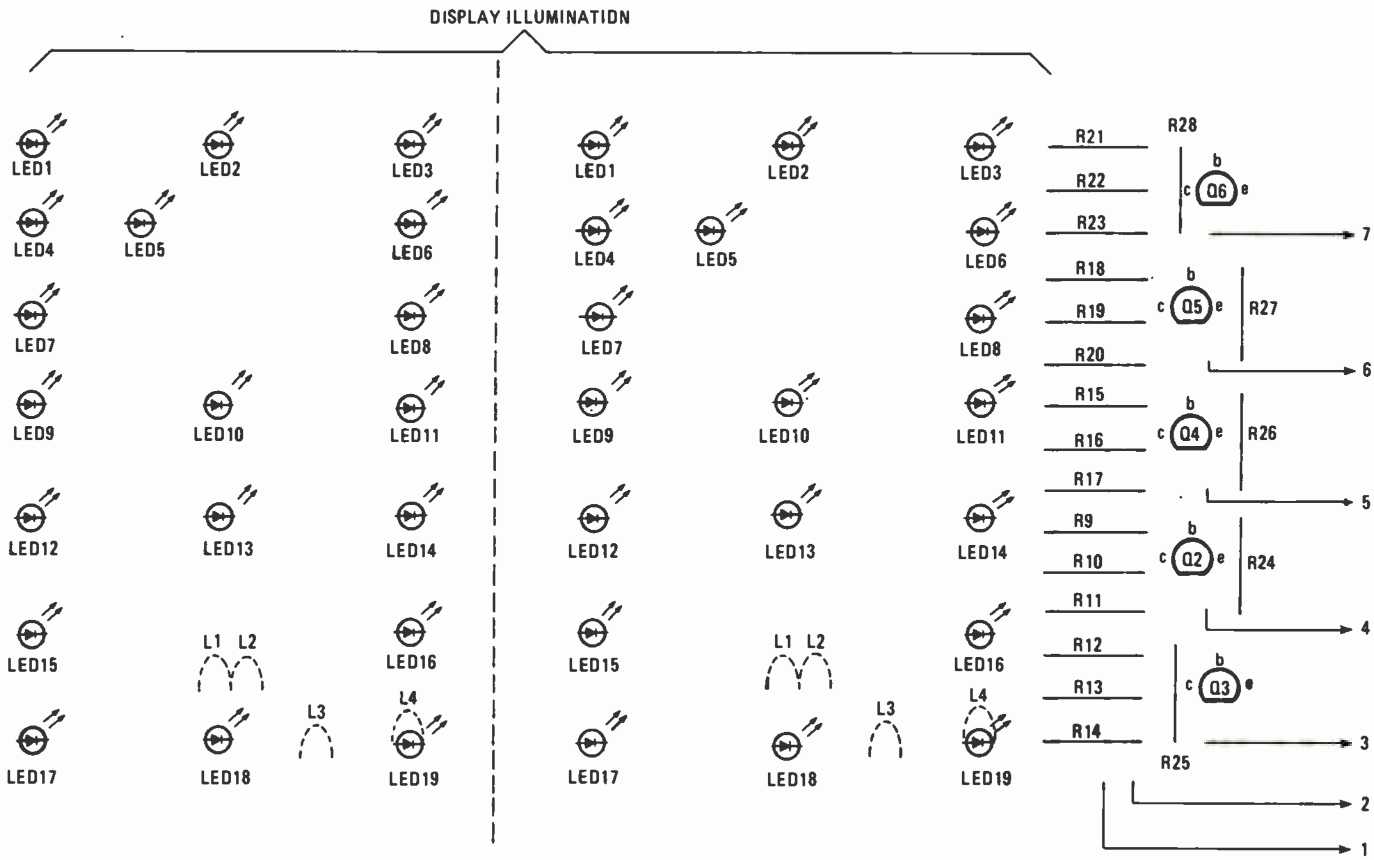


Fig. 6—This layout shows the location of the display-board components. Consult Table 1 before installing LED at any position. Some of the LED locations may need to be outfitted with jumper connections, which in this layout are referred to as links (L).

TABLE 1
DISPLAY ILLUMINATION GUIDE

Numeral	High-Efficiency LED's	Dummy LED's	L1	L2	L3	L4
1	3, 6, 8, 11, 14, 16, 19	13	•			
2	2, 4, 6, 11, 13, 15, 17, 18, 19	1, 10			•	
3	2, 4, 6, 8, 10, 14, 15, 16, 18	1, 11, 17		•		
4	2, 3, 5, 6, 7, 8, 9, 11, 12, 13, 14, 16, 19	1, 2*, 15	•			
5	1, 2, 3, 4, 7, 9, 10, 14, 15, 16, 18	2*, 6, 17		•		•
6	2, 5, 7, 9, 10, 12, 14, 15, 16, 18	1, 2*		•		•
7	1, 2, 3, 6, 8, 11, 14, 16, 19	2*, 4, 10	•			
8	2, 4, 6, 7, 8, 10, 12, 14, 15, 16, 18	1, 2*, 3, 9, 11		•		•
9	2, 3, 4, 6, 7, 8, 10, 11, 14, 16, 19	1, 2*, 9	•			
0	2, 4, 7, 6, 8, 9, 11, 14, 15, 16, 18	1, 2*, 3, 10		•		

*Install at second digit position.

adjacent to the printed-circuit board, and secured with epoxy adhesive. We also mounted the optional retrigger switch adjacent to the LDR's.

The battery holder can be manufactured from a piece of scrap aluminium. Make sure that it's of reasonably heavy gauge and that the batteries are firmly secured. Should the battery terminals happen to make contact with the holder, or some other mounting hardware, there will certainly be a spectacular display—at least for a few seconds.

To test the Solar-Powered House Number, temporarily alter the values of R1 and C1 so that a much shorter time period results. Substituting 56,000-ohm resistor for R1 and a .01-µF capacitor for C1 will give a period of about 10 seconds. Once power is connected, cover the LDR's or turn off the room light. The circuit should now trigger for the duration of the time interval, provided that the darkness continues. Turning the lights on should cancel the cycle immediately.

While the circuit is operating, try altering the level of light falling on LDR2. That should alter the brightness of the display. Calibration of the control, however, can only be carried out properly at the site where the unit is to be located.

Allow the circuit to go through one cycle, then press the retrigger switch. That should cause another cycle to commence. Resetting should occur after LDR1 is exposed to light, irrespective of whether the switch is fitted or not.

Provided that the circuit appears to be working properly, restore R1 and C1 to their normal values. The solar panel can now be connected, but make certain that the diode on the

(Continued on page 112)

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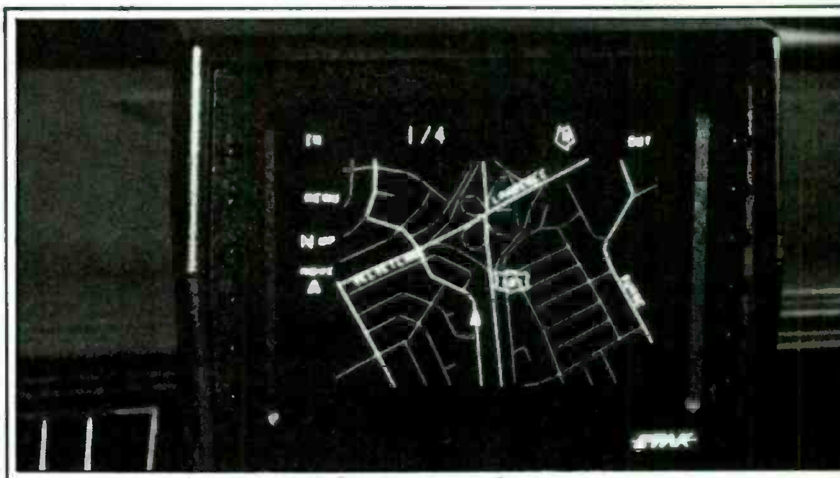
What's Inside . . .



Etak Navigational System

1986: The Year's Best, Worst & Silliest Gadgets

Becoming jaded is something of an occupational hazard at GADGET newsletter. In discussing 1985's "Gadgets of the Year" in last January's issue, we groused: "Sure, there were attempts to push technological change on a number of consumer fronts—compact discs, 8mm home video, the never-say-die video disc—but the transformations just didn't generate the excitement they might have in past years."

Our problem was in getting ahead of ourselves. In 1986, both CDs and 8mm video generated enormous consumer excitement. The video disc may not have set sales records, but Pioneer introduced an intriguing compact disc/laservision player (CLD-900) which may turn out to be a harbinger of things to come.

The basic lesson, of course, is that gadgetry doesn't conform to the calendar year. A product introduced one year may not take off or show its potential until months, even years later.

In putting together our eighth annual "Gadgets of the Year" feature, we've tried to guard against the tendency not to see what's important or promising about a new product because of prototype limitations or flaws—the electronic age version of not seeing the forest because of the trees.

Even aside from the '85 products which had their major impact in '86, the past year has been an exciting one in gadgetry. There was a torrent of development in television technology, with stereo audio making progress and digital TV arriving in a big way.

The year also saw the appearance of at least two long-awaited new technologies—an electronic navigation system for cars and (to be reviewed by GADGET later this year), the first practical "picture phone." Both of these systems are dear to the spirit of gadgetry. Electronic highway navigation has been discussed for decades. The "picture phone," first developed nearly a quarter-of-a-century ago by AT&T, is the prototypical "life in the future" gadget, a science fiction cliche which has finally arrived on the market.

The 1986 "Gadgets of the Year" compilation, as usual, is divided into "best," "worst" and "silliest" lists,

(Continued on page 3)

GADGET: A Rebirth

During GADGET's first decade of life, it has established itself as America's most unusual consumer newsletter. We've spotlighted the newest electronic wizardry, often far in advance of the mass media, while never hesitating to criticize, even ridicule, products that are badly conceived or poorly engineered.

From volume one, number one in September of 1975—when we featured the first solar digital watch, headlining it, "Sun Watch Fails Son Test" (my eight-month-old managed to permanently stop it)—we've written with humor and a finely developed sense of whimsy about a universe of consumer products. They've ranged from a Rolls Royce (we panned it), through hovercrafts and residential earth stations to bizarre items like the potato-powered clock and the battery-powered roller skates found in this issue's "1986 Gadgets of the Year" compilation. We've also offered consumer-eye views of products which are reshaping the world we live and play in, from home video to home computers, cellular phones to compact discs.

We've been described as "the bible of gizmo lovers" by the Miami *Herald*, praised as a "consumer watchdog" by the Chicago *Tribune* and lauded as a "mini-magazine of the newest and neatest" in the San Francisco *Chronicle*. Frankly, however, our circulation has never matched our reputation.

In the first decade of GADGET, we've faced complicated financial burdens. The basic problem has been the economics behind the concept of this newsletter. Since GADGET does not accept advertising—for the obvious reason that we would be beholden to the advertisers—we have been denied periodical publishing's most important source of revenues.

The subscription price for GADGET is extremely low. To increase its circulation through costly direct-mail or other sorts of promotional campaigns would be prohibitively expensive. Were it not for my pride and love of what GADGET represents, to me and hopefully to its readers, the newsletter might have died years ago. As it was, we seemed doomed to remain basically a mom-and-pop scale operation, a monthly David monitoring the consumer products of a myriad of corporate Goliaths.

In an effort to sustain our commitment to our loyal readership and put GADGET on a financially even keel, we have entered into an unusual publishing partnership. Beginning with this issue, we are joining forces with *Hands-On Electronics*, among the nation's most respected technical magazines for electronic enthusiasts, published by Gernsback Publications, Inc.

Those who build and delve into electronics and those who use electronics are sometimes one in the same. Perhaps as often, especially in today's expanding electronic marketplace, they are not. But enjoyment of and love for well-made, well-designed electronic products is a perspective both groups share.

In joining forces with Gernsback Publications, we are infusing new life into GADGET. We think this unique arrangement will extend our visibility and editorial reach, as well as bringing both publications new readers. Although GADGET and *Hands-On Electronics* will remain editorially independent of one another, the two publications will be part of the same monthly package.

Hands-On Electronics readers will receive a wonderful bonus—an exciting, dynamic newsletter-style insert which reports on electronics with insight but in consumer terms. GADGET's current readership will receive a second publication for the price of their original subscription, one which furnishes an inside look at the how and why of contemporary electronics.

We believe this experiment in joint publishing will allow GADGET to concentrate on what it does best—offering reviews and news of the latest in gadgets and gadget-related items, written with humor and enthusiasm. As an insert in *Hands-On Electronics*, it will make available to readers of that publication a consumers' view of the technical accomplishments (and failures) of the contemporary electronics industry.

GADGET is not some massive, sealed monolith. We welcome the comments and criticisms of our readers, old and new. Your input and your needs influence and help shape our editorial product, as they have from its very first issues.

First a magnificent toddler and then a wonderfully energetic youngster, now as GADGET trundles towards adolescence in a new form, we anticipate exciting challenges in the future. GADGET is newly invigorated and readers in the months to come will receive a newsletter which is more current, better informed and more alive than ever before. To both our old readership and our new audience, welcome to the future—as reflected in the pages of GADGET newsletter.—Al Goldstein

Publisher: Al Goldstein **Editor:** George Arthur **Senior Editor:** Gil Reavill **Art Director:** C. Giordano **Associate Art Directors:** Kevin Hein, Rob Weisberg **Production:** Bill Mudie **Administration/Reader Service:** Kathryn Hartman **Contributing Editors:** Philip Eisenberg, Alan Freedman, Jordan Ari Goldstein, Steve Gruberg, Aprile Guarino, John Kois, Chris Stevens, Ken Swisher.

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BEST, WORST, SILLIEST

(Cont. from p. 1)

with a top item in each category. Beyond that, the items on each list are arranged alphabetically. The month at the end of each entry is the issue of GADGET in which the product was first reviewed or reported on.

Dimensia Audio/Video System

BEST GADGETS OF '86

The Best of the Best: **ETAK NAVIGATIONAL SYSTEM**. Manufactured by: *Etak, Inc., 1455 Adams Drive, Menlo Park, CA 94025.* Price (exclusive of installation and software): $1,595. GADGET called this "the first major innovation in auto travel in at least the past two decades." A powerful car-installed computer, a tape drive, an electronic vector graphic display, sophisticated magnetic compass and wheel-mounted sensors enable the *Etak Navigational System* to guide drivers using an *EtakMap* cassette of the streets and highways to be traveled. As the car travels, an arrow in the lower center of the vector graphic display represents the vehicle, remaining stationary as the projected *EtakMap* moves and changes.

The *Etak* company indicated that development of the product would take two directions. The firm planned to broaden the coverage of the *EtakMap* cassettes (when introduced, the system only covered California from San Francisco to San Diego) and, at the same time, further detail the guidance maps. Eventually offering a system taking advantage of the nearly infinite expandability of computer software. (April)

GENERAL ELECTRIC CONTROL CENTRAL. Manufactured by: *General Electric, 800 Third Ave., New York, NY 10022.* Price: $150. We liked the *Control Central* for what it does—replacing multiple remote controls by "learning" their signals and combining their functions within a single unit. The unit can combine up to four separate remote controls, whether for TV, video or stereo. No breakthrough technology was necessary for this, just some smart design aimed at simplifying life in the age of electronic home entertainment. (June)

OMNIBOT 2000 ROBOT. Manufactured by: *Tomy Corp., 901 E. 233rd St., P.O. Box 6252, Carson, CA 90749.* Price: $400 to $600. GADGET's review of *Tomy*'s *Omnibot 2000* was less than overwhelming in its enthusiasm. We called it "a potentially entertaining electronic tyke," but also labeled it "rudimentary," capable of only "limited tasks," and "more than a toy, if less than the robot of the future."

However, *Omnibot 2000* clearly deserves points for keeping the home robot flag flying. While industrial use of robots has continued to expand, the consumer version has been left to a few visionaries, including the folks at *Tomy*.

The unit's on-board computer, which makes it programmable via a remote master control, is an important indication of robotic development. While *Omnibot 2000* might be limited to a few parlor tricks and functions which currently can be performed more easily by non-robotic beings, it's a beginning. As our original review put it, "it may not be our electronic equal, but at least it's a start." (May)

PIONEER COMPACT DISC/LASERVISION PLAYER (CLD-900). Manufactured by: *Pioneer Video, Inc., 200 W. Grand Ave., Montvale, NJ 07645.* Price: $1,200. With *Pioneer*'s *CD/Laservision Player*, consumers got a glimpse of a possible video future, and also a product which in an intriguing way combines two of the applications of laser technology. A single "disc table" plays either audio or visual recordings at the flick of a switch. In contrast to some dual-application gadgets, the *CLD-900* doesn't require any compromise of either function in combining them. Instead, the audio and the video are merely different applications of the same laser diode.

Given its price tag, this splendid application of laser technology won't appeal to any but a limited market for some time to come. But it represents both smart design and a step-up for the laser disc, the neglected Cinderella of home video. (February)

RCA DIMENSIA AUDIO/VIDEO SYSTEM. Manufactured by: *RCA Consumer Electronics, 600 N. Sher-*

(Continued on page 4)

Control Central

Compact Disc/Laservision Player

BEST, WORST, SILLIEST

(Cont. from p. 3)

man Drive, Indianapolis, IN 46201. Price: About $5,500. This ultimate in home entertainment systems (at least until a competitor comes up with a counter product group), according to GADGET signaled "the end of the age of the component system and the dawn of the age of the rack."

We also called it an "audio-and-visual consumer extravaganza" and the *Dimensia* is certainly that. The total system includes a color TV (the *FKC2600*); video cassette recorder (*VKT700*); integrated amplifier (*MSA-200*); AM/FM stereo tuner (*MAT110*); CD player (*MCD 140*); audio cassette deck (*MTR120*); linear tracking turntable (*MTT130*); graphic equalizer (*MGE160*) and the *SPK375* speaker system. When it takes an entire paragraph to list the components of a system, you know it's a big one.

The *Dimensia* system utilizes several electronic "arms" linked to a central "brain," enabling the user to switch between modes and functions without leaving his or her seat. If price, and space, were no object, the *Dimensia* is the kind of system many gadget fans would select, in our review's words, "a fully realized dream." (February)

SMITH CORONA XD 7000 ELECTRONIC TYPEWRITER. Manufactured by: *SCM Corp., 839 Route 13 S., Box 20202, Cortland, NY 13045.* Price: $618.95. GADGET liked this electronic typewriter for its position "midway between a typewriter and a computer word processor." But most of all, we liked it for its "Spell-Right II" option, a spelling checker with some 50,000 words in its electronic memory and the capability of adding 300 further words of the user's own choice.

We found the *XD 7000*'s controls simple to master and easy to understand, and we were most impressed by *Smith-Corona*'s sophisticated add-on, the PWP System 12 monitor, with built-in menu, micro-wafer cassette and a hand-held keypad that features command and cursor keys. With just the typewriter itself, an individual could become familiar with the ways and means of electronic word processing, while adding the PWP System 12 (at a retail price of $499) would allow the user to cross the threshold into word processing.

Not so impressive was the discovery that the first batch of *XD 7000*s had a design glitch which made it impossible for all of the Spell-Right II's functions to transfer to the PWP monitor screen. *Smith-Corona* admitted the design flaw and offered free service at *SCM* service centers to correct it.

Sony Digital Monitor/Receiver

Still, we rate the *Smith Corona XD 7000* one of 1986's smartest, and most user-friendly, applications of computer technology to a familiar product. (January)

SONY TRINITRON DIGITAL MONITOR/RECEIVER (KV-25DXR). Manufactured by: *Sony Corp. of America, Sony Drive, Park Ridge, NJ 07656.* Price: $1,399.95. *Sony*'s first digital TV set includes a feature long predicted by technological crystal gazers, a microcomputer memory with applications beyond the TV set itself. Dubbed the "Home Management Helper," the built-in computer is preprogrammed to alert the owner to upcoming dates from an appointment list, a file of personal dates and a bill payment schedule. Programmed via an "alphanumeric" keyboard in the TV's remote control, when the television is turned on, an on-screen symbol alerts the watcher to the designated date. The computer functions also allow the television to be programmed to turn on for selected programs and to block the reception of broadcasts or cable transmissions during certain times on selected channels. In short, the very model of a modern television set, one which GADGET thought moved *Sony* "once again to the head of the class." (February)

SONY VIDEO 8 SYSTEM. Manufactured by: *Sony Corporation of America, Sony Drive, Park Ridge, NJ 07656.* Price: $1,800. Putting aside all the commercial questions surrounding the introduction of another videotape format, we found the *Sony Video 8* system a pleasure to use, making "video recording as easy as taking snapshots."

In all of its aspects, this miniaturized video camera and playback system delivered more than its weight in value—exceptional picture quality (under all kinds of conditions), excellent audio recording and reproduction and well-thought-out design throughout. Instead of going head-to-head with other video formats, the *Sony 8mm* was wisely designed to be an adjunct to them. In order to record from a television set, for example, the system's playback has to be connected to a standard video recorder. Transfer of 8mm recordings to Beta or VHS requires the same link-up. Instead of cannibalizing the video market, the *Sony Video 8* system, we judged would "significantly expand it, attracting new buyers with its strong home movie orientation." As other manufacturers have jumped into the 8mm fray, many initial misgivings about the format's place in the market have disappeared, although after only a year the

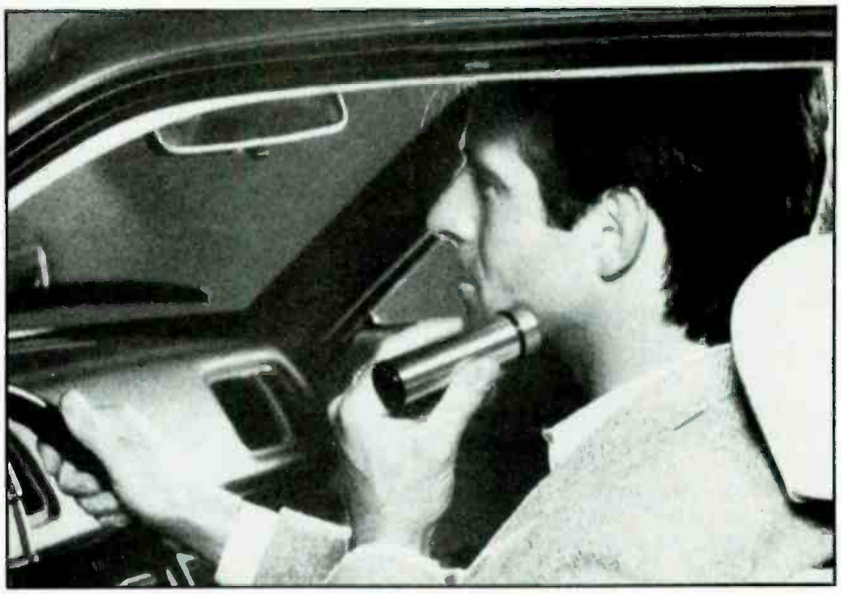
8mm Video System

story is far from over. (April)

SOUNDSHAVE. Manufactured by: *Advanced Products & Technologies, 15151 N.E. 92nd St., Redmond, WA 98052*. Price: $25. A nifty update of the electric shaver, this battery-operated portable razor tells the user where to shave. The blades vibrate into cutting position when they make contact with a whisker so the user knows what area needs to be shaved, perfect for shaving on the go. (March)

TOSHIBA DIGITAL COLOR TV/MONITOR (CZ2094). Manufactured by: *Toshiba America, Inc., 82 Totowa Rd., Wayne, NJ 07470*. Price: $1,299.99. Beating Sony to the market with its digital set, *Toshiba* also offered "P.I.P." capacity—picture-in-picture. Possible only with a digital TV, the feature allows a viewer to monitor a second source within the screen's main image. Perhaps a little disappointingly, the two images can't both come from a broadcast or cable source (two set receivers would be necessary for that). Still, we called p.i.p. "a fascinating feature, nearly irresistible for the TV and video enthusiast."

The *CZ2094* can also be linked with a computer and is equipped to receive stereo transmissions. The set is equipped with its own timer, allowing it to be programmed automatically to turn itself off at any time up to three hours later. A state-of-the-art television/monitor and one of the reasons that last year was a banner one for America's favorite electronic appliance. (February)



Soundshave

WORST GADGETS OF '86

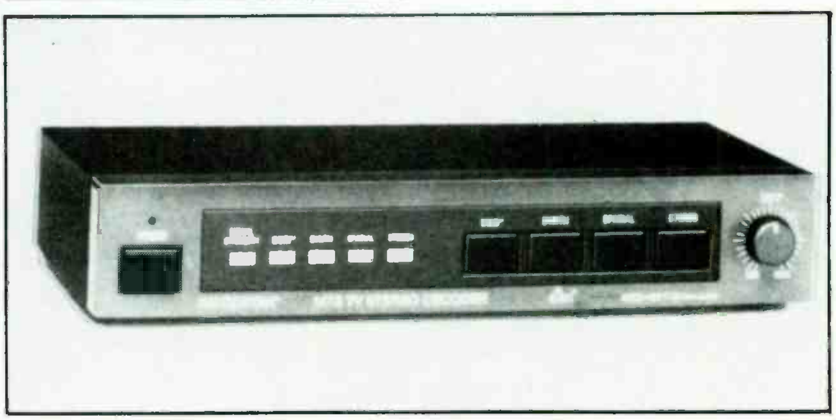
The Worst of the Worst: **BOOKVISION COLOR LCD TV/VIDEO MONITOR.** Manufactured by: *Citizen Electronic Group, 1200 Wall St. W., Lyndhurst, NJ 07071*. Price: $249.95. Even last year, miniature television was an idea which had been pretty nearly run into the ground. Although *Citizen*'s continuing interest in the LCD system of picture delivery is probably praiseworthy (technologies, like children, need time to develop), it doesn't produce a mini-TV image worth having delivered. As we put it, "as with all the tiny tubes we've seen, the *Citizen Bookvision*'s performance matches its diminutive size." Its place of dishonor on our roll call of losers is a reflection of our publisher's frustrations in using the set. What should have been a breakthrough turned out to be a bust. (April)

Bookvision LCD TV

ELECTRIC CORKSCREW. Manufactured by: *Norelco, Consumer Products Division, High Ridge Park, Stamford, CT 06904*. Price: $39.95. GADGET called this "in one sense, the ultimate gadget: a frilly electrification of a process that proceeds very well enough by hand, but goes spectacularly when motorized." But we found its lack of reverse capability (useful in dealing with delicate, broken or decayed corks, or when removing the cork from the device) a minus, while the electric cord was cumbersome. "Although perfect for restaurants or caterers," we concluded that for the home it's "an expensive piece of conspicuously affluent fluff." (February)

F.R.E.D. TELEVISION STEREO DECODER. Manufactured by: *Recoton Corp., 46-23 Crane St., Long Island City, NY 11101*. Price: $149.95. Our problem with this clever adapter for non-stereo television sets were in two areas; stereo broadcasting's current condition and our inability to hook *F.R.E.D.* up to our television without a

(Continued on page 6)



TV Stereo Decoder

BEST, WORST, SILLIEST

(Cont. from p. 5)

costly visit from a repair technician. Admittedly, our test was conducted with one slightly older Sony set, but the problem was enough to make us dubious about *F.R.E.D.*'s usefulness for many consumers. *Recoton* may have gotten the message. In the months after GADGET's review, the firm introduced an improved version of the device. (July)

KOSS SOUND CELLS. Manufactured by: *Koss Limited, 4129 N. Port Washington Ave., Milwaukee, WI 53212.* Price: $9.99. At such a low price, maybe we shouldn't complain, but these small speakers, designed to plug into a Walkman-style personal stereo, struck us as a good idea badly executed. The sound was tiny *and* tinny. (July)

MAGNAVOX VIDEOWRITER. Manufactured by: *North American Philips Co., Home Interactive Systems, 1111 Northshore Drive, Knoxville, TN 37919.* Price: $800. This is an example of the direction in which word processing design shouldn't go. Designed as a word processor for the non-professional, the *Videowriter*'s built-in printer produced ugly, utilitarian computer-style type at an extremely low speed. We clocked the print-out of four double-spaced pages at a tedious eight-and-a-half minutes. In addition, the *Videowriter* retains some of the computer's most obnoxious word processing traits, like dumping text and occasionally separating lines in the middle of the text.

Still, the *Videowriter* does have some praiseworthy features, like its dual display screen which incorporates a "prompt screen" to guide the wary user. We also found its spelling correction system less cumbersome to use than the Smith-Corona's Spell-Right II checker. Finally, however, the unit's limited memory capacity, a mere 53 pages of standard letter-size text and its overly simplified approach to word processing made it one of our worst items of 1986. (May)

SHOWMATE 2 VIDEO PRESENTATION SYSTEM (6427). Manufactured by: *Bell & Howell, Visual Communications Group, 700 McCormick Rd., Chicago, IL 60645.* Price: $1,210. Although manufactured for business and commercial use, we hoped this all-in-one portable video system would be a "harbinger of future mass-market goodies." The *Showmate* is capable of playing VHS video cassettes, recordings from its built-in color TV or other video sources and has audio and video dubbing and editing capabilities. It also displays stills and plays cassettes at either fast or slow search rates. In addition, a video camera can be connected to the *Showmate* to originate footage.

Showmate 2 Video System

Unfortunately, the *Showmate* turned out to be a botched execution of a good idea. From a difficult-to-understand instruction manual, oddly designated unit controls (to view a cassette, a switch marked "TV/Monitor video monitor" has to be set at. . .TV) right through to not including the two cables necessary to record from the *Showmate* TV (they're sold as separate options instead), *Bell & Howell*'s design department seemed to be asleep at the switch. It was a judgment apparently shared by its intended market. Last summer we saw these units being offered at an extremely discounted price on a cable TV home-buying program. (March)

SONY DISCMAN COMPACT DISC PLAYER (D-7S). Manufactured by: *Sony Corp. of America, Sony Drive, Park Ridge, NJ 07656.* Price: $299.95. An update of the *Discman* which created such a sensation among consumers in 1985, our beef with the *D-7S* was its rechargeable battery pack. Weighing nearly as much as the CD player itself, the *Sony* battery pack requires eight hours of charging for "approximately 4.5 hours" of continuous play. Adding to its limitations, the rechargeable pack can be "recharged for approx. 200 times," meaning that after those 200 times, consumers would be shelling out $45 for the BP-200 rechargeable battery pack. Despite the CD player's sophisticated features and high audio standards, its rechargeable battery pack made us wonder what *Sony* was attempting to do. (July)

Discman CD Player

SILLIEST GADGETS OF '86

Just because something is silly, doesn't imply it's without merit. Something silly can also be a lot of fun. While "silly" may not be the ultimate accolade, it doesn't preclude enjoyment of the item on its own terms.

The Silliest of the Silliest: **BATTERY-POWERED ROLLER SKATES**. Available from: *Hammacher Schlemmer, 147 E. 57th St., New York, NY 10022.* Price: $479.50. One of the wonderful aspects of contemporary gadgetry is watching venerable gags and visual jokes become reality, like these battery-powered skates. Supposedly capable of speeds up to 20 mph, these traditional black leather skates are powered by four rechargeable 6-volt gel cell batteries. Speed is regulated by an electronic pulse control, worn on a belt along with the batteries. Range is "20 miles on a single 7-hour charge." From the classic animated cartoons of yesteryear onto the consumer market, this is one of our favorite items. (February)

THE ELECTRONIC CAT DOOR. Available from: *Hammacher Schlemmer, 147 E. 57th St., New York, NY 10022.* Price: $99.95. Electronic management of household pets has never struck us as an industry with much growth potential, but we've been wrong before. A special "key" worn around your cat or small dog's neck signals the door to open from either side, or both, depending on your choice. From our experience with felines, we'd guess getting your cat to use this would be the major battle. (July)

GOBALL. Available from: *Sporting Edge, 22121 Crystal Creek Blvd., S.E., Bothell, WA 98021.* Price: $79.95. Something about the philosophy behind a remote-control ball strikes us as a bit demented, like maybe this is the perfect gift for the ultimate sloth? Of course, the advantages of a ball which you never have to chase, merely signal to return, probably shouldn't be discounted. (March)

Electronic Cat Door

LIGHTRON. Manufactured by: *Intromark, Inc., 701 Smithfield St., Pittsburgh, PA 15222).* Price: $5.95. Here's a battery-powered, light emitting diode way to say, "Hey, bartender." A smoked plastic case, circled by five red LED's, the *Lightron* signals a bartender or waitress when an empty glass or bottle is placed on it. "It may be a joke to teetotalers," GADGET suggested, but in retrospect it's probably pretty funny even to drinkers. (April)

PLANETARY GEAR MASSAGER. Available from: *Hammacher Schlemmer, 147 E. 57th St., New York, NY 10022.* Price: $89.50. You would have to see this in action to understand how silly it is. A cam-action powers five phalange-style nodules in a semi-circular motion, in an attempt to "replicate the action of human fingers." Behind this device obviously stands someone with an obsession. The result is a salami-sized massager, unwieldy, a bit hard to control and very silly looking. (July)

Battery-Powered Roller Skates

SNORE STOPPER. Available from: *S&K Co., Flowerfield, building No. 7, St. James, NY 11780.* Price: $39.95. We know snoring is a serious problem for a percentage of the population, but the *Snore Stopper*'s approach struck us as something right out of the funny papers. A microphone sensor is connected to small electrodes which emit a tiny electric zap when snoring is heard. Even with the assurance that "the electrical stimulus is too insignificant to interrupt sleep, but is effective enough to stop snoring," we had to wonder about shocking yourself into a night of snoreless slumber. (March)

WEBCOR FLOATING FONE. Available from: *Exeters, 3303 Harbor Blvd., Suite B-5, Costa Mesa, CA 92626.* Price: $144.95. More electronic-age indolence, perfect for all those Hollywood hotshots who can't be bothered to climb out of the swimming pool to take a phone call. Oddly enough, in our test, while the wireless handset is water resistant, its base isn't, "which may require you to dry off before hanging up." So how soon before *Floating Fone* accessory towels come onto the market? (May)

Wristalkie

WRISTALKIE. Manufactured by: *SFI Sawafuji America, 23440 Hawthorne Blvd., Suite 130, Torrance, CA 90505.* Price: $40. There was a time when GADGET wouldn't have considered a wrist-mounted vocal transceiver silly, but that was years ago and in the brave new electronic world, something out of Dick Tracy seems a charming throwback to a past technological age. And, as with earlier attempts at this kind of device, the unit doesn't appear to be all that wrist-sized. (January)

Eloquent LX

TRAVEL MASTER LX PORTABLE DICTATION RECORDER. Manufactured by: Dictaphone Corp., 120 Old Post Rd., Rye, NY 10580. Price: $399.

As anyone who's ever transcribed a recording using an ordinary tape recorder could tell you, all recorders (even good-quality ones) are not equal. What transcription demands is a feature which used to be attributed, by salesmen anyway, to automobiles: the ability to stop on a dime.

Since *Dictaphone* built its reputation on transcription equipment, it's not surprising that its *Travel Master LX Portable Dictation Recorder* is a prime example of what a dictation transcribing recorder should be. The bonus comes in the unit's generally high level of design.

In appearance, the *Travel Master* looks much like any contemporary portable recorder. It uses standard, although leaderless, cassette tapes. Side-mounted controls can be manipulated with a single thumb. Besides the usual record functions (record, play, stop, rewind, eject), the recorder includes some use-specific features.

The "cue" control allows the user to insert an electronic beep onto the tape, indicating the beginning or end of material dictated for transcription and instructions inserted for the transcription typist. In rewinding, these cue signals are audible, allowing fast location of materials on a cassette.

A control designated "vox" voice-activates the unit. According to the instructions, once this control is set and the "primary thumb control" is put on record, "recording begins when you start speaking. Tape movement will continue for approximately 5 seconds after voice stops and resume when dictating continues." A final adjustment sets the recorder's microphone for either dictation or conference use.

The *Travel Master*'s timing functions also set it apart from the ordinary portable recorder. A liquid crystal display on the front of the unit, to the left of the cassette compartment, includes a digital clock function, an alarm, a tape counter and a feature labeled timer "up" and "down." With "up," the minutes and seconds being filled on the cassette are totaled up as the user records. "Timer down" allows the user to preset the amount of time to be filled.

The LCD in this mode counts down the minutes and seconds being used, "preceded by a minus sign." Setting these time and timer functions is done via a trio of small buttons. "Mode" moves an LCD indicator into position under each of the five functions printed at the edge of the display window. "Select" activates either minutes or seconds or hours and minutes (depending on selected mode) for setting, while "set" changes the LCD numerals.

The unit's alarm, besides alerting the user at a time selected, can be used to turn on the recorder at a preset time, a feature which will probably give this model the lion's share of the espionage market. The same control which activates the alarm function is also a "lock," which, according to the instructions, should be in place whenever the recorder isn't in use.

Dictaphone's thoroughness in designing the *Travel Master* is indicated by some of its built-in protection features. When a cassette's protection tabs are removed, it's impossible to engage the record mode. "It is therefore impossible to erase material accidentally," the instructions confidently declare, consigning one of the secretary's handiest excuses for flubbed transcriptions to office history. Similarly, when there's no cassette in the recorder, the "primary thumb control" won't move. Via a warning tone, the *Travel Master* also indicates the end of a tape or a broken cassette.

The *Travel Master LX* is sold with a soft case, an earpiece and a rechargeable *Dictaphone* battery with charger, which also functions as an AC adapter. Separately sold options include a foot control, "for stop/start control of transcription playback"; a telephone microphone, or "induction coil" for recording from a phone conversation (another espionage market plus) and a "compact high-sensitivity condenser microphone."

The last option seems the tape recorder equivalent of wearing a belt with a pair of suspenders. In GADGET's test, we used the *Travel Master* to interview exhibitors at a trade show. Although the hall was alive with other voices and their echoes, the unit's built-in microphone picked up voices clearly and distinctly.

In transcribing the interviews, the recorder's audio pick-up clarity, and precise start/stop action, made getting the spoken word onto paper a smooth task. Despite its lofty price tag, the *Travel Master LX Portable Dictation Recorder* is perfect for those using a tape recorder as an everyday tool. To return to an automotive frame of reference, this *Dictaphone* portable recorder is definitely the Cadillac of its market category.—G.A.

Bits & Pieces

Nagaoka is Japan's "leading manufacturer of video and audio accessories and cartridges" and beginning last year, its products have been imported exclusively by *Angstrom Associates, USA, Inc. (210 8th St., Lewiston, NY 14092)*. Among these is a right-on-time **8mm video cleaning cassette (8W-28CL)**. The product, which uses a company supplied cleaning fluid, "eliminates dust from record, playback and erase heads, capstan, pinch roller and tape guides." A small amount of fluid is placed in a reservoir in the cleaning cassette. The tape is then "played" through and the cleaning is complete. Cleaning fluid refills for this 8mm video cleaning cassette are available. Price: $20.

8mm Video Cleaning Cassette

Described as "the world's first sound-activated light switches" by *Sporting Edge Catalog (22121 Crystal Creek Blvd., S.E., Bothell, WA 98021)*, **Audiolites** have a built-in sensor which, when it detects a sound will switch on a lightbulb, radio or small appliance. The Audiosocket fits into any conventional socket and can be used with light bulbs up to 150 watts. Audioplug is designed for standard electrical outlets, while Audioswitch replaces standard switches. The user can control the volume of sound needed to trip the switch and for how long the light or appliance stays on—seven seconds to seven minutes. This gadget would appear to have excellent home security applications. Price (for each of the three Audiolite components): $24.95.

"A hotplate for the well-to-do" was how one GADGET staffer described **Magna-Range**, and the description is apt. Available from *Bloomingdale's (115 Brand Road, Salem, VA 24156)*, the stove-top unit uses a slightly futuristic method of cooking: magnetic induction. When a metal pan or pot is placed on its ceramic top, a current is generated which heats the pot to the desired cooking temperature. The virtues are a more efficient use of energy, a cooler cooking surface and a faster and cleaner way of cooking. The limitations come in with the choice of cookware: Only cast iron or non-bonded metal pans will do. The small size of the unit, which is two inches high and about a foot square, is also a plus. Price: $250.

The **Tape-A-Message** sounds like a telephone answering machine without the telephone. Called the Message Machine by *Sporting Edge Catalog (22121 Crystal Creek Blvd. S.E., Bothell, WA 99021)*, this is a 15-second, continuous loop tape recorder for leaving messages for other householders. Press a button to record and lift it up and the message plays automatically. Power is supplied by three AA batteries, included with the Tape-A-Message. Price: $22.95.

Tape-A-Message

The **Supertype 240** is a top-of-the-line office electronic typewriter with upgradeable memory (maximum of 28,000 characters) and a 40-character display. Powered by a built-in micro-disc drive which uses 8.000 character micro-diskettes to store text permanently, the unit also features a 25-character per second printer, proportional spacing, document assembly, automatic pagination, stored formats and much more. Manufactured by *Olympia U.S.A., Inc. (Box 22, Somerville, NJ 08876-0022)*, the typewriter also features search and delete and vertical line tabulation. From the material we've seen, the Supertype 240 seems fully capable of lightening any office workload. Price: $1,849.

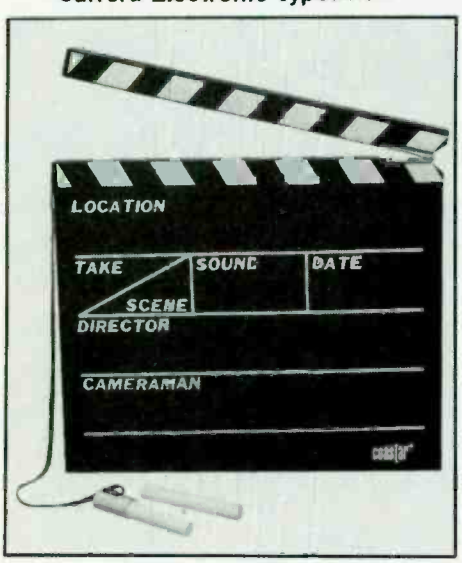
The Bionaire 104 is a fan's fan. A fan for anyone who's a fanatic about keeping cool in the summer and—because the Bionaire doubles as a space heater—warm in the winter. The fan function of the Bionaire is fulfilled by a steel-mesh-covered blade within a plastic housing, powered by a three-speed motor. There is also a rotating louvre in front, to direct or disperse the flow of air as you wish. Available from *The Sharper Image (680 Davis Street, San Francisco, CA 94111)*, the Bionaire also doubles as a heater, with dual settings powering 750 or 1,500 watts worth of heat into a room. This is definitely a step above your ordinary air blower. Price: $149.


Bionaire 104

Bits & Pieces

30CTV1 Color Television


Carrera Electronic Typewriter



Video Clap Stick

Sanyo's entry into the pocket-size TV market may have brought the long-awaited flat television set a step closer. The model **30CTV1** has a three-inch screen and utilizes "beam index" technology, as do new full-size sets from *Sanyo (1200 W. Artesia Blvd., Compton, CA 90220)*. In contrast to conventional color TV systems, "the beam index color tube features a single electronic beam whose intensity and position is coordinated through an index signal," which Sanyo says "will make it possible to decrease the thickness of color television as thin as 50 mm." The mini 30CTV1 features a 68-channel tuner, one-button color control and AC/DC operation. Price: $499.95.

Here's an off-beat solution to an irritating problem, an endless loop tape, trademarked as **C.I.A.—Cindy**, which the manufacturer, *The Video Kit Co. (P.O. Box 8571, Rowland Heights, CA 91748)* says "stops obscene phone callers in their tracks." Without giving the tape's game away, Video Kit says the tape "turns the table on obscene phone callers" by using "human nature," and claims nearly "98 percent effectiveness" in its test of the tape before marketing. Made for use with telephone answering machines, if the buyer's machine doesn't use the endless loop system for outgoing calls, the C.I.A. Cindy tape's message must be transferred. From the descriptive literature, we'd guess this is predicated on the idea that obscene phone calls necessarily come from strangers. Unfortunately, this isn't always the case, as social research and police investigations have often indicated. Nonetheless, if you or someone you know is routinely bothered by these telephonic harassments, C.I.A. Cindy might be worth looking into. Price: $19.95.

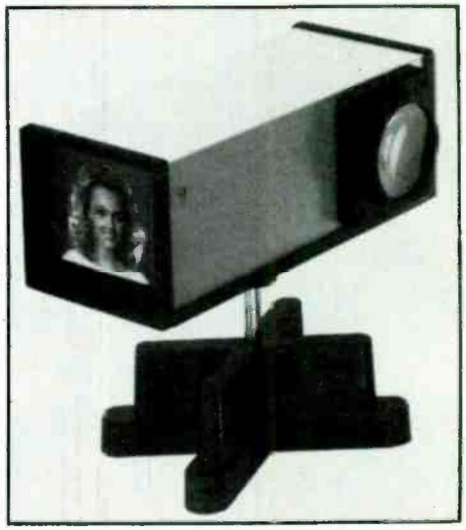
The **Carrera** is a portable daisywheel electronic typewriter with an improved standard American keyboard. A product of *Olympia USA, Inc. (Box 22, Somerville, NJ 08876-0022)*, the Carrera has an integrated carrying case, 24-character automatic correction memory for fast error lift-off, a relocate key that speeds the printer back to the last typing position after corrections have been made, automatic margin settings and paragraph indent. The Carrera can also serve as a PC letter-quality printer with an optional parallel interface. Special print enhancements such as bold and expand print give a professional look to your typing, and interchangeable daisywheels offer a variety of typefaces. Price: $349.

The Little Black Book, the shirt-pocket traveling directory has been upgraded to Release 2.0 (we're not sure, frankly, what this means, but we assume computer fanciers out there will), and now features a genuine calfskin book cover and pre-perforated textured bond paper. The upgrade gives the user the ability to print any of The Little Black Book's 30 separate index categories as a separate book. For instance, a category of contacts in New York City could now be a self-contained volume. Made by *Cygnet Technologies, Inc. (1296 Lawrence Station Road, Sunnyvale, CA 94089)*, the Little Black Book software features sophisticated auto and screen-dialing capabilities and makes a 400-entry, pocket-sized directory. Each entry includes a name, telephone number, address and space for notes. Entries are organized automatically in alphabetical order and can be put into 30 index categories by the user. After using the perforations or cutting and stapling the paper, the directory slips into the pocket-sized leather cover included in the package. Price: Release 2.0 and leather cover, $20 to current users; same package for first-time users, $79.95.

Here's a product that aspiring Cecil B. DeMille's among home video makers have probably been clamoring for—the Coastar **CL-186 Video Clap Stick**. It's an "authentic reproduction of the familiar movie industry 'scene starter,'" complete with chalk for marking scenes, takes, location, date, director and cameraman. From *Coast Manufacturing (118 Pearl St., Mt. Vernon, NY 10550)*, with this and a canvas folding chair any video camera owner can indulge fantasies of absolute directorial authority. Price: $19.95.

Bits & Pieces

One of the new product categories spawned by the nation's switch from celluloid to video tape as the preferred medium for home "movies" is film-to-video transfer equipment. *Ambico (50 Maple St., P.O. Box 427, Norwood, NJ 07648-0247)* has introduced a new model of **The Director** transfer device. The **V-0612** allows the user to project films onto the device's screen, which are then picked up and transferred to video tape cassettes in any video camera which has been properly focused onto the built-in "macro lens." According to Ambico, the V-0612's "macro lens" is a big advance, making The Director "easy to use with all types of video cameras," while preventing "ambient light problems." It's also possible to add an audio track to any silent black-and-white or color film footage. The company promises "truly professional type transfers." Price: $79.95.



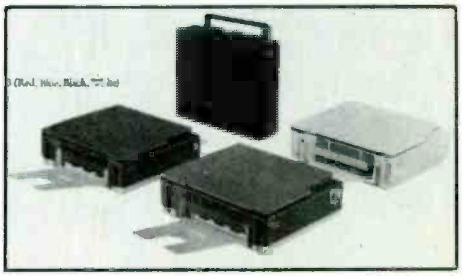
Film-to-Video Transfer Device

Want to give your den or study the authentic look of a fast-paced newsroom? Feel the need to keep track of disparate friends and relatives no matter where they are in the country? Have telephone business dealings which take you across five time zones in five minutes? **The U.S.A. Wall Clock** from *Sporty's Pilot Shop (Clermont County Airport, Batavia, OH 45103)* may be just the ticket. A handsomely designed map of the United States is sectioned off into the five major time zones, with a separate clockface mounted over each. The whole is encased in a blond wood case with a glass front. Price: $345.

Even that most mundane of household devices, the thermostat, has felt the effects of the microchip revolution. *Honeywell*'s residential controls division *(1985 Douglas Drive N., Golden Valley, MN 55422)* has introduced a **microelectronic programmable thermostat**, the **T8200A2010**. Controls can be programmed to reflect a household's peak and minimum demand periods for heat, via keys hidden under the thermostat's cover, which itself includes a temperature dial, an LCD digital clock and a "change" button which allows a user to "accommodate temporary schedule changes" in the household by "switching between energy-saving and comfort temperatures." There's also a thermometer and two small system lights. According to Honeywell, the T8200A2010 can mean savings of "from 9 to 32 percent annually on energy costs." Usually sold through residential heating contractors, a brochure describing this Honeywell product is available from the company. Price: $120.

Programmable Thermostat

Already dominant in the market, *Canon (1 Canon Plaza, Lake Success, NY 11042)* has updated its line of **personal copiers** with three new models, including a super-compact **PC 3**. The unit, which weighs in at 25.5 lbs., has a built-in carrying handle. Canon calls it "ideal for the home, small business, desk or college dorm." As with predecessor models, the PC 3 uses a replaceable mini-cartridge available in five toner colors—red, green, blue, black and brown—and good for 1,500 copies. This new model produces plain paper copies of anything from business cards to letter-size sheets. The company says it can also copy "three-dimensional objects." Price: $695.

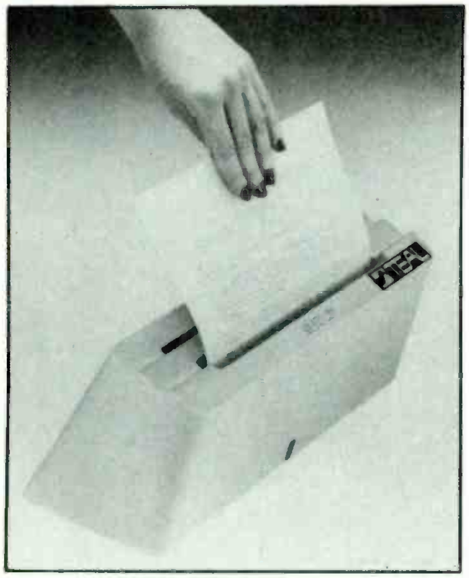


PC 3 Personal Copier

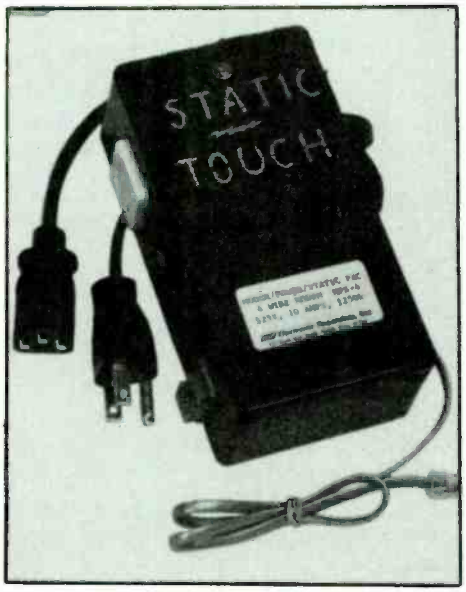
Time was when "programmable" was the very latest in calculator features. Now, *Hewlett Packard (1000 N.E. Circle Blvd., Corvallis, OR 97330)* has introduced calculators which the company proudly boasts are "capable of solving user-defined equations without the need for programming." Called **The Business Consultant**, the products feature algebraic data entry and built-in programs for finance, general business, statistics, summing and number lists, mathematics and time/appointments. A feature dubbed "the formula solver," allows users to enter their own equations, in words using alphabetic keys. Then, using the numeric keys to type in the known values, users can solve for any unknown variable in the resultant equation. The Business Consultant features a four-line, 23-character display, weighs 8 ounces and, when opened for use, measures less than 8" by 7". Also available from the company, a series of Consultant Series application books providing instructions and application ideas for sales, finance, marketing, real estate, banking, personal investment and other fields. Price: $175.

Business Consultant Calculator

Bits & Pieces



Electric Letter Folder



Modem/Power/Static Pac

The idea of an electric letter folder may invoke visions of Rube Goldberg contraptions, but if your office or company sends out a lot of correspondence, it's no laughing matter. **Quik-Fold** is AC powered, fits on a desk top and can fold 1 to 3 letter-size pages (stapled or unstapled) of up to 24-lb. bond in 1½ seconds. A product of *Teal Industries, Inc. (1741 Lomita Blvd., Lomita, CA 90717)*, Qwik-Fold makes neat, precise folds and eliminates paper cuts. Just drop in a letter and it comes out perfectly folded into a 3 panel letter ready to stuff and mail in a standard business envelope. There's no on or off switch—the insertion of an 8½ x 11 sheet activates the mechanism. Qwik-Fold weighs 8 lbs. and blends into any office decor. Price: Under $200.

The home video revolution has created a host of new products. A new accessory from *Coast Manufacturing Co., Inc. (118 Pearl St., Mt. Vernon, NY 10550)* may not be a big-ticket item, but it is an important one. The Coastar **VNK-2** Professional **TV/Video Cleaning System** has everything the home video consumer needs to keep image quality clear and clean. The kit, which comes in an easy-to-store case, includes VHS video cassette cleaner, VHS head cleaning fluid, a lint-free cleaning and polishing cloth and "resolution enhancer" screen and monitor spray cleaner. Price: $24.95.

Perhaps the ultimate in small-size vacuum cleaners, the **Mini-Vac** from *Sporty's Tool Shop (Clermont Airport, Batavia, OH 45103-9747)* is powered by a single nine-volt battery and is ideal for removing small particles of dust and dirt from camera and stereo equipment, electric typewriters, computers and the like. It can also be used as a blower to clean impossible-to-reach spaces or areas. The Mini-Vac comes equipped with both straight and curved extension tubes, pony hair and human hair brushes and a dirt and dust collection bag. Battery not included. Price: $29.95.

The literature we received from *Electronic Specialists, Inc. (171 South Main Street, Natick, MA 01760)* describes their products as "computer protection" equipment for traveling portable computers, but unfortunately, we're not specialists enough to figure out what *kind* of protection they're talking about, and they don't specify. Anyway, the **Modem/Power/Static Pac** combines broadband AC power filtering, extended range spike suppression, modem RF filtering, modem spike suppression and a static discharge plate. Sounds pretty impressive to us. Power is available from a conventional 3-prong outlet and a CEE-22 universal portable computer power connector. Modem connection is through standard modular RJ-11 connectors. If you can figure all this out, perhaps you need one. Your move. Price: $184.95.

Coming, in next month's GADGET newsletter

- **Video Update—GADGET tests the Canovision 8 Video System and JVC's "video movie all-in-one," the GR-C7U camera/recorder.**
- **Tele-picture—A quarter of a century after it was first developed, a "picture phone" has finally arrived. GADGET looks at, and through, the Luma "visual telephone" from Mitsubishi.**
- **Wireless Rabbit—A few laps with the Jac-Rabbit, radio-controlled, gasoline-powered off-road racer.**

Also in the next GADGET—the Skier's Speedometer, Sony's "Boodo Khan" personal stereo, Canon's electronic Image Editor, Info source for 8mm, Sharp's "fashion color" 3LS36 personal TV, the Bathroom Heater Plus, a Table Tennis Robot and more. . . .

COMPRESSOR FOR COMPACT DISKS

Ever tried to record a compact disc on a conventional cassette recorder? Unless your deck has dbx, you're not in the race. Even those machines with automatic level control cannot cope with the wide dynamic range of compact discs. That's where our CD Compressor comes in.

By Colin Dawson

WIDE DYNAMIC RANGE IS SUPPOSEDLY WHAT'S needed when you want to reproduce sound exactly as it was recorded. Unfortunately, unless you're relaxing in a quiet listening environment, *dynamic range* often interferes with maximum listening enjoyment because it's either fighting equipment limitations or the ambient noise level. What is high-fidelity dynamic range for your home is not necessarily hi-fi for autosound, your Walkman, or even disk-to-tape duplication.

With the compact disk rapidly taking over the home market, much of the "on the run" listening will be from tapes duped from compact disks. While at first consideration it might appear that that is the way to get "fi" that is really "hi," in actual fact the end product might well be sound quality that is less than acceptable.

For example, when you're barreling down the expressway you don't want wide dynamic range, anyway; you need a lot less because the average car is so noisy at highway speed that ambient noise would drown out the soft (*pianissimo*) parts of the music. And should you be into running for fitness, you're not going to be interested in *pianissimo* passages.

*Original article appeared in Electronics Australia, May, 1986 edition, and reappears here by permission.

So if you are going to record usefully, and listen to cassette tapes made from compact discs, you'll want to restrict the dynamic range deliberately, and for that you'll want a compressor: a device that makes the soft passages louder and the loud passages softer. That's the kind of performance you'll get from our *CD Compressor*.

Ideally, a compressor should operate so that: 1) the volume control for playback is set to the same level for a compressed tape as an uncompressed one, *ie*, the average volume should be about the same; 2) the quiet passages should be increased in level sufficient to overcome an automobile's ambient noise; 3) the loudest passages should be reduced in level so that they do not cause distortion or discomfort to the listener in a car.

Our *CD Compressor* uses a relatively simple, low-distortion circuit to meet those objectives, all the while keeping distortion to a low level.

Naturally, there is some compromise that mainly applies to very low-level signals. Some classical music passages have sections so quiet that they are barely audible even in an ideal listening environment. Amplifying those sufficiently to overcome the noise of your turbo-charged horses under the hood isn't practical; therefore, our design has a maximum gain of

+9.2dB for small signals (a voltage gain of about 3).

For the loudest passages, the circuit has a maximum signal attenuation of -14.5dB (a voltage loss of about 5.3), which takes the sting out of the *fortissimo* (really) loud passages.

Overall, the circuit reduces the dynamic range of the music by 9.2 + 14.5dB, or about 24dB. That is enough to allow just about all compact discs to be satisfactorily recorded on just about any cassette deck.

How It Works.

The heart and soul of the compressor is the Signetics NE572 *compandor* integrated circuit (U2), which can be used either as a compessor or expander, hence the contraction "compandor." In fact, the NE572 has two independent compandor sections because it's intended for stereo applications.

The compandor is essentially a variable transconductance cell, which means that it is basically a resistance that varies in proportion to a control voltage.

For a compressor circuit, the resistance is inserted into the negative feedback path of an op-amp so that it can control the gain of that op-amp. Refer now to the circuit diagram (Fig. 1), which shows both channels.

The control voltage is derived directly from the input op-amp's output signal. The output signal is fed into a rectifier inside the compandor (pin 3 for the left channel—we shall refer only to the left channel for most of the circuit description). The resultant voltage varies in proportion to the output signal amplitude.

The rectified voltage does not directly control the gain cell. It is first passed through a buffer that permits control of the attack and release times. A capacitor connected to pin 4 of U2a sets the attack time (in conjuction with an internal resistor). Similarly, a capacitor connected to pin 2 of U2a sets the release time (again in conjuction with an internal resistor).

An external series-connected resistor of 47 ohms was also found to be prudent in the release circuit because it improves the stability for high-amplitude transients. With the components selected, the attack time is about one millisecond and the release time about 10 milliseconds. Those times represent a compromise between good signal control (to prevent signal transients from beating the system) and distortion, which particularly affects the bass frequency range.

U2 has an output (pins 6 and 10) for each of its respective sections which is the "THD trim" facility. They are connected to the respective non-inverting inputs (pin 3) of op-

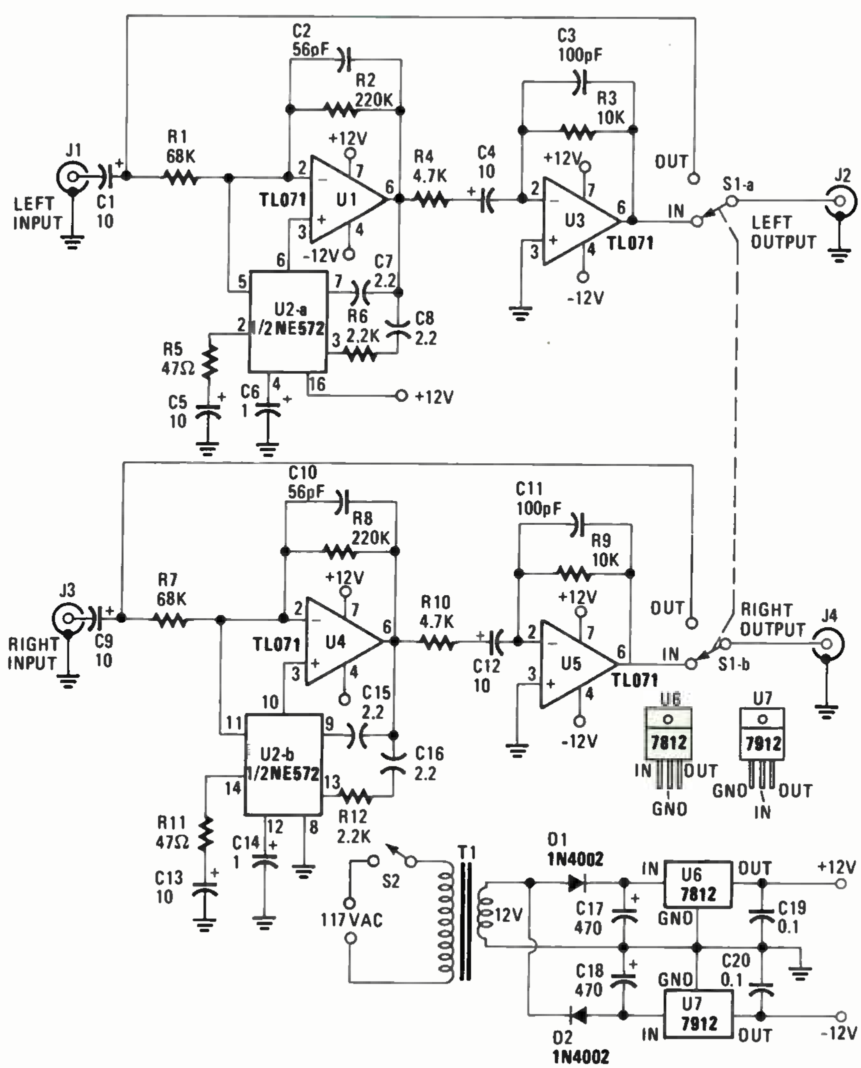


Fig. 1—Although the circuit appears to be large and complex, it is actually two identical (stereo) channels. Be extremely careful that you install U6 and U7 with the correct polarity because U7 has a *negative* ouput voltage.

PARTS LIST FOR CD COMPRESSOR

SEMICONDUCTORS

D1, D2—1N4002, silicon diode rectifier
U1, U3, U4, U5—TL071, FET-input op-amp
U2—NE572, stereo compander integrated circuit
U6—7812, +12-volt regulator integrated circuit
U7—7912, -12-volt regulator integrated circuit

RESISTORS

(All resistors are ¼-watt, 5%, fixed units)
R1, R7—68,000-ohm
R2, R8—220,000-ohm
R3, R9—10,000-ohm
R4, R10—4700-ohm
R5, R11—47-ohm
R6, R12—2200-ohm

CAPACITORS

C1, C4, C5, C9, C12, C13—10-µF, 16-WVDC, electrolytic
C2, C10—56-pF, ceramic disc
C3, C11—100-pF, ceramic disc
C6, C14—1-µF, 16-WVDC, electrolytic
C7, C8, C15, C16—2.2-µF, 16-WVDC, non-polarized, electrolytic
C17, C18—470-µF, 25-WVDC, electrolytic
C19, C20—0.1-µF, Mylar

ADDITIONAL PARTS AND MATERIALS

J1, J2, J3, J4—Phono jack
S1—DPDT toggle switch
S2—SPST toggle switch
T1—Transformer: AC-line, step down, power; 12.3-volt, 300-mA secondary winding
Cabinet, terminal block, printed-circuit materials, wire, hardware, solder.

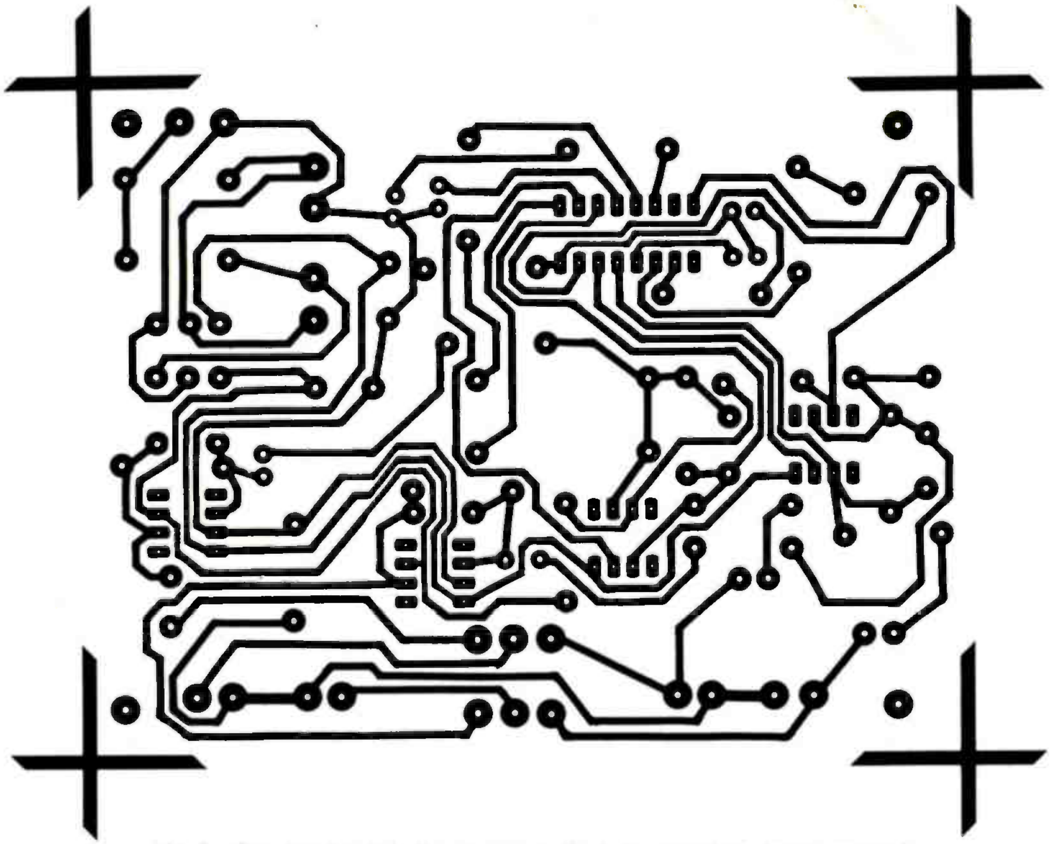


Fig. 2—The *doughnuts* in the corners indicate the locations for the printed-circuit board's mounting screws. Simply use a drill bit that matches the screws.

amps U1 and U4, and can be adjusted to minimize the circuit's distortion.

However, for the "THD trim" facility to work correctly, the NE572 needs to be used in conjunction with bipolar op-amps. (It depends on the fact that bi-polar op-amps draw relatively high input bias currents.)

We preferred to use FET-input op-amps for this circuit because they give low-noise performance at low cost. We also did not want any user-adjustments in the circuit, so it would be simple to build and get going.

We have still connected the trim outputs to the respective op-amps (U1 for the left and U4 for the right) because that ensures that the op-amps are biased to nearly the same level as the gain cells.

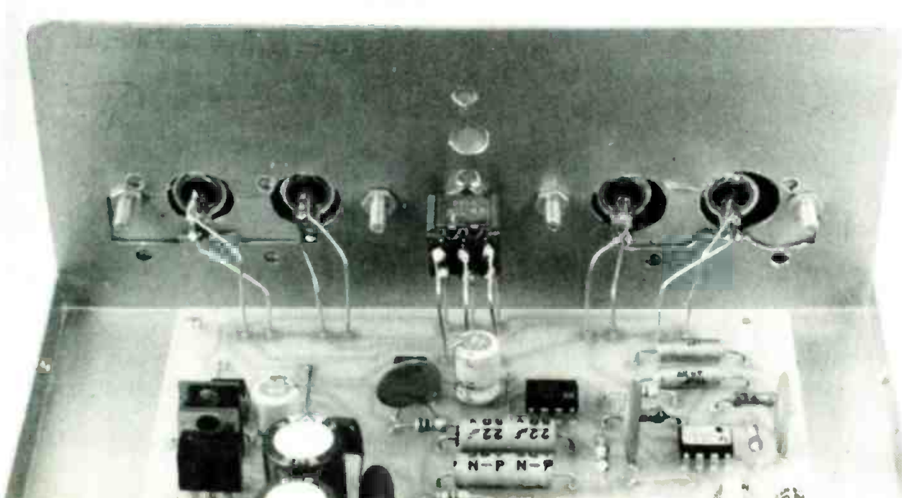
Distortion tends to rise dramatically when the op-amps' output exceeds about 400mV. To avoid that situation, we have set up the compressor so that it has severe attenuation for large inputs. As the overall output level would be too low with that characteristic, a gain stage (U3) has been added after the compressor.

U3 has a nominal gain of just over two, which provides the circuit with an acceptable overall gain characteristic. For a 2V RMS input, the output will be 370mV.

The resulting distortion of the circuit is around 0.15%, which is well above compact-disc standards but well below the distortion levels of typical cassette decks.

Power supply

U2 is a little unusual in that it operates from a single-ended power supply while the op-amps require a bi-polar (balanced



For maximum stability the input jacks must be isolated from direct contact with the chassis. Cut away sufficient metal so that the jacks don't short to the panel.

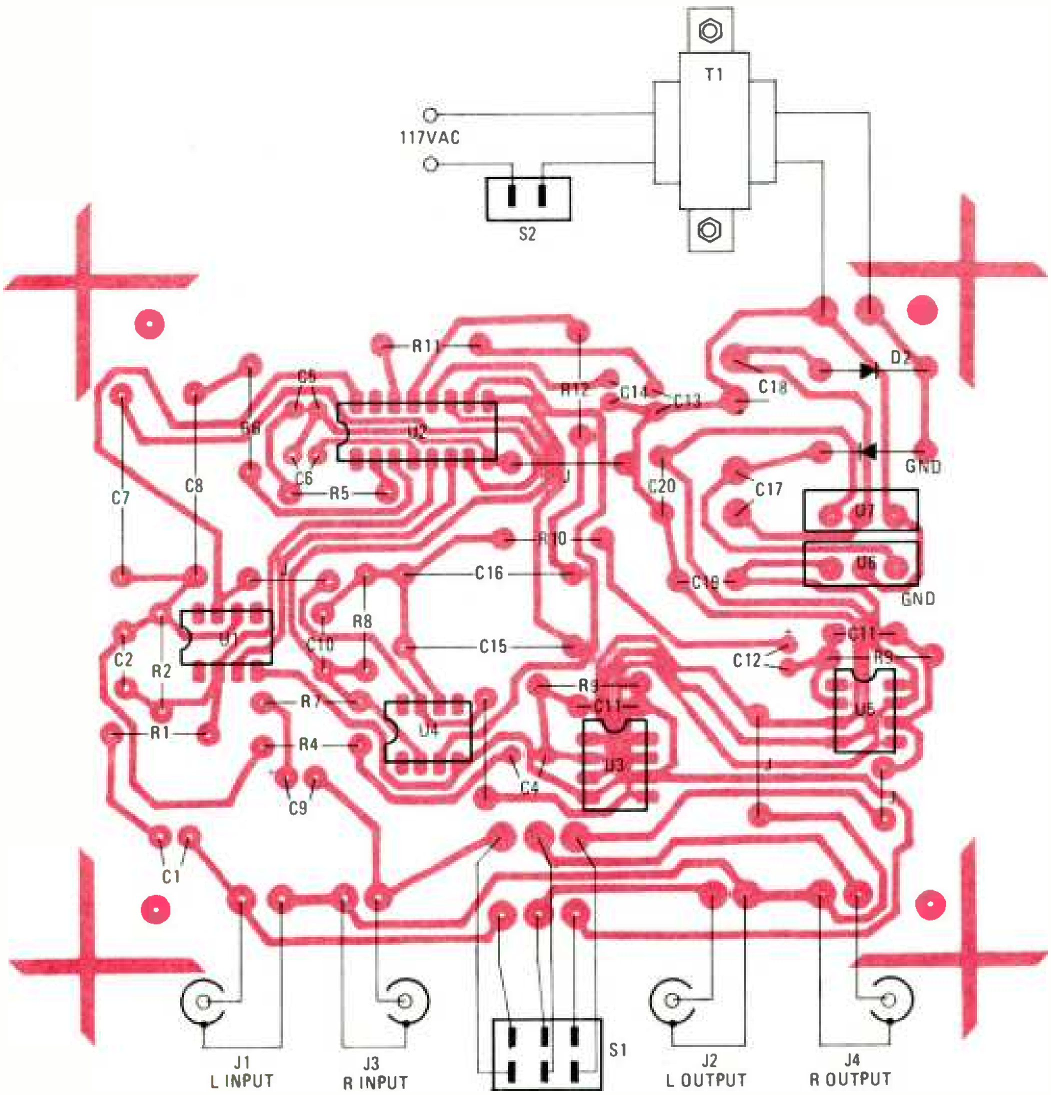


Fig. 3—When populating the printed-circuit board, make certain you get the polarity of the electrolytic capacitors correct. Some are non-polarized, while others have conventional polarization; it tends to get confusing when they get mixed.

positive and negative) supply. Even so, the power supply is quite simple. It uses a small transformer that feeds 12-VAC to positive and negative half-wave rectifiers D1 and D2 and 470-µF electrolytic filter capacitors. That results in ±17-VDC sources, which are fed to positive and negative 12-volt three-terminal regulatiors.

Because we envisage that the *CD Compressor* will be set up between a CD player and a cassette recorder more or less permanently, it has been equipped with a bypass switch (S1). In the bypass position the circuit need not be switched on for normal operation of the associated equipment.

Construction

The circuit must be built into a metal box to provide good shielding and a safe electrical ground. We chose a standard folded metal box from Dick Smith Electronics, measuring 7.3 x 2.75 x 6.3 inches (Cat. No H-2744). We mounted the input and output sockets and the bypass switch on the front panel, and the power switch on the rear panel.

All the circuit components except for the bypass switch are mounted on a printed-circuit board that measures approximately 4.5 x 3.5 inches. No shielded cable is required, and the phono jacks and the bypass switch are connected directly to the printed-circuit board with short lengths of hookup wire.

Assembly of the printed-circuit board is non-critical and straightforward: The components can be mounted in any order, but don't forget to install the wire jumpers (there are five of them).

Drill the case after the printed-circuit board is assembled following the overall layout shown in the photographs. An oval-shaped hole is needed in the back panel for the cord clamp grommet; also, a hole for power-switch S2, holes for the terminal block used for the linecord connections, and a hole for the ground point.

Other holes that must be drilled are: two for the transformer mounting screws (in the base, toward the rear of the box); four for the printed-circuit board's mounting screws (keep the board toward the front of the box); one on the front panel for bypass switch S1, and four more front-panel holes for the input and output phono jacks.

The input and ouput connections should be insulated from the cabinet, so that they can use a single, common-ground

(Continued on page 116)

AM 3 WALKABOUT RADIO

Most miniature AM radios compromise on sound quality but you'll be surprised by the sound from this one. It's a "Walkman" style unit that comes as a kit of parts, ready for easy assembly.

By Steve Payor and David Whitby

DESPITE THE AVAILABILITY OF VERY-CHEAP COMMERcially manufactured receivers, many people still prefer the satisfaction of building their own, even if the results may not be quite as good as a factory-built one. However, this new circuit, which we have dubbed the AM-3, has a performance for which no apologies are necessary. When fitted in the optional dark-brown case it has a solid look and a feeling of quality. The sound quality is also excellent—equal to any Walkman-style portable.

Building this radio will also save you money on batteries. It requires only a single 1.5-volt AA cell, and the current drain is so low (only a few milliamps) that the continuous battery life for this radio will be measured in months, instead of hours—as it often is for a 9-volt transistor radio.

The AM-3 is available as a complete kit of parts from Technicraft Electronics, which saves the effort normally spent on locating the specialized parts such as the ferrite rod and tuning capacitor, not to mention all the "fiddly bits" like screws, spacers, etc. High quality components are supplied throughout, including a tinned Fiberglas printed-circuit (PC) board.

Construction is a breeze—all components, including the tuning and gain controls, ferrite rod aerial, battery, and headphone socket, are mounted on the PC board. The case (which is optional) is supplied with attractive, silk-screened gold lettering and is pre-drilled; so no special tools are needed for a professional finish. Quality lightweight headphones are available with or without the case. Alternatively, you can use any existing type of headphone if you already have a pair.

The circuit is based on the Feranti ZN414 "radio-on-a-chip" integrated circuit. Experienced builders of small radios using that IC will have noticed some shortcomings in its performance: in particular its limited strong-signal handling capability, and the need for an audio transformer to drive low impedance hi-fi type headphones. The volume level is also inadequate for noisy environments. Those problems have all been rectified in this latest design. An *RF gain control* has been added to the basic circuit, which enables the ZN414 to be adjusted for optimum reception of signals of any strength. A one-transistor audio amplifier has also been added to eliminate any complaints about the volume level.

Inside the Chip

The ZN414 forms the heart of the circuit. When fed with the signal picked up by a small ferrite rod aerial, it performs all the necessary functions of radio-frequency amplification and demodulation, to produce an audio output sufficient to drive most headphones directly at a modest volume.

Internally, its operation is fairly complicated, but that need not concern us. We can simply view it as a "black box" which produces an output current that is linearly proportional to the amplitude of the RF input.

Physically, it looks like a standard 3-pin transistor package. Normally we would expect an IC to have at least four external connections: IN, OUT, GND and V.

The ZN414 makes do with only three pins by combining the functions of power supply and output.

How it achieves that is interesting. In essence, the IC varies its supply current a small amount in proportion to the amplitude of the incoming signal. Thus, by feeding the power to the output pin through a 1K resistor, there will be a small AC voltage developed across that load, which follows the amplitude variations of the incoming signal. That is the demodulated audio we are looking for, although it is rather small. That's because the output-pin voltage cannot be allowed to fluctuate too much, since the rest of the circuit derives its power from that point. An audio amplifier is needed for nothing more than headphone-listening sound levels.

Besides RF amplification and demodulation, all "serious" radio receivers also include some form of *Automatic Gain Control* (AGC). That is essential, because the amplitude of signals from various stations (some close by, others further away) can vary from 10-μvolts to 100-millivolts or more. Without AGC, nearby stations would overload the receiver, giving a harshly distorted output, while distant stations would be barely audible. The normal ZN414 circuit implements a moderate amount of automatic gain control by feeding the average DC voltage at the output back to the input, where the gain is strongly affected by changes in DC bias. When a signal is received, the average voltage at the output drops slightly; and consequently the DC input voltage is reduced, which tends to turn off the radio-frequency amplifier, reducing the overall gain.

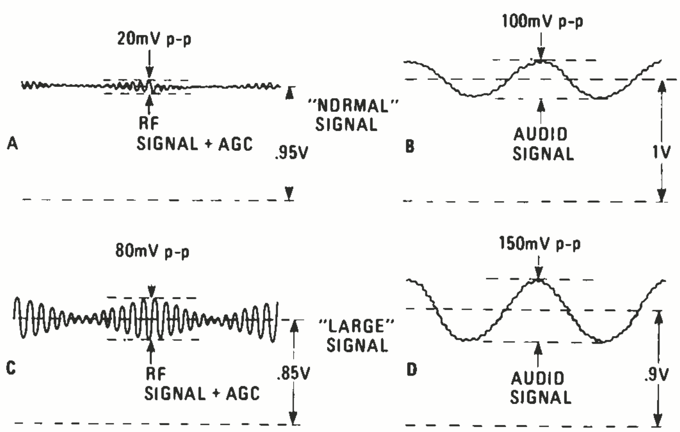


Fig. 1—When an RF signal of moderate amplitude is detected by the ZN414, as in Fig. 1A, it is demodulated and amplified as shown in 1B. The automatic gain control for input signals that are very strong, as in Fig. 1C, keeps the circuit from over-amplifying the demodulated signal shown in Fig. 1D.

Voltages for a typical circuit are shown in Fig. 1 and the circuit in question is in Fig.2. Notice that the AGC voltage is roughly equal to the output voltage, with any audio or radio-frequency signals removed by the low-pass filter formed by the 100K resistor and 0.1μF capacitor. Waveforms are shown for a *normal* signal level (one which just gives full output), and a *large* signal (at the point of output distortion). For a four-fold increase in signal input, the output only increases 50%. That amount of control is achieved with an AGC voltage variation of 0.1-volts. Unfortunately, that amount of gain control, although useful, is not really adequate. By comparison, a well-designed six or seven-transistor AM radio receiver will cope with a 1000:1 range in signal voltage without overloading.

In the past, builders of ZN414 radios have managed to live with that limited amount of AGC by either adjusting the nominal 1K load resistor to vary the control-voltage range, or by rotating the ferrite rod aerial to reduce the signal pickup from strong stations. Many designers even resorted to using the smallest possible ferrite rod, in order to keep the signals weak. All those methods work to some degree, but the authors have developed an improved circuit that overcomes that problem and offers some additional bonuses.

Improved circuit

Figure 3 shows an RF gain control added to the basic circuit, which allows manual adjustment of the AGC voltage. (RF gain controls are normally only found on receivers used by amateur radio operators, who, by the nature of their hobby, like to get the utmost out of their receivers whether communicating half way round the world, or just across town).

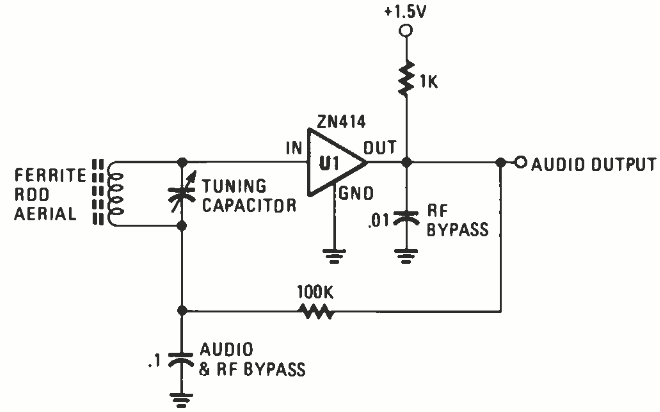


Fig. 2—The ZN414 needs to use only 3 pins, since its audio-out pin is also used for powering the chip; thus it controls the output by adjusting its drain on the circuit.

When receiving strong signals with that circuit, one simply *backs off* the RF gain control a little until the signal is clear and undistorted. The fidelity of the signal with the correct gain setting is excellent, especially with a good pair of wide-range headphones. The audio quality has to be heard to be believed! Reducing the gain too much will drop the volume and cause some distortion, and ultimately silence, because the input passes from partial to complete *cut-off*. Increasing the gain too much will also result in distortion, and sometimes complete silence on very strong signals, because the ZN414 output stage will be completely saturated.

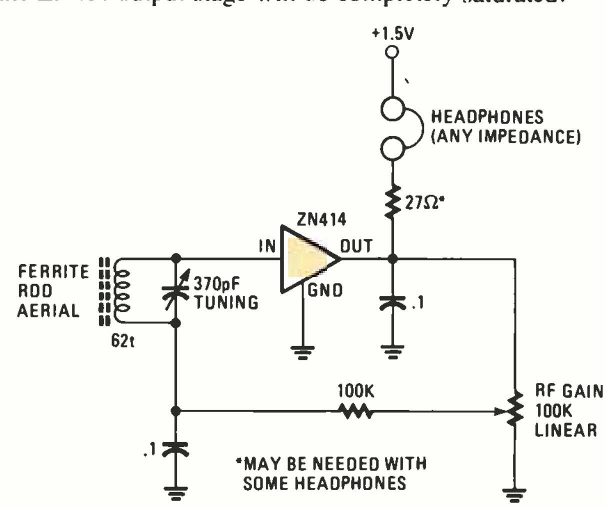
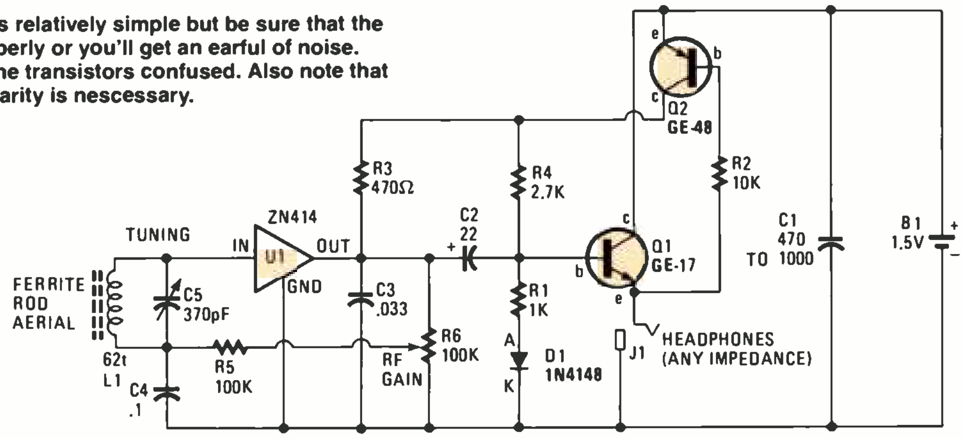


Fig. 3—By making the RF gain adjustable, the radio can reproduce either a near or a far station's audio with great clarity and little power drain. Since the battery is connected through the headphones, when they are unplugged the radio is turned off, eliminating the need for a switch.

Fig. 4—The circuit is relatively simple but be sure that the coil is wrapped properly or you'll get an earful of noise. Be sure not to get the transistors confused. Also note that the correct plug polarity is nescessary.



On weak signals, the control is advanced to the point where the input just starts to draw appreciable current. That gives the maximum possible gain for receiving distant stations. You can tell if the control has been advanced too far, because the tuning will become quite broad, and stations will merge together. That is because the input impedance of the ZN414 drops as the input starts to draw current, and the normally sharp response of the tuned circuit becomes progressively dampened. The most sensitive point is just before that happens.

All that may sound a little involved, but in practice the correct setting of the gain control is easily found, and this slight added complication is well worth the following benefits:

Firstly, distortion is easily minimized, and the sound quality approaches that of the best wideband AM tuners.

Secondly, the 1K load resistor is no longer critical, and the circuit, as it stands, will accept any load between 20 ohms and 1.5K. That means that almost any pair of headphones can be used directly, with no real need for the usual output transformer to match impedances.

Even with low-impedance hi-fi headphones, the output is better than that obtained using a 1K load resistor and an audio transformer, and the frequency response is limited only by the headphones.

A further spin-off is the fact that simply un-plugging the phones turns off the circuit—no battery switch is needed.

Finally, the circuit is quite tolerant of falling battery voltages. With low-impedance phones, the battery voltage can drop to as low as one volt before you cannot adjust the RF gain control.

Circuit Description

The resulting simple circuit is shown in Fig. 4. Here we have added a one-transistor audio amplifier to boost the output to a level sufficient to drive even the most insensitive of modern high-fidelity headphones.

The *auto-power-off* facility has been retained by using an additional transistor, Q2, to disconnect the power to the ZN414 and the audio amplifier when the headphones are unplugged.

In the RF section the load for the ZN414 has been set at 470-Ohms (R3) which is large enough to allow a fair amount of normal AGC action, but small enough to feed sufficient current to the ZN414 under low-battery conditions. With that load, the RF gain-control will need manual adjustment on only the strongest stations.

The exact value of the gain control potentiometer R6 is not critical—any value from 20K to 200K will do. From here the AGC voltage is filtered by R5 and C4 before being applied to the *cold* side of the aerial tuned circuit.

At the ZN414 output, C3 bypasses any RF signals, while C2 couples the audio signal to the output stage.

The audio amplifier consists of NPN transistor Q1, which buffers the output from the ZN414. An emitter-follower configuration is used here, as we only need to amplify the current (not the voltage) of the audio signal. Class A operation is achieved by setting the base voltage to approximately 0.8-volt, which results in a DC voltage across the load of about 0.1 volt, which is slightly more than the peak AC signal amplitude.

Q1's base voltage is derived from the voltage divider formed by R4 and R1 added to the voltage drop across the forward-biased silicon diode D1. That diode provides a voltage which matches the temperature variations of the emitter-

PARTS LIST FOR THE AM-3 RADIO

SEMICONDUCTORS

D1—1N4148 small signal diode
Q1—GE-17, 2N6015, or BC548 (Radio Shack 276-2059 or equivalent) NPN transistor
Q2—GE-48, 2N5818, or BC558 (Radio Shack 276-2023 or equivalent) PNP transistor
U1—ZN414 Radio-on-a-chip integrated circuit

CAPACITORS

C1—470-μF, radial
C2—22-μF, tantalum
C3—.033-μF, tantalum
C4—.1-μF, tantalum
C5—370-pF, variable

RESISTORS

R1—1000-ohm
R2—10,000-ohm
R3—470-ohm
R4—2700-ohm
R5—100,000-ohm
R6—100,000-ohm, linear potentiometer

ADDITIONAL PARTS AND MATERIALS

B1—1.5-volt AA-size battery
J1—Subminiature jack
L1—62 turns of AWG 26 wire around a 3/8" diameter ferrite rod
AA battery holder, light-weight headphones, printed circuit material, solder, etc.

THE DIRECTIONAL AERIAL AND DIRECTION FINDING

In the *good old days* of broadcasting, all the best 8-tube superhets used a loop aerial. That was simply a large, square tuning coil, up to a meter across, which picked up signals by virtue of the magnetic field of the electromagnetic radiation passing through the loop.

Compared with a normal aerial and ground system (which responds to the electric field component of the radiation), those loop aerials had the advantage of being directional, and could be rotated to pick up the maximum signal from a wanted station, or to minimize the interference from an unwanted one. Signal pickup was proportional to the area of the loop, and consequently they were quite large, but then so were the old tube radios.

All that changed with the invention of transistors and ferrite. Both the radio and its aerial shrank to pocket size. A miniature tuning coil wound on a rod of ferrite will pick up almost as much signal as a loop aerial. Ferrite has a magnetic permeability many times that of air, and so magnetic fields in the vicinity of the rod are "conducted" through the center of the coil. Signal pickup is proportional to the length of the rod.

The ferrite rod aerial is sharply directional, just like its ancestor, and the AM-3 uses that to advantage. If you live very close to a powerful station, and wish to receive a distant station which is on a nearby frequency, just rotate the radio (in a horizontal plane) until the interfering signal is *nulled*. That will occur when the ferrite rod is at right angles to the unwanted incoming magnetic field (ie. when the rod is pointed directly at the source.)

This property can be used for direction finding, and triangulation of your position. To do that you will need a compass, and a map with the locations of two or more broadcasting stations marked on it. Air and/or marine navigation charts are best for that purpose.

Attach a plastic ruler to the bottom of the AM-3 case with tape, and make sure that it is parallel to the internal ferrite rod. Align the map in a north-south direction using the compass. (Most maps have the direction of magnetic north clearly marked).

Now place the AM-3 with the ruler on the map and rotate it for a complete null on a selected station. Use the ruler to draw a pencil line from the station location to your estimated position. Do that a few more times with different stations and the intersection of the lines on the map will indicate your position.

Note that longer-wavelength stations are more useful because the radiation is less affected by diffraction and reflection from mountains, city buildings etc.

Other Frequency Bands

In fact, a whole band of frequencies below the broadcast band has been set aside specifically for this purpose. Most airports have NDBs (Non-Directional Beacons) which provide voice information about weather conditions etc. To tune that low-frequency band, you will need to wind the ferrite rod with 200 turns of 0.25mm enamelled copper wire. On the prototype, this gives a tuning range of 175kHz to 850kHz.

The recommended winding to cover the broadcast band (531-1602kHz) is 62 turns of 0.4mm wire. On the prototype this gave a tuning range from 525kHz to above 2MHz. Fewer turns can be used if you are interested in reception on higher frequencies.

The ZN414 is designed to work at frequencies up to 3MHz, and individual devices may work at even higher frequencies, although the ferrite rod will start to become a bit "lossy" above that range.

Nevertheless, the AM-3 is perfectly usable for listening in on the lower frequency short-wave amateur bands. Readers can experiment by reducing the number of turns on the ferrite rod a little at a time until they have the desired frequency coverage. Sufficient wire is provided in the kit to wind several coils. ■

base voltage of Q1. Without D1, the voltage across the headphones would increase excessively if the AM-3 were left out in the sun.

For the *power-up* circuit when a load is plugged into the output, current flows through R2 turning on PNP transistor Q2. That applies bias voltage to the NPN audio output stage, and the supply voltage for the ZN414, to within about 50-millivolts of the full battery voltage. With no load, Q2 stays off—the only current flowing is a few nanoamps of leakage. Finally, a 470µF to 1000µF capacitor (C1) bypasses any internal resistance that the battery may develop as it nears the end of its life.

Construction

All components are mounted on a single Fiberglas PC board. The potentiometer and tuning capacitor are mounted on the component side of the board, and their lugs bent down to protrude through to the track side of the board. The battery holder and headphone socket also reside on the component side, while the ferrite rod is mounted on the track side. Leave that 'till last.

When fitting the smaller components, be sure to check the wiring diagram to ensure correct orientation of transistors Q1 and Q2, the diode D1, and the ZN414 (U1). Make sure that the two electrolytic capacitors are the right way around.

The aerial coil consists of 62 turns of 0.4mm (26 AWG) enamelled copper wire. That can be wound directly on the ferrite rod if you first remove any sharp edges with some fine abrasive paper. Alternatively, use a single layer of tape under the winding.

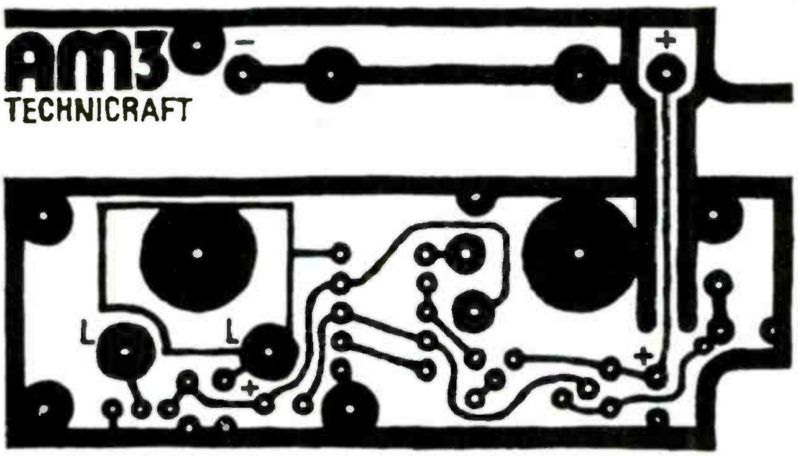


Fig. 5—Here's the foil pattern for the receiver supplied by the author. It is a bit decorative, but it does add some interest to those viewers who will inspect your work.

Wind neatly and carefully in the direction shown in the wiring diagram, and secure the ends of the coil with tape or two small dots of *super glue*. The ends of the winding may now be stripped of enamel and tinned, ready for soldering.

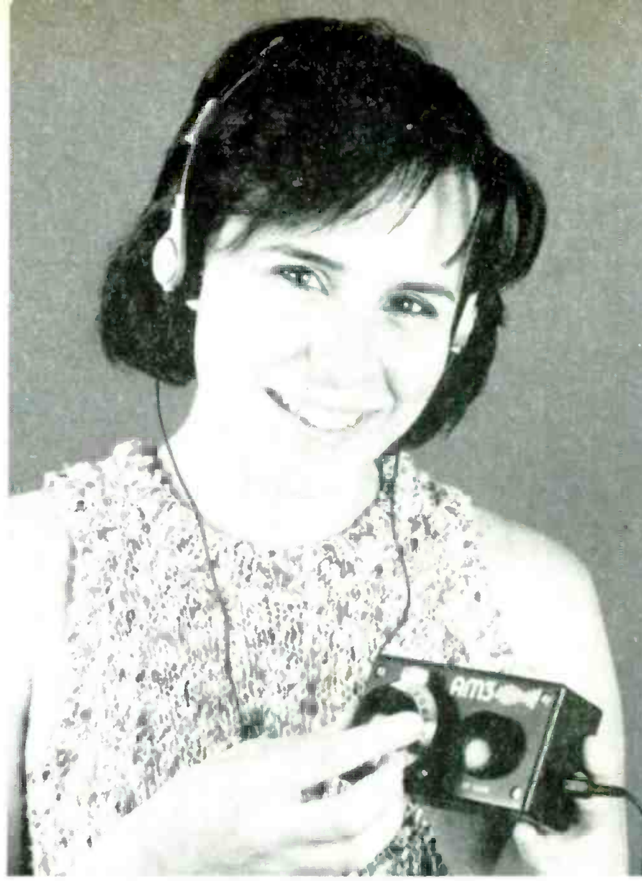
With that done, the ferrite rod can be mounted on the solder side of the board with two plastic *P* clips (clips shaped like a P with a hole in the tail). Check the wiring diagram for the correct way to connect the coil. The reason for that is explained later.

Take note that—and this is a general hint for any circuit using the ZN414 IC—since the ferrite rod is such a good inductive pickup for radio signals, it also follows that any RF current flowing in the output circuit will also be picked up by the aerial circuit—that is unavoidable. There is a 50-50 chance that that will lead to instability and oscillation (depending on whether the feedback is positive or negative). Evidence of instability includes whistles and bursts of severe distortion when the RF gain control is advanced. There is no need to panic—the cure is simple. Simply reverse the connections to the aerial coil. If you stick to the circuit layout as described, and wind the coil in the direction shown, all should be well the first time around.

Having soldered the coil leads to the two pads marked *L*, the AM-3 is now ready for the "smoke" test.

Initial Testing

Temporarily fit the knobs to the tuning and gain controls, turn the gain right up, and set the tuning capacitor to half mesh. Insert a battery, and plug in the headphones—you should hear something at that point. If not, try retuning, and if there is still no sound, disconnect the battery and check the circuit carefully. It would be wise to check the current consumption at that point.



The size of the AM-3 is no indication of its sound quality. It delivers clean audio that rivals high-priced models.

The complete kit is available from Dick Smith Electronics, Inc., POB 8021, Redwood City, CA 94063. Ask for The AM Radio Kit K-9005 and send $24.95 plus $3.75 shipping and handling. California residents add 6½% sales tax. Orders outside the U.S. must include U.S. funds and add 20% of the total price to cover shipping.

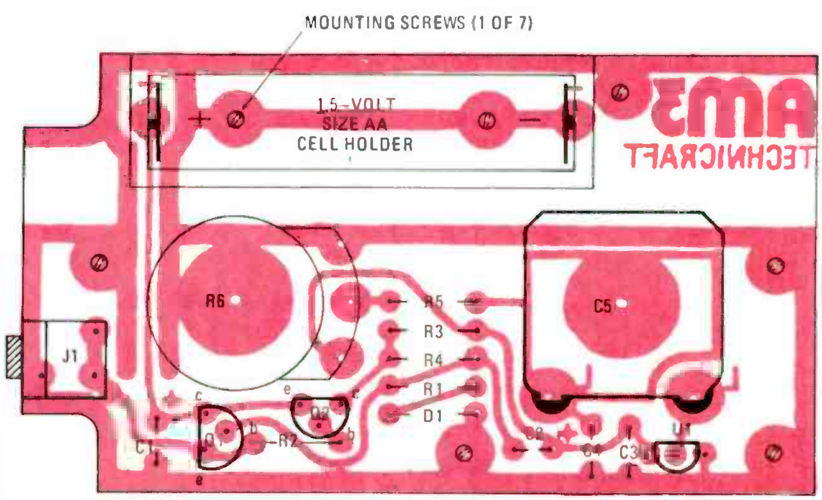


Fig. 6—Be sure to bend the tabs on both the RF gain potentiometer R6 and the tuning capacitor C5. Note that C5 connects to the same solder pads as the inductor L1 so don't solder it in until the leads from L1 are in place.

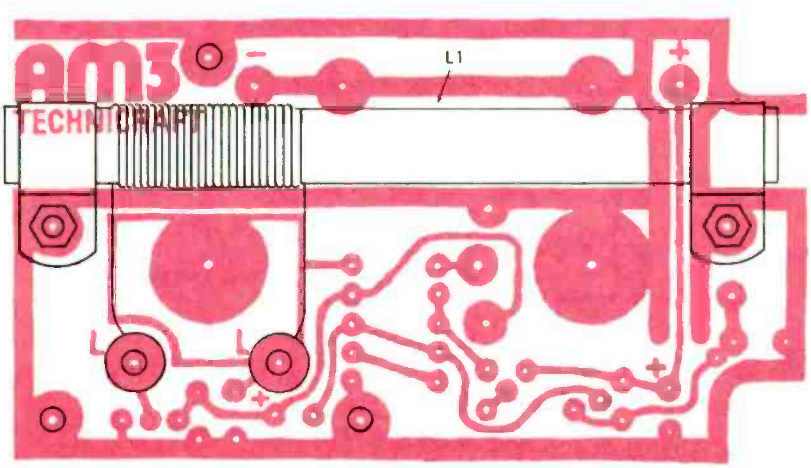
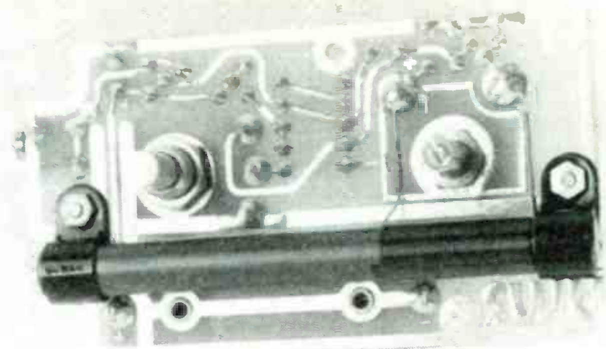


Fig. 7—While winding the coil, be sure to use AWG 26 wire and to wrap the turns close together. Using a different number of turns changes the frequency range of the receiver.



The coil should appear to be wound in a clockwise direction as you look down the ferrite rod from behind the P clamp nearest the coil. Be sure to solder the capacitor connections while soldering the inductor leads in place.

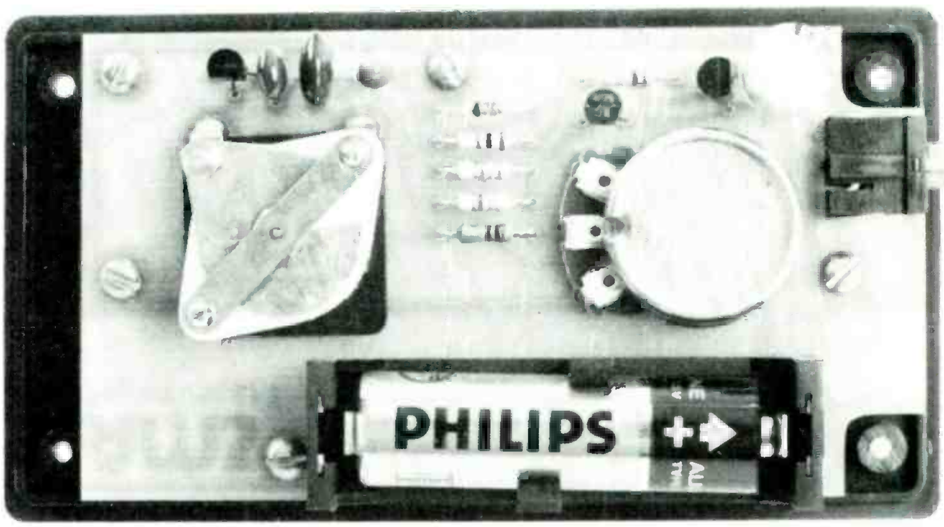
Start with the headphones unplugged, and connect a multimeter in series with a battery. A brief surge of current will flow as C1 charges up, followed by nothing. When the headphones are plugged in, the current consumption should be between 3mA and 7mA (depending on the headphone resistance), and the maximum current with a shorted load should be about 10mA.

Final Assembly

Assuming that all is well, you may now fit the board into the case. That is delightfully easy. First, position the two tapped spacers on the bottom dial screws, and the single clearance spacer behind the top of the dial. Line up the extension shaft on the tuning capacitor with the dial bushing, and seat the board on the spacers. Two short screws anchor the board to the tapped spacers, while one long screw goes through the top clearance spacer into the back of the dial housing.

Set the tuning dial to "O," move the capacitor plates to full mesh, tighten the grub screw in the dial bushing, and that's it!

When the case is assembled, the headphone socket should nestle snugly in the hole in the side of the case. Additional support for the circuit board is provided by the internal ledges against which it firmly rests. The whole assembly is impressively rugged, and should literally last a lifetime.



Parts-placement for the radio is straightforward, but be sure not to confuse the ZN414 chip with one of the transistors. Also make sure that you use the proper transistor in the proper place, with the leads placed properly.

Performance

In overall performance the AM-3 is one of the best beginner radios ever. On local stations the sound is loud, and completely free of audible distortion. In fact, the major limiting factor seems to be the audio quality of the program material transmitted by most broadcast stations.

Selectivity is not as sharp as a conventional *superhet* receiver (with its multitude of fixed-tuned circuits); but, on the plus side, it means that no loss of treble results from the tuning being too sharp. The selectivity is adequate even for some areas where some stations may be less than 50kHz apart, while the sensitivity is sufficient to pick up some remote stations. ■

The AM-3 can be used with any of the light-weight headphones on the market or headphones available with the AM-3 kit.

USING CMOS PHASE-LOCKED LOOPS

Now that we tackled some of the theory behind the operation of the PLL circuits, it time to look at some of the practical applications.

By Fernando Garcia Viesca

☐ IN OUR LAST DISCUSSION IN THE LAST ISSUE, WE COVERED some of the theory of operation of PLL circuits. Though circuit theory may be interesting, the fun and satisfaction in electronics comes when you breadboard a circuit and watch it work! Well, we've reached that phase of our discussion.

This time around, we'll look at several useful and interesting circuits, which will be displayed in *casebook* fashion, that you can use in your own designs. Don't hesitate to modify any values to suit your particular needs. Only the limits on the resistor's values, as described in the next section, should be followed to avoid damage to the device.

The Heart of the Circuit

The voltage-controlled oscillator (VCO) is the heart of the PLL circuit. Whenever you think of IC oscillators, it certainly brings to mind the ever-popular 555. However, the 4046 PLL circuit (when used as an oscillator) has several distinct advantages: ultra-low power drain, which may be further reduced via the inhibit input; frequency setting with a single resistor and capacitor; a 50% duty cycle; very linear frequency modulation; frequency-offset capability, and a higher top frequency (1.3 MHz vs. 500 kHz typical). A block pinout diagram of the 4046 is shown in Fig. 7.

The 4046 is more expensive than the normal 555; but its price is certainly comparable to low-power versions of the

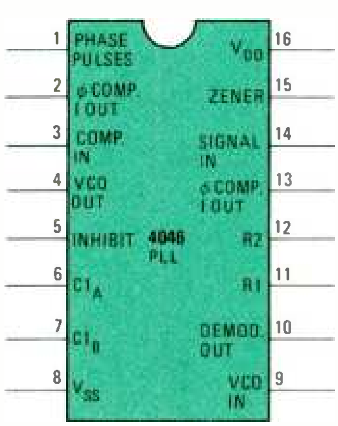


Fig. 7—Block pinout diagram of the CD4046 CMOS PLL.

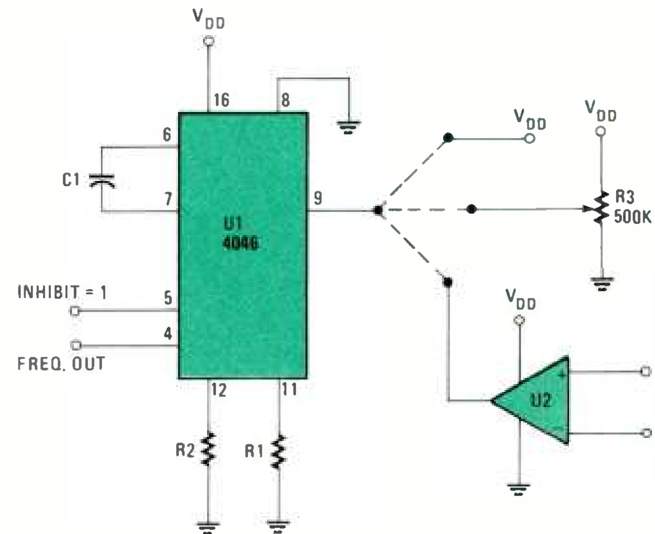


Fig. 8—The CD4046's internal VCO may be set for a fixed output frequency via a potentiometer, or modulated by an op-amp.

555, like the 7555 or the XR-L555. And you may see that there is no significant price difference. The formula for the output frequency is a little more complicated, but you should have no problem using your handheld calculator (see Fig. 8). The output frequency is given by:

$$f = \frac{K\cdot[(VCO_{IN} - 1.65)/R1 + (V_{DD} - 1.35)/R2]}{(C1 + 32)\cdot(V_{DD} + 1.6)}$$

where f is the output frequency in MHz; $5.0 \le V_{DD} \le 15.0$ VDC; $1.65 \le VCO_{IN} \le V_{DD} - 1.35$; $R1 > 0.005$ Megohm, $R2 < 10$ Megohm; $C1 > 50$ pF; $K = 0.95$ $V_{DD} = 5$-volts; $K = 0.95$ $V_{DD} = 10$ volts; $K = 1.08$ $V_{DD} = 15$ volts. Note that you can vary VCO_{IN} from zero to V_{DD} without damage. (The limits shown are for linear frequency modulation.) Damage may occur to the IC, however, if either R1 or R2 is smaller than 5000 ohms.

If a CMOS databook (published by any of the major semiconductor manufacturers) is available, you can use the graphs instead to calculate the frequency. There are several things that should be kept in mind when using the 4046

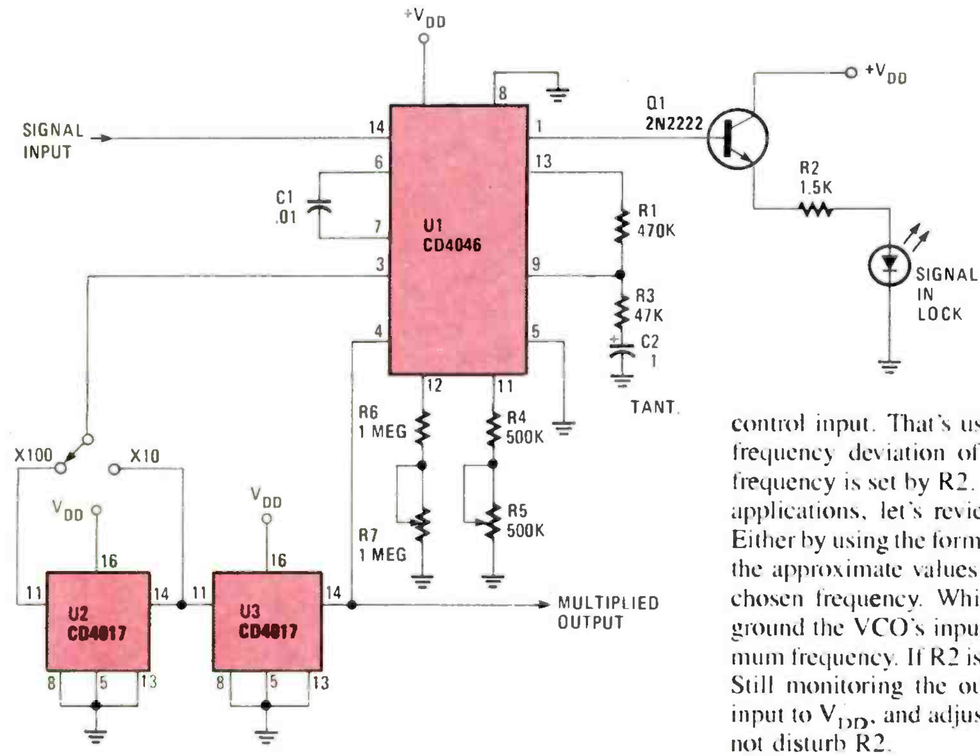


Fig. 9—This upconverter circuit may be used to increase the output frequency of the VCO, by dividing the signal frequency presented to the CD4046's comparator input at pin 3, which forces the VCO to oscillate at a higher frequency.

oscillator. The formula and graphs are intended as a guide only; some breadboard trimming may be required to achieve a precise frequency. And because frequency is affected by supply-voltage variations, regulation is strongly recommended.

The oscillator may be set in the fixed-frequency mode with pin 9 connected to V_{DD} (as indicated by the dashed line in Fig. 8), while using R1 and C1 exclusively to set the frequency. If modulation is desired, a signal with a peak swing between V_{DD} and ground should be used. That could provide, via a potentiometer or by way of an op-amp (again shown as dashed-line connections in Fig. 8), for frequency modulation. In the latter case, the signal from the op-amp is the modulation signal, and should be centered at $V_{DD}/2$ for no-signal input.

Last, is the capability of the oscillator to be set at a minimum frequency other than zero for zero volts at the control input. That's useful, among other things, to set the frequency deviation of the FM modulator. The minimum frequency is set by R2. Since the VCO is the heart of all the applications, let's review a sure way to adjust it properly. Either by using the formula or the manufacturer's graphs, find the approximate values for R1, C1, and R2 (if used) for the chosen frequency. While monitoring the output frequency, ground the VCO's input (pin 9), and adjust R2 for the minimum frequency. If R2 is not used, the frequency will be zero. Still monitoring the output frequency, connect the VCO's input to V_{DD}, and adjust R1 for the maximum frequency. Do not disturb R2.

The oscillator is now adjusted. All the following circuit applications will use those steps when adjusting the oscillator.

Frequency Meter Upconverter

Frequency meters are very useful test instruments, but are intended mostly for RF work. If you've ever tried to measure low-end audio signals accurately, you've probably found the resolution unsatisfactory or the gate times excessively long. As shown in Fig. 9, it's very easy to multiply the frequency by 10 or 100. The heart of the circuit is a PLL—whose VCO covers the frequency span from 1 to 11 kHz, and is useful for input frequencies from 10 to 110 Hz in the X100 range, and frequencies from 100 to 1100 Hz in the X10 range.

The operation of the circuits is as follows: Assume that a 50-Hz signal is present at the signal input, pin 14. The PLL adjusts its control voltage until a signal of the same frequency is present at the comparator input, pin 3. But that frequency has been divided down by 100, (with the switch in the position shown) by a pair of cascaded divide-by-10 counters,

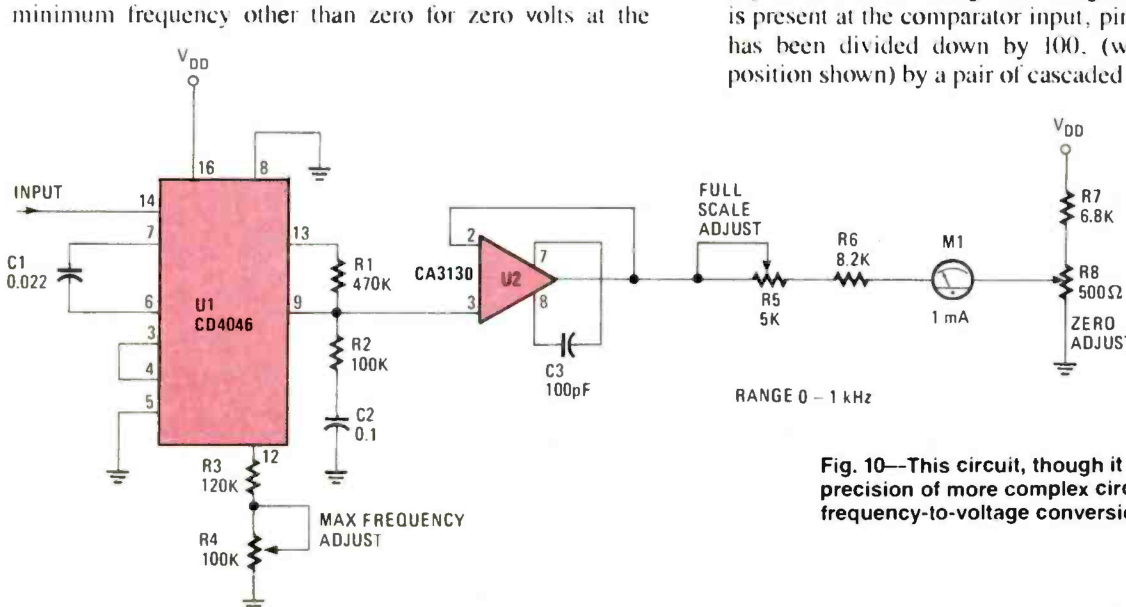


Fig. 10—This circuit, though it does not have the precision of more complex circuit, may be used in frequency-to-voltage conversion applications.

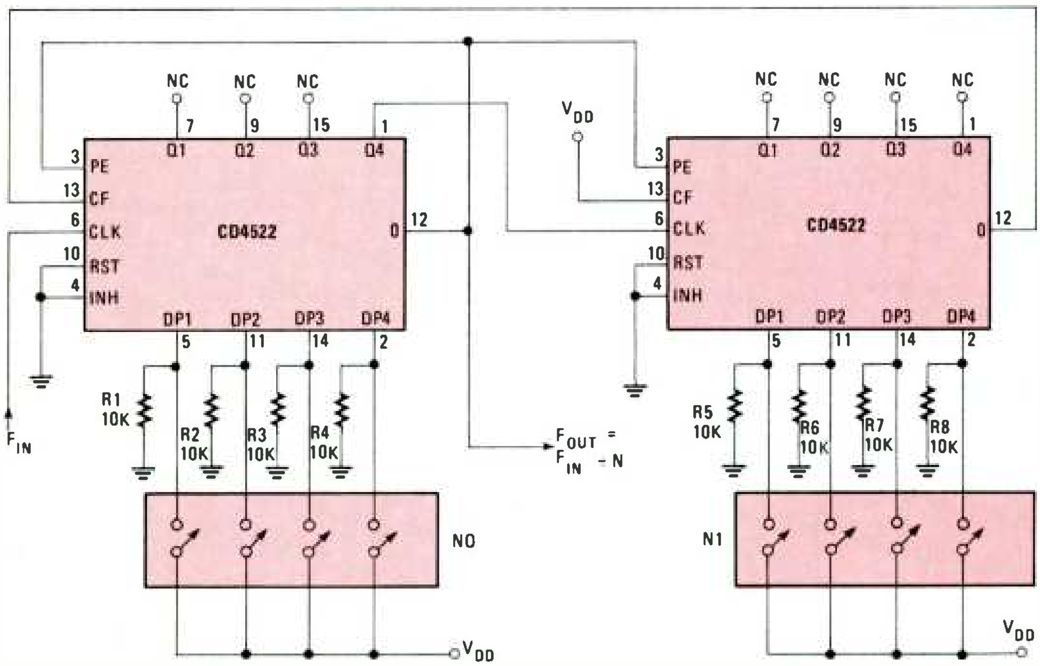


Fig. 11—The CD4046, when coupled with this cascaded programmable divide-by "N" counter circuit, can be used to provide various signal frequencies.

so the VCO must be running at 5 kHz. Since that frequency is within the 1—11 kHz VCO range (as set by R1, R2, and C1), the PLL will be in lock. If the switch position is changed to X10, then the VCO would have to run at 500 Hz, clearly out of range.

To alert the user to the out-of-range condition, an LED driven by an emitter follower from the phase-pulse (pin 1) output is used. Whenever the PLL is in a suitable range and therefore locked, the LED will glow brightly. When unlocked, the LED will dim notably and even flicker.

Since we're dealing with low frequencies, the signal input should be driven with CMOS level and fast risetime squarewaves. An input Schmitt trigger is recommended for sinewave use.

Frequency-To-Voltage Converter

Since the VCO frequency bears a direct relationship to the control voltage, and VCO frequency is also equal to the input frequency in a locked PLL, the control voltage will track the input frequency. That frequency-to-voltage conversion, though not having the precision of more complex circuits, may be realized with a minimum of parts and expense, as shown in Fig. 10.

Adjust timing resistor R1 for the maximum frequency of interest, as described earlier. With zero signal input, adjust for a zero reading on the meter. Lastly, apply an external source (of the same maximum frequency) to the signal input, and adjust for full-scale deflection.

You may recall from the theory that it was stated that no loading should be imposed to the filter. That's why a CA3130 op-amp with its ultra-high input impedance is used to buffer the filter voltage. A plus is that its common-mode range includes ground, and the output swings completely from V_{DD} to V_{SS}.

Frequency Synthesis

Figure 11 shows a 2-decade counter, using the CD4522 counter, that may be preset to divide by any number between 1 and 99 through the thumbwheel switches. That range, of course, may to be extended to 256 by replacing the CD4522 with a CD4526. The CD4522 and CD4526 are programmable CMOS counters that allow easy implementation of frequency scaling, by dividing down a reference by a BCD or binary code appearing on their control inputs D1, D2, D3, D4. Thus with a high-precision master-reference frequency, any number of divided-down frequencies with the same accuracy may be generated.

That circuit is used to produce lower frequencies than the master frequency. By the same token, when a higher frequency is required, a multiplier may be built easily with a PLL as shown in Fig. 12. The counter circuit is inserted in the feedback loop; thus, the frequency appearing at pin 3 is lower than that of the VCO's output (pin 4) by "N" amount of

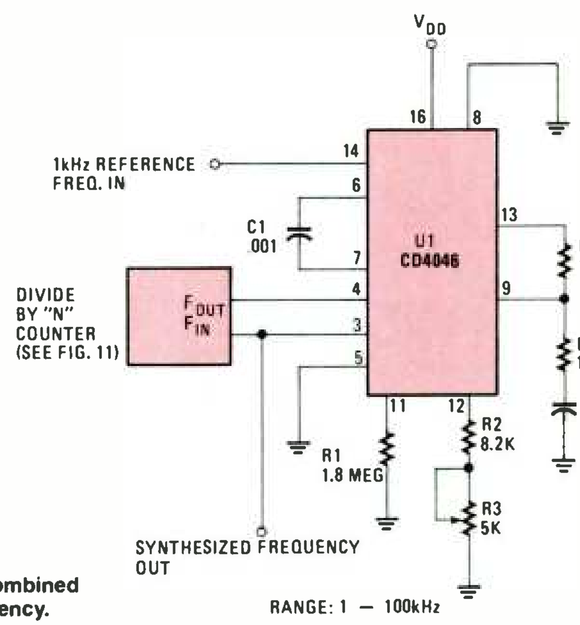


Fig. 12—The divide-by "N" circuit of Fig. 11 can be combined with the CD4046 PLL to synthesize the desired frequency.

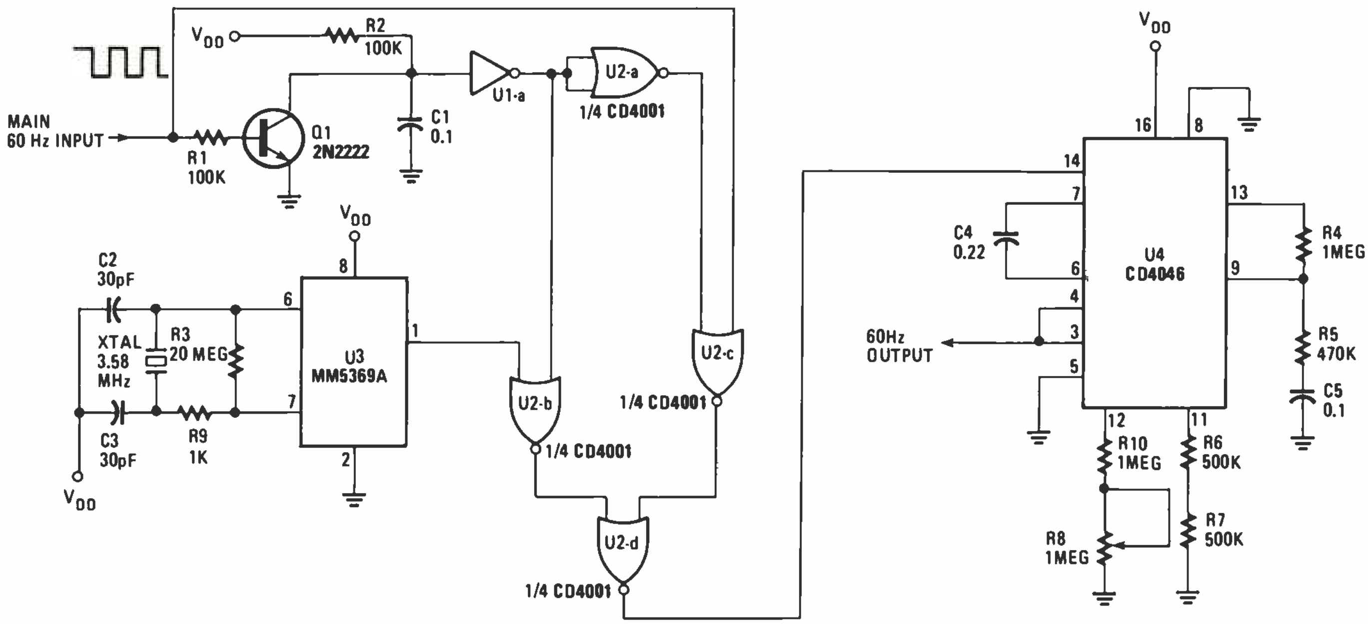


Fig. 13—The double-sync oscillator allows two reference = EP signals to be synchronized without losing a single cycle.

times. A locked condition may be achieved only if the VCO output is running "N" times higher than the input frequency.

Any frequency within the lock range may be synthesized. But beware: The frequency cannot be multiplied too far; the ripple present at the VCO's control input increases as "N" increases. With large values of "N," the output frequency may *warble*, degrading short-term accuracy. For proper circuit operation, all capacitors should be low temperature-coefficient, low-leakage types. Calibration of the circuit involves adjusting only the maximum and minimum frequencies.

Double Sync Oscillator

There are circuits, like real-time clocks, where you may be synchronized to a certain frequency—say, the 60 Hz AC line—and should be able to switch to another alternate frequency when the former is lost. With a PLL, it's very easy to synchronize both frequencies without losing a single cycle in the transference.

Figure 13 shows how that is done. The main frequency turns Q1 on, causing C1 to discharge. When the input voltage zero-crosses during each half cycle, the transistor cuts off and C1 begins to charge through R2. But since the time-constant of R2/C1 is slightly longer than a half period, the next zero crossing arrives before C1 has charged enough to allow Schmitt trigger U1-a to change states. Therefore, the Schmitt trigger output is a logic "1" whenever the main frequency is on.

The output is complemented, and fed to a NOR network, which is also fed with the main and alternate frequencies. You can easily understand that whenever a logic "1" is present at U1-a's output, the main frequency passes through and a logic "0" enables the alternate frequency. That may be generated (as shown) with a crystal-driven timebase. The MM5369A circuit divides the 3.58-MHz crystal frequency to 60 Hz.

The gated and selected frequency is applied to the PLL's input. For best response, the PLL should be adjusted so that its upper and lower frequencies are very close to the reference frequency (64 and 56 Hz, respectively).

When the AC-line frequency is powered, the PLL will be locked to it. When power is lost, the PLL will run free for the short time that it takes the alternate frequency to appear. Thus, not a single cycle is lost in the process and only a small wiggle is present in the output frequency. As stated before, use high-quality components for optimum performance.

(Continued on page 122)

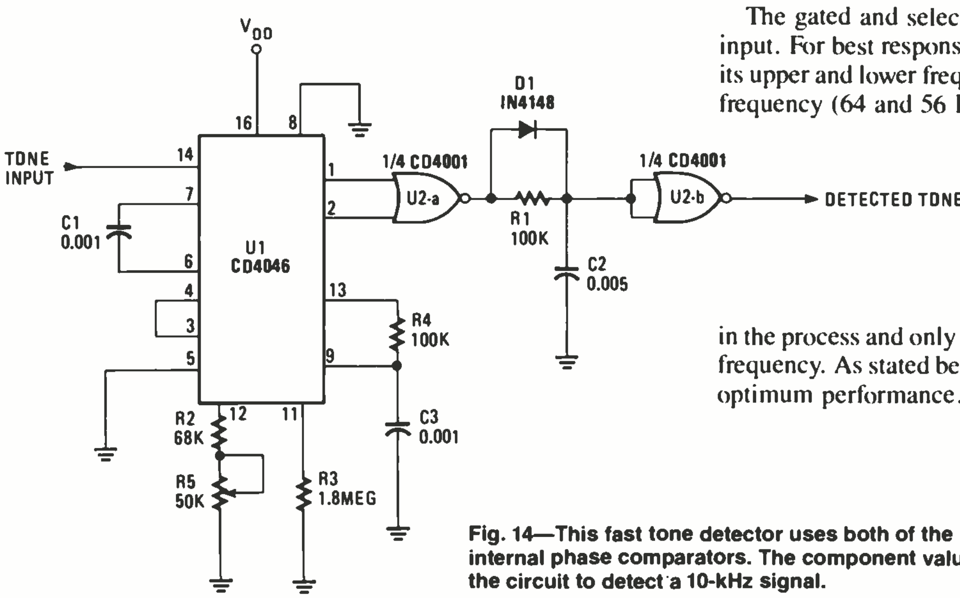


Fig. 14—This fast tone detector uses both of the CD4046's internal phase comparators. The component values shown set the circuit to detect a 10-kHz signal.

Electronic Fundamentals

Louis E. Frenzel, Jr.

Inductors and transformers make modern technology possible

IMAGINE FOR A MOMENT THAT ALTERNATING CURRENT does not exist; that the world is powered by direct current—as it was in the early days of electric power. It is more than likely that, among other things, radio as we know it, stereo, TV, and computers would not exist. Nor would there be great hydro-electric generating stations to supply cheap power to users hundreds of miles from the nearest water. And most likely, our cities would be blighted by DC-generating plants every few miles, and the smoke from their stacks would probably cast a gray pall over the landscape.

Most modern technology, as well as our lifestyle, owes its existence to alternating current, and the key to AC is *inductance*. In this month's lesson on *Electronic Fundamentals*, we're going to look at *inductance* and *transformers* so we understand why they are so important in a high-tech world.

Keep in mind that the lesson is organized in what is called *programmed instruction format*. The information is presented to you in small step-by-step "chunks" called *frames*. You will read the information in each frame and then immediately answer a question based on the material by filling in the blanks with appropriate words or terms. The answer to each question is given in parentheses at the beginning of the next frame in the sequence. As you are going through the lesson, use a piece of paper to keep the frame immediately below the one you're reading covered so you won't accidentally see the answer. The easiest way to do that is to slide the paper down until it just separates the line that separates the frames.

The immediate testing in each frame helps you to understand the material by giving you a chance to apply what you have just learned, and it also aids your retention. Begin now with Frame 1.

Inductance

1. Inductance is the opposition to a change of current offered by a component called an inductor. An inductor is basically a coil of wire, as shown in Figure 1. While the wire itself has a small value of resistance, its effect on current flow is small. It is the special effect produced by the alternating current (AC) in the coil that causes an opposition to current flow called reactance.

Inductance causes an opposition to a ____________ *in current in a circuit.*

---

2. (change) When current flows through a wire, the moving electrons set up a magnetic field around that wire. If the wire is coiled, the magnetic lines of force around each turn of wire combine to form a strong magnetic field. If DC flows in the coil, then the coil simply becomes an electromagnet. If AC flows in the coil, the magnetic field increases and decreases as the current rises and falls.

Current flowing in an inductor produces a ____________ ____________ *around it.*

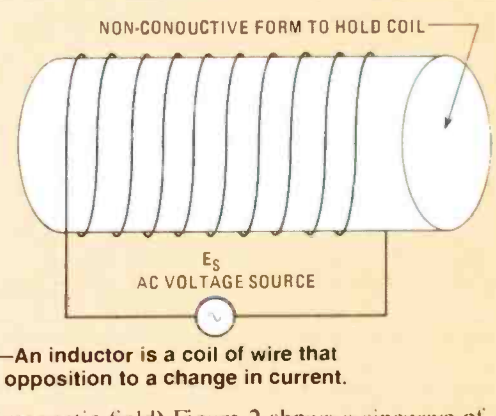


Fig. 1—An inductor is a coil of wire that offers opposition to a change in current.

3. (magnetic field) Figure 2 shows a sinewave of AC that flows in an inductor. As the current increases, the magnetic field expands outward. As the current decreases, the magnetic field collapses; then the direction of current flow reverses. Again, the magnetic field expands as the current increases in the opposite direction. The magnetic field then collapses as

NOTE: This article was derived from the soon to be published book "Crash Course in Electronic Technology" by Louis E. Frenzel, Jr. It is used by courtesy of the publisher, Howard W. Sams & Co.

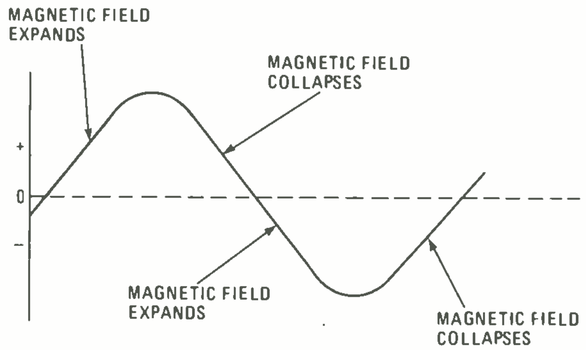


Fig. 2—The magnetic field increases during the increase in the rate-of-change of the current in the coil.

the current decreases. *As the current changes, the magnetic field around the inductor* ______________ *and* ______________.

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4. (expands, collapses) As the magnetic field expands and collapses, it cuts across the turns of wire in the coil. In doing so, it induces a voltage in the coil. That effect is called induction. The coil with its varying magnetic field becomes a small AC-voltage generator. *Induction is the process of a varying magnetic field causing a* ______________ *to be induced into a coil.*

---

5. (voltage) A key fact here is that it is the change in current that produces the induced voltage. The induced voltage is highest when the rate of change of current is maximum. That occurs when the current is zero as it changes from positive to negative or negative to positive. The induced voltage is lowest or zero when the current change is minimum or zero. That occurs at the positive and negative peaks. (See Figure 3.) This shows the complete relationship between the coil current and the induced voltage. *When the current is zero, the induced voltage is* ______________.

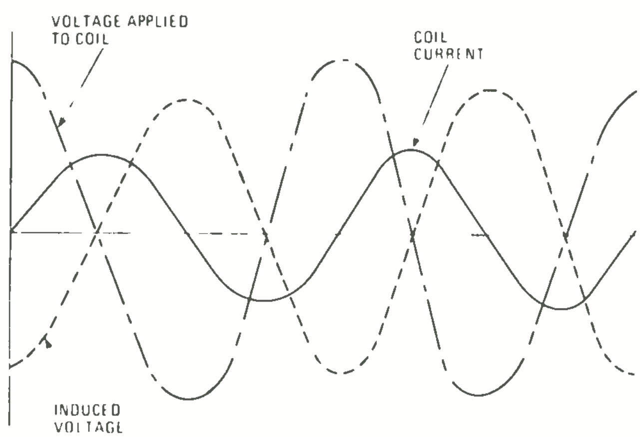

Fig. 3—Unlike the in-phase current/voltage relationship in a resistor, there is a phase difference between the voltage applied to a coil and the coil current. The maximum induced voltage corresponds to the maximum rate of change of the coil current, which occurs at the zero axis.

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6. (maximum) The induced voltage has the opposite polarity of the applied voltage but is lower in amplitude. The total effective voltage in causing current to flow is less than the applied voltage because the induced voltage cancels a portion of the applied voltage. As a result, the current is less. Again refer to Figure 3. The opposition to a change in current offered by the inductor produces an induced voltage that, in effect, lowers the current. The inductor or coil, therefore, is an opposition to current flow. *The polarity of the induced voltage is* ______________ *that of the applied voltage.*

---

7. (opposite) The waveforms in Fig. 3 show the complete relationship between current and voltage in an inductive circuit. As you can see, the maximum, minimum and zero points do not all occur at the same time. Because of that, a phase shift exists between the various signals. A phase shift is the time difference between various signals of the same frequency. *If one signal in a circuit occurs at a different time than another, a* ______________ *is said to exist.*

---

8. (phase shift) Phase shift is usually measured in degrees. Each cycle in a sinewave has 360 degrees, 180 degrees for the positive half cycle and 180 degrees for the negative half cycle, as shown in Fig. 4A. At Fig. 4B, the two sinewaves are in phase with one another. The phase shift is zero. *When two sinewaves are shifted 180 degrees from one another, the zero-crossing points are the same but the positive peak of one occurs at the same time as the negative peak of the other. The voltage polarities are opposite. See Fig. 4C. The polarities of*

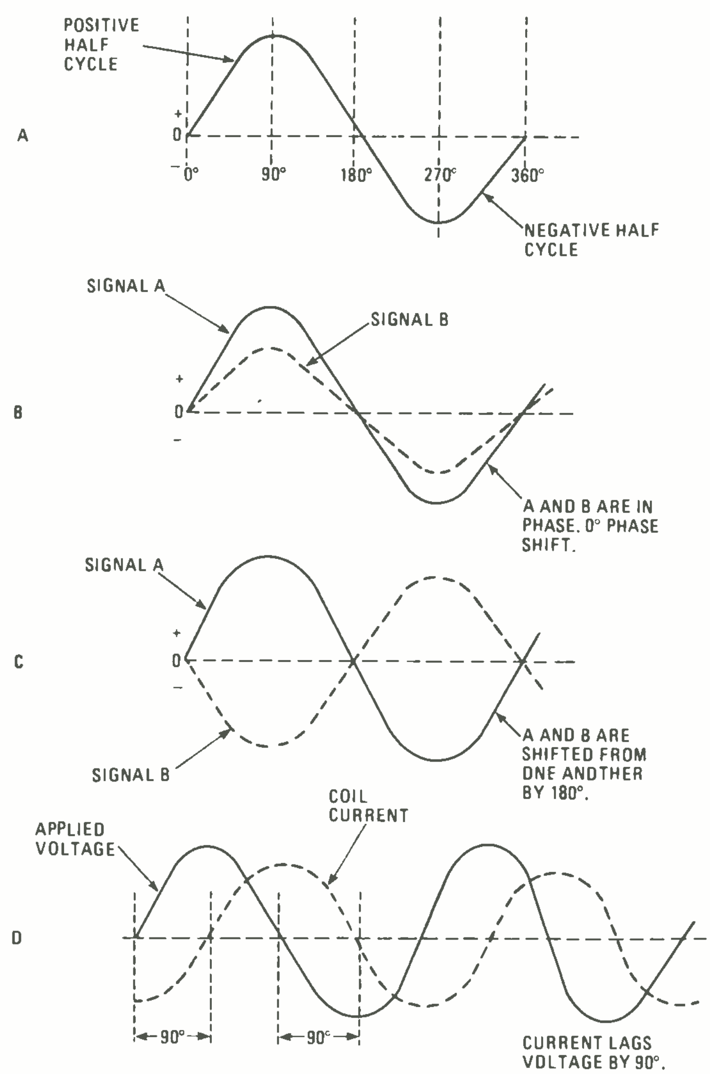

Fig. 4—The phase of the applied voltage is shown in A. In B and C phase relationships to the applied voltage are illustrated. As shown in D, the current in a coil lags the applied voltage by 90°.

two sinewaves are opposite when they are ________ degrees out of phase.

---

9. (180) In Fig. 4D, the current and voltage are shifted from one another by 90 degrees. That is what you saw in Fig. 3. Since the current peaks occur later in time than the applied voltage, we say that the current lags the voltage. That is a common characteristic of all inductive circuits. Or we could say that the applied voltage leads the current: that is, it occurs earlier in time.

In an inductive circuit, the current ________ the applied voltage by ________ degrees.

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10. (lags, 90) Go to frame 11.

Factors Influencing Inductance

11. The amplitude of the induced voltage in a coil and the amount of opposition to a change in current is determined by the inductance. In turn, the inductance depends upon how concentrated the magnetic field is and how many turns of wire are cut by the changing magnetic field. The inductance is determined by the number of turns of wire used, the diameter of the coil, its length, and the kind of core it is wound on.

For example, the greater the number of turns, the higher the inductance because the magnetic lines of force cut more turns, inducing a higher voltage. *A coil with 50 turns has ________ inductance than one with 100 turns.*

---

12. (less) The diameter of the coil also determines its inductance. The larger the diameter, the greater the inductance. The length of the coil also affects inductance. Inductance is inversely proportional to length. The longer the coil for a given number of turns, the lower the inductance. Making a coil longer stretches out the turns, thus, fewer turns are cut and the magnetic field is less concentrated, making the induced voltage lower. *For a fixed number of turns, increasing the diameter of a coil causes its inductance to ________. Decreasing the length causes the inductance to ________.*

---

13. (increase, increase) A major factor affecting the inductance is the type of core material used. The turns of the coil wound with copper wire may be totally self-supporting. Therefore, the core is just air. But many coils are wound on insulating forms made of ceramic, Bakelite, or cardboard. Such core materials have no effect on the coil. They, too, are called air-core inductors. The schematic symbol for such inductors is shown in Fig. 5A.

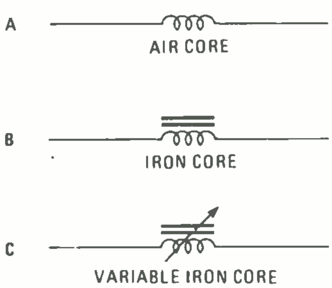

Fig. 5—These three symbols are the ones most commonly used for inductors, although there are variations depending on who draws the schematic symbol and where it is drawn.

But if a magnetic core is used, the inductance increases dramatically. If an iron, steel, or ferrite core is used, the magnetic field becomes stronger and more concentrated: the induced voltage, and thus the inductance is higher. The symbol for a magnetic core inductor is shown in Fig. 5B. *Removing a ferrite core from an air core coil causes its inductance to*

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14. (decrease) Some coils are made so that a ferrite core can be slid or screwed in and out of the coil, thereby providing a variable inductance. A variable-inductance symbol is shown in Fig. 5C.

Go to frame 15.

Units of Inductance

15. The unit of inductance is the *henry* (H). That is, coils are measured in terms of henries. One henry is the inductance that permits a current change of one ampere per second, and induces a voltage of one volt. *Inductance is measured in ________.*

---

16. (henries) One henry is a fairly large amount of inductance. Lower values are more common in electronic circuits. Smaller units of inductance are: millihenry (mH) = 1/1000 of a henry; microhenry (µH) = 1/1,000,000 of a henry. *A millihenry is ________ (smaller or larger) than a microhenry.*

---

17. (larger) One mH is a bigger unit than one µH. Figure 6 shows how to convert from one unit to another. *An inductance of 2.5mH is equivalent to ________ henries.*

TO CONVERT	TO	THEN
H	mH	Multiply by 1000
H	µH	Multiply by 1,000,000
mH	H	Divide by 1000
mH	µH	Multiply by 1000
µH	H	Divide by 1,000,000
µH	mH	Divide by 1000

Fig. 6—If you have difficulty converting between large and small units, tape this table to your workbench.

18. (.0025) A value of .8H is the same as ________ mH.

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19. (800) A coil of 10,000 µH is the same as ________ mH.

---

20. (10) Go to frame 21.

Inductive Reactance

21. While inductance is the opposition to a change in current, the opposition to current flow in an AC circuit offered by an inductor is called the *inductive reactance*. Inductive reactance is designated by X_L and, like resistance, is measured in ohms. X_L is just as effective in controlling or setting the value of current in an AC circuit as a resistor. *Inductive reactance is the ________ to current flow measured in ________.*

---

22. (opposition, ohms) The inductive reactance of a coil depends upon two factors, the inductance value (L) and the frequency of operation (f). The formula below is used to compute the inductive reactance:

$$X_L = 6.28fL$$

where L is in henries and f is in Hz (cycles per second). For example, the reactance of a .5H coil at 60Hz is:

$$X_L = 6.28 \times 60 \times .5 \quad X_L = 188.4 \text{ ohms}$$

The two factors influencing X_L are ____________ and ____________.

---

23. (inductance, frequency) The reactance is directly proportional to the coil inductance and the operating frequency. Figure 7 shows that relationship. *Decreasing the inductance or the frequency causes the reactance to ____________.*

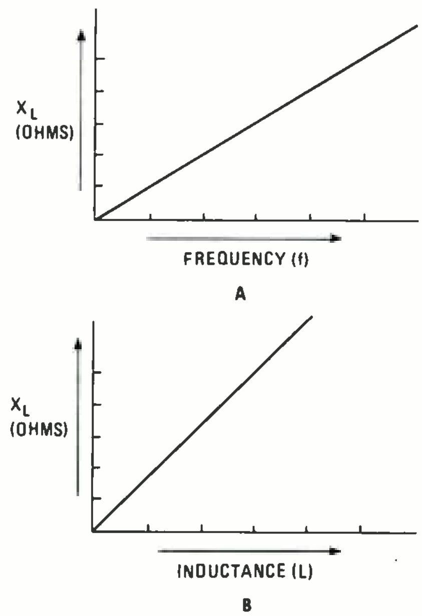

Fig. 7—The variation of X_L for frequency using a fixed value of L is shown in A. In B the variation of X_L with L for a constant frequency is illustrated.

24. (decrease) If a ferrite core is inserted into a coil, its reactance at a given frequency is ____________.

---

25. (increased) Inserting the core increases the inductance and its reactance. *The reactance of a 15mH coil at 455 kHz is ____________ ohms.*

---

26. (42,861) The computation is as follows:

$$X_L = 6.28 \times 15\text{mH} \times 455 \text{ kHz} = 42{,}861 \text{ ohms}$$

Just remember to convert the inductance and frequency values to basic units, H and Hz, before using the X_L formula. Go to frame 27.

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27. Ohm's law for inductive circuits is the same for resistive circuits, with X_L replacing R. The current is directly proportional to the voltage and inversely proportional to the reactance. Expressed mathematically, it is:

$$I = E/X_L$$

where I is the current in amperes, E is the applied voltage in volts, and X_L is the reactance in ohms. *Refer to Fig. 8. The current in a circuit with 5 volts and a reactance of 2.5K ohms is ____________ mA.*

---

28. (2) That calculation is:

$$I = E/X_L = 5/2500 = .002\text{A (2 mA)}$$

Increasing the number of turns of wire in a coil will cause the circuit current to ____________ for a given applied voltage.

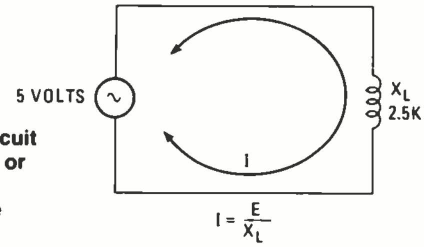

Fig. 8—In a series circuit the inductor controls or sets the value of the current flowing in the circuit.

29. (decrease) Increasing the number of turns increases the inductance and, therefore, the reactance. As a result, opposition increases and the current drops. Go to Frame 30.

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30. All inductive circuits like those in Fig. 9 consist of two types of opposition to current flow: reactance and resistance. The reactance comes from the inductive effects produced by the coil when AC is applied. The resistance comes from a resistor deliberately connected to the inductor, or from the resistance of wire used to wind the inductor, or both. The inductor resistance may be as low as a fraction of an ohm to several hundred ohms depending upon the type of inductor.

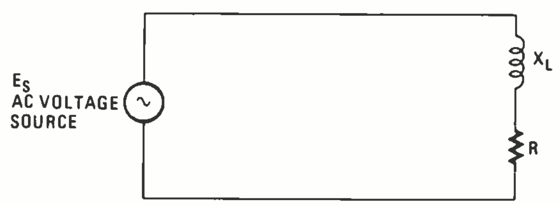

Fig. 9—R represents the resistance of the wire used to make the coil. Opposition to current flow is produced both by the coil's reactance and the resistance of the wire.

Opposition to AC in an inductive circuit comes from the circuit ____________ and ____________.

---

31. (reactance, resistance) That combined opposition is called *impedance* (Z). Impedance is simply the total opposition to current flow offered by all the reactances and resistances in a circuit. Impedance is also expressed or measured in ohms. *The total opposition to current flow in an inductive circuit is called ____________.*

---

32. (impedance) In a series circuit using only resistors, the total resistance (R_t) or total impedance (Z_t) is simply the sum of the individual resistor values or:

$$Z_t = R_t = R1 + R2 + R3 + \ldots$$

However, in an inductive series circuit, you simply cannot add the resistance and reactance to get the impedance. For example, the equation:

$$Z = R + X_L$$

is incorrect.

The reason for that is that, because the inductor produces a phase shift between current and voltage, the individual oppositions do not add directly. The proper way of adding the resistance and reactance is given by the formula:

$$Z = \sqrt{R^2 + X_L^2}$$

The impedance cannot be obtained by directly adding the reactance and resistance because of the ____________ ____________ introduced by the inductor.

---

33. (phase shift) Assume the resistance is 300 ohms and the reactance is 400 ohms. The impedance is computed as follows:

$$Z = \sqrt{300^2 + 400^2}$$
$$Z = \sqrt{90{,}000 + 160{,}000}$$
$$Z = \sqrt{250{,}000}$$
$$Z = 500 \text{ ohms}$$

Those calculations are easy if you use a calculator with a square-root function. *Now, try it yourself. Find the impedance of a circuit with R = 50 ohms and X_L = 70 ohms. Z = ____________ ohms.*

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34. (86.02) Such calculations are often illustrated in the form of a right triangle as shown in Figure 10. The length of the vertical side represents the reactance value, the length of the horizontal side represents the resistance. The length of the hypotenuse represents the impedance.

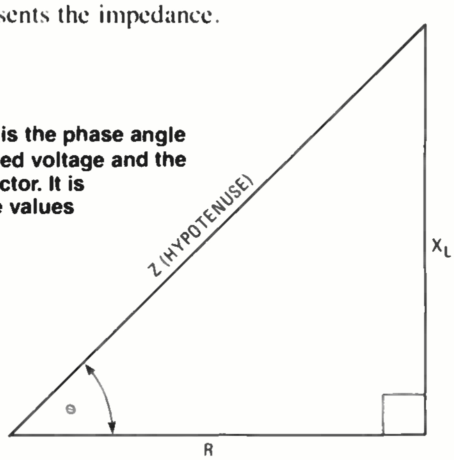

Fig. 10—*Theta* (θ) is the phase angle between the applied voltage and the current in an inductor. It is determined by the values of X_L and R.

Actually, the impedance formula is nothing more than the well-known Pythagorean theorem used in geometry for computing sides in right triangles. Of course, that formula may be rearranged to compute for either the resistance or reactance as shown below:

$$R = \sqrt{Z^2 - X_L^2}$$
$$X_L = \sqrt{Z^2 - R^2}$$

The angle θ (Theta) between the horizontal side and the hypotenuse turns out to be the phase angle or phase shift between the current and applied voltage as produced by the combination of resistance and reactance in the circuit. *The values of reactance and resistance in an inductive circuit determine the ____________ and ____________ ____________ of the circuit.*

---

35. (impedance, phase shift) An inductive circuit consists of a fixed value of resistance and a coil. If the frequency of the applied AC is increased, what happens to the impedance and phase angle? *The impedance ____________ and the phase angle ____________.*

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36. (increases, increases) Increasing the frequency causes the inductive reactance to increase. That also increases the impedance. A higher value of reactance with the same resistance also produces a larger phase angle.

The quality or figure of merit of a coil is called the Q. Q is a measure of the ability of a coil to produce an induced voltage. That depends upon the reactance. But the resistance of the coil reduces current flow which affects induced voltage. A coil's Q, therefore, is a function of X_L and R. *The ability of a coil to produce an induced voltage is called the ____________.*

---

37. (Q) The Q is computed with the simple formula:

$$Q = X_L/R$$

Q is directly proportional to the reactance and inversely proportional to the resistance. *The Q of a coil of 10mH at 50 kHz with a resistance of 31.4 ohms is ____________.*

---

38. (100) First you computed the X_L:

$$X_L = 6.28\ fL\ (10\text{mH} = .01\text{H})$$
$$X_L = 6.28 \times 50{,}000 \times .01$$
$$X_L = 3140 \text{ ohms}$$

Next, Q is computed:

$$Q = 3140/31.4 = 100$$

Typical Q values range from 10 to 1000 depending upon the frequency of operation and the type of coil. Generally, the higher the Q, the better the coil. The need for a high Q depends upon the application. *Most Q values fall in the ____________ to ____________ range.*

---

39. (10, 1000) Coils used in tuned circuits and filters normally need a high Q.

Go to Frame 40.

Inductors in DC Circuits

40. Basically, an inductor has no effect on a DC circuit. Inductance is present only when the current in the circuit is changing. In a DC circuit where the current is some constant value, only the resistance of the coil will affect the circuit. *Inductance is not effective in a DC circuit because the current is not ____________.*

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41. (changing) The only time that current in a DC circuit changes is when power is applied and removed. Consider the circuit in Fig. 11. With the switch open, no current flows. If the switch is closed, electrons begin to flow. That change in current, from zero to some value $I = E_s/R$, is met by opposition from the inductor. When the power is removed, current drops from $I = E_s/R$ to zero. Again, the inductor opposes this change. *The inductor in a DC circuit offers opposition to a change in current when power is ____________ and ____________.*

---

42. (applied, removed) The instant that the switch is closed, a magnetic field rapidly expands outward cutting the turns of the coil. That induces a voltage in the coil equal to the DC source voltage E_s. Since the induced voltage has the opposite polarity of the battery, it exactly cancels the battery voltage, making the total effective circuit voltage zero. Therefore, initially no current flows. As you can see, the inductor opposes the change in current brought about by the power being applied. *The polarity of the voltage induced in the coil when power is applied is ____________ the*

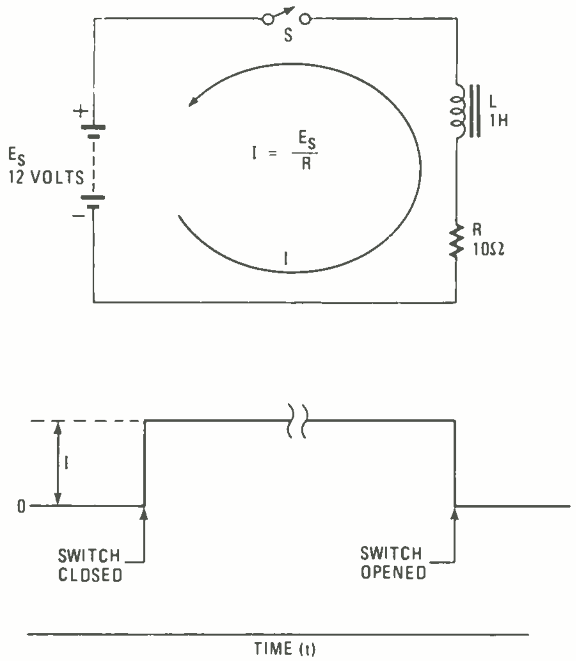

Fig. 11—In an inductive DC circuit, the current rises sharply to maximum when the switch (S) is closed, and falls to zero when the switch is opened.

source voltage.

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43. (opposite) The current gradually begins to rise as the induced voltage drops toward zero, as shown in Figure 12. The magnetic field instantly expands outward when power is applied. But since no further change takes place, the induced voltage decreases, allowing the current to rise. *It takes the current a time (t) equal to the inductance (L) divided by the*

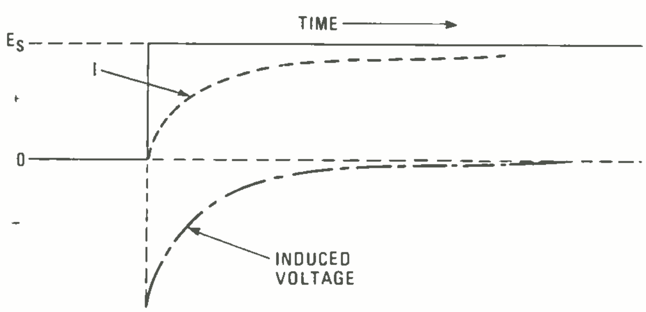

Fig. 12—Because an inductor opposes a change in current, the current in the coil is minimum when voltage is first applied; it builds to maximum over a period of time.

circuit resistance (R) to rise to 63.2% of the final current value of E_s/R. That is called the time constant:

$$t = L/R$$

The time it takes for I to rise to 63.2% of its final value is called the ______________ ______________.

---

44. (time constant) If L is 1 henry and R is 10 ohms, then the time constant in seconds is:

t = L/R
t = 1/10 = .1 second

The final current (I) is determined by the source voltage:

E_s = 12 volts divided by the resistance 10 ohms.

Refer back to Figure 11.

I = 12/10 = 1.2 amperes

63.2 percent of I is:

1.2 × .632 = .7584 amperes

Therefore, it takes .1 second for the current to rise to .7584 amperes. See Figure 13. *The current rises to .7584 amperes in* ______________ *second.*

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45. (.1) It takes approximately five time constants for the current to reach its full value of 1.2 ampere. See Figure 13. *In the problem above, that is* ______________ *second.*

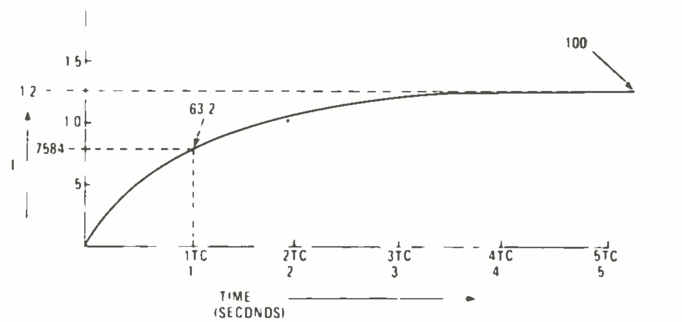

Fig. 13—It is possible to calculate the time it will take for current to build to a predetermined value. Generally, the "time constant" is the time required for the current to build to 63.2% of the maximum possible value.

46. (.5) Once the final current value is reached, it remains steady. With no further current change, the inductor no longer affects the circuit.

However, if power is removed by opening the switch, current ceases. The magnetic field around the coil collapses, thereby inducing a voltage in the coil. The polarity of that voltage is such that it would tend to keep the current flowing in the same direction if the circuit where not open. As you can see, the sudden drop in current is met by opposition from the inductor which tries to maintain the status quo. *Removing power induces a voltage caused by the* ______________ ______________ ______________.

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47. (collapsing magnetic field) With the switch open, the circuit resistance is very high, near infinite. With such a high resistance, the time constant is low. Therefore, the current

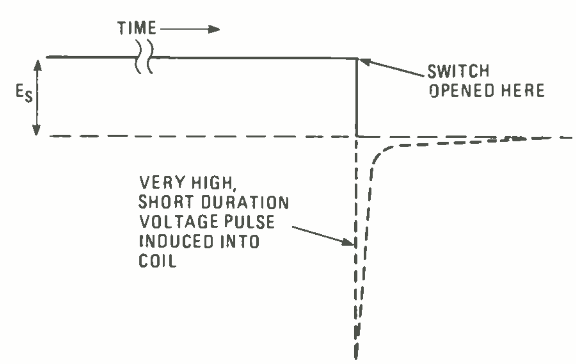

Fig. 14—An inductor in a DC circuit will have an extremely high voltage-pulse induced at the instant the DC current flow is interrupted. The peak pulse value can be thousands of volts even at low supply (E_s) voltages.

drops very quickly. But the main effect is the very high value of induced voltage. See Fig. 14. Depending upon the value of the inductance, that voltage can be several hundred or many thousands of volts. In any case, it exceeds the applied voltage by a considerable amount, but its duration is very short. This high induced voltage causes arcing at the switch contacts which can damage them. If the switch is a low voltage semiconductor device like a transistor or an SCR, the high voltage "spike" caused by the collapsing magnetic field can damage the device. *The high induced voltage can ____________ the switch.*

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48. (damage) Usually, some other component is connected into the circuit to help minimize the voltage spike. One method uses resistor R2 connected as shown in Figure 15. The resistor has no effect on the circuit when the switch is initially closed to apply power. It does draw some current from the source, however.

Its real impact is when the switch is opened. The circuit resistance has some finite value because of R2. The induced voltage causes current to flow in R2 when power is removed. The lower that resistor value, the lower the induced voltage. Note the polarity of the induced coil voltage in Figure 15. *The purpose of R2 in Fig. 15 is to ____________ the induced voltage.*

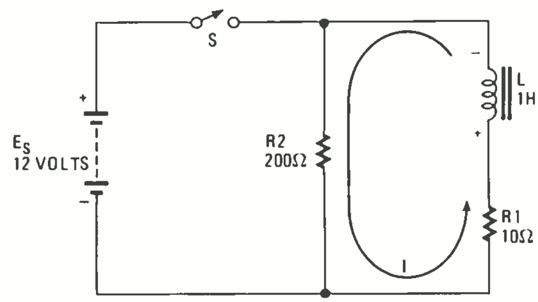

Fig. 15—A damping resistor (R2) connected across the DC supply voltage will reduce the peak value of the voltage pulse developed when switch S is opened.

49. (reduce or minimize) Using our previous example with E_s = 12 volts, L = 1 henry, and R1 = 10 ohms, assume R2 is 200 ohms. The current in the inductor is 12/10 = 1.2A. When the switch is opened, the induced voltage will initially try to maintain that current in R2. With Ohm's Law we can compute the voltage peak across R2:

$$E = I \times R2 = 1.2 \times 200 = 240 \text{ volts}$$

If R2 was 500 ohms, the voltage spike would be ____________ volts.

---

50. (600) E = I x R2 = 1.2 x 500 = 600. The voltage is still high but it could be several thousand volts if R2 were not used.

The current decays from its peak value to zero. It takes one time constant (t = L/R) for the current to drop to 36.8 percent of its maximum value. The total resistance of the circuit is R1 + R2 when the switch is opened. That value is substituted for R in computing the time constant.:

$$t = L/R = 1/10+200 = 1/210 = .00476 \text{ seconds } (4.76 \text{ mS})$$

The current decreases from 1.2A to 36.8 percent of that, or .368 x 1.2 = .44 amperes in 4.76 ms. See Fig. 16. *It takes about five time constants or ____________ ms for the current to decay to zero.*

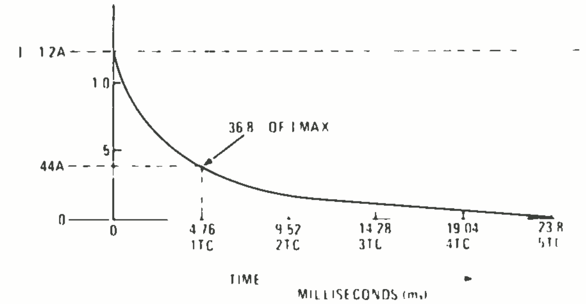

Fig. 16—The current in an inductor takes time to decay after the source voltage is turned off. The "time constant" is the time it takes for the current to decay to 38.8% of the maximum value when the source voltage is disconnected.

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51. (23.8) 5 x 4.76 = 23.8.

The principle of a high induced voltage when a switch is opened in an inductive DC circuit is often used in electronics to produce high voltage (HV). The flyback transformer (an inductor) used in TV sets and computer video monitors uses that method to generate 10,000 to 30,000 volts to operate the cathode ray tube (CRT).

The same principle is used in automotive ignition systems to generate the high voltage to operate the spark plugs.

Go to Frame 52.

Transformers

52. A transformer is a component that consists of two or more independent inductances wound on the same core. They are not used because of their reactive properties to control current flow. Instead, the transformer is used to isolate one circuit from another and to translate AC voltages and currents to different levels. *A transformer is made up of two or more ____________ ____________.*

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53. (independent inductances) The schematic symbol for a transformer is given in Fig. 17. It has two coils wound on a common iron core. An AC voltage is applied to the left-hand or input winding called the *primary*. A load is connected to the right-hand, output winding called the secondary. Even though there is no direct electrical connection between the primary and secondary circuits, current will flow in the load. *In a transformer, the AC input is applied to the ____________ and the load is connected to the ____________.*

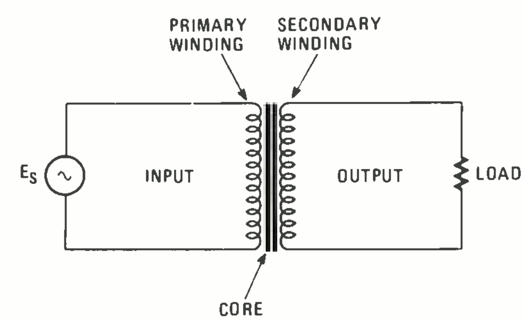


Fig. 17—An iron-core transformer is indicated by two vertical lines between the primary and secondary windings.

54. (primary, secondary) Power is transferred from primary to secondary by induction. The AC source causes current to flow in the primary winding. That produces a varying magnetic field. That field not only induces a voltage back into the primary winding that produces it, but also induces a voltage into the secondary winding by induction. If one coil can induce a voltage into another, the coils are said to have mutual inductance. *Coils have mutual inductance if one can ____________ a voltage into another.*

55. (induce) The amount of voltage induced into the secondary depends upon the degree of coupling between the two windings, the number of turns of wire in the two windings, and the voltage applied to the primary. If all the turns of the secondary are cut by the magnetic flux produced by the primary, as they would be in an iron-core transformer, then the number of turns in the two windings will determine the secondary voltage as the expression below shows:

$$E_s = E_p(N_s/N_p)$$

Where E_s is the secondary voltage, E_p is the primary voltage, N_s is the number of turns on the secondary, and N_p is the number of turns on the primary. N_s/N_p is called the *turns ratio*. The turns ratio is related to the voltage ratio as follows:

$$N_s/N_p = E_s/E_p$$

The voltage induced in the secondary is determined by the ____________ ____________ and the ____________ ____________.

56. (primary voltage, turns ratio) Assume that $N_s = 200$ and $N_p = 200$. $E_p = 120$ volts. E_s then is:

$$E_s = 120(200/200) = 120 \text{ volts}$$

When the number of primary and secondary turns is equal, the turns ratio is one and the secondary voltage equals the primary voltage. If the number of turns in the two windings is not equal, then obviously the secondary voltage will be higher or lower than the primary voltage. *If $N_s = 200$, $N_p = 50$ and $E_p = 120$ V, then E_s = ____________ volts.*

57. (480) In that example, the turns ratio is 200/50 = 4/1 or 4 to 1. That multiplies the primary voltage by 4. Therefore, the induced secondary voltage is 480 volts. With a turns ratio greater than one, the transformer steps up the voltage. In other words, the output voltage is higher than the input voltage by a factor equal to the turns ratio. *If $N_p = 300$, $N_s = 100$, and $E_p = 120$, then E_s = ____________ volts.*

58. (40) The turns ratio in that example is 100/300 = .333 or 1 to 3. In that case, the secondary voltage is simply one-third of the primary voltage or 120/3 = 40 volts. Here, the transformer is used to step down the voltage. One of the most common applications of a transformer is to increase or decrease the voltage level of an AC signal. *When a step-up transformer is used, the secondary voltage is ____________ than the primary voltage.*

59. (higher) Transformers may have two or more secondary windings as shown in Fig. 18. Each secondary winding has its own turns ratio with the primary. Both step-ups and step-downs can be obtained on the same transformer. *In Figure 18, the output voltage from the secondary winding #3 is ____________ volts.*

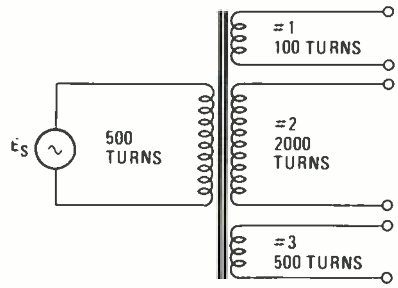


Fig. 18—A transformer can provide more than one output voltage by using multiple secondary windings. Each winding can be wound for a specific voltage output.

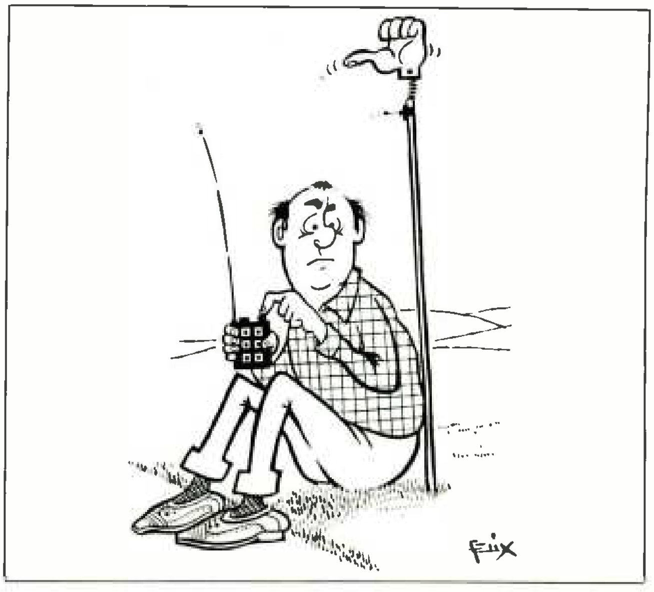
60. (10) The number of turns on winding #3 is equal to the number of primary turns. Therefore, the turns ratio is one and the secondary voltage equals the primary volts.

Iron-core transformers like those described here are used primarily at frequencies below 100 kHz. Most iron-core transformers are used in power supplies at 60 Hz and audio amplifiers in the 20 Hz to 20 kHz range.

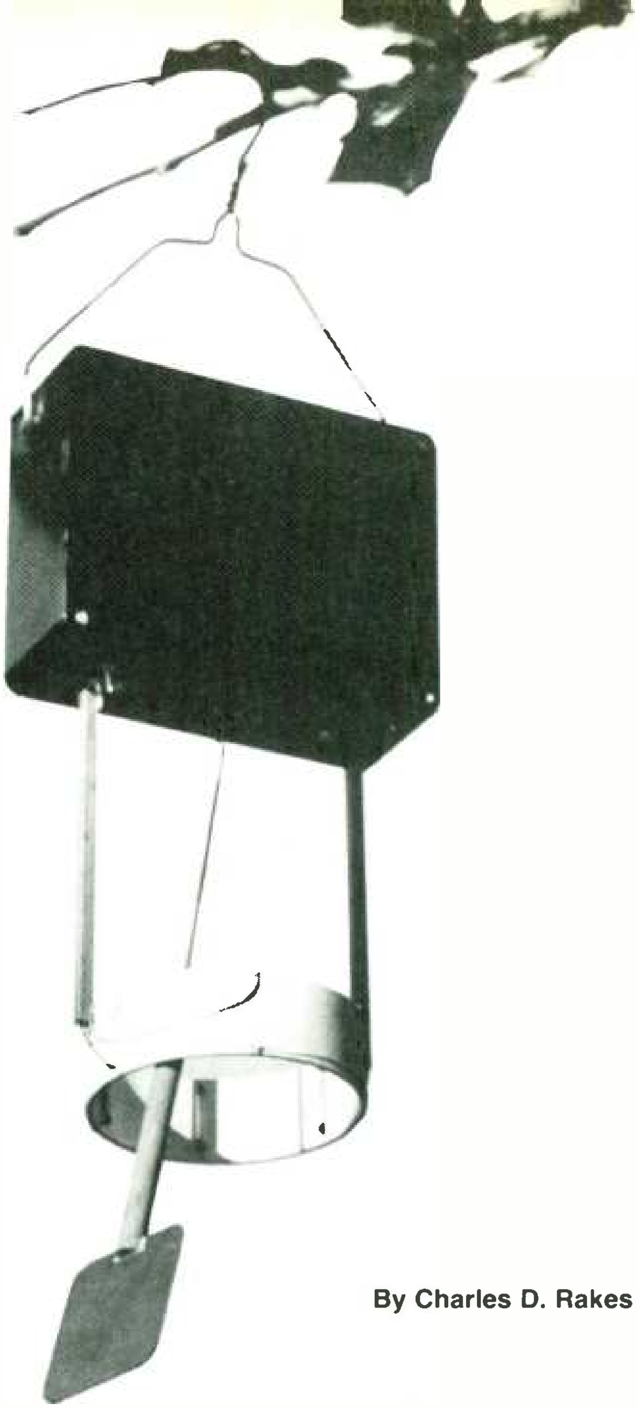
There are also air-core transformers used in radio frequency (RF) applications. When no iron core is used, the turns ratio relationship described above no longer holds true, since without the core to concentrate the magnetic lines of force, there is a lot of flux leakage. All the lines of force do not cut all the turns. Yet the transformer is still useful. *Air-core transformers are used in ____________ ____________ circuits.*

61. (radio frequency) ■

Now that you understand what inductance is all about, you also can understand why most modern technology would not be possible without it. Just for fun, try to figure out which of life's modern conveniences—from stereo broadcasting, to computers, to the microwave oven—would not be possible without inductance. And here's a hint: The telephone would be possible because it can be entirely DC-power (except for the ringing circuit). ■



ELECTRONIC WIND CHIME—
HEAR MUSIC IN THE AIR. . .



With this wind chime you can kick back and enjoy the gentle tinkling of the breeze; with the satisfaction of knowing you made it yourself. You build the instrument, and Mother Nature plays the tunes!

By Charles D. Rakes

HERE'S A MUSICAL DEVICE THAT YOU CAN BUILD, AND after a day of hard work or play, you can settle back and let Mother Nature's gentle breezes write and play the music for you. Our *Electric Wind Chime* music maker is a construction project that requires neither a special expensive IC, or any hard-to-find component; it can be built, with some junkbox searching, for only a few bucks. The Electronic Wind Chime is designed to hang indoors or outdoors where a mild breeze can make contact with the chime's paddle. Twelve different tones and their sequence, depend entirely on the whim of the flowing breeze.

How It Makes Music

A look at the circuit diagram in Fig. 1 will help to make the musical mystery clear. U1, a 555 timer, is connected in tone-generator fashion with R1, R2, and C1 through C6, setting the oscillator's tone frequency. Each of the six small reed switches are connected to a capacitor and diode pair, which set the oscillator's frequency and, at the same time, turn the power to the chimes circuitry on.

As shown in the photo, the wind paddle hangs down through the plastic pipe that S1 through S6 are mounted on. A doughnut magnet is attached to the upper end of the wind paddle and is spaced on the dowel to match up with the center of each of the vertically mounted reed switches. As long as the wind paddle remains motionless, all reed switches are normally open; but if a breeze moves the paddle far enough to activate one of the reed switches, power will be turned on and a tone will sound. Singularly activated reed switches account for six of the twelve different tones that the chime can produce; but if the magnet swings out far enough between two of the reed switches, both will close and a new lower tone will sound. That double closure produces the six additional tone outputs for a total of twelve.

A mini-toggle switch (S7) is included so that the chime's power can be turned off for storage or to stop the music. T1, a mini-transistor output transformer, is used to match the oscillator's output impedance to the speaker's low-impedance voice coil.

Chime Up Your Own

The circuitry of the chime is housed in a 7 × 5¼ × 2¼-inch plastic or Bakelite cabinet, but any similar enclosure of wood or metal will do. The majority of the circuit parts are mounted on a 2½ × 4½-inch section of perfboard. The six reed switches are mounted on a piece of 4½-inch plastic pipe cut to a length of 1½-inches (see Fig. 2).

Start construction by cutting a 12" section of ¼-inch square brass tubing into two equal parts. That type of brass tubing can be found in most hobby shops. Form two small 90° angle brackets from a piece of brass stock, and solder one to each of the brass tubes. Punch or drill a hole large enough to clear a 4-40 screw in the other side of the angle bracket. At the opposite end of each of the brass tubes solder a ¼-inch 4-40 flat-head screw, it will be used to secure the plastic pipe section in place.

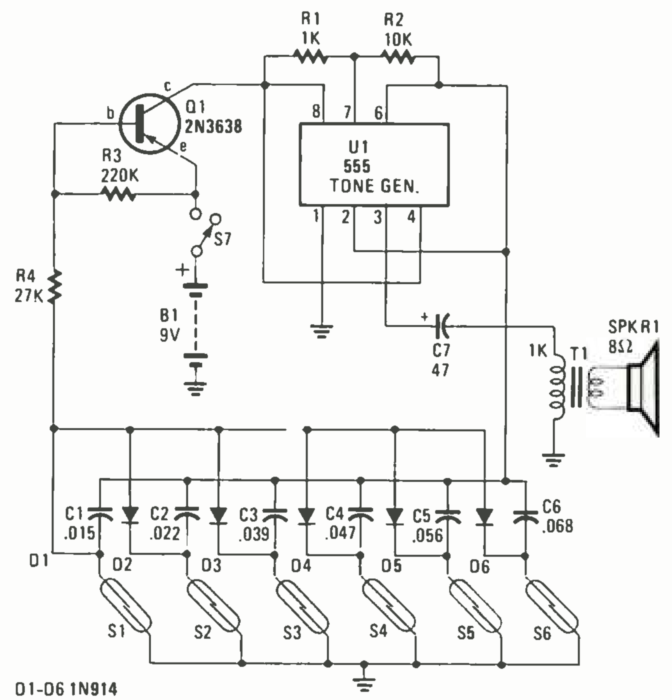


Fig. 1—The circuit uses little power and can be run off a 9-volt battery pack for a long time. As you can see, the circuit assembly is straightforward and inexpensive.

Cut off a 1½-inch piece of plastic pipe that will be used to mount the six reed switches. The reed switches are vertically mounted to the inside of the plastic pipe, equally spaced. Mark the piece of plastic pipe at six equally spaced locations around its circumference. Carefully bend both leads of a reed switch at a 90° angle so they point in the same direction. Bend all reed switches in like fashion, and position them parallel to the pipe's axis with equal distance between the top and bottoms of the pipe at the places marked. Drill two small holes to allow each lead of the switch to pass through to the outside of the plastic pipe. Push the leads through the inside of the pipe and bend them over to hold the reed switches in place. Add a drop or two of Super Glue to guarantee a permanent mount for each of the switches.

Mount the plastic pipe on the two brass tubes with the 4-40 hardware. Set the plastic pipe on a flat surface and position each of the brass tubes so that they are parallel to its axis and tighten them in place. The two brass tubes attached to the plastic pipe are mounted to the bottom of the plastic cabinet, so center them on the cabinet and mark the cabinet so that two mounting holes can be drilled. Also, while in that position, mark around each of the square tubes and drill a 3⁄16" hole in the center of the marked areas to match up with the openings of each of the brass tubes. These holes will be used to snake wire through later.

The perfboard, speaker, battery pack, and off/on switch can be positioned and mounted as shown in the photos, or any other workable arrangement. Actually the project is so uncomplicated that, if the reed switch and magnet arrangement are understood, almost any construction method, component layout, or cabinet choice can be used. Just suit yourself when building your Electric Wind Chime.

After completing the point-to-point component wiring of the circuit, attach the reed switch assembly to the cabinet with the 4-40 hardware. Connect all of the bottom leads of the six reed switches together and run a wire up through one of the brass tubes and into the cabinet through one of the 3⁄16-inch holes. Connect it to the circuit common (battery negative). Attach a wire to the top terminal of each reed switch, and run three leads through one brass tube and the remaining three through the other, snaking them through the holes as before. Connect the six wires to the capacitor-diode pairs to match the schematic diagram.

The wind paddle is made by taking a 6½-inch length of wire cut from a coat hanger, a five-inch length of 7⁄16-inch diameter dowel, a doughnut magnet, and a small piece of circuit-board material all connected together as shown. Start by bending a nice "O" shaped hook in the top of the coat hanger wire, with an inner diameter of about ⅛-inch. Drill a hole about 1-inch deep in one end of the dowel a size smaller than the diameter of the hanger wire. Carefully work the hanger wire down into the hole and add a drop of Super Glue to the dowel where the wire meets the wood as added as-

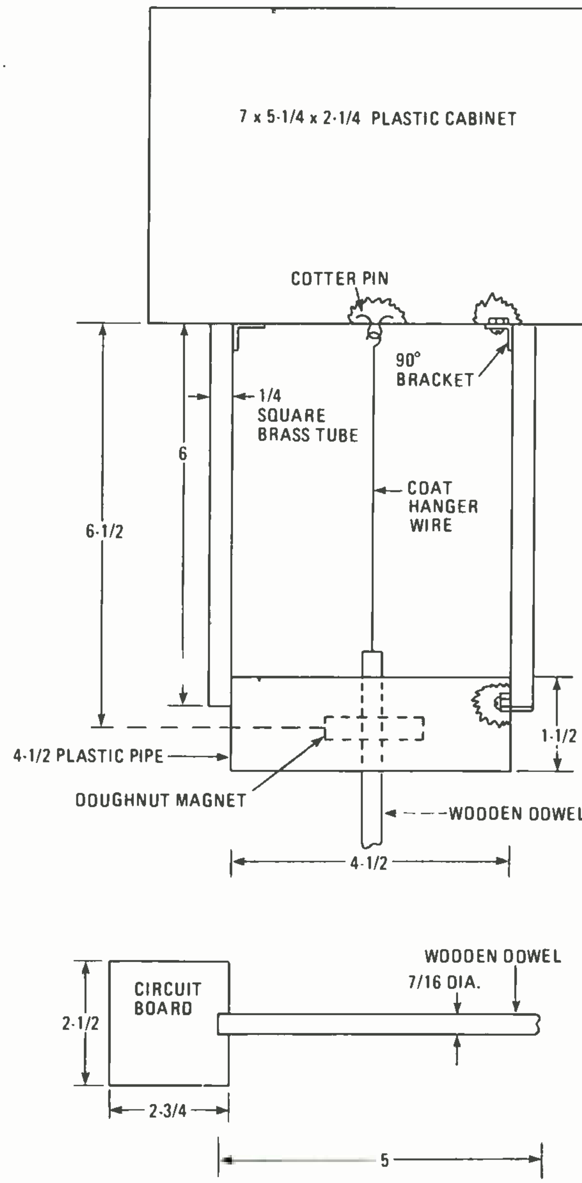


Fig. 2—The complete assembly of our model is shown here, but your wind chime need not be an exact copy. The cabinet type, size of hardware, and even the capacitor values can be up to you. Please note that the nuts and bolts used were all 4-40 size and that all dimensions shown are in inches.

PARTS LIST FOR THE ELECTRONIC WIND CHIME

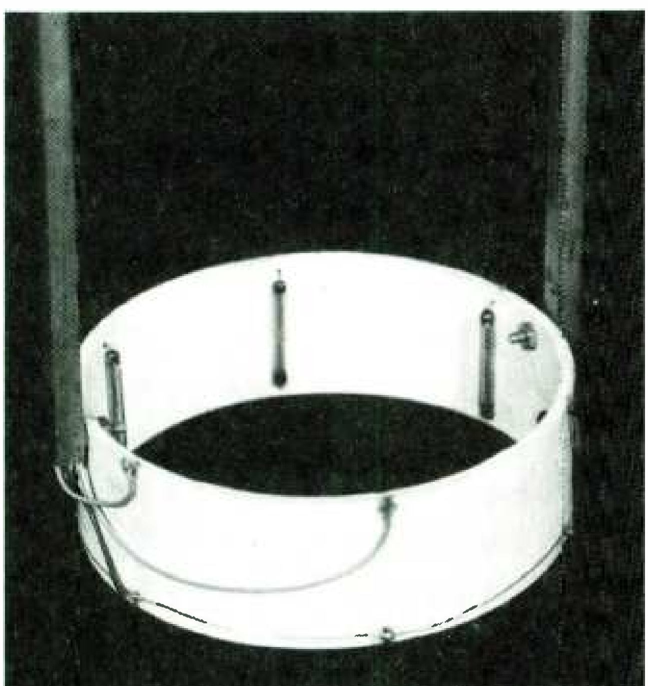
SEMICONDUCTORS
D1-D6—1N914 silicon signal diode
U1—555 timer integrated circuit, 8-pin Mini-Dip
Q1—2N3638 PNP silicon transistor

CAPACITORS
(Select voltage rating for lowest cost)
C1—.015-µF, mylar
C2—.022-µF, mylar
C3—.039-µF, mylar
C4—.047-µF, mylar
C5—.056-µF, mylar
C6—.068-µF, mylar
C7—47-µF, electrolytic

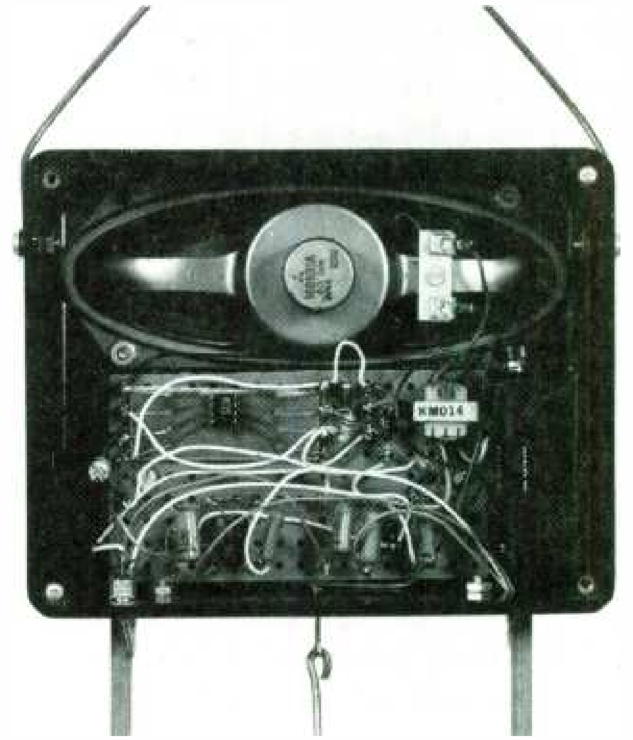
RESISTORS
(All resistors are ¼-watt, 10% units
R1—1000-ohm
R2—10,000-ohm
R3—220,000-ohm
R4—27,000-ohm

SWITCHES
S1-S6—Reed switch, small
S7—SPST mini-toggle switch

ADDITIONAL PARTS AND MATERIALS
T1—1000- to 8-ohm transistor-matching audio output transformer
SPKR1—8-ohm 2 × 4" speaker
B1—9-volt battery pack (six Penlite cells)
Misc.—Cabinet 7 × 5¼ × 2¼-inch plastic cabinet, 1-doughnut magnet, ¼-inch brass square tubing 12" long, 7/16-inch diameter dowel, coat hanger, 4-40 hardware, piece of 4½-inch plastic pipe, section of 1/16-inch thick circuit board, wire, solder, etc.



Be sure to bend and solder the leads for the reed switches before gluing them in place just in case one of them breaks. They should be evenly spaced around the plastic tubing and should not interfere with the mounting screws.



The assembly can be fitted neatly into almost any cabin you chose if you're inventive with the placement of the speaker and perf-board. The left-over portion of the coat-hanger can be used as a hook for the wind chime.

surance that the dowel and wire will stay put. Saw a ½-inch length slot in the opposite end of the dowel to hold the paddle in place. After inserting the paddle (circuit board) use a drop of super glue to hold it in the dowel.

In the center of the bottom of the cabinet (between the two brass tubes) drill a 1/16-inch hole. Place a small cotter pin through the hole with the round hook part sticking through the bottom of the cabinet. Hook the paddle assembly onto the cotter pin, which should swing freely in all directions, and mark the dowel at the centers of the reed switches. This should be done with the dowe moved toward the plastic pipe. This is to insure that the magnet will placed high enough to activate a reed switch when it swings close to one.

The doughnut magnet should be positioned on the dowel over the center of the mark. If the hole in the center of the magnet is too small to pass over the dowel, then trim the dowel to a size where the magnet will just snugly fit in place, and once again use a drop of glue to hold it in place. Re-hook the wind paddle in place.

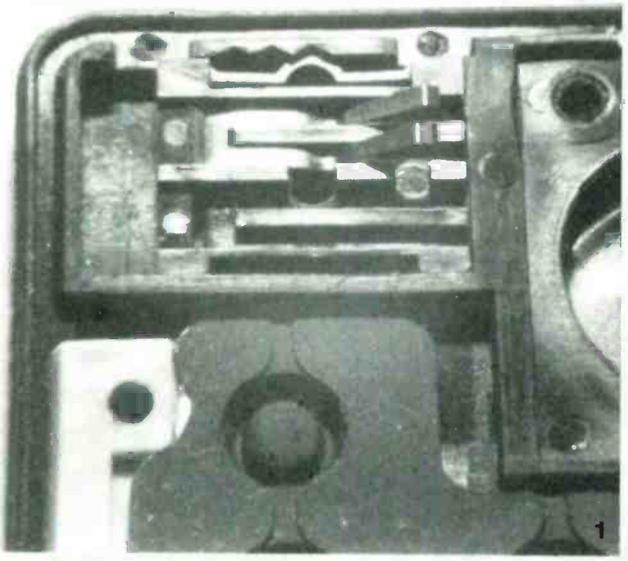
Most any method can be used to hang the completed chime, our choice was to use the remaining part of the coat hanger by attaching it to each side of the cabinet with the hook positioned over the center of the top of the cabinet. No matter how the chime is hung, it should be positioned in a balanced level condition so that the paddle and magnet are hanging straight down through the center on the 4½-inch section of pipe.

With the chime hanging in a breezy location turn the power on with S7, and you should begin to hear the fruits of your work playing a wind song just for you. If the tone frequencies are not in the range you would like to hear, just change the values of C1 through C6. Increase the values for lower tones and decrease the values for higher tones. Have fun! ■

Selection and Repair of BARGAIN TABLE ITEMS

By Victor Meeldijk

Incredible bargains can result from careful selection of "as-is" or "close-out" merchandise. Many items only need minor repair.



This calculator had a contact in the wrong place. A good example of an assembly error, the problem was easy to diagnose and repair for just pennies.

EVERYONE HAS SEEN THOSE "AS-IS/CLOSE-OUT" SECtions where customer returns, damaged, and store-demonstration merchandise is sold at low prices. Many times, prices will be cut even further if a customer shows interest in the item. If, however, selection is not made wisely and repairs are costly, or impossible, the purchase is no longer a bargain. You can make various visual checks and tests can be performed to increase the probability of a successful purchase. The opportunity to sharpen your troubleshooting skills and experience is an added bonus.

Item Selection

The variety of merchandise on a bargain table can include multimeters, clock radios, calculators, electronic equipment, and even television sets. The first thing to do when making a purchase is to inspect the item carefully. Note any cosmetic defects, missing knobs, covers, and especially hardware. Missing hardware indicates that someone may have already tried, unsuccessfully, to repair the unit. Try to examine the inside of the unit, either by removing the back or looking through a ventilation slot. Any components that are solder-tacked in place, or are missing, will confirm past troubleshooting attempts. Unless you are a gambler, or can negotiate a low price for the item, it should not be purchased.

During the visual examination, be aware that any missing cabinet parts such as knobs or covers may be difficult to replace. All knobs will have to be replaced if one of a matched set is missing and covers may have to be fabricated to match the cabinet of the device. Further details on that will be covered in the section on Cosmetic Repairs.

Next look at the brand name and model number. If it is a new or recent model, by a well-known manufacturer, schematics, test data and repair parts will be easily obtainable. Many consumer items are brand-named for the particular store in which they are sold. Often the same item can be found under a few different labels, and information about the product may be obtained from a source other than the one on the nameplate. An example of that is some of the calculators sold under the "Radio Shack" label which are actually manufactured by Texas Instruments. Radio Shack does provide excellent repair information and parts for the items they sell. Similar items may also have almost identical schematic diagrams. A schematic you already have may be useful in repairing a bargain purchase. An example of that will be discussed in the paragraph on Television purchases.

After visual checks, make an operational check observing all malfunction symptoms. The store will usually allow that evaluation, which also aids price negotiations—particularly if the unit doesn't function at all. Knowing the malfunction symptoms, again examine the unit looking for blown fuses, loose wires, or poor solder connections. The latter, along with manufacturing errors (see photo 1), are the basic causes for customer-returned merchandise.

Malfunctioning items such as calculators, electronic clocks and watches often have one main component, an LSI (large scale integrated) microcircuit. Those microcircuits are often impossible to replace or sell for a price close to the cost of a new clock or calculator. Specific selection and repair techniques for those and other items are covered in the following paragraphs.

Calculators

One of the most common items found on the bargain table is the pocket calculator. Many styles and models ranging from the basic four-function, to solar-powered, to scientific calculators are often available.

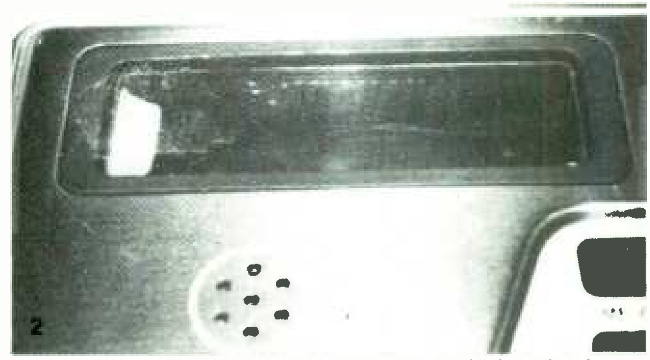
As already recommended, the first thing to do is to visually examine any potential purchase for signs of abuse or previous repair work. Any LCD (liquid crystal display) unit that has a cracked or blackened display should not be considered, because replacements are very costly or unavailable (see photo 2). If a few units are available that are all non-functioning it can be assumed that a manufacturing defect or assembly error may be the problem.

Poor connections or cold solder joints may be verified by observing the calculator operation. If the entire display does not work or sections don't operate, gently apply pressure to the calculator case especially around the display. Be extremely careful with liquid-crystal displays because they are made of glass and break easily. If the display changes, or the calculator suddenly operates normally, poor internal connections are the problem and repairs are relatively easy and at low cost.

Photos 3 and 4 show scientific and solar-powered calculators which required only internal connection reworking. For the scientific calculator, solder joints were re-heated around the integrated circuit. (Note that to do that type of repair a grounded soldering iron should be used to prevent the integrated circuit from being damaged by static electricity.) The solar powered unit required a more complex repair.

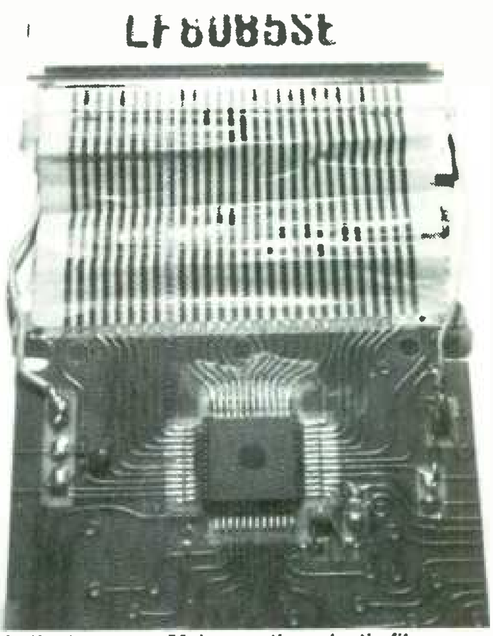
As seen in the photograph, part of the electrical circuit is made by carbon traces deposited on a thin plastic film. That film was then bonded to the printed-circuit card and the display. A multimeter confirmed that some traces were open-circuited while a visual examination showed that other connections had separated from either the printed-circuit card (PC) card or the display. Using a pencil, the open-carbon traces were momentarily repaired by depositing a layer of graphite where the connections were broken. A better "fix" is made later.

Reattaching the plastic film conductor could have been done with an electrically-conductive adhesive. However, as that was not immediately available, a different method was



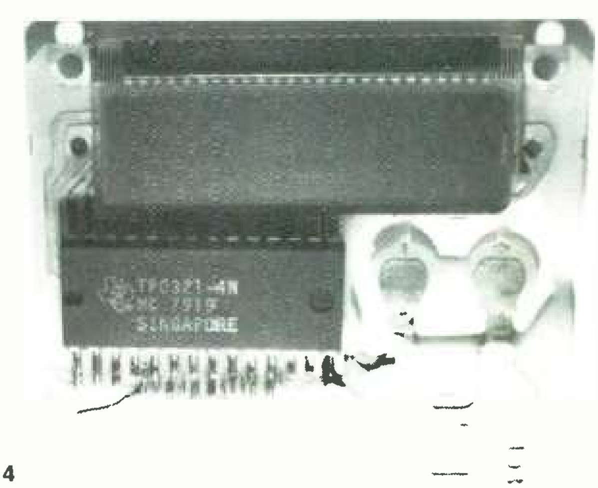
2

A cracked liquid-crystal display will appear black and unless a replacement for it is found the item cannot be restored. Be advised that calculators and watches sometimes have very complex displays that may be hard to replace.



3

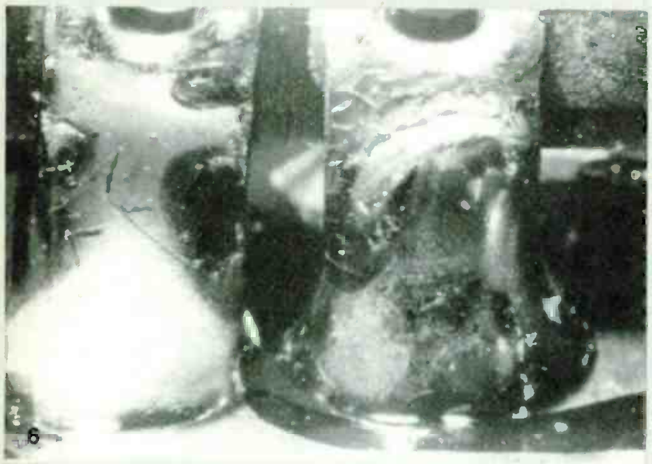
Breaks in the traces on Mylar or other plastic films can be the cause of calculator malfunction. That sounds severe but can be remedied with foil tape used around windows for burglar alarms or even a pencil.



4

Repairing of poor solder connections is as easy as discovering and resoldering them. However, care must be taken in order not to burn out components.

Some repairs can be as simple as the one this clock radio needed. All that had to be done was to resolder the volume control. Analysis is as easy as audio tracing.



Bad solder connections, although not always easy to spot, are easily repaired. A good example are the solder connections of this potentiometer. If you look at the top of the photo, notice that the terminals are not soldered to the terminal itself.

This solder connection looks sound but it isn't. That is a perfect example of why a conductivity meter is a must for repairing items that work intermittently.

tried. The film conductor was aligned with both the PC card and the display. Thin strips of adhesive-backed rubber were then placed on the back of the conductor where there were connection problems. The back cover of the calculator case would then press on the rubber strips forcing the conductive film to make electrical contact with both the PC card and the display.

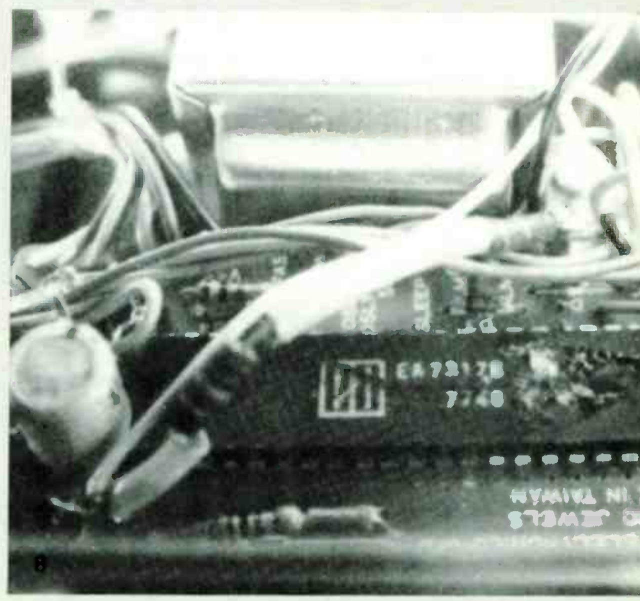
Radios and Clock Radios

This is another group of items commonly found on the bargain table. In the case of clock radios, determine whether the clock or the radio is malfunctioning.

In radio repairs the basic troubleshooting techniques of signal tracing and injection should be used. Be alert for failed electrolytic capacitors, especially in older units, and suspect plastic- or epoxy-encapsulated transistors when there are audio-output problems. Problems observed by the author include a radio with a microphonic output (a ringing that occurs when some tubes are tapped) and a radio with a very low volume.

The first problem was traced to the ceramic disc capacitor which coupled the audio amplifier to the volume-control potentiometer.

The low volume output was at first thought to be caused by cold solder joints around the volume-control potentiometer (see photo 5). Reheating those joints restored normal operation (see photo 6). However, once the radio was reassembled it again stopped working. Wiggling the suspect potentiometer, trying to determine the exact problem, resulted in the discovery that the terminals of the potentiometer were staked, not soldered, to the carbon traces. Squeezing those connections with a pair of pliers tightened the connections and repaired the radio. The initial resoldering of the printed-card connections to the potentiometer resulted in a temporary repair of the different temperature coefficients of expansion of the potentiometer terminals, and the carbon trace substrate. During the radio reassembly, the solder joints cooled



Sometimes replacing parts requires jumpering above the circuit board. That is allowable as long as all component leads are insulated, and soldered to provide for physical strength.

down and the terminal/potentiometer trace connections again loosened.

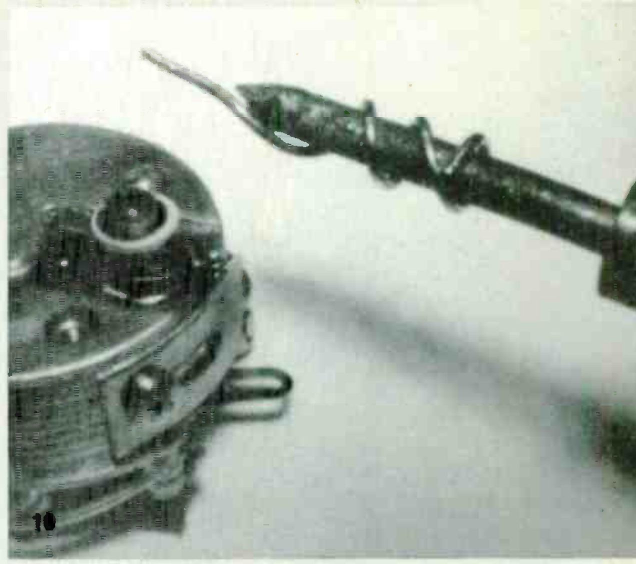
Solder-connection problems are also quite common. A portable AM radio, purchased for $2, was completely dead until the circuit card was tapped, or flexed near the station-adjustment knob. While the poor connection which caused that may not look any different than a good one, examination under magnification showed a gap around the component lead and the solder pad (see photo 7).

Clocks may be either mechanical or electronic. The mechanical versions are easily replaced at low cost as long as the proper spacing between control shafts is observed when purchasing a replacement. Prior to replacement however, determine whether the problem may be caused by a stuck clock motor. If the motor does not rotate when energized, but an ohm-meter check of the armature shows continuity, the motor may only need to be lubricated.

Remove the motor and heat it with a heat gun or soldering iron. Drop some light lubricating oil around the motor shaft and allow the motor to cool. Add more oil as the cooling process takes place. Heating and cooling the assembly results in a vacuum which sucks the oil into the motor. Gently rotate the shaft with a pair of long nose pliers, taking care not to damage any gears attached to the shaft. The motor should now operate properly and can be installed into the clock movement.

Electronic clocks—like calculators—often contain a single integrated circuit as the main circuitry. Unless a replacement IC can be obtained, which may prove difficult, assemblies with malfunctioning electronic clocks should be avoided, unless the cost is low and you wish to experiment.

One such experiment was performed on a clock which was stuck in the calendar mode. Obtaining a data sheet from the manufacturer of the clock IC, it was discovered that an internal pull-down resistor connected to pin 24 enabled the clock mode unless 20 volts (V_{ss}) was applied to the pin. Measuring pin 24 indicated it was at 20 volts. Installing a

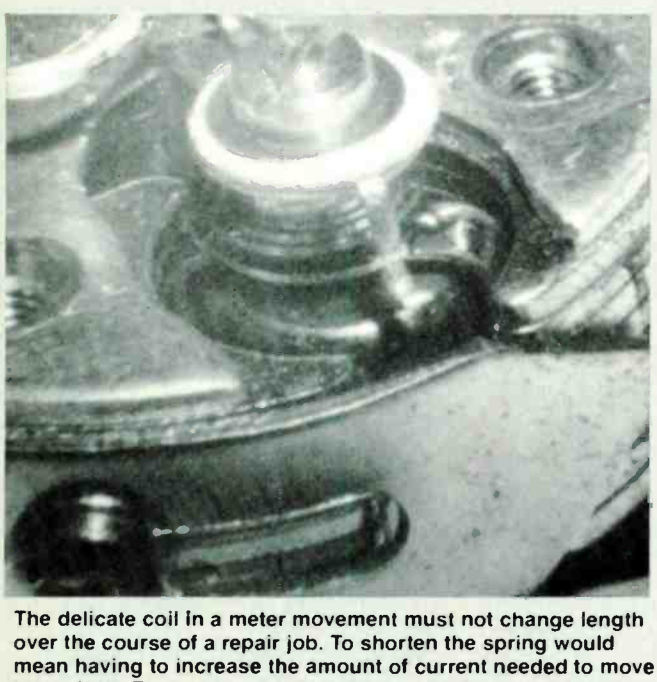


10

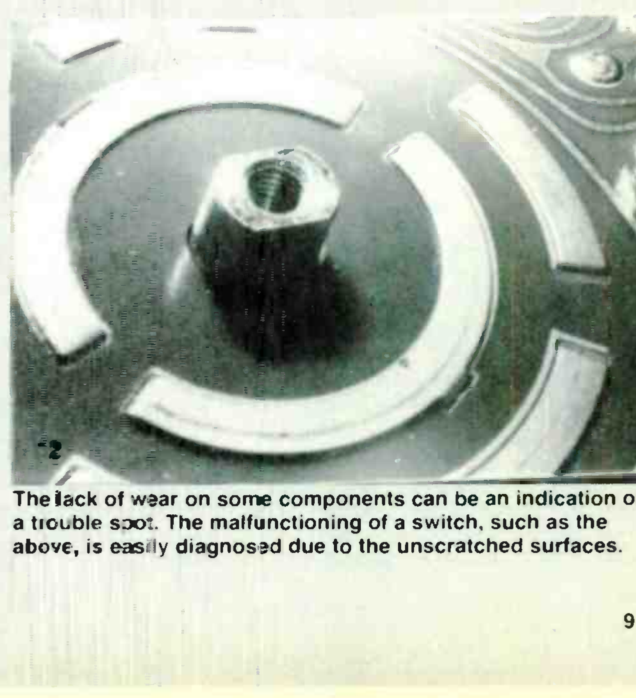
Modifying the soldering tip as shown will make the repair of small delicate parts easier and more accurate. Be careful not to overheat small parts as that can be done easily.

11

While repositioning the meter movement, be careful not to bend the pointer or damage any of the coil windings on the movement. The windings are hair thin and break easily.



The delicate coil in a meter movement must not change length over the course of a repair job. To shorten the spring would mean having to increase the amount of current needed to move the pointer. That makes the faceplate markings incorrect.



12

The lack of wear on some components can be an indication of a trouble spot. The malfunctioning of a switch, such as the above, is easily diagnosed due to the unscratched surfaces.

14.2-kohm resistor (see photo 8) between this pin and ground (pin 29) pulled the voltage down to 14.5 volts, and restored proper clock/calendar operation. That is obviously a special case but it did allow for experimentation and the use of an unusual repair technique.

Meters and Multimeters

Analog panel meters and multimeters are often reduced because of broken meter faces or inoperability. The meter movement can be repaired if the following method is used.

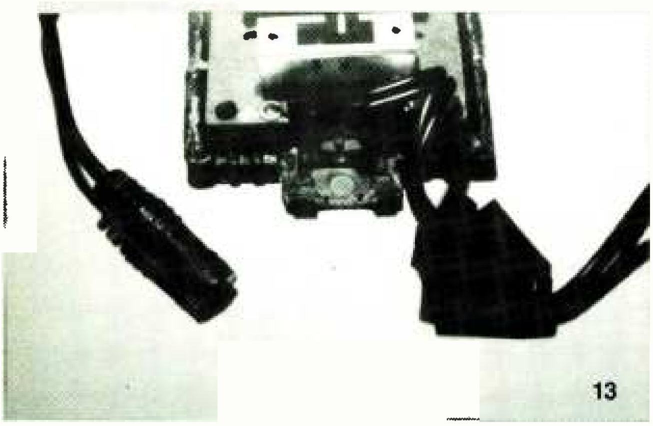
Verify that the movement is the problem by connecting a series circuit consisting of a variable resistor (set to 10-kohms) and a 1.5-volt battery to the meter. Slowly reduce the resistance, watching for any meter deflection. If the meter pins to the left, reverse the battery connections.

If the meter oscillates, examine the control springs (see photo 9). One spring is probably touching the meter chassis as the moving coil is rotating. Insulate the chassis either with some tape or Glyptol.

If no movement is observed, carefully examine the meter with a magnifying glass. Look at the control springs and verify that they are still making electrical contact between the meter leads and the moving coil assembly. The control spring may have broken away from the moving coil, or the fine wire from the moving coil may have been broken.

To make any solder repairs in those areas requires a very fine-pointed pencil soldering iron. In lieu of that, a wire added to a regular soldering-iron tip, as in photo 10, will work. No disassembly of the meter movement should be attempted because it has been delicately adjusted to provide a specific full-scale deflection for a measured current input. Carefully maneuver the tip of the soldering iron to the area of the repair and use tweezers, or other instruments, to hold the control spring or moving coil wire in place. The meter shown was repaired in that manner.

A much simpler type of repair involves only the repositioning of the meter pivot. The battery-tester meter movement shown in photo 11, was repaired by removing the pivot screw, centering the pivot point through the screw hole, and replacing the screw. A piece of tape was used to secure the meter pointer to the instrument face, preventing the pivot from moving as the screw was being replaced.



13

Wire breaks in the strain reliefs of adapters is the most common of adapter failure problems, especially if the adapter has been used before. Continuity checks can be performed on the line cord (while unplugged) by sticking two straight pins into it and hooking the pins to a continuity tester.

If meter-movement repair is unsuccessful, new movements are usually available from the instrument manufacturer. Adding the price of the replacement movement to the marked-down instrument price often yields a final cost that is still less than that of a new unit.

Digital-multimeter problems may also prove simple to diagnose and repair. While the store where a $15 "as-is" meter indicated that the a/d converter was bad, it was noted that the reading would change as the range dial was rocked. Disassembly of the function switch showed little or no contact marks in some contact areas (see photo 12). Some mechanical adjustments to the switch contacts were all that were necessary to make the unit fully operational.

Television Sets

The decision to purchase that item is usually based upon price if the picture tube is intact and no major assemblies are missing.

Different sets may be similar especially when comparing brand names with department store models. Horizontal-output/high-voltage sections from Zenith and XAM (sold by Korvettes) receivers are similar enough to allow the use of the Zenith schematic to signal trace and find a defective horizontal output transistor in the XAM set. Therefore, until the schematic for the set being repaired is obtained, one from a similar receiver may be used.

Miscellaneous Merchandise

Tape recorders, AC adapters, and small amplifiers are also often available. The same general evaluation and troubleshooting techniques apply to those items as well as those already discussed.

In the case of AC adapters, wire breaks at the strain reliefs of the DC output wires are generally the case of failure (see photo 13). Molded wire strain relief connections can be repaired by drilling out the broken wire from the strain relief and then rewiring it.

Cosmetic Repairs

Invisible cosmetic repairs can be made using a few easily obtainable items. Cracks, chipped corners, or burn holes can be repaired by first smoothing down the surface with sandpaper (or a file), if necessary. Fill in deep holes and cracks with wood putty, using a flat surface coated with water to smooth the putty as it is applied. After the putty has dried, it can be stained to match the equipment cabinet. To further disguise the repair, apply a coat of clear paint to the whole cabinet.

Badly damaged surfaces can be hidden by covering them with a piece of Formica. Wood-grained cabinets with a damaged top can be easily repaired in this manner. After the Formica is cut to size, and all holes for controls have been made, paint the cut edges to match adjacent cabinet surfaces.

Replacements for missing or damaged parts, when parts are not available from the manufacturer, can be fabricated from scrap pieces of wood, metal or plastic. Replacement clock hands can be cut from thin-gauge metal, and face plates can be made from acrylic plastic with glued-on tabs to secure them to the instrument cabinet.

Silver trim can be restored by using an artists brush and a small bottle of silver model paint.

The extent of cosmetic repairs possible is limited only by your imagination. ■

A burglar alarm tells you there was a break-in. Our photo-trigger tells you who did it!

ALARM-TRIGGERED PHOTOS

By Dave Sweeney

SUPPOSE YOUR SECURITY SYSTEM SOUNDS AN ALARM, and upon investigating, neither you nor the police find any evidence of an intruder. A burglar could have triggered the alarm, or the system may have sounded a false alarm. How will you know? With photographic evidence, you can instantly document the presence or absence of an intruder, and, a photograph will aid prosecution in the event that someone later nabs a burglar. In addition, the sudden light from the flash bulb could scare away the intruder and thus help protect your property.

You can easily add alarm-triggered photographs to your security system by upgrading an inexpensive Polaroid camera to operate by remote control. With the remote control, the camera can take a picture when an event occurs, and thus provide instant evidence of the event. For example, when an intruder opens a window or when the neighbor's dog sneaks through your gate, a magnetic switch at the gate or window, connected to the camera via a trigger control circuit which you build, starts the picture-taking sequence as if you had been there and pushed the camera's button.

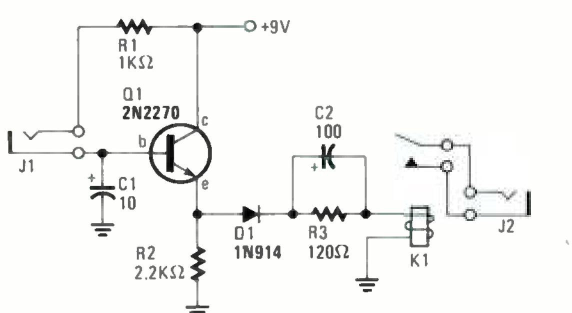


Fig. 1—Because relay K1 is actually activated by the charging of capacitor C2, it will not remain closed even if input jack J1 is continuously shorted. The relay only pulses.

The security-system camera takes a picture by closing an external switch that is connected in parallel with the camera's shutter—which is also a switch. The remote-switch closure starts a sequence of events within and under control of the camera. Because the camera ejects the picture almost immediately, holding the remote-switch closed would trigger a continuous stream of instant photos. To avoid that problem, we must use the trigger control shown in Fig. 1. In that circuit, transistor Q1 pulses relay K1, and the resulting momentary closed-circuit limits the instant camera to one picture each time a remote switch on a gate or window closes. In this way, the trigger control circuit adapts the Polaroid instant camera to the security job.

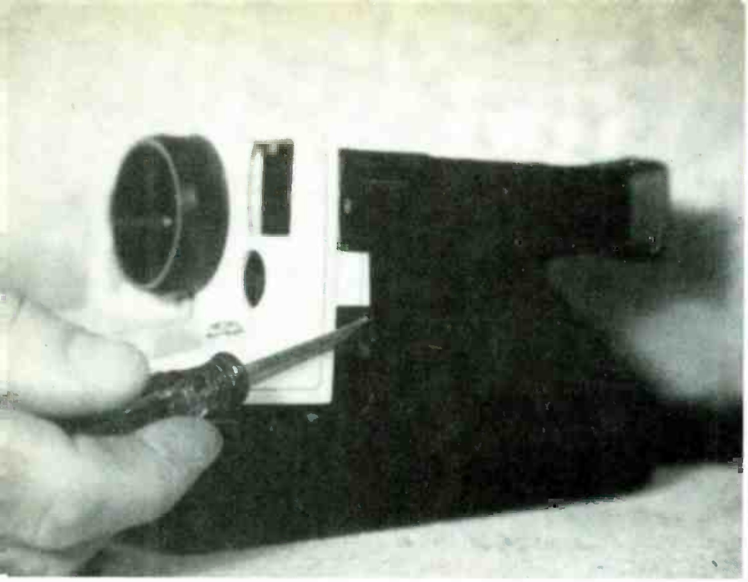
Easily Modified

Instant cameras such as the Polaroid *One Step* adapt well to a security job because they are unusually easy to modify. Rather than a mechanical shutter, the instant camera is driven by an electric motor. Controlling the camera remotely requires simply a switch to start the motor-driven sequence. Another reason for using the *One Step* is its size: While 120 and 220 roll-film cameras, 35-mm cameras, and disc cameras use every micro-inch of space in their housing to reduce overall size, the instant camera contains plenty of room for installing a jack that will permit you to easily connect a remote-control switch in parallel with the factory switch.

Picture Yourself

With a jack installed on the camera for the trigger-control circuit, you can leave the remote trigger hardware in place, yet still disconnect the camera so it can be used for conventional photos when it's not "minding the store."

Also, because the remote-control jack is a permanent part of the camera, it can be used "to put yourself in the picture." You can pose for your own picture, or, if you're taking a group



To remove the cover of the *One Step* camera, gently pry the sides of the case with a small screwdriver to release the plastic tab on each side. The front cover will slide forward when both tabs are released.

PARTS LIST FOR TRIGGER CONTROL UNIT

C1—10-µF, 25-WVDC electrolytic capacitor
C2—100-µF, 25-WVDC electrolytic capacitor
D1—1N914 diode
J1, J2—Subminiature phone jack
K1—Relay, 5-VDC coil (Radio Shack 275-232)
Q1—2N2270 NPN transistor
R1—1000-ohms, ½-watt, 10% resistor
R2—2200-ohms, ½-watt, 10% resistor
R3—120-ohms, ½-watt, 10% resistor

ADDITIONAL PARTS AND MATERIALS

Cabinet, perforated wiring board, wire, solder, etc.

Fig. 2—In the usual way group pictures are taken, the person taking the picture is left out.

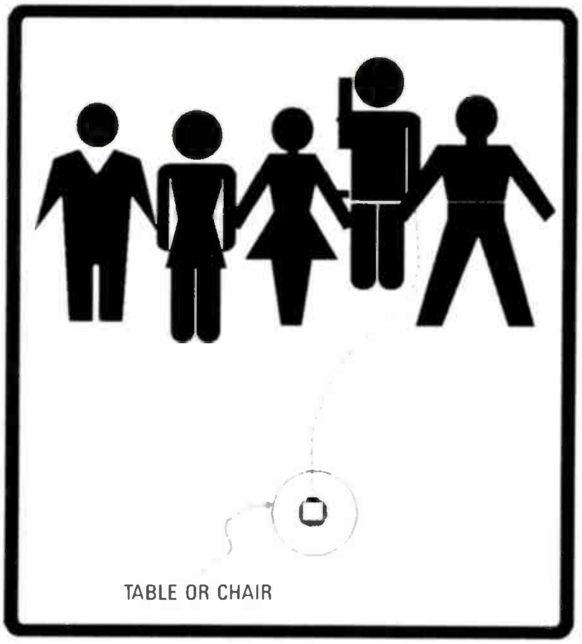


Fig. 3—When you use the remote trigger control, you can put yourself in the picture and trigger the camera through a remote control cable.

photo, you need not be the "missing person:" You can join the group and operate the camera with a switch concealed in your hand, as shown in Figs. 2 and 3. (Your pictures will be more complete, and you will probably save a little film money by including everyone in the first shot.)

Any kind of single-pole, single-throw switch will trigger the camera. When you want remote control, you insert the plug which connects your hand-held switch in parallel with the factory switch: Either pressing the usual button to close the manufacturer's switch or pressing the button at the end of your remote control cable takes the picture.

Modifying the Camera

To open the Polaroid *One Step* camera, on one side of the case insert a small screwdriver between the white outer cover and the case itself, and gently pry the case away from the cover. As the case separates from the cover the cover will suddenly come free on that side. Do the same on the other side of the camera and the front cover will slide off the case.

Any kind of small jack can be used, although a miniature phone jack will most likely prove to be the most convenient. Drill its mounting hole using a sharp drill bit and light pressure: The plastic will drill very nicely as long as you don't try to rush it.

You don't have to be an expert in camera electronics to install the proper electrical connections to the jack because you will work only on the two terminals to which the camera's red push-button shutter-release connects when the camera is used normally. To wire the jack, set the camera chassis on the bench with the four leaf switches facing you. The red button on the front of the camera presses one of these switches and completes a circuit when you take a picture. That closure begins a sequence of events which causes the flash to be energized, the film to be exposed, the picture to eject, and the film-counter to advance. The leaf switches control these events, but the only switch you care about is the one which the red button closes. That switch is located at the far right of the switch array.

Connect one wire from the jack to the switch on the right.

(Continued on page 112)

ALARM *FLASHER* FOR YOUR DASHBOARD

This is a phony car burglar alarm— an alarm you connect when you can't be bothered with sirens, detection circuits, and the like.

By Colin Dawson

☐SALES OF CAR BURGLAR ALARMS HAVE BOOMED IN RE-cent years. With the poor level of security offered by most cars, and the willingness of many repair shops to buy spare parts with a doubtful background, "car thieving" has become a growth industry.

Paradoxically, the person most likely to be inconvenienced by a car burglar alarm is the driver. From the moment it is fitted, the hapless motorist is haunted by every alarm in the neighborhood. In addition, there is the inconvenience of having to enter and exit the car within a specified time.

Much of the inconvenience of an alarm can be avoided with a fake alarm. One of the most effective deterrents of any alarm circuit—even the most sophisticated—is the flashing light on the dashboard.

In fact, many car owners have been quick to realize that, and have simply fitted an authentic-looking flashing light in the place of a real alarm. Those are generally purchased from car-accessory shops for around $20.

That type of fake alarm has a few advantages. First, it never false-alarms during the middle of the night. Second, the driver doesn't have to worry about making a frantic dash for the kill switch upon entering the car. And third, it is far cheaper and easier to install than a real alarm.

By contrast with the commercial units, this unit can be built for around $10 (depending on the lamp used). Once installed, you need never worry about the flasher again. It automatically starts when you switch the ignition off.

The project would be most effective when used with a proper red or yellow square 12-volt light bulb assembly found in the commercial devices. Those can be purchased from car accessory shops.

Alternatively, most kit suppliers carry round, 12-volt lamp assemblies which still look fairly convincing, particularly if you put a couple of warning stickers on the car as well. Don't buy a combined switch and lamp—they're too expensive.

Circuit Description

The circuit is based on a 555 timer IC. Its configuration in this instance is typical (see Fig. 1): the device is being wired as an astable oscillator. That means that it oscillates, with its output (pin 3) going alternately high and low whenever the IC is enabled.

The rate of flashing is controlled by three components: R2, R3, and, C2. With the component values shown, the rate will be about one flash per second. The simplest way to adjust the rate is to alter the value of R2.

The enabling portion of the circuit is somewhat unconventional. During normal operation, pin 2 of the 555 will oscillate between ⅓ and ⅔ of the supply voltage. Clamping it to any fixed voltage inhibits astable operation.

That function is controlled by transistor Q1 and the ignition switch. When the ignition is switched on, transistor Q1 is biased on and clamps pin 2 to ground. That disables the 555 timer and turns the lamp off.

When the ignition is switched off, Q1 turns off and releases

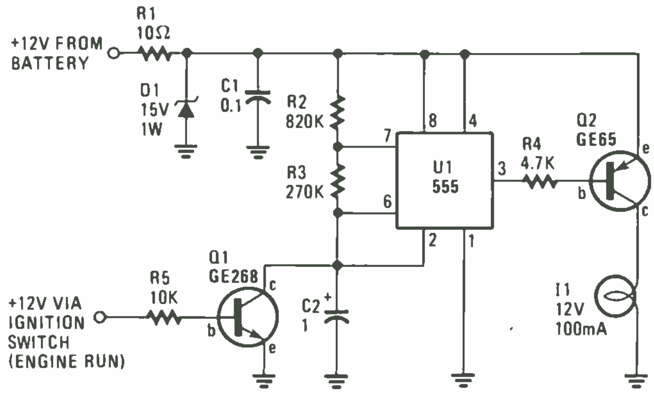


Fig. 1—The circuit is unusual in that it is turned off when 12 volts appears at R5. That shuts the circuit off when the car is started. You may wish to add a manual switch to shut the system off if your car will not be turned over for a long time. That will prevent the circuit from draining the battery while you're on vacation, or the car's being repaired.

releases its clamp on pin 2. The 555 immediately begins oscillating, its output (pin 3) switching high and low. That drives transistor Q2 which, in turn, drives the lamp.

Power for the circuit is derived directly from the car battery. R1 and C1 provide supply decoupling while D1 clips any voltage spikes exceeding 15 volts.

Construction

The parts are mounted on a small PC board measuring 29 × 46-mm (see Fig. 2). No special order need be followed when assembling the board, but take care to ensure correct orientation of the polarized components. Those include U1, Q1, Q2, D1, and C2 (see Fig. 3).

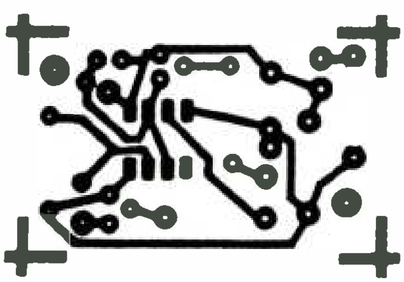


Fig. 2—A copy of this full-scale foil pattern can be used to make a circuit board for your fake alarm, but you could also wire-wrap the project without worry.

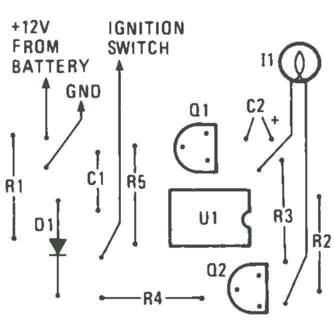


Fig. 3—The order of parts placement is not critical; however be sure that good conections are made, because the vibration of the car may rattle your project apart. Also check for proper polarization of parts.

PARTS LIST FOR THE FLASHER ALARM

SEMICONDUCTORS

U1—555 oscillator/timer, integrated circuit
Q1—NPN GE-268, SK3124, BC547
Q2—PNP SK3200, GE-65, BC547
D1—15-volt, 1-watt Zener diode ECG145A, SK3063

CAPACITORS

C1—0.1-μF
C2—1-μF, 16-WVDC, Electrolytic

RESISTORS

(All resistors are ¼-watt, 5% units.)
R1—10-ohm
R2—820,000-ohm
R3—270,000-ohm
R4—4700-ohm
R5—10,000-ohm

ADDITIONAL PARTS AND MATERIALS

Circuit board, 12-volt lamp assembly, wire, solder, IC socket if used, etc.

Once the board has been assembled, it can be tested by connecting the power leads to a car battery. The lamp should immediately begin flashing at 1 Hz. The lamp should stop flashing when the input to R5 is connected to 12V.

Incidentally, the lamp used was a round 14-mm bezel. Alternatively, a larger square lamp bezel (20 × 20-mm) is available from most electronic parts dealers.

Installation is straightforward, there's no need to fit the circuit into a case. The best approach is to wrap the board in insulating foam and then tape or glue it to some convenient location behind the dashboard.

The external wiring connections should be run using medium-duty hook-up wire. Connections must be made to the power supply (car battery), the lamp, and the ignition switch.

Note that the latter connection need not be made directly to the switch—it could just as easily be taken from an accessory switch or some accessible point on the ignition wiring. Similarly, the +12-volt supply rail can also be derived from under the dashboard (for example, from a glovebox light switch terminal or from the headlight switch).

Finally, although the circuit is designed to operate automatically, some constructors may prefer to switch it on and off manually. No problem—just install a switch in the power-supply lead and connect the input to R5 to the chassis.

In fact, R5, and Q1 could be left out of the circuit altogether. It goes without saying that any power-supply switch should be well hidden.

If the circuit fails to operate in the prescribed manner, disconnect the power and check the orientation of the semiconductors. Also check that you have not accidentally switched the two transistors. If the PNP (Q2) unit is placed in the position of Q1, the lamp will continually flash, and will stop only when disconnected from the power source. (Remember, for an PNP transistor to turn on, its base must be more negative than its emitter and less negative that its collector.) It's also a good idea to check all solder connections to ensure that good contact has been made, and keep an eye out for solder bridges. ■

**The Alarm Flasher was originally published in the February, 1986 issue of Electronics Australia and appears here by permission.

THE ASTABLE MULTIVIBRATOR

Let LED's tell you what's happening in the circuit.

By Don Kennedy

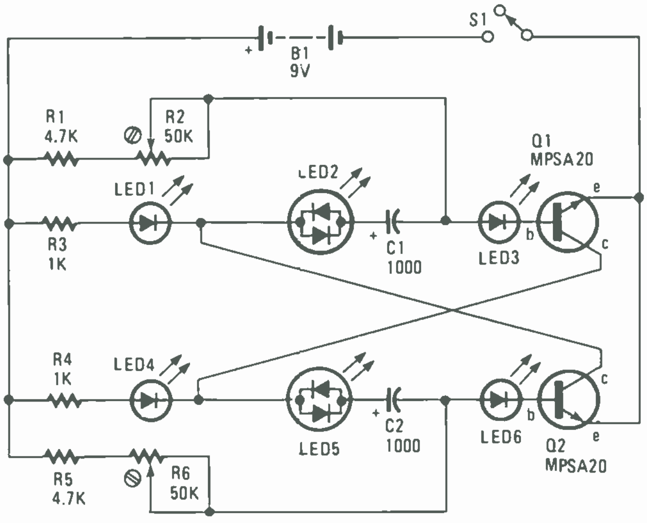
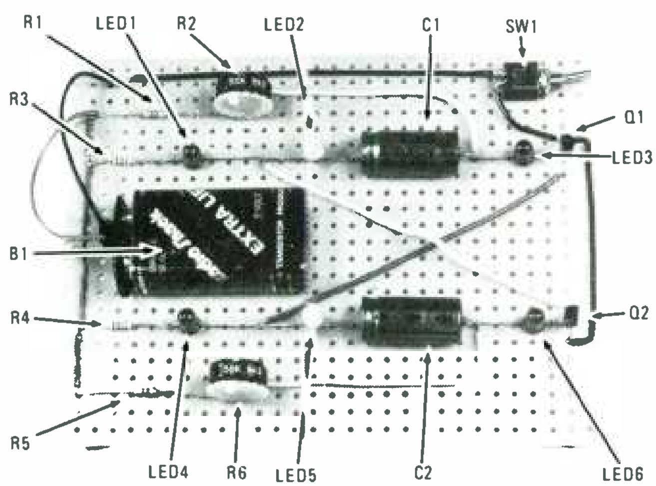


Fig. 1—LED's 2 and 5 actually contain two LED substrates in each plastic case. Since the substrates are in parallel and in opposite directions, the LED package will emit light when current flows in either direction. One substrate emits green light and the other red; thus the LED indicates the direction of current flow by the color it emits.



The PC-mount potentiometers control circuit timing, and the values for the capacitors are large in order to accommodate a wide timing range to provide good flexibility.

Have you ever tried explaining to a friend how astable multivibrators work? This demonstration circuit will make it easier for you. The circuit is constructed on a perfboard with all components and connections clearly visible from the top. The frequency of oscillation is adjustable from approximately 3 seconds to 1 minute. Red LED's show when the transistors are on, and the tri-color (red and green) LED's, 2 and 5, are used to indicate whether the capacitors are charging or discharging.

Figure 1 shows a schematic diagram of the circuit. Assume that it is operating and that Q1 has just turned on. At this point in time: **1.** LED4 is lit by the current passing through Q1 and R4. **2.** C2 begins discharging through Q1, R6, and R5. That current lights LED5 in green and holds LED6 and Q2 off. **3.** C1 begins charging via the emitter-base junction of Q1 and R3. As C1 charges LED1, LED2 (now red), and LED3 light and then dim. With a longer cycling time, LED1 and LED2 will go out but LED3 is held on by the current passing through the emitter-base junction of Q1, R2 and R1.

PARTS LIST FOR THE ASTABLE MULTIVIBRATOR

SEMICONDUCTORS

LED1, LED3, LED4, LED6—Jumbo red Light-emitting diode

LED2, LED5—Tri-color Light-emitting diode (Radio Shack #276-035 or equivalent)

Q1, Q2—MPSA20, NPN silicon transistors

CAPACITOR

C1, C2—1000-µF, 25 WVDC, electrolytic

RESISTORS

(All fixed resistors are ¼ watt, 5% units)

R1, R5—4700 ohm

R3, R4—1000 ohm

R2, R6—50,000 ohm PC mount potentiometers

ADDITIONAL PARTS AND MATERIAL

SW1—SPST switch, perfboard, 9-volt transistor radio battery, double sided foam, wire, solder, etc.

At slower rates, you will notice that when C2 discharges LED 1 will light while LED 5 is still green. C2 has not only lost all its original charge but has been charging in the opposite direction. The voltage level at the junction of C2, R6, and LED6 has reached the point where current can begin to flow through the emitter-base junction of Q2. That turns Q2 on then: **1.** LED 1 is lit by the current passing through the Q2 and R3. **2.** C1 begins discharging through Q2, R2, and R1. That current lights LED 2 green and holds LED 3 and Q1 off. **3.** C2 begins charging via the emitter-base junction of Q2 and R4. As C2 charges LED 4 and LED 5 (red) light and then dim. LED 6 and Q2 are held on by the current passing through R5 and R6 until C1 discharges and reverse charges to the point where Q1 can turn on. The cycle repeats as long as power is applied to the circuit.

Construction Tips

A prewound coil (3 to 4 turns) of light-gauge wire was placed over the leads on the bottom of the perfboard. When soldered, that provided a solid mount for the components. Be sure to use heatsinks on the transistors and diodes because that technique requires more heat than necessary when soldering a lead to a PC board.

The battery can be held in place by double-sided foam tape. ■

By Joseph J. Carr, K4IPV

CARR THE HAM SHACK

Our new column for radio amateurs cuts loaded antennas to size.

THIS MONTH WE KICK OFF A NEW COLumn—*The Ham Shack*—intended for readers who are already amateur radio operators, and those of you who think you might want to get into amateur radio. I'm Joe Carr, and my amateur radio call sign is K4IPV (which was first KN4IPV in 1959 when I was a novice). Over the years, my articles have appeared in **Radio-Electronics**, **Hands-on Electronics**, and many other magazines.

The column is intended for the activist who doesn't have a lot of technical knowledge at present, but wants to learn more. Some of you will eventually go on to learn a great deal of technical *smoke* about radio communications, while others will continue near the level that you are at right now—an intelligent hobbyist who wants to know how to make something work without learning differential calculus.

Varied Topics

We expect to cover a wide range of interests as they affect amateur radio: How things works; how to fix them; how to build something useful; and other topics that strike my—or your—fancy.

We'll also present equipment reviews, especially where the equipment is particularly uncommon, very useful for a large number of readers, or simply interesting in some way. But we won't do equipment reviews that are merely rewrites of manufacturer's press releases—you deserve better. When we do an equipment review, you can be certain that either some technically-qualified person has had his or her hands on the device and actually tried it out.

Although this column is not specifically a *news and views* affair, a certain amount of that material will be presented if it appears that it will be of interest to a large number of readers. If you know of a newsworthy event or topic that you believe would be of general interest, please write to me at the address given at the close of this article (the CALLBOOK address is no good, at least not until the next edition is published).

Heard at the Ham Shop

It's a lot of fun to stand around a ham-radio store on Saturday morning and just listen to the conversations. Recently, I was in the Electronic Equipment Bank (EEB) in Vienna, VA, and heard a conversation between two hams on the topic of antennas. Because I am always interested in antennas, and because I am building a file for future use in this column, I listened carefully, and then interjected a minor correction.

The two guys were talking about the problem of cross polarization. That is, receiving a vertically-polarized signal on a horizontally-polarized antenna, or vice versa. One of the fellows claimed that he would never use a vertical because most amateurs use horizontally-polarized antennas "...and there's 40-dB of loss due to cross polarization."

The first bit of *meadow pies* in that claim is the number: 40 decibels represents a power loss of 10,000:1! If a horizontally-polarized signal arrived at a vertically-polarized antenna, it would be down in the noise about the same as a moonbounce signal from the dark side. There is a cross polarization loss, but the 40dB claim stands precariously at the edge of a logical chasm, too broad for the healthy mind to leap.

The second problem is that those guys were talking about HF (high frequency) operation. Cross-polarization loss is a problem mostly on direct line of sight circuits, which means it is limited to VHF and UHF for the most part. At over-the-horizon distances, there are too many reflection sources to keep the polarization the same for a long haul. For skywave applications, it's not a factor at all.

In skywave cases, the ionospheric reflection that makes skywave "skip" possible rotates the polarization randomly. It is sometimes merely reversed (V to H, H to V), but most of the time the signal is polarized either elliptically or circularly...so it doesn't matter what kind of antenna is used for receiving. Even if an antenna is right for a given signal at a given time, it will be wrong for the next signal tuned in (sigh).

A second conversation I overheard (actually participated in) raised an old *bugaboo* from my CB repair and installation days. The guy claimed that cutting the transmission line was a way to reduce VSWR on an antenna. The only way to actually reduce VSWR is to match the antenna to the transmission line either by design; by cutting to proper resonance; by using a matching network or transformer; or all three. The reason why that myth continues to be resurrected is that it appears to be true when using low-cost voltage or current sensing SWR meters.

In a future column we will discuss SWR in depth, so for now take it on faith that changing the transmission line length won't do you any good.

There are sometimes good reasons to cut a transmission line to specific length (usually an integer multiple of a half-wavelength), but none of them have anything at all to do with reducing SWR.

A Shortened HF Dipole

A novice called me on the phone recently and asked what he could do for a 40-meter antenna in his townhouse. Of course, he faced the same restrictive cove-

(*Continued on page 117*)

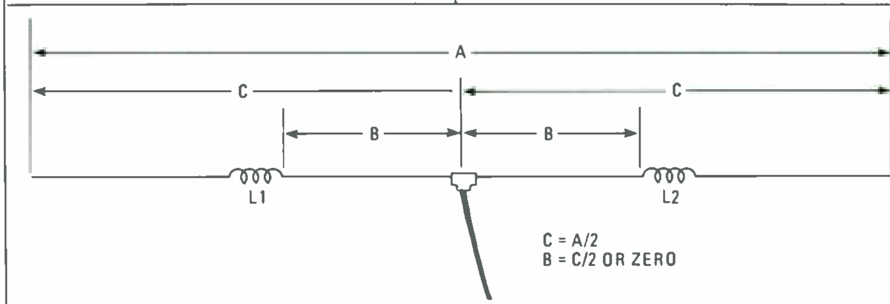


Fig. 1—The values for L1 and L2 depend on the measurements for A, B, and C, which interlock. Table 1 and Table 2 provide values for different antenna sizes.

BY Mark Ellis

ELLIS ON ANTIQUE RADIO

Knowing where to look is the most important part of building your antique-radio collection. Here are a few hints to get you going in the right direction!

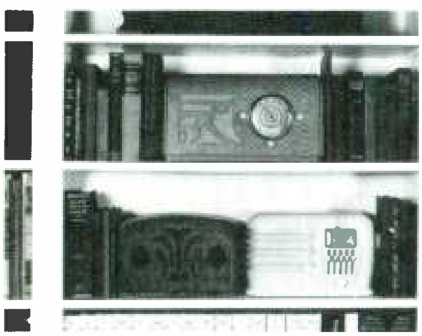
☐IN THE LAST ISSUE, WE FINISHED UP A once-over-lightly orientation to radio collections for the newcomer to the hobby. If you've been following the column and wondering how to get in on the action, read on. We'll be talking about how to define your goals as a collector, and how to find the collectibles that you want.

Your Collection and Your Lifestyles

The kind of collection that you build, and how you go about building it, will depend heavily on your personal taste, lifestyle, and the physical limitations of your living space. If your taste runs to massive console models, that's fine—as long as you have lots of extra room in your home, not to mention an extremely understanding spouse. But, even if you live in a two-bedroom, high-rise condo, you can still build a rather interesting collection.

First, you should give a little consideration to the why of your collection. Are you turned on by the thought of restoring time-worn cabinets to their original beauty, or coaxing archaic circuitry back to life? If so, then you might prefer to keep an eye out for diamonds in the rough, as opposed to pristine and highly-expensive units. On the other hand, if you're attracted to the romance of early radio and are not interested in restoration, you'll be considering only pieces that are already in good shape.

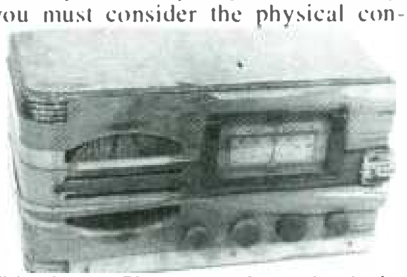
Of course, very few of us fall wholly into one category or the other. The person who never intended to get into wood refinishing or cabinet repair might still fall in love with a wonderful old set that just needs a little work to put it in showroom condition. The table-model collector who lives in a one-room efficiency unit might suddenly be tempted to somehow find room for a floor-model Stromberg-Carlson, which is the size of a small juke box. That's what makes us human!



A collection of small table radios makes an interesting bookshelf display, for condo or apartment dwellers.

The Importance of an Open Mind!

When you start out in collecting, don't be too quick to set your goals. Obviously, you must consider the physical constraints of your living space and the needs of other family members. But don't specialize too soon. Keep an open mind and pick up the things you like regardless of what category they fall into. Your tastes may take some time to develop. If you decide to make your collection more specialized at some future time, you can always use your early finds as trading pieces.



This vintage Silvertone, although missing most of its veneer, the speaker, and a few tubes, still has a nice dial (complete with tuning eye) and all of its original knobs. Would you consider this set worth fixing up? How you answer that question might help you define your goals.

When I started my own collection (some time back), I decided to collect only early battery-powered sets. If a set was new enough to plug in, I didn't want it. But as time passed, I changed my mind. I hadn't made any interesting finds in a long time, and my collection had become overloaded with 5-tube battery-powered units in long, hinged-cover cabinets (see photos).

Which period interests you most; 1920's, 1930's or 1940's? You might have to collect for a while before you find out.

Then I began to be drawn to table-models of the thirties and forties because of their greater diversity of style and more sophisticated circuitry. So I sold the surplus battery sets and reoriented my collection. But I'm still sorry about some of the nice sets I passed up while I was being closed-minded.

Finding new items for your antique-radio collection can be one of the most satisfying aspects of the hobby. How you go about it, depends heavily on how much time you have to spend searching, where you live, and how intensely you want to look.

The Way the Dealers Do!

The ideal way to purchase old radios, or any other type of collectible, is the way antique dealers do—get in touch with people who (for whatever reason) are breaking up long-established households. To them the selling price most often isn't as important as expeditious disposal.

An old radio that has sat for years in a garage or on an attic shelf might be a prize for your collection, though to the seller, it be a piece of junk that he or she would just as soon trash as sell. In cases like that, just do your best to suppress a broad grin as you shell out a couple of bucks and walk away with your find. Collectors sometimes call acquisitions like this *primary finds*, as opposed to purchases made from other collectors, antique dealers, or other knowledgeable people.

How can you go about making some

primary finds? If you live in a rural or semi-rural area, watch for farm auctions, auction barn operations, or yard and garage sales. If you're a suburbanite, you might have to drive quite a ways to find a farm auction. But keep your eyes open for house sales (try the classified section of your local newspaper), particularly if the house seems to have been occupied by the same family for a long period of time.

In many suburban communities, yard and garage sales are a spring and summer tradition, and are often advertised in the local newspapers. A weekend tour of such events can net you a large selection. If you're of an organized turn of mind, you can plan your itinerary in advance using a good street map as a guide.

City dwellers are going to have to drive farther to make primary finds. Watch the suburban newspapers for house and garage sale announcements. And don't forget the church rummage sales held in many locations (generally in spring). They can be a treasure-trove of collectibles—oh yes, be sure to get there early! The good ones attract determined buyers from miles around.

Flea Markets and Swap Meets

Whether you are a city dweller, a suburbanite, or live in a rural area, one of your best opportunities for making primary finds might well be the flea market/swap meet circuit. Many areas support very large ones held several times during the year. Most are outdoors: held in public parks, drive-in theater parking lots, and other large open areas. Some are held under cover in permanent buildings.

Keep an eye peeled as you stroll through flea markets or swap meets. You may spot an exciting addition to your collection.

The sellers range from individuals with surplus possessions to dispose of, to small entrepreneurs who buy and sell rummage to specialized dealers (in antiques, tools, electronics, etc.). Many of the dealers return to the same flea market every time it is held—always occupying the same spot. A well-run flea market with a good representation of sellers is worth a hundred-mile trip on a weekend morning. Walk slowly and keep your eyes peeled as you make the rounds: An exciting discovery could be just around the corner!

This dealer is usually in evidence everytime I attend my favorite flea market. I can't always afford his wares, but I still enjoy looking at them!

You'd also be wise to keep an eye on current amateur-radio publications for announcements of hamfests in your area. In addition to their other activities, the ham get-togethers almost always feature an extensive electronics flea market. The prices are usually reasonable, and you'll have the opportunity to find not only sets, literature, and other collectibles, but also test equipment, parts, tubes, and other items for restoring and maintaining your collection.

Up to now, we've been talking about how to find sets that have not yet fallen into the hands of dealers or other collectors. But there certain times when it pays to deal with such sources.

Buying From Antique Dealers

Off hand, you wouldn't expect to do very well at an antique store. The antique dealer is obviously out to make the biggest buck he can—and if he thinks he has a nice piece, he'll hang onto it until he gets his price. Still, I've made some nice finds in antique stores (I never hesitate to stroll through one whenever I have the opportunity).

It sometimes happens that a dealer, specializing in the more conventional antiques, picks up a nice radio as part of a lot purchase. Many such dealers might overprice the set, making it impossible for you to buy. Others may not consider old radios to be a true antiques and, therefore, be willing to dispose of them for pocket change.

I once picked up a very fine *gothic cathedral* set from the latter type of dealer. My wife and I happened to be shopping for furniture in a fairly upscale antique shop when she pointed out the set sitting in a corner. It didn't work, the proprietor said, but he'd have to charge me $20.00 because, as he said, "I know there's some interest in the cabinet style."

At the other end of the scale is the dealer who likes technological antiques, always has some in his shop, and charges a fair price for them. Shops like this are fun to visit because there are lots of things to look at. And you might find a treasure that you'd be willing to shell out a little extra for.

So make it a point to get to know the antique dealers in your own and neighboring communities. You'll soon find out which ones are worth return visits. Then, as opportunity affords, drop in from time to time. Be persistent, and its almost a sure bet that it will worth your while.

The Collector's Market

It also pays to keep in touch with other radio collectors. One of the best ways to do this is by subscribing to a newspaper or newsletter devoted to the hobby. Study the classified ads to discover opportunities to acquire sets and locate sources of parts and servicing information. Chances are, you won't be able to purchase sets at bargain prices from other collectors—but you might very well be able to make a very advantageous trade! And watching the prices in the "for sale" ads will give you a feeling for current values of the various types of collectibles.

One publication that I've subscribed to for several years and can recommend highly is *The Horn Speaker.* That little newspaper is published every month, except July and August. It contains interesting reprints from vintage radio magazines, collecting and restoration tips, large display ads from dealers in parts and supplies, individual "Wanted" and "For Sale" ads, and many other features of interest to collectors. Subscriptions to that publication cost $10.00 for one year; $17.00 for two. (For more information, contact Jim Cranshaw, 9820 Silver Meadow Drive, Dallas, TX 75217.)

That about wraps it up for now, fellow collectors! In the meantime, let me hear from you. Would you like to share some of your ideas for finding collectibles?....brag about your latest find?....locate a special part or set? ....make some suggestions about future topics for the column? Send your correspondence to Marc Ellis, C/O **Hands-On Electronics**, Gernsback Publications, Inc., 500-B Bi-County Boulevard, Farmingdale, NY 11735. ■

By Marc Saxon

SAXON ON SCANNERS

The bear is bullish in the marketplace

Uniden Bearcat hasn't been letting the grass grow beneath their feet, what with a nice assortment of new scanners being issued on a rather regular basis. The recent unveiling of their Model BC-170 16-channel base station really caught our eye.

The unit is capable of receiving 11 frequency-bands, including all public-service bands, four Ham bands, federal government, VHF aircraft, and land-mobile bands. Its LCD display shows the frequency being programmed and being monitored, as well as operation modes. Its other features include automatic search and squelch, patented scan delay and track tuning, lockouts, priority check, memory backup, and direct channel access. The suggested retail price of the BC-170 is $229.95.

The BC-170's lower priced brother goes by the name BC-140. The 140 is a 10-channel base unit covering 10-frequency bands, including all public-service bands, four Ham bands, federal government, military, and land-mobile bands. Other key features this unit include direct-channel access, frequency review, channel lockouts, built-in delay to prevent missing replies to transmissions, a telescoping antenna, and two-digit LED display. The BC-140 can be on your desk for only $139.95 (suggested retail price).

Further information on those and other Uniden Bearcat scanners can be obtained by contacting the Uniden Corporation of America, 6345 Castleway Court, Indianapolis, IN 46250.

Here Come the Judge

Recently, a couple of teenagers dug themselves into a rather deep hole via radio. A $2,000 handheld police-band VHF transceiver was stolen from the home of a police officer in Warren, Michigan. The handheld somehow ended up in the possession of three 17-year old chaps who came to the conclusion that the set was a CB rig. Actually, it operated on a police VHF frequency.

Two days after the theft, a new would-be CB'er—with the handle *Bulldog*—was on the air, and assumed that he was on a regular CB channel. The Warren deputy police chief, Gerald Norkiewicz, said of the transmission, "He was just talking garbage. Just talking on it."

Then the *fix* went in: A female police employee was used to reply to Bulldog and make a date with him. That led police investigators to a motel where the three suspects were observed standing on a balcony with the handheld transceiver trying to make additional CB contacts. They were promptly arrested for receiving and concealing stolen property. Furthermore, breaking-and-entering charges relating to the actual theft were also being considered.

As the man said, things aren't always what they seem to be—on police *CB!*

Cordless Quizzer

Jeffrey Arnold of Revere, Mass., reports that he's been unsuccessful in figuring out the frequency of his GE cordless telephone. The question is: Can **Hands-on Electronics** give him the right number?

Well, Jeff, your particular cordless telephone might well be operating on any one of several pairs of frequencies that have been set aside for those communications devices. Generally speaking, though, the

(Continued on page 112)

The Uniden Bearcat BC-170 is capable of receiving 11 frequency bands, and its LCD display shows the frequency being programmed or monitored, as well as operation modes—all at a suggested retail price of $229.95.

The BC-140 ($139.95, suggested retail price) features direct-channel access, a built-in delay, LED display, channel lockouts, and frequency review.

THINK TANK

(Continued from page 30)

triggered, the resulting light that falls on photo-transistor Q1 activates the circuit, which in turn fires the slave or secondary flash unit. It's interesting to note that the photo-transistor has a built-in lens that not only increases the light-gathering abilities of the unit, but also enables you to provide a directional effect.

Automatic Light

C.K., of Secaucus, NJ asks about an automatic switch to turn on his outside yard lights when dusk falls. No problem at all, C.K. See Fig. 8. You'll find stable threshold characteristics due to the dependence on the photo-transistor current to generate a base-to-emitter voltage drop across the sensitivity resistor (R5). The double phase-shift network supplying power to D5 (an ST4 triac driver or diac)

SUGGESTED TRIAC	LAMP WATTAGE MAXIMUM 120V	220V
SC141D	400W	800W
SC146D	550W	1100W
SC151D	750W	1500W
SC260D	1200W	2500W
SC265D	2000W	4000W

ensures triac activation at line-voltage phase angles small enough to minimize RFI (*R*adio-*F*requency *I*nterference) problems with a lamp load. Just choose the right triac from the table according to the power consumption of your lamp.

Outage Light

We received a letter with an interesting request from H.R., of Oswego, NY. The local diner where he has dinner each night, has a device over the counter that's topped-off with a couple of floodlights. He asked the diner owner about the gadget, but the only information the owner could supply is that the floodlights would come on to provide emergency illumination when the power failed. H.R. wants to know if we can fill him in.

Sure thing, H.R.; just take a look at Fig. 9. The light generated by line-monitor lamp NE1 (plus ambient light) striking photo-transistor Q1 turns it on, pulling the base of Q2 low. That keeps the 6-volt lamp, I1, turned off. (I1 represents the floodlights.) But when the power fails, the neon lamp extinguishes, raising the Q2 base-voltage enough to trigger the circuit; at which time the 6-volt lamp comes on to provide necessary lighting.

Infrared Transmitter

One of our readers bought a small infrared burglar alarm system, and now wants to add a second transmitter but does *not* want to buy a whole 'nother system. F.B., of Fresno, CA asks if we can provide an easy-to-build infrared transmitter. Sure

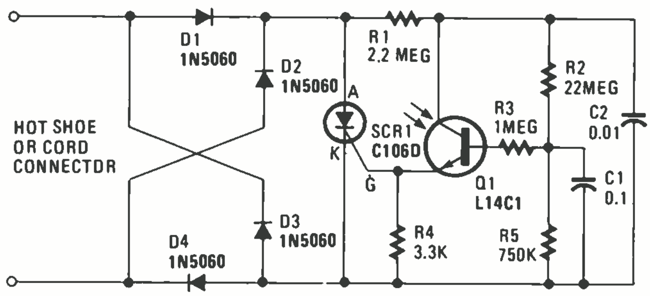


FIG. 7

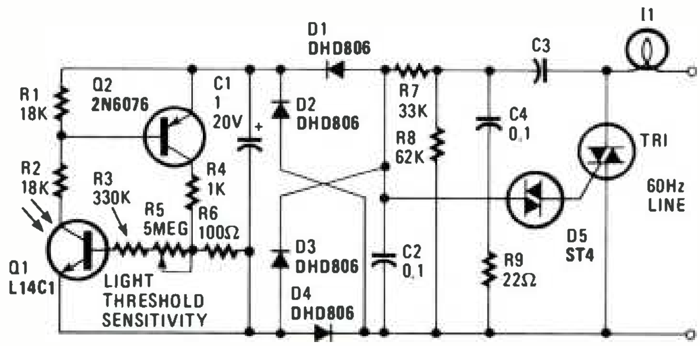


FIG. 8

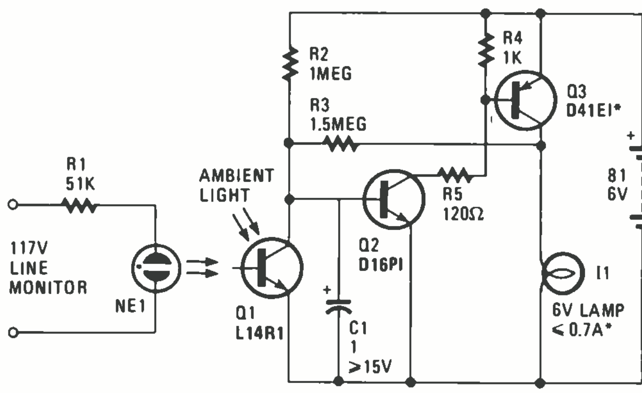


FIG. 9

can, F.B.! Look at Fig. 10. This one is built around an ordinary flashlight, too. All you have to do is add an infrared filter over the lens, such as a Kodak 87C or 88A, which you can get at almost any large photographic suppliers.

In our circuit, U1, an NE555V timer, is connected in the astable mode and oscillates at about 455Hz. The actual frequency of modulation isn't critical. The output of the 555 drives the flashlight bulb. It's best to remove the bulb, lens and reflector assembly from the flashlight and build your own housing for these components.

Miniature Power Amp

A.B., of Oswego, NY asks about a small power amplifier, and we think this one (Fig. 11) might just turn the trick. It uses a single DIP IC, a ULN2283B. Potentiometer R1 biases the input to the IC and also serves as a volume control. C1 offers DC blocking at the input, and C3 serves as output blocking capacitor. C2 decouples the supply to the preamp, and

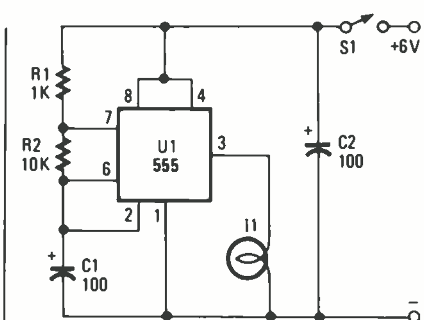


FIG. 10

C4 is the power supply decoupler.

Voltage gain is about 140 times, and a smidge under 20 mV *rms*. Maximum output power is about 100 mW with an 80-ohm speaker and can rise to 600 mW with an 8-ohm speaker.

Fuzz Sound

Maybe I'm getting old, but I can't understand why *anybody* would want to deliberately distort a musical instrument amplifier! However, M.K., of Mercerville, OH, wants a fuzz unit for his electric guitar. Check Fig. 12, M.K. Q1, a 2N109, is a common emitter/preamp that increases the input to drive the Schmitt trigger. C3 rolls off the highs and prevents instability.

The Schmitt trigger is based on an op-amp IC, an LF351. R6 and R7 bias the inverting input of U1 to almost half the supply voltage, and R4 is set to bias the input to the same level. The output of Q1 is coupled to the wiper of R4 through C4 and the signal from Q1 modulates this voltage at the input frequency. R8 introduces positive feedback between the output and input of U1, giving a triggering action so the output switches cleanly from one state to the other without instability under quiet conditions.

When you build this unit, make switch S1 a foot pedal switch.

Transistor Amplifier

H.R., of Spokane, WA, asks about a small amplifier that can convert a transistor radio from earphone to loudspeaker operation. The schematic diagram in Fig. 13 describes an amplifier with more than sufficient drive. The amplifier boasts 0.6 volts input sensitivity, and the output transistors should be matched and have a high current gain. Harmonic distortion is in the neighborhood of 0.3% for 1 kilohertz, and that's a pretty-nice neighborhood. After you build this unit, connect the inputs to a suitable plug so it can connect easily to your transistor radio, and control the volume with the radio's volume control. I think you'll like this one!

Guitar Preamp

"If you've got magnetic pickups on your guitar, how can you connect to the high-impedance input of an amplifier?" That's the question from J.C. of Topeka, KS, who goes on to explain that "We've just organized our group and since we haven't made a lot of money yet, we're using a simple hi-fi amplifier.

J.C., lots of big names had to start small. The schematic diagram (Fig. 14) we provide should be easy to put together. Here's how it works: The signal voltage is fed through the volume voltage divider and is applied to the non-inverting input of U1. A frequency-dependent r/c network permits feedback from the output to the inverted input of the IC. The potentiometer lets you control the "flavor."

Switch S1 helps eliminate noise. And if you put another switch in the power line, it can be used by your family to reduce noise even further!

I guess we've simply run out of space once again. So until we get a paper stretcher or next month's issue (whichever comes first) do stay in touch. Send your schematic diagram requests to Wels, **Hands-On Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

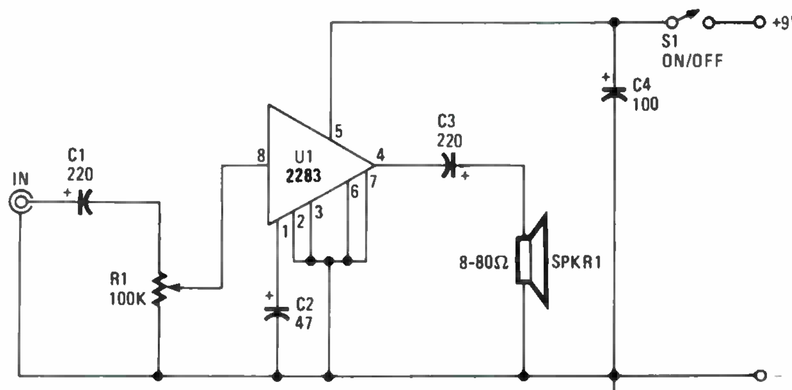


FIG. 11

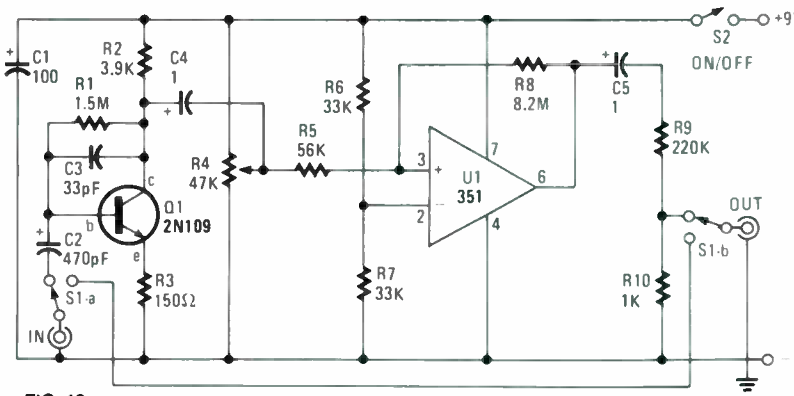


FIG. 12

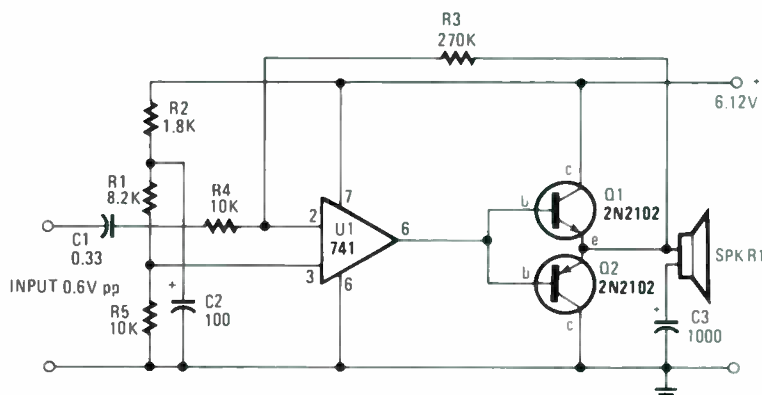


FIG. 13

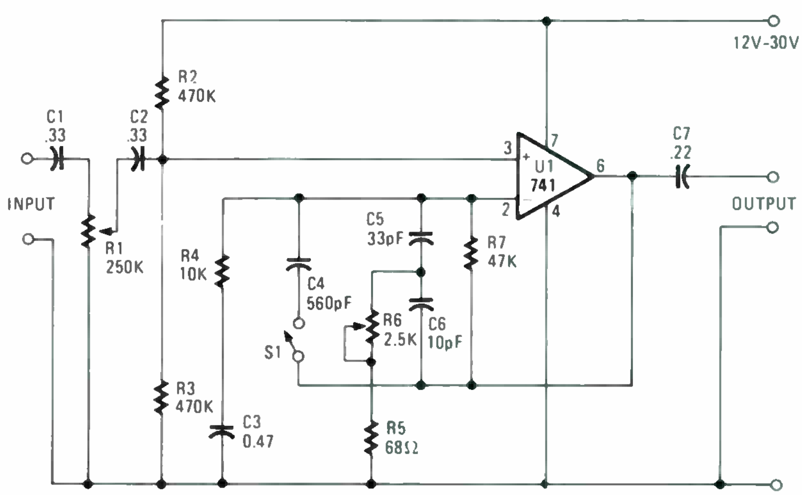


FIG. 14

SOLAR POWERED HOUSE NUMBER

(Continued from page 56)

panel is installed with the correct polarity. If the lead-acid cells are heavily discharged, it may be advantageous to leave them charging for a few days before connecting them to the rest of the circuit. Otherwise, the circuit is ready for permanent installation.

Installation

The solar-cell array should be mounted on the roof of your house and tilted towards true north to ensure maximum solar illumination. Make sure that you choose a spot that will not be shaded by trees or other objects at any time during the day. If the solar cells are shaded, their output will be drastically reduced and the panel may not recharge the batteries.

Note that the optimum angle of inclination of the cells varies according to the latitude of your town or city. That needn't be exact, as a few degrees either way won't make all that much difference. Table 2 lists the optimum angle of inclination for various U.S and Canadian cities.

TABLE 2—OPTIMUM INCLINATION FOR SOLAR-CELL ARRAY

San Francisco, CA	42°
Los Angeles, CA	38°
Dallas, TX	37°
Chicago, IL	47°
New York, NY	45°
Washington DC	43°
Miami, FL	30°
New Orleans, LA	34°
Tacoma, WA	51°
Montreal, Canada	50°
Quebec, Canada	51°
Vancouver, Canada	53°

Perhaps the best way of mounting the solar-cell panel is to attach it to the top of the TV antenna mast. The leads can then be run down the mast, adjacent to the antenna lead-in, and routed to the control unit. ■

ALARM-TRIGGERED PHOTOS

(Continued from page 102)

Connect the other wire from the jack to the solder point that is common to all of the switches. To make sure you have the correct points, insert a film pack (the film contains the batteries), and momentarily short the wires that you installed. If you have located the correct points the motor will run and the camera will take a picture.

After installing, wiring and testing the jack, replace the white plastic cover by pressing it into place.

Figure 1 is the circuit used for triggering the camera from a remote location. The circuit can be assembled on *perfboard* and mounted in a small aluminum box along with its 9-volt battery, which will last a long time because transistor Q1 remains off until the magnetic switch connected to J1 closes. When that happens, the 9 volts is connected through R1 to Q1's base. Q1 turns on, thereby charging C2 through relay K1, which causes K1's contacts to close. Since the contacts connect via J2 to the remote control jack which you installed in the camera—which in turn connects to the camera's shutter release—the closure of K1's contacts will cause the camera's shutter to trigger.

After C2 charges, K1 opens because current through it's coil ceases: The camera won't take another picture. If Q1 turns off because the magnetic switch on the window or gate opens, C2 discharges and the circuit is ready for another cycle. But as long as Q1 remains on, C2 stays charged and prevents K1 from triggering more photos.

Capacitor C1 by-passes spurious magnetic switch noises from physical phenomena such as a rattling window or a gate shaking in the wind, and reduces the likelihood of an unwanted picture. Resistor R2 biases Q1 and dampens K1/C2 oscillations which might cause contact bounce. Diode D1 prevents C2 from discharging through K1: the relay coil isn't polarity conscious and C2 discharging through it would trigger an unwanted picture.

You can make a hand-held remote control by gluing a pushbutton switch into a short length of 3/8-inch diameter plastic pipe. Run the two-conductor wire through the pipe so that the pipe acts as a handle for the switch. Connect a miniature plug to the wire. When you insert the plug into the camera the remote control switch will close the circuit that initiates the picture.

To use the remote control, set the camera on a table or other convenient surface, sight through the view finder, then join the group. ■

SAXON ON SCANNERS

(Continued from page 109)

handset portion of the two-part unit operates on a 49-MHz frequency, and the base (pedestal) portion operates on a 46-MHz channel. That holds true for GE and all other brands. In most instances, you can hear both sides of conversations only if you monitor the 46-MHz channel used by the base unit.

While most cordless telephones are advertised as having a 1200-ft. range, in actual fact, a scanner with a well-placed outdoor antenna can often pick up 46-MHz cordless, telephone calls from a mile (or more) away. Most users of cordless telephones seem blissfully unaware that their conversations are an open book (actually, more of an open line), and can be easily overheard by anybody in the neighborhood with a scanner!

Lots of folks program all ten 46-MHz channels into their scanner, put up a 6-meter band, (50 MHz) ham antenna, and have a *grand ol' time* listening to the most intimate and personal details of the lives of their neighbors.

Of course, that is a rather tacky form of entertainment and we would certainly be shocked to think that any of our readers would be so downright sneaky and nosy. However, Jeff, if you just want to see which frequency pair your own unit uses, there's no harm at passing along the frequencies that you can check out. They are: 46.61/49.67; 46.63/49.845; 46.67/49.86; 46.71/49.77; 46.73/49.875; 46.77/49.83; 46.83/49.89; 46.87/49.93; 46.93/49.99; 46.97/49.97 MHz.

No fair being a snoop, Jeff. Just listen to your own station's frequency! Right?

High-Flying Scanner.

Reader William Farnsworth (of New Haven, CT) asks how to scan the frequencies used for two-way communications during simulated combat by military aircraft. In your area, Bill, the NORAD ground station uses the tactical identification of *Huntress*. The aircraft have been monitored on 228.7, 233.6, 238.7, 273.4, 278.4, 292.8, 318.4, 338.1 and 364.2 MHz. Those frequencies may well be in use nationwide; however, you'll have to have a scanner that covers the 225- to 400-MHz UHF, military aero-band to monitor the frequencies.

(Continued on page 121)

SELECTING AND USING MULTIMETERS

(Continued from page 47)

(Look familiar? What you see here is one application of the theory outlined for Fig. 4.) Since the R_s resistance is nine times that of R_M, the meter reads only 1/10 of the actual applied voltage. Thus, a 30,000-volt potential will be displayed as 300 volts on the meter.

Meters in RF Circuits

Very few multimeters are designed to operate in RF circuits. So what do we do when it's necessary to measure DC voltages in the presence of large RF voltages, or we want a relative indication of the value of RF voltage present? The obvious answer is to build probes that serve both functions. The RF blocking probe shown in Fig. 6 is designed to measure DC voltages in circuits where RF is likely to be found; radio transmitters, for example.

The Fig. 6 circuit is little more than a low-pass filter, consisting of a 2.5-mH RF choke (L1) and a 0.01-µF capacitor, capable of (in most cases) blocking enough RF to permit a reliable reading. If there is still some problem, try two or three sections of the RF-choke/capacitor circuit to provide additional attenuation. On the other hand, that circuit also presents a few problems: the RF-choke/capacitor combination can interact with any LC elements in the circuit; and may, therefore, distort the readings.

It is also possible to damage certain circuits by detuning them—try detuning a plate tank circuit while the circuit is live, for example. Another problem is that RF chokes have a resonant frequency, which is a result of the inductance and inter-winding capacitance of the choke. When using the probe at the natural resonant frequency, the probe will act like a resonant circuit and could possibly self destruct.

RF voltmeter probes (which are also called demodulator probes because of their demodulating affect on AM signals) are shown in Fig. 7. If the low-impedance probe of a signal tracer (which is little more than an audio amplifier) is replaced with one of the circuits of Fig. 7, we will be able to troubleshoot AM-receiver RF and IF circuits.

With the diodes (either 1N60 or ECG-109) shown in Fig. 7A and Fig. 7B, we can measure RF potentials up to about 50- or 60-volts peak. For greater potentials use two or more diodes in series. Although largely displaced by silicon units, there are still many 1N60 diodes used in TV video-detector circuits, so that unit or a replacement part, like the ECG-109, can still be found. ■

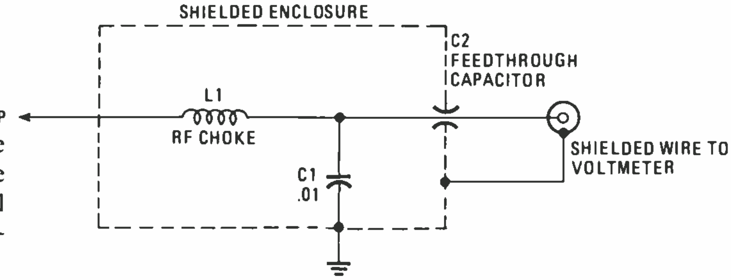


Fig. 6—Few multimeters are designed to operate in RF circuits. But, with the aid of a low-pass filter, like this one, a reliable reading can be made.

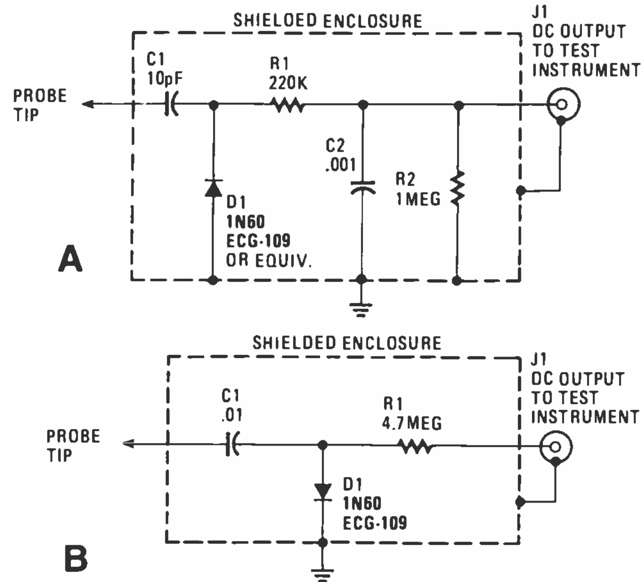


Fig. 7—RF voltmeter probes (or demodulator probes), such those illustrated in A and B, can be coupled with a signal tracer to allow for troubleshooting consumers AM-receiver RF/IF circuits.

CD COMPRESSOR

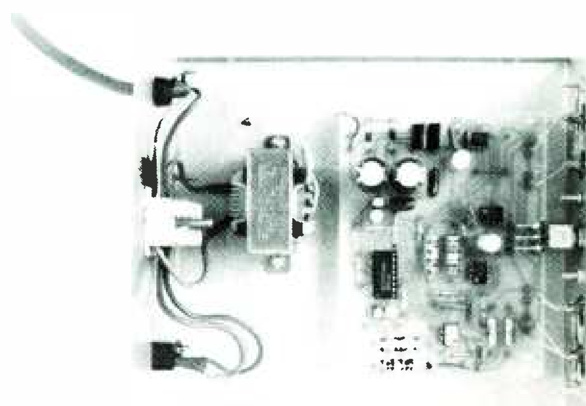
(Continued from page 72)

point; we used a pair of *duplex* phono sockets because they are supplied pre-mounted on a strip of insulation.

When the assembly is complete, check all your work thoroughly against the wiring diagram. With your multimeter switched to a low-ohms range, make sure that the ground pin of the power plug is connected to the chassis, and that both the active and neutral wires of the power cord are isolated from the rest of the circuit and the chassis.

If everything checks out, connect your CD player to the inputs of the compressor and your cassette deck to the compressor's output. If bypass switch S1 is set for bypass (*out*), the player-to-cassette recorder setup should work irrespective of whether the compressor is turned on or not.

Next, apply power to the compressor and set S1 to *in*. If the compressor is working satisfactorally, the loud passages should be reduced in volume compared to how they sound when the bypass function is selected. ■



There's plenty of room inside the cabinet we recommend so there's no need to crowd the printed-circuit board. However, keep T1 towards the rear apron, away from the board. The terminal block on the rear of the chassis is the linecord tie points.

THE HAM SHACK

(Continued from page 106)

nants as most other hams afflicted with a local homeowner's association—he couldn't install any outdoor antennas, unless it was a partially submerged satellite dish disguised as a picnic table (as was the case near Washington, DC last year). How could he put a 66-foot 40-meter dipole in a 33-foot townhouse attic?

Well, there are a couple of solutions to that problem. First, he could cut the antenna for 66 feet, and bend the arms to conform with the roof line. The pattern and feedpoint impedance will be all messed up, but he would be on the air. He would probably have to *diddle* with the length to make the antenna resonant, but that's easy enough. Contrary to popular belief, non-resonance is not fatal to all antennas.

The second option is to use a shortened dipole, as shown in Fig. 1. The shortened dipole is a regular dipole with an inductor in each element (L1 and L2). A dipole that's shorter than its operating frequency exhibits a certain capacitance to the transmission line. The inductors (in Fig. 1) are used to cancel the capacitance, and thereby make the transmission line think that the antenna is resonant.

The inductance of the coil required for a particular case is calculated from the reactances shown in Tables 1 and 2. Table 1 assumes that the coils are connected at the feedpoint, making dimension "B" in Fig. 1 equal to zero. The Table II assumes that the coils are halfway between the feedpoint and the end of the element: For this case, each element is one-half the overall length.

Dimension "A" will be a certain percentage of full size. Table 1 shows the equivalent reactance values (X_L) for specific percentages of full size (10 through 95 percent). For example, my friend wanted to make his 40-meter antenna 50% of full size. According to the usual formula—L(ft.) = 468/F(MHz)—the length at 7.15 MHz is 65.45 feet, so half size ("A" = 50% of full size) would be 65.45/2, or 32.73 feet (32' 9"). For a 50-percent antenna, we need a coil with a reactance at 7.15 MHz of 950 ohms (see Table II) if the coils are placed at the halfway point in each element.

Next, we calculate the inductance of a 950-ohm coil at 7.15 MHz. The formula is $L = X_L/(6.28 * F)$, where X_L is in ohms, F is in hertz and L is in henrys. Keep in mind that some unit conversion is needed: when working the problem convert 7.15 MHz to 7,150,000 Hz; when finished convert 0.000021 henrys to 21 microhenrys.

From there you can either construct or buy a coil. For the example case, my friend built a half-size antenna that was 32.73 feet long, in which "C" was 16.37 feet long, and the coils were placed 8.2 feet from the feedpoint. If you don't want to go to a lot of bother, then check with any ham radio shop. On the same display where they sell dipole kits and parts, they usually carry a shortened dipole kit that includes pre-cut coils. Also, Barker & Williamson sells coil kits for 80/75 and 40-meter applications. ■

TABLE 1
COIL REACTANCE FOR CENTER LOADING

B = 0 Percent	
A(%)	X_L
10	2800
20	1400
30	900
40	700
50	500
60	375
70	260
80	160
90	78
95	37

These are the reactance values for an antenna with the loading coils located in the center of each individual element.

TABLE 2
COIL REACTANCE FOR FEEDPOINT LOADING

B = 50 Percent	
A(%)	X_L
10	4800
20	2700
30	1750
40	1300
50	950
60	700
70	500
80	320
90	155
95	80

The loading coil reactance depends on the overall length of the antenna compared to that of a full-size dipole. This chart is for an antenna with the loading coils located at the antenna's feedpoint (which is at the center).

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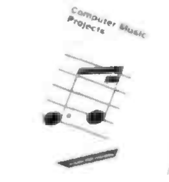

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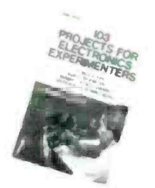

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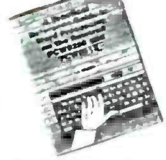

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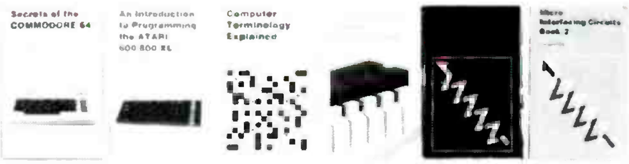

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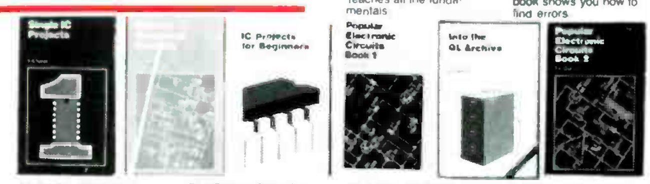

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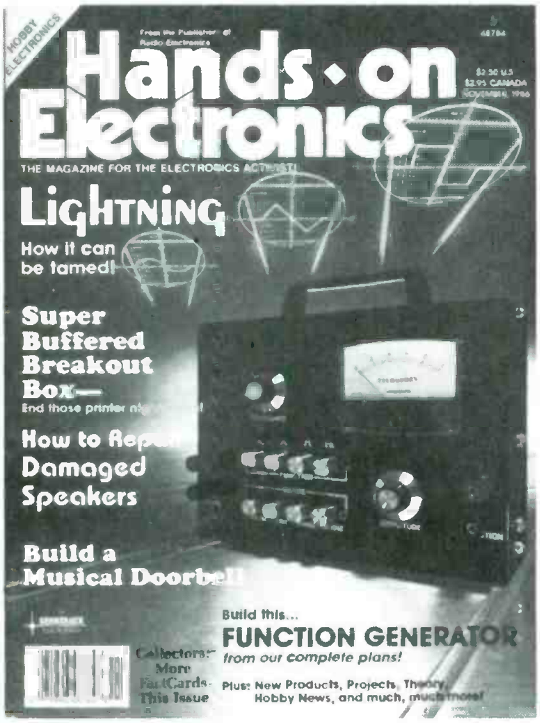

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SAXON ON SCANNERS

(Continued from page 112)

A Real Sport

A reader in Atlanta who wishes to remain anonymous asks for the best frequencies to monitor at sport arenas in order to hear crowd control, security, parking, as well as the teams and race car drivers. Again, lots of different frequencies might well be in use, but we have found the following to be the best bets for communications: 151.625, 154.57, 154.60, 457.525, 457.55, 457.575 and 457.60 MHz.

The Corps of the Problem

B.J. Howard of Arkansas requests information on the frequency used by the Army Corps of Engineers. That's a big order, B.J., since those guys operate on a rather-wide range of frequencies. A few popular frequencies that you might wish to try on for size include: 163.4125, 163.4375 and 163.5625 MHz.

It looks like we've run out of space! We're always on the lookout for reader mail, photos, questions, info on what you're hearing. Write to: *Saxon On Scanners*, **Hands-on Electronics**, 500-B Bi-County Blvd., Farmingdale, NY 11735. ■

ADVERTISING INDEX

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PART II: PLL CIRCUITS AND APPLICATIONS

(Continued from page 82)

Adjustable Tone Detector

With the aid of a CMOS PLL, a tone detector may be easily built whose characteristics may be readily tailored. You may wonder about that. If there are IC's that already perform that function, why should we want to build a tone detector with a PLL? The answer is that, for the price, you can't beat the performance. The NE567, with almost the same cost, has a maximum frequency of 0.5 MHz vs 1.3 MHz typical for the CD4046. Very low power consumption and CMOS level swings are other pluses.

Refer to Fig. 14. Whenever the PLL is in lock (tone detected), the pin 1 output is at a logic "1" (except for very narrow negative-going pulses resulting from small differences between the input frequency and the VCO output). The phase-comparator I output at pin 2 is at logic "0," except for narrow positive-going pulses that result for the same reason. Therefore, a logic "0" will be present at the first gate's output, and a logic "1" at the next one. The combination of R4/C3 provide the time constant, thus determining how long the PLL is in lock before its output changes states.

The detected tones can be of any frequency within the PLL's lock range. Since that is dictated by the VCO's range, it can be made as wide or narrow as you wish by merely adjusting the frequency-determining components, R3 and R5. That's also a decided advantage over other types of tone detectors, with bandwidths that are not easily expanded without sacrificing other parameters.

FM Demodulator

So far, we've restricted our applications to circuits using phase-comparator II, because of its several advantages over phase-comparator I. But there is a circuit, the FM demodulator, where the latter does the trick much better. That's mainly because of the higher noise immunity and the fact that for no-signal input, the VCO's frequency will adjust to a center frequency not zero. That last characteristic implies that the VCO control voltage will settle at $V_{DD}/2$.

With a frequency-modulated signal present, the control voltage swings above and below $V_{DD}/2$, following the deviations around the carrier frequency. If those voltage swings are amplified, we've successfully detected the modulation.

Figure 15 shows a demodulator built around the CMOS PLL. The input signal may be capacitively coupled if its amplitude is not within the CMOS logic levels. Of course, if your signal is CMOS-level compatible, then couple it directly, so that you have greater noise immunity and lower power drain. We're not as free to choose the loop-filter component values, since the capture range for phase-comparator I is preset.

Assuming a center frequency f_o = 10 kHz, with no offset resistor and a +/− 400 Hz deviation then:

$$fl = (f_{max} - f_{min})/2$$

The lock range equals the full VCO range. And since our example uses no offset resistor, f_{min} = 0 Hz, and f_{max} = 20 kHz; therefore fl = 10 kHz. (You'll find that whenever the offset resistor is not used fl will be equal to f_o). Calculate the capture range, f_c, set by the low-pass filter elements R1 and C3 using the formula:

$$f_c = \frac{\pm 1}{2\pi}\sqrt{\frac{2\pi fl}{R3 \cdot C2}} = \pm 400 \text{ Hz}$$

The values of 100,000-ohms for R1 and 0.1-μF for C3 satisfy the equation. Finally, having calculated the filter components, adjust R3 so that when pin 9 is shorted to V_{DD}, the VCO's output frequency is 20 kHz, twice the center (or carrier) frequency.

The VCO control voltage is the FM demodulated signal. No loading is tolerated on the filter, so we must take the signal off the demodulator output terminal (pin 10), biased through a 100,000-ohm resistor to ground. With the values in this example, the demodulation gain is about 250 mV/Hz.

Higher gains may be achieved by narrowing the VCO range using offset resistor R3, so that for a given frequency deviation, the control voltage has a larger swing.

By now, you perhaps have realized another benefit when using the PLL as a demodulator: Once the FM signal has been captured, the carrier frequency may change substantially the full VCO range, and the PLL will still be locked, meaning that the it's still demodulating properly. In our example, the carrier frequency may shift upwards to 19.5 kHz before the demodulator ceases to operate. You are certainly familiar with that phenomena in an FM radio equipped with AFC—once a station is tuned in, the selector has to be detuned substantially before the station fades away. ■

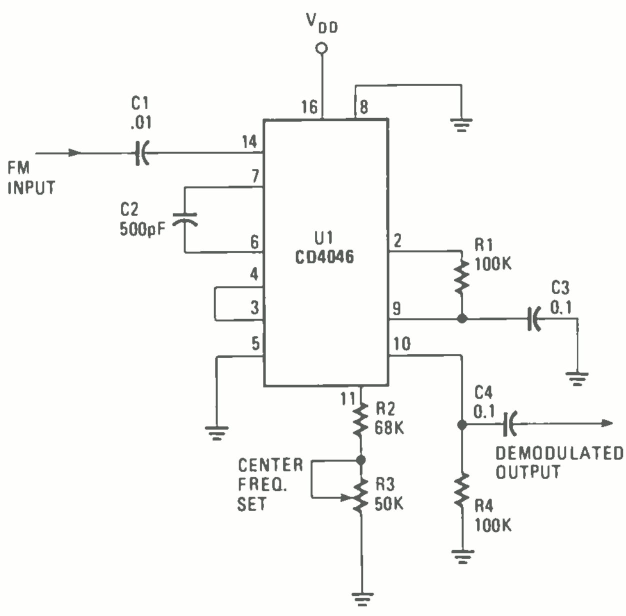

Fig. 15—The input signal to this FM demodulator may be capacitively coupled to the circuit if the input is outside of TTL logic levels.

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- **Covers 100 kHz-30 MHz in 30 bands, with additional coverage from 108-174 MHz (with VC-20 converter installed).**
- **Superior dynamic range.** Exclusive Kenwood DynaMix™ system ensures an honest 102 dB dynamic range. (14 MHz, 500 Hz bandwidth, 50 kHz spacing.)

- **100 memory channels.** Store mode, frequency, antenna selection.
- **Voice synthesizer option.**
- **Computer control option.**
- **Extremely stable, dual digital VFOs.** Accurate to ±10 ppm over a wide temperature range.
- **Kenwood's superb interference reduction.** Optional filters further enhance selectivity. Dual noise blankers built-in.
- **Direct keyboard frequency entry.**
- **Versatile programmable scanning, with center-stop tuning.**
- **Choice of either high or low impedance antenna connections.**
- **Kenwood non-volatile operating system.** Lithium battery backs up memories; all functions remain intact even after lithium cell expires.
- **Power supply built-in.** Optional DCK-2 allows DC operation.
- **Selectable AGC, RF attenuator, record and headphone jacks, dual 24-hour clocks with timer, muting terminals, 120/220/240 VAC operation.**

Optional Accessories:

• VC-20 VHF converter for 108-174 MHz operation • YK-88A-1 6 kHz AM filter • YK-88S 2.4 kHz SSB filter • YK-88SN 1.8 kHz narrow SSB filter • YK-88C 500 Hz CW filter • YK-88CN 270 Hz narrow filter • DCK-2 DC power cable • HS-5, HS-6, HS-7 headphones • MB-430 mobile bracket • SP-430 external speaker • VS-1 voice synthesizer • IF-232C/IC-10 computer interface.

R-2000 150 kHz-30 MHz in 30 bands • All modes • Digital VFOs tune in 50 Hz, 500 Hz, or 5 kHz steps • 10 memory channels • Programmable scanning • Dual 24-hour digital clocks, with timer • 3 built-in IF filters (CW filter optional) • All mode squelch, noise blanker, RF attenuator, AGC switch, S meter • 100/120/220/240 VAC operation • Record, phone jacks • Muting terminals • VC-10 optional VHF converter (118-174 MHz)

Specifications and prices are subject to change without notice or obligation.

More information on the R-5000 and R-2000 is available from Authorized Kenwood Dealers.

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