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1986

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Beginning this issue

ELECTRONICS FUNDAMENTALS

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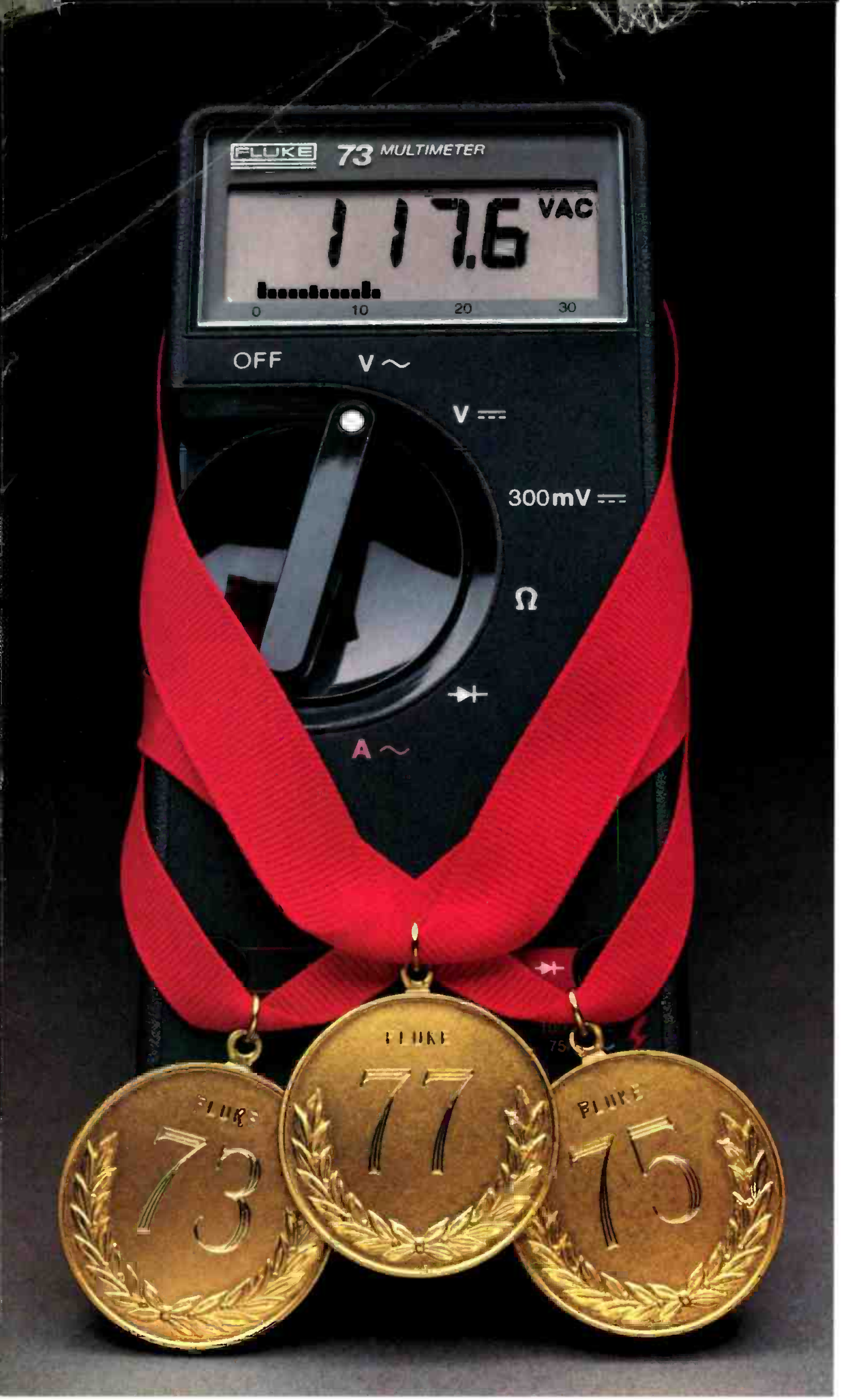
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Hands-on Electronics Volume 3, No. 7 December 1986

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CONSTRUCTION PROJECTS

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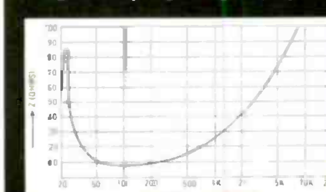

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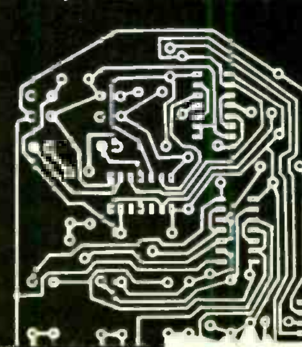

Hands-on Electronics

The Magazine for the Electronics Activist!

Volume 3, No. 7

December 1986

EDITORIAL PAGE

Great things come from great minds!

Our publisher (he's the boss) said, "Put a coupon in the December, 1986 issue of **Hands-on Electronics** offering a free copy of the 1986 Annual Index!" My reply was, "OK, however, who is going to put the Index together?" As he left my office I could hear his bone-chilling laugh in the corridor.

Before you could say, "Staff meeting in the conference room!," I had one. My directive went something like this, "Crew, I've got a great idea! We'll put a coupon in the December 1986 issue of **Hands-on Electronics** which will offer our readers a free copy of our 1986 Annual Index of the magazines' contents." As you can guess, they asked the same question that I did. The second bone-chilling laugh heard in the corridor that day came from me.

So, as you read this editorial some 20 or so shopping days before Christmas bear in mind that:
1. A coupon appears on page 101 of this issue. Follow the instructions on it carefully to get your free index. This is a time-limited offer, so do it today;
2. A group of dedicated editors may have to forgo their plum-pudding party in order to get the Index completed on time;
3. Should you care to thank me personally for the Index, look for me on the white sands of Ft. Lauderdale Beach right after Christmas, and;
4. For you and yours, have a very Merry Christmas and a Happy New Year!

Julian Martin

Julian S(anta) Martin
Editor and beachcomber

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Mates Graphics

Cover photography by
Dan Muro

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Postmaster: Please send address changes to **Hands-On Electronics,** Subscription Dept., P.O. Box 338, Mount Morris, IL 61054-9932.

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.

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.

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.

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: ________________

CIRCLE 14 ON FREE INFORMATION CARD

LETTER BOX

Different Strokes

I found a slight error in the "Auto Ignition Systems" article on page 29 in the July/August 1986 issue of **Hands-on Electronics**. Under the paragraph headed "Give Me A ZAP!," the sixth line down, "needs ready stroke to be driven downward in an exhaust stroke," should be "power stroke!"

Just thought I'd be a little picky! New to your magazine (first home subscription issue) and I enjoy it very much. W.M.B., Spokane, WA

Video Switch

Here are a couple of hints for success in building the "Video Switch" (July/August 1986). First be sure your supply voltage is really 9 volts. Some DC adapters can put out as much as 13 volts under minimum load conditions. Also due to wire types, tightness of turns, and core tolerances, you may have to wind L1 with as many as 11 or 12 turns to get the .15 μH value. J.W.K., Richmond, TX

Thanks for the tips.

Reconciliation

For a while, I felt that the editors of **Hands-on Electronics** had forgotten that there are always newcomers and novices coming up in electronics, as there was so much concentration on computers and advanced circuits, rather than practical basic circuits and ideas. So I was about to let my subscription expire. However, I was impressed by your September/October 1986 copy that arrived just after the announcement of your publication going monthly.

I particularly liked the "TV Wireless FM Mike" page 93–94, which I think is adaptable to the handicapped and hard-of-hearing, who I've been assisting in trying to improve their enjoyment of TV, one of the few things that aged or disabled shut-ins can enjoy.

I hope you will have some articles in the future on home infrared security detectors/systems/innovations. I think most of the wired types are now quite passe under current state-of-the-art developments. H.S., San Luis Obispo, CA

That was one of the project's primary purposes, H.S. As for this publication going bonkers over computers and other advanced circuits of that nature, it'll never happen here. We try to cater to every one from the beginner to those with a good understanding of electronics. Not every issue can cover all bases, but we try.

Chiming In

Regarding your article, the "Musical Madness Machine" (July/August 1986 issue), I'm trying to determine if that circuit might satisfy the requirements of a project that I have in mind. I'm interested in a musical circuit that would play Westminster Chimes, which could be struck 10 to 12 times signifying one of those hours.

Does the "Musical Madness Machine" generate random notes or can the notes be sequenced at a steady tempo. I realize that to expect the full Westminster Chimes on the hour would be impractical, since 8 notes are used in a particular sequence prior to the repetitive hourly chimes. Still, I'm wondering if the hourly chimes could be generated alone. J.C., Pearl River, NY

The "Musical Madness Machine" is probably not the best circuit to try to extract chimes from, J.C. However, the "Musical Doorbell" (based on the music synthesizer chip sold by Radio Shack) appearing in the the November 1986 issue, will do the trick. Not only will that circuit generate Westminster Chimes, but it can be programmed to generate several other tunes, as well. Good luck with your project J.C.

Hearing Saved

My son imagines himself to be a rock musician (debatable), and spends much of his time banging away at his electronic guitar. It's not that I'm against his to enjoying himself; but, after a long day at the office, that noise is not the most pleasing thing to come home to. So when a friend told me about your article on the "Silence Guitar Amplifier" (March/April 1986), I couldn't wait to put it together and shove it into his mit.

Except for finding the integrated amplifier specified, which was eventually replaced with another chip, the project was extremely easy to put together. Needless to say, now going home is a pleasure. I just thought you'd like to know that you've saved my hearing, as well as my sanity. P.R., Tokeland, WA

It's always good to hear from a satisfied reader, P.R. Getting that chip was a problem for many. However, the dual version, the LM1896 (which is available from Jameco Electronics, 1355 Shoreway Rd., Belmont, CA 94002), is a near perfect substitute. Near perfect because to use that chip the board must be modified. We found out too late that the LM1895 had been discontinued.

Anyway, we're glad to hear that the tranquillity of your home has been restored.

You Goofed

In your July/August "Letter Box" column, the ± 9-volt power supply won't work. C1 will charge to about 18 VDC (if is doesn't blow up) and C2 will get no charge. The correct way to handle that is to connect the junction of D1/D2 to the line labeled − 9V and the center tap of the transformer to the center line (ground). R.S., Vallejo, CA

You're absolutely right. The way the power supply is shown, it's almost certain that filter capacitor C1 would go poof and there certainly would be no negative voltage. C2 would receive no charge; it is, in effect, a component without a cause. As shown, the D1/D2 junction becomes the effective ground.

Error in Parts List

I had elected to build the "Sound Sentry" project base on the article by John Cooper, which appeared in your November/December issue. However, I have found two discrepancies that I would like cleared up. First, R9 in the schematic has a value of 2 megohms; while in the Parts List, its value is given as 2000 ohms. The piezoelectric buzzer used as an audio detector seems to be a fixed unit, but the Radio Shack number (273-064) given in the Parts List is for the

(Continued on page 100)

cable tv

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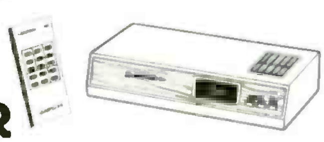

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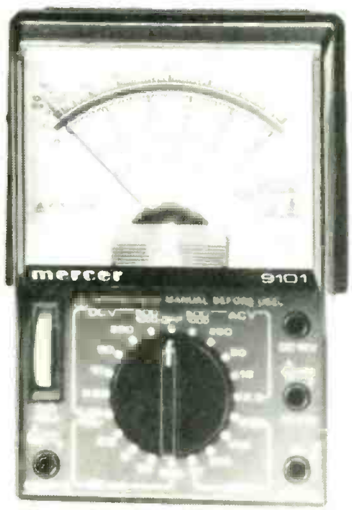
CIRCLE 13 ON FREE INFORMATION CARD

NEW PRODUCTS SHOWCASE

Compact VOM

Mercer Electronics' compact volt-ohm-milliameter, Model 9101) is 5¼" × 3½" × 1½", and weighs only 9 oz. The 9101 has 27 ranges and measures up to 1000-volts DC, 1000-volts AC, 500-milliamperes DC, 100-megohms resistance, and -20 to 56 dB. Sensitivity is 20,000 ohms/volt DC and 8,000 ohms/volt AC. High-energy fusing is provided in addition to standard fusing and diode meter protection. The model 1901 has a single-knob range/function switch with an off position and a color-coded 3-inch mirrored scale



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which provides easy reading. Batteries, test leads and an operator's manual are furnished with this unit. It is priced at $29.

To purchase one or ask questions, write or call Mercer Electronics, Division of Simpson Electric Company, 859 Dundee Avenue, Elgin, IL 60120; 312/697-2265.

PC Software Optical Disk

PC-SIG has introduced a CD-ROM optical laser-read disk. It contains thousands of easily-accessible computer programs for IBM and compatible personal computers.

The CD-ROM disk runs on a laser drive and is the first product of its kind for the PC consumer market. The CD-ROM holds approximately 9,290 software programs that, if purchased separately, would fill 490 disks costing several thousand dollars—more than one-half a gigabyte of data can be stored on a single 4.75-inch optical disk.

The single-disk CD-ROM library features many popular products, such as the

CIRCLE 49 ON FREE INFORMATION CARD

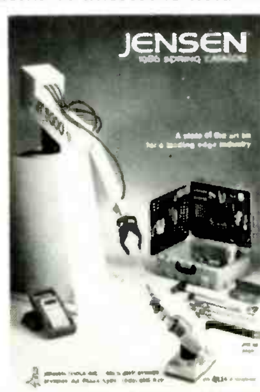
word processing program PC-Write, the relational database management program PC-File, the spreadsheet PC-Calc, and the communications program QModem. PC-SIG's CD-ROM also offers business applications like the Finance Manager and PC-Check Manager, Home Finance Analyst, a number of Lotus 1-2-3 macros and templates, including those used to file federal income taxes, and a variety of accounting packages.

Access to programs on the CD-ROM disk is fast via a variety of simple index options. All program documentation is located on disk.

Available from PC-SIG, the CD-ROM disk is priced at $195. A Hitachi laser drive, controller, cabling and software drivers also are available directly from PC-SIG for less than $1,000. PC-SIG membership, priced at $20 per year, entitles users to software discounts, a yearly subscription to PC-SIG News magazine, and a yearly directory listing the thousands of available programs. PC-SIG, Inc. is located at 1030-D East Duane Avenue, Sunnyvale, Ca. 94086; 408/730-9291.

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,



CIRCLE 50 ON FREE INFORMATION CARD

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.

CIRCLE 48 ON FREE INFORMATION CARD

Communications Microphones

Shure Brothers has added two communications microphones, the Shure 550L Base Station Microphone and the Shure Prologue 6L Hand-held Communications Microphone, to their line.

The 550L is suitable for radio communications, paging, and dispatching system applications. The 550L's omnidirectional cartridge is specially tailored for voice intelligibility, and its balanced, low-impedance design makes it useful for long cable runs and use under severe hum conditions. Retail price is $66.25.

The Shure Prologue 6L is a low-priced hand-held communications microphone. It features a dynamic low-impedance cartridge with tailored response for high in-

telligibility, a sturdy push-to-talk switch, a durable coiled cable, an extra-strength mounting bracket, a relay closure circuit, and compact, lightweight construction. The Prologue 6L's list price is $41.75.

For further information about the Shure 550L and Prologue 6L, write to Shure Bros., Evanston, IL 60202-3696; tel. 312/866-2534.

Catalog of Remote Control Transmitters

The ECG Remote Control cross reference guide lists ECG remote control transmitters and the popular brands they replace. The ECG line includes 71 types which can replace more than 170 original equipment transmitters used with television sets, video cassette recorders, and channel converters. All ECG remote control units are completely new, not rebuilt.

CIRCLE 52 ON FREE INFORMATION CARD

One section of the 26-page guide lists original equipment and transmitter part numbers cross referenced to the equivalent ECG replacement type. Another section cross references equipment model numbers to the appropriate ECG transmitter, and a third section contains side-by-side illustrations of popular brand transmitters and their ECG replacements. ECG remote control transmitters and all other Philips ECG products are available from franchised distributors. To locate the nearest distributor, consult "Electronic Parts & Supplies" in the telephone directory yellow pages or call toll-free 800/225-8326, or in MA. 890-6107.

Slim Speaker System

The Altec Lansing Model 501 is a 3-way acoustic suspension speaker (at a slim 12"W × 13½"D × 46"H) that features two 10" carbon fiber woofers, a 2" polyimide vacuum-deposition titanium midrange, and a 1" tweeter of the same polyimide material.

Specifications for the Model 501 include a frequency response of 28 Hz—22 kHz ± 3 dB; THD from 100 Hz to 22 kHz

CIRCLE 53 ON FREE INFORMATION CARD

is less than 1%; crossover frequencies at 550 Hz and 3.5 KHz; power rating is 150 watts nominal to 300 watts maximum; sensitivity is 93 dB watts/meter; the impedance is 4 ohms.

The suggested retail price for the Altec Lansing Model 501 is $1,500 per pair. Available from quality audio outlets across North America.

Capacitance Meter

Mercer Electronics introduces the Model 9670, a digital capacitance tester that can measure from 0.1-pF to 20,000-µF in 9 ranges with a basic accuracy of 0.5%. Priced at $99.00, the unit features input discharge protection, easy-insert cap-lead jack, and color-coded test leads with alligator clips. The Tester has a 0.5-inch LCD display with over-range and low battery indicators. Weighing in at only ¼-lb., the unit is housed in a flame-retardant plastic case (measuring 6.85" × 3.54" × 1.42").

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The Mercer product line consists of DMM's, digital capacitance testers, digital amp-clamps, and hand-held analog multimeters, available from electronics and electrical distributors nationwide. For more information, contact Mercer Electronics (a Division of Simpson Electric

(Continued on page 12)

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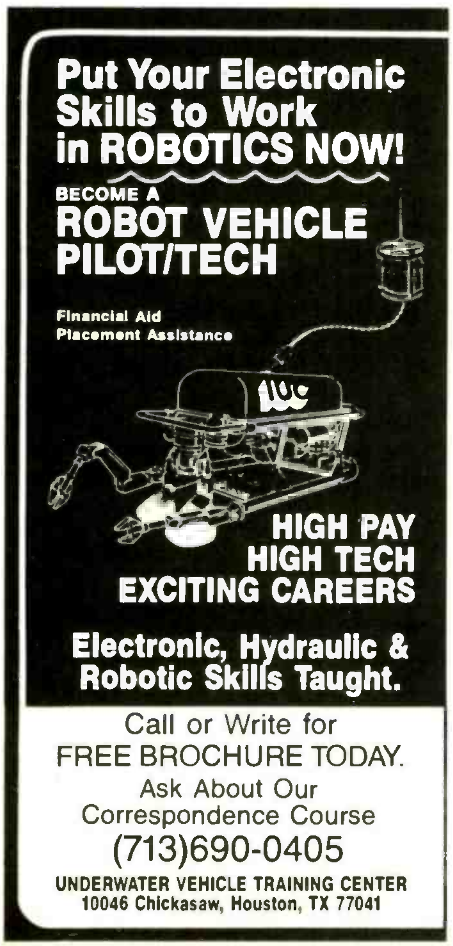

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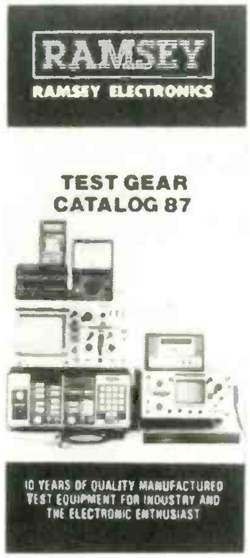


CIRCLE 58 ON FREE INFORMATION CARD

the all new Com 3 service monitor.

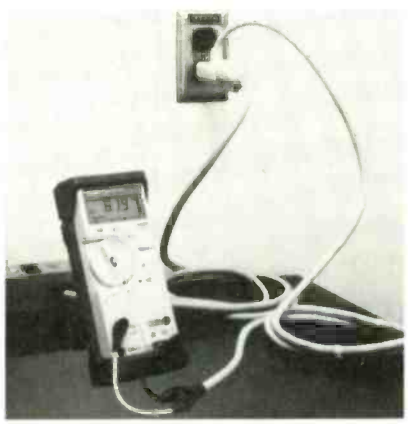
For the satellite television enthusiast there is a section devoted to satellite TV components. Everything from LNB's to receivers can be found. For more information and a free copy of the catalog write to Ramsey Electronics Inc., 2575 Baird Road, Penfield, NY 14526; tel. 716/586-3950.

New Line Current

The Fluke LCA-10 line current adapter provides a simple way to accurately measure the current of a 120-volt AC electrical device.

The LCA-10 resembles an extension cord with shrouded banana plugs on one end. Unlike clamp-on current meters, the LCA-10 does not require separating the wires in an appliance cord or using an adapter to isolate one wire. The LCA-10 plugs directly into a 120-volt AC wall socket; the device being measured plugs into a VOM or DMM that has banana plugs for the meter's 10-amp input.

It can be used for servicing, troubleshooting, energy surveys, engineering, or for determining if 120-volt AC circuits are being overloaded. It can measure normal "on" current (power consumption), "inrush" current (for meters that measure surge current), or "off" current (for stray or standby current such as memory or clock circuits).



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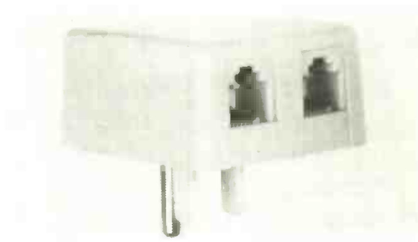
The LCA-10 can handle AC currents to 10-amps continuously, and up to 20-amps for 30 seconds. It is designed for use in the United States, Canada, Japan, Mexico, Taiwan, and other countries using U.S. style plugs. The LCA-10 is ideal for use with appliances, personal computers, office machines, hand tools, heaters, air conditioners, electronic devices, stereos, televisions, lights, and machinery.

The line current adapter is compatible with multimeters that have a 10-amp input and are designed to accept shrouded banana plugs. It has a suggested U.S. list price of $12. It is available through more than 600 distributor locations throughout the U.S., and through Fluke's worldwide sales network. For more information write John Fluke Mfg. Co., Inc., P. O. Box C90090, Everett, WA 98206; 800/426-0361.

Telephone Line Surge Suppressor

The EMF-232 telephone-line surge-suppressor, designed to protect solid state circuitry in telephones, answering machines, and modems, is available from Amperex. The surge-suppressor plugs into any AC power outlet, but uses only the ground terminal and not the AC power line. The jack from the telephone, or other equipment, plugs into one of the modular jacks of the EMF-232, and a cord, supplied with the unit, plugs into the remaining jack. The other end of this cord plugs into the original phone jack and the equipment is then protected against transient voltage surges occurring on the phone lines.



CIRCLE 60 ON FREE INFORMATION CARD

The EMF-232 employs Metal Oxide Varistors (MOV's) to protect solid-state circuitry. The surge suppressor is inconspicuous and relatively inexpensive compared to other protection devices. It is available from all Philips ECG distributors in North America. See "Electronic Parts & Supplies" in the telephone directory yellow pages, or call toll-free 800-225-8326 for the name of the nearest Philips ECG distributor. ■

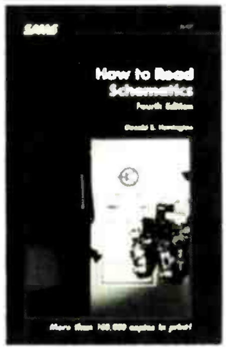
BOOKSHELF

How To Read Schematics
By Donald E. Herrington

To keep up with the latest technology this new edition has been revised and expanded to include the latest electronic developments, along with logic diagrams and flowcharts. Beginning with a general discussion of electronic diagrams, the book systematically covers the components of a circuit: printed capacitors, transformers, electron tubes, resistors and more.

Author Donald E. Herrington has 33 years of experience in Sams' technical book division, which aids in the presentation of electronic circuit diagrams—for the beginner, hobbyist or engineering technician.

This 272 page fourth edition of How to Read Schematics retails for $14.95



(softbound) and is available through bookstores, computer retailers, electronic distributors, or directly from Sams by calling 1/800-428-SAMS, or writing to: Howard W. Sams & Co., 4300 W. 62nd St., Indianapolis, IN 46268.

Understanding Advanced Solid State Electronics
By Don Cannon

No single invention has influenced the electronics industry more than the integrated circuit. Understanding Solid State Electronics covers all the major benefits of IC technology for the experimenter, serious hobbyist, and electronics technician.

This easily-understood, fully-illustrated text provides self-paced instruction beginning with a review of IC technology and logic circuits.

The text includes integrated circuit technology, logic circuits, logic cells and arrays, microprocessors, digital signal processing, graphics processors, communications processors, bit-slice systems, linear integrated circuits,

(Continued on page 18)

BOOKSHELF

(Continued from page 15)

interface integrated circuits, glossary, index, and chapter review questions and answers. Understanding Solid State Electronics is 272 pages in length, is retailing for $14.95, and is available through bookstores, electronics distributors or directly from Sams by calling 1-800/428-SAMS.

24 Silicon-Controlled Rectifier Projects
By Robert J. Traister

A treasure trove of exciting projects using SCR's and other low-cost thyristor devices for power-control applications is found in *24 Silicon-Controlled Rectifier Projects*.

Protect your home and property with a sophisticated burglar alarm system, built for a fraction of the cost of a comparable commercially-made model.

Build your own SCR-based smoke alarm system, a remote-control garage door opener, or even a high tech light dimmer that uses the audio output from your stereo to modulate the intensity of your lights.

And these are just a few of the practical and useful projects you'll find in this one-of-a-kind guide.

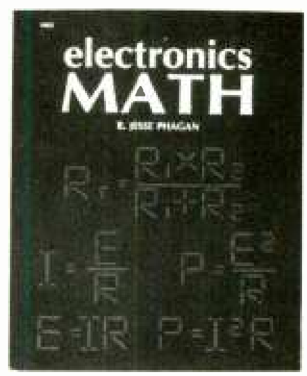
Text is soft covered, 168 pages with 79 illustrations and sells for $9.95. TAB Books Inc., Blue Ridge Summit, PA 17214; or tel. 717/794-2191.

Electronics Math
By R. Jesse Phagan

Any hobbyist or student who finds mathematics frustratingly hard to master, or any technician who's looking for a practical, easy-to-use reference to basic electronics math will find *Electronics Math* useful.

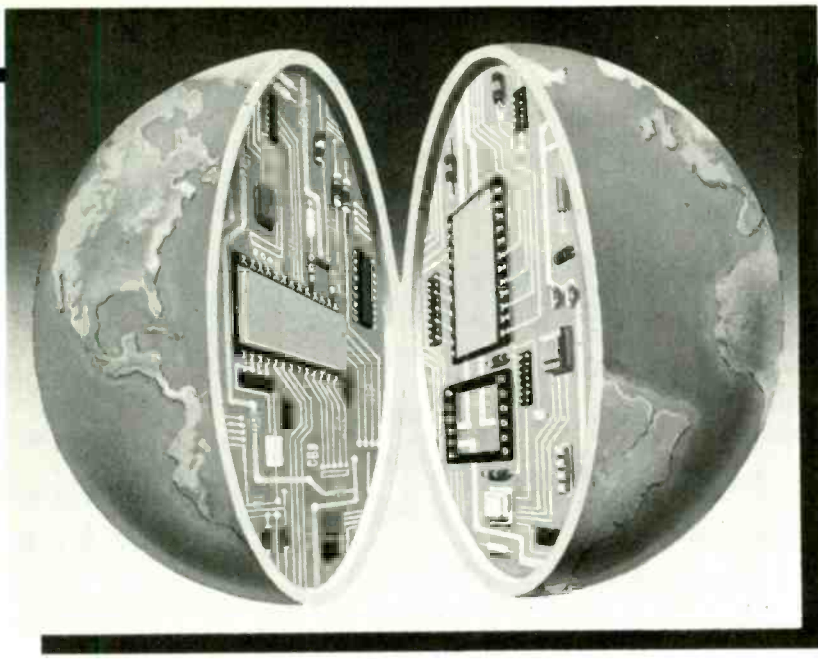
What makes this book different is the basic, useful level of mathematics covered, the sample problems that illustrate step-by-step exactly how each problem is done when working out an electronic design problem, and the clear, concise explanations of each concept with examples of why it's important, and how it's used.

The author avoids the overly theoretical approach used in most other electronics math texts. Instead he leads the reader logically and painlessly from the basics of scientific notation, through the principles of AC and DC circuit math, on into transformers, and inductive and capacitive reactance. Along the way, he introduces the use of the oscilloscope for measuring phase shift, the theory and applications of time constants used in R-L circuits, even a comprehensive short course in understanding power supplies and how to measure them.



Making use of numerous illustrations and writing in clear, readable style, the author provides a wealth of practice problems which help the reader easily, and almost painlessly, acquire all the electronics math skills needed to move forward in his electronics practice.

The text has 265 pages, 247 illustrations, paperback bound, and sells for $15.95. For more information write to TAB Books, Blue Ridge Summit, PA 17214; tel. 717/794-2191. ■



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CIRCLE 7 ON FREE INFORMATION CARD

By Byron G. Wels

WELS' THINK TANK

On phones and other things!

IF YOU'RE THE SORT OF READER WHO likes to get the most for his money, and reads every word in the magazine, you may have noticed that **Hands-On Electronics** is a Gernsback Publication. Our parent company, Gernsback Publications, also publishes *Radio-Electronics Magazine*, *ComputerDigest Magazine*, and others. Hugo Gernsback, the founder of the company, used to write a special article each April, which was the annual "April Fool" issue. Those articles were recently assembled into a 76-page book. Mr. Gernsback was a skilled *wordsmith* with a deep knowledge of electronics, and those articles were so convincing that many people actually tried to construct the devices!

If you're into electronic circuits, I strongly urge that you send in a check or money order for $12.00 plus $2.75 shipping, and we'll send you your copy of those classics. I *know* that you'll enjoy them.

We've got a goodly assortment of schematics to offer this month, and we hope you're saving them from month-to-month because sure as shootin', the minute you toss an issue away, you're going to find a use for one of the circuits and wonder where you saw it! So let's get to this month's problems and see what we can do about them.

Telephone Spy

"I'm not really a monster" writes J.B., of Corpus Christi, TX, "but I do feel I have the right to hear what my kids are talking about when they're whispering into the phone."

J.B., we won't make any moral judgement—it's not our place. What you want is called a Telephone Bug, and you'll find a suitable schematic in Fig. 1.

Break one side of the phone line at any convenient point, and connect the two broken ends at the input across R1, which effectively completes the telephone circuit. The four diodes in a bridge configuration produce a varying DC voltage according to the audio signals on the line. That serves as a supply for the common-emitter Colpitts oscillator, Q1, a 2N5179. The tuned circuit for the oscillator is formed by C2, C3 and L2.

Construction isn't critical and you can mount the components on a piece of perfboard with wirewrap connections.

The best place to install the circuit is at the block where the telephone lines enter the house. To test the unit, use an ordinary FM receiver and have somebody make a call and stay on the line talking while you listen to the radio. You should be able to pick up the signals at about 95 MHz on the dial. It does, of course, have a limited range (in order to comply with FCC requirements), so start out rather close to the Bug.

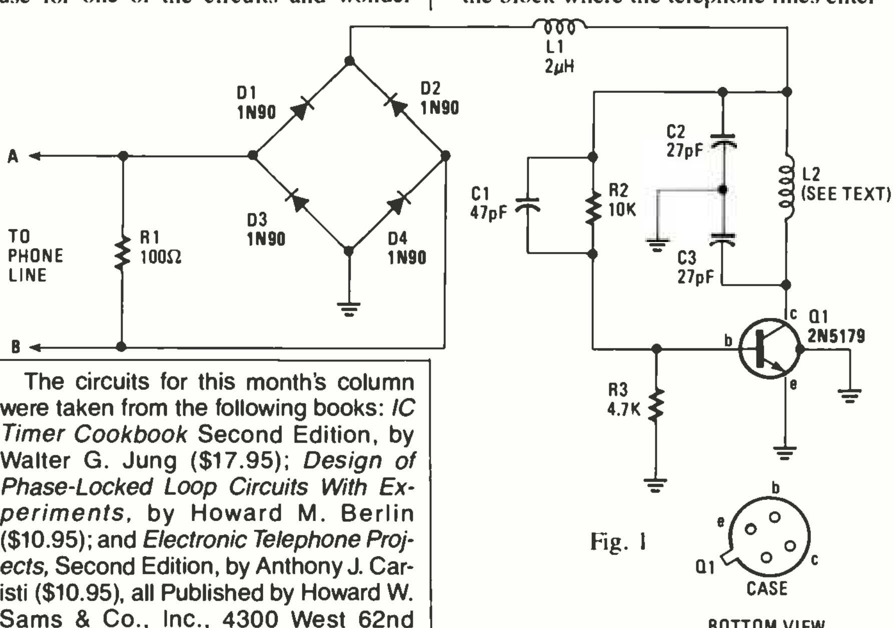


Fig. 1

The circuits for this month's column were taken from the following books: *IC Timer Cookbook* Second Edition, by Walter G. Jung ($17.95); *Design of Phase-Locked Loop Circuits With Experiments*, by Howard M. Berlin ($10.95); and *Electronic Telephone Projects*, Second Edition, by Anthony J. Caristi ($10.95), all Published by Howard W. Sams & Co., Inc., 4300 West 62nd Street, Indianapolis, IN 46268. Call 1-800-428-SAMS to order.

The Phone is Lit

R.L., of Boston, MA writes that he works in a very noisy environment. As a result, he and his coworkers are required to use ear protection. That's fine, except that they are unable to hear the telephones ringing. The phone company installed larger bells, but that still didn't help.

Well, R.L. the circuit in Fig. 2 will solve your problem. That schematic diagram is quickly and easily converted to a working circuit and connected to your telephone lines. Then when the phone does ring, you'll know it—for the lamp you've plugged into the unit will go on with each ring of the phone! The triac is triggered into conduction by a signal applied to its gate (G) through a bilateral switch (diac), D2. As you can see, the triac acts as a switch, conducting only when a signal is present at the gate. We do want total isolation from the phone lines: That is accomplished with the optoisolator, consisting of an LED and a photocell. You can purchase such devices at electronics stores, or easily make your own by mounting a photocell and an LED in a suitable enclosure.

Construction isn't critical, although an etched circuit board is suggested. Use an ordinary line cord and plug for the 117 VAC connection, and a chassis-mounted receptacle for the lamp. The unit will work with any lamp up to 100 watts.

PLL/BC Receiver

K.S., of Waukesha, WI, writes to ask if there's such a thing as a phase-locked loop broadcast receiver. Actually, there is and while it took a bit of doing to find one, we were able to turn it up and it's a very-interesting circuit indeed! Figure 3 shows the schematic diagram, and this simple AM circuit uses a 561B. You'll notice first of all, that there's no inductance/capaci-

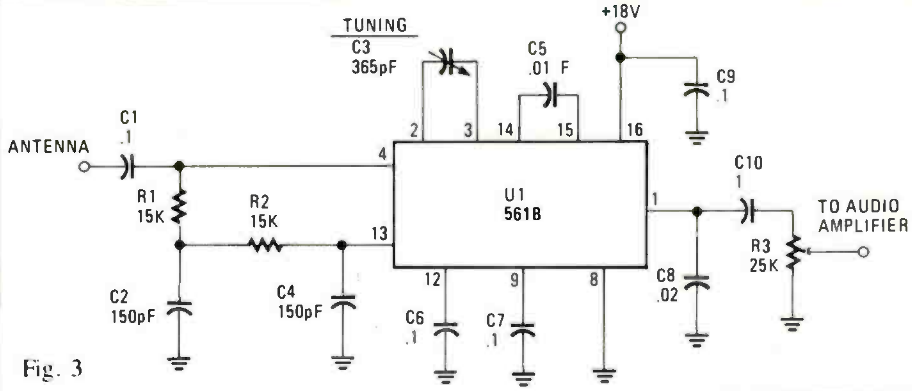


Fig. 3

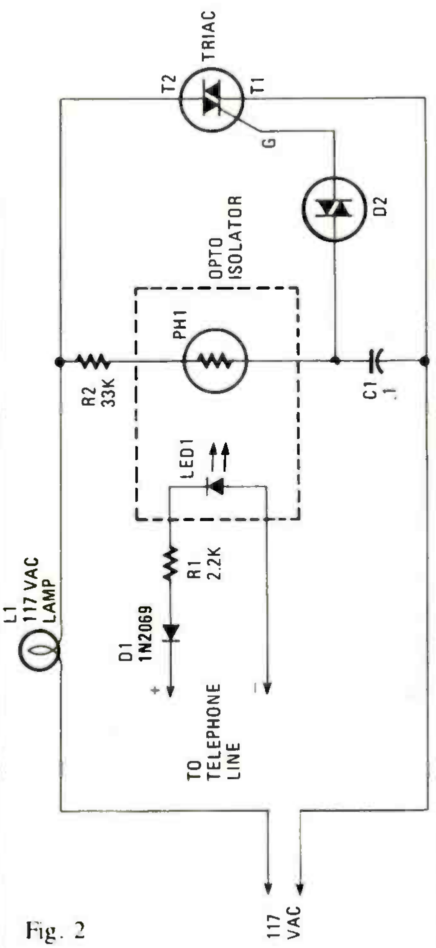


Fig. 2

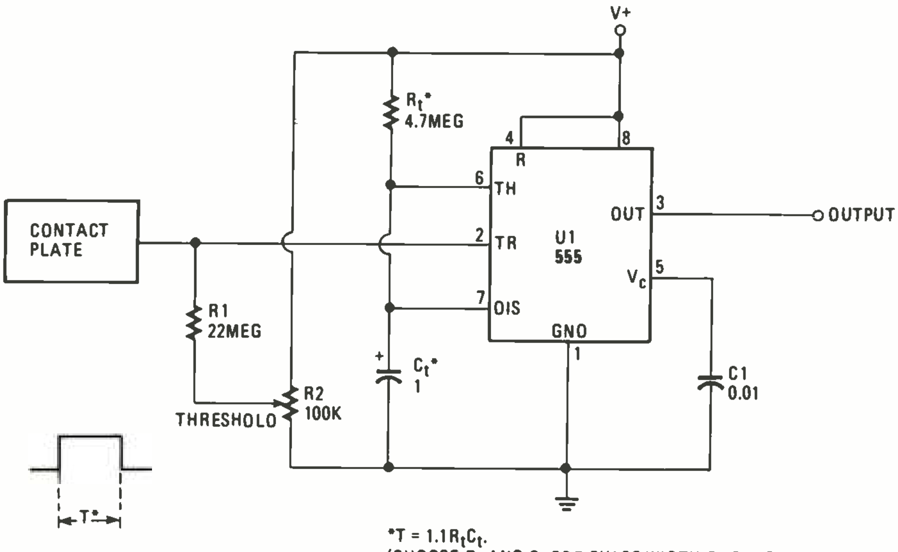
tance tuning circuit. The 365-pF capacitor connected between pins 2 and 3 does all the tuning.

You'll need a good outside antenna and a solid ground. And if you don't have enough signal, you're going to get a *swishing* sound. You'll also want an insulated shaft on the tuning capacitor to help eliminate stray hand capacitance. And if you want to further improve operation, stick a broadband amplifier in front of the receiver and you'll jack up the sensitivity considerably. Just make sure the input voltage doesn't climb over 0.5-volt rms.

Touch Switch

"Many, many years ago," writes L.T., of Lubbock, TX, "I built a touch switch using an old radio tube. I was just wondering if you could find a similar circuit with modern components?" Sure can, L.T.! Look at Figure 4. As you'll see, we're accomplishing a switching action with no mechanical switching involved, as there would be with switches or relays. That makes it handy for use where electrical switching has to take place in a hazardous environment.

With the THRESHOLD control R2 adjusted so the voltage at pin 2 of the 555 is held above ⅓ volt, the circuit remains in a low-output state. But touch the contact



*T = $1.1R_tC_t$.
(CHOOSE R_t AND C_t FOR PULSE WIDTH GREATER THAN ANTICIPATED CONTACT TIME.)

Fig. 4

plate (any conductive material set-up for finger contact) and the signal pickup between pin 2 and ground is enough to exceed the threshold. That triggers the timer, which times out to produce an output pulsewidth (t = 1.1RC). With the values indicated in the schematic for R_t and C_t, the time constant will run about 5 seconds. The running time can be changed by altering the values of R_t and C_t.

One-Minute Timer

We got a rather mysterious letter from B.J., of Miami, FL. Usually, readers who write in will give us some indication of the application to which a circuit will be put. That usually helps us in deciding between one or another of the possibilities. But perhaps B.J. was in a rush. All his letter said, was "One-Minute Timer."

Okay, B.J., check out Fig. 5. While the 7555 can be used for extended-period timing, high-value capacitors and resistors are often called for, and they can be quite costly and hard to get. Use a 10-µF film capacitor for C2, and you should have no real problem.

Assemble the unit carefully on a piece of perfboard with wirewrap connectors.

Time-Delay Relay Driver

A letter from C.D., of Norwalk, CT, explains that he is interested in sequentially powering-up separate circuits. He therefore needs a time delay to operate a relay. Well, C.D., the solution to your problem appears in Fig. 6. Connect your primary power to a double-pole, single-throw switch. One side of the switch will be used to apply power to the primary circuit instantly. The other side of the switch applies power to the circuit in Fig. 6. While you did not specify a delay time, the components shown will deliver a delay of about 11 seconds. By varying the values of R1 and C1, you can vary the delay time. Apply the old TC = 1.1RC formula.

The 555 timer will deliver voltage to the relay after the delay period, enabling the relay contacts to close. The relay used here is a Potter & Brumfield KHP, KUP or equivalent series, rated 12-volts at 80 mA.

Depending on how elaborate a system you intend to create, the unit is not critical and can be wired up on any convenient piece of breadboard you have handy.

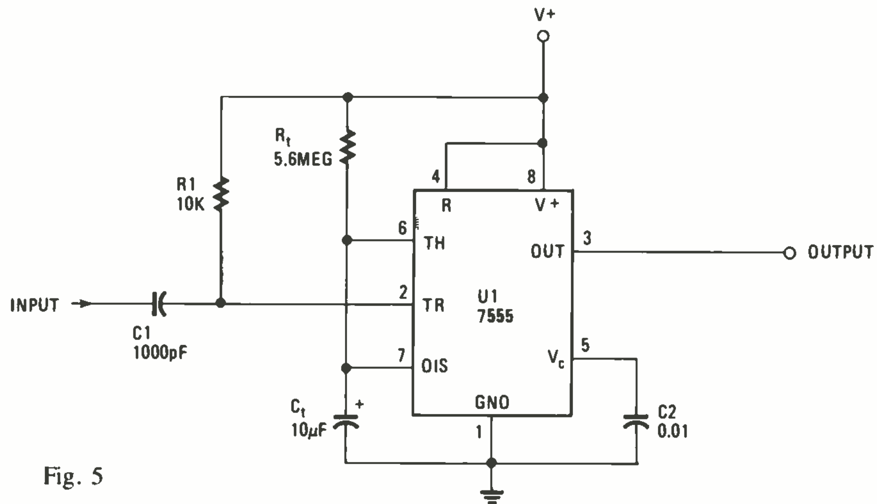
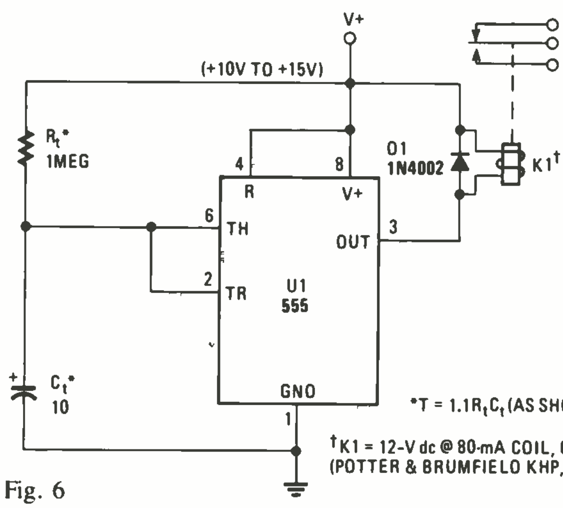


Fig. 5



*T = $1.1R_tC_t$ (AS SHOWN, T = 11 s.)

†K1 = 12-V dc @ 80-mA COIL, CONTACTS TO SUIT.
(POTTER & BRUMFIELD KHP, KUP SERIES OR EQUIVALENT.)

Fig. 6

Water Detector

"My basement is fitted with a sump pump and sump pit," writes R.J., of Atlanta, GA. "I've got a feeling that when the water rises and the pump starts, I'm not getting sufficient action. I'm afraid that when the rains really come, I'm going to find out—too late—that I should have installed a larger pump. Anyway, I'd like a small alarm system to let me know when the water reaches a given level so I can go down there and check things out."

Gotcha, R.J. Check out Fig. 7. I think that circuit is exactly what you need. The electrodes are placed at the level in the pit at which you want the signal to be given. For dry conditions, R1 and R2 bias the 555's inputs to a high level, thereby holding the output low. But let water bridge the

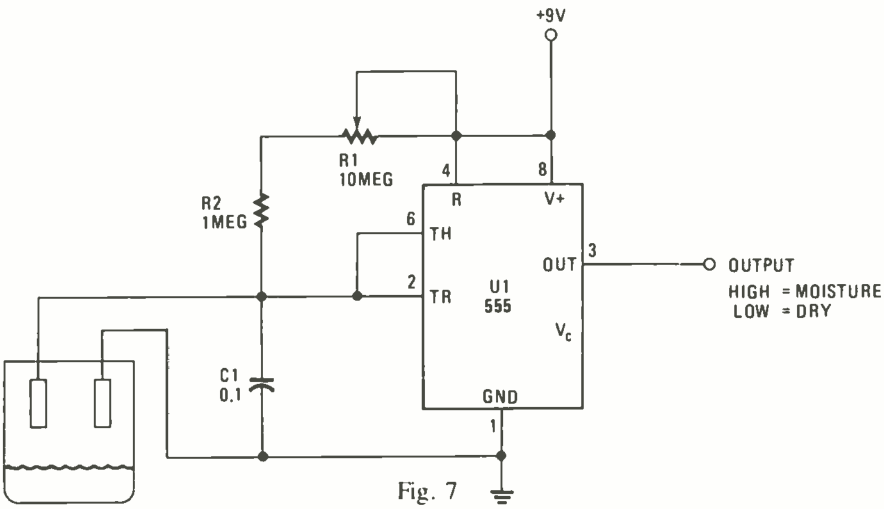


Fig. 7

electrodes, and you get a conducting path lowering the input to ⅓ volt plus the threshold. That, in turn, forces the pin 3 output high, triggering your alarm. Adjust the value of R1 to suit the conditions, and C1 is used to block out any noise conditions. Incidently, substitute the 555 with a 7555 and a battery supply, and you can use the unit continuously.

3-Way Lamp

"A friend," writes P.L. of Boca Raton, FL, "showed me a lamp he says he built that has *three speeds*." In the first switch position it's off; in the second, only half bright, and in the third, it's fully bright. Now I've seen 3-way lamps before, but this guy is using a *single, 60-watt lamp!* Now how is he doing that? Did he get a 3-way lamp that's mis-marked?"

No, P.L. It's really simple, and you can do it, too. See Figure 8. Use a three-position switch and any diode with a peak-inverse voltage rating (PIV) of 200 volts or better. As you can see, in the first position, the electricity is cut off. In the second, the applied voltage goes through the diode, which provides half-wave rectification. In the last position, the diode is out of the circuit so the full voltage is applied to the lamp. There are some things you ought to know: In the first place, while the voltage is half-wave rectified, it isn't really cut in half. About two-thirds or so of the voltage is applied to the lamp through the diode. Still that reduces the brightness appreciably. Also, by applying so little of the rated voltage to the lamp, the filament will last a good deal longer as well.

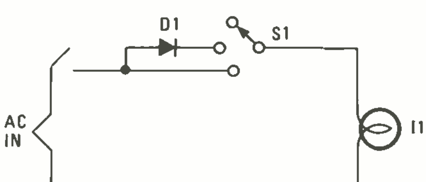


Fig. 8

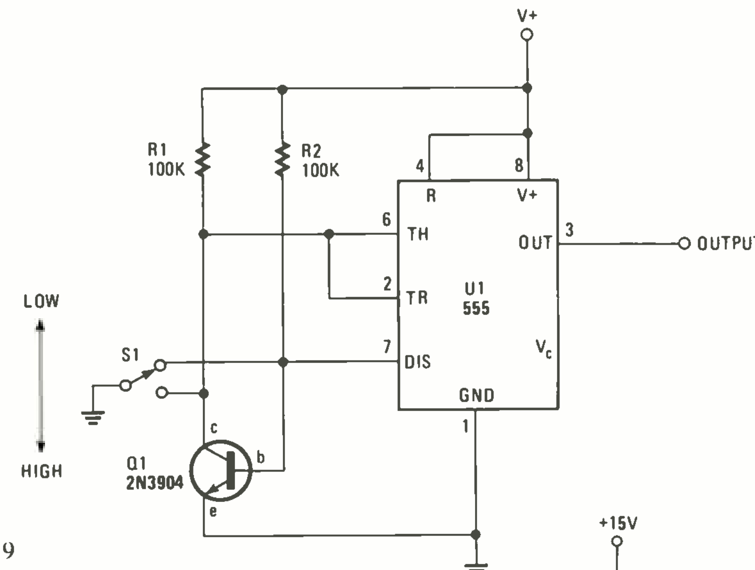


Fig. 9

Debouncer

T.M., of Baltimore, MD, writes to say "I'm an old hand at electronics, and go back to the old vacuum tube days. Now that I've retired, I thought I might renew my interests. But I was surprised to find that things have changed drastically. I have to learn all over again, and you've been nominated to help me. Now what, exactly is a debouncer?"

T.M., as you can imagine, one of the changes is that things have speeded-up tremendously! Maybe in the lethargic vacuum tube days, when you closed a switch it closed. Period. But as I said, things have speeded up. We know now that when a mechanical switch closes, it *bounces*, generating noise. If you'll look at Fig. 9, you'll see how we clean things up.

Using a simple 555 timer, we use S1 (a SPST toggle switch) to manually program low or high output logic levels. The 555 is operated as a low-input state sensitive latch using transistor Q1 as an inverter to provide overall positive feedback. A low at either switch contact forces that input to remain at the low level due to regeneration. The pin-3 output offers a buffered high-current source for both high and low logic states. Neither R1 nor R2 are critical, and you can use any npn transistor.

LED Flasher

G.Z., of East Orange, NJ, writes to ask about LED flashing circuits. The circuit shown in Figure 10 is a simple one. You can vary the value of resistor R_t to set up the desired forward current. The unit will light the LED when the 555 output is high. Use the dotted part of the circuit if you prefer to have the LED come on when the output is low, and if you'd like alternately-flashing LED's, use *both!*

Well, we've simply run out of space for this month. It's really difficult, for we could continue almost indefinitely! Rest assured that when you write to us for information, each and every letter gets a rapid and personal answer, the most-interesting are used in the magazine. So let's hear from you! Write to Byron G. Wels, **Hands-On Electronics** Magazine, 500-B Bi-county Blvd., Farmingdale, NY 11735. ■

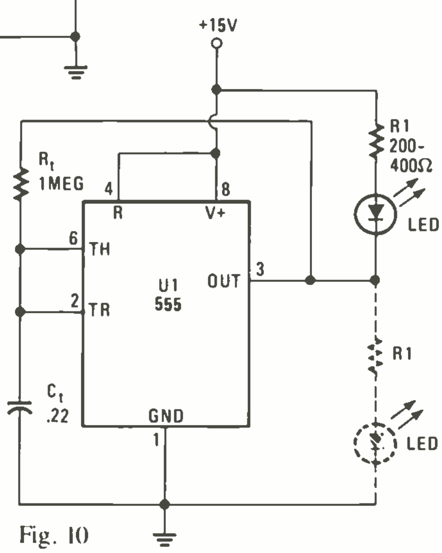


Fig. 10

CHOOSING THE RIGHT PRINTER

If you're in the market for a printer, it's wise to find out what model will best be able to handle your printing needs.

By Jeff Holtzman* and Marc Stern

YOU'VE FINALLY TAKEN THE PLUNGE AND BOUGHT A computer in order to keep pace with your competitors, but you find that you really need to make hard-copy printouts. Or, perhaps you're a student working on your term paper: *cranking it out* on a word processor gives you a chance to turn in a much better looking document than if you had *punched it out* on a typewriter. Not only that, but the typing time you save, as well as the ease of editing afforded by a word-processing program, allows you to turn in a better organized paper. Even if you have a faithful dot-matrix printer, the one that has been pouring out page after page for years, it may not measure up anymore. It may be too slow, the print quality may be poor, or it may be simply worn out. Whatever your reason or need be, you need a printer.

But if you've looked into buying your first printer or a replacement, you've surely realized how easy it is to be overwhelmed by the range of choices—print quality and speed, sound (noise!) output, type of interface, price, etc.

*Assistant Technical Editor, Radio-Electronics Magazine

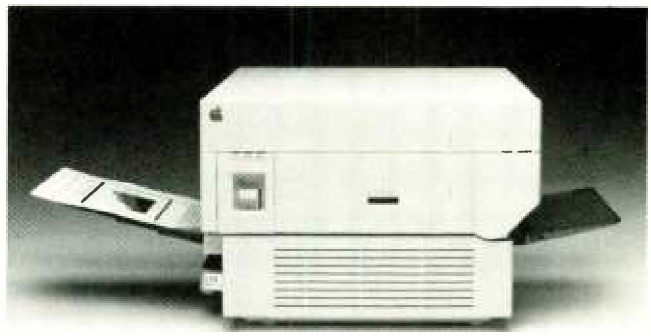
Not to forget that today there are more printer manufacturers competing than you would have imagined possible. Even printers previously used with low-cost computers or copying machines have a place in the market, due to improvments in technology. For example, thermal printers have gained respectability because of such changes. Of course, each manufacturer makes its own claims and each shouts that it is the best, so how can you make an intelligent decision as to which printer is best for you?

Printer Overview

There are many, many different types of printers, but they can be generally categorized as laser, solid-character, and dot-matrix printers. The output may be printed, drawn, blown, melted, or lasered onto paper. We'll briefly discuss laser printers, and then go on to examine several examples of each of the other two types.

Let's begin with the highest quality (read that "most expensive") type, the laser printer. The laser printer represents a marriage between copier and printer technology. Its output rivals that of a typesetting machine (like that which produced this magazine). A laser printer takes a page of information at a time from storage, and it writes with minute bursts of light which appear as small dots on the paper (see Fig. 1). In fact, 300-dots per inch is not uncommon, and that is three to five times what typical dot-matrix printers can produce, as we'll soon see. Typical laser printers can print six to eight pages per minute, which can be six to eight times as fast as a slow Daisy-wheel printer. In addition, with the right software, a laser printer can print truly professional-looking graphics.

Those features may excite you; but, for the student, the main disadvantage of a laser printer is its price. Laser printers currently cost between two and five thousand dollars. They are available from Canon, Hewlett-Packard, Xerox, NEC, and others.



Laser printers produce quality hard copies rivaling that of typesetting machines at speeds 6 to 8 times faster than a Daisy-wheel. And with the right software, they can print graphics like those used in newsletters and newspapers.

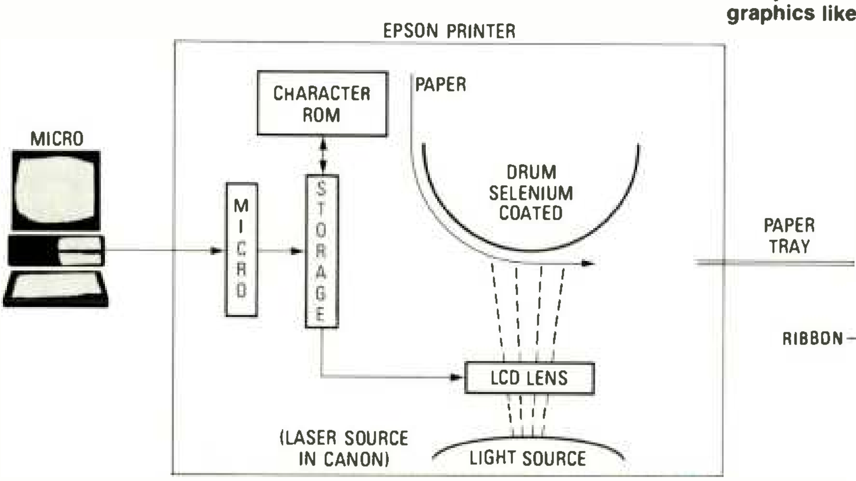


Fig. 1—A laser printer takes a full page of information and burns it into the paper as a series of tiny dots. That method forms newspaper/magazine quality type similar to this.

Daisy-wheel and Thimble Printers

One notch down, in terms of print quality, are the Daisy-wheel and thimble printers. Of the types of printers discussed here, only they produce a solid character; all other types compose characters from separate dots. Daisy-wheel and thimble printers are very similar in price and features, so we'll talk about Daisy-wheel printers only; but keep in mind that unless specified otherwise, we're referring to both types.

A Daisy-wheel resembles a miniature bicycle wheel without a rim. A print thimble resembles a small plastic cup whose sides have been slit. The *spokes* of a Daisy-wheel and the *slats* of a print thimble are formed of plastic. At the ends of the spokes (or slats) letters, numerals, and symbols are formed, usually from the same plastic as the spokes (or slats). But to provide longer life, some Daisy-wheels and print thimbles have metal characters.

Daisy-wheels attach vertically to a mechanism that rotates the wheel (thimble) (see Fig. 2), on instructions from the printer's hardware, so that the proper character is in position to be struck by a small hammer. The end of the spoke strikes a ribbon, and that produces an impression on a sheet of paper. Print thimbles attach horizontally to a rotating mechanism; otherwise its operation is similar to the Daisy-wheel type.

Most printer manufacturers supply Daisy-wheels and print thimbles in a variety of type styles and pitches. You can buy print wheels in italic and other type faces (fonts), or with special mathematical symbols, and even complete foreign-language character sets. Ten (pica), twelve (elite), and 15 (microtype) characters per inch are the most common pitches.

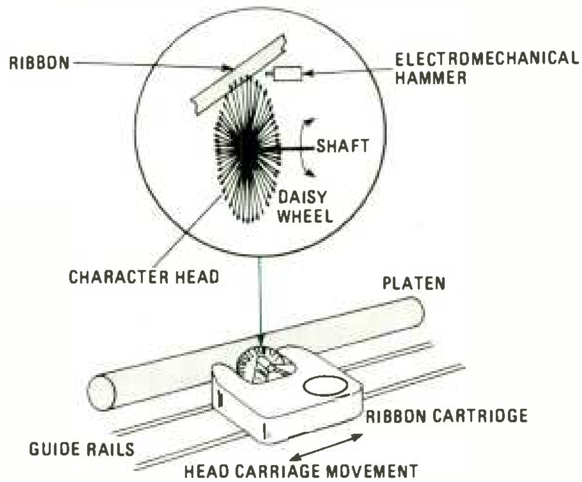
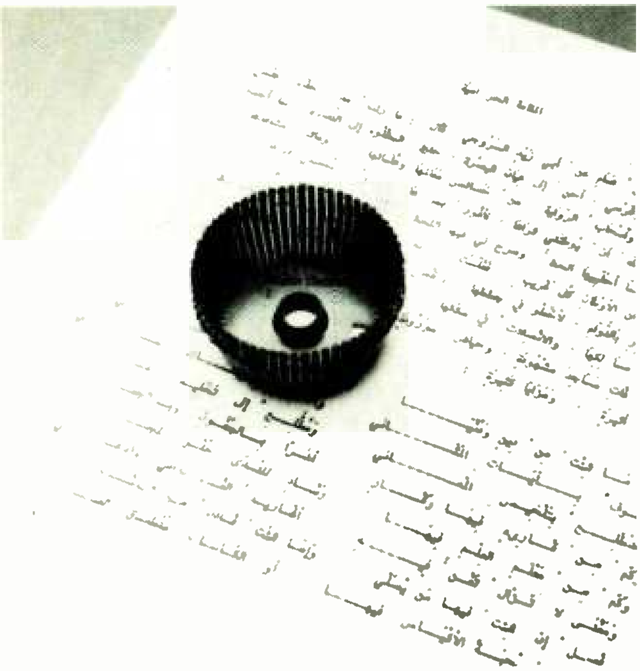


Fig. 2—With a Daisy-wheel printer, a small hammer strikes a "flower petal" containing a character against the ribbon.

Many Daisy-wheel or thimble printers also feature bidirectional, logic-seeking printing, proportional spacing, underlining, and boldface. Some are capable of minimal graphics, and some can even be used both as a typewriter and as a printer. However, even bidirectional daisies are slow, printing only 12 to 20 characters per second (cps).

Market prices of Daisy-wheel and thimble printers range from as little as $200 to as much as several thousand dollars for the higher speed units. More expensive models are very ruggedly built, may have internal logic to accomplish word-processing functions, and can print three or more times faster than the inexpensive models.

Alternatively, you can buy one of several typewriters offered by Brother, Panasonic, or Canon, and, with the proper interface, turn the typewriter into a slow-speed Daisy-wheel printer. Usually portables, those machines run from $200 to $300. What has made this possible? It's like everything else: competition, technology, and the decreasing cost of more powerful microchips.



Thimble printers have cup-shaped printheads, that look as if they have been slit to form spokes or slats. There is a solid-character type at the end of each spoke which forms the letters. The thimble is rotated so that the desired character is over the paper and then a hammer strikes the printhead.

Daisy-wheel and thimble printers, which produce letter-quality hard copies, can be found selling for as little as $350. But because the wheel or thimble must be rotated mechanically and struck by a hammer, they are very slow.

Dot-matrix Printers

There are four basic types of dot-matrix printers: impact, thermal, ink-jet and penwriter. Each type has its advantages and disadvantages; no one type is inherently better than another. What they share in common is that their characters are formed from a matrix of dots. The absolute minimum matrix size, as shown in Fig. 3, is 7 (high) × 5 (wide) dots. You may find used equipment with that minimum matrix, (especially relatively old Teletype machines); but the vast majority of printers currently in production use a matrix size of at least 7 × 9, and some matrices are much denser than that. Epson's FX-286 for example, prints characters in a 9 × 9 matrix.

Some dot-matrix printers have a printhead that contains two rows of hammers (see Fig. 4). For example, the hammers

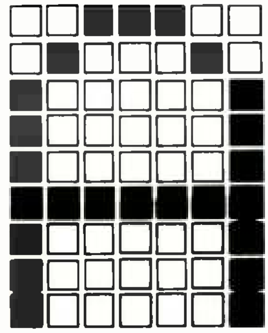


Fig. 3—There are four basic types of dot-matrix printers—impact, thermal, penwriter, and ink-jet—all of which form characters from a matrix of dots. Most matrix-type printers print in two modes: draft mode, and a near-letter quality (NLQ).

in NEC Information System's P6 and P7 printers are arranged in two vertical columns of 12 hammers each. The extra row of hammers produce characters that are very close to those produced by a solid-character printer. Some other printers use a slightly smaller matrix (7 × 9), but print the same line of data several times, offsetting the paper by some small fraction of an inch between passes. Still there are other printers that combine the two techniques.

Most matrix-type printers print in two modes: One, usually referred to as the draft mode, is useful for printing drafts of documents, and program listings. When a document is finalized, it can then be printed in the high-quality correspondence mode, or NLQ (*Near-Letter-Quality*) mode as it is referred to by various manufacturers.

Another important factor is pitch. Most recently manufactured matrix printers can print in more than one pitch: 10, 12, and 17.1 cpi (*characters per inch*) are the most common. Therefore, you can print 85 columns on standard 8½" wide paper at 10 cpi, 102 at 12 cpi, and 145 at 17.1 cpi. Characters printed at the smallest pitch may be rather hard to read, but for printing spreadsheets and other multi-column data, that may not be a disadvantage.

A useful feature of current matrix printers is the ability to print graphic images. In the graphics mode, common dot-matrix printers can print about 100 dpi (*dots per inch*)—a third of that obtainable using a laser printer. Also platen width must be considered: Most small dot-matrix printers can only print in an 8½-inch wide space. That's not wide enough for business-size envelopes.

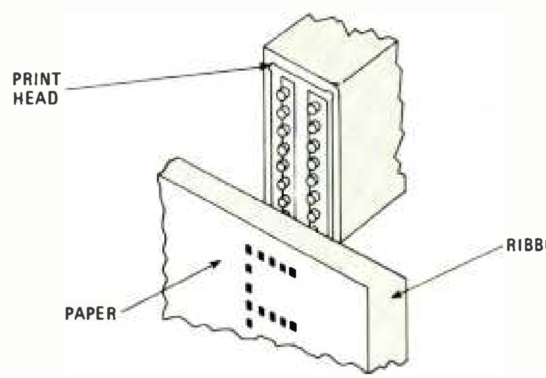


Fig. 4—Solenoid-actuated pins produce the tiny dots that form the characters in an impact-type dot-matrix printer.

Making Dots

Different kinds of dot-matrix printers get their dots on paper in very different ways. All of the matrix printers mentioned so far are of the impact type, which, as their name suggests, produce dots by the action of a group of solenoid-driven hammers striking a ribbon. Software determines the pattern of firing that will be used to create the letter. Ultimately, dot-matrix print quality depends on the density of the hammers in the printhead and the level of software sophistication, which have improved to the point where they allow near letter-quality printing in even the least expensive printer. They have several advantages including the ability to have more than one typestyle, addressable graphics, and bidirectional logic-seeking. The bidirectional logic-seeking feature allows the printhead to take the shortest path between letters; and that speeds up printing.

But there are several other ways of forming characters and graphic images on a piece of paper. For example, the *thermal* printer literally burns its dots into specially-treated paper, the ink-jet printer sprays its dots on paper, and the penwriter draws its dots. What are the practical differences between the various types of dot-matrix printers?

Some printers, like this Twinriter 5 by Brother, can be used both as a printer and a typewriter for convenience's sake.

The Thermal Printer

Thermal transfer printers at one time were looked on as the low-cost alternative for inexpensive systems. Although they were quiet and quick, they required special paper that quickly became discolored; and the print was hardly draft quality, let alone letter-quality. Today, thermal transfer printers are not only quiet, but offer some of the best print quality on the market.

Like impact printers, thermal printers rely on multi-wire printheads. However, instead of forcing a ribbon against a piece of paper to form the letter, the thermal printer relies on heat. Looking more closely we see that the microprocessor-controlled printhead pierces a ribbon as the paper beneath passes over a heater bar. Using a plastic ribbon, the dots that are created by the printer are melted onto the paper and they form the letters.

That those printers are capable of high-quality print is easily seen from the fact that the printers have 36 to 40-wire printheads. Since there are so many, and because they are so fine, they can be lined up so that the dot pattern slightly overlaps (dithering), and the letters look as if they were created with a Daisy-wheel machine. Typewriter-printers, such as the $200 to $300 Canon Typestar series, are prime examples of that type of printer.

A variation of the method is found in the IBM Quietwriter I and Quietwriter II. Like the Typestar, it is a thermal-transfer printer, but instead of using a heater bar, the Quietwriter uses a special ribbon (see Fig. 5) which, when combined with current from the printhead; places the letters on paper. The result is print quality that is indistinguishable from Daisy-wheel machines. The Quietwriter strikes the first layer of a multilayed ribbon with the pins of its dot-matrix printhead, the pins then drive through to a resistive layer and a tiny current is applied through the wire. That current creates heat which melts a special layer containing ink; ink is thus deposited on paper, where it dries instantly. The result is high-quality print from a thermal dot-matrix device. Although the Quietwriter II is graphics-capable you must be prepared to lay out about $1,395 whereas the Quietwriter I costs about $1,000 (not to mention $11 for short-lived ribbons).

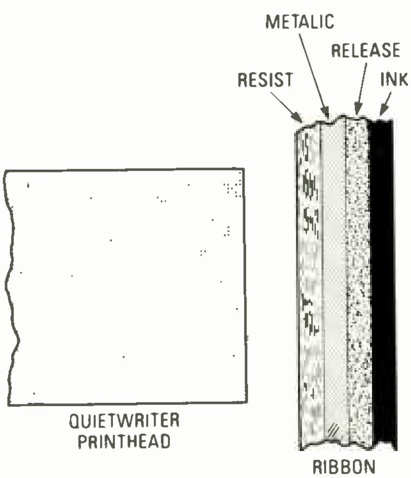


Fig. 5—A thermal transfer or thermal printer depends on heat to create print. In the IBM thermal printer, a special plastic ribbon is melted by current to create the characters.

The Ink-jet Printer

Another matrix machine is the ink-jet printer. Rather than relying on solenoids or a Daisy-wheel, the special printhead actually sprays a fine series of ink dots that are created by ink held in a special reservoir. In the microcomputer world, the drop-on-demand ink-jet printer is the dominant printer of its type. In that system (see Fig. 6) a small droplet of ink is held at the mouth of one of the ink jets. When it is needed, a small piezoelectric device fires and forces the droplet out of the ink-jet printhead.

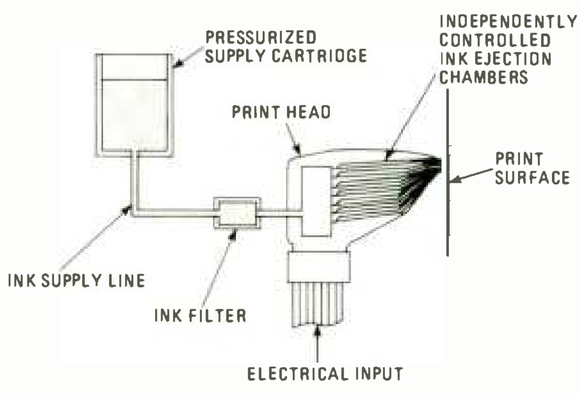
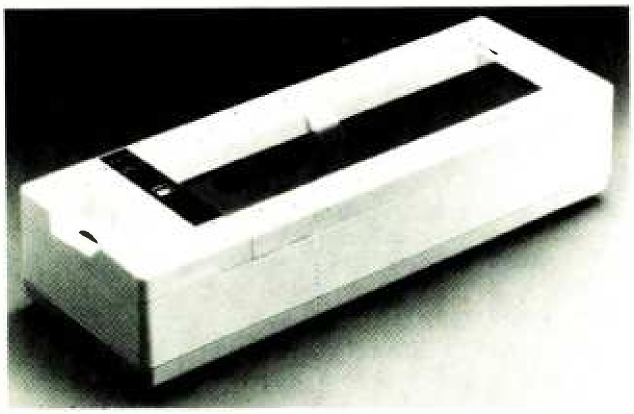


Fig. 6—An ink-jet printer creates text by firing jets of ink from a special printhead onto the paper to form dots.

Some dot-matrix printers, like the NEC's Pinwriter P6 and P7, have a printhead that contains two rows of hammer wires. The extra row helps the printer to produce well defined characters that are close to solid-character output.



Ink-jet printers—such as Epson's HS-80 Letterjet, which measures about 14 × 5 × 3 inches, weighs four pounds, and runs off a set of built-in rechargeable Ni-Cd batteries— form characters from dots placed on paper by a bank of nozzles.

Hewlett-Packard with its ThinkJet and Siemens with their own line have high-end offerings in the dot-matrix printer and plotter market. Generally they cost in the $500 to $800 range. Because of the fact that they can be precisely dithered, they also offer high-level graphics capability.

Several ink-jet printers have come to market recently that are battery-powered portables. Epson's HS-80 Letterjet printer measures about 14 × 5 × 3 inches, weighs four pounds, and runs off a set of built-in rechargeable Ni-Cd batteries. It forms its dots from nine ink nozzles; the manufacturer claims that a resolution of 240 dpi can be obtained. In addition, it can print at a speed of 160 cps in draft mode, and 32 cps in NLQ mode.

Further, the HS-80 is a very quiet printer and requires no special paper. The printer's ink wells must be filled periodically, however. And, to obtain maximum quality output, special bond paper is required. The HS-80 lists for about $500.

The Diconix 150 is another battery-operated ink-jet printer. It also weighs about 4 pounds, but it's slightly larger than the other portables that we've discussed: 2 × 6.5 × 10.8 inches. It prints at 150 cps in draft mode and 40 cps in the NLQ mode. In addition, it has the advantage of being compatible with Epson's FX series of printers. It lists for about $479.

The Penwriter

The penwriter's special printhead is capable of plotter-like graphics, as well as high-resolution text. The printhead is actually a pen cartridge holder with four slots. A pen cartridge fits into each slot and the printhead creates each letter through a series of dots placed on the paper. The printhead, rather than the printhead element, moves the pen cartridge up and down as it lays down its matrix of dots that makes up each letter.

Relatively inexpensive (about $300), the penwriter is also capable of high-level, multi-color graphics. Since each pen cartridge can be precisely positioned, the penwriter can also serve as a plotter. Thus in one device you have both a printer and a plotter, as well as a high-level graphics machine.

Interface

Every printer, from a high-quality laser printer to a lowly teletype-writer, must be connected to a computer by either a serial or a parallel interface. Both types of interfaces have their merits; choosing one or the other depends on several things. For example, if your computer has only one type or the other, you may have to get a printer with that type. But if your computer has one of each type, you may want to use a parallel interface. That leaves the serial port free to connect a modem or other device. Another thing to consider is that some printers can operate in either mode, which can make them useful in an environment where equipment is being changed frequently.

In general, parallel-printer interfaces are cheaper and faster than serial interfaces. But the connectors are not standard, and the connecting cable cannot be very long. Serial connectors are somewhat more standard, but the arrangement of pins inside the connectors is not. However, serial interfaces can be operated over much greater distances than parallel

PRINTER MANUFACTURERS

Apple Computer, Inc., 20525 Mariani Ave., Cupertino, CA 95014
Bell and Howell, 16691 Hale Ave, Irvine, CA 92714
Brother International Corporation, 8 Corporate Place, Piscataway, NJ 08854 (201-981-0300).
Canon U.S.A., 1 Canon Plaza, Lake Success, NY 11042
Commodore Business Machines, 1200 Wilson Dr., West Chester, PA 19380
Data General Corp., 4400 Computer Dr., Westborough, MA 01580
Diconix (a Kodak Company), 3100 Research Blvd., Dayton, OH 45420 (513-259-3437).
Epson America, Computer Products Div., 2780 Lomita Blvd., Torrance, CA 90505 (800-421-5426; in California, 213-539-9140).
Hewlett-Packard, 16399 W. Bernardo Dr., San Deiago, CA 92127-1899
IBM Entry Systems Division, P.O.B. 1320, Boca Raton, FL 33432
Laptopp Systems, 515 Calle San Pablo, Dept. 4, Camarillo, CA 93010 (800-LAP-TOPP; in California, 805-482-9699).
NEC Information Systems, Inc., 1414 Massachusetts Avenue, Boxborough, MA 01719 (617-264-8000).
Panasonic Industrial, 1 Panasonic Way, Secacus, NJ 07094
Radio Shack, 1 Tandy Center., Ft. Worth, TX 76102
Sanyo Business Systems, 51 Joeseph St., Moonachie, NJ 07074
Sharp Electronics, 10 Sharp Plaza, Paramus, NJ 07652
Sony, 101 E. Green St., Champaign, IL 61820
Swintec Corp., 23 Poplar St., E. Rutherford, NJ 07070

ones. And you can often connect a printer with a serial interface to several different computers by judicious use of jumper cables. If you plan to print mostly graphics, you may prefer the speed advantage of a parallel interface.

Recommendations

So how do you go about choosing a printer? The first thing to do is to decide what you're going to do with it. If you plan to print only text—term papers, reports, and the like—a solid-character printer is for you. But if you expect to be printing graphic images, you'll have to get a dot-matrix printer. Next you'll have to decide how much you're willing to spend. Since the low-end models of both matrix and solid-characters cost about the same, price shouldn't influence your decision about which type of printer to buy.

In general, higher speed corresponds to higher price. If you expect to run your printer only a few times per week, a high-speed unit is probably unnecessary. But if you expect to run it several hours per day, a high-speed unit probably is worth the price—because you'll wear out a low-speed unit, and drive yourself (and those around you) crazy in the process.

If noise is a problem, thermal and ink-jet printers are much quieter than impact printers (both matrix and solid-character). Thermal printers require less maintenance than ink-jet printers, but ink-jet printers produce a higher-quality output.

If portability is an issue, an ink-jet or thermal printer may also be appropriate, as you can tuck one in a backpack, briefcase, or suitcase easily. Battery-powered printers are perfect for camping and trips abroad.

You may want to consider what will happen if your printer breaks down. Could you use a friend's computer in an emergency? And what kind of warranty (and non-warranty) service is available in the area in which you'll be living? If you're going away to school in an unknown area, you may want to find out what sort of service is available in that area.

And what happens if your computer breaks down? If you had a combination printer/typewriter you would at least be able to type a paper manually. In addition, it is difficult or impossible to print envelopes on small dot-matrix printers, so that's another reason to consider a combination printer/typewriter.

Another factor to consider is the availability of supplies. Thermal printers require special paper; ink-jet printers require ink and possibly special paper. Both solid-character and dot-matrix impact printers require ribbons, and it's wise to keep an extra Daisy-wheel or print thimble on hand, because the spokes are flimsy and easily broken. You'd hate to turn in a paper with all the e's missing!

TABLE 1—PRINTER CHECKLIST

Compatibility
- With your computer
- With your software

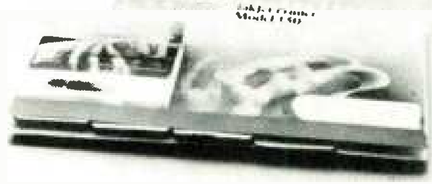
Interface
- Serial
- Parallel

Print Quality

Speed
Graphics
Alternate character sets
Sheet feeder
Envelope feeder
Portable
Maintenance
Warranty
Platen Width

Availability of Supplies
- Ribbon
- Paper
- Daisy-wheels
- Ink

Printer Price



Dot-matrix printers, like Epson's FX-286, can handle high-speed (200 cps for this unit) draft-quality print jobs. In the letter-quality mode, the FX-286 outputs 40 cps.

Buying a Printer

So how do you go about buying a printer? You can buy one at a local shop or by mail. Mail order is usually cheaper, but obtaining service can be difficult. On the other hand, computer salesmen are notoriously pushy, so don't go to a store without having a pretty good idea of what you want. If you'll be going away to school, the advantage of a local shop will be lost. But if you buy by mail, buy only from the larger distributors that advertise regularly. And make sure that the printer you want to buy is compatible with both your computer and the programs you want to run on it.

Whatever type of printer you buy, you'll probably want to purchase a tractor feed. A tractor feed is useful for keeping continuous-forms computer paper—paper with sprocket holes along the sides—aligned correctly. Tractor feeds are occasionally included in the price of a printer, but most often they're not. So you'll have to budget an extra $50 to $100 for the tractor feed.

And regardless of the type of printer you buy, you should consider the cost and availability of the supplies you'll need to run that printer: paper, ribbons, and print-wheels. Mail-order suppliers are often the best source of those supplies.

Other useful accessories available for most printers are single-sheet (also called cut-sheet) feeders; and even envelope feeders. Some Daisy-wheel and thimble printers allow you to use dual-color ribbons. And most printers of both types can be configured to operate with serial or parallel interfaces. So whether or not a printer can make use of those extras may be important.

The last things you may want to consider are the convenience and maintenance features. How easy is it to change ribbons and paper? How easy is it to activate special modes (NLQ, etc.)? Can you use front-panel switches, or must you send special printer codes? If you must send codes, is your software capable of doing so? Make sure that a prospective printer is compatible with both your computer and the software you'll be using with it. We've summarized things to consider when buying a printer in Table 1. Good luck! ■

CMOS PHASE-LOCKED LOOPS

Meet the Cinderella of precision timing circuits, the CMOS phase-locked loop—a versatile and exciting circuit.

By Fernando Garcia Viesca

Before the age of solid-state devices, the phase-locked loop—or PLL as it is more commonly known—was rarely used for consumer or commercial equipment. More or less, the PLL fell within the province of the astronomers, because it was specifically their need for the precise timing and frequency-control characteristics of the PLL that justified its cost and complexity.

But solid-state changed all that. Although a PLL is a complex and expensive device to build with vacuum tubes, it can be squeezed into a single integrated circuit that sells for little more than pocket change (we're talking about going from hundreds of dollars to a few "George Washingtons").

Simply Amazing

For what it is, the PLL is an amazing device. It can provide precise timing pulses, utilize a low-cost low-frequency crystal to precisely stabilize high-frequency oscillators that would normally drift "all over the band" without the PLL, and it can be a fantastic detector: digging out signals that we didn't even know existed from under the noise.

The only real problem with the PLL is that it appears to be more complex and difficult to use than it really is. In actual fact, it's a rather easy and interesting circuit to experiment with once you get beyond the seemingly endless tables, equations and graphs found in the databooks—they can be overwhelming and confusing.

For general experimentation with the PLL, you probably won't need to juggle the technical mumbo-jumbo. Actually, it's sort of like transistors: to bias a one-transistor amplifier, you don't have to calculate all the H-parameters; for the less-than-critical applications a very simplified model and some common sense rules will suffice.

The same is true with PLL's: If you don't intend to push them to performance limits, simple approaches plus breadboard component trimming will let you experiment with, and use PLL's.

Getting Started

To help you get started experimenting with and using PLL's, we'll discuss a simplified PLL theory—using a minimum of equations—and review the features unique to the CMOS 4046 phase-locked loop. We'll also discuss several useful and interesting experimenter circuits.

As shown in Fig. 1, a generic PLL has three major building blocks: a phase comparator; a low pass filter; a voltage-controlled oscillator (or VCO, as it is more commonly called). Sometimes, as indicated by the dashed lines in Fig. 1, a frequency divider (flip-flop or counter) is included in the feedback loop coming from the VCO's output.

The *phase comparator* detects the phase difference—caused by a frequency difference—between a reference (input) signal and the VCO's output. The output from the comparator is a voltage that tracks the phase relationship between the input and output signals, increasing when the phase difference increases; decreasing when the phase difference decreases. Since the phase difference is a function of the frequency difference, in reality the voltage tracks the frequency difference.

That, however, is not totally straightforward. When we speak of an increase in the phase comparator's output voltage,

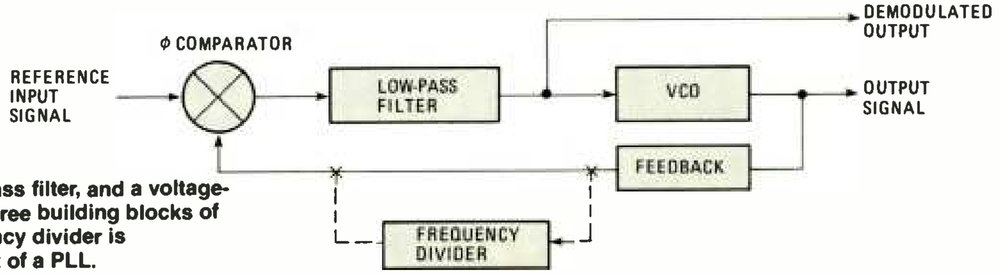


Fig.1—The phase comparator, low-pass filter, and a voltage-controlled oscillator (VCO) are the three building blocks of a phase-locked loop (PLL). A frequency divider is optional, and may or may not be part of a PLL.

it is an *average* value increase, which is not a DC level but a complex series of pulses having varying widths. Since the pulses cannot be fed directly to the VCO (erratic behavior would occur), we must use the second block—a low-pass filter—to recover the average DC voltage.

The filter, sometimes called an *integrator*, may be a simple RC network or an elaborate multipole active filter. Either way, it is vital for proper PLL operation because the damping, capture range, and loop stability are dependent on the filter's design (we'll describe those terms later).

The last block is the VCO, whose free-running or center frequency (f_0) can be modified by the control voltage supplied by the low-pass filter. The control voltage from the filter is used to "tune" the VCO; hence, the VCO will track the voltage variations of the phase comparator's output.

We know by now that an increase in the reference input signal's phase angle with respect to the feedback signal from the VCO will, in turn, increase the average voltage level from the filter, and therefore the output frequency. The opposite is also true.

Frequency Tracking

Suppose that we close the loop by feeding back the VCO's output signal to the phase comparator's input (shown in Fig. 1). Imagine for a moment that a stable frequency is fed to the comparator's reference input (section A of Fig. 2). If this frequency is within the PLL's lock range, then there will be a certain voltage level developed at the low-pass filter's output (shown in Fig. 2B), which will bias the VCO at the same frequency. (Because of the nature of the closed loop, this will always be the case when the input frequency is within the lock range).

Next, assume that the reference input signal frequency increases. As shown in Fig. 2, there will be an instantaneous phase change between the reference input signal (2A) and the VCO's output frequency (2C), causing an increase in the low-pass filter's average voltage (2B). That filtered voltage, in turn, is fed to the VCO's control input, which causes the VCO's output frequency to increase until it catches up with the reference frequency. If the reference frequency decreases, the process will reverse itself.

So we can see how the derived DC control voltage determines the VCO's output frequency; but what would have happened if the VCO's control voltage had been monitored in the process? Correct! It's an FM demodulator because its value is determined by the difference between the input and output frequencies.

High-Tech Demodulation

When high-fidelity and communications equipment are advertised as having a "PLL detector," it means that a phase-locked loop has been used as the detector instead of a lower-linearity demodulator, such as a Foster-Seely. But FM demodulation is only one of the many applications for PLL's. We'll get a chance to look at several others; meanwhile, let's review what we have covered:

1—The PLL has two inputs to the comparator: the reference (input) signal and the feedback from the VCO. (The operation is analogous to the non-inverting and inverting inputs of the op-amp, but in this case we're working with frequency, not voltage.)

2—The low-pass filter averages the voltage variations of the comparator's output which are caused by the phase differences between the signals fed to the comparator.

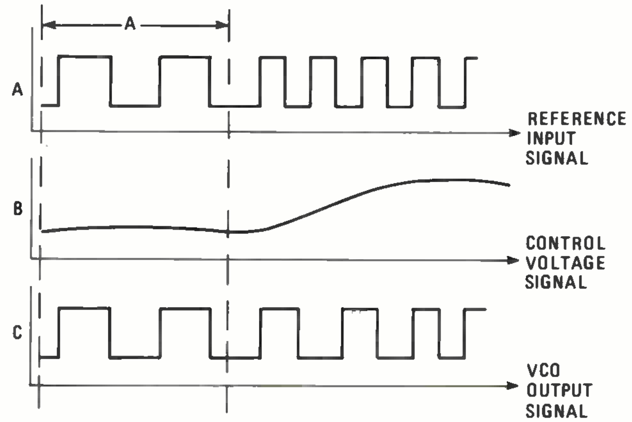


Fig. 2—A VCO control voltage is developed only when there is a difference in frequency between the reference input signal and the VCO's output.

3—The DC output from the low-pass filter controls the VCO's output frequency, which is also called *the main frequency output*.

The Frequency Divider

Back at the beginning, we briefly mentioned the "frequency divider," shown as a dotted line in Fig. 1. The divider is needed to bring back a signal from the VCO which is somewhere within the frequency comparator's working range. For the sake of illustration and discussion only, assume the comparator can accommodate frequencies somewhere in the range of 100 kHz, but the VCO is a a 50 MHz oscillator. There is no way the comparator will accommodate the 50 MHz feedback. If we use a ÷500 "frequency divider" between the VCO and the comparator the feedback signal to the comparator will be around 100 kHz. How the division is done isn't important: it might be five cascaded stages of ÷10 plus one stage of ÷5 (an absolutely ridiculous way to do it, but it will work), or one stage of ÷100 and a stage of ÷5.

Regardless how the division is done, the output of the divider—the signal fed to the comparator—will be nominally 100 kHz, even though the VCO's output is nominally 50 MHz.

Some Important Terms

To finish our look at basic PLL theory, let's define some terms you should be familiar with:

- *Center frequency*: The VCO's free-running frequency, usually with no signal input to the comparator.
- *Capture range*: When a PLL is in an unlocked state and a feedback signal from VCO is applied to the comparator, its frequency must be within the PLL's capture range to become locked. The capture range is equal to, or usually smaller than the lock range.
- *Lock range*: Once a frequency has been captured and the VCO's frequency is tracking it, the PLL has become locked, and will stay so until this frequency departs from the lock range. The lock range is usually dictated by the VCO's frequency span.
- *Damping*: Dictated by the low-pass filter's characteristics, it indicates the closed-loop response to a step change in the reference input frequency. Too much damping, and the PLL won't be able to follow fast frequency changes: too little, and the PLL overshoots.

The CMOS Integrated-Circuit PLL

Figure 3 shows the block diagram of the CD4046 (or MC14046) integrated-circuit PLL. This very complete IC has four main parts:

- Two distinct phase comparators with buffered inputs and independent outputs, labeled phase comparator I and II. (One buffer feeds both comparators.)
- A source follower to buffer the demodulated voltage. The follower may also be inhibited.
- An internal Zener diode for voltage regulation.
- CMOS technology for all functions

The CMOS Technology

The phase comparators, whose simplified schematics are shown in Fig. 4, are driven by a buffered input, unique because it allows the input signal to be either coupled for CMOS-compatible level swings, or capacitively-coupled for small-signal operation. The input amplifier is self-biasing in this latter mode for ease of operation, but the signal amplitude should be at least 400 mV and have a fast risetime. (For our purpose, "fast risetime" means at least 10 kHz for a sinewave, less for a squarewave.) Anyway, the capacity-coupled mode should be avoided when using phase comparator II because of its poor noise immunity. (More about this later.) Always try to use CMOS-compatible level swings.

Phase comparator I is an exclusive-OR (XOR) network. To operate properly, both the signal and the comparator (feedback) input frequencies must have a 50% duty cycle (meaning a symmetrical squarewave), but you'll have to worry only about the input signal since the VCO's output meets this condition.

When there is no reference input signal to the comparator—when the comparator's only input is the feedback from the VCO—its output will be a symmetrical squarewave (50% duty-cycle) whose value is $V_{DD}/2$. The VCO will always attempt to adjust its frequency to produce this value, hence, the VCO frequency that results in the value $V_{DD}/2$ is known as the VCO's center frequency: the frequency to which the VCO, by design, should default.

When a reference signal is input to the comparator, the output duty cycle will change, and therefore its average value; the VCO's frequency will change accordingly.

Whenever phase comparator I is used, four distinct characteristics are realized:

1) The capture range is dependent on the low-pass filter's component values.

2) The phase angle between signal input and comparator input is 90 degrees at the center frequency, and approaches 0 and 180 degrees at the ends of the lock range.

3) The VCO may lock into frequencies that are harmonics of the center frequency.

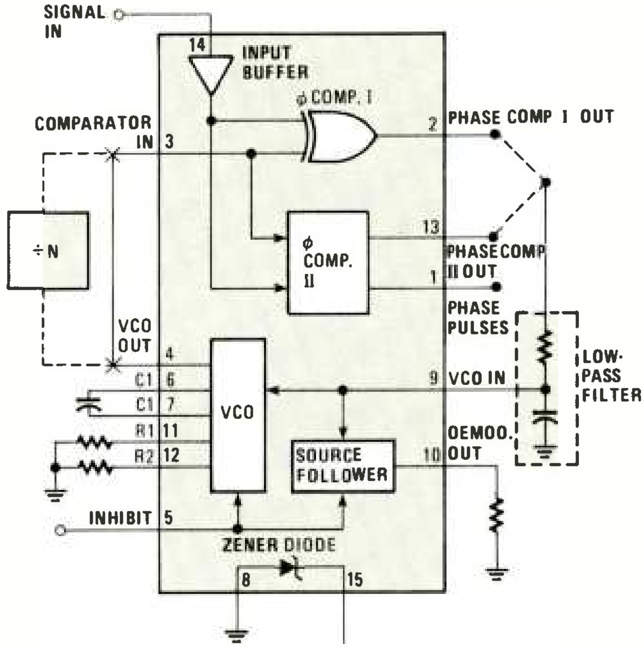


Fig. 3—Even an integrated-circuit PLL requires external components. The low-pass filter can be connected to the output of phase comparator I or II.

4) The noise immunity is high, provided that the noise pulses are narrow enough so they don't noticably disturb the 50% duty cycle.

Characteristics 1) and 3) are disadvantages in most applications, but 4) is a sure advantage in an FM demodulator.

Phase comparator II is an edge-sensitive flip-flop circuit, an arrangement gives us freedom from the reference input signal's duty cycle because flip-flops detect transitions only. But this advantage is also its greatest disadvantage: any narrow noise pulse is seen by the comparator as another cycle and, therefore, the noise-immunity is poor.

Sample and Hold

The output circuit for comparator II is a three-state arrangement of PMOS and NMOS transistors (see Fig. 4). With appropriate gating, this kind of output functions as a sample and hold circuit.

To understand how it works, imagine that the reference input signal has a higher frequency than the comparator's VCO input frequency. The control flip-flops will gate the PMOS transistor on, thus connecting the V_{DD} voltage directly to the output. If the opposite is true, the flip-flops will gate the NMOS transistor on, connecting the output to V_{SS}

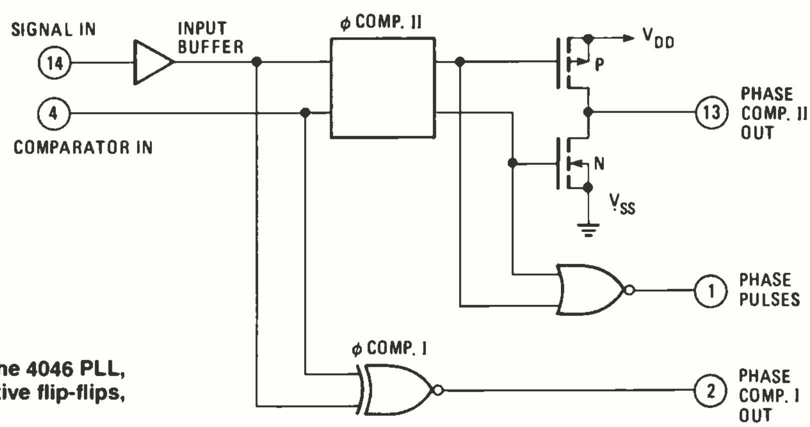


Fig. 4—In the phase comparator section of the 4046 PLL, comparator II's logic circuits are edge-sensitive flip-flips, hence, they are more susceptible to noise.

(ground). And if both frequencies are equal? Then both transistors will be gated off and the output appears in a high-impedance state.

We can see that for no signal input the NMOS transistor will always be on, the output low, and the VCO will adjust to its lowest frequency.

Phase comparator II has an additional "phase pulses" output that is at a logical high when both the NMOS and PMOS transistors are off, thus providing a handy "in-lock" indication.

There are also four distinct characteristics when using phase comparator II:

1) The capture range is equal to the lock range and is independent of the low-pass filter component values.

2) The phase angle between the signal input and the comparator input is very close to 0 degrees when the PLL is "in-lock."

3) The VCO is immune to harmonics of the center frequency.

4) The noise rejection is poor.

Frequency Offset

The VCO, whose simplified schematic is shown in Fig. 5, is a 50% duty-cycle oscillator with a frequency offset function. To understand the VCO's operation, assume that resistor R2 is not connected to pin 12. This will leave only resistor R1, capacitor C1 and transistor N1 as the sole frequency-determining components. If the voltage present at the transistor's gate is zero, it will be at cutoff and R1 is effectively out of circuit, making the charging current I_s and the frequency zero (or almost zero). If now we make the control voltage (VCO_{in}) equal to V_{DD}, N1 will turn on and both the current I_s and the frequency will be maximum. At intermediate voltage values, the current I_s and the frequency will be proportional to the control voltage. For maximum linearity, the value of R1 should be large compared with the transistor's "on" resistance. (Let R1 > 10,000-ohms.)

Now let's assume that R2 is in circuit. If the control voltage is zero, there will be a current path from the VCO's control logic through R2, and the frequency won't be zero. If the control voltage increases to V_{DD}, then the equivalent resistance will be the parallel value of R1 and R2. At an intermediate voltage, the current path will be R2 in parallel with a fraction of R1.

We can see, then, that R2 offsets the frequency from zero.

FM Demodulation

The *source follower* (shown in Fig.3) is useful when the VCO's control voltage (VCO_{in}) must be monitored. An example is an FM demodulator. Theoretically, the demodulated FM appears at the VCO input, which is taken from the low-pass filter (shown in Fig. 3), however, any loading—even with a 10X oscilloscope probe—will impair the filter's operation. The internal source follower functions as an isolation network between the filter and the rest of the world, thereby allowing us to monitor the voltage without imposing a load. Just connect a resistor in the range of 10,000 to 100,000-ohms to ground at the source follower's output (shown in Fig. 3), and the demodulated FM signal will appear across the resistor with a 1.0 to 1.5 volt) DC level. For an FM demodulator, which is usually AC coupled, the DC offset level presents no problems.

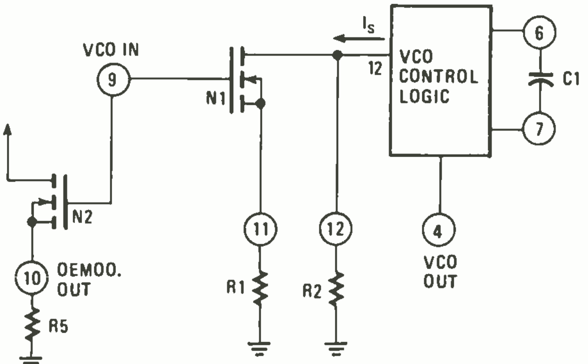


Fig. 5—This is the simplified schematic of the PLL's voltage-controlled oscillator. Current I_s regulates the VCO output frequency. N2 is the source follower.

Fig. 6—Only three components are needed for the low-pass filter. Inclusion of R4 gives best overall response, but there are occasions when it must be reduced to zero.

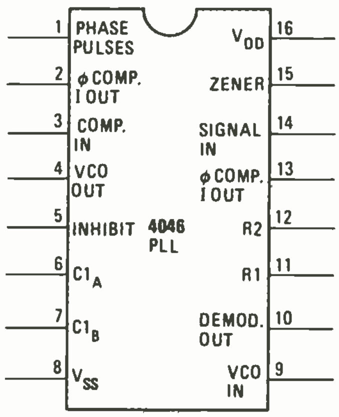


Fig. 7. Although we'll have several PLL projects for you in the next part of this series, you might want to start experimenting now, so here's the full set of connections for the 4046 phase-locked loop.

Voltage Regulation

Last in the 4046's features is the internal Zener diode (shown in Fig. 3). It is a 7.0 volt, monolithic Zener, seldom used now because of the reliability and low cost of the 3-terminal voltage regulators. But if you do need to use it, play it safe and use a 25-mA Zener current.

The Low Pass Filter

As mentioned earlier, the filter is vital to proper PLL operation. There are many textbooks loaded with equations on filter design, but we'll follow a simple approach:

As shown in Fig. 6, the simplest form of filter has three components, R3, R4, and C2. The time constants of R3 and C2 establish the settling time, and should have a ballpark value of 3 to 10 times the period of the lowest frequency.

The ratio of R4/R3 sets the damping, and is usually from 0.05 to 0.4, but in certain applications it may be zero (R4 = 0). Feel free to experiment with those values.

We have now finished this brief theory of PLL's in general, and of the CD4046 integrated circuit—shown in Fig. 7—in particular. Next month, we'll cover some practical applications and circuits for the CD4046. ■

Electronic Propulsion for Satellites

An ion can get real pushy when it gets a little help from its friends

By Marty Knight

A new propulsion system for space satellites using a jet of high-energy ionized particles is being investigated in a series of programs coordinated by Britain's new National Space Center. Here, an ion thruster is being inspected. Particles of xenon, krypton, or argon (rare gases) are used as fuel because they are inert. Unlike mercury, tested in previous ion thrusters, they won't contaminate or damage the spacecraft in which they are used.

YOU'VE SEEN THE SCENARIO MANY TIMES BEFORE: UNmanned and manned spacecraft heading for space. Giant boosters ganged to form rockets, lifting into space refrigerator-size satellites that are to be parked above selected equatorial sites. All that hardware and fuel to position a telecommunications satellite so that we may see weather maps or the Sports Channel in the comfort of our living rooms. And a few years later another launch must be executed because on-board chemical fuel, used by positioning-thrusters to fix and periodically adjust a communications satellite's orbit, has been depleted.

With the payload so small, thruster fuel is a significant fraction of a communication satellite's mass at the time of launch. Even the art of micro-miniaturization cannot reduce the satellite's overall mass so that the satellites can be launched with more fuel. Thus the increasing interest in developing ion-propulsion systems that are designed to replace chemical rockets. The new ion-propulsion systems promise large savings in fuel mass, with correspondingly greater communications payloads and/or extended service time when parked in orbit.

Parking a Satellite

Almost all commercial satellites are destined for geostationary Earth orbit. That is an orbit with a period of 24 hours, which means the satellite orbits the Earth at the same rate as Earth rotates upon its axis. Thus the satellite will then appear to be fixed in the sky, so that the earthbound antennas receiving a satellite's signals do not have to be steered to track it.

The greater part of Earth's long-range communications are now routed this way including intercontinental telephone calls, and television from the other side of the world. Plans are already well advanced for direct broadcasting by satellites that will relay signals with such high power that they can be picked up by a relatively small dish antenna in the home, bypassing the need for large receiving stations.

But a satellite would not remain fixed in its 24-hour orbit for very long without occasionally adjusting that orbit. Because the gravitational pull of the Sun and the Moon on a satellite distorts its orbit, it would wander about the sky and make tracking difficult. That effect has to be corrected for by using an on-board propulsion system to correct the satellites's orbital velocity and position.

So, a satellite's lifetime comes to an end once it is unable to maintain stationary orbit; the communications payload is switched off, and the satellite is abandoned and left to drift for many decades, if not centuries. It becomes so much interplanetary Star War's junk.

Propulsion Systems

A satellite orbit-control system must be reliable and have a long life, which is about 10 years for a modern communications satellite. It should also weigh very little, because every kilogram (one kilogram equals about 2.2 pounds) that is not used for the communications payload reduces the revenue that the satellite earns.

Satellites now in service use chemical rockets for orbital control. The propellants used are allowed to react in a rocket chamber and the gas products from the exothermic reaction expand and exit through a nozzle to produce a jet of fast-moving gas. The velocity of the jet, or exhaust, which the propulsion system can achieve is important. The amount of propellant that has to be used to provide a change in velocity (usually about 50 meters-per-second or 11 miles-per-hour) is proportional to the exponent of the ratio between the velocity change and the exhaust velocity. The higher the exhaust velocity, the lower the mass of propellant that must be carried to keep the satellite on station. Monopropellant rockets have exhaust velocities of about 2.2 kilometers per second and, for a 10-year mission, must carry 200 grams of propellant for every kilogram of satellite mass (a 1 to 5 ratio) at the start of operation. Bipropellant systems have an exhaust velocity of about 3 kilometers per second, which means they must carry about 150 grams of propellant for each kilogram of satellite, but at the expense of a heavier, more complex rocket system, (see Fig. 1).

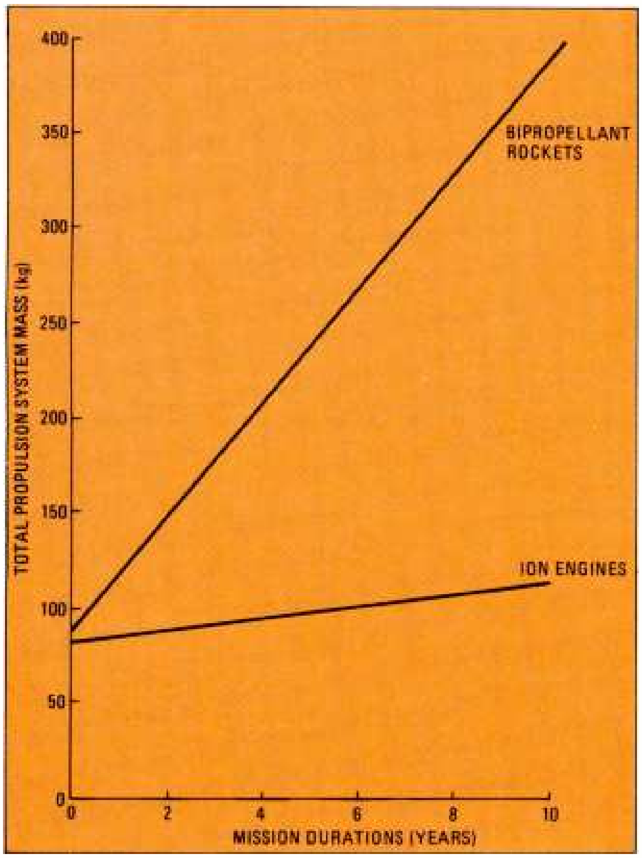


Fig. 1—This is a graphical comparison between ion propulsion and chemical rockets, for 10-years of station-keeping duty. The data is for a two-ton geostationary satellite, capable of initial station acquisition and 50 meters per second of velocity change annually.

Electronic Thrust

Ion-propulsion systems offer a practical alternative to chemical rockets. Electric potential is used to accelerate propellant to much higher velocities, in the range of 30 to 40 kilometers per second. That means only 12 to 17 grams of propellant are needed per kilogram of satellite mass. Of course, the mass of the electric rocket and its power supplies must be reckoned as part of the propulsion system; but even so it can be seen that the payload gains possible with this type of system are very large.

The case of a 4400-pound satellite, typical of those that will be used for communication links until the end of the century, can be used to illustrate this point. The electronic propulsion system must provide velocities up to 50 meters per second to keep "on station" and 60 meters per second at the beginning of the mission to place the satellite in the correct orbit. If ion-propulsion systems were used to carry out those maneuvers, gains in the payload of about 25 percent could be realized. That boils down to about a 300-kilogram savings for a 4400-pound satellite if ion-propulsion were used instead of chemical rockets. Comparing that difference to the communications payload of a modern telecommunications spacecraft, the Olympus-1 satellite, scheduled for its first launch in 1987, has a communications payload of 307 kilograms.

How An Ion Thruster Works

The propellant in an ion thruster is accelerated by an electric field to high velocities to produce thrust. For that to happen, the propellant must have its electrons removed from its atoms, leaving positive ions behind. By far the most effective means of carrying out that *ionization* process is to use electrons to bombard the propellant's atoms and knock off electrons. So, in an electron bombardment ion thruster (see Fig. 2), electrons are emitted from a cathode and accelerated toward a cylindrical anode, colliding on the way with propellant fed into the discharge chamber. At the front of the chamber is an ion-extraction system, usually consisting of

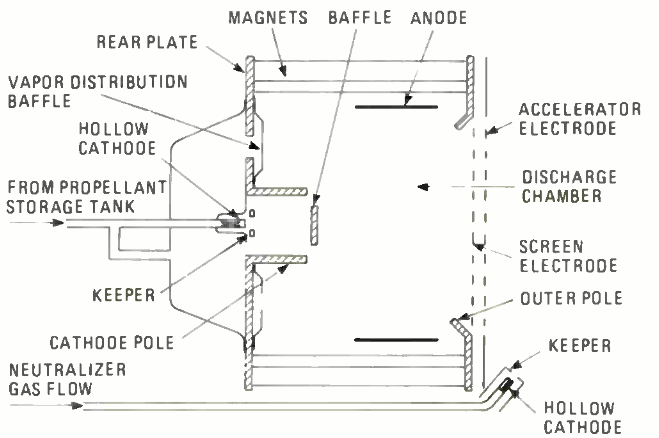


Fig. 2—This is a cross-section of an electron-bombardment ion engine. Fuel from the storage tank enters the discharge chamber. Electrons from the cathode bombard the gas, knocking off electrons, and the resulting positive ions are accelerated out of the chamber providing thrust for the satellites. Some gas is bled off to remove excess electrons.

two grids (something like the inside of a simple vacuum tube). An electrical potential, usually in the range of 1000 to 1500 volts, is applied across the grids, thereby causing the ions to be pulled from the discharge chamber and accelerated toward and through the second grid to form the beam of ions that provide the thrust. If only the positive ions were extracted from the discharge chamber, the satellite would build up a large negative charge very quickly. So a neutralizer is used to eject the electrons and balance the charge on the spacecraft.

We've talked about the thruster part of the system, but what about the electrical power source? The system taps off of the main solar-cell array that powers the satellite. The array is usually oversized relative to the needs of the communications payload to allow for solar-cell degeneration over the lifetime of a satellite. "Station-keeping" ion thrusters need a few hundred watts of power to operate them, which is a small fraction of the several kilowatts that are available on large communications satellites.

The need to draw satellite power limits the size of the electronic propulsion system as a whole. High exhaust velocities, achieved by high accelerating voltages, reduce the amount (mass) of propellant needed. But that also means that the power unit, which converts the output from the solar array or battery to the voltages required by the electronic propulsion system, becomes heavier and heavier because of the need for higher power. So there must be a compromise between a reduction in propellant mass and an increase in power-supply mass.

What's in the Future

Even with all the benefits to be gained, there are several good reasons why satellites still do not use ion-propulsion. Although ion-propulsion systems would be capable of increasing the payload by 20 to 25 percent on a wide variety of satellites, it is only recently that communications satellites with masses of more than one ton have become relatively commonplace. Previous generations of space vehicles had masses of about 750 kilograms and the payload was not considered enough to warrant the cost of development for a different propulsion system. The method of delivering packages into space on a rocket or a space shuttle, has been comparatively inexpensive, even when the gross payload was small. But now the space-shuttle program will no longer subsidized space launches, raising the overall cost.

It is only quite recently that communications satellites with powers of several kilowatts, as opposed to the 500 to 1000 watts common previously, have become operational. Ion-propulsion systems would absorb only a small fraction of the total power available.

Many factors kept this new-wave propulsion from reaching beyond the drawing board stage. For one, the designers' natural resistance to change and reluctance to adopt what is often seen as a complex system of strange thrusters, power supplies, and controls. Further, the popular choice of propellant for most of the research carried out on thrusters, namely mercury, poses technical problems. It is almost ideal as a propellant because it is dense and easily stored. But it is not an ideal material as far as spacecraft designers are concerned, for it amalgamates rapidly with many metals—such as copper, gold and aluminium, all extensively used in the structure of satellites. That means that the spacecraft structure, electrical wiring, power-producing solar cells, and so forth, could all be vulnerable to attack. That disadvantage is eliminated, or at least greatly reduced, if a gas is used instead of a liquid metal. A favored candidate is the rare, heavy gas xenon, which is inert. It does not contaminate or react with the other elements of a space-system, so it removes most of the worries about the structural integrity of long-life spacecraft. Further, it would not condense on components, so it does not cause electrical trouble.

What's In the Cards

All the leading nations in space technology are planning to test ion-propulsion systems over the next few years. The U.S. is due to fly a satellite with two mercury-propulsion devices. Japan has already flown a small mercury system and operated it for 200 hours in space, and Germany has plans to fly a xenon system with a 10-centimeter exhaust for a six-month test on the European Retrievable Carrier (EURECA). Great Britain is developing a xenon system with a 12-centimeter exhaust that will be space-tested as well.

With so many supporters it is obvious that ion propulsion has come of age and will have more and more applications in the 1990's. The focus of attention will then shift away from the proof-of-principle stage and turn toward finding the most efficient, flexible, and commercially attractive product for commercial users. Though ion propulsion will have been a long time in coming, it will soon be here to stay—in orbit. ■

SQUARING THE CIRCLE—FLAT AND ROUND CABLE ALL IN ONE

What do you do when you want to connect a nice flat ribbon cable to a whole lot of terminals—mass termination (flat cable makes neater connections), but you've not much space to snake the cable through? Flat cable generally does not leave enough space for cooling if stacked on other flat cable. You may say you can roll the cable up like a cigar, but this makes it inflexible, and the insulation on ribbon cable is prone to wear in tight spots anyway. Sure, you can buy expensive shielded cable, even though the application may not require shielding, but now there's another alternative—Scotchflex 3759!

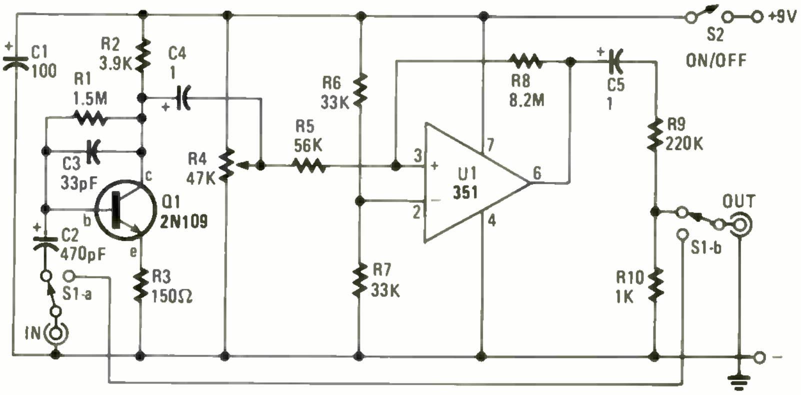
The new cable is ribbon-like, but it is folded and protected by two layers of insulation. The outer layer is durable and almost round to facilitate cooling and protection, and the inner layer is pleated to conform to the ribbon within to protect it from wear inside connectors.

It is also flexible because the cable is bonded only intermittently along its length, where as ribbon cable is bonded along its entire length. The absence of shielding also insures better flexibility than shielded cable. ■

Something Different In Sound

Often needed, but hard to locate circuits

Unusual Fuzz—It seems that guitar fuzz boxes have been around since the beginning of rock, and have seen little improvement over the years. This one is somewhat different because rather than simply distorting the sound, it also *pulses* in step with the peaks of the waveform from the pickup because of the Schmitt trigger op-amp circuit. Capacitor C2 requires some explanation. It should normally be a 1- or 2-µF electrolytic capacitor. However, we show the value as 470 pF because it's recommended as an experimental value giving far out effects.

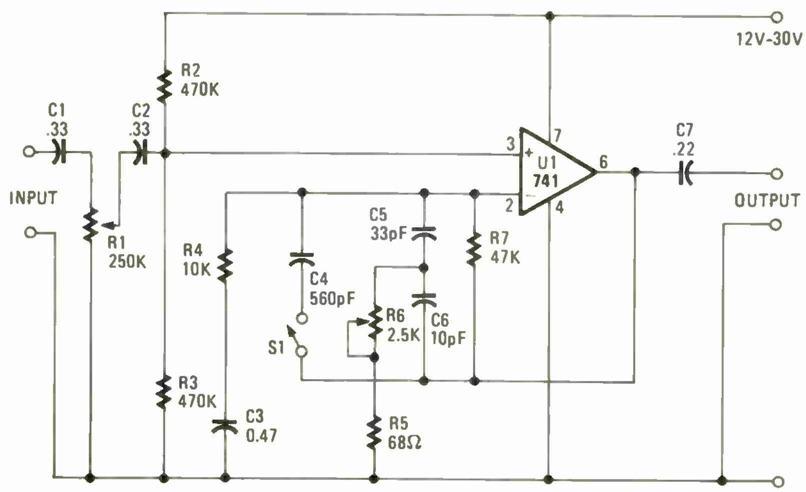


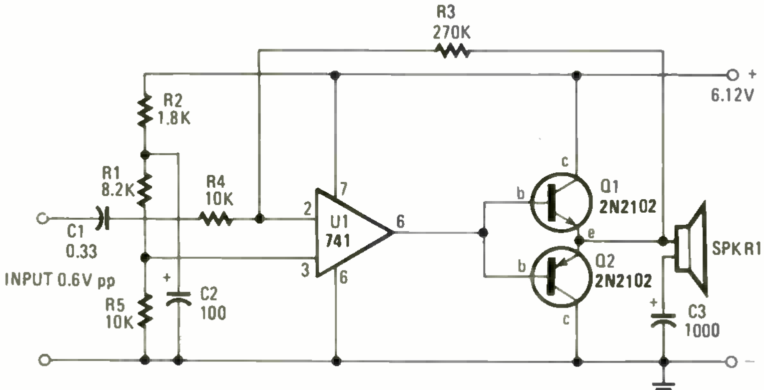
Instrument Preamp—The hottest sellers in just about every camera, electronic, and discount store are electronic instruments—everything from electronic *kazoos* to concert grand pianos. The only problem is, your present sound gear might not have an input left with sufficient gain for the instrument. Until you can squeeze your budget for an amplifier especially designed for electronic instruments, try this audio preamplifier if your sound system needs extra *oomph*.

The input impedance is the value of potentiometer R1. If your instrument has extra-deep bass change capacitor C1 to 0.5 µF. What appears to be an extra part in the feedback loop is a *brightening* tone control.

The basic feedback from the op-amp's output (pin 6) to the inverting input (pin 2) consists of resistor R7, and the series connection of resistor R4 and capacitor C3, which produce a voltage gain of almost 5 (almost 14dB). That should be more extra *oomph* than usually needed.

If you find the circuit is somewhat short on bass response, increase the value of capacitor C3 to 1 to 10 µF. Start with 1 µF and increase the value until you get the bass effect you want. However, keep in mind that many general-purpose, replacement and even high-fidelity speakers cannot safely handle the high-level, almost constant deep-bass output produced by many electronic instruments. You may decide to pick up a *monitor* speaker, or two, to handle the power.





Porta-Amp—Walkman tape players and radios are convenient, but there are times when the annoyance of having your ears plugged isn't really necessary. "When?," you ask. When you're sitting in the comfort of your home, or driving in a car that's not equipped with an in-dash tape player. That's when you want "room filling" sound, and that's what you'll get from this portable amplifier. Simply connect the amplifier to the Walkman's headset jack and use the Walkman's volume and tone controls to adjust the sound level and tone. The only caution is to match Q1 and Q2. ■

BITS & BYTES For BEGINNERS

In Your computer bits and bytes do it all ... and just about everywhere else!

By Herb Friedman

☐ASK THE AVERAGE PERSON TO DEFINE *BITS* AND *BYTES* AND it's an odds-on bet he or she will respond in terms of a personal computer. Similarly, many elementary school children who can barely read can rattle off an "official" definition of bits and bytes as easily as they can tell you the colors of the rainbow.

In actual fact however, bits and bytes enter our lives through more than the personal computer, for the most modern microwave ovens, blenders, washers, burglar alarms, fire alarms, telephone dialers, and anything else that's *digital* or microprocessor-controlled depends on bits, bytes and mini-bytes.

So What's a Bit?

Bits are the way we know whether a burglar alarm is armed, or whether the swinging door that lets the cat in and out of the house is jammed open, or the roast is cooked, or even whether your personal computer's printer is turned on. It is the universal code for digital devices.

A bit is the smallest unit of information that can be used to describe a function, condition, voltage, or whatever. It tells us whether something is *on* or *off*, *heads* or *tails*, *hot* or *cold*, *live* or *dead*. A bit is represented by a 0 (zero) or a 1 (one). For example, if you stick your finger in a live electric outlet and your nose lights up we know the outlet is *on*, which can be represented by a 1. It doesn't matter what the actual voltage is, we are only concerned with whether it is *on*, which we represent with a 1. If your nose does not light up, the outlet is *off*, which we represent with a 0. Alternatively, if someone asked the condition of the outlet and it was "live" we could respond by simply stating: "It's a one." Similarly, if an armed house burglar alarm is represented by a 1, an unarmed alarm would be represented by a 0. If a roast beef cooking in a microwave oven is a 1, a cooked roast (having reached the proper internal temperature) would be a 0 because the roast is no longer being cooked. (Take time to figure this one out because in digital something can remain on (1) after the controller is off (0). For example, a raw roast is 0, a *cooked* roast is 1; a *cooking* roast is 1, the *cooked* roast is 0).

By usual convention—and there are exceptions to the rule—the on or 1 state is called a *high*; the off or 0 state is called a *low*. As is commonly done, we will use the terms interchangeably. For example, if we say an electric outlet is high it means the outlet has a voltage present. If we say a home alarm system is low it is the same as saying it is off.

Except when it's necessary to know the precise value of a voltage, temperature, water level, or whatever, digital circuits are concerned primarily with whether something is on or off, but the on/off states of just one or several bits can be used to represent numeric values; all that's needed is to use the required number of bits.

Many Make Up Just One

For example, assume you want to wire your home's fire alarm system into a *central monitoring station* (via a telephone dialer) so that the station personnel will know if a fire breaks out in your home, and precisely where it's located.

To keep things simple we'll assume a total of eight fire detectors. The microprocessor-controlled gizmo that keeps track of the fire detectors transmits its information (data) through an RS-232 two-wire connection to the telephone dialing and modem equipment. Do you see the problem? "How do we transmit information on the eight fire detectors through two wires?"

One way to do it easily is to convert the fire-detector data to a byte—eight bits of information, each bit representing one detector. The arrangement is shown in Fig. 1: bit 1 is for detector A, bit 2 is fire detector B, etc. The bits will be transmitted serially through the RS-232 interface to the central-station equipment.

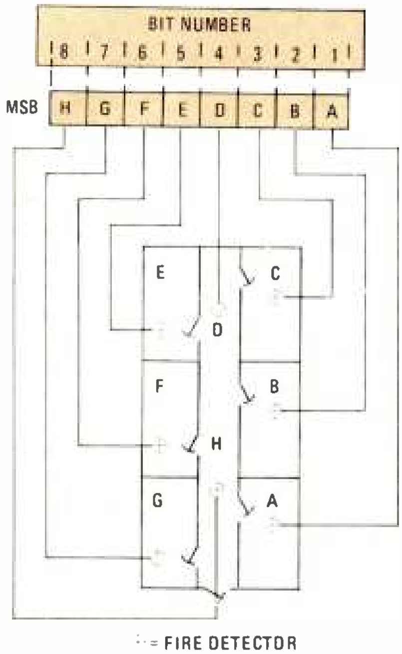


Fig. 1—Each detector provides one single bit of information in the eight-bit byte to indicate its state (ON or OFF). The most significant bit (MSB) is the bit assigned the highest value, as opposed to the least significant bit (LSB) which is assigned the lowest value (one of course).

In the most simple monitoring system, the central station has a small box that is assigned specifically to your home. On the front of the box is a numeric display that shows decimal value when information is received from your home. This single value tells the monitoring person all there is to know about the fire: if there is a fire and where it's located.

The decimal value is determined by the status of all eight detectors, because a string of bits—from one to umpteen—can always be represented by a single decimal value, the value determined by the arithmetic sum of all the bit values (which are read from right to left, not left to right). How can one decimal value represent any combination of eight bits? Because a decimal value can represent only one specific bit pattern, so it requires just one value to know the individual states of any number of bits; we really aren't limnited to just eight bits.

If I have lost you, refer to Fig. 2 which shows how we handle bit values. Although each bit can have a bit value of either 1 or 0, the 1s and 0s, can represent small or large decimal values. Let's start off with the single bit shown in Fig. A of diagram 2. If the bit is set low, the decimal, or numeric value of the bit is zero. If the bit is set high the decimal value of the bit is 1. If we want to represent the value 3 we must add another high bit *to the left*, as shown in Fig. B of diagram 2. Since the first bit represents the decimal value 0 or 1, the new bit must represent the values 0 or 2: zero when the bit is low, 2 when the bit is high. The total value of both bits is the sum of the individual bit values. We now have the ability to bit-represent the decimal values 0 (00), 1 (01), 2 (10) and 3 (11). If we add a third bit to the group it must represent a 4 when it is high because the first two bits can represent all the decimal values from 0 to 3. If all three bits are high the bits represent a value of 7—the sum of the bit values 4, 2 and 1. Let's expand the illustration to a full byte—the eight bits shown in Fig. C of diagram 2. Inside each box representing a bit is its decimal value when the bit is high. If the bits are 00101011, as shown in Fig. C of diagram 2, they represent the decimal value 43. (Remember, we read the bit values from right to left). Try working it out for yourself; simply add up the decimal values of all the high bits. What's interesting about a bit-value is that no other combination of bits can sum up to or represent the value 43.

Let's try working out a few problems I created at random. For example, what is the decimal value if the bits represent 10000111. If you say 135 you've got it hacked. If you came up with a different answer work on it a little more. (The bit-value concept is not the easiest thing to understand for newcomers to digital circuits).

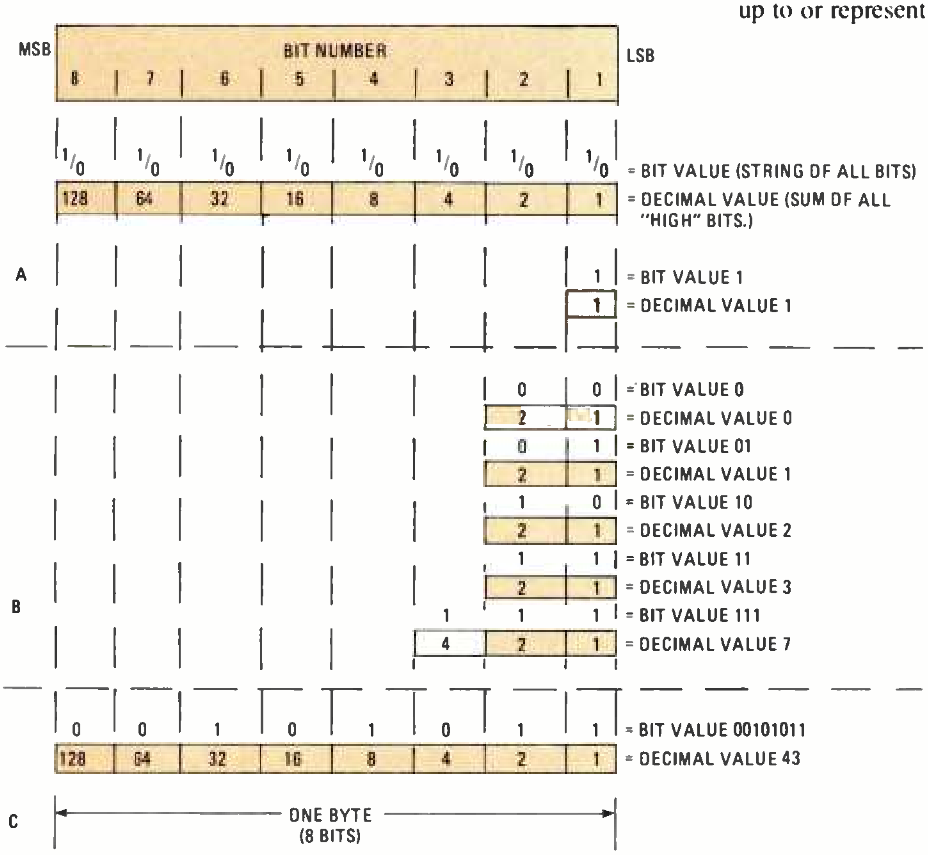


Fig. 2—Assigning each bit in a byte a numeric value and summing the values of the "ON" bits allows us to represent numeric values. For A the value is 1 because the LSB is the only one ON. In B various values (0-7) are created using just 3 bits. The number 43 can be represented as in C.

Fig. 4—The data stream of nibbles (half-bytes) representing the decimal number sequence 135792.Take note that the data stream reads from right to left.

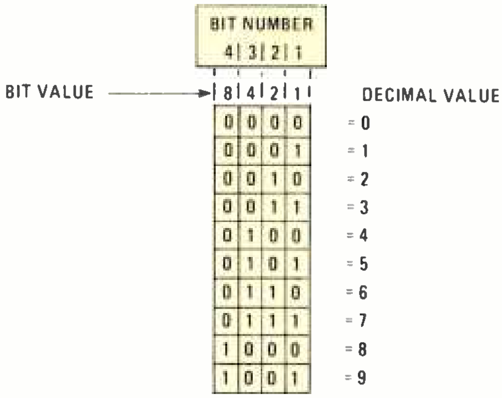


Fig. 3—On digital keypads, such as for alarm systems, only four bits (a nibble) are used to represent numbers 0-9. Note that the values used by such a system are the numeric values, not the ASCII values you would recieve from a computer.

How Are Bits Used?

In modern digital equipment the creation and calculation of bit values and what they represent are handled by hardware specifically intended for a given purpose; for example, a computer's data-entry keyboard with its alphanumeric symbols. In reality, the keyboard usually creates a bit-representation of the keyboard characters for the computer; it is the computer that has been instructed (programmed) to convert a specific bit pattern into a character. For example, assume you're using a teletypewriter terminal to input data into a computer. You want to enter the word HELP so you depress the H, E, L, and P keys. What is transmitted to the computer are four eight-bit (byte-size) groups that represent the ASCII decimal value of each letter or character. In this instance: H = ASCII 72 = 01001000; E = ASCII 69 = 01000101; L = ASCII 76 = 01001100; P = ASCII 80 = 01010000. Why do these bit values represent the letters HELP? Because ASCII means American National Standard for Communications Interface Interchange. Most communications circuits, and most personal computers, will recognize the ASCII values as "standard" characters and symbols.

We don't have to use ASCII, however; we might be using a device that uses a telephone-type decimal keypad for data or control-function entries. Perhaps it's a home burglar alarm that uses a keypad to provide a changeable electronic combination so that you don't have to carry a key around with you. The pad provides a maximum of ten decimal values, 0-9, so we only require four bits to represent each value. Fig. 3 shows the bit representation for 0-9. In microprocessor terminology, four bits is called a *nibble* (two nibbles equal a byte) or a half-byte.

If the system needs six keypad entries to disarm the alarm, we might select a "key code" that required the buttons to be pressed in the sequence 135792. Pressing that series of buttons would produce the data stream shown in Fig. 4 for the alarm's microprocessor (remember, read the bits from right to left). On receipt of that data stream the alarm would be disarmed. If just one entry was wrong the alarm would not disarm. How could we set the key code? By entering a "key-change" code that sets up the microprocessor to accept the next six digits as the key code. For example, assume our alarm's key-change code is the five-digit code 12345. On receipt of 12345 the alarm's microprocessor would wipe out its memory of the old key code and accept the next six digits as the new key code.

Let's look at another example of a bit value. Say you own a user-friendly personal computer, such as the old Radio Shack Model I. It doesn't allow you to inadvertently wipe out hours of effort if you forget something, like failing to close the door of a disk drive, or not having your printer connected. If you goof you get a message on the screen that tells you what went wrong, such as "DISK DRIVE NOT AVAILABLE." or "PRINTER NOT READY." The computer knows of those conditions through a bit value.

Each byte-sized unit of storage in a computer really consists of eight individual bit-storage cells. The computer's internal software might set aside one single byte to indicate partial or overall computer status. As shown in Fig. 5, each bit of a single byte can represent a specific hardware state, just as the bits in Fig. 2 were use to represent the status of a fire detector. Bit 1 is the first disk drive. If the drive is ready, bit 1 is high. Bit 2 is the second disk drive's status. Bit 3 is the status of a third disk drive, while bit 4 is the status of a fourth disk drive. Bit 5 is the printer status: high if the printer is

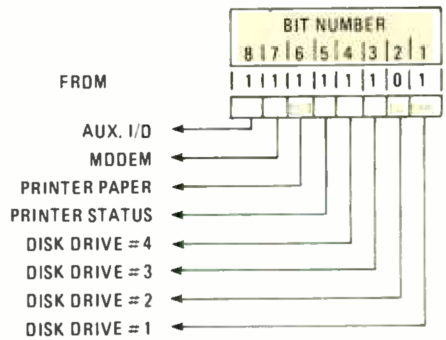


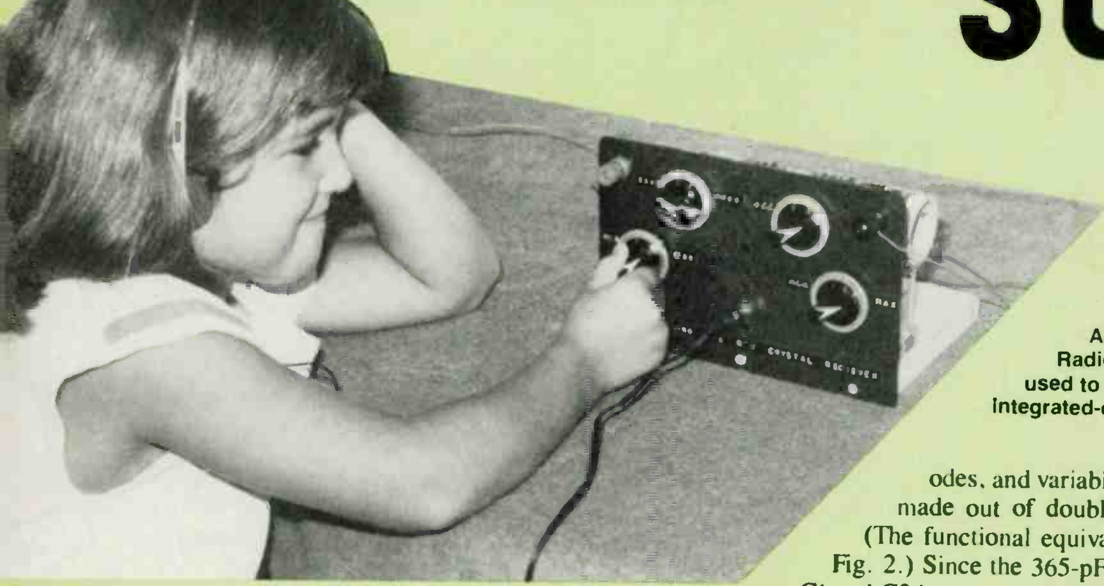
Fig. 5—One byte, consisting of 8 bits, can be used to indicate the status of up to 8 peripherals, devices, or the operating condition. Two bytes could be used to indicate the status of up to 16 devices. The code above would indicate that disk drive number 2 is not availible for use.

turned on; low if it is off. Bit 6 is the printer's paper feeder: high if there is paper; low if the printer is out of paper. Bit 7 is the status of the modem: high if ready; low if not ready. Bit 8 is the status of an auxiliary I/O port; high if an auxiliary peripheral such as a high speed ink jet printer is connected and ready.

If the computer "reads" the status-memory location and sees the bit pattern 1111101 it knows the second disk drive isn't available (maybe the door isn't closed); it stops the computer so it doesn't lock up and flashes the message on the screen: "DISK 2 NOT AVAILABLE." Try one on your own. Suppose the byte's bit pattern is 1101111: What's gone wrong? If you say "The printer is out of paper!" you've got a pretty good grasp of how bit-values work. When the computer reads the pattern it displays the message: "PRINTER IS OUT OF PAPER."

(Continued on page 103)

SUPER



By Homer L. Davidson

Although the Supercharged Crystal Radio looks like the one grandpa used to listen to KDKA, its got an Integrated-circuit output amplifier

☐CRYSTAL RADIOS WERE BUILT BACK IN THE DAYS BEFORE grandpa was old enough to be courting grandma, and yet the crystal radio still provides the same thrill and excitement for the modern generation as it did for our grandparents.

Today, we use a handful of IC's, transistors, resistors, and other hardware to build a radio receiver. Back when grandpa dropped in for a slice of grandma's apple pie, a homebrewed *tuning coil*, a variable capacitor, a piece of *galena* crystal, and an earphone was all that was needed to pick up the local broadcast station.

Today, you can still get the thrill of crystal-radio reception, but without the hassle of literally *fishing* for a station by dragging a fine wire (a *cat's whisker*) across the surface of a crystal.

Supercharged Crystal Radio

Figure 1 shows the circuit for a *Supercharged Crystal Radio* that combines the old with the new. The new consists of a low-power integrated-circuit audio amplifier, fixed diodes, and variable tuning capacitors (C1 and C2) made out of double-sided printed-circuit boards. (The functional equivalent of the circuit is shown in Fig. 2.) Since the 365-pF variable capacitors needed for C1 and C2 have become more expensive than gold—assuming you could locate them—they are synthesized from sections of printed-circuit board: the tuning is done by switches that vary the number of boards in the circuit.

Since grandpa's old 2000-ohm magnetic headphones are similarly expensive and difficult to locate, the integrated-circuit audio amplifier allows you to directly substitute modern low-cost, low-impedance 8-, 16-, 32- and 39-ohm types.

Although the crystal receiver was designed for headphone operation, some local stations may drive a small loudspeaker.

The Radio Circuit

The tapped-coil circuit, consisting of L1–L4, is wound on a section of 2-inch PVC plastic pipe. Separate switches (S1 and S4) tune the antenna and main coils for the whole broadcast band. A plastic front panel and wood chassis are from the old, but not forgotten, yesterdays.

Although the crystal receiver may take a few evenings to build, it's all worthwhile, because it takes you back to the era when radio was at it's best. Each section, such as the chassis, tuning capacitors, coil assembly, and the amplifier *perfboard*

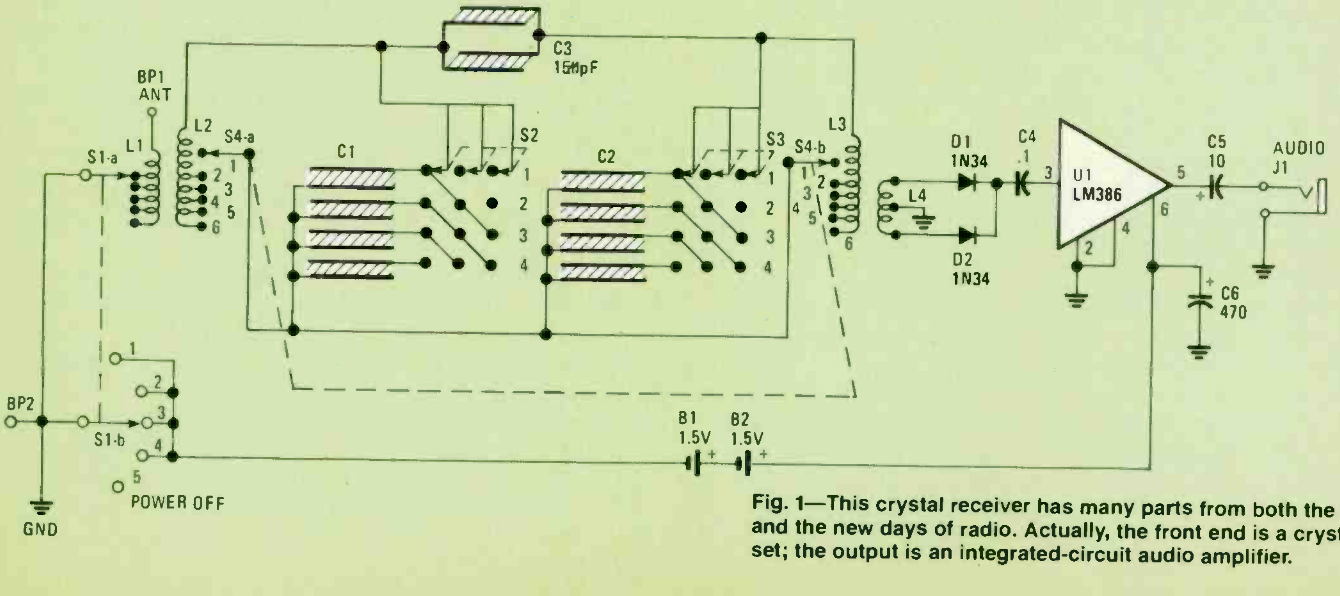


Fig. 1—This crystal receiver has many parts from both the old and the new days of radio. Actually, the front end is a crystal set; the output is an integrated-circuit audio amplifier.

CHARGED CRYSTAL RADIO

Integrated circuits add super-performance to grandpa's crystal radio.

are constructed separately and then wired together. This is a fun project, so let's give it a try.

Construction

In the unit shown in the photographs, the 6 × 9-inch front panel was made from a piece of black plastic salvaged from a discarded stationary holder. But either plastic or a Masonite panel will do. The 6 × 8½-inch wood chassis was cut from a piece of white pine. Leave the wood as it comes—don't paint it. Drill all holes in both pieces before they're fastened together. Push down on the capacitor mounting bolts to dent the wood and mark the mounting holes. Mount the capacitors first, then the four switches.

Making The Tuning Capacitors

Tuning capacitors C1 and C2 are made from four separate double-sided printed-circuit boards cut to 2 × 2-½ inches. (See Fig. 3.) Each 2 × 2½-inch double-sided board has a capacity of 110-pF. The top side of each is wired to the switch assembly. The bottom side of each board is connected to

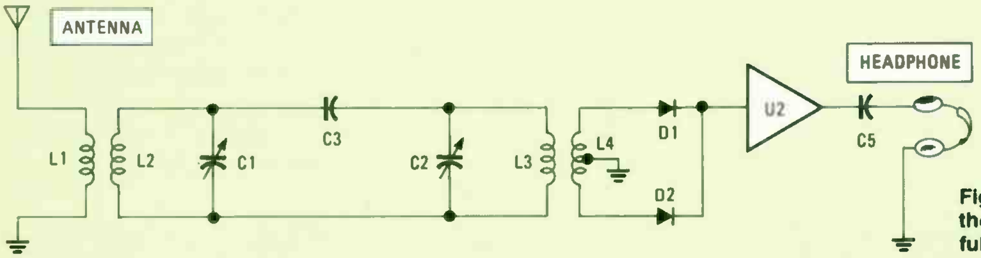


Fig. 2—The tuning circuit itself—without the fancy switching—is a conventional full-wave-rectified crystal radio.

ground. When all four capacitor boards are switched into the circuit, the total capacity is somewhere around 400-pF.

Capacitor C3 couples the signals between coils L2 and L3. It is made from two 2 × 1½-inch printed-circuit boards, each providing 75-pF capacity. When the two boards are wired in parallel the total capacity is about 150-pF.

Lay out the correct dimensions for C1 and C2 on a large piece of double-sided printed-circuit board. Cut out the boards with a metal band, saber, or a hacksaw. Place all four pieces in a vise and trim up the edges with a file or with a bench sander. Stack all four pieces, clamp them in place, and then drill the mounting holes—using a No. 28 drill bit for 6-32 screws—through all four pieces.

Using a pocket knife, ream out the copper foil around each hole on the top and the bottom sides. Just once around will do, because the copper is easy to scrape off. Do not enlarge the hole: take off only the printed copper around the hole. That's to prevent the foil from shorting against the mounting screws and nuts.

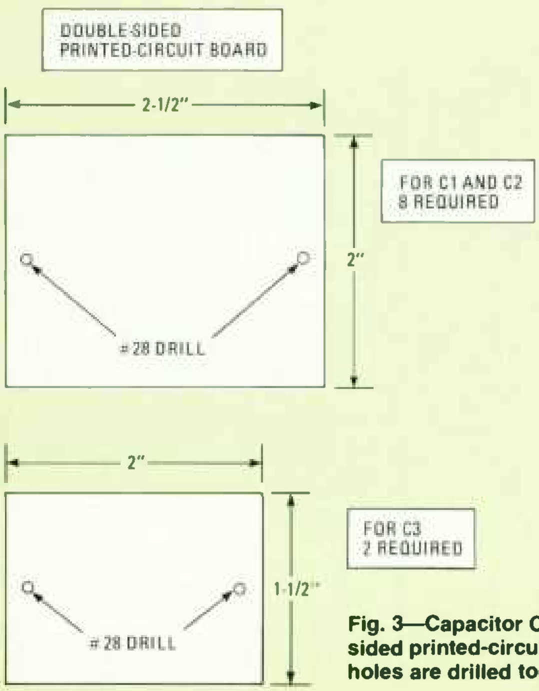
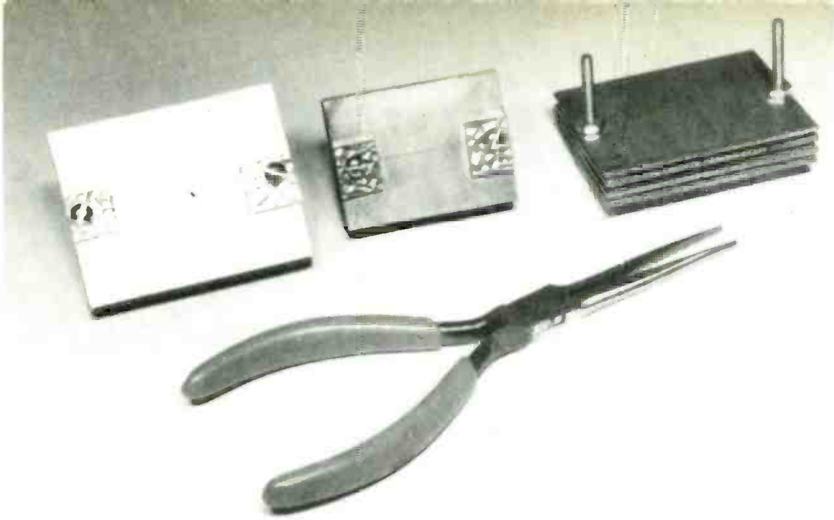


Fig. 3—Capacitor C1, C2, and C3 are made up from double-sided printed-circuit boards. Stack the boards so the mounting holes are drilled together in registration.



The capacitors are easy to make. Cut them out with a saber saw or hacksaw. Smooth out the edges with a file, grinder or sander. Drill the holes in each end with all four pieces held together. Then bolt the printed-circuit sections together.

Four Makes One

The four printed-circuit boards used for C1 (and C2) are held together with two 2-inch/6-32 screws. Place a plastic washer approximately ½-inch in diameter between the boards to insulated them from each other. (You can make washers from a ⅛-inch thick plastic sheet. After drilling the mounting holes, cut out ½-inch square washers.)

Before assembling the printed-circuit boards, solder a 4-inch length of hookup wire to the top copper foil of each board. Solder a 1-inch length of hookup wire to the bottom foil of each board. Stack four printed-circuit boards so that all 4-inch wires are facing up, then slip a plastic washer between the boards at the holes and install the mounting screws and nuts, placing the nuts at the bottom of the stack. (The bottom foil of the bottom board is the ground.) If an ohmmeter is handy, check each topside wire to the ground side to determine whether a short exists between the double-sided board(s). Solder the short 1-inch length of hookup wire to the bottom side of the last printed-circuit board.

Cut out two printed-circuit boards 2 × 1½-inches for C3. Connect a 4-inch hookup wire to the top foil and a 1-inch hookup wire to the bottom foil. Drill holes for two 6-32 screws in each end so the holes will match up during assembly. Ream out the copper on each side of hole as you did for the previous eight printed-circuit boards. Place a piece of plastic on top of the first printed-circuit board and insert plastic washers between the boards. Bolt the two pieces together and place the mounting nuts on the bottom. Check for shorts with the ohmmeter between top and bottom connections.

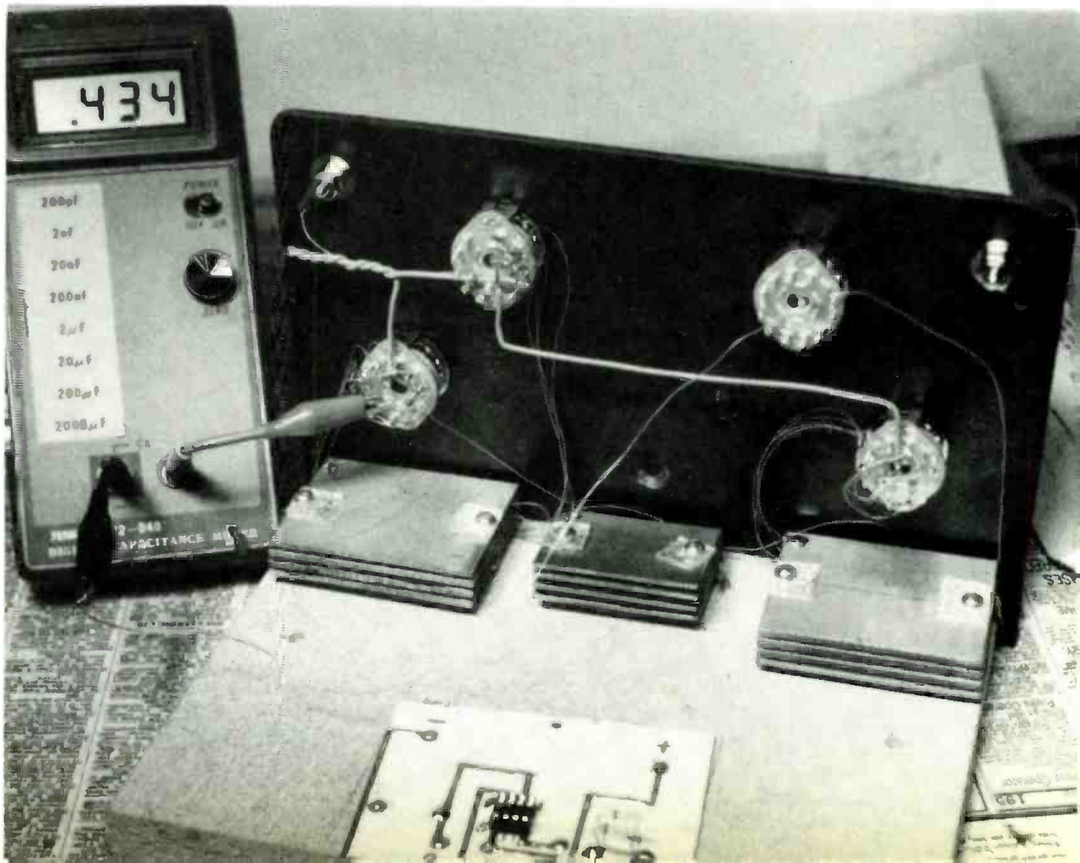
Making The Coils

All coils are close-wound in the same direction on a 2-inch section of PVC plastic pipe. Coils L2 and L3 are similar. First, wind coil L3, which is 110 turns of No. 24 enameled wire. (L3 and C2 selects the broadcast stations.) Begin the first tap after 70 turns; the remaining three taps are at 80, 90, and 100 turns. It's not all that critical so don't worry if a tap is off by a turn or two. (All coil taps can be added as the wire is held in place. Try to place all taps at the top side of the coil assembly.) Snug up the tap wires after each coil is completed. Use the photographs as a guide in positioning the windings on the plastic form.

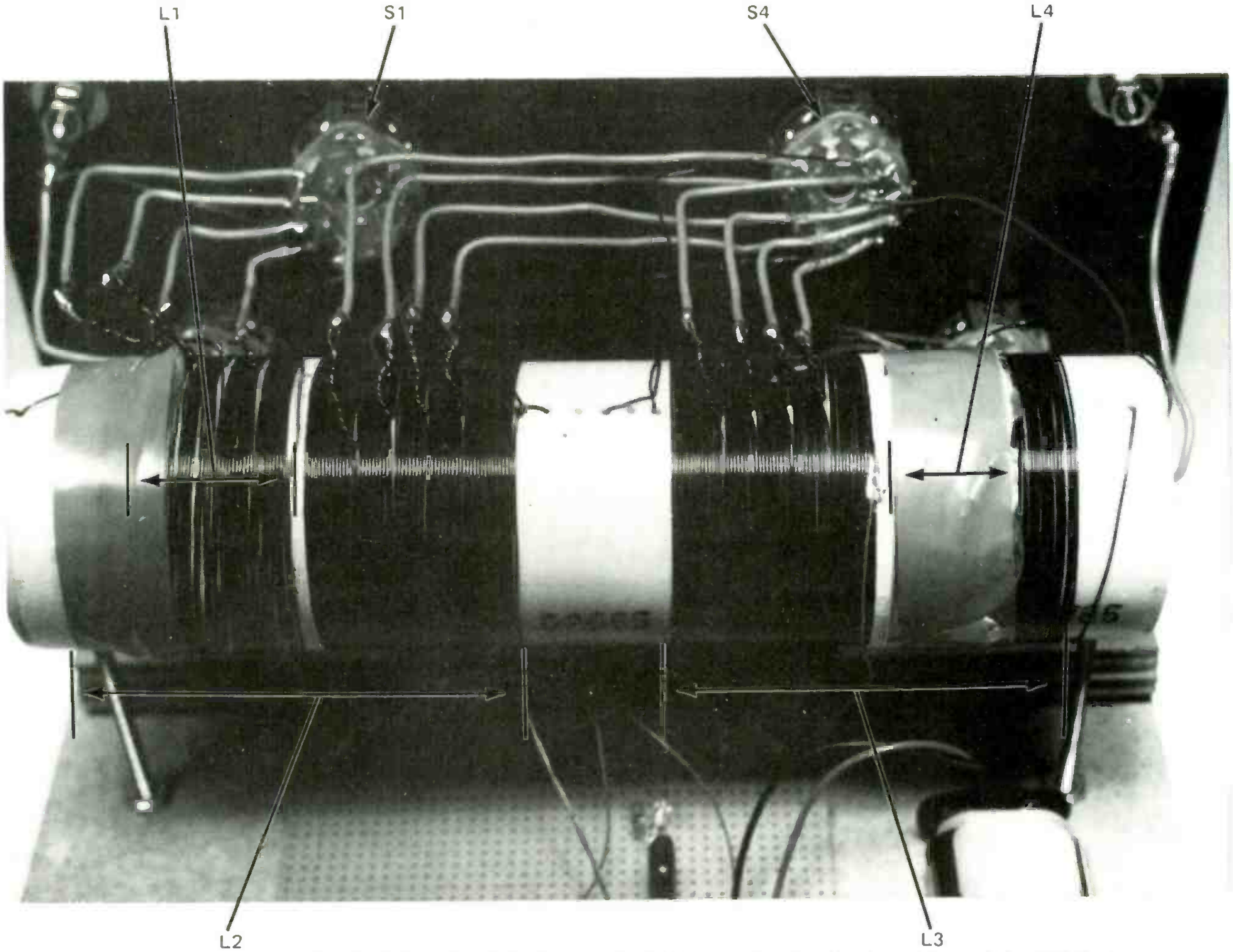
Wind coil L2 1-½ inches from L3. However, keep in mind that L2 is a mirror image of L3, so that the "top" of L2 is adjacent to the "top" of L2. The taps will be positioned correctly if you count them from the outside—the far end—of the winding. Since the positioning on the form of L2 and L3 isn't critical, you could measure the overall length of L3, add the value to 1-½ inches, and use the value as the total distance to start L2 from the "top" of L3. In short, use whatever works—it really isn't all that critical.

Wind coil L4 directly over L3, about ¼-inch from the start of L3. (To start the winding, place a layer of masking tape over L3. L4 can be held in place with masking or Scotch tape.) L4 is a total of 42 turns center-tapped at 21 turns.

To wind L1, place a layer of masking tape over the beginning end of L2. Wind 55 turns of number 24 enameled wire over the end of L2 for the antenna coil (L1). Start the front tap



Connect the capacitor wires to their respective switch terminals. Then check out each connection with the low-ohm range of a VOM or DMM.



All coils are wound on a 7-½-inch length of 2-inch diameter PVC plastic pipe. First, wind L3 and then L2. L1 is wound over the top half of L2 while L4 is placed over the top half of L3. L1 and L4 are secured with tape.

at the 20th turn; then four equally-spaced taps. Use masking or Scotch tape to hold L1 in position. On all coils, leave about four inches of wire to connect to the respective switches. Place the coil assembly on two 3-inch/6-32 bolts.

Scrape the enamel insulation from the coil ends, and to ensure a good connection, tin the wires with solder before soldering them to the switch terminals. Although No. 18 bell-wire was used to tie the taps to the switches, regular solid hookup wire may be used. (Heavy bell-wire gives the crystal receiver an *antique* appearance.) Mount the coil assembly with 3-inch/6-32 bolts and nuts.

Check each coil tap and connection with the low-ohm scale of a VOM or DMM, if handy. That will ensure that the connections are good and on the correct switch terminals. (A small tester is great to check the operating current and voltage, if the receiver doesn't operate when it is fired up for the first time. The total amplifier current may vary from 6.5 to 7 mills.)

The Amplifier Board

The small integrated-circuit amplifier components are mounted on a 3½ × 3-inch prepunched perforated wiring board (perfboard). U1's socket and all component leads are fed right through the holes in the *perfboard*. Bend the small pins of U1's socket over to hold it in place. Connect and solder each part in place as they are mounted. Keep capacitor

PARTS LIST FOR THE SUPERCHARGED CRYSTAL RADIO

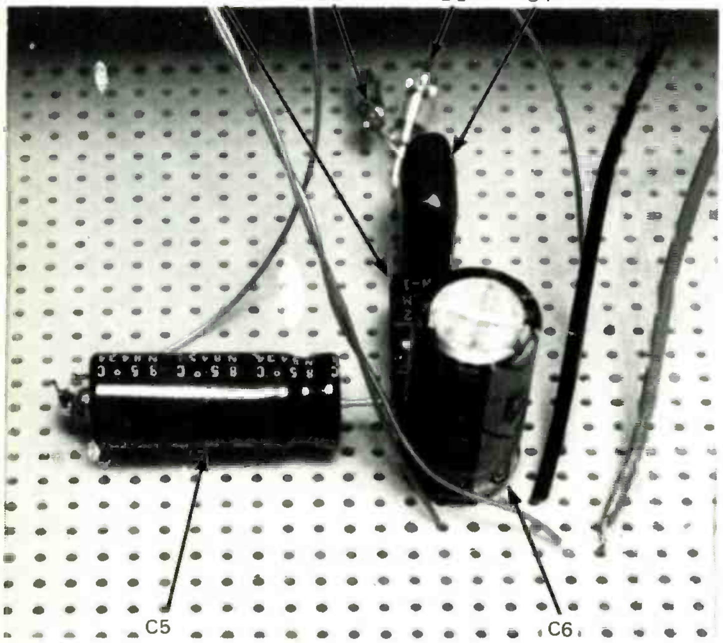
CAPACITORS
C1, C2—Approximately 360-pF, homebrew, see text
C3—Approximately 150-pF, homebrew, see text
C4—0.1-µF, 100-WVDC, Mylar or ceramic disc
C5—10-µF, 35-WVDC electrolytic
C6—470-µF, 35-WVDC, electrolytic

COILS
L1—55 turns #24 enameled copper wire, see text
L2, L3—110 turns #24 enameled copper wire, see text
L4—42 turns #24 enameled copper wire, see text

SWITCHES
S1, S4—2-pole, 6-position rotary (Dick Smith Electronics No. S-6306)
S2, S3—3-pole, 4-position rotary (Dick Smith Electronics No. S-6304)

ADDITIONAL PARTS AND MATERIALS
B1, B2—1.5-volt battery, type AA
BP1—Binding post, red
BP2—Binding post, black
D1, D2—1N34 germanium diode
J1—Jack to match headphones
U1—LM386 integrated-circuit audio amplifier
Plastic front panel, wood chassis, battery holder, IC socket, knobs, wire, solder

U1 D1 D2 C4



The *perfboard* parts are mounted as they are wired into the circuit. Keep the input and output parts on opposite sides of the integrated-circuit amplifier U1 to prevent feedback.

C4 at 90° from C5 to prevent feedback. Make all ground connections as short as possible. U1 isn't placed in its socket until all wiring is complete.

Putting It All Together

After the switches and components are mounted on the front and bottom panels, connect the capacitor plate wires to the correct switch terminals. Do not mount the coil assembly until switches S2 and S3 are wired to C1 and C2. Double check all connections: they should be the same on S2 and S3. Fixed capacitor C3 is wired between coils L2 and L3.

Mount the large coil assembly after c pacitors C1 and C2 are connected to their respective switches. Coil L2 should be directly behind S4. Coil L1 is at the left when looking at the back side of the chassis. Leave position No. 1 of S4a and S4b open. Tie each tap wire of L2 into S4a. Likewise, connect each tap wire of L3 to S4b.

Connect coil L1 to switch S1a. One section of S1 (S1a) is used to switch the antenna coil; the remaining section (S1b) is the power switch. Note that positions 1 through 4 of S1b are wired together. Position 5 is left blank to turn the receiver off.

Twist the two outside leads of L4 and solder them directly to diodes D1 and D2.

Capacitors C1, C2 and C3, the *perfboard* assembly, and a battery holder can be cemented to the wood chassis with a dab of clear rubber silicone cement.

Earphone Selection

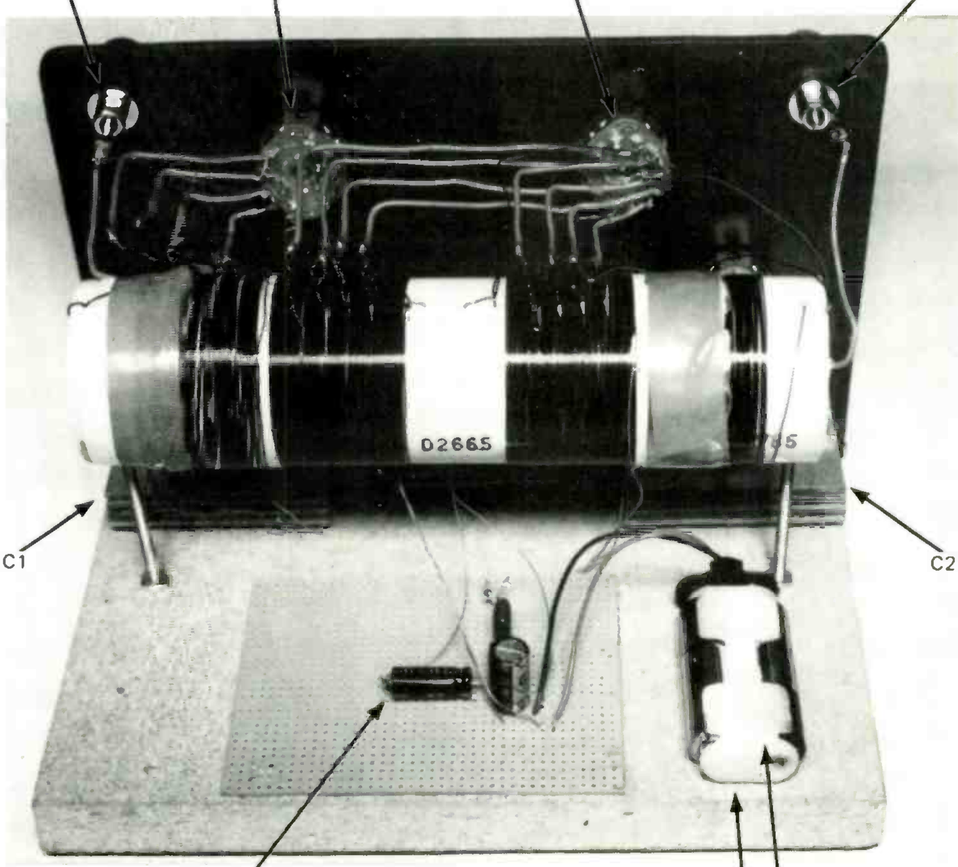
Inexpensive earphones can be used with this crystal receiver. An 8-ohm earphone works directly from the small integrated-circuit amplifier. If low cost stereo phones are used they should be connected in parallel for monophonic operation.

Checkout

Go over the complete wiring at least twice before applying battery power to the receiver. This crystal receiver must have a good ground and antenna before it will operate successfully. Any water pipe connection makes an excellent ground. A 50- to 100-ft. insulated "L" antenna wire will work well. A wire clipped to the metal body of the telephone assembly may also work as the outside antenna.

Set S2 and S3 to the left, or maximum capacity. Then, turn S1 to position 5 (full on). Rotate S4 to pick up a local

BP2 S1 S4 BP1



C1 C2 AMPLIFIER B1, B2

Except for the *perfboard* containing the integrated-circuit amplifier, and the batteries, the radio looks as if it was built *umpteen* years ago.

broadcast station. Extreme clockwise rotation of S4 picks up stations around 1400 kHz, while counter-clockwise adjustment tunes in stations around 550 kHz. After a station is located with S4, turn the other three switches to increase the volume or clear up reception.

Troubleshooting

If the receiver does not operate when fired up, double-check all connections. Make a current measurement to see if the amplifier is operating. Insert the 20-mA DC scale of a VOM or DMM in series with the negative terminal of the batteries: normal current is 6.5 or 7 milliamperes. If the current is above 15-mA, suspect improper connections or a leaky integrated-circuit. (It's possible to obtain a defective new integrated circuit.)

Disconnect L4's leads from D1 and D2 to check out the amplifier. Touch the input to C4 with a screw driver blade and you should hear a hum in the earphones. If not, take voltage measurements on U1. Be careful not to short out the terminals. Very low voltage measurements may indicate a leaky U1. Check the wire connections at the earphone jack. One may break off when connected to the earphone jack. You should hear a click in the earphones when the receiver is turned on.

When the amplifier has a hum and voltages are normal, suspect improper wiring in the front end. Re-connect the wires to D1 and D2. Inspect each switch assembly for a broken wire. Sometimes the wires break off at sharp ends or you may have a poorly-soldered connection. If a station is tuned in intermittently, clean up the switch contacts or check for a poor soldered connection. A good visual check usually finds the problem.

Dress Up The Front Panel

After the crystal set starts picking up several stations, mark each switch knob with white slip-on letters or tape labels to simplify operation. Mark S4 with both ends of the broadcast band. Mark S1's *power off* position.

Dress up each knob with a circle of plastic under each knob. Drill out four 2-inch diameter pieces with circle cutter from a ¼-inch piece of plastic. Sand down all rough edges. Spray each plastic circle with chrome or silver paint. Cement each circle to the plastic knob with clear epoxy cement and allow for curing time. A dab of enamel paint here and there will add a bit of class.

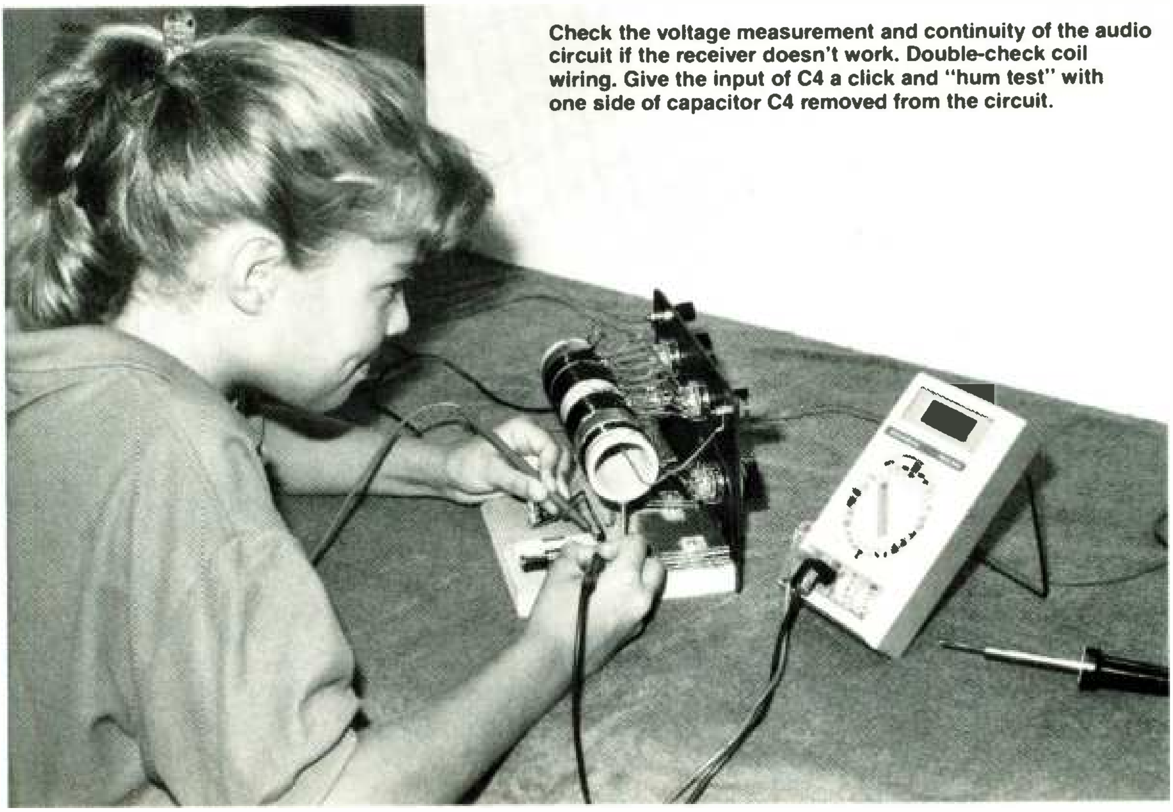
Things to Do and Don't

Do check each wire lead with an ohmmeter as you tie and solder it to the coil and switch terminals. Be sure to scrape off the enamel coating from the coil terminals and taps. Check all three switch connections on S2 and S3, and make sure the three terminals are soldered together. Twist the two outside leads going from L4 to the input terminals of diodes D1 and D2. Do the same for the hookup wire going from jack J1 to capacitor C5 and ground.

Do not use acid-core solder for electronic connections; use only rosin-core solder. Do not insert integrated circuit U1 in its socket until all the wiring is completed.

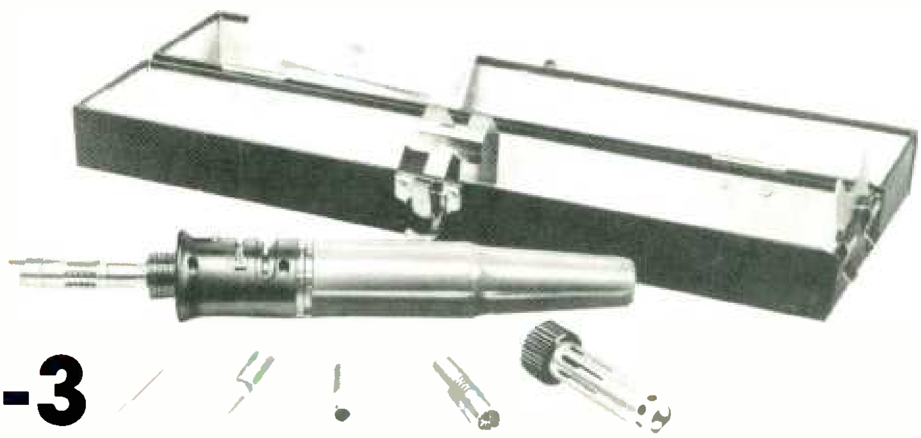
Do use a pair of long nose pliers as a heatsink when soldering D1 and D2 into the circuit. Do go over the schematic diagram and wiring at least once to check out the wiring. Do visually inspect all IC pins for correct seating in their socket.

And, most of all, do enjoy tuning the AM band with the new and old crystal receiver. ■



Check the voltage measurement and continuity of the audio circuit if the receiver doesn't work. Double-check coil wiring. Give the input of C4 a click and "hum test" with one side of capacitor C4 removed from the circuit.

HANDS-ON REPORT



Ultratorch-3

A gas-powered soldering iron, flameless heat gun, and mini-torch you can carry to any job—in your pocket

IF YOU HAVE EVER BEEN 50-FEET OFF THE GROUND TRYING to repair soldered antenna connections, you know how fast a battery-powered soldering iron poops out. If you have ever tried to heat shrinkable tubing buried in a multi-wire cable with a match (who can afford a heat gun?), you know how fast the insulation on adjacent wires will burn before the shrink-tubing shrinks. And if you have ever had to heat rusted antenna or mobile radio connections in order to loosen the mounting hardware and fittings, you know it can be an almost impossible task with conventional test-bench tools.

But the recently introduced *Ultratorch-3* can handle all these jobs and more, because it's specifically intended for modern electronic installation and service problems.

A Fat Pencil

The Ultratorch-3 is a butane-powered 3-in-1 tool that's about the size of a fat soldering pencil. Unlike other gas-powered soldering devices and torches that *spit* fire and flame, the Ultratorch-3 uses the *catalyst* principle for the soldering and heat-gun functions. A catalyst works like the *mantles* used for gas-operated camping lamps and heaters, or any other gas device that must avoid an open flame. The *burn* is strictly confined to the honeycomb catalyst device, which is inside the soldering and heat-gun nozzles. The developed heat is infrared—very hot—and with the gas pressure pushing through the mantle an intense hot air flow is generated, which can be used to heat a soldering tip.

A special shield for the heat gun nozzle allows you to heat shrinkable tubing without damaging adjacent wires.

Although there is intense heat within the catalyst's honeycomb, there is no flame even within micro-inches of the mesh itself.

The handle contains an on-off gas valve and a separate gas-flow (heat) control. A third control operates a sliding shield at the tip that chokes the ignition flame after the catalyst heats (a few seconds).

Three kinds of tips are available: soldering, heat gun, and torch. Soldering tips come in several sizes and shapes, which provide everything from micro-heat for printed-circuit board repairs, to the high-heat needed when trying to solder to a large metal area, such as an antenna element or a #10 mobile power cable.

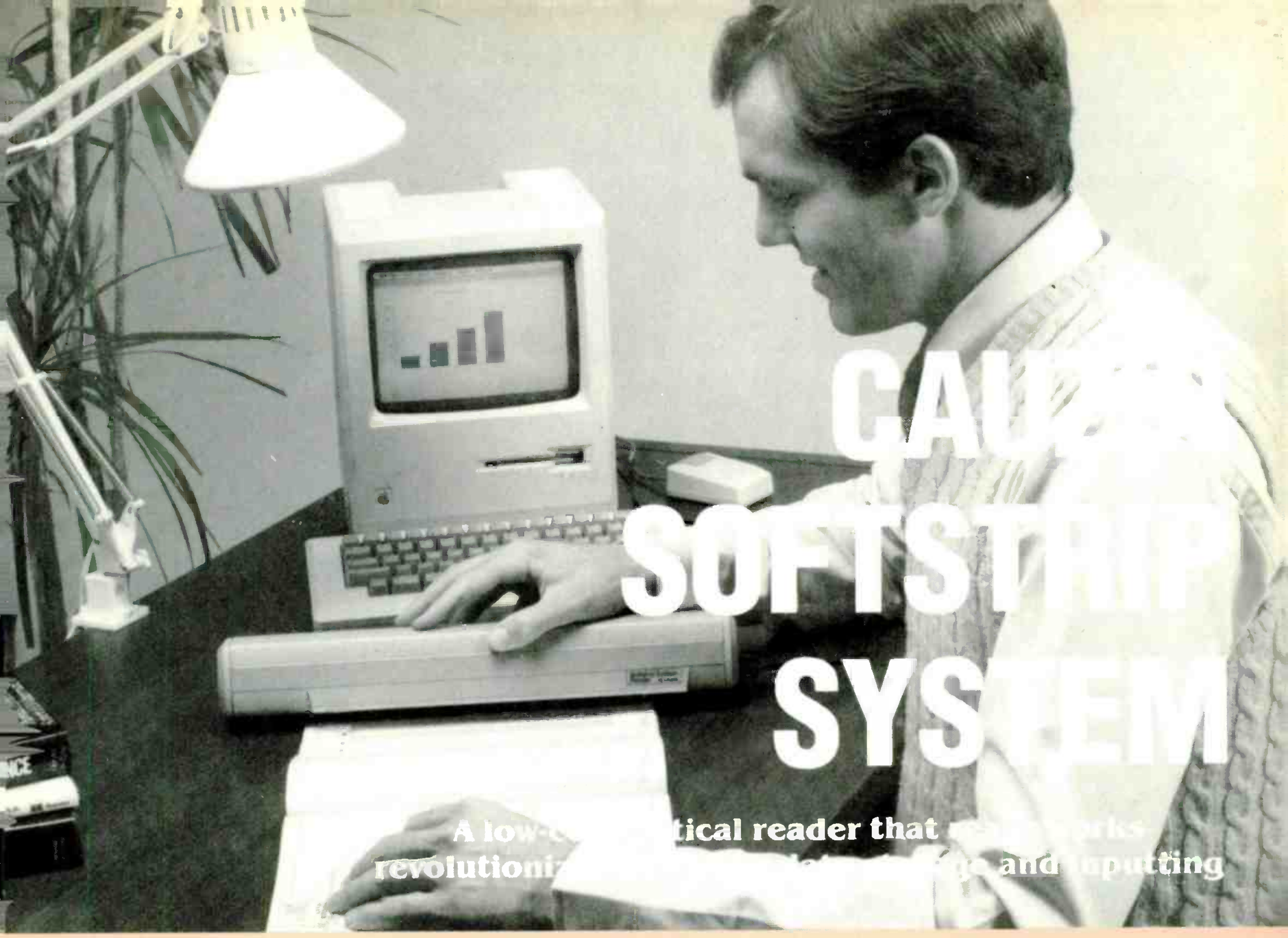
A hollow tip functions as a small heat gun having a pattern about ¼-in. in diameter. The concentrated beam of flameless heat can be used for heating components when troubleshooting intermittent electronic circuits, or it can be used to heat the larger sizes of shrinkable tubing. A special heat-shrink accessory that clips on the end of the hollow tip restricts the heat to a narrow area so that adjacent wires and connections aren't burned or damaged.

Finally, a torch tip delivers a narrow beam of concentrated flame, which can be used for silver and lead soldering, repairs, or for *busting* rust-encrusted or weathered hardware; such as antenna clamps, mobile antenna mounts, and acid-damaged wet-cell battery clamps.

Conventional Fueling

The Ultratorch-3 uses conventional cigarette-lighter butane: the stuff available at most hardware and houseware stores. The fueling is done the same way as for a cigarette lighter: You simply press the butane canister's nozzle against a valve located at the rear of the Ultratorch-3's handle; the torch is full when the hissing-noise caused by the fuel transfer

(Continued on page 105)



By Jeff Holtzman

FROM MARCONI'S FIRST FEEBLE TRANSmissions to the latest in satellite transmissions, no aspect of our lives has been so affected as the way in which we communicate with each other.

In actual fact, communications have always been the pathway for great advances in civilization. When the ancient Egyptians invented papyrus, communication took a huge step forward. No longer was information destined to be chiseled in stone, at great cost in both time and materials. Anyone capable of dipping a pointed stick in some kind of ink could record his thoughts for all time. In addition, papyrus made it feasible for scribes to copy the original, so that information could be shared or securely stored.

For thousands of years, first papyrus, then paper has been the primary means of communication, and many far-reaching social, political, economic, and even religious changes have been brought about by changes in the technology of paper—the way in which it is made, and the way that communications are imprinted on it.

But even after papyrus was invented, mankind was far from satisfied with the tremendous amount of manual labor still required to produce a single document, much less copies. It took several thousand more years before Johann Gutenberg mechanized the process of manufacturing type in the 1400's, thereby making it possible to bring the printed word to the masses.

The printing process changed very little for 500 years, but today, because of electronic computers, the publishing of books, magazines, newspapers, advertising, etc., has become almost unimaginably fast and inexpensive. At the same time, and also because of electronics, wholly new forms of communication have developed, including radio, television, and telephone, among others. And computers, of course, are largely responsible for the overall functioning of the global communications networks we have set up.

The End of Paper?

Ever since the personal computer brought computer power within the reach of anyone who needed it, proponents of purely electronic communications have predicted that paper was approaching the end of its useful life as a means of communication. After all, it's much easier to spend half an hour watching the evening news than to read a newspaper. In addition, the electronic media can also provide a sense of realism that paper cannot, and the electronic media can provide instantaneous communications that paper cannot. Last, it was prophesied that offices would be able to get out from under the mountain of paper beneath which they were being buried.

On the other hand, you can't halt a television broadcast temporarily to get a cup of coffee, answer the door, etc. (You could tape the news with a VCR, but few people bother because it's always possible to pick up a later broadcast.) Nor can you conveniently clip an electronic broadcast to save for future reference. Furthermore, people like the hands-on interaction with paper, so that they can mark interesting passages, re-read others, clip coupons, etc. And no special viewing equipment is ever required. Last, due to the ease of creating and modifying new kinds of reports, *more* paper is generated in the office because of computers, not less.

So regardless of what the prophets of paper-doom say, paper is still a thriving means of communication. And one company to recognize that fact, while simultaneously understanding the efficiency of electronic communications, has brought the oldest means of communication together with the newest in a marriage that will benefit us all.

The Cauzin System

Most people are familiar with bar codes. If you've ever been to a supermarket where the cashiers don't punch in a price for each item, but instead whisk each item past an optical reader system—then you've seen bar codes. The Cauzin *DataStrips* are similar in some respects, but greatly superior overall, to bar codes. They're superior because *DataStrips* provide high reliability and high-data density, and because they can be the means of distributing many kinds of information.

Such as? Anything from plain text, to computer programs, to financial data, to graphics images, to electronic music scores—anything that can be represented as eight-bit bytes—can be encoded, reproduced, and distributed in *DataStrip* form.

How it Works

A Softstrip Reader is shown among the photographs, and a Softstrip *DataStrip* is shown in Fig. 1. The Reader measures about 16½-in. × 3-in. × 2½-in. and weighs less than a pound. Inside the lightweight plastic case is a high-tech package of mechanical, optical, and electronic systems all working together to provide a very inexpensive yet highly reliable means of transferring data in digitally-encoded form.

The mechanical dimensions of a *DataStrip* are shown in Fig. 2. The maximum length of a *DataStrip* is about nine inches; the minimum length is well under ½-in. As shown in Fig. 3, a *DataStrip* is composed of seven distinct areas.

Rotating Reader

The reader has a system of eight rotating lenses that read the data strips according to the commands of an internal microprocessor that automatically senses and compensates for strips of different densities. All internal reader functions and communications with the outside world are controlled by a microprocessor and a custom VLSI (*V*ery *L*arge *S*cale *I*ntegration) integrated circuit.

Each line of a *DataStrip* is scanned at least four times; the area where each scan is taken is a rectangle that measures about 0.003 in. × 0.004 in. After each scan the reader's "truck" moves down the strip 0.0025 in. The height of a line of data in a high-density *DataStrip* may be as little as 0.010 in.; a low-density strip may have a maximum height of 0.040 in.

The strips themselves are highly reliable. In fact, you can crumple them up, spill coffee on them, even write on them, and still be able to read them. The reason is that the Softstrip system works by bouncing infrared light off a *DataStrip*,

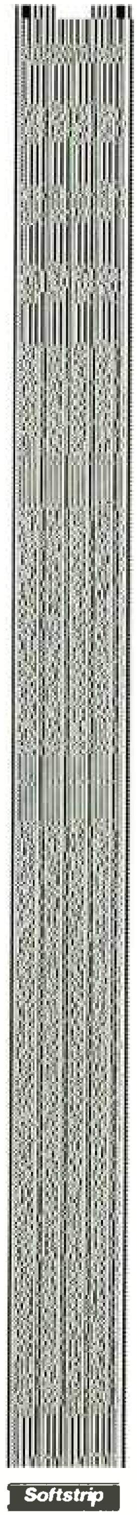


Fig. 1—This *DataStrip* represents what is perhaps the most famous speech made in the history of mankind. It took the orator several minutes to deliver the speech. The Softstrip system can read it in less than 30-seconds. Take it to a Cauzin dealer to find out what goodies are concealed in the dots and blobs.

The pencil points to the small window in the "truck" that sweeps over the *DataStrip* and does the actual reading of the printed pattern.

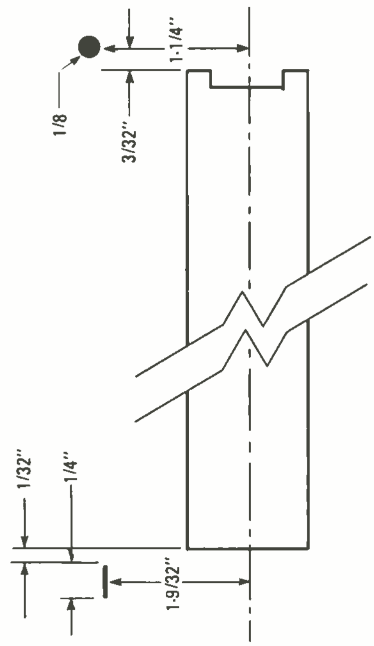


Fig. 2—Regardless of its overall size, a *DataStrip* contains a precisely positioned dot and a short bar, which are used to position the reader.

and carbon in the ink reflects that light. Coffee stains (and many others) are transparent to infrared light.

Making Strips

Low-density DataStrips can be produced by anyone with an Epson FX or RX-series printer. A computer club, for example, could print programs in *DataStrip* form, photocopy the DataStrips, and distribute the copies to members, where they could, in the pri-

(Continued on page 106)

By David A. Ward

COMPUTER-CONTROLLED VOICE SYNTHESIZER

Give your computer a voice— then sit back and listen to what it has to say.

MOST PERSONAL-COMPUTER OWNERS HAVE SPENT TIME talking to their machines—mostly using a rich assortment of less-than-complimentary words to describe its operation. And after having *mastered the beast*, every owner (myself included) seems to derive great satisfaction from hooking peripheral devices like printers, plotters, modems, etc., to their machines and watching them (under program instruction) *do their thing*.

However, one of the most interesting peripheral devices—the speech processor—has somehow been overlooked, at least as far as the home computerist is concerned. Speech-processor modules have been around for quite some time, and have been incorporated into things like medical-monitoring equipment, banking machines, security devices, and so on. But unlike most other computer add-ons—whose prices have dropped significantly—speech processors remain priced beyond the means of the average hobbyist; that is, until now. With just a handful of readily available components, a little patience, and a touch of *electronic magic*, you can build this *Computer-Controlled Voice Synthesizer*, add it to your computer system, and let the machine do the talking for a change.

Let's Talk Basics

The Voice Synthesizer, built around General Instrument's SP0256-AL2 speech processor, can be used to prompt the computer user and/or provide feedback. A pinout diagram of the SP0256-AL2 is shown in Fig. 1. You need only to add a +5-volt DC power supply and a few support components to that 28-pin LSI DIP unit to build the complete Voice Synthesizer.

The chip contains a software-programmable digital filter, a microcontroller, a pulse-width modulator, and a 16K ROM for program and data storage. The ROM contains 64 allophones or sounds used in the English language, which are used to form words. The ROM also contains five pauses that are used to separate words and clarify the speech output. The booklet supplied with the chip contains a list of the allophones, the addresses where they are stored, and a "dictionary" of common words showing how they are addressed.

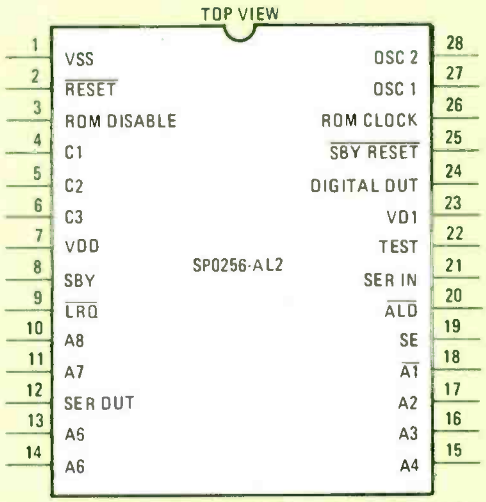


Fig. 1—The pinout diagram of the SPO256-AL2 speech synthesizer will assist you in wiring the project.

For example, in the "dictionary," the word *four* is spelled as "FF FF OR." The address for the "FF" sound is listed as 050 (octal) and the"OR" sound is listed as 072 (octal). Then each octal address must first be converted to its decimal (base 10) equivalent and then PRINTed to the parallel printer port.

Since 050 (octal) is equal to 40 (base 10) and an octal 072 is the equivalent of 58 (base 10), the word *four* would be output from the computer as: 40, 40, and 58. A list of the allophones, along with their addresses (in decimal form), is given in Table 1. Because the SPO256-AL2 uses allophones, it is possible to program just about any word imaginable.

There are two possible modes of addressing the SPO256-

TABLE 1—ALLOPHONES

ADDRESS	EXAMPLE		DURATION	ADDRESS	EXAMPLE		DURATION	ADDRESS	EXAMPLE		DURATION
0	PA1	Pause	10mS	22	UW1	To	100mS	43	ZZ	Zoo	210mS
1	PA2	Pause	30mS	23	AO	Aught	100mS*	44	NG	Anchor	220mS
2	PA3	Pause	50mS	24	AA	Hot	100mS*	45	LL	Lake	110mS
3	PA4	Pause	100mS	25	YY2	Yes	180mS	46	WW	Wool	180mS
4	PA5	Pause	200mS	26	AE	Hat	120mS*	47	XR	Repair	360mS
5	OY	Boy	420mS	27	HH1	He	130mS	48	WH	Whig	200mS
6	AY	Sky	260mS	28	BB1	Business	80mS	49	YY1	Yes	130mS
7	EH	End	70mS*	29	TH	Thin	180mS*	50	CH	Church	190mS
8	KK3	Comb	120mS	30	UH	Book	100mS*	51	ER1	Fir	160mS
9	PP	Pow	210mS	31	UW2	Food	260mS	52	ER2	Fir	300mS
10	JH	Dodge	140mS	32	AW	Out	370mS	53	OW	Beau	240mS
11	NN1	Thin	140mS	33	DD2	Do	160mS	54	DH2	They	240mS
12	IH	Sit	70mS*	34	GG3	Wig	140mS	55	SS	Vest	90mS*
13	TT2	To	140mS	35	VV	Vest	190mS	56	NN2	No	190mS
14	RR1	Rural	170mS	36	GG1	Got	80mS	57	HH2	Hoe	180mS
15	AX	Succeed	70mS*	37	SH	Ship	160mS	58	OR	Store	330mS
16	MM	Milk	180mS	38	ZH	Azure	190mS	59	AR	Alarm	290mS
17	TT1	Part	100mS	39	RR2	Brain	120mS	60	YR	Clear	350mS
18	DH1	They	290mS	40	FF	Food	150mS*	61	GG2	Guest	40mS
19	IY	See	250mS	41	KK2	Sky	190mS	62	EL	Saddle	190mS
20	EY	Beige	280mS	42	KK1	Can't	160mS	63	BB2	Business	50mS
21	DD1	Could	70mS								

*These sounds may be coupled together with themselves to lengthen their duration if needed.

AL2: mode 0 and mode 1. In mode 0, the SE (strobe enable) line, pin 19, is held low, thereby disabling the $\overline{\text{ALD}}$ line, pin 20. That causes the speech processor to latch onto an address when any one or more of the address lines makes a high-to-low transition. In mode 1, the SE line, pin 19, is tied high so that the SPO256-AL2 does not latch onto an address until pin 20 ($\overline{\text{ALD}}$) is pulled low. Our circuit is designed to operate in the mode-1 configuration, so pin 19 (strobe enable) is tied to the +5-volt supply rail.

Circuit Operation

Figure 2 shows the complete schematic diagram of the circuit that turns your computer into a regular *chatterbox*. The allophone addresses are fed to the speech processor through card-edge connector CE1, which is connected to the 8 address lines (pins 11, 10, 13–18) of the speech processor, U1. When there's a valid address on the address lines, the computer's STROBE line—which is connected to pin 20 ($\overline{\text{ALD}}$) of U1—pulses low. That low causes the address to be loaded into U1's input buffer, forcing pin 9 to go high. The high on pin 9, which is connected to the computer's BUSY input, puts the computer on hold: The loaded address then causes an allophone to be retrieved from U1's internal ROM, processed, and output at pin 24.

The output signal is then fed through a low-pass filter to the non-inverting input of U2 (an LM386 audio amplifier), which provides sufficient drive for speaker SPKR1. When the speech processor's input buffer is emptied, the $\overline{\text{LRQ}}$ line (pin 9) once again goes low. At that point, another address is loaded into the U1's input buffer and the process is repeated.

The author used parallel interfacing to connect the SPO256-AL2 to the parallel-printer port of his Kaypro 2X computer. The LPRINT command in BASIC automatically takes care of the handshaking signals and makes programming the SPO256-AL2 very simple. As you experiment with the SPO256-AL2, you'll see that your software is the key to its successful operation.

The sample program shown in Table 2—which causes the Voice Synthesizer to say "*testing, one, two, three, four*"—is provided to test the operation of the circuit. The main problem with programming the circuit is preventing the carriage return and line-feed signals from reaching the SPO256-AL2, causing it to make unwanted sounds.

In the sample program, unwanted sounds are eliminated until the end of the program by placing pauses after the last word in the data line. If the circuit begins to make unwanted sounds, it probably needs to be reset—either by turning off the power supply or by momentarily placing a low on pin 2, the $\overline{\text{RESET}}$ line.

Potentiometer R8 is the volume control for the amplifier, and adjusting it can make a difference in the clarity of the output. The circuit's output is a slightly robotic-sounding voice; therefore, some people will need to hear several words and have them explained before the words can easily be understood.

Power for the circuit is provided by a handful of additional components. AC power is fed to stepdown transformer T1, as shown in the schematic diagram in Fig. 3. Then the 6.3-volt secondary voltage is rectified by BR1, a 50-volt, 0.5-ampere bridge rectifier, fed across filter capacitor C13, and regulated to 5-volts by U3. After further filtering by C14, the voltage is used to power the Voice Synthesizer. R10 serves as a dropping resistor for power-on indicator LED1.

Circuit Board Construction

The author's prototype Voice Synthesizer was built on two printed-circuit boards: one for the synthesizer circuit (Fig. 4) and the other for the power supply (Fig. 5). The layouts may be copied from the page and used to etch your own printed circuits. Once the boards are prepared, you can stuff them according to the parts-placement diagrams in Fig. 6 and Fig. 7—the synthesizer and power-supply board layouts, respectively.

First install IC sockets for U1 and U2: Besides acting as

Fig. 2—This schematic diagram of the Computer-Controlled Voice Synthesizer needs only to be combined with a +5-volt regulated supply.

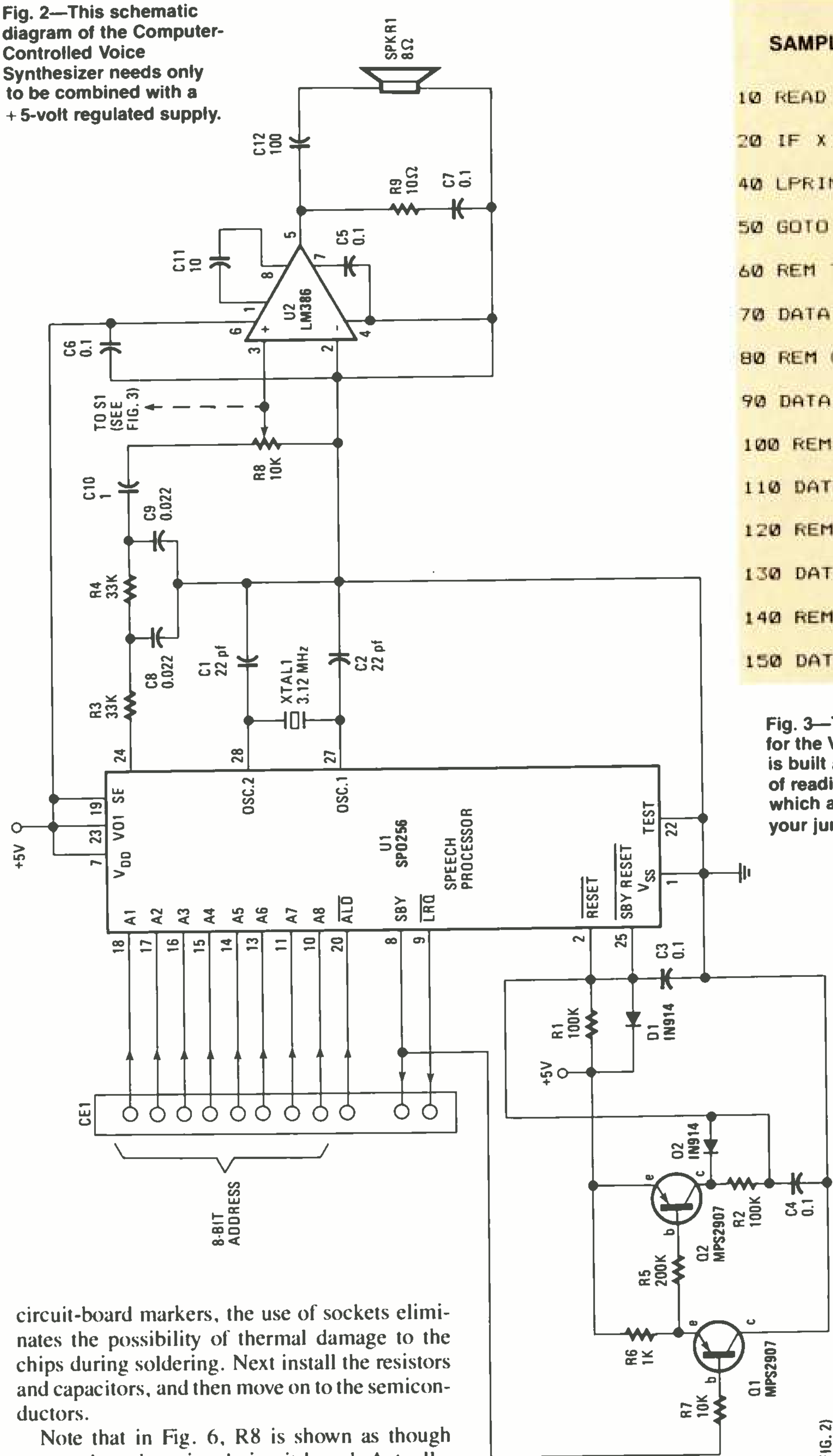
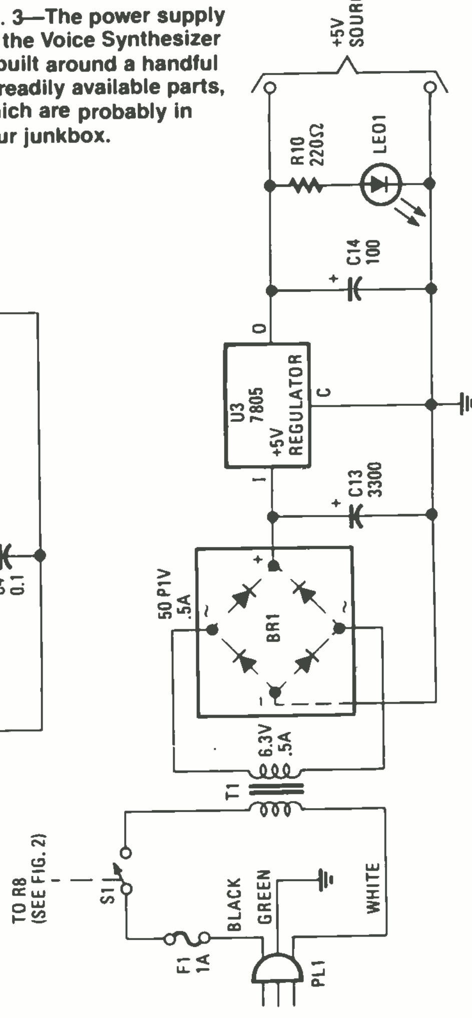


TABLE 2
SAMPLE PROGRAM IN M-BASIC

```
10 READ X
20 IF X = 100 THEN END
40 LPRINT CHR$(X);
50 GOTO 10
60 REM TESTING
70 DATA 13,7,55,2,13,12,44,4,4
80 REM ONE
90 DATA 46,15,15,11,2
100 REM TWO
110 DATA 13,31,2
120 REM THREE
130 DATA 29,14,19,2
140 REM FOUR
150 DATA 40,40,58,4,4,4,4,4,4,100
```

Fig. 3—The power supply for the Voice Synthesizer is built around a handful of readily available parts, which are probably in your junkbox.



circuit-board markers, the use of sockets eliminates the possibility of thermal damage to the chips during soldering. Next install the resistors and capacitors, and then move on to the semiconductors.

Note that in Fig. 6, R8 is shown as though mounted on the printed-circuit board: Actually, provisions have been made for both on-board and off-board installation of R8 through the extra (unused) solder pads. The author used a switched audio-taper potentiometer mounted to the front

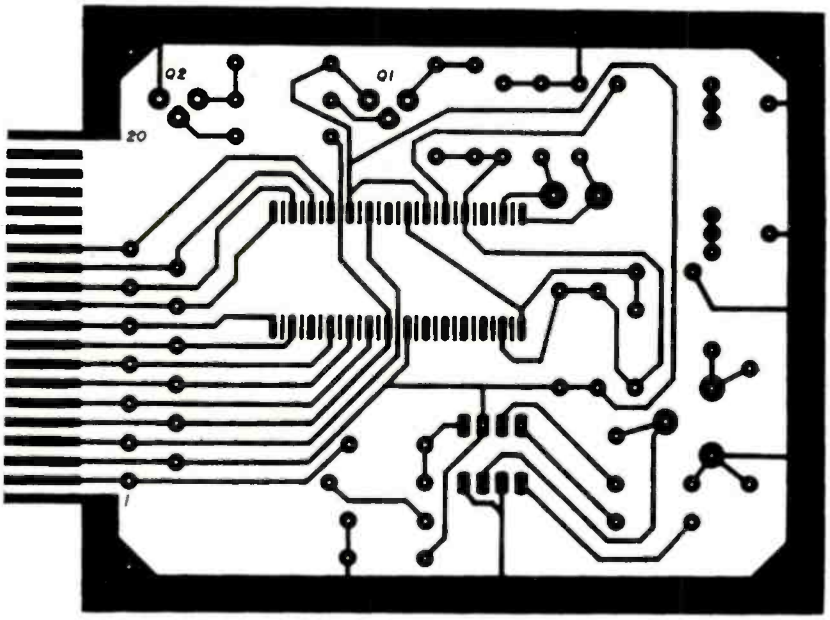


Fig. 4—This full-scale printed-circuit foil template of the Voice Synthesizer board can be copied from the page and used to etch your own printed circuit.

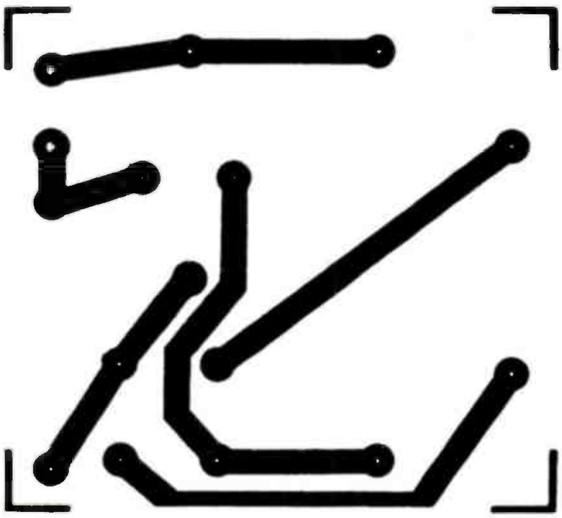


Fig. 5—The power-supply board for the Voice Synthesizer is a really simple circuit: Although the author provided this printed-circuit layout, the power supply might just as easily be built on perfboard or even hard-wired to a barrier strip.

panel of the enclosure (see photos) to handle both the on/off and volume-control functions.

Resistor R10 (see Fig. 7) is tack-soldered to LED1's anode lead, the LED mounted to the front panel, and connected to the output of the power-supply board through hookup wire.

Once the two boards are completely populated, check for cold solder joints, solder bridges, misoriented and mispositioned components, and so on. If all appears correct, put the two boards to one side, and prepare the cabling that will connect the Voice Synthesizer to your computer.

Cable Preparation

Table 3 shows the cable connections used by the author for his Kaypro 2X, which uses a Centronics-type connector. First wire up card-edge connector CE1 as indicated and terminate the other end of the data cable in a suitable connector for

Note: Address lines A7 and A8 can be tied to ground, since there are only 64 allophones to be addressed. Also, the speaker connection and SBY (card-edge pin 2 and pin 5, respectively) do not connect to the Centronics connector. And as indicated, the supply voltage can provided via Centronics connector from the computer or from an external power supply.

PARTS LIST FOR THE SPEECH SYNTHESIZER

SEMICONDUCTORS

BR1—Bridge rectifier, .5-A, 50-PIV or better
D1, D2—1N914, small-signal, silicon diode
Q1, Q2—MPS2907 PNP, silicon AF preamp/driver transistor
U1—SPO256-AL2 speech processor, integrated circuit (Radio Shack #276-1784 or equivalent)
U2—LM386 op-amp, integrated circuit (Radio Shack #276-1731 or equivalent)
U3—7805, 5-volt, 1-A regulator, integrated circuit
XTAL1—3.12-MHz crystal

RESISTORS

(All fixed resistors are ¼-watt, 5% units)
R1, R2—100,000-ohm
R3, R4—33,000-ohm
R5—200,000-ohm
R6—1000-ohm
R7—10,000-ohm
R8—10,000-ohm trimmer or audio-taper potentiometer (see text)
R9—10-ohm
R10—220-ohm

CAPACITORS

C1, C2—22-pF, ceramic disc
C3–C7—0.1-µF, ceramic disc
C8, C9—0.022-µF, ceramic disc
C10—1-µF, 16-WVDC, electrolytic
C11—10-µF, 16-WVDC, electrolytic
C12, C14—100-µF, 16-WVDC, electrolytic
C13—3300-µF, 16-WVDC, electrolytic

ADDITIONAL PARTS AND MATERIALS

F1—Fuse, 1-A, 3AG
PL1—Three-conductor power cord with molded plug
S1—SPST switch (part of R8)
T1—Stepdown power transformer, 117-volt primary, 6.3-volt secondary
Printed-circuit material or 44-pin edge-card board, DIP sockets (8 and 28 pin), 44-pin edge-card connector, 8-ohm speaker (1½-inch), hardware, enclosure, wire, solder, etc.

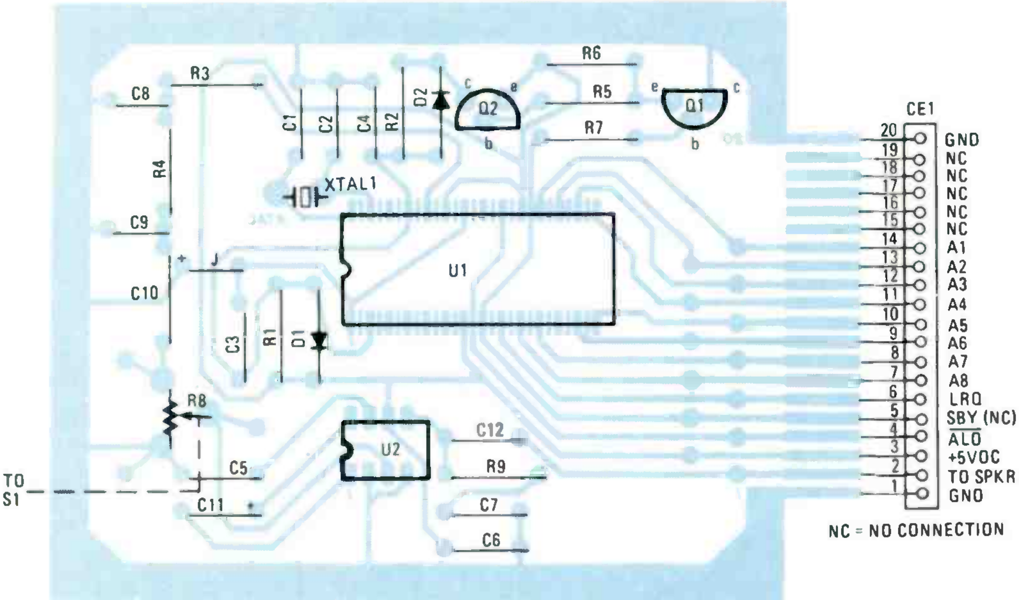


Fig. 6—This printed-circuit layout of the Voice Synthesizer should enable you to put the circuit together with little trouble. Just make sure that all semi-conductors are properly oriented.

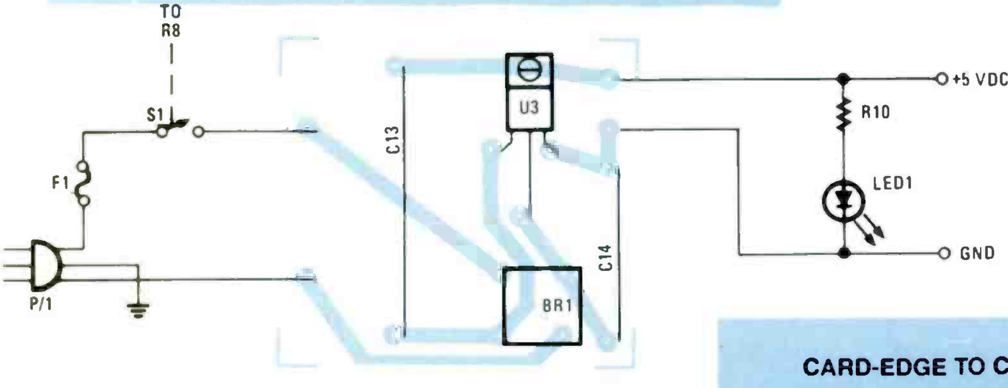
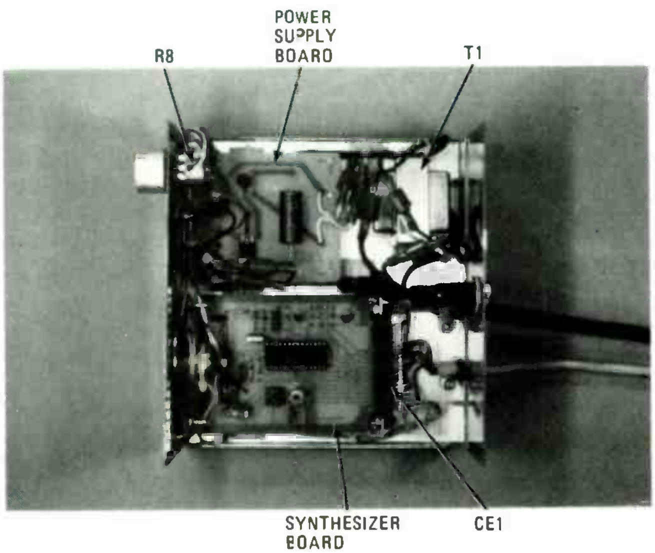


Fig. 7—Printed-circuit board layout for the Voice Synthesizer's power supply. Other than the orientation of the parts, there's little that can go wrong here.

TABLE 3
CARD-EDGE TO CENTRONICS INTERFACING

Card Edge	Centronics
1. Ground	17. Any Ground
2. Speaker (+)	No connection
3. +5-VDC	18. +5-VDC (or external source)
4. ALD (active low)	1. Strobe (active low)
5. SBY	No connection
6. LRQ (active low)	11. Busy (active low)
7. A8	No connection necessary
8. A7	No connection necessary
9. A6	7. Data 6
10. A5	6. Data 5
11. A4	5. Data 4
12. A3	4. Data 3
13. A2	3. Data 2
14. A1	2. Data 1



The author mounted the Voice Synthesizer's two printed-circuit boards side-by-side in the enclosure. To the rear of the case, he mounted the power transformer, which was then connected to the power-supply board through short lengths of wire.

mating with a parallel I/O port on your computer. Port pinouts are usually provided in the computer's operation manual.

Once you've located the pinout and have a suitable connector, make the connections with the A1 terminal of CE1 going to bit 1 of the I/O port; A2 to bit 2; A3 to bit 3, and so forth; ALD line connects to the computer's STROBE line and LRQ to the BUSY line, as outlined in Table 3. Note that A7, A8, and the SBY are not connected (in the author's layout) to the computer. That's because only six address bits are needed to access the 64 allophones.

In addition, pin 2 of CE1 does not connect to the Centronics connector, but is instead connected to the speaker through a short length of hookup wire. The extra ground connection (CE1 pin 20) in the layout completes the audio-output circuit. Now that the cable assembly is complete, it's time to wire everything together.

Now that we have all the sub-assemblies put together, it's

(Continued on page 102)

THE TELL-TALE *MAGNETISM* OF HEART-THROBS

The use of magnetic resonance techniques has succeeded in producing pictures of the heart that reveal blood vessels 2-mm in diameter. Moreover, the working of the heart and blood flow can be measured, opening the way to painless detection of hidden vascular diseases before they lead to sudden death.

BY J. M. Sienkiewicz

NUCLEAR MAGNETIC RESONANCE WAS DISCOVERED INDEPENDENTLY in 1948 by two American scientists, Professor Bloch and Professor Purcell. They received a joint Nobel Prize for their work. Since then, nuclear magnetic resonance has been used routinely as an analytical instrument in chemistry throughout the world.

It was a logical extension of nuclear magnetic resonance to apply it to studying biochemistry in the living body. Dr. Mansfield, at Nottingham University in England, was probably the first to produce a human image, in 1976.

Magnetic resonance (MR) has the greatest potential of any non-invasive (does not invade or injure live tissue) technique that has been designed or even envisaged so far. MR techniques probe deep into the human body to produce valuable pictures and do not harm the person, or even cause temporary discomfort. To date, it has produced pictures of hitherto inaccessible parts of the body.

Since MR is an immensely powerful diagnostic technique, it has great potential in preventive medicine because it is safe, painless, and can be used to screen seemingly healthy people. As X-rays are used less and less, because they can do more harm than good, MR will fill the gap, as well as expand a doctor's diagnostic capabilities.

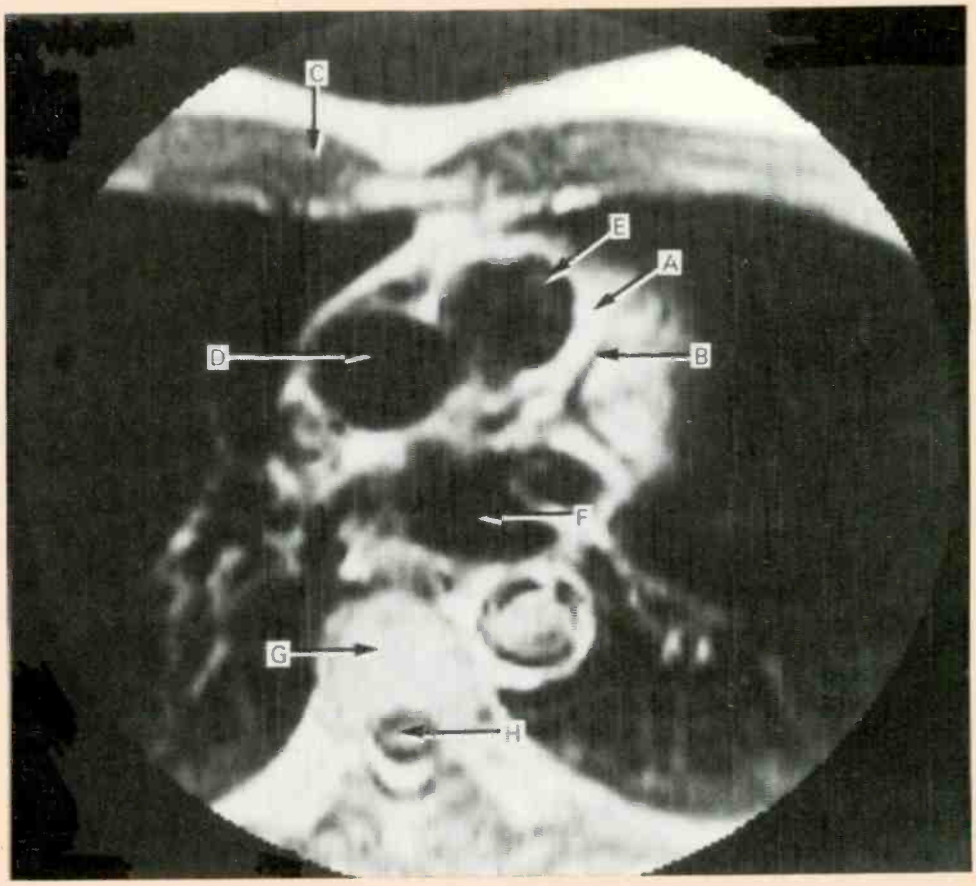
About half of all deaths in the western world are caused by one disease—the blockage of arteries with atheroma—and one-third are due to cancer. So it is logical to use nuclear magnetic resonance to screen for such diseases. To do that effectively it was necessary to develop a technique to measure the working of the heart and blood flow.

Dimensional Accuracy

The National Heart and Chest Hospitals Group in London has been able to measure the volume of heart cavities and blood flow with great accuracy. It first showed the dimensional accuracy of the technique, by using motionless models called *static phantoms*, designed to mimic the heart chambers. Results from experiments with *phantoms* showed that it was possible to measure accurately the volumes of cavities the size and shape of the heart chambers.

To study the heart, which is capable of rapid movement, a system which could both monitor the heart and activate the MR machine at the right moment (gating) had to be devised and tested. So special so-called *dynamic phantoms* were made, to pulse hearts and blood vessels artificially. The ability of MR imaging to *freeze* motion was shown with a device known as a *pulse duplicator*, which could inflate a balloon inside a cadaver's heart with varying volumes of fluid at various rates, in order to simulate its contractions and expansions. Simulation of the heart's movement in this way was controlled by the electrocardiograph (ECG—a reading of the heart's action) recorded from a healthy person. The experiment tested the accuracy of the ECG gating procedure and the MR volume measurements taken from a moving target.

The next step was to apply and prove the technique with a living man. To do so, the blood-volume outputs of the right and left ventricles were compared. The outputs of the two sides of a healthy heart should be identical. The technique for measuring the volume of blood was to measure the areas of adjacent slices of known thickness in the heart, use the known thickness' and the areas supplied by the MR scan to find the volume of each slice, then sum the volumes of all slices to find the total volume of blood within the heart. That is like measuring the areas of slices of bread in a sliced loaf of known and consistent slice thickness, and adding the volume of the slices to find the volume of the loaf. All the volume measurements of heart cavities were accurate to within two percent. Measurements of heart-wall thickness—not avail-



This magnetic resonance (MR) picture of a slice 0.5-cm thick through the upper end of the heart (A) is remarkable, because, for the first time, details of the left coronary artery (B) and its branches, some of them of only about two millimeters in diameter, have been recorded by non-invasive scanning—the heart was that of a live patient. That means that it is now possible to see small coronary arteries and measure the blood flow in them for the diagnosis or prediction of heart disease. Among other details that can be clearly seen are the internal mammary arteries and veins to the chest wall (C): During certain operations on the heart they are sometimes plugged into the coronary vessels to bypass blockages. Prominent in the scan are the left and right ventricular outflow tracts (D,E), the left atrium (F), the backbone (G) and spinal cord (H).

able from X-rays—were also found to be accurate.

After receiving a delayed signal from an ECG machine, the MR machine would take a reading. By varying the delay time, accurate measurements of the heart's volume when fullest, emptiest, and all stages in between could be taken, even though the heart's contractions are extremely rapid. Using an ECG reading (trace) of the person whose heart was being tested as the gate for the MR machine, laboratory experiments proved that it was possible to accurately calculate the volumes of the heart chambers.

As an example of the value of the MR technique in medicine, the volumes of contracted and expanded right and left ventricle chambers were measured in a large number of normal and diseased hearts of living patients. Over 256 beats of each heart have to be monitored to provide the data. If no heart valve is leaking, and there is no abnormal communication between heart chambers, the two sides of the heart pump the same amount of blood. Any discrepancy in the measurements must be caused by a defect such as leaking valves or holes between the heart chambers. MR was found to be more accurate than nuclear medicine, ultrasound, and cardiac catheter techniques for detecting such leaks.

There are various ways of measuring blood flow by MR. Before they are described, let's take a look at the principle of MR itself.

How Does MR Work?

The particles that make up an atom (protons, electrons, and neutrons) have two properties important to MR: charge and spin. Charge is something you're likely to be familiar with, so you might wonder why neutrons (particles which are considered neutrally "charged") are associated with charge. The truth is that neutrons are a combination of a proton, an electron, and a little bit of mass to glue the two together. Even though the proton and electron are close to one another, their charge doesn't vanish; it just becomes extremely hard to notice as you move away from the neutron.

Spin can be compared to the rotation of the earth on its axis—or more accurately, like a top slowing down. As science understands it, any moving charge creates (or displays if you will) a magnetic field. Thus, the particles comprising an atom all display magnetic fields because they move (spin) and have some charge; however, in most atoms the electrons are in pairs of equal and opposite spin which makes their magnetic field unnoticible at large distances. Even though the spins of neutrons and protons are opposite, they are not equal because the neutron spins slower due to its slightly larger mass—and besides, they don't *always* come in pairs. Thus the nucleus (the place where the protons and neutrons are located) contains the magnetic field we will discuss.

Unlike a compass needle, the magnetic fields of those particles don't line up when you stick them in a magnetic field. Instead they point at one of several possible angles, determined by the atom they're in and the strength of the applied magnetic field. They act like the tuning knob on a TV set; they can only point in one of several directions without any in-between points, and they "click" in and out of place. That may seem rather stiff but such particles not only spin, they precess as well (see Fig. 1). That means that a particle's axis can move around as long as it stays at a given angle with the applied magnetic field, like a top wobbling around as it slows down. In effect, the axis itself is rotating and that

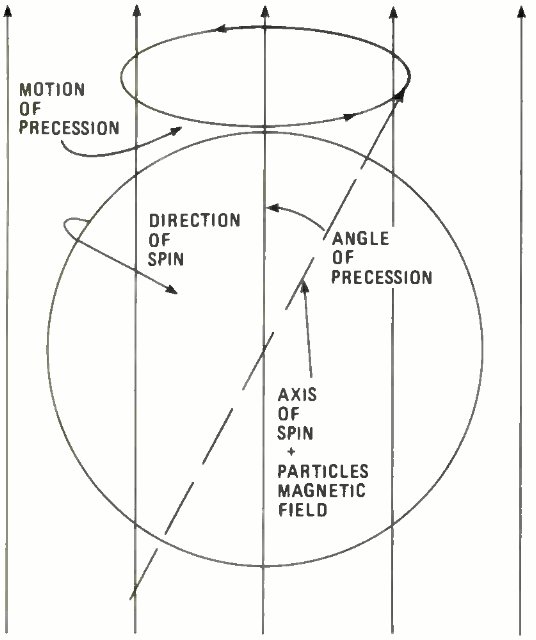


Fig. 1—Particles in the atom do not line up with an applied magnetic field. Instead, they precess like a wobbling top, with their axis of rotation (spin) at some fixed angle with the applied magnetic field. Note that the axis of rotation points in the same direction as the particle's magnetic field.

rotation is constant in time. Of course the rate of precession, as well as the angle of precession, is dependent on the atom the particles are in, the strength of the magnetic field, and the energy of the particle.

To move them from one angle to the next takes a precise amount of energy, which can be supplied in the form of radio waves. The frequency of a radio wave determines the amount of energy it can deliver to a particle. When we introduce radio waves into a material within a magnetic field, the particles not only precess at the same rate, but they do so in phase with one another (resonate). That causes the material to transmit radio waves at the frequency of precession, like an antenna. Therefore, when we place a substance, such as human tissue, in a magnetic field and shoot radio waves of different frequencies into it, if we notice that any of those frequencies are absorbed then we have found a frequency that causes particles to jump back and forth between those angles of precession (energy states). Further, if the substance continues to transmit a radio-wave signal after the injected radio waves have ceased—then it does so at the frequency of precession and has been affected by both the magnetic field and the radio waves.

Knowing the frequency, thus the energy and angle, can tell us which atom contains those particles, just as fingerprints can identify a person. By controlling the frequency we can make the MR machine sensitive to only a select group of atoms.

Three Techniques

There are three techniques for measuring blood flow. The first is called the *time-of-flight* or *downstream-slice* technique (see to Fig. 2), in which a small area of the patient is subjected to a magnetic field and radio waves (the first half of a MR sequence); then, at some distance from the treated area, another area is tested for a resonant signal (the second half of

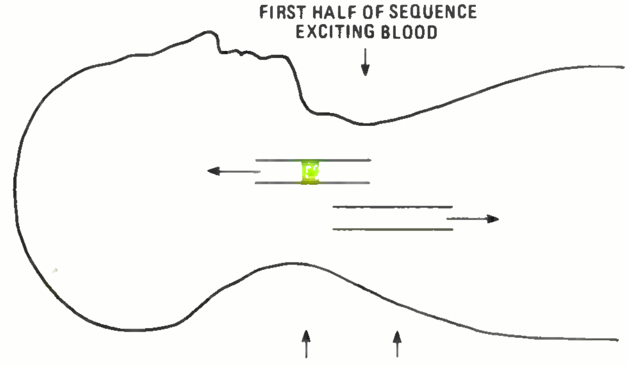


Fig. 2—The time-of-flight or downstream-slice technique for measuring blood flow is shown here. The sequence is performed in halves: first the magnetic field is applied and an RF pulse is used to start the precession of nuclei in phase at one location of the body. Second, a return signal is then looked for at another location.

the sequence). Only the material that moves into the second area, and has been prepared by the first half of the sequence, can be detected. By varying the time delay and distance between the areas, the velocity of the flow can be assessed.

The second technique relies on making a thin area of the body unsuitable for MR imaging by pulsing it with random radio signals. That temporarily causes chaos, so no *one* resonant signal can be obtained from it. An MR signal applied to the slice after a suitable interval will be sensitive only to the magnetically "clean" material that has flowed into it over that time; the amount of signal at any time is

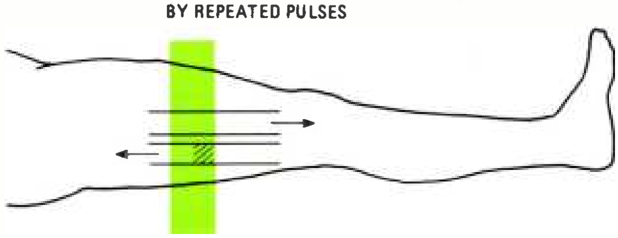


Fig. 3—In the saturation technique for measuring blood flow in the body, an area of the body is again placed in a magnetic field and exposed to a group of various radio frequencies (noise). Then the region is then probed for a resonant signal. The stronger the signal the more fresh blood and other bodily fluids that have entered the region.

proportional to the amount of new blood or other fluid that has flowed in (see Fig. 3.)

The experiment can be repeated with a number of different time delays, producing a graph of signal intensity vs. flow with a slope that flattens off acutely. The steepness of the slope is proportional to the flow velocity and the height of the plateau is proportional to the diameter of the blood vessel.

The third, and most accurate, way of measuring blood flow is to apply a magnetic field and transmit an RF signal into the tissue, just as before, but then turn the magnetic field off and after a certain time reverse the precession of the nuclei by changing the phase of the radio pulse by 180 degrees (see Fig. 4). That causes the particles of the treated tissue (flesh and old

(Continued on page 100)

Converting the TI99/4A Keyboard for Sinclair ZX-81 Use

The underside of a finished keyboard with all the cuts made and the jumpers in place, ready to connect to the ZX-81.

An easy, inexpensive way to replace that ZX monster with a full travel keyboard

By Victor Meeldijk

WITH THE LARGE NUMBER OF INEXPENSIVE FULL-TRAVEL keyboards available, especially the TI99/4A keyboard which sells for $2.95 at Radio Shack, now is the time to update your Sinclair computer. The conversion is very simple, requiring only a ribbon cable (with 13 conductors), and the cutting and jumping of some of the connectors on the TI keyboard.

Cutting

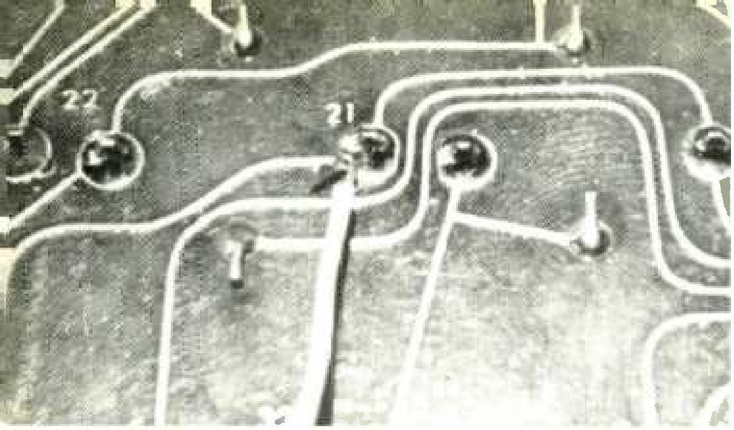
Below is a list of all the cuts necessary to convert the keyboard. Make the desired cuts with a sharp Exacto knife and be sure that the cut forms a wide gap in the connecting strip. The numbers referenced below are those found on the TI keyboard.

1. Cut the A key (#23) left trace.
2. Cut the Z key (#35) right trace which goes to the Zero key (#10) left connection.
3. Cut the P key (#21) right trace which goes to the ; key (#32) right connection. Make the cut at the right connection to the #32 key.
4. Cut the X key (#36) right trace which goes to the S key (#24) right connection. Make the cut at the right connection of the X key.
5. Cut the C key (#37) right trace.
6. Cut both traces to the V key (#38) left connection.
7. Cut the B key (#39) left trace.
8. Cut both traces to the Enter key (#33) left connection.
9. Cut both traces to the Enter key (#33) right connection.
10. Cut both traces to the Space Bar (#47) right connection.
11. Cut the Space Bar (#47) left trace.
12. Cut the Shift key (#34) left trace.
13. Cut the Shift key (#34) right trace.
14. Cut the Shift key (#44) right trace.
15. Cut the Shift key (#44) left trace which goes to the right connection of the Function key (#48). The other trace was cut in step 8.
16. Cut the , key (#42) left trace.
17. Cut the N key (#40) right trace.
18. Cut both traces to the M key (#41) right connection. Make the cuts at the right connection of the M key.
19. Cut the Slash key (#22) left trace.

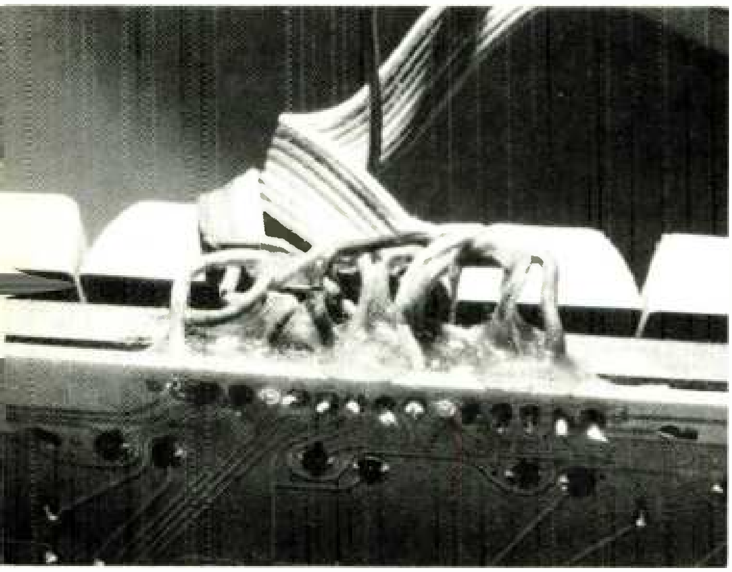
Jumping

For secure jumper connections it is recommended that a small hook is made at the end of the jumper wire to fit around the solder pad being connected to, as shown in the photo.

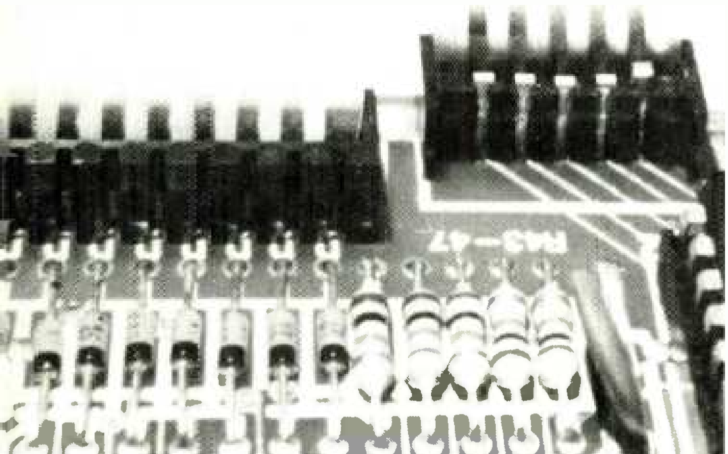
1. Jumper the left connection of the A key (#23) to the right connection of the Q key (#12).
2. Jumper the right connection of the Shift key (#44) to the right connection of the Slash key (#22).
3. Jumper the left connection of the Shift key (#44) to the right connection of the V key (#38).
4. Jumper the right connection of the Shift key (#34) to the left connection of the 1 key (#1).
5. Jumper the left connection of the Shift key (#34) to the left connection of the Z key (#35).
6. Jumper the right connection of the Z key (#35) to the right connection of the S key (#24).
7. Jumper the right connection of the X key (#36) to the right connection of the D key (#25).
8. Jumper the right connection of the F key (#26) to the right



By making a small hook in the jumper wire before soldering it, stronger and better electrical contact will be made.



Glueing the ribbon cable connections to the keyboard with epoxy will ensure that they will not work themselves loose.



The mylar film and two connectors that form the connection between the Sinclair keyboard and the circuit card.

connection of the R key (#15).
9. Jumper the right connection of the C key (#37) to the right connection of the F key (#26).
10. Jumper the left connection of the V key (#38) to the right connection of the B key (#39).
11. Jumper the left connection of the B key (#39) to the left connection of the N key (#40).
12. Jumper the right connection of the N key (#40) to the right connection of the J key (#29).
13. Jumper the right connection of the Enter key (#33) to the right connection of the P key (#21).
14. Jumper the left connection of the Enter key (#33) to the right connection of the ; key (#32).
15. Jumper the right connection of the Space Bar (#47) to the left connection of the B key (#39). Note that there is already a jumper connection to this point, see step 11.
16. Jumper the left connection of the Space Bar (#47) to the right connection of the P key (#21). Note that there is already a jumper connection to this point, see step 13.
17. Jumper the right connection of the M key (#41) to the right connection of the , key (#42).
18. Jumper the right connection of the R key (#15) to the right connection of the J key (#29). Note that there are already two jumper connections to both those points, see steps 8 and 12.
19. Jumper the left connection of the P key (#21) to the solder connection which is adjacent to the lettering "TOP ASSY". This connection can be traced to connection #1 at the top of the keyboard circuit card.

Making the Big Connection

Once all the above rework has been completed it is time to connect the keyboard to the Sinclair computer. Remove the back of the computer by unscrewing the mounting screws, including those under the rubber feet. Lift the cover to expose the rear of the circuit card assembly. Remove it by taking out two screws located at the top right and bottom left of the card, as shown in the photo. (To avoid possible damage to the computer by static electricity discharges a wrist strap should be worn during the rest of the modification procedure.)

With the circuit card mounting screws removed, the card can be turned over to expose the membrane keyboard connection. The Sinclair keyboard is connected by a mylar film to two connectors on the circuit card. Pull out the mylar film connections and unsolder the circuit card connectors. Wire the TI keyboard to the Sinclair computer circuit card following the instructions below and the connector diagram in figure 1.

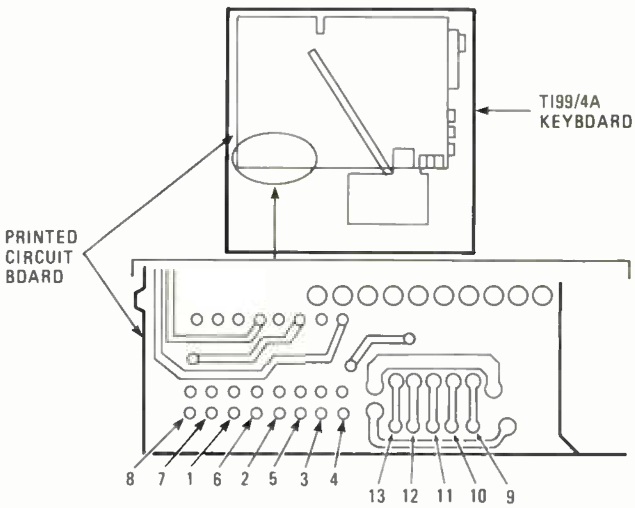


Fig. 1—This is the diagram for the keyboard connecter's solder pads. After removing the connectors use the diagram along with the instructions to connect the keyboard.

1. Connect keyboard 1 to computer 6.
2. Connect keyboard 2 to computer 5.

(Continued on page 103)

DEGAUSS DISKS

Here's a bulk tape and disk degausser you can build for pennies and even get change!

By Lou Hinshaw

A powerful degausser for demagnetizing disks and tapes can be built from a motor salvaged from a defective appliance.

IF YOUR TAPE OR DISK WON'T LOAD INTO YOUR COMPUTER; if it seems to be reluctant to accept new data; or if your audio tapes hiss at you, maybe your problem is *residual magnetism*: bits and pieces of previously recorded signals which were not wiped out or erased by the recorder or disk drive. Essentially, the internal erasing circuit of the recording device is leaving your magnetic media "dirty." Fortunately, it's a problem that's easily resolved by literally sweeping the magnetic garbage off the disk with a *degausser*, a device that's also known as a *bulk tape eraser*.

Two Kinds of Dirt

The value of physically-clean disk and tape drives is known to everyone. The value of *magnetically* clean disks and tapes—which we will call *magnetic media*—is a little foggier. When people think of the cleanliness of a disk or tape they usually think of grease and dirt, which will quickly destroy the media. But residual magnetism doesn't destroy the media itself; rather, it destroys the integrity of the newly-recorded data or program—making it unusable. If the residual garbage is digital data (such as on a disk), the computer can't distinguish between the old and the new, and prints an error message. If the residual garbage is on an audio tape, it manifests itself as a "second program" running in the background, or as *tape hiss*.

Erase to Write

While residual magnetism can cause *Big Trouble*, it's easy to cure because all you have to do is pass the media through a very strong alternating magnetic field. As the media moves through the field—or the field moves over the media—all traces of prior recordings, and of magnetization (polar alignment of the oxide molecules) are erased. That kind of data/program erasure is called *degaussing, usually done by a degausser*, a device that generates an unusually strong alternating magnetic field

While the kind of degausser you can buy at your local parts distributor runs anywhere from $15 to well over $100 (depending on overall size), by salvaging some hardware from dead or dying household appliances you can build one capable of degaussing computer disks, cassettes, and tapes for literally pennies—and maybe you'll even get change. The parts you'll need can be salvaged from small electrical appliances such as a hair clipper, electric scissors, small fan, phonograph—almost anything with a small, single-coil motor. You can also use a vibrator, a solenoid, or a large relay. If you don't have any of those gadgets in your junkbox, look at garage and yard sales, where they are often sold for well under $1. You don't care whether the gadget works or not as long as the motor or solenoid coil is OK; so bring along an ohmmeter.

Simply assemble the parts, making certain that all wires are insulated. Doublecheck that no wires can short.

Construction

The first step is to take out the motor and remove the armature (the little cylinder that spins in the motor), and you have the beginning of a good degausser. Figure 1 shows how to wire the stator (with the armature removed). Be very sure that all bare wires are insulated and secure before trying to test your handiwork: Never forget that you are dealing with a deadly voltage.

If you're salvaging a vibrator instead of a motor, follow the procedure shown in Fig. 2. Remove the vibrator from its case and discard the loose bar-armature (that spans across the top). Connect the normally-open momentary switch and linecord to complete the project. (The switch needs to be the momentary-type so that you will never have to worry whether you left it on.)

Finally, position the switch on the coil so you can hold and operate the assembly as a hand-held device; then wrap it all

PARTS LIST FOR DEGAUSSING DISKS AND TAPES

P1—Power plug
S1—SPST momentary switch, normally open
1—Salvaged vibrator or motor core (stator)
1—Linecord
1—Electrical tape

Neatly fold all the components together and wrap the assembly with several turns of plastic electrical tape.

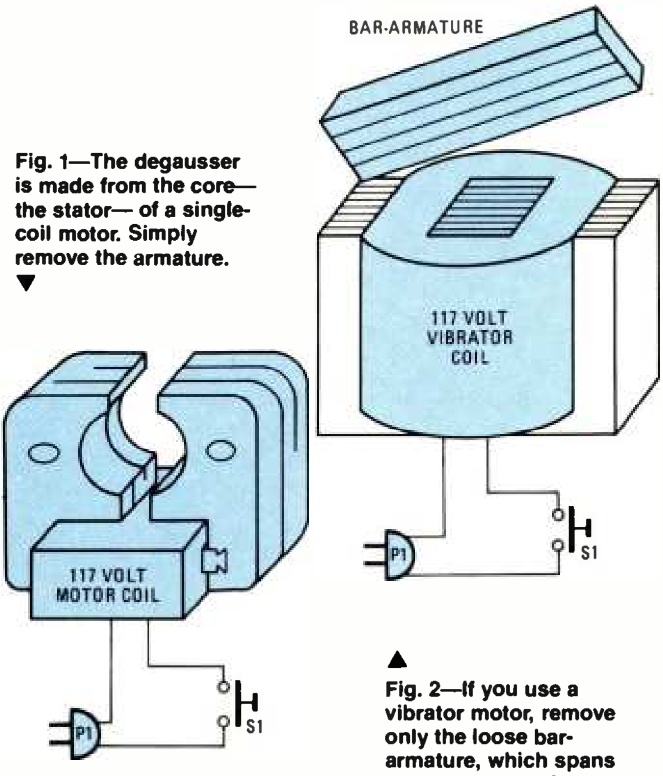


Fig. 1—The degausser is made from the core—the stator— of a single-coil motor. Simply remove the armature. ▼

▲ **Fig. 2—If you use a vibrator motor, remove only the loose bar-armature, which spans across the top of the core.**

together with several layers of plastic electrical tape. Don't stint on the tape, because it's the only thing between you and the powerline.

When assembling and tape-wrapping the unit, keep in mind that it's the open or "flat" end of the coil that's active—the end you want facing down so that it is closest to the magnetic media.

Using the Degausser

Plug the degausser into the electric outlet. Hold it in one hand, and in the other hand hold a reel or cassette of tape, or a disk in its envelope. The envelope protects the surface of the disk from direct contact with the degaussing device.

Press the switch, and while the eraser is on, move it close to the disk or tape with its active surface (the open or flat end) close to the media, and slowly pass it by the disk surface—or the flat part of a reel or cassette—several times: as though you were trying to use a tanning lamp on the disk, or like brushing butter onto a pancake. Then move the degausser away from the media and turn it off—in that order. If you turn the degausser on or off too close to the media you may add just the kind of problem to the disk or tape that you wish to avoid.

The first time you try the degausser, use an old unwanted recording that you can play with, or record something for the purpose. Degauss the recording, record something new, and try degaussing again.

With an old audio tape, play it and listen to the tape hiss. Then degauss the tape and listen again for hiss. You should be pleasantly surprised. For the real reward, put a new (virgin) blank tape in the player at full volume and listen to the hiss. Then degauss the tape and listen again. I think you'll be sold on degaussers forever. ■

ASTRONOMERS DISCOVER MASSIVE GRAVITATIONAL LENS

ASTRONOMERS HAVE DETECTED THE INfluence of an unexpectedly large gravitational lens that is 400 times more massive than any other observed lens. A gravitational lens results when light from a distant object is bent as it passes near a strong gravitational field. The bent light, passing on different sides of the object causing the gravitational field, reaches the observer from slightly different directions, giving the impression that two or more objects are being seen.

Another puzzling aspect of the newly discovered lens is that the astronomers are unable to detect the gravity source either with optical or radio telescopes.

The separation of the two images that the astronomers detect is 157 arc seconds compared with only seven arc seconds for the previous largest separation of images. An arc second is one 3,600th of a degree. A separation of 157 arc seconds is comparable to the angle presented by a dime at a distance of 25 yards.

A gravitational lens is not a new phenomenon. Predicted by Einstein in 1936, the first one was discovered in 1979. Since then, eight others have been reported, including this latest one observed by a team headed by Dr. Edwin L. Turner of Princeton University.

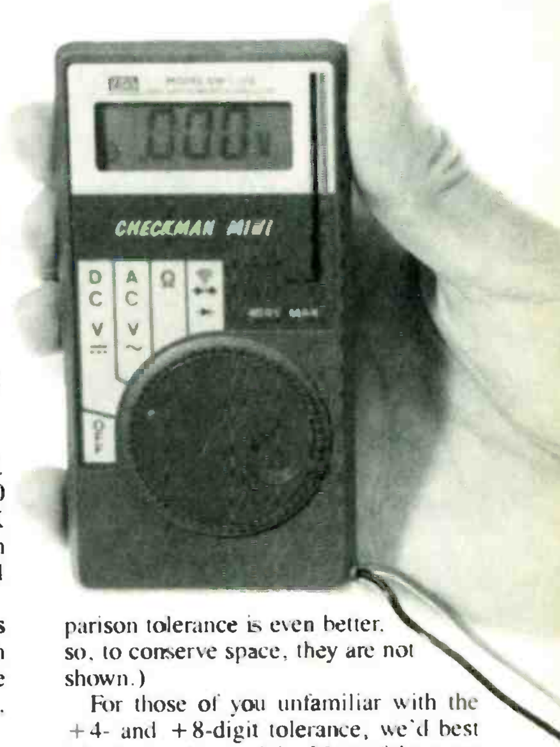
What the astronomers observed were two images of a quasar with identical spectra or colors, and red shifts—speeds of recession. The quasar, or quasi-stellar object, from which the light originated is about five billion light years from earth in the direction of the constellation Leo.

The astronomers used the 158-inch Mayall optical telescope at Kitt Peak National Observatory in Arizona and the Very Large Array, a grouping of 27 antennas in New Mexico that is part of the National Radio Astronomy Observatory. The researchers first detected the gravitational lens on March 4, 1986.

Three possible explanations of the mysterious gravitational lens are offered. It could be a giant cluster of galaxies; a gigantic black hole with a mass 1,000 trillion times that of the sun, or a cosmic string—a theoretical object that might be left over from the early universe. All three emerse mass.

This gigantic lens that beams 5-billion-year-old images to us may not exist at all today! ■

Checkman Mini



Puts a full-function DMM in your shirt pocket!

IT WASN'T TOO MANY YEARS AGO THAT a digital multi-meter (DMM) having a relatively large display was line-powered and almost as heavy as a small-boat anchor. Today, the very same volt-ohm coverage—including auto-polarity, auto-ranging, audible prompting, and a diode-check—is small enough to fit into a shirt-pocket-sized wallet that also contains the test leads.

The gadget packing that kind of big-league performance into a midget-sized case is the Checkman Mini, a DMM that measures only 4.25 × 2.1 × .3 inches: 4.6 × 3 × .48 inches in its wallet with its test leads. To ensure that nothing is missing when needed, the test leads are permanently attached to the meter, and are shorter (20 inches) than usual so that they can fold into the miniature wallet.

Measurements are indicated on a 0.4-in. LCD display, which also indicates the selected meter function: **V** (for DC); ACV; **kΩ**; and **B** (for "battery replace"). The AC/DC measurement range is 2-450 volts. The resistance ranges cover 2K ohms through 1.999 Megohms, which translates to a measurement range of 1 ohm to 1.999 Megohms.

The resistance measurement is always shown in **kohms**, hence, the maximum value is 1999 (effectively 2000) **kΩ**, while the minimum value is 0.001 **kΩ**, which is, of course, 1 ohm.

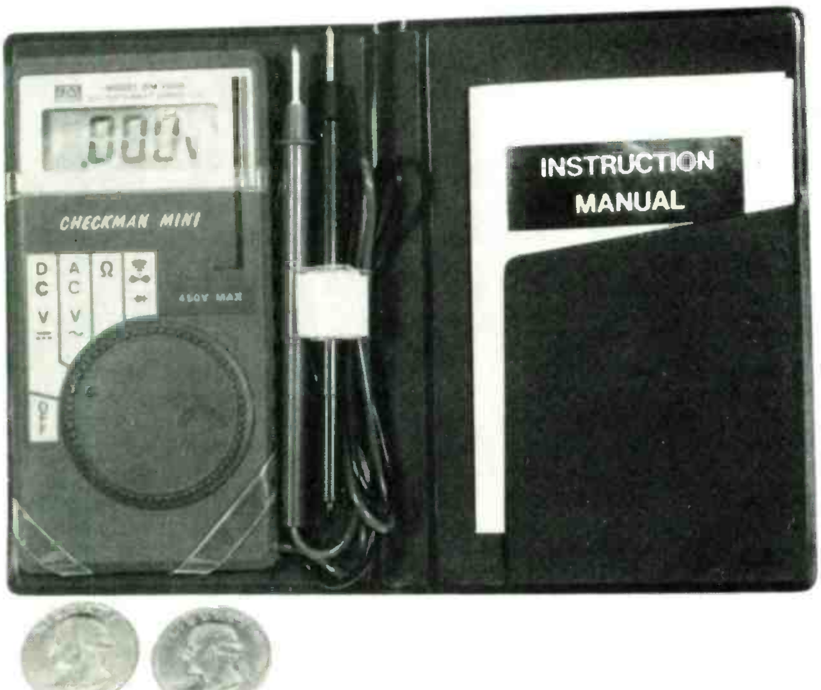
The diode test is actually a resistance measurement that uses its own form of values to indicate *good/bad*.

The meter has an accuracy of ±(0.7-1.3% of reading +4 digits) for DC; ±(2.3% of reading +8 digits) for AC; ±(2.0% of reading +4) digits for resistance. As shown in Table 1, the actual real-world performance compares favorably with a conventional line-powered, service-grade DMM. (Only the worse-case measurements are shown. The DC comparison tolerance is even better, so, to conserve space, they are not shown.)

For those of you unfamiliar with the +4- and +8-digit tolerance, we'd best take time out to explain. Most of the more costly digital instruments have an accuracy of X.X% ±1 digit, meaning the very last digit can vary either way by one count. For example, 120-VAC could be indicated on a 3 or 3-½ digit display as 120, 121, or 119. Similarly, a 10-ohm resistor might be displayed as 10.0, 10.1, or 09.9; or .010, .011, or .009. Measuring the same values, a meter with +8-digit tolerance would display 120 or, 121 to 128, or 10.0 through 10.8 ohms, or 0.010 through 0.018.

Keep in mind, however, that the +4 and +8 tolerance is worst-case; as shown in the table, the Checkman Mini has nice competitive performance. (Don't expect lab-grade performance for only $29.95.)

(Continued on page 101)



Two quarters give a good idea of how small the Checkman Mini really is. The meter can be removed from the wallet; however, the wallet provides a storage "clip" for the test leads—which are permanently attached to the meter.

Here is a cover-off, back view of the Checkman Mini DMM. The small black square is the single integrated circuit that provides most of the circuitry.

MAKE YOUR SPEAKERS

By David B. Weems

You can improve speaker quality with junk box

MANY YEARS AGO, BEFORE ELECTRONICS PEOPLE HAD discovered the word "interface," amplifier designers noticed that the electrical behavior of speakers was not exactly ideal. An audio amplifier that performed very well on the test bench, with a resistive load in the output circuit, might "go into orbit" when a speaker was connected to it. On the way back to the drawing board the amplifier engineer might condemn all speakers, muttering, "Why can't they behave like resistors?"

Amplifiers are more stable today but speakers are still speakers. Unlike the first hi-fi models, our speaker systems almost always consist of separate woofers, tweeters, and often, additional mid-range drivers. If you put together a speaker system, you will have to deal with crossover networks which, like the early amplifiers, work best when connected to a resistive load. By making your speakers more like resistors you can improve their performance. In fact, many commercial speaker systems, especially lower priced models, can be improved by altering the electrical behavior of the drivers.

The problem is caused by the way the average speaker's impedance varies with changes in frequency. Electronic stores sell universal crossover networks that do a rough job of dividing the frequency into three ranges—for woofers, mid-ranges, and tweeters. Such crossover networks are usually designed for use with 8-ohm drivers. To see why one of these networks may not perform as you wish, look at the impedance curve for one "8-ohm woofer" in Fig. 1. It is not an unusual curve.

No matter whether you buy a ready-made crossover network or make up your own, the uneven load presented to it by the speaker can affect its performance. You may look at the curve in Fig. 1 and be tempted to doubt that because much of the variation occurs above the normal crossover frequency of a 12″ woofer. That is true, but the speaker's impedance in the stopband is even more important than in the passband. It is in the stopband that the crossover network does its job.

The Impedance Equalizer

Most of the rise in speaker impedance at high frequencies is caused by the inductance in the voice coil. You can counter that inductance by connecting a simple network across the voice coil. Such a network is diagrammed in Fig. 2. To calculate the right values for the components you need only to know the DC resistance (R_e) and the inductance (L_e) of the voice coil. You can calculate the value of the capacitor (C) by:

$$C = L_e/R_e^2$$

and the optimum value for resistance (R) by:

$$R = 1.25R_e$$

Here is an example: the spec sheet for the Peerless TX255F 10″ woofer shows the value of the voice coil inductance at 0.84 mH, or 0.00084 Henries. It lists R_e at 5.2 ohms. Using these values the correct value for C is:

$$C = 0.00084/27 = 31\ \mu F$$

And, in the case of the TX255F

$$R = 6.5 \text{ ohms.}$$

Figure 3 shows two impedance curves for a TX255F. The solid line indicates the impedance of the driver alone. After running that curve I made up an impedance equalizer consisting of a 6.5-ohm resistor and some paralleled capacitors that had a total capacitance of 31 µF. I connected the equalizer across the speaker and ran another curve which is shown by the dashed line. As you can see, the new curve is almost ruler flat at high frequencies.

How to Test Your Speakers

Many speakers are sold without complete specifications. In fact, it is rarely possible for you to obtain the value of the voice coil inductance from the seller of your speakers. For a driver with no such specs you can run a simple test if you have access to an ohmmeter or multimeter, an audio generator, a

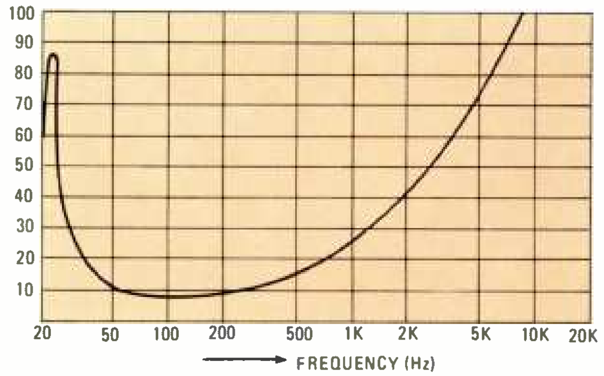
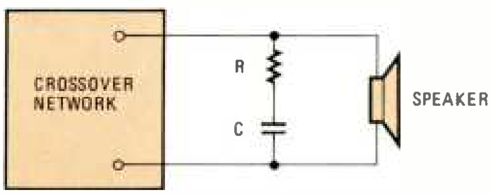


Fig. 1—This impedance curve from a 12″ woofer (Peerless TX 305F) indicates the varying impedance over the crossover network. That variation can cause poor sound quality.

Fig. 2—This impedance equalizer flattens out the impedance curve over a wide range of frequencies and, if designed properly, can enhance the crossover's performance.



BEHAVE LIKE RESISTORS

parts in one evening; it's easy and inexpensive!

precision 10-ohm resistor, and a sensitive AC voltmeter.

First, measure the DC resistance of the voice coil to get R_e. You can use a precision low value resistor to calibrate the ohmmeter. Then connect the audio generator, the voltmeter, and the driver to be tested in the circuit shown in Fig. 4. Use the precision 10-ohm resistor to adjust the the output of the generator so that the volt meter points to (reads) the lowest 1 on the voltmeter scale. If you have a digital voltmeter this might be 0.10 volts, however, you can read the voltage with greater accuracy if you use 0.100 volts. After setting the voltage level of your generator you can read the impedance of the speaker directly because a voltage of 0.010 indicates an impedance of 10 ohms. A reading of 0.012, for example, would indicate 12 ohms. If you use a higher output from the generator, or an audio amplifier after the generator, the reading would be 0.120 for 12 ohms or 0.122 for 12.2 ohms and so on.

Switch to the speaker and change the frequency until the impedance equals twice that of R_e. If you are using a digital voltmeter you should switch back to the precision 10-ohm resistor and see if you need to readjust the output of the generator at the new frequency. Digital voltmeters have a limited range of flat frequency response.

After finding the frequency where the impedance is twice the DC resistance, you can find L_e by:

$$L_e = R_e/2\pi f$$

For the TX255F I measured R_e at 5.1 ohms and f at 1040 Hz. This gives an inductance value of 0.78 mH, slightly below the value listed in the spec sheet. If you do this test, you can save some arithmetic by this formula:

$$C = (0.16/R_e)f$$

Substituting 5.1 ohms for R_e and 1040 for f, we find the suggested value for C by this test to be 0.00003 Farad or 30 µF. I ran an impedance curve with a 30-µF value and found virtually no difference from the earlier one done with 31 µF.

As a rule of thumb you can calculate the optimum capacitor value and then use the next higher value that is easily obtainable.

Impedance equalizers are practical for mid-range drivers too. Figure 5 shows the impedance curve of a titanium dome mid-range, the MCD 51M, a German-made driver sold by McGee Radio. It also shows the impedance curve after two circuits were added, an impedance equalizer, which was effective from about 600 Hz and above, and a resonant peak filter, which will be described later. When I tested the MCD 51M and calculated the component values for an impedance equalizer, I arrived at 8.4 ohms and 3.65 µF. I used a resistor that measured 8.8 ohms with a standard 4 µF capacitor. They worked well as shown by the relatively flat line above 600 Hz in Fig. 5.

A Few Rules of Thumb

After running the tests described here you will usually find that the value of C for woofers will fall in the 10 to 50-µF range; for mid-range domes, from 2 to 5 µF; and for mid-range cone drivers, from 3 to 8 µF. Impedance equalizers are usually unnecessary for tweeters, but some tweeters may sound smoother if one is used. The value of C for tweeters usually varies from 1 to about 2 µF. If you measure R_e of small tweeters, try to use a digital ohmmeter that limits the current. If you don't have access to such an ohmmeter, try an 8 to 10-ohm resistor with various capacitors until you obtain the performance you want. It's a good idea to create an impedance curve to check the performance of any equalizer. If the curve isn't reasonably flat at the upper frequencies, try other values for R and C.

While impedance equalizers will flatten the impedance curves of your speakers, their use may require the redesigning of your crossover networks. An equalizer will reduce the impedance of a woofer or mid-range driver to a value about equal to the DC resistance of the voice coil. Because of that you should use R_e as the impedance of the driver in calculat-

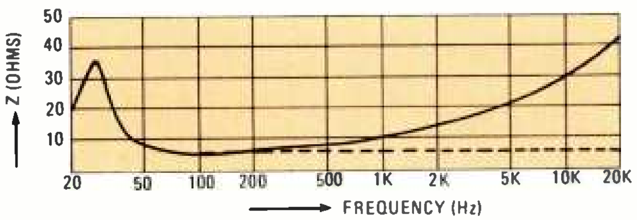
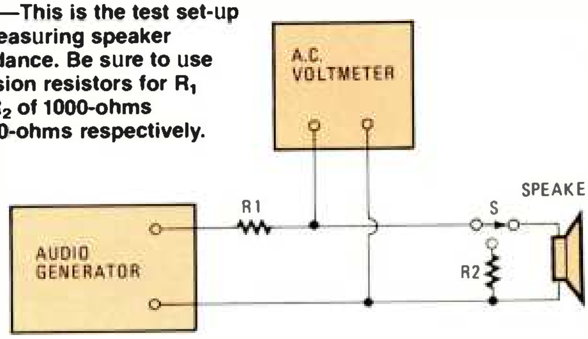


Fig. 3—Here we can see the difference in impedance vs. frequency response of a 10 inch woofer (Peerless TX255F) in its modified and unmodified state. The linearity of the equalized speaker shows an overwhelming improvement.

Fig. 4—This is the test set-up for measuring speaker impedance. Be sure to use precision resistors for R_1 and R_2 of 1000-ohms and 10-ohms respectively.



ing the value of crossover network components.

Resonant Peak Filters

Although most tweeters don't need equalizers to control their upper range impedance, some tweeters present a problem at the low end of their response range, at the tweeter's frequency of resonance. This resonance normally occurs in the tweeter's stopband, at a point an octave or more below the crossover frequency. Unless you can control the impedance peak, your crossover network may not produce the desired cut-off slope in the tweeter's response. The solution: a series-tuned circuit that resonates at the same frequency as the peak. Figure 6 shows the circuit.

To design a resonant peak filter, run an impedance test to find the frequency of the peak. Then calculate C by:

$$C = 1/50\ f$$

This formula works well with most 8-ohm tweeters. If you have a 4-ohm tweeter, substitute 25f in the denominator.

To find the value of L that will resonate with C at the peak frequency, use this formula:

$$L = (0.025/f^2)C$$

Choose a value for R that is equal to the rated impedance of the tweeter or slightly higher.

The impedance curves for one tweeter, before and after a resonant peak filter was connected, are shown in Fig. 7. The resonance on the tweeter caused noticeable output from the tweeter, even when the crossover point was placed an octave above the resonance with an 18-dB/octave network. The 1100-Hz peak was then neutralized with a filter made with an 18-µF capacitor, a 1.14-mH inductor, and an 8-ohm resistor.

The formulas listed here will produce filters that work well in most cases. There are other, more specific, formulas but they require more extensive testing procedures and, from my tests, do not produce any significant difference in the impedance curve. Just remember that these formulas are only rough guides and may be altered for any good reason. For example, if you found the values above by calculation but you had only a 1.25-mH coil, you can substitute another value of C to obtain resonance at the desired frequency. It is often an advantage to choose L first because odd values of coils may not be available. In such cases you can obtain the matching value of C by:

$$C = (0.025/f^2)L$$

Resonant peak filters are good for mid-range drivers too. Again, their resonant impedance peaks occur below the operating range of the driver where the crossover network requires a more resistive load. For mid-range drivers the calculated values for L may turn out to be rather large. The coil used in the resonant peak filter for the MCD 51M, to produce the flattening of the peak as shown in Fig. 5, had an inductance of 4.15 mH. Fortunately a coil with an iron core was available. The formulas given here produce circuits with LC ratios of about 63. As mentioned above, this is not a magic ratio so you can substitute lower values for L and obtain good results.

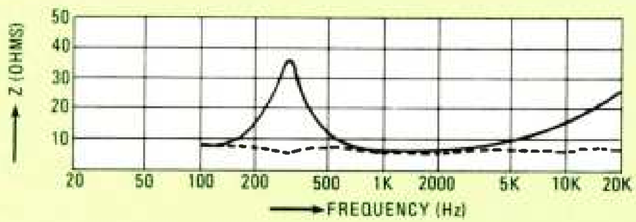


Fig. 5—Here we can compare the difference in the impedance curves of an MCD 51M mid-range dome in its modified and unmodified state. The linearity of the equalized speaker with a resonant peak filter is an overwhelming improvement.

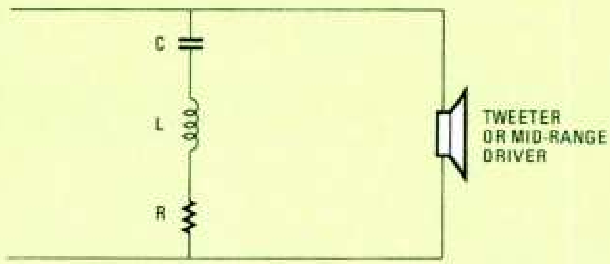


Fig. 6—The resonant peak filter shown here, when coupled with the appropriate equalizer, can help a tweeter or mid-range appear to have a constant impedance independent of frequency even at its resonant frequency.

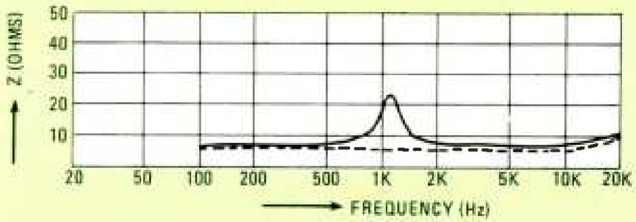


Fig. 7—The difference in the impedance curves of a MCM 25S dome tweeter in its modified and unmodified state makes the usefulness of a resonant peak filter evident.

After making up a filter connect it to your driver and run an impedance curve. If you are using the resonant peak filter on a mid-range driver along with an impedance equalizer, run an impedance curve with both networks in the driver circuit. If the frequency of the dip produced by the filter is off, you can juggle values of C until it is right. In any case if the impedance falls below 3 or 4 ohms at any point you can increase the value of R to 10, 12, or even 15 ohms.

Resonant peak filters are not practical for woofers. Also they aren't needed because woofer resonance occurs within the passband where it doesn't cause the kind of problems for crossover networks which is presented by stopband resonance.

Speakers, with only two wires to connect, appear to be simple devices. In reality they make up a complex load for amplifiers or crossover networks. By making them act more like resistors your crossover networks can perform the way they should. It is a low cost way to improve a sound system. ■

NEW This Issue

Electronic Fundamentals

By Louis E. Frenzel, Jr.

Our self-instructional tutorial on electronic fundamentals takes you from novice to technician in small, easily-digested bites!

WHETHER YOU'RE A NEWCOMER TO ELECTRONICS OR an "old hand" at electronic construction and have trouble understanding some circuits because you you don't know *the fundamentals*, our six-part series on *Electronic Fundamentals* is going to fill you in on the the nitty-gritty that makes things work: resistive circuits, inductance and capacitance, LC circuits and transformers, diodes and transistors, amplifier basics, and op-amps.

Unfortunately, even the most exciting subjects can be made dull by poorly-written books and manuscripts. In particular, *electronics*—which is considered by many to be the most exciting subject because it's where the future is happening now—is often a real eye-closer, because much of what's written is sold by the pound, rather than by substance. (The thicker the book the higher its price.)

Well, we we have a real winner for the **Hands-on Electronics** reader when it comes to learning about electronics: A way to get right into the meat of the subject at your own pace. A way to move ahead to step B *only when you're absolutlely certain* you understand step A.

The "magical way" we keep the excitement in electronics is called the *programmed instruction (PI) format*, whereby 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 a question-blank(s) with appropriate words. The answer to the question is given in parenthesis at the beginning of the next frame in sequence.

As you progress through the lesson, use a piece of paper to keep the frame immediately below the one you are reading covered so that you won't accidentally see the correct answer. The easiest way to do this is to slide the paper down until it just touches the line that separates the frames.

We hope you enjoy learning about electronics through programmed instruction. Please write and let us know how you like it. Begin now with Frame 1.

Part 1—Resistors and Resistive Circuits

1. Whenever a voltage source is applied to a load, a complete electric circuit is formed and electrons (the current) flow. The voltage is the pressure that causes current flow in the load to produce some useful function. Figure 1 shows a battery voltage source that causes direct current (DC) to flow in a load, in this case a light bulb. That light bulb has resistance and thus offers opposition to the current. Most loads in a circuit are a resistance.

The resistance in a circuit that produces some useful end result is called a ____________.

---

2. (load) The amount of current in the circuit depends upon the amount of the applied voltage and the value of the load resistance in ohms. This relationship between current, voltage, and resistance is, as you know, known as Ohm's law. It states:

"The current is directly proportional to the voltage and inversely proportional to the resistance."

If the voltage increases while the resistance remains the same, the current will ____________.

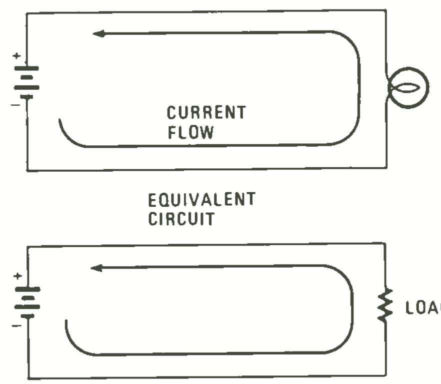


Fig. 1—This is the most basic electronic circuit. The light bulb used as a load has resistance, so the circuit can be drawn showing a resistor instead of the bulb.

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.

3. (increase) *Holding the voltage constant, the current will* ______________ if the resistance increases.

---

4. (decrease) Ohm's law is usually expressed mathematically by the simple formula:

$$I = E/R$$

where I = current in amperes, E = voltage in volts and R = resistance in ohms.

You can also rearrange the basic formula with algebra to compute voltage and resistance.

$$E = I \times R$$
$$R = E/I$$

If the voltage in a circuit is 4.5 volts and the resistance is 30 ohms, the current is ______________ *amperes.*

---

5. (.15) $I = E/R = 4.5/30 = .15$ amperes, or 150 milliamperes (mA) (NOTE: 1 ampere = 1000 mA, or 1 mA = 1/1000 ampere.)

In this part of our series we are concerned with circuit resistance—the opposition to current flow. Any circuit element, whether it is just a wire or an actual component called a resistor, has resistance. By selecting a certain resistance value, the current in a circuit can be controlled. Conductors or components can be combined to form various useful circuits that will be described here.

A component that can be used to control current flow is called a ______________.

---

6. (resistor) Go to frame 7.

Series Circuits

7. A series circuit is one where two or more resistances are connected end to end to the voltage source. Figure 2 shows a series circuit. The most important thing to note is that there is

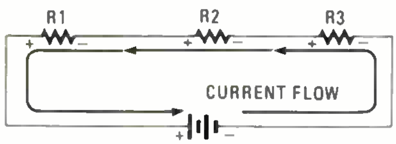


Fig. 2—When all the elements that make up a circuit are connected in series the circuit is described as a *series circuit*, and current flow through all elements are equal.

only a single path for current flow. Therefore, the same current flows in all resistances.

A key characteristic of a series circuit is that there is a ______________ *path for electron flow.*

---

8. (single) Since the same current flows through all of the resistors, each offers some opposition. In fact, the total opposition or resistance (Rt) of the circuit is simply the sum of the individual resistances.

$$Rt = R1 + R2 + R3$$

For example, if R1 = 1000 ohms, R2 = 2700 ohms and R3 = 33000 ohms, the total resistance is:

$$Rt = 1000 + 2700 + 33000 = 36700 \text{ ohms}$$

The effect is as if all three resistors were replaced by one with a value of 36,700 ohms.

The total resistance of a series circuit with resistors of 56, 180, 220 and 750 ohms is ______________ *ohms.*

---

9. (1206) Whenever current flows through a resistor, a voltage is developed across that resistor. That voltage is called a voltage drop. In a DC circuit, the polarity of the voltage drop is such that the end of the resistor into which current flows is

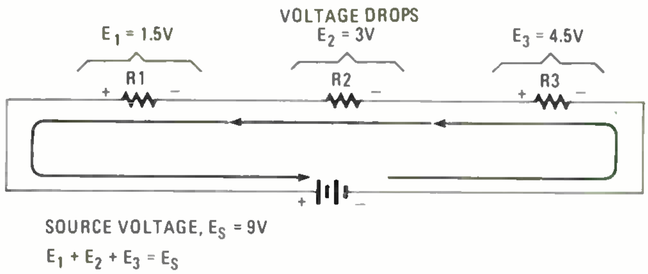


Fig. 3—The sum of all voltage drops in a series circuit always equals the source voltage.

negative (-) and the end of the resistor that the current flows out of is positive (+). (Refer to Fig. 3.)

Current flowing in a series circuit causes a ______________ ______________ *to be developed across each resistor.*

---

10. (voltage drop) Another key characteristic of a series circuit is that the sum of the voltage drops in a series circuit is equal to the value of the source voltage. This is known as Kirchhoff's law for series circuits. In Fig. 3, if the resistor values and the circuit current are known, each voltage drop could be computed with Ohm's law. The voltage drops are E1 = 1.5, E2 = 3, and E3 = 4.5. Their sum, of course, is equal to the source (battery) voltage.

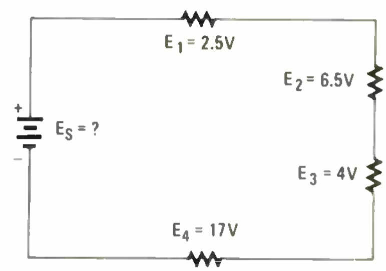


Fig. 4—For practice, use the voltage drops to determine the source voltage applied by the battery.

The source voltage in the circuit of Fig. 4 is ______________ *volts.*

---

11. (30) In a series circuit, we can say that the source voltage is distributed across each resistance in proportion to its value. That makes sense since the same current flows in each. Therefore, by Ohm's law, the greater the resistor value, the greater the voltage drop and vice versa.

In a series circuit with resistors of 470, 1200, 6800 and 9100 ohms, the smallest voltage drop will appear across the ______________ *ohm resistor.*

---

12. (470) The key characteristics of series circuits are summarized in Fig. 5.

Now consider the circuit shown in Fig. 6. The goal is to operate a 3-volt light bulb that draws .06 amps from a 9 volt

KEY CHARACTERISTICS OF SERIES CIRCUITS

* Single path for current flow
* Total circuit resistance is equal to the sum of individual resistances.
  $R_t = R1 + R2 + R3 + ...etc$
* The sum of the voltage drops across the resistors in a series circuit equals the source voltage

Fig. 5—Three characteristics determine a series circuit.

battery without burning it out. To do this, we use a series dropping resistor, R1. The unneeded voltage is dropped across this resistor. We need to compute the value of this resistor.

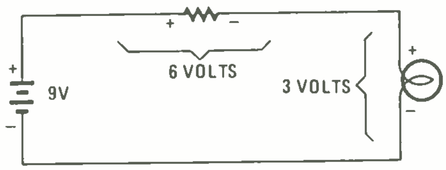


Fig. 6—A series dropping resistor can be used to reduce the voltage applied to the load—in this instance, the bulb.

With a source voltage of 9 volts, and 3 volts across the bulb, the voltage across the series dropping resistor is ______________ *volts.*

---

13. (6) Remember, in a series circuit, Kirchhoff's law says that the sum of the voltage drops equals the source voltage. We subtract the bulb voltage from the source voltage to get the resistor voltage.

$$9 - 3 = 6$$

The same current flows in all parts of the circuit since there is only one path. Therefore, the current through the resistor is ______________ *amps.*

---

14. (.06) This is the required bulb current. Now, using Ohm's law, the resistor value can be found.
The value of R1 is ______________ *ohms.*

---

15. (100) The value of R1 is the resistor voltage drop divided by the current or:

$$R1 = 6/.06 = 100 \text{ ohms}$$

Go to Frame 16.

Parallel Circuits

16. A parallel circuit is one where each resistor is connected directly across the source voltage as shown in Fig. 7. Instead

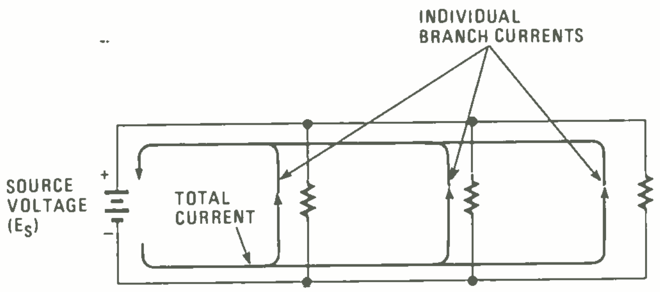
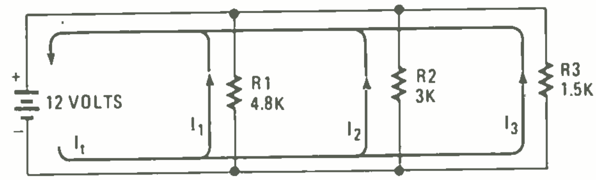


Fig. 7—In a simple parallel circuit the total current is split between the individual branches.

of there being a single path for current flow, there are multiple paths, one for each resistor or circuit branch.
In a parallel circuit, each resistor is connected across the ______________.

---

17. (source voltage) If you know the source voltage and the value of each resistor, you can compute the current in each branch with Ohm's law, as the example in Fig. 8 illustrates.



$$I_1 = \frac{12}{4800} = .0025A = 2.5 \text{ mA}$$
$$I_2 = \frac{12}{3000} = .004A = 4 \text{ mA}$$
$$I_3 = \frac{12}{1500} = .008 = 8 \text{ mA}$$

Fig. 8—Here's how we calculate the branch and total current. make up your own parallel circuit for practice.

Since each resistor or branch draws current from the battery, then the total current (It) drawn is simply the sum of the individual branch currents.

$$It = I1 + I2 + I3 = 2.5 + 4 + 8 = 14.5 \text{ mA}$$

This is known as Kirchhoff's law for parallel circuits. *In a parallel circuit, adding the* ______________ *currents gives the total current drawn from the voltage source.*

---

18. (branch) The current in each branch is, of course, inversely proportional to its resistance value. As Ohm's law states, the lower the resistance for a given source voltage, the higher the current and vice versa.
In a parallel circuit, the lowest branch current has the ______________ *resistance.*

---

19. (highest) The total resistance offered by the combined resistors in a parallel circuit can be found with Ohm's law. If the source voltage is known, and the total current is determined by adding the branch currents, then the total equivalent circuit resistance (Rt) is:

$$Rt = E_s/It$$

In other words, all of the parallel resistances could be replaced by a single resistor with a value of Rt that would draw It.

The more resistors that are connected in parallel, the higher the total current drawn from the source. Therefore, the lower the total equivalent resistance of the circuit.
The greater the number of resistors in parallel, the ______________ *the total resistance.*

---

20. (lower) The total resistance of a parallel circuit, as it turns out, is less than the smallest value resistor. You can verify this yourself by referring back to the circuit in Fig. 8.
The total circuit resistance is ______________ *ohms.*

---

21. (827.6) All you do is divide 12 by It of .0145 A.

The combined resistance of two parallel resistors can be computed with the simple formula:

$$Rt = R1 \times R2/R1 + R2$$

If R1 = 20 ohms and R2 = 30 ohms, then the total resistance is:

$$Rt = 20 \times 30/20 + 30 = 600/50 = 12 \text{ ohms}$$

Note that the total resistance is less than the smallest value, which is R1 = 20 ohms.

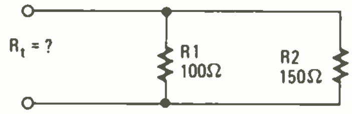


Fig. 9—You've had the practice. Now what is R_t's value?

The total resistance of the circuit in Fig. 9 is _____________ ohms.

---

22. (60) If equal value resistors are connected in parallel, the total resistance is just the value of one resistor divided by the number (N) in parallel. For example, if four 300 ohm resistors are connected in parallel the total resistance is:

$$Rt = 300/4 = 75 \text{ ohms}$$

The total resistance of three 150 ohm resistors in parallel is _____________ ohms.

---

23. (50) You can use the two resistor formulas given above to compute the total resistance in circuits with three or more resistors. You just combine the resistors two at a time. The circuit in Fig. 10 illustrates this idea.

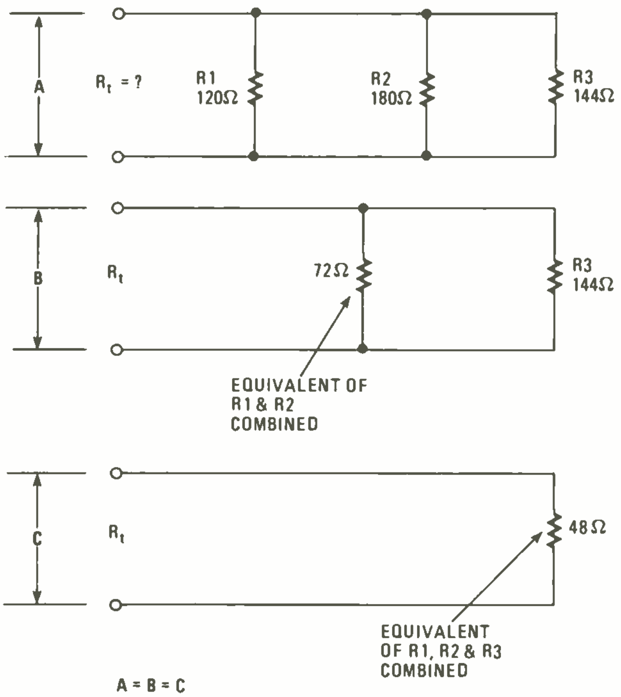


Fig. 10—This problem is harder because there are three branches. What's the value of R_t.?

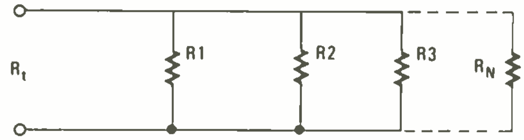
First we find the total resistance of R1 and R2.

$$20 \times 180/120 + 180 = 21600/300 = 72 \text{ ohms}$$

Now, combine this with R3 which is 144 ohms to get the total _____________ ohms.

---

24. (48) Here's the computation:



$$R_t = \frac{1}{\frac{1}{R1} + \frac{1}{R2} + \frac{1}{R3} + \cdots \frac{1}{R_N}}$$

Fig. 11—Try using this way to calculate the value of R_t.

$$Rt = 72 \times 144/72 + 144 = 10368/216$$
$$Rt = 48 \text{ ohms}$$

An alternate way to compute parallel resistance is shown in Fig. 11. It is difficult by hand but easy if you use a calculator.

The basic characteristics of parallel circuits are summarized in Fig. 12. Go to Frame 25.

KEY CHARACTERISTICS OF PARALLEL CIRCUITS
* All resistances (branches) connected across voltage source. * The total resistance of two resistors connected in parallel is Rt = (R1 × R2)/(R1 + R2) * The sum of the individual branch currents is equal to the total current drawn from the source.

Fig. 12—Three characteristics also determine a parallel circuit.

Combined Circuits

25. As you would expect, it is possible to combine series and parallel circuits. In fact, most electronic circuits are some combination.

A simple combination is shown in Fig. 13. Here a parallel circuit (R2 and R3) is connected in series with two other resistors R1 and R4.

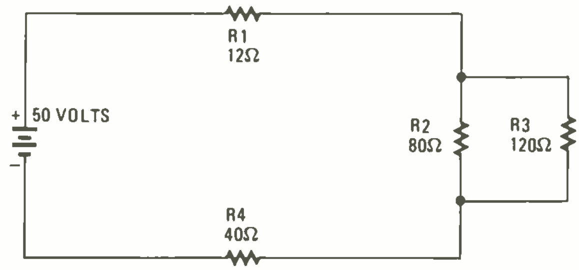


Fig. 13—Series and parallel elements are used in a combination circuit.

Given the resistor values and the battery voltage, the total circuit resistance and current can be computed as shown. First, the total equivalent resistance of R2 and R3 is computed. Then, the total series resistance is obtained by adding R1, R4, and the combined parallel value. The total resistance is then used with the battery voltage in Ohm's law to compute the current. Go through these calculations now.

The total resistance in Fig. 13 is _____________ ohms.
The total current is _____________ amp.

---

26. (100, 0.5) Using Kirchhoff's laws for series and parallel circuits along with Ohm's law, any circuit parameter can be computed if enough of the circuit values are known.

The voltage drop across R4 in Fig. 13 is _____________ volts.

NEW This Issue

27. (20) Go to Frame 28.

Voltage Dividers

28. One of the most common resistive circuits is the voltage divider. A voltage divider is used to develop a lower voltage from a higher voltage.

A simple voltage divider is shown in Fig. 14. It is nothing more than a series circuit. The source voltage is applied to the series circuit and the output voltage is taken from across R2.

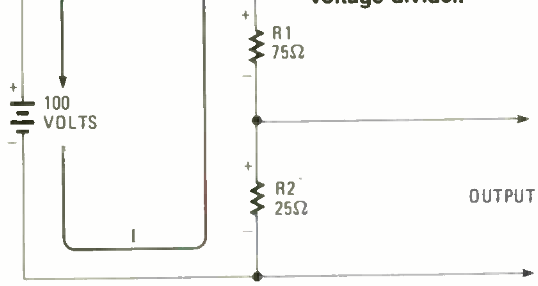


Fig. 14—A series circuit can also function as a basic voltage divider.

We know from Kirchhoff's law that the sum of the voltages across R1 and R2 equals the source voltage. Obviously then, the voltage across R2 is less than the input (source) voltage.
The output of a voltage divider is ____________ than the input voltage.

---

29. (less) If the source voltage and resistor values are known, the output voltage can be computed as the circuit in Fig. 19 shows. First, the total circuit resistance is calculated. Then the circuit current is found with Ohm's law. Finally, the output voltage across R2 is computed.
The output from a voltage divider with $E_s = 30$, $R1 = 50$ and $R2 = 100$ is ____________ volts.

---

30. (20) These procedures can be combined to derive a simple formula to compute the output voltage if the input voltage and resistor values are known.

$$E_o = E_i(R2/R1 + R2)$$

Using the formula, complete the output voltage of a circuit with $E_s = 20$, $R1 = 6$, $R2 = 4$ is ____________ volts.

---

31. (8) The formula above assumes that no load is connected to the voltage divider output. But in practice, that is not true. Some load, a resistance, will appear across the output as shown in Fig. 15. That load, of course, will draw current from the circuit. The resulting circuit is no longer a simple series circuit. Instead, it is a combination circuit. Therefore, the formula above no longer holds true. To find the output voltage, you simply use the procedures described previously for computing combination circuits.
The ____________ draws current from the voltage divider.

---

32. (load) As Ohm's laws tell us, the lower the value of the load resistance, the more current it draws from the circuit. On the other hand, the higher the load resistance, the less current drawn. In practice, the load on a voltage divider is usually minimized by making it as high as practical. By making the

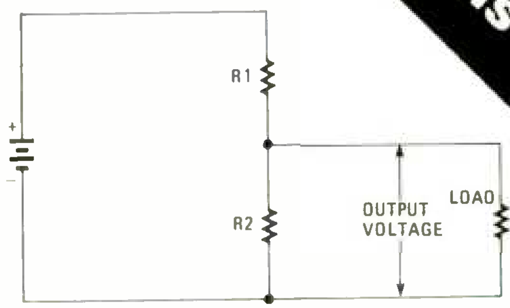


Fig. 15—When a load is used with a voltage divider the series current splits between the parallel resistors.

load resistance ten or more times the value of R2, the current drawn is minimal. If the load is 100 or more times R2, then the effect is even less. If we assume that the load is negligible, the formula given earlier applies.
In a voltage divider, $R1 = 1500$ and $R2 = 4000$ ohms. The lowest possible load resistance to minimize the current drawn is ____________ ohms.

---

33. (4000) With a load value 10 times R2, there will still be some error if the formula is used. The error will be reduced as the load resistance is made larger.

In many applications more than one output voltge may be needed. In such cases, a voltage divider can be constructed to provide multiple lower output voltages from the higher source voltage. An example is shown in Fig. 16.

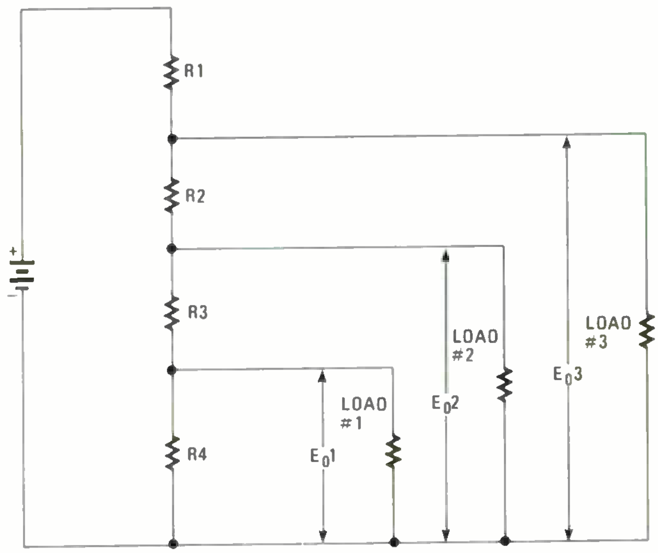


Fig. 16—The basic voltage divider can be easily expanded to provide multiple ouput voltages and loads.

Using the fundamentals of series circuits you can compute the voltage at each output. E_{o3} is the sum of the voltages across R2, R3 and R4. E_{o2} is the voltage across R3 and R4. And E_o1 is the voltage across R4.
Output voltage E_{o2} is ____________ than voltage E_o3.

---

34. (less) If loads appear on the outputs you can calculate the output voltages using the procedures described previously for combination circuits.

If no loads are present or the load resistances are very high, then the formulas below can be used for the circuit in Fig. 16.

$$E_o3 = E_s(R2 + R3 + R4/Rt)$$

where

$$Rt = R1 + R2 + R3 + R4$$
$$E_o2 = E_s(R3 + R4/Rt)$$
$$E_o1 = E_s/R4/Rt$$

Go to Frame 35. ______

Variable Resistances

35. In many circuits, it is possible to vary the resistance in a circuit for the purpose of controlling the current in the circuit or setting the output voltage to a desired value. Variable resistors are used for this purpose. A variable resistance is a component whose resistance value can be conveniently changed. The most commonly used variable resistance is called a potentiometer (or pot for short). A typical pot is illustrated in Fig. 17.

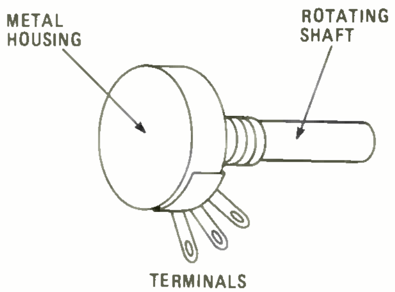


Fig. 17—A conventional potentiometer uses a moveable arm as the resistor tap.

A variable resistance is called a ______.

36. (potentiometer) Inside the pot is a resistive material coated onto a base in a circular form. A wiper arm touches the resistive element and is made to rotate from one end of the element to the other as Fig. 18 shows. A knob attached to the arm shaft makes adjustment easy. In this way, the arm taps off a part of the resistance. The schematic symbol for a pot is also given in Fig. 18.

If the total element resistance between terminals 1 and 3 is 10,000 ohms and the arm is set to the center of the element, the resistance between the arm and either end of the element will be 50% of the total or 5000 ohms.

Refer to Fig. 18. If the arm of a 10,000 ohm pot is set one quarter of the distance from the left end of the element, the resistance between terminals 1 and 2 is ______ *ohms and the resistance between terminals 2 and 3 is* ______ *ohms.*

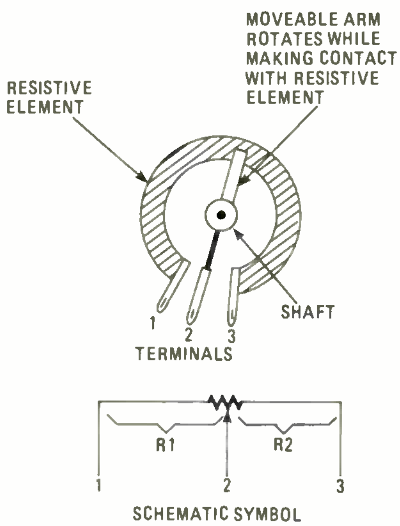


Fig. 18—The conventional potenetiometer also uses a metal cover to provide shielding against stray magnetic fields.

37. (2500, 7500) As you can see, the pot is really two resistors R1 and R2 connected in series, the arm defining their separation. Their total resistance remains constant, but the values of R1 and R2 can be continuously varied. As R1 increases, R2 decreases and vice versa.

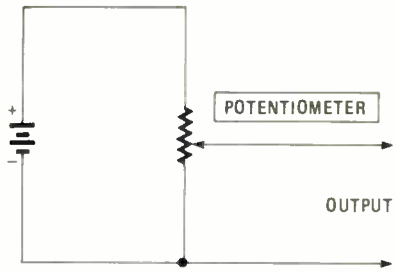


Fig. 19—Only a potentiometer is needed for a simple voltage divider, also other resistors can also be used in the circuit.

Because of its unique configuration, a pot can be used as a variable voltage divider as Fig. 19 shows. The source voltage is applied across the pot and a portion is tapped off by the arm.

The output voltage will usually be ______ *than the source voltage.*

38. (less) When the arm is set to the top of the element, the output voltage will simply be equal to the source voltage since the output is being taken from across the entire element.

Moving the arm down creates a voltage divider whose output voltage decreases as the arm is moved toward the bottom. With the arm all the way down at the bottom of the element, the output voltage will be zero.

A source of 5 volts is applied to a pot used as a variable voltage divider. The output voltage may be set to any value between ______ *and* ______ *volts.*

39. (0,5) Another way to use a pot is as a simple variable resistor. To do this, only one end of the pot element is used. Rotating the pot changes the resistance between that end of the pot and the arm. A pot used in this way is called a rheostat.

Another name for a variable resistance is ______.

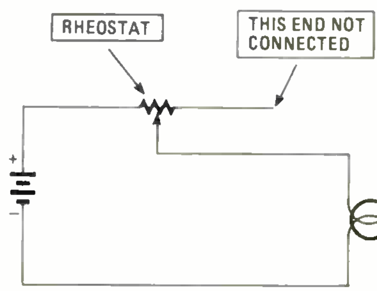


Fig. 20—A potentiometer can also be used as a rheostat.

40. (rheostat) Fig. 20 shows a pot used as a variable resistance. In this case, varying the resistance controls the current in the circuit thereby varying the brilliance of the bulb. With the pot at one end of the element, the resistance will be zero. Therefore, the full source voltage will be applied to the bulb and its brightness will be maximum. Turning the pot inserts some resistance thereby decreasing the current and lowering brightness. When the arm reaches the other end of the pot element, maximum resistance will be inserted and minimum current will flow. Bulb brightness will be the lowest. The bulb may even appear to be off if the current is low enough.
A pot used as a rheostat has a total element resistance of 50 ohms. The maximum and minimum resistance values obtainable are ______ and ______ ohms.

---

41. (0, 50) There are numerous other types of variable resistances used in electronics. Unlike the pot that is adjusted manually, these resistances vary with changes in surrounding physical conditions. Two examples are thermistors and photocells.
The resistance of a pot is changed ______ while the resistance change in a thermistor or photocell is due to ______ ______.

---

42. (manually, physical surroundings) A thermistor is a component like a resistor whose resistance varies with temperature. While the resistance of any wire conductor or resistor usually increases with an increase in temperature, that change is minute over a wide range. Therefore, we normally assume a constant resistance if the temperature range is narrow.

Thermistors on the other hand are deliberately made so that their resistance varies dramatically over a narrow temperature range. Most thermistors are designed with a negative temperature coefficient. That is, if the temperature increases, the resistance decreases and vice versa.
The resistance of a thermistor is increasing, therefore, the temperature must be ______.

---

43. (decreasing) A thermistor is called a sensor since it detects temperature changes and produces corresponding

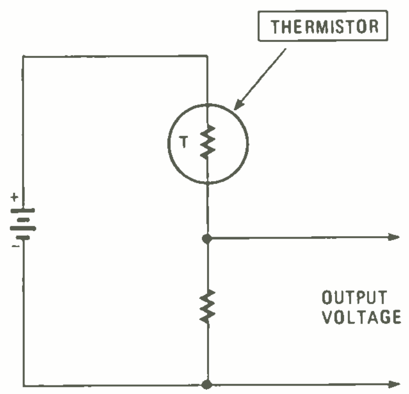


Fig. 21—Since a thermistor is basically a heat-sensitive resistor, it, too can be used in a voltage divider.

resistance variations. When used in a series circuit, a thermistor can control the current. A thermistor can also be used as part of a voltage divider to produce a voltage that varies with temperature as shown in Fig. 21.

Thermistors are widely used in electronic circuits. Some

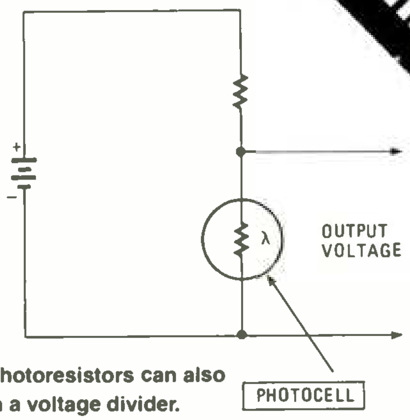


Fig. 22—Photoresistors can also be used in a voltage divider.

NEW This Issue

typical applications include temperature measurement with an electronic thermometer, automatic temperature sensing and control in a heating circuit, and compensation for temperature variations in heat sensitive circuits.
Negative temperature coefficient means that the current in a circuit using a thermistor will ______ if the temperature increases.

---

44. (increase) Another variable resistor is the photocell or photoresistive detector. This is a component whose resistance element is exposed to light. Its resistance varies with the light intensity. More specifically, the resistance varies inversely with light intensity.
If the light shining on a photocell is bright, its resistance will be ______.

---

45. (low) If the light is dim, the resistance will be high. In the dark, the resistance of the photocell goes to some maximum value. This maximum "dark" value is usually several megohms. The value with bright light may only be a few ohms.
Refer to Fig. 22. The output of the voltage divider will be maximum when the light shining on the photocell is ______.

---

46. (minimum) Photocells are used in a variety of ways in electronic circuits. They can detect the presence or absence of light, measure light intensity, or provide isolation between two different circuits.

Go to frame 47.

Bridge Circuits

47. The basic bridge circuit is shown in Fig. 23. It consists of an input voltage source, four elements or arms, and an

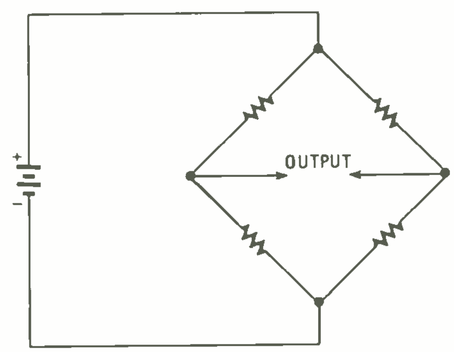


Fig. 23—The basic bridge circuit uses for resistor "arms."

output. For simplicity, we have shown a battery as a voltage source; however, any DC or AC voltage source can be used. The elements, or arms, shown here are resistors but practically any other electronic component can be used as well. A load resistor or indicating device such as a meter is usually connected to the output.

Notice the unique diamond shape of the bridge. When it is drawn this way, it is easy to recognize. Sometimes, however, it is drawn in other configurations and is not so readily recognized. An example is shown in Fig. 24.

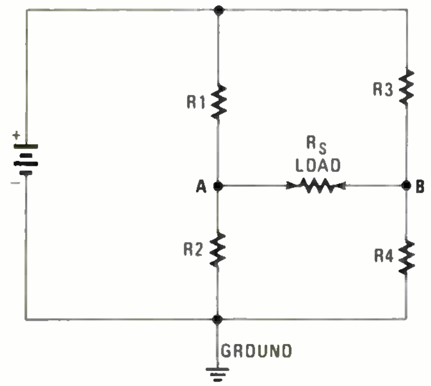


Fig. 24—This is just a different way to draw the bridge circuit shown in Fig. 23.

A bridge circuit has ____________ basic elements.

---

48. (four) If you will look carefully at Fig. 24, you will see that the bridge simply consists of two voltage divider circuits connected across a battery. One voltage divider is made up of R1 and R2; the other is made up of R3 and R4. A load, R_s, is connected between the two voltage divider outputs. By knowing the resistor values and the applied voltage, E, you can calculate the output of each voltage divider, that is, the voltage between point A and ground and between point B and ground. The formula for the voltage divider output is:

$$EA = E(R2)/(R1 + R2) \text{ and } EB = E(R4)/(R3 + R4)$$

where EA and EB are the two voltage divider outputs and E is the applied voltage.

Suppose that the applied voltage E = 10 volts, R1 = 400 ohms, R2 = 100 ohms, R3 = 1200 ohms, and R4 = 300 ohms. Calculate EA and EB. EA is ____________ ____________ EB.

---

49. (EA is equal to EB) Your calculations probably looked something like this:

$$EA = E(R2)/(R1 + R2) = 10(100)/(100 + 400) = 1000/500 = 2 \text{ volts}$$

$$EB = E(R4)/(R3 + R4) = 10(300)/(1200 + 300) = 3000/1500 = 2 \text{ volts}$$

This means that the two voltage divider outputs, those voltages across R2 and R4, are equal.

Now consider the load resistor, R_s. It is connected between points A and B. Since the voltage on both ends of the load resistor is 2 volts, there is no potential difference or voltage across the resistor. Therefore, no current flows through it. When the bridge is in this state, it is said to be balanced. We could easily determine whether the bridge was balanced or

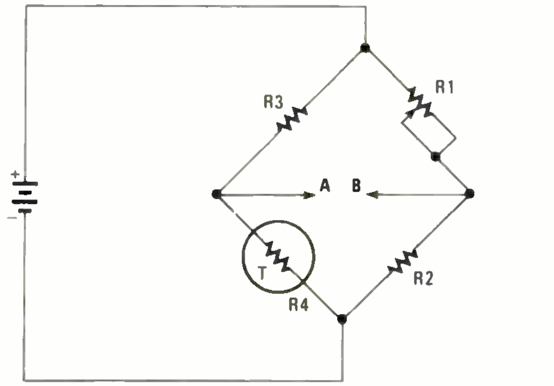


Fig. 25—In a typical application, one bridge arm can be replaced by temperature-senstive resistor R4; another arm uses a rheostat to balance the bridge.

not by connecting a voltmeter between points A and B. If the voltage is zero, the bridge is balanced. On the other hand, if the voltage at point A is not equal to the voltage at point B, then the bridge is said to be unbalanced. A potential difference will exist across R_s and current will flow through it.

Suppose that EA = +4 volts and EB = +5 volts. Current will flow from point ____________ to point ____________ in Fig. 24.

---

50. (A, B) Electrons will flow through the load, R_s, from left to right. When EA = +4 volts and EB = +5 volts, the left end of R_s is negative with respect to the right end. While both voltages are positive with respect to ground, EA is less positive, making it negative with respect to EB. Since electrons flow from a negative point to a more positive point, the direction of current flow is left to right.

If EB was less than EA, then the direction of current flow would be reversed. In either case, the bridge is unbalanced when current flows in R_s.

When current flows in the load, the bridge is ____________.

---

51. (unbalanced) You can always tell if the bridge is balanced by comparing the ratios of the resistors in the voltage dividers. The bridge is balanced if the ratio or R1 to R2 equals the ratio of R3 to R4 or R1/R2 = R3/R4.

If R1 = 10,000 ohms, R2 = 25,000 ohms, R3 = 30,000 ohms, and R4 = 60,000 ohms, the bridge is ____________.

---

52. (unbalanced) If R1/R2 = R3/R4, then balance is achieved. With the values given, however, the ratios are not equal, as you can see:

R1/R2 = R3/R4
10K/12K $\neq$/30K/60K
0.4 $\neq$/0.5

To obtain balance, change the value of R2 to ____________ ohms.

---

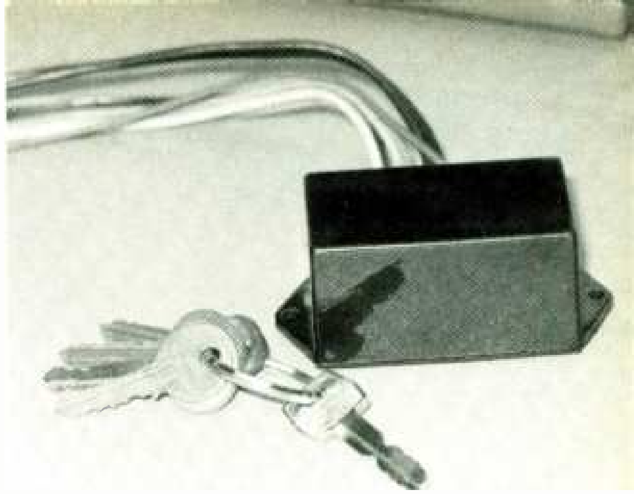
53. (20,000) If we change the value of R2 to 20,000 ohms, leaving the other values alone, we will balance the bridge. The ratios become:

R1/R2 = R3/R4
10K/20K = 30K/60K
0.5 = 0.5

(Continued on page 96)

HANDS-ON REPORT

AUDIOVOX SECURITY TOUCH SENSOR



A keyless, passive circuit secures your car or van!

☐ON A DARK NIGHT NOT TO LONG AGO, A shadow suddenly came to life as it stealthily moved forward from behind tall shrubs over to a luxury sedan parked in a driveway of a quiet residential street. Smash! The passenger window shattered, the thief slipped through the opening, slid into the driver's seat, forced a tool into the ignition switch, and started the engine. Before a house light came on the car was out of the driveway accelerating toward a nearby Interstate.

Come morning, the car was found on a side street with its front bumper, grillework, front fenders, hood, four mag-wheels, and windshield missing. As if almost an afterthought, the dashboard was destroyed and the expensive hi-fi removed. The trunk lid was damaged so that the spare tire and contents of the trunk could be removed. All this could've been avoided had the car not started!

The Touch Sensor System

The scenario would've been much different had the owner of the car installed the Audiovox Touch Sensor Module, Model AA-9170. The Module can either stand alone as a *passive*-starter or ignition-cutout device or be interconnected with any existing *passive* car alarm. (A *passive* alarm is any system that is armed and disarmed by turning the ignition key on and off.)

The Audiovox Touch Sensor system provides a high-security disarming method that requires the person disarming the system to touch two separate points at the same time. The Touch Sensor system eliminates the need for alarm keys or special entry codes—a touch and the system is disarmed. Should an improper start be attempted, the Touch Sensor system can also trigger the car's alarm (if any) with one simple wire connection.

The special passive arming feature (so liked by the insurance companies) insures that your vehicle is *automatically* protected every time you leave the vehicle. You do nothing except turn off the engine, and within 15 seconds the system is *automatically* armed. There is no specific time limit in which you must leave the vehicle.

In the event you attend a restaurant or catering hall that provides valet service, the Touch Sensor system can be placed in the *valet mode* which bypasses the system. When in the valet mode, a dash-mounted LED will blink letting you know that the system is placed on hold.

The Touch Point

The secret switching system that is used by the Touch Sensor is this: When your body makes contact with a special terminal and ground, the system will be disarmed. The ignition key itself will be ground and a non-grounded screw-head would be the special terminal. In the installation made to test the device, a decorative screw on the side of the dashboard was used. Which screw? There were over a dozen to be selected from! The screwhead selected was easily reachable by the driver's left hand since all American and foreign cars have their ignition locks available for right-handed persons. (Some how that's not fair to lefties.)

The vehicle used in the installation test of the Touch Sensor system was a 1986 Ford LTD. Like most cars, the plastic dashboard panels can be quickly removed to get at the underdash wiring. That is the best time to select the screw-head terminal and be sure that it is not grounded.

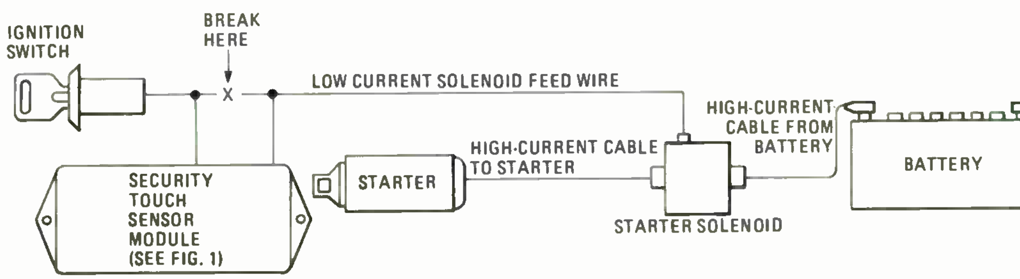
Installation

Before you begin it would be a good idea to obtain an electrical wiring diagram for your car. Manufacturers sell them and you will agree that they are worth the purchase price the first time you use them to troubleshoot the wiring system of you car. Study the wiring diagrams carefully and you will quickly realize that the wires that you must interconnect the Touch Sensor system to the vehicle are *reachable* from the car's front seat—usually behind the dashboard or inside the steering column's plastic shell.

Once you know where the connection points are, consider where you want to mount the module. The site selected in the Ford LTD was in front of the passenger seat under the dashboard. The cosmetic plastic was removed and the module mounted with two machine screws, lock washers, and nuts. Two holes were drilled in the plastic frame of the sub-dashboard. Audiovox supplied two self-tapping screws for this purpose, but, for the location chosen, those screws were not used.

The LED indicator was installed on the dashboard along side the climate controls. The place selected was a removable panel that could be worked with care in the shop. The spot was so selected that the driver could easily see the LED (from the outside as well—let the thieves know that it would be better to go elsewhere) and

Fig. 1—If you are not color blind, this wiring diagram is all you need to install the Audiovox Touch Sensor system. As the text suggests, reference to the vehicle's electrical manual would greatly speed up the installation process for first-time installers who do not know where the car's cables are located.



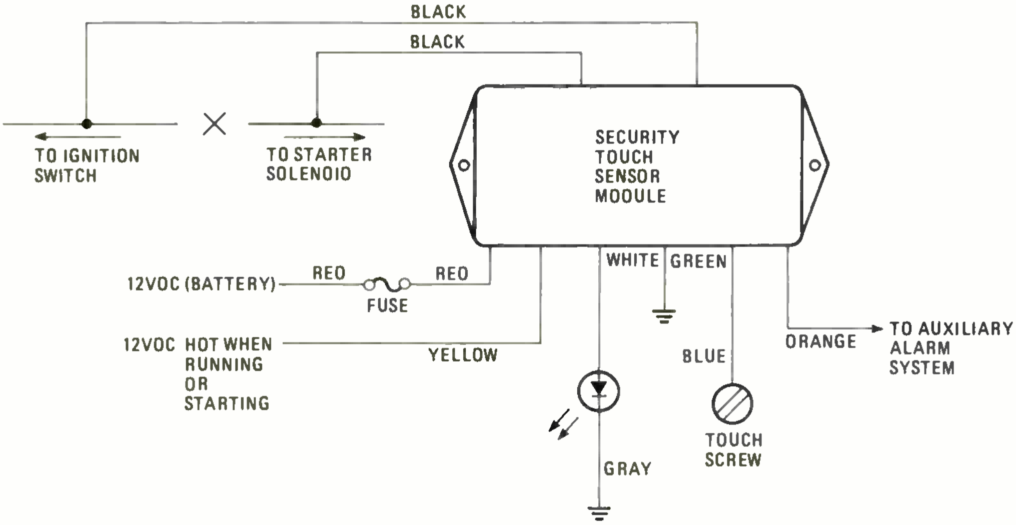
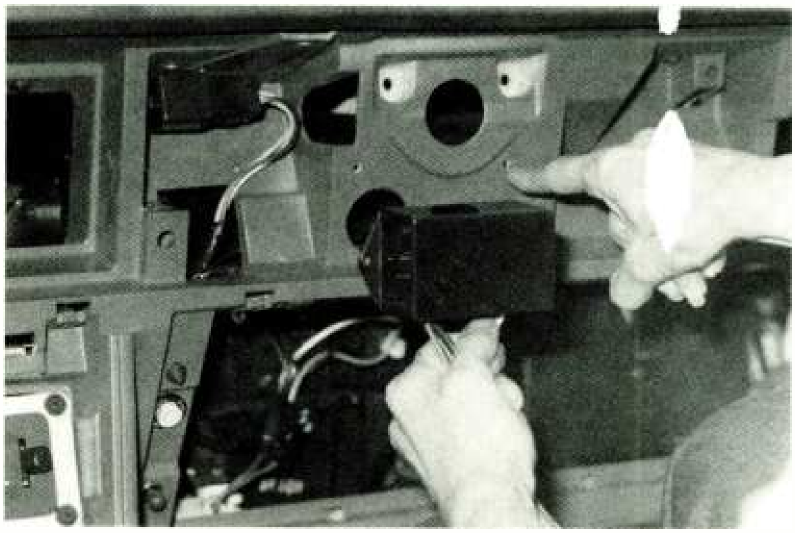


Fig. 2—A block diagram of a vehicle's engine starting system is shown here. The low-current solenoid wire begins at the ignition key and ends at the starter solenoid. In most cars it passes through the transmission neutral/park switch which offers another wire to connect with the Audiovox system. Never cut the high-curent starter cables in an attempt to use them to disable the ignition or starting systems. For more information circle No. 75 on Free Information Card.



The audiovox circuitry was inconspicuously concealed behind the dash and the dash sub-dashboard. It was held in place by two nut-bolt sets and the wire connections were snaked around the back of the glove compartment and up through the steering column wheel and connected to the ignition switch.

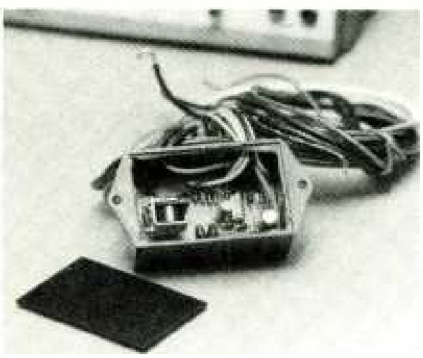
there was sufficient space behind the LED so that the electrical connections could be made.

Plastic in-line clamp-on connectors were used whenever a lead from the module had to be attached. A fuse holder and fuse are supplied to protect the car's wiring should a fault develop. Audiovox supplied an adequate instruction sheet complete with diagrams to assist the installer make the wiring connections. Figure 1 is based on the drawing that Audiovox supplied.

How It Works

The sensitive and selective electronic circuitry in the Audiovox Touch Sensor system functions automatically once it is connected and the battery is charged. When the ignition is turned off, the system will be armed in 15 seconds. The LED will come on with a steady red glow. Starting the car will be impossible because the low-current starting-solenoid wire will be open and the engine will not turn over (see Fig. 2). Touching the key (ground) and a selected dashboard screwhead (sensor terminal) will enable the system and close the starting-solenoid circuit. The LED will go out. Turn the key and start the engine.

To enter the valet (by-pass) mode do so while the engine is running. Touching the key and the sensor terminal will cause the LED to begin blinking. Now, when the engine is turned off, the LED will continue to blink and the engine can be started by turning the ignition key. There is no secret switch to bypass the system.



In tests the relay in the circuitry held its position proving it was bounce free under bumpy road conditions. Needless to say, this is advantageous because you don't want the alarm coming on for each pot hole and speed bump you come across.

It Works

Under test conditions on the test bench, the device performed as designed with a simulated battery voltage that ranged from 9.0 to 17-volts DC. The performance was repeated in the test vehicle with battery voltages varying from 10- to 14.8-volts DC. In-car temperatures up to 140°F were recorded and the system continued to function. Humidity up to 100% had no ill effect. The contacts of the relay inside the module did not bounce (open or close unexpectedly) when the car was driven over a rough road surface.

The Audiovox Touch Sensor system comes complete with instructions so that the installer can fully understand the operation of the unit and the scope of the work required to be done. The LED, fuse, fuse holder, screws, two crimp-on connects, and grounding lugs are included in the purchased package. The suggested retail price is $59.00. You can obtain a system direct from your local Audiovox dealer anywhere in North America. For more information circle No. 75 on the Free Information Card in this issue of **Hands-on Electronics**. ■

BUYING YOUR FIRST RECEIVER

You can listen in on the world...if you know what to buy

By Bob Grove

So you've been "bitten by the bug" as they say? And now you are puzzled as to which radio receiver will best suit you? Certainly, there is a puzzling array of radios on the market and plenty of Madison Avenue blitz to get your attention! The fact of the matter is that cute, cheap portables have only their size going for them—no inexpensive portable is going to measure up when the going gets rough.

The portables are easily overloaded by strong signals and they cannot separate closely-spaced signals on the air. Sound quality is often marginal and their dial settings are often unstable, resulting in drift from their settings. In a nutshell, portable radios are designed for mass-marketing at low cost, and you get what you pay for.

How to Choose

Once you have made your mind up that you are going to skip the portables and move into a real radio receiver, how do you decide which radio will do the best job for you? Let's start by pointing out that there are two basic listening targets of the SWL (shortwave listener): broadcasting and utilities. Broadcasting refers, of course, to those transmitting organizations whose emissions are designed for everyone to hear. Examples include the Voice of America, Radio Moscow, the BBC, and even your local AM, FM, and TV stations. Utilities are everything else—essentially, the two-way communicators of the shortwave spectrum: hams, ships at sea, long-distance aircraft, military units, government agencies, and so forth.

Different Modes

Even a casual glance through a club bulletin or book for radio hobbyists will immediately disclose some user-unfriendly terms like SSB, RTTY, passband tuning, RIT, CW, ECSS, selectivity, noise blanker, attenuation, notch filter, AGC, images, intermodulation, spurious signals...the list goes on. How is it possible, given an apparently endless variety of technical specifications, to make a valid decision as to which radio finally represents the best choice? It isn't easy, but there are some guidelines.

Then and Now

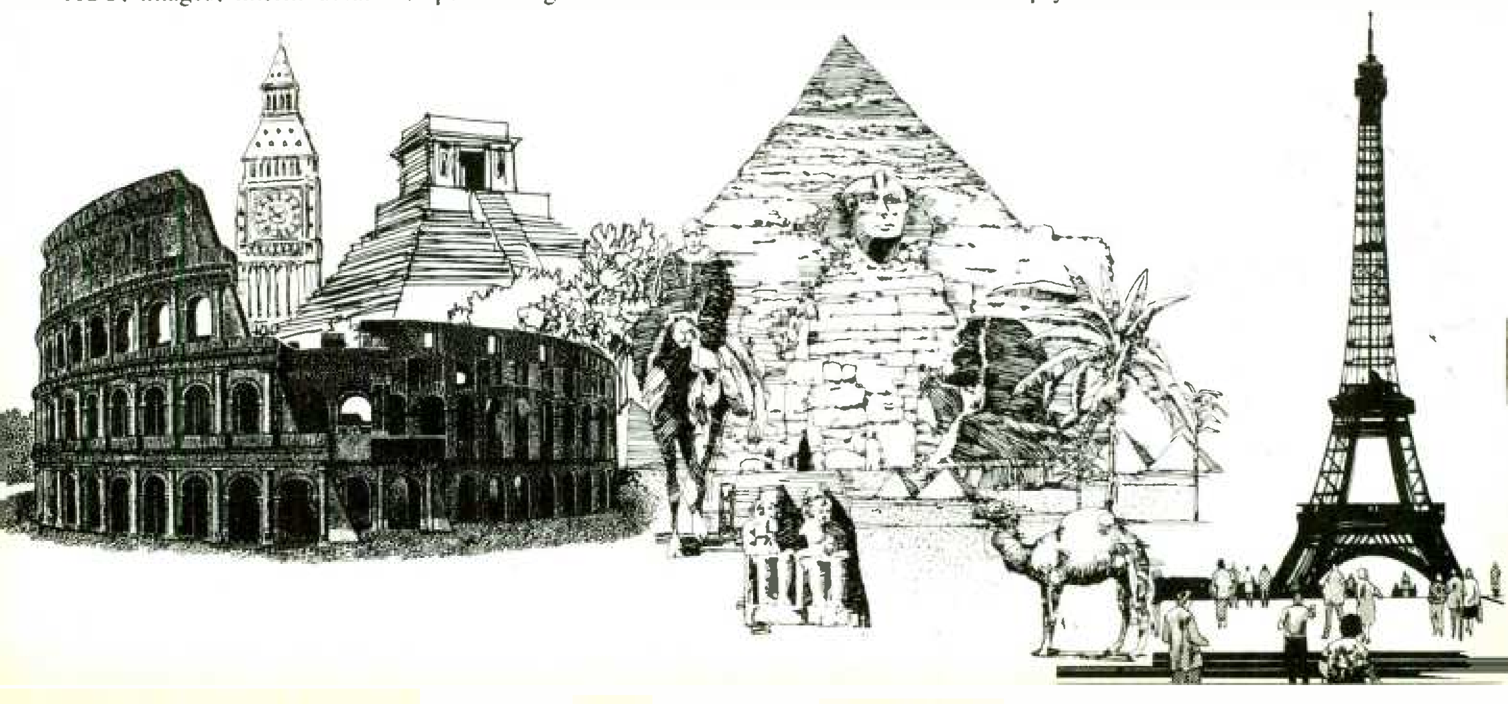
Years ago, during the vacuum-tube era, a minor handful of manufacturers—Hallicrafters, National, and Hammarlund, to mention but three—dominated the hobby marketplace. Today, off-shore manufacturers by the dozens compete for the American dollar. Sony, Panasonic, Yaesu, Kenwood, ICOM, Japan Radio Company, Sangean, and many other competent merchandisers vie for the market. Yes, the names sound familiarly Japanese with one or two Korean and Taiwanese representatives included for good measure. But the rising value of the yen and falling dollar on the international market have prompted some American companies to begin exploring the possibility of entering the foray.

DX'ers—A Special Breed

In the early days of radio, to expedite the inherently slow method of sending messages by Morse code, a system of abbreviations was adopted. The symbol "DX" meant distance; now, DX'ing means the art of tuning for obscure signals not readily intercepted by casual tuning of the dial. Trying to weed out an elusive, weak signal in the background mire of static and strong interfering signals can be like trying to find a needle in a haystack—unless you have the right equipment.

Decisions, Decisions

It's time to decide just which receiver meets our needs. How do we greet judgment day? By nailing down just exactly what we want to hear and how much we want to spend to do it. How much should we pay? Yes, that's the bottom line, isn't



it? We all want the best radio for the least money; and in this business, as we've said before, you do get what you pay for. Generally speaking, any shortwave receiver that costs under $200 is not going to give competitive performance. It may be cute, and it may have great sound, but when the going gets tough, it won't pull the weak ones through. From about $300 to $500, there is a substantial improvement in performance; this is the domain of Kenwood, Yaesu, and the better Sony and Panasonic radios. The $600 to $1000 range is dominated by two receivers of supremely good quality at this writing; the ICOM R71A and the JRC NRD525. It would be difficult to make a recommendation between those two fine performers without knowing just what the application would be.

Utility or Broadcast?

Are you really serious about listening or is it a passing fancy? Will you be at home with the major world-broadcasting services or are you looking for more exotic DX? Will your home turf be full-carrier AM (amplitude modulation) as used by the broadcasters or are you interested in listening in on some of the two-way intrigue?

If you are only a casual listener to the shortwave bands, you probably won't need one of the more feature-filled receivers; a simple inexpensive portable might just fill the bill. Choose one that has good audio (sound), decent weak-signal sensitivity, and reasonable selectivity to avoid adjacent signal interference. Plan on settling for the big guns of the shortwave spectrum like the VOA, BBC, Radio Moscow, and so on.

The Sony SR6506 was the first model to prove it was possible to build high-performance into a small, "pocket size" radio.

If you are more serious about all that, then pay more attention to the specifications and stay with name-brand receivers. Sensitivity should be 1 microvolt or better; the receiver should have a selectivity switch for battling interference on the crowded shortwave spectrum.

For AM reception, selectivity of around 6 kHz will provide excellent clear-channel crispness, while sharper selectivity (3-4 kHz) will help stave off the brutal interference...but at a reduction in fidelity.

For SSB, CW, RTTY, and ECSS reception modes, you need even sharper selectivity—typically 2-3 kHz for SSB and ECSS, and 0.25-0.5 kHz for CW.

Spurious-signal suppression should be as great as possible, typically stated at 50-60 dB (decibels) in the specifications. Consult the accompanying glossary for other considerations.

Generally speaking, if the manufacturer is willing to publish the detailed specifications of his radio, it is probably a pretty-good radio. Compare stated specs among competitors and find the best price for the best specs. Shortwave listening can open the horizons of your imagination, providing unbridled wings of exploration. Travel the ancient Andes while listening to haunting Quechua tunes on HCJB, the Voice of the Andes; stir with renewed patriotism as you listen to Voice of America; and compare the objective news reporting of the internationally respected BBC with the pedantic hard line of Radio Moscow. It's all there—at your fingertips.

Turn on the Receiver—Then What?

Click—the receiver comes alive. Status lights glow, the S-meter wavers slightly and, as the volume control is advanced, a hiss emerges from the speaker. An appropriate antenna has been connected. "Now what?" you ask. The operating manual is usually pretty good about telling you what your initial control setup should be:

RF gain control fully clockwise.
Audio gain (volume) control at a comfortable listening level.
Bandswitch set to the frequency range of interest.
Mode on AM (broadcasting) or USB (for voice communications).
ANL (automatic noise limiter or noise blanker) off unless severe electrical noise is present.
Attenuator off.
AGC fast (for AM) or slow (for SSB or CW).
Filter (selectivity) wide (unless the band is unusually crowded).
Passband tuning and notch filter off.

AM Reception

Now, start tuning! Naturally, AM broadcast signals will be the easiest to find: Simply watch the S-meter for greatest deflection as you tune into the signal. If adjacent-channel interference is present, try using the passband tuning or notch filter to remove the irritating signal. If that doesn't work, switch to the next narrower selectivity filter. If the interference is still present, repeat the passband tuning/notch filter "tweaking" for reduction of the unwanted intruder. Some additional juggling of the main tuning dial may be necessary to optimize the interaction of all controls.

SSB Reception

Single sideband is a little more difficult to tune in initially, but with slight practice, it will become as automatic as tuning

Kenwood R-2000: Sporting ten memory channels and continuous 100 kHz-30 MHz tuning, Kenwood's R-2000 receiver is a leading contender among mid-price-range receivers.

AM. First, a rule of thumb: Outside the amateur bands, virtually all SSB heard in the shortwave spectrum will be upper sideband (USB). That includes ship-to-shore, aircraft, government, commercial, and military. Hams use USB above 10 MHz, LSB below. If your receiver is equipped with a control that allows choice of upper or lower sidebands, simply select the appropriate mode and slowly turn the main tuning dial for the most natural voice. If you have only an SSB switch, you will need to adjust the main tuning dial first in the AM mode, watching the S-meter for the strongest deflection of the muffled SSB signal, then switch on the SSB mode and slowly tune the BFO (beat frequency oscillator) control for a natural voice sound. Interference may be reduced in the SSB mode similar to the procedure used above for AM interference, using the passband tuning and notch filter along with switching to a narrower selectivity filter.

CW Reception

Morse-code reception is performed identically as with SSB, only an even narrower selectivity may be used, since only one tone frequency need be passed by the filters, thus reducing background noise as well.

The Right Stuff

Are you interested only in international broadcasting stations with their voice and music programs? Is your quarry two-way intrigue utilizing single sideband, radioteletype (RTTY) or CW (continuous wave or Morse code)? Those different modes require different receiver adjustments, and not all receivers adequately handle all modes. A while back we listed quite a number of perplexing terms which are likely to be seen while perusing the specifications of a new receiver. Let's take a brief look at what they mean.

Selectivity—We are interested in receiving only one signal at a time. The ability of a receiver to slice a piece out of the spectrum just wide enough to detect that one signal is a measure of its selectivity.

Sensitivity—Weak signals have enough trouble getting through the background of atmospheric static and man-made electrical interference. But the circuitry of radios also adds noise of its own. Low-noise circuits must be designed to allow the weakest signal to stand out above the noise. That is sensitivity.

Stability—A radio signal occupies a very small space in the electromagnetic spectrum. In order for it to be heard, the receiver must be able to remain right on frequency, unaltered by a jarring of the cabinet or changes in temperature.

Images and Intermodulation—Modern superheterodyne (there's another one of those words!) receivers—and they all are superhets—create additional unwanted spurious signals as a result of their design. The ability of a receiver to suppress those unwanted products of signal processing is a measure of its quality.

AGC—Automatic gain control is a method that a receiver uses to decrease its amplification of a received signal when that signal proves to be of such a high intensity that it could cause overloading problems (like intermod and images). AGC used to be called AVC (automatic volume control).

Passband Tuning—It is possible to electronically manipulate a signal in the receiver to "move it" away from a nearby interfering signal via that control. *PBT* is an excellent feature and often an indicator of quality design.

Attenuation—As a guard against the inrush of excessively strong signals, some receivers allow manual front-panel selection of a resistor "pad," a small network of components, which lower the strengths of all incoming signals.

(Continued on page 105)

JRC NRD-525: The Japan Radio Company rig is a top grade receiver for serious listeners, as well as government and commercial agencies, and offers 200 memory channels.

DESIGNING AUDIO AMPLIFIERS

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DESIGNING AUDIO AMPLIFIERS

Designing audio amplifiers is a snap if you use op-amp building blocks. And we provide a BASIC program that makes it even easier!

By Jack Cunkelman

THE OPERATIONAL AMPLIFIER—USUALLY CALLED AN *OP-AMP*—is one of the basic building blocks of the linear circuit designers: it has made designing audio amplifiers easier for *them*, and it can open up a whole new world for *us*.

To use an op-amp it's really not necessary for us to know what's inside the device, only how it reacts to the outside world. As far as the outside world is concerned, an op-amp functions as a self-contained "gain block" that can be cascaded with other gain blocks. For example, if your project calls for 80-dB gain—a value usually beyond the range of a single op-amp stage—you can cascade two 40-dB op-amp "gain blocks."

One of the really big features of the op-amp "gain block"—as far as the experimenter is concerned—is that it takes five or fewer components to determine the dynamic characteristics of an amplifier, and when you have that few components it's easy to use a computer program—such as the BASIC program shown in the listing—to determine generic op-amp parameters. Because the program is written in simplified BASIC, it will run on just about any commonly-used "business" or home-and-family personal computer.

The program is specifically written to make it easy for the experimenter to determine the component values necessary to interface op-amp audio "gain blocks" with the outside world. The values selected by the program for the resistors and capacitor(s) will work with almost any type of op-amp, among them the 5532, 5533, and 5534 series from Signetics, and the TL060, 70, and 80 series of op-amps from Texas Instruments.

How They Work

Modern op-amps share a common group of "ideal" specifications. There are: Infinite gain, infinite input impedance, zero output impedance, and infinite bandwidth.

As with most other things, the real-world op-amp is somewhat less than ideal, but it will perform admirably for most experimenter applications. (We will cover the op-amp in a limited manner: as it relates to hobbyist audio circuits. For those of you who want to know more about op-amps, you will find many "in-depth" books at your local library.)

The program designs the op-amp in response to how you answer a series of questions relating to various amplifier functions. The first decision the computerized op-amp design program asks for is the amplifier's configuration: inverting or noninverting.

The Inverting Amplifier

The inverting-amplifier configuration is shown in Fig. 1. It's called an inverting amplifier because the polarity of the output signal is inverted (180° out-of-phase) compared to the signal applied to the inverting input. (The inverting input is designated by the " − " symbol: the noninverting input by the " + " symbol.)

Coupling capacitor C1 isolates the op-amp's input so that the amplifier provides only AC, not DC gain. The value of capacitor C1 determines the lower limit of the amplifier's audio response; it is calculated when the program asks you to enter the desired low-frequency limit.

The circuit's gain is established by the ratio of resistors R1 and R2:

$$V(oltage)\ G(ain) = R1/R2$$

Since audio circuits are usually designed in terms of dB gain and loss rather than in voltage ratio, the program automatically converts voltage gain and loss to dB gain and loss.

The inverting amplifier's input impedance is simply the value of resistor R2. You can choose the value or let the computer pick a value for you based on the gain you specify. Resistor R3 is an optional resistor and is used to reduce or eliminate DC bias problems.

The resistor values displayed by the computer will be the standard 5% values that are nearest the calculated values.

The computer-calculated value for capacitor C1 is a minimum value. Always choose the next highest value available. For example, if C1 is calculated as 4.2-µF, use 4.7- or 5-µF.

The Noninverting Amplifier

The noninverting amplifier is shown in Fig. 2. In this

```
10 REM * AUDIO OPAMP DESIGN  2.4 *
20 REM * BY JACK CUNKELMAN *
30 REM * AUGUST 1986 *
40 CLS : GOSUB 1500
50 CLS
100 PRINT"AMPLIFIER CONFIGURATION - INVERTING (1) NONINVERTING (2)
110 INPUT T
120 IF T = 1 THEN 500
130 IF T = 2 THEN 1000 ELSE 110
500 CLS : A$ = "INVERTING"
505 ON ERROR GOTO 1700
510 PRINT TAB(20) "INVERTING AMPLIFIER DESIGN"
520 INPUT "LOW FREQUENCY LIMIT IN HZ";F
530 INPUT "DESIRED GAIN OF STAGE IN DB";G
535 V = 10^(G/20)
540 INPUT "INPUT IMPEDANCE ( 0 IF NOT CRITICAL )";Z
550 IF Z = 0 THEN 555 ELSE 590
555 GOSUB 4000 : R1 = S1
570 R2 = S1 / V
580 RX = R2 : GOSUB 2010 : S2 = R(S)
585 GOTO 630
590 RX = Z : GOSUB 2010 : S2 = R(S)
610 R1 = V*S2
620 RX = R1 : GOSUB 2010 : S1 = R(S)
630 F1 = F/10 : C = 1/(6.28*S2*F1)
640 VG = S1/S2
650 R3 = (S1*S2)/(S1+S2)
660 RX = R3 : GOSUB 2010 : S3 = R(S)
670 GOSUB 3000
680 GOSUB 5000
690 CLS : GOTO 530
1000 CLS : A$ ="NONINVERTING"
1010 PRINT TAB(20) "NONINVERTING AMPLIFIER DESIGN"
1020 INPUT "LOW FREQUENCY LIMIT IN HZ";F
1030 INPUT "DESIRED GAIN OF STAGE IN DB";G
1040 V = 10^(G/20)
1050 GOSUB 4000 : R1 = S1
1060 R2 = R1 / (V - 1)
1070 RX = R2 : GOSUB 2010 : S2 = R(S)
1080 F1 = F/10 : C = 1/ (6.28*S2*F1)
1085 VG = S1/S2 + 1
1090 R3 = (S1*S2)/ (S1 + S2)
1100 RX = R3 : GOSUB 2010 : S3 = R(S)
1110 GOSUB 3000
1120 GOSUB 5000
1130 CLS : GOTO 1030
1500 DIM R(144) : REM 5% RESISTOR TABLE
1510 R(1)=1:R(2)=1.1:R(3)=1.2:R(4)=1.3:R(5)=1.5:R(6)=1.6
1520 R(7)=1.8:R(8)=2:R(9)=2.2:R(10)=2.4:R(11)=2.7:R(12)=3
1530 R(13)=3.3:R(14)=3.6:R(15)=3.9:R(16)=4.3:R(17)=4.7
1540 R(18)=5.1:R(19)=5.6:R(20)=6.2:R(21)=6.8:R(22)=7.5
1550 R(23)=8.2: R(24)=9.100001
1555 PRINT TAB(15)"SETTING UP RESISTOR TABLE"
1560 B=1:FOR N=25 TO 48:R(N)=10*R(B): B=B+1 : NEXT N
1570 B=1:FOR N =49 TO 72:R(N)=100*R(B): B=B+1 : NEXT N
1580 B=1:FOR N =73 TO 96:R(N)=1000*R(B): B=B+1 : NEXT N
1590 B=1:FOR N =97 TO 120:R(N)=10000*R(B): B=B+1 : NEXT N
1600 B=1:FOR N= 121 TO 144:R(N)=100000!*R(B): B=B+1 : NEXT N
1610 RETURN
1700 PRINT "RESISTOR R1 VALUE TOO LARGE"
1710 PRINT "LOWER GAIN OR INPUT IMPEDANCE"
1720 RESUME 530
2000 REM * RESISTOR SEARCH ROUTINE *
2010 U = 145 : L = 0
2020 S = INT ((U+L)/2)
2030 IF S = L THEN 2100
2040 IF RX < R(S) THEN 2070
2050 L = S
2060 GOTO 2080
2070 U = S
2080 S = INT ((U + L)/ 2)
2090 GOTO 2030
2100 E = ABS( R(S) -  RX) : H = ABS (R(S+1) - RX)
2110 IF E<H THEN S =S ELSE S = S+1
2120 RETURN
3000 CLS
3010 PRINT TAB(20) A$ " OPAMP AMPLIFIER"
3020 PRINT:PRINT TAB(10)"LOW FREQUENCY LIMIT IS "F"HZ"
3030 PRINT:PRINT TAB(10)"GAIN IS "G"DB"
3040 PRINT:PRINT TAB(10)"VOLTAGE GAIN IS "VG
3050 PRINT:PRINT TAB(10)"RESISTOR R1 IS "S1"OHMS"
3060 PRINT:PRINT TAB(10)"RESISTOR R2 IS "S2"OHMS"
3070 IF A$ = "NONINVERTING"THEN 3090
3080 PRINT:PRINT TAB(10)"OPTIONAL RESISTOR R3 IS "S3"OHMS"
3090 PRINT:PRINT TAB(10)"C1 IS "C*1000000!"UF"
3100 RETURN
4000 IF G<=30 THEN S1 = 10000 ELSE S1 = 100000!
4020 RETURN
5000 PRINT : PRINT
5010 INPUT "ANOTHER CALCULATION (A) : RESTART PGM (R) : QUIT (Q) ";R$
5020 IF R$ = "A" THEN RETURN
5030 IF R$ = "R" THEN 50
5040 IF R$ = "Q" THEN END
5050 RETURN
```

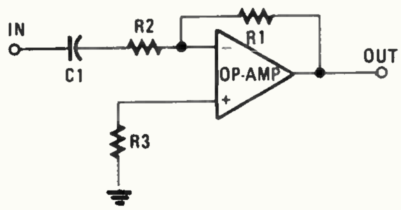


Fig. 1—The inverting op-amp amplifier. Resistor R3 is used only to avoid DC offset problems. In many instances it isn't needed, and can be replaced with a direct wire to ground.

configuration the polarity of the output signal is the same as the input signal. The input impedance is equal to the value of R3. Capacitor C1 performs the same function as it does for the inverting configuration.

The resistor values for R1 and R2 again determine the gain, but the relationship is now:

V(oltage) (G)ain = R1/R2 + 1

Resistor R3 is the same value as R1 in this configuration.

Again, standard 5% resistor values are calculated by the computer.

To have the computer design an amplifier ("gain block"), simply decide whether you want an inverted or noninverted configuration and then plug in the information requested by the computer.

Important Program Lines

If you want to modify or customize the program for your particular needs some of the important program blocks (lines) are:

0500-0690—Inverting Amplifier Calculations
1000-1130—Noninverting Amplifier Calculations
1500-1610—5% Resistor Table
2000-2120—Resistor Table Search Routine
3000-3100—Summary Page Routine

A Few Final Thoughts

If more than 50-db gain is needed it should be done with two stages, in particular because resistor values greater than 1 Megohm can cause stability problems and should be avoided. If the resistor values get too high, the program will ask you to reconsider some of the parameters. ■

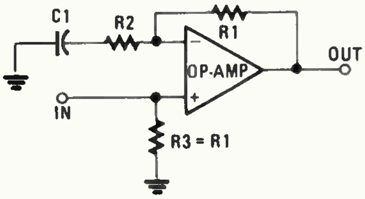


Fig. 2—The noninverting amplifier. R3 needs to be equal to R1 only to avoid DC offset problems. However, R3 is the amplifier's input impedance.

By Herb Friedman

FRIEDMAN ON COMPUTERS

Digital spin-offs also have "english"

THE DICTIONARY DEFINES A SPIN-OFF AS "a collateral or derived product or effect." In plain language, it usually means a totally new product derived from a technology originally intended for something else. For example, modern cookware uses the ceramic technology originally intended for the design of heat-resistant rocket nose cones.

Generally, a spin-off—be it cookware or a new TV sitcom—stands alone, becoming a totally new product, movie, idea, or whatever. But when it comes to computers and other digital circuits, the spin-offs often emulate a rubber ball with "english:" spin that directs the ball back to whence it came. Digitized analog signals are a good example of what's possible when we return a computerized spin-off back to the computer.

Bits and Pieces

When we digitize an analog waveform, a computer samples the signal at a periodic rate, and the bit of waveform at the sampling instant is converted to a digital representation of the waveform's value. For high-fidelity sound, the sampling rate is slightly more than 40-kHz, which is adequate for low-distortion reproduction. If the analog signal is complex—having considerable high-frequency energy—the sampling rate might be say, 500-kHz. Regardless of what the precise sampling rate might be, eventually we end up with a digital representation that can eventually be used for sound output, TV pictures, voltage measurements—just about anything you can imagine.

Whatever its intended purpose, because the digital representation can be stored in memory (RAM)—or permanently on magnetic storage-media such as a disk—it's possible to store just about any kind of sound, photo, or information as digital data for eventual processing or re-processing by a personal computer. Since the personal computer can do just about anything if it has the proper software, it can not only restore the original signal, but it can integrate the digital representations into a totally new function.

For example, you are probably familiar with the digitized voice recording of the new telephone-answering machines; you speak into the microphone, and your message is digitized and stored in RAM. When the machine answers the telephone, it restores the digitized data into an analog announcement. If the sampling rate is sufficiently high, the caller cannot tell the difference between the digitized announcement and one that might have been recorded earlier on an answering machine that used a cassette tape for the announcements.

Cm'ere Watson

Keeping the idea of a digitized voice in the back of your mind, consider a device for IBM PC's known as a *Watson*, named after Alexander Bell's famous command "Come here Mister Watson."

A Watson has two units: software, and a hardware device. The hardware is a plug-in card containing a modem, and A/D (analog-to-digital) and D/A converters. (Actually, the modem is not a conventional modem; it, too, uses A/D and D/A processing.) Both the telephone line and the local instrument connect to the Watson.

You can speak into the handset and the Watson will digitize and store your voice on disk. Similarly, the Watson can digitize and store incoming calls. A simplified functional Watson-type digitizing circuit is shown in Fig. 1.

While digitizing is no big deal, we put the "english" on it through Watson's software. The software serves both as a telephone directory, automatic dialer, call-forwarder, and selective message center—most of it controlled by telephone touch-tones. You can record both a general *We're not at home* message and individual personalized messages.

If a caller sends his or her authorized touch-tone code, the computer will recall your digitized message from disk, restore it to voice, and transmit your message to the caller. An authorized caller can then answer your message, which Watson will save on disk. If you have given Watson the appropriate computer command, after receiving messages from selected callers, Watson will automatically dial you at a new telephone number, play back the received message, and if necessary, store your reply message digitally—and then automatically dial and send your reply to the caller at a predetermined time.

Not Complex

While all the coming and going of digital messages appears formidable, it's really not. Once the messages are digitized the computer handles the bits and bytes as it would any other data. It's the A/D-D/A conversion and data storage that makes the software's juggling possible.

Digital Storage Scopes

The same kind of digitizing can be used independent of the computer to turn your

(Continued on page 102)

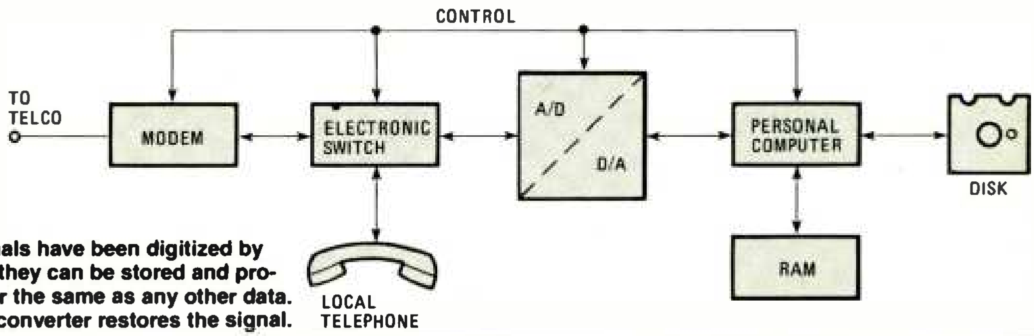
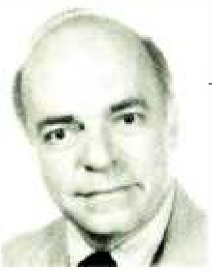


Fig.1—After the telephone signals have been digitized by an analog-to-digital converter, they can be stored and processed by a personal computer the same as any other data. Eventually, a digital-to-analog converter restores the signal.

By Marc Ellis



ELLIS ON ANTIQUE RADIO

You've got to also collect parts if you want to keep your antique radios up and running

HELLO, AND WELCOME TO THE SECOND issue of your new antique radio column! Last month, we began a tour through the world of radio collectibles especially aimed at newcomers to the hobby. We took a look at crystal sets, one- and two-tubers, multiple-tube battery sets, early AC sets, and the more sophisticated AC sets of the early 1930's. Now I'd like to finish our tour, beginning with some of the changes that took place in radio receivers as a result of the 1930's depression.

The AC-DC Sets

With the coming of economic depression, radio listening became an even more popular pastime. The programs were free, provided an escape from everyday cares, and could be enjoyed without leaving the home. But if the radio industry wanted to sell sets, they had to be sold cheaply. Designers cut costs by making ingenious circuit changes that eliminated two expensive power-supply components, the power transformer and the filter choke. As a fringe benefit, the elimination of the power transformer made it possible to operate the set on DC as well as AC power. (At that time, the downtown sections of many big cities still had DC power—and ordinary radios couldn't be used without expensive power converters.) The AC-DC sets, as they were called, were smaller and lighter than any table model made up to that time.

The Emerson AC-DC table radio has a classically-styled moulded-plastic cabinet and a 5-tube circuit. During the 1940's, sets like these began turning up in every room of the house.

Even after the return of prosperity, AC-DC sets maintained their popularity in North American households. Further technical advances had made them even more inexpensive, and the family could now afford to have several sets placed strategically throughout the home. Housed in molded plastic cases (which generally replaced the wooden cabinets of the earlier models), the little AC-DC sets were ubiquitous—until made obsolete by the advent of transistorized circuits in the 1950's.

Portable Radios

Lightweight battery-powered radios that could be carried anywhere first made their appearance in the late 1930's. They were made possible by the development of a new series of tubes having much reduced power requirements. The original models sported fabric-covered, luggage-style cases designed to make their owners feel like world travelers. Enormously popular with teenagers, the little portables soon appeared on beaches, and in parks and other recreational areas all over the country. Over the years, portables were developed in a variety of case styles and sizes. Many had ingenious mechanical arrangements to accommodate batteries and dials in the smallest possible space, and to position the antenna for maximum reception. Like the AC-DC radio, the "suitcase-style" portable retained its popularity throughout the post-war years until made obsolete by the pocket-type transistor sets of the 1950's.

Other Antique Radio Collectibles

Most radio collectors are also tube collectors—at least of the types needed for set maintenance and restoration. But many collect tubes for their own sake—and some specialize only in tubes. There are a variety of approaches to tube collecting. The early types were numbered serially, and some collectors try to acquire one of each number. (I once noticed a classified ad from a desperate individual who needed only a few numbers to complete his collection of transmitting tubes having designations beginning with 8!). Many different base and envelope designs were also produced over the years, creating additional collectible categories. In addition, a profusion of oddball and special-purpose tubes have been manufactured through the years—all fair game for the collector. Tube packaging can be as interesting as the tubes themselves. Most came in colorfully lithographed boxes that make interesting shelf displays. It can be educational to collect and compare boxes from one manufacturer covering several different eras.

Radio Parts

Just as they keep an eye open for tubes, most antique radio collectors watch for

Typical of early 1940's portables, the Zenith Model 5G401 Universal Radio has an airplane-luggage case. The separate loop antenna has rubber suction cups so that the antenna can be attached to the window of a car, plane, or bus.

parts they can use to restore old sets. But some consider the parts themselves to be collectibles. By today's standards, it's hard to understand why anyone would want to collect parts. Whatever the amazing results you can obtain with them, today's integrated circuits, transistors and other printed-circuit components don't look like much. You buy them by the dozen (or the hundred) in bubble packs, and quite often it's difficult to tell one from the other. This wasn't so in the early days of radio—particularly in the mid 1920's. Back then, parts were marketed and sold somewhat the way high-performance auto parts are sold now. They were made to be looked at: beautifully finished and individually packaged in colorful boxes. If your tastes run to collecting parts, you can put together a very nice display indeed.

In the 1920's, vacuum tubes came in many shapes and styles. These are some old favorites. From left to right: the UV201, UV201A, WD12, C12, and CFX199. All but the WD12 and the CFX199 have an early- style brass base and tip-seal envelope.

Reproducing Equipment

Throughout much of the 1920's, radio sets were sold without speakers. These were purchased separately, just as hi-fi speakers are today. Within the limitations of his budget, the buyer picked the unit that seemed to offer the best sensitivity and tone. There was a variety of models to choose from, but their construction was similar. Most contained a driver unit built like a large headphone. This was generally located in the base of the unit, with acoustical amplification provided by a large horn that sat on top. But sometimes the driver was located at the center of a large decorated paper cone mounted in a metal stand.

An arrangement of speakers, with horns and cones of different styles and sizes, makes a very interesting addition to your radio collection. Headphones, too, come in an interesting variety of types, and can round out your collection of antique radio reproducers. If you're lucky, you might even uncover an example of a phonograph adapter unit. This is a driver without a built-in horn or cone. Instead, it attaches to a phonograph's tone arm in place of the needle assembly—allowing the radio to be played through the phonograph's acoustical system.

Radio Test Equipment

From a visual standpoint, pieces of antique radio test equipment are some of the most interesting radio-related items you can collect. The archaic panels, knobs, dials and meters are fascinating to look at, and many instruments come in beautifully-finished wood, bakelite or metal cases.

Among the items you might find are set testers (which measure key operating voltages through special adapters designed to be inserted between a tube and its socket), audio and radio signal generators, measuring instruments of various kinds and tube testers. Some collectors actually make a point of using the old instruments for trouble shooting and maintenance. This generally isn't a good idea unless you have modern instruments to check the calibration and accuracy of the old ones. One exception is the tube tester. You'll obviously need an older tester to check your vintage tubes. But try to find a top quality, relatively new model. Testers made well into the 1950's handled most of the older tubes.

Radio Literature and Advertising

Like so many of the collectibles we've talked about so far, these can be acquired for their own sake or as an aid to radio restoration and maintenance. The wide range and potential of the literature and advertising field have attracted many specialized collectors. Old radio advertising, catalogues, trade and popular magazines, books, broadcasting schedules, store display items and servicing literature are some of the major categories of interest. But even if you're primarily a collector of radio hardware, you'll find it hard to keep from getting involved. Old magazines contain display advertising and technical discussions that will help you date and understand your sets. Collections of vintage schematics and servicing data (such as the *Rider*'s and *Supreme* manuals) will be of great assistance when you're trying to bring your relics back to life.

At the left is the Readrite Set Tester: An array of adapters allowed the test probe to be inserted into any commonly-used tube socket. On the right is the Clough-Brengle Model 00 RF Signal Generator, whose frequency range covered approxi mately 50 kHz through 35 MHz.

Future Plans

That finishes up our overview of radio collectibles. But don't be disappointed if I haven't covered some types of special interest to you. I've been trying to "hit the high spots" for people who might be newcomers to the hobby. More specialized topics can be covered in future columns, and if you have something in mind, let us know. In the meantime, be sure to get in touch if you're looking for parts or information, have something to swap, or want to share anything at all concerning antique radio with other readers of the column. Pictures are welcome! Write to me in care of **Hands-On Electronics**, Gernsback Publications, Inc., 500B Bi-County Boulevard, Farmingdale, NY 11735. ■

By Mark Saxon

SAXON ON SCANNERS

Yes, you can get gold-plated performance at a budget price

THE GREAT SWAMI (THAT'S ME) predicts that by the end of December you'll be giving and receiving many gifts. (Remember, I'm never wrong with my gift predictions.)

For scanner fans, one of the nicer aspects of the giving and receiving of gifts is that you can use that occasion to get a father, mother, son, daughter, or grandchild a "starter" scanner and open up for them many hours of excitement and enjoyment. You may also wish to give yourself a second (or third) scanner to be used at your home, or for your summer vacation place.

That all becomes very economical with the introduction of Regency's new R1075 fully programmable low-cost scanner. Hard to believe, but it's true, the suggested list price is only $179.95. That puts the scanner in reach of almost everybody and makes it a great gift idea.

You're possibly saying, "Sure, for that price the scanner offers *zip* in the way of features and performance." Wrong, wrong, wrong! That is no *Mickey Mouse* toy; it's a full-function unit made up in a small and easy-to-use package.

The new Regency R1075 walks tall, in step with features normally reserved for expensive top-of-the-line scanners. It will receive more than 15,000 frequencies in the following ranges: 30 to 50 MHz, 144 to 174 MHz, and 440 to 512 MHz. A dual-scan speed control allows selection of the scanning rate. It can scan-search, accept a priority channel, and be set for a 2-second scan-delay. There is also a channel lockout. It doesn't even require a battery to save the programmed frequencies if there should be a powerline failure lasting up to several hours.

The R1075 is also simple to program. There's a numbered keyboard and a dual-level vacuum fluorescent display that flashes visual-prompt messages to aid programming. The R1075 operates from 117-VAC, comes with a telescopic antenna, and is set to go with a very well prepared instruction manual.

Complete details from the many Regency suppliers, or directly from Regency Electronics Inc., 7707 Records Street, Indianapolis IN 46226.

One of the questions we are frequently asked relates to whether stations heard on a scanner will verify (QSL) reception reports the way shortwave and AM broadcasters usually (but not always) do. Would that it were so simple on the scanner bands!

Keep in mind that (with but a few exceptions, such as NOAA weather, airport ATIS, and USCG marine safety broadcasts) everything you'll hear on a scanner is a two-way transmission intended for use by a specific "addressee" or station. There's a world of difference between such transmissions and what gets sent out over an AM/FM/TV/SW broadcasting station that is intended for reception by the general public.

Aside from the fact that transmissions from non-broadcast stations (except hams) are covered under federal communications privacy statutes (in the Communications Act of 1934). The operators of such stations often cherish the notion (or may believe) that their communications are their own. While they may understand that there is a potential for their signals to be received by "strangers" (that's you), a reception report asking for verification will only prove that their fears are justified. Moreover, those stations don't have QSL cards printed up to send to whatever audience they may have acquired.

Nevertheless, some scanner owners have achieved some degree of success in obtaining verifications consisting of prepared reply cards. Those cards, made up by the listener, are sent along with the reception report; they are filled in and signed by the transmitting station's operator, then dropped (postpaid) in the mail. There's no guarantee of 100% return, but (with practice) you might get better than a 50% response.

Some hints: You'll stand a better chance of returns from aero, maritime, fire, and business/industrial stations than you will from police or military/civilian federal stations. Also, in your report to the station, never (ever) give details of their conversations: That's a sure road to a zero-percent response! Try to keep your QSL

(Continued on page 95)

Despite its modest price, the Regency R1075 programmable scanner is packed with features, among them, automatic search, and priority channel.

By Charles D. Rakes

CIRCUIT CIRCUS

It doesn't take much to generate enough high voltage to curl your hair

THIS MONTH'S CIRCUIT SELECTIONS are for the experimenter having a touch of Ben and Nikola's fascination for working with high voltage. But unlike these two brave pioneers who flirted with lightning and gigantic spark coils, our high voltage circuits are mild in comparison, having outputs of less than 50-kV. Even so, don't ever become careless when working with high voltage: To do so could be dangerous to your health and your good nature. So please take care.

The circuit shown in Fig. 1 generates a high voltage by discharging the energy stored in a large value capacitor through the primary winding of a high-turns-ratio step-up transformer. This method of producing high voltage is known as a *capacitor discharge system*. It's the same concept used by many of the high performance auto-ignition systems to produce a super-hot spark. It's also the same kind of system used by a some of the top-of-the-line electric fence chargers. And not to forget one of the most popular personal-defense devices to be found in the marketplace: the electronic *Stun Gun*, which also generates its *zap* with a capacitor-discharge circuit.

How We Make the Zap

As shown in Fig. 1, stepdown transformer T1 drops the incoming line voltage to approximately 48-VAC, and in the process adds a degree of safety through the transformer's primary-to-secondary isolation from the powerline. T1's 48 volt secondary voltage is rectified by diode D1; the resultant DC charges capacitor C1—through current limiting resistor R1—to a voltage level pre-set by R4. When the voltage on R4's wiper reaches about 8.6 volts, Q1 begins to turn on, drawing current through R7 and the base-emitter junction of Q2. Q2 turns on and supplies a positive voltage to the gate of silicon-controlled rectifier Q3. The positive gate voltage causes Q3 to conduct, thereby discharging C1 through the primary winding of step-up transformer T2, which results in a high voltage arc at the output terminal (X).

The value of the high voltage developed at T2's output is determined by the value of C1, the voltage across C1, and the turns ratio of transformer T2.

The frequency or pulse rate of the high voltage is determined by the resistance of T1's primary and secondary windings, the value of R1, and the value of C1. The lower the value of each item the higher the output pulse rate, but the peak output voltage will only remain unchanged if C1's value remains unchanged.

Building the CD System

The circuit shown in Fig. 1 is non-critical, so any parts layout and mounting can be used; in particular, perforated wiring board will probably make for the easiest assembly. But no matter what kind of construction is used, keep T2's output terminal (labeled X) at least three inches clear of all circuit components, yourself, and anything else that can conduct electricity.

The transformer used for T2 can be almost any 6 or 12 volt auto-ignition coil, but one designed with a high turns ratio for a capacitor-discharge ignition system will produce the greatest output voltage. The CD coil that we used produced a spark 1-¼ inches in length from the output terminal to the coil's common terminal.

An old (but good) TV flyback transformer can also be used for T2. Simply wind about 10 turns of test-lead wire around the transformer's ferrite core and connect the free ends of the wires to the

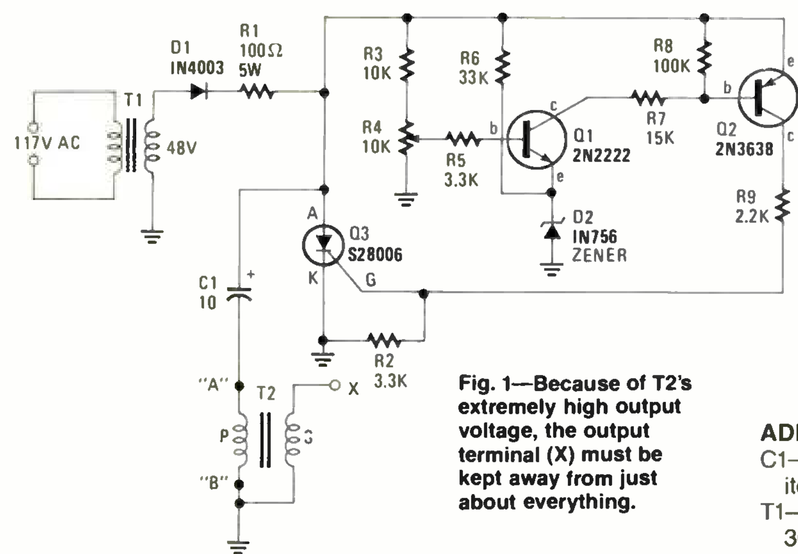


Fig. 1—Because of T2's extremely high output voltage, the output terminal (X) must be kept away from just about everything.

PARTS LIST FOR FIG. 1

SEMICONDUCTORS
D1—1N4003, 1-A, silicon rectifier
D2—1N756, 8-volt Zener diode
Q1—2N2222 NPN transistor
Q2—2N3638 PNP transistor
Q3—Silicon-controlled rectifier, 6-A, 200-VDC

RESISTORS
(All fixed resistors ½-watt, 5% fixed units, unless otherwise noted.)
R1—100-ohm, 5-watt
R2, R5—3300-ohm
R3—10,000-ohm
R4—10,000-ohm, linear-taper potentiometer
R6—33,000-ohm
R7—15,000-ohm
R8—100,000-ohm
R9 —2200-ohm

ADDITIONAL PARTS AND MATERIALS
C1—220 or 440-μF, 75 to 100-WVDC electrolytic capacitor
T1—Transformer: AC-line step-down, power; 48-VAC, 300-mA
T2—Auto-ignition coil, also other types, (see text)

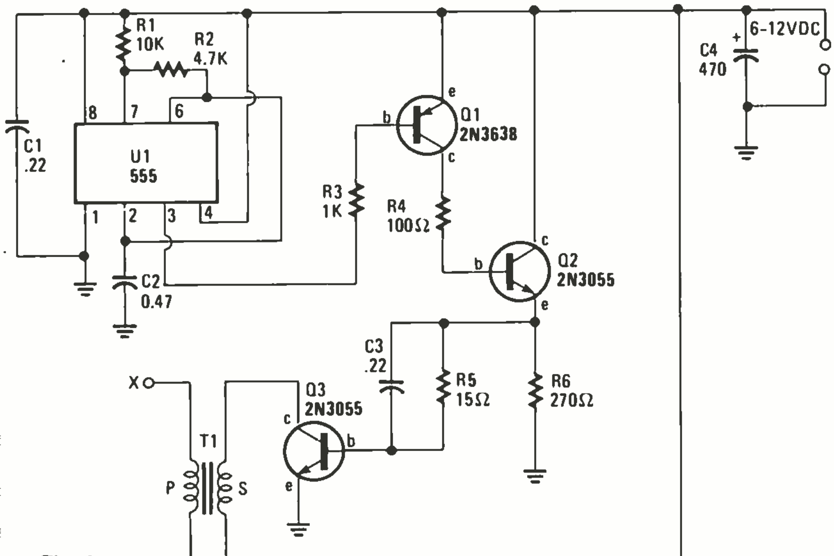


Fig. 2

PARTS LIST FOR FIG. 2

SEMICONDUCTORS
Q1—2N3638 PNP transistor
Q2—2N3055 NPN power transistor
Q3—2N3055 NPN transistor with heat sink.
U1—555 timer integrated circuit

CAPACITORS
C1,C3—0.22-muF, 100-WVDC Mylar capacitor
C2—0.47-muF, 100-WVDC Mylar capacitor
C4—470-muF, 25-WVDC electrolytic capacitor

RESISTORS
(All resistors ½-watt, 5% fixed units, unless otherwise noted.)
R1—10,000-ohm
R2—4700-ohm
R3—1000-ohm
R4—100-ohm
R5—15-ohm, 5-watt
R6—270-ohm

ADDITIONAL MATERIAL
T1—Auto-ignition coil (see text)

points labeled "A" and "B" in Fig. 1. Some experimenting with the number of turns may be necessary to obtain good results with this type of transformer. Our experiments with the TV flyback produced a voltage that would jump a ¾-inch gap.

If a small-engine repair business is located in your area, see if the owner or mechanic will give you a few of the old ignition coils. Hopefully, if several coils are obtained, one or more will be usable. To produce high voltage with a small-engine ignition coil, connect the primary leads to terminals "A" and "B," and a ½- to ¾-inch spark should be possible.

To make a "magnetic charger," select one of the ignition coils that has a good primary winding and carefully remove the secondary winding from the coil's core. Connect the primary wires to terminals "A" and "B." Position any object that you want to magnetize on the exposed core laminations and apply power: *Zap-Zap!* is the sound you should hear as the magnetic pulses hit the metal object.

To Smack of Spark

For maximum spark select a CD ignition coil and use a 440-µF, 75- to 100-WVDC electrolytic capacitor for C1. Using a DC voltmeter, monitor the voltage across C1. Adjust R4 so that the Q3 fires when the charging voltage across C1 reaches 50 to 55 volts. This setting should produce a spark 1-¼ to 1-½ inches long every second or so.

To obtain a faster pulse rate—with some reduced output— change C1 to a 10-µF, 220-VAC motor capacitor (or any other lower value with a rating of 75 volts or more). Experiment with different component values to obtain the desired results.

An excellent electric fence charger can be made by building the CD circuit in a suitable case and selecting a 220-µF capacitor for C1: Adjust R4 for a range of one to two pulses per second.

Battery-Powered High Voltage

A high-voltage generator circuit that can operate from a battery or other low-voltage DC. source is shown in Fig. 2. Output voltage great enough to jump a 1-inch gap can be obtained from a 12 volt power source, and with a higher pulse rate than the one from the circuit shown in Fig. 1, but it operates as well.

It's Timer Controlled

A 555 timer integrated circuit is connected as an astable multivibrator that produces a narrow negative pulse at pin 3. The pulse turns Q1 on for the duration of the time period. The collector of Q1 is direct-coupled to the base of the power transistor Q2, turning it on during the same time period.

The emitter of Q2 is direct-coupled through current limiting resistor R5 to the base of the power transistor. Q3 switches on, producing a minimum resistance between the collector and emitter. The high current pulse going through the primary of high voltage transformer T1 generates a very high pulse voltage at its secondary output terminal (labeled X). The pulse frequency is determined by the values of R1, R2, and C2. The values given in the parts list were chosen to give the best possible performance when an auto-ignition coil is used for T1.

Here also, a CD-type ignition coil will produce the greatest output voltage.

Perforated wiring board construction is also a good choice for this, but here too, be careful when working around the output terminal of T1 while the power is on.

Whether you build just one or both of this month's circuits, you're certain to get the same thrill and excitement as Franklin and Tesla did when they worked with high voltage.

On Getting Parts

To ensure that your time spent building a **Circuit Circus** project isn't wasted, as much as possible we try to design our circuits around devices which are themselves often used as "substitutes" for other types; or we use devices which are so commonlyy used that they are generally available from sources that cater to hobbyists as well as OEM's.

Naturally, Radio Shack is a prime source for components because there are so many Radio Shack stores. Unfortunately, the extent of their line of solid-state devices and even connectors is somewhat limited, and we can't often match our needs to their stock. So we move on to an even better stock distributor: that's Digi-Key Corp. (P.O. Box 677, Thief River Falls, MN 56701).

It's quite possible that you will need a powerful magnifier to read their ads, but just about any common electronic component used in one of our projects should be available from Digi-Key.

A good selection of unusual compenents—such as photo-flash capacitors and telephone transformers—can be obtained from All Electronics Corp. (905 S. Vermont, Los Angeles, CA 90006); and of course, Dick Smith Electronics Inc., P.O. Box 2249, Redwood City, CA 94063.

While you should get all the catalogs you can, if you get catalogs from at least these four sources you'll probably have no difficulty at all building your **Circuit Circus** projects. ■

By Don Jensen

JENSEN ON DX'ING

Clandestine radio out of Central America

Some seasons back, there was a popular TV show called, "To Tell the Truth." Despite the name, its aim was to do just the opposite. It featured a contestant with some distinctive but obscure claim to fame and two impostors. On the basis of their answers to questions—two-thirds of which were lies—the panel was supposed to figure out who was telling the truth! There's a bit of the old "To Tell the Truth" in Central American clandestine broadcasting on shortwave these days.

Clandestine radio—revolutionary stations broadcasting anti-government programs—seem to quickly crop up wherever in the world there is tension and turmoil. A decade and a half ago, the clandestine broadcasting focus was on southeast Asia. Today, the action is a lot closer to home in Central America.

Nearly six years ago, in January 1981, a clandestine station called *Radio Venceremos*—translated from Spanish, *We Will Win*—went on shortwave. Since then, it has operated as the official voice of the left-wing rebel Farabundo Marti Liberation Front, opposing the government of El Salvador.

Reportedly, this clandestine broadcaster operates from somewhere in the rugged Morazan province of northeastern El Salvador. *Radio Venceremos* is often monitored by North American news agencies, even though its propaganda programs and claims of victories over government forces sometimes stretch their credibility to the extreme, because it often does provide an idea of what the guerrilla opposition is thinking and doing. The American-supported government forces have tried repeatedly to silence the secret broadcaster, but it remains on the air.

Perhaps with the notion that if you can't beat'em, join'em, a new Salvadoran clandestine radio went on the air last summer. It too calls itself *Radio Venceremos*, but it is an impostor. Logic says the phony station is "ours," though that is vigorously denied. The phantom copy more or less follows the format and style of the rebel transmissions on shortwave, but its political line is pro-government. Presumably its aim is to confuse the revolutionary FMLN troops in the hills, attacking their morale, encouraging desertion, and sniping at recruiting efforts. It's not on the air every day; not by any means. But ever since early summer of 1985, it has turned up occasionally on shortwave with programming designed to toss a propaganda monkey wrench into the real *Radio Venceremos* operations. As "black"—pretending to be what it is not—propaganda clandestine stations go, the pseudo-*Venceremos* isn't very good. It is easy to spot, North America SWL'S report. The guerrilla recruit who can't tell the real from the phony must be naive indeed.

Cleveland DX'er and frequent monitor of the clandestine shortwave scene, George Zeller spotted both stations going simultaneously a few months ago. The genuine *Radio Venceremos* was operating on 6,569.5 kHz, from about 0100 UTC. Just a bit down the dial, the copycat version was broadcasting, simultaneously, on 6,565.3 kHz. The real station, Zeller observed, had alternating man and woman announcers, some stirring brass band martial music, and its own special *Radio Venceremos* theme song. The voice and accent of the phony operation were distinctively different, according to the Ohio monitor, and the music and identifying theme were missing, although it too, clearly identified itself as *Radio Venceremos*. All programming, of course, was in Spanish.

In a bizarre twist, a third station, a transmitter presumably run by or for the Salvadoran government to jam the real *Venceremos*, was pumping out Latin music on 6,564.8 kHz, doing more damage to the fake than the real thing. Was the jammer jamming the phony station in some sort of sly attempt to add a touch of credibility, Zeller wondered, or was it simply a foul-up. *Mad* magazine's "Spy vs. Spy" cartoons have nothing on the wireless wackiness going on in El Salvador these days!

This is a photo of Vashek Korinek who was born in Czechoslovakia and had emigrated to South Africa nearly 20 years ago. Now he is one of the top DX'ers in his country.

Bytes and Pieces

Shortwave listeners who also are computer buffs will be interested in this list of computer bulletin boards catering to the radio hobbyist, compiled by Bill Cole, editor of the *Computer Corner* column in the North American SW Association bulletin, *Frendx*. All are 300 baud, no parity, 8 bit.

ACE BBS, operated by the Association of Clandestine Enthusiasts, P.O. Box

Some shortwave stations send colorful cloth pennants to listeners who report reception. This pennant was sent to some lucky listeners by a station in Columbia.

JENSEN ON DX'ING

46199, Baton Rouge, LA 70895. Phone (913) 677-1288. Mainly for listeners who have an interest in the unlicensed and, frankly unlawful, "pirate" radio.

UBIX, operated by Universal Shortwave Radio, 1280 Aida Drive, Reynoldsburg, OH 43068. Phone (614) 866-4267 for information only. Shortwave and other information; can be used to order merchandise too.

AMSAT Software Exchange, operated by AMSAT, Box 27, Washington DC 20044. Phone (512) 852-8194. Provides information on amateur radio satellites.

ANARC BBS, operated by the Association of North American Radio Clubs Computer Information Committee, 4347 29th St. SE, Rochester, MN 55904. Phone (507) 289-7903. Shortwave and other radio listening hobby news and information.

ODXA Bulletin Board, operated by the Ontario DX Association, c/o Steve Webster, 5 Hoshlega Drive, Scarborough, Ontario, MG1 2X4, Canada. Phone (416) 598-1934. Part of a larger BBS system, contains news from the club's bulletin.

73 Magazine Bulletin Board, operated by 73 Magazine, 80 Pine St., Peterborough, NH 03458. (603) 924-9809; or for information only, 924-9471. Amateur radio information.

Book Look

A book published by Universal Shortwave Radio (address above) may serve as your introduction to other radio hobbyists around the country and around the world. It is *The DX'er's Directory*, and it lists the names and addresses of more than 800 SWL'S and other radio listening fans who requested their publication in this volume. Compiled by Universal's friendly honcho, Fred Osterman, the directory also indicates the radio listening interests of each of those listed, be it shortwave, medium or long wave listening, VHF/UHF scanner monitoring or whatever. It also lists the radio hobby clubs, over a hundred of them.

The DX'er's Directory is available from Universal for $4.95, plus $1.05 for shipping.

Down the Dial

What are you hearing on shortwave? Here are some of the catches other DX'er's are reporting. Join them next month in this column. All you have to do is drop me a line and tell me what stations you're hearing, the frequency, and the time. And while you're at it, what programming did you like—or hate, if that's the case. The address is JENSEN ON DX'ING, **Hands-on Electronics**, 500-B Bi-County Boulevard, Farmingdale, NY 11735.

ABBREVIATIONS

ANARC	Association of North American Radio Clubs
DX	long distance (over 1000 miles)
DX'er	listener to shortwave broadcasts
DX'ing	listening to shortwave broadcasts
GMT	Greenwich mean time
kHz	kiloHertz (1000 Hertz or cycles)
SW	shortwave
SWL('s)	shortwave listener('s)
TV	television
UHF	ultra-high frequency
USSR	Russia (Union of Soviet Socialist Republics)
UTC/GMT	Universal Time Code/ Greenwich Mean Time
VHF	very-high frequency
WWV	U.S. time and standard frequency station

The times are given in UTC (Universal Coordinated Time) and frequencies are listed in kilohertz:

Portugal—9,680, Radio Portugal begins its English language transmissions at 0030 with the announcement that it is "broadcasting from Lisbon through the International Service." News and cultural items follow in this half hour nightly program.

Luxembourg—6,090, you can catch a brief English newscast and the weather from Luxembourg at 0000, but expect some interference from other stations which "bracket" this frequency.

USSR—11,860, *Radio Kiev* was heard at 0220 with an English language commentary on patient health care in the Ukraine. This was several weeks before the nuclear disaster at nearby Chernobyl.

Tahiti—15,171, RFO, Papeete, was heard with pleasant island music and French announcements between 0345 and 0400. The signal was weak but clear.

Canada—6,160, CKZN is one of the smaller shortwave voices of Canada, directing programs relayed from medium wave AM station CBN from St. John's, Newfoundland, to domestic Canadian audiences. Those in eastern North America should be able to hear its "Morning Show" around 1030 or so.

Antarctica—15,474, a very nice logging indeed is LRA36, *Radio National Arcangle San Gabriel* in Argentina Antarctic territory. Its signal—poor to fair—was logged in Canada around 2330 to 0000.

Credits—Dean Shewring; Tom Manley; Werner Funkenhauser; Cedric Marshall; Gladys Martin; Julian Martin; John Yacono; all from Ontario except the last three who are from New York, and the Ontario DX Association, 3 Camrose Crescent, Scarborough, Ontario MIL 2B5, Canada ■

SAXON ON SCANNERS

(Continued from page 91)

along the lines of: "Base station in contact with Units 3 and 8," or, "TWA 744 calling Los Angeles Center."

Stay clear of descriptions the likes of, "The skipper of your ship was talking to another skipper and telling him that he hoped that the cheap owner of the ship would come up with all of the back pay for the crew."

Include with your report, a brief description of your station, the approximate distance between your station and theirs (if known), and mention that part of your hobby is collecting verifications (QSLs) from the stations you hear on your scanner.

It may take a little ingenuity to get the best address to use for sending your reception report, but that's all part of the fun of this highly specialized aspect of scanning. Write and let us know how you've made out!

Reader Mail

Bob Chaffee of Alexandria, VA asks for the frequency used by the Federal Aviation Administration (FAA) police, who you see at many major air terminals, and if there are any scanner directories listing the (as he puts it) "more interesting" federal agencies.

In your area, Bob, I'd suggest listening on 165.50 for the operations at Dulles, also 165.6625 for Washington National Airport (WNA also operates on the Dulles frequency). A wide-ranging 168-page directory of the "most interesting" federal frequencies (FBI, Secret Service, military, Treasury, Border Patrol, FAA, Immigration, FCC, etc.) is known as the *Top Secret Registry of U.S. Government Radio Frequencies, 5th Edition*. That excellent guide has become the standard reference for scanner owners.

The text costs $14.95 (plus $1 postage to addresses in USA/Canada/APO/FPO) and is available from CRB Research, P.O. Box 56-GP, Commack NY 11725. CRB Research has a large assortment of scanner frequency directories in addition to that one; their big catalog is worth having and is sent free. Make it your business to get one today!

Sam Cantor, Chicago Heights, IL wants to know if there are any special frequencies to monitor around Chicagoland in order to hear United Air Lines activities.

At O'Hare Airport, UAL appears to be using 128.9, 129.3, 129.35, 130.15, 130.225, 131.4 and 131.8 MHz. That should keep you busy!

Send your photos, questions, tips, and comments to: Mark Saxon, Saxon on Scanners, **Hands-on Electronics**, 500-B Bi-County Boulevard, Farmingdale, NY 11735. ■

ELECTRONIC FUNDAMENTALS

(Continued from page 80)

A simple way of achieving a balanced condition is to make one (or more) of the arms of the bridge a variable resistance. Then, by monitoring the voltage across the load, the variable element can be adjusted until the load voltage is zero. All practical bridge circuits are provided with some means of adjusting one or more arms to achieve balance.

A typical application for a bridge circuit is shown in Fig. 25. Here one of the arms of the bridge (R1) is a variable resistor used to balance the bridge. Resistor R4 is a thermistor.

Assume that the bridge circuit is balanced at room temperature. The temperature rises and the bridge becomes unbalanced. Point __________ will be more positive than point __________.

54. (B,A) There is another way to use the bridge arrangement. It involves replacing two of the bridge arms with power supplies or voltage sources like that shown in Fig. 26. This circuit works like any of the other bridge circuits we have discussed. The bridge is balanced if the following ratio holds:

$$E1/E2 = R1/R2$$

No current flows in the load.

The most common way of using this modified bridge is to ground the junction of the voltage sources and one end of the load. Then if the bridge is balanced, the junction of R1 and R2 will also be zero volts.

If E1 = E2 = 10 volts and R1 = 100 ohms and R2 = 150 ohms, current will flow from point __________ to point __________ in the circuit.

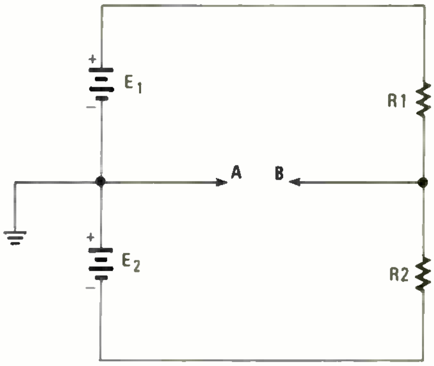


Fig. 26—A bridge can also use voltage sources for arms.

55. (A, B) With E1 equal to E2 and R1 not equal to R2, the bridge is unbalanced, so current will flow in the load. Since R2 is greater than R1, the voltage across it will be greater than that across R1. This makes the junction of R1 and R2 positive with respect to ground, so electrons flow from A to B.

As in any bridge circuit, R1 and R2 can be any component. Diodes, transistors, capacitors, and inductors can all be used. You will discover a variety of uses for bridge circuits throughout electronics. ■

LETTER BOX

(Continued from page 4)

oscillating type (a three terminal device). Could it be that that part should be a 273-064? R.F.S, Raleih, NC

The Parts List is wrong on both counts; R9's value of 2 megohms is correctly shown in the schematic diagram. As for the piezoelectric element, it should have been listed as a 273-060, as you suspected.

Why Show Power Supplies

I've noticed that almost all of your construction articles include a power supply. Since all are practically identical, why show them.
J.W.R., Signal Mountain, TN

Well, J.W.R., that's a question that has come up from time to time around here. But we decided that it is better to show a power supply for those who may not be as experienced as others (like yourself) in building such circuits. Do you remember when you were first starting your electronic hobby? The lack of a suitable power supply often determines if the novice will attempt building a project or not. ■

High-Power Blues

I've got a strange laser power-supply problem. The power supply charges a capacitor bank which, when fired, discharges through an inductor which should fire two xenon flash lamps placed in series through a coax cable. The capacitor bank charges and retains its charge just fine, but when the fire button is pressed the flash lamps don't fire. I've tested the coax, firing mechanism, and supply under fire conditions with a discharge resistor connected to the cable shield and center conductor, and the bank dropped its charge when fired. Of course I've tested the lamps, which are new, against their spec's and they check out fine. The power supply was designed around the lamps so I'm confident that the two should work well together, but what's up?
Dave Witter, MS., Hoboken, NJ

This would be easier to explain if you were up on telecommunications, but since you may not be, suffice it to say you are creating standing waves in the coax. This means the electrons will not arc across the lamp as long as they can bounce back and forth inside the cable. Shielding the flash lamps will keep standing waves from forming by eliminating the voltage node set up by the coax shield termination. This can be done easily by connecting the laser encasement to the shielding from the two pieces of coax. Thus, the entire system (the cable and lamps) is surrounded by shielding at the same potential throughout. note that this, however, will change the impedance of the system, so over-charge slightly.

If this is not possible or unappealing, try stripping back the coax shielding a few inches. You will have to experiment with how much to strip, but if the shielding is removed at a point where the standing waves reach a, maximum the electrons will rush past that point and into the first lamp.

HEART THROB

(Continued from page 62)

blood that has not left the region yet) to flip upside-down because there is no longer a magnetic field to lock them in place. Reapplying the magnetic field as before causes the old tissue to return to a moderate position while the new blood begins to resonate. The difference in phase between the tissue in the first and second applications of the magnetic field is proportional to the velocity of the blood flow.

Why Bother?

Prior to MR, there has been no way of measuring blood flow in detail in intact blood vessels within the heart. Fortunately, the methods described above have given us consistently accurate results. A four-way comparison of the output of the right ventricle and the flow into the pulmonary artery, and the output of the left ventricle and the flow into the aorta, allows cross checks to be made. If all four are equal, the flow measurement is validated. That technique is now being applied to smaller vessels.

The diagnostic power, that is now available to doctors, of measuring heart function and blood flow means that it has become possible to understand the natural history of occlusive vascular disease and to study the disease's development throughout the life of the person.

(Continued on page 102)

CHECKMAN MINI

(Continued from page 67)

Button-Batteries

The Checkman Mini is powered by two type-LR-44 1.5-volt button cells. Since it's a popular size for camera equipment, they'll be readily available. The batteries fit into a compartment on the back, which is somewhat unusual for battery compartments, with a *slide-to-open* door; it is secured by a screw. (*Nice touch.*)

Really Mini

The amazing part about the meter is what's inside. Everything except the

Resistance measurement might be a little confusing at first, because there is only one range (kΩ) below 1 Megohm. Unit in photo reads 1 ohm.

small sounder, that *beeps* when a function or voltage reading changes, is mounted on a printed-circuit board. The function switch itself, whose overall diameter is that of a conventional switch, is printed on the circuit board; its knob carries three shorting bars that make the function selection.

As for solid-state components: Even in this age of large-scale integrated circuits, the Checkman Mini is amazing. There is only one VSLI (*V*ery *L*arge *S*cale *I*ntegration) IC, and, as far as we can tell, only one transistor. (Most of the board is taken up with resistors and the battery holder.)

While not lab-grade by any means, if you're looking for a small, rock-bottom priced DMM that you can toss in an attache case or carry in your shirt pocket, you'd be hard-pressed to find something with the performance of the Checkman Mini. For more information and specifications write to Siber-Hegner North America Inc., 5 Landmark Square, Stamford, CT 06901; or Circle No. 74 on Free Information Card. ■

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HB126

HEART THROB

(*Continued from page 100*)

Much more important is that the MR technique enables doctors to monitor the practical effect of drugs that might be used in the control of arterial disease. MR promises to give doctors a rapid way of finding out whether or not therapeutic substances arrest or reverse the disease.

Through those fundamental discoveries and their application to diagnostic techniques, it seems certain that a new generation of MR machines and applications, cheaper and simpler to use, will make an invaluable contribution to the eradication of occlusive vascular disease and other diseases and afflictions. ■

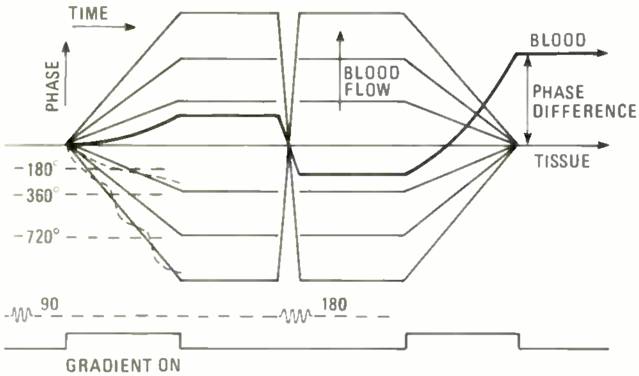


Fig. 4—As in the other techniques, phase-mapping begins with the introduction of radio waves into tissue exposed to a magnetic field. However, the magnetic field is shut off and a radio pulse 180 degrees out of phase is transmitted. That flips the precession set up by the magnetic field, so when the magnetic field is reappilied it pushes those particles to a moderate position. Whatever new fluids enter that region begin to resonate with more than moderate intensity and makes them stand out from the background.

VOICE SYNTHESIZER

(*Continued from page 59*)

time to combine them. First, connect the power-supply board to the synthesizer board through a couple of short lengths of wire soldered to the points indicated in the Fig. 6 and Fig. 7 layouts. Connect two lengths of wire between the speaker and the synthesizer board. Next, mount SPKR1 to the enclosure, plug the card-edge into CE1, and finally install the circuit boards (see photos). Once completed, make a final check of your wiring job. If all seems correct, apply power to the circuit and check for +5 volts DC at the points indicated in the schematic diagrams (Fig. 2 and Fig 3).

If everything checks out OK, power-down the circuit, plug the data cable into your computer, and run the sample program in Table 2. If the Voice Synthesizer responds with "*testing, one, two, three, four*," power-down the circuit and close the case. Your computerized chatterbox is ready to bend your ear. If the circuit does not respond as expected, recheck your work. ■

The Computer-Controlled Voice Synthesizer can be housed in a metal project case (as shown here) with R8, LED1, and SPKR1 mounted to the front panel

FRIEDMAN ON COMPUTERS

(*Continued from page 88*)

inexpensive oscilloscope into a digital storage scope. Figure 2 shows the functional digitizing circuit of a Sybex Model 602 *Scope Memory*. Each channel is identical, consisting of an A/D converter, CPU-controlled RAM, and a D/A output. With that arrangement we can, for example, feed a squarewave into Channel 1 and store its digital representation in RAM. We can then disconnect the squarewave source and feed a sinewave into Channel B, similarly storing the sinewave's digital representation in RAM. The D/A output for each channel will continuously convert the stored data back to its analog form as long as we don't change the data in RAM.

As shown in the photograph, if the Sybex's outputs are connected to a conventional dual vertical input oscilloscope set up for *switching*, both traces will be displayed as long as needed: minutes, hours, days, etc. In this instance, the traces are those from tests run on an audio amplifier earlier in the day. The amplifier has long been turned off; yet, because of digital storage a technician can compare the amplifier's performance when handling both sinewave and squarewave test signals.

With the proper software and interface, which we will cover in the near future, instead of observing the signals on an oscilloscope, the data could be fed to a personal computer, and *permanently* stored on disk for future viewing. ■

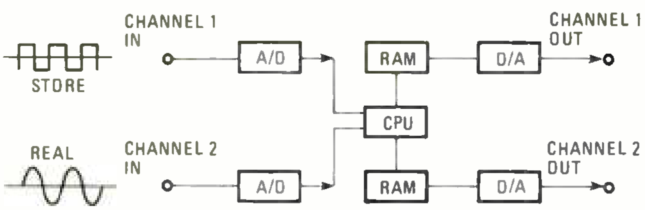
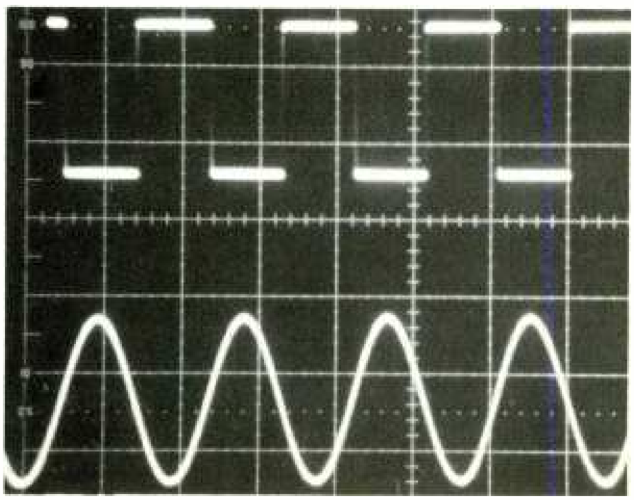


Fig. 2—If a digitized analog signal is stored in RAM, it can be continuously restored (looped) to an analog form.



These two signals actually didn't exist at the time the photograph was made of the oscilloscope screen. Both the square and sinewave signals had been stored earlier in digital form in a Sibex *Scope Memory*.

TI99/4A KEYBOARD

(Continued from page 64)

3. Connect keyboard 3 to computer 2.
4. Connect keyboard 4 to computer 7.
5. Connect keyboard 5 to computer 8.
6. Connect keyboard 7 to computer 4.
7. Connect keyboard 8 to computer 13.
8. Connect keyboard 9 to computer 9.
9. Connect keyboard 10 to computer 3.
10. Connect keyboard 11 to computer 1.
11. Connect keyboard 13 to computer 12.
12. Connect keyboard 14 to computer 11.
13. Connect keyboard 15 to computer 10.

Secure the connections to the TI keyboard using epoxy. Reassemble the computer with the ribbon cable protruding from the bottom of the computer case.

Relabeling

The final step in the conversion process is to relabel the keytops of the new keyboard. The easiest way to accomplish that is to photocopy the keyboard layout shown in the Sinclair instruction book (a 129% enlargemant is best). Overlay the photocopy with a clear plastic film, clear contact paper for example. Cut and paste each key outline onto the new keyboard. Each key on the new keyboard corresponds to the same Sinclair key, with the Space key becoming the Space Bar (#47), and the TI Comma (#42). The function (#48), Equals (#11), Slash (#22), Colon (#32), Control (#46), and Alpha Lock (#45) keys are not used. A blank piece of paper can be placed over the tops of those keys.

The new keyboard is now ready for use and it is left to the reader to decide whether to continue upgrading the Sinclair computer by installing the new keyboard, and possibly the computer itself, in a new enclosure. However, it is advisable for you to check all connections before your first fire up to make sure that the jumpers are placed correctly and all the proper traces are cut. ■

Use a 129% enlarged photocopy of the Sinclair keyboard and clear contact paper to relabel the modified ZX-81 keyboard.

BITS & BYTES FOR BEGINNERS

(Continued from page 45)

If we wanted to transmit those conditions out of the computer to another location we need only transmit the decimal value represented by the bit-value. For the "missing" second disk drive, the decimal value of the byte is 253. The number 253 can only be represented by 11111101, so any equipment receiving a 253 would know the second disk drive was not available. Work out the bit-value for the "PRINTER OUT OF PAPER" status for yourself.

A Little Bit More

Whether it's a microwave oven, a home burglar alarm, a personal computer, or whatever; whether the system responds

(Continued on page 105)

HANDS-ON MARKETPLACE

FOR SALE

WORLD'S best channel 3 notch filter. $19.95. (dealer inquiries invited). **CROSLEY (F).** Box 840, Champlain, NY 12919.

SEE in complete darkness with amazing new infrared nightviewers. Kit $189. Factory assembled $295. Super long range model $750. (Dealers wanted). Catalog $1. **CROSLEY (F).** Box 840, Champlain, NY 12919. (514) 739-9328.

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To run your own classified ad, put one word on each of the lines below and send this form along with your check to:

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( ) ______________________

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PLEASE PRINT EACH WORD SEPARATELY, IN BLOCK LETTERS.
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31 ($38.75)	32 ($44.00)	33 ($41.25)	34 ($42.50)	35 ($43.75)

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CLASSIFIED COMMERCIAL RATE: (for firms or individuals offering commercial products or services) $1.40 per word prepaid (no charge for ZIP code)...**MINIMUM 15 WORDS.** 5% discount for same ad in 6 issues within one year; 10% discount for 12 issues within one year if prepaid. **NON-COMMERCIAL RATE:** (for individuals who want to buy or sell a personal item) $1.15 per word, prepaid....no minimum. **ONLY FIRST WORD AND NAME** set in bold caps at no extra charge. Additional bold face (not available as all caps) 25¢ **per word additional (20% premium).** Entire ad in boldface, **add 20% premium** to total price. **TINT SCREEN BEHIND ENTIRE AD: add 25% premium** to total price. **TINT SCREEN BEHIND ENTIRE AD PLUS ALL BOLD FACE AD: add 45% premium** to total price. **EXPANDED TYPE AD: $1.85 per word prepaid.** All other items same as for STANDARD COMMERCIAL RATE. **TINT SCREEN BEHIND ENTIRE EXPANDED TYPE AD: add 25% premium** to total price. **TINT SCREEN BEHIND ENTIRE EXPANDED TYPE AD PLUS ALL BOLD FACE AD: add 45% premium** to total price. **DISPLAY ADS:** 1" × 2¼"—$135.00; 2" × 2¼—$270.00; 3" × 2¼"—$405.00. **General Information:** Frequency rates and prepayment discounts are available. **ALL COPY SUBJECT TO PUBLISHERS APPROVAL. ADVERTISEMENTS USING P.O. BOX ADDRESS WILL NOT BE ACCEPTED UNTIL ADVERTISER SUPPLIES PUBLISHER WITH PERMANENT ADDRESS AND PHONE NUMBER. Hands-on Electronics** is published monthly, therefore copy to be in our hands for Jan. 87, 10/15; Feb. 87; 11/15.

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ANTIQUE radio hobbyists—20 page catalog of tubes, parts, and literature for radio restoration. Send $2.00 to **ANTIQUE ELECTRONIC SUPPLY,** 688 W. First St., Tempe, AZ 85281.

LASERS: Surplus parts, and units, "the source for laser surplus!" Free catalog. **MEREDITH INSTRUMENTS,** P.O. Box 1724, Glendale, AZ 85311.

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P.O. BOX 1628, SOQUEL, CA 95073

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BUILD this five-digit panel meter and square wave generator including an ohms, capacitance and frequency meter. Detailed instructions $2.50. **BAGNALL ELECTRONICS,** 179 May, Fairfield, CT 06430.

CRYSTAL radio sets, plans, parts, kits. Catalog $1.00. **MIDCO,** 660 North Dixie Highway, Hollywood, FL 33020.

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DESCRAMBLE the latest video cassette copy protection scheme. Our simple Line Zapper circuit takes the jitter out of your picture. Complete plans and theory only $9.95 plus $1.50 postage and handling. **ELEPHANT ELECTRONICS INC.** , Box 41865-H, Phoenix, AZ 85080.

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NEW...Repair any TV...easy. Retired serviceman reveals secrets. Write, **RESEARCH,** Rt. 3, Box 601BH, Colville, WA 99114.

CABLE EQUIPMENT

CABLE descrambler Jerrold equipment including new Jerrold Tri-Mode and DRZIN systems, Hamlin, SB-3, N-12 Mini-Code, Zenith, Z-TAC and more. All products enable you to pick up most stations. Best prices around! For information, send $1.00, plus S.A.S.E. or call (312) 434-6788. **SWENSENS ELECTRONICS,** 6839 So. Maplewood, Chicago, IL 60629. No Illinois orders accepted!

directly to the bits themselves or to a decimal equivalent, all depends on the particular device or system—how the engineers designed the circuits. Within the device itself it's easier for the microprocessor to respond directly to the digital bits. When moving the information from one location to another the least expensive way to do it is through a 2-wire circuit, which can be a piece of zip cord lying on the floor, or a telephone circuit. In that instance, the bits would be transmitted as a serial data stream, one bit after another. Unfortunately, that is a relatively slow procedure. If the pieces of equipment are close to one another, we might use a simultaneous or "parallel" bit transmission through a cable having nine wires, as is done within the computer itself. (Eight wires for the signal lines, one for the common or return).

As you can see, bits can represent only two states; hence its value system is based on the number 2—or, as mathemeticians would say, it's a *bi*nary number system.

We should not overlook the fact that within the world of computers—as differentiated from microprocessor-controlled devices such as alarm systems—hex values are often used in place of decimal and binary values because the computer itself utilizes hex values. Hex is a counting system based on the number 16 and will be the subject of another article. This time out we've only shown how to transmit information and relatively large decimal values in small bites, bit by bit. ■

ULTRATORCH REPORT

(Continued from page 52)

stops. A clear window in the handle continuously shows how much fuel is available. A single fueling powers the device from 50 minutes to 4 hours depending on the gas flow used. Fuel-up only when the tool is cool to the touch.

Hard To Believe

Both the soldering and heat-gun tips proved surprisingly effective. In fact, it was essentially impossible to tell that the soldering tip is gas powered. Except for a small slot that exhausts the combustion products from the catalyst, the tip looks and behaves like a controlled electric tip in that the heat can be adjusted over a very broad range.

The heat-gun tip throws a lot of heat, but in a very concentrated beam that is easily controlled both by position and gas flow. We could raise the temperature of components in order to test for intermittent operation without destroying anything; or, we could raise the temperature high enough to melt lead solder within a few inches. However, the beam width and heat range proved just right for setting heat-shrink tubing on heavy #8 conductors or #24 hook-up wire.

With the special shrink-tip adapter installed on the heat-gun tip, it was actually possible—as shown in the photographs—to shrink insulation on but one wire of a multi-wire cable, without damaging adjacent components.

The torch (flame) tip worked the same as any other adjustable-heat-range miniature torch; it could be set to just melt solder, or literally burn its way through rust, corrosion, and the other *gunk* that develops on mobile antenna hardware. If there is a problem, it's that so much heat isn't usually expected from so small a torch: You've got to be careful before setting the gas flow (heat) to maximum.

Overall, it's a great addition to any toolbox.

The Ultratorch-3 is available in a basic kit (priced at under $40) that includes the handle, three tips and the shrink-shield, a spanner wrench, and a metal carrying case. For more information write to the Master Appliance Corp., 2420 18th St., Racine, WI 53403. Ask for brochure UT-100. If you wish, circle No. 81 on the Free Information Card in this issue. ■

The handle is refueled with conventional smoker's butane canister through a valve located at the rear of the handle.

FIRST RECEIVER

(Continued from page 85)

In low cost receivers, the attenuator camouflages the inability of the receiver to handle a wide range of signal strengths, a characteristic called dynamic range.

Noise Blanker—Early-on in radio, it became apparent that if the listener's ears were to be salvaged during high static levels, as during a nearby thunderstorm, some means of quieting those deafening cracks had to be devised. Automatic noise limiters (ANL's) which would "clip" high static levels were developed, but those inevitably led to distortion of desired audio signals.

More recently, circuits have been developed which detect the incoming burst of noise and shut down the receiver during the period of the annoying noise pulse.

RIT—Modern general-coverage receivers usually rely on frequency synthesizers for their tuning circuits, which use crystals for their inherent stability. Those circuits tune in frequency increments rather than continuously, thus resulting in the inability to be perfectly on frequency for some signals. By providing a circuit which allows a slight "pulling" of the crystal frequency, one can tune through that increment. Receiver incremental tuning (RIT), then, is simply a fine-tuning control for a synthesized receiver.

Notch Filter—Many received signals are accompanied by annoying whistles or tones superimposed on them by near-frequency interfering signals. A notch filter is a tunable control which permits a "razor-sharp" setting to be swept across the signal and left at a setting which suppresses the unwanted tone.

(Continued on next page)

ECSS—Exalted Carrier Selectable Sideband is a technique of tuning in a full-carrier AM signal from a broadcasting station as though it were a single-sideband signal. That procedure eliminates at least half of the signal's bandwidth in the receiver, along with any interference imposed on that half.

For example, if interference is being experienced from a strong signal slightly below the desired station, upper sideband mode would be selected, eliminating the lower sideband and its attendant interference.

Frequency Readout—Years ago, a printed (analog) dial provided approximate frequency readout, often subject to erroneous interpretation by the user, and certainly subject to drift with age.

Now, modern electronics has brought digital display, whereby the exact frequency is called out in glowing numerals which change as the tuning dial is moved.

Frequency Coverage—It is common for virtually all general-coverage receivers to tune continuously from 100 kHz through 30 MHz with no gaps. Above 30 MHz, the scanners take over and FM (frequency modulation) dominates as a mode. No FM will be heard below 25 MHz, so the presence of that feature on a shortwave receiver is of marginal value unless the receiver is intended to be used with a VHF or UHF converter.

Memory—Of great convenience to a listener who likes to target-shoot throughout the spectrum is frequency memory. Depending upon the capacity of the particular radio, anywhere from a few to as many as 200 discrete frequencies (and mode) may be memorized, selected instantly, or even scanned among while looking for activity. Depending upon your listening habits and your budget, that feature is either a luxury or a tremendous convenience. ■

CAUZIN SOFTSTRIP SYSTEM

(Continued from page 54)

vacy of their own homes, read the DataStrips into their computers. Magazines (like ours) can print specially-prepared DataStrips, and subscribers can read the data at their convenience. That allows the publisher to pack more information into each issue, because the space taken by program listings and similar data can be minimized.

Low-density strips contain about 800-1500 bytes; high-density strips can contain as many as 5500 bytes. To give you some idea what that means, a full 8½ × 11 page of bar codes can be represented by a *DataStrip* about two-inches long.

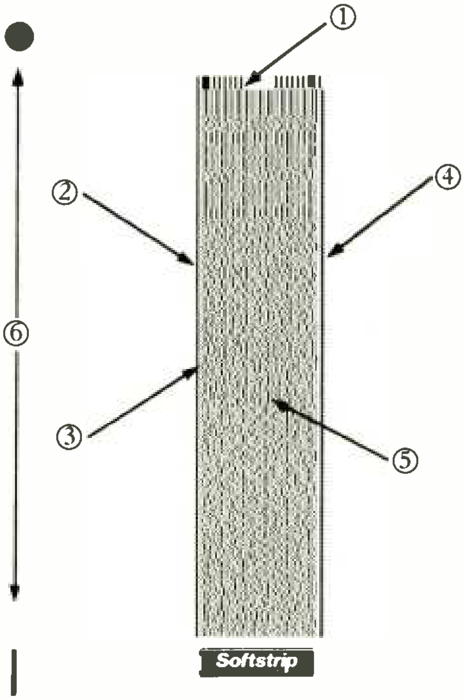

Fig. 3—Each *DataStrip* contains a lot more information than just the data. There is: 1) The header at the top of the strip that tells the reader the number of bytes per line, the height of each line, and the paper/ink contrast level; 2) A left-edge *startline*; 3) Left boundary marker; 4) Right boundary marker; 5) The data; 6) The positioning dot and bar.

It Really Works

The process really works—you actually can read the *DataStrips* printed in magazines. If you'd like to see it work for yourself, take this issue to your local Cauzin distributor and read the strip in Fig. 1. It contains the complete contents of the Gettysburg Address.

System requirements

The Softstrip Reader can communicate with any computer capable of receiving data at 4800 baud, 1 start bit, 1 stop bit, and no parity. You can use the computer's normal telecommunications software to read Softstrip data. Cauzin has written special communications programs that simplify reading DataStrips. The programs are available for the IBM-PC, the Apple II, and the MacIntosh personal computers.

When you buy a reader (which currently retails for just under $200), you get a communications program for one computer, a Softstrip Reader, and a booklet containing 50 or so sample programs. In addition, you get a free subscription to Cauzin's monthly newsletter, which contains one or more programs in *DataStrip* form.

Is It Worth It?

Most of the major consumer computer magazines are beginning to publish software and other data in Softstrip form, and at least one magazine dedicated to presenting information on electronic music (*Keyboards, Computers, and Software*) will be publishing scores in Softstrip form.

However, at the present time, there is little commercially-available software. Software producers are afraid to open new avenues of distribution until they are sure that there will be an adequate return on their investment. Consumers, meanwhile, are afraid to buy a reader because there is little software available.

But things are changing rapidly, and we think that the Softstrip system has the potential to be the medium of data transfer people have been looking for ever since the dawn of personal computing some ten years ago. Don't rush out and buy a reader unless you have a pressing need to, but keep your eye on Cauzin—we think the Softstrip system is going to go big. ■

ADVERTISING INDEX

HANDS-ON ELECTRONICS magazine does not assume any responsibility for errors that may appear in the index below.

2001
IS COMING IN MAY

An electronics revolution is in the making, but you can't have to wait until 2001 to find out how it will change your life in the 21st century. Radio-Electronics will forecast the coming changes and how they will affect you in the May 1987 issue!

Created by a special editorial task force—two years in preparation—this unique issue, 2001, takes you into the research laboratories of Westinghouse, Texas Instruments, Ford and Bell Labs where the future is being invented today.

You'll get an advance look at what's coming in artificial intelligence... new cars and highways (cleaner, quieter and more efficient)... futuristic energy sources like magneto-hydrodynamic and particle-beam generators... personal communications systems that will give you instant access to anyone anywhere... super computers and teaching breakthroughs that will multiply your capacity to learn!

Arthur Clarke introduces 2001. Isaac Asimov explores the marvels of robotics. But it is not science fiction. Rather it is emerging technology with a solid foundation in current research and development.

And its impact will be enormous. It will change the way you work... the way you think... the way you live!

2001 is the kind of special publishing event that can only happen once in any magazine's lifetime and it will happen to Radio-Electronics in May, 1987.

With extra features and extra pages, 2001 will bear a premium cover cost, but you can reserve your copy now at less than the regular cover cost by mailing any one of the subscription orders in this issue.

2001 is coming in May. Make sure now that you don't miss it!

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