Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

MARCH 1981/95¢

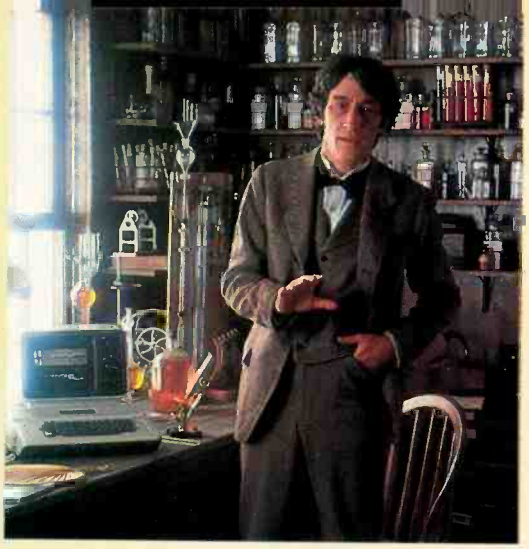
PE Tests Pioneer's VP-1000 Video Disc Player

Beep!
A Look at Pocket Telephone Pagers

Low-noise, Low-distortion Phono Preamplifier

Reactance Measuring Set

Audio Product of the Month:
Luxman Model K-8 Cassette Deck



Edison had over 1,800 patents in his name, but you can be just as inventive with an Apple.

Apple is the company with the brightest ideas in hardware and software *and* the best support — so you can be as creative with a personal computer system as Edison was with the incandescent bulb.

How Apple grows with you.

With Apple's reliable product family, the possibilities of creating your own system are endless. Have expansion capabilities of 4 or 8 accessory slots with your choice of system.

Expand memory to 64K bytes or 128K bytes. Add an A to D conversion board. Plug into time sharing, news and electronic mail services. Use an IEEE 488 bus to monitor lab instruments. Add 4 or 6 disk drives — the 5¼", 143K bytes, high-speed, low-cost drive that's the most popular on the market.

Apple speaks many languages.

Since more than 100 companies create software for Apple, you'll have the most extensive library in the personal computer world. Want to write your own programs? Apple is fluent in BASIC, Pascal, FORTRAN, PILOT and 6502 assembly language.

There's even a series of utility programs called the DOS Tool Kit that not only lets you design high-resolution graphic displays, but lets you work wonders with creative animation.

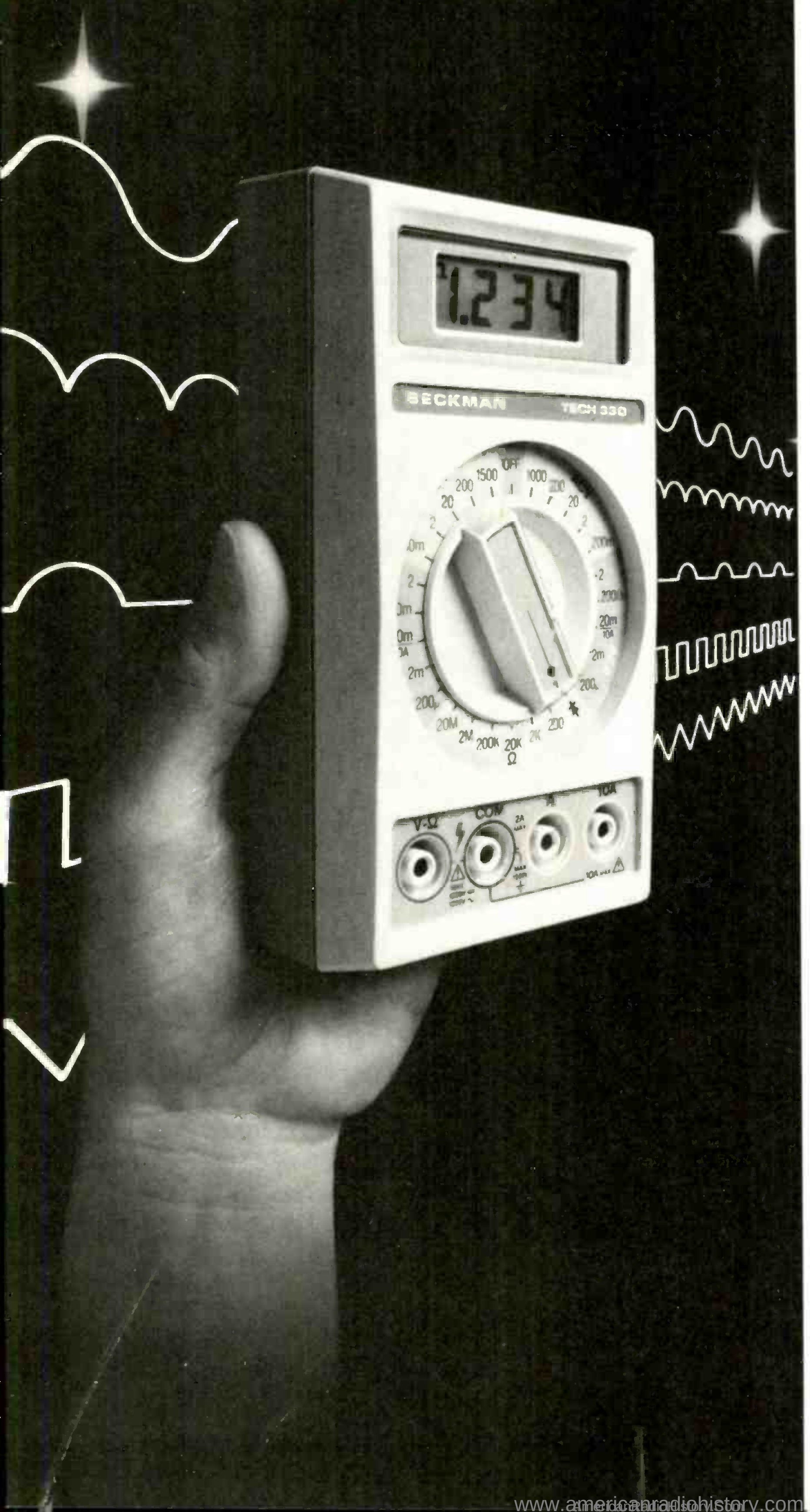
More illuminating experiences in store.

You won't want to miss all the Apple products being introduced at your computer store all the time. Don't let history pass you by. Visit your nearest Apple dealer or call **800-538-9696**. In California, **800-662-9238**. Or write: Apple Computer, 10260 Bandley Drive, Cupertino, CA 95014.

apple® computer inc.

CIRCLE NO. 6 ON FREE INFORMATION CARD

Beckman brings a new dimension to hand held Digital Multimeters



True RMS capability at an affordable price

Now you can measure the exact power content of *any signal* — regardless of waveform. Beckman delivers the new TECH™ 330 multimeter with true RMS capability and many more fine performance features for just $210.

Unlike most multimeters calibrated to read only the true power content of sine waves, the TECH 330 extends its true RMS capability to give you accurate readings of both sine and non-sine waveforms.

True RMS makes a significant difference in accuracy when measuring switching power supplies, flyback power circuits, SCR or TRIAC controlled power supplies or any other circuit generating a non-sine signal.

The TECH 330 also accurately measures the entire audio band up to 20 kHz. But that's not all you can expect from Beckman's top-of-the-line multimeter.

Measurement Comparison Chart

Waveforms (Peak = 1 Volt)	Average Responding Meter	Beckman TECH 330	Correct Reading
Sine Wave	0.707V	0.707V	0.707V
Full Wave Rectified Sine Wave	0.298V	0.707V	0.707V
Half Wave Rectified Sine Wave	0.382V	0.500V	0.500V
Square Wave	1.110V	1.000V	1.000V
Triangular Sawtooth Wave	0.545V	0.577V	0.577V

You also get 0.1% basic dc accuracy, instant continuity checks, 10 amp current ranges, a separate diode test function, 22 megohm dc input impedance, and an easy-to-use rotary switch.

With so much capability in hand, you'll be able to depend on the TECH 330 for a long time. That's why Beckman designed it tough enough to go the distance.

Enclosed in a rugged water-resistant case, the TECH 330 can take a 6-foot fall onto concrete and still perform up to spec. And to further ensure reliable, trouble-free operation, the TECH 330 gives you 1500 Vdc overload protection, RF shielding, 2000-hour battery life, gold switch contacts, and fewer electronic components to worry about.

Add another dimension to your world of electronics. Visit your Beckman distributor today for more information on the TECH 330 and Beckman's complete line of digital multimeters, starting at $120.

For your nearest distributor, or a free brochure:

CALL TOLL FREE
24 HOURS A DAY, 7 DAYS A WEEK
1-(800)-821-7700 (ext. 517)
in Missouri 1-(800)-892-7655 (ext. 517)

BECKMAN

CIRCLE NO. 63 ON FREE INFORMATION CARD

MARCH 1981 VOLUME 19, NUMBER 3

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

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 Popular Electronics (ISSN 0032-4485) March 1981, Volume 19, Number 3. Published monthly by Ziff-Davis Publishing Co., at One Park Ave., New York, NY 10016. Philip B. Korsant, President; Selwyn Taubman, Treasurer; Bertram A. Abrams, Secretary. One year subscription rate for U.S. and Possessions, $14.00; Canada, $17.00; all other countries, $19.00 (cash orders only, payable in U.S. currency). Controlled circulation Postage Paid at Salem, IL 62881. Authorized as second class mail by the Post Office Dept., Ottawa, Canada, and for payment of postage in cash. POPULAR ELECTRONICS including ELECTRONICS WORLD, Trade Mark Registered. Indexed in the Reader's Guide to Periodical Literature. Ziff-Davis also publishes Boating, Car and Driver, Cycle, Flying, Popular Photography, Skiing, Stereo Review, Electronic Experimenter's Handbook, and Tape Recording & Buying Guide. **Forms 3579 and all Subscription Correspondence:** POPULAR ELECTRONICS, Circulation Dept. P.O. Box 2774, Boulder, CO 80302. Please allow at least eight weeks for change of address, enclosing, if possible, an address label from a recent issue.

EDITORIAL

Hunting of the Quark

How often does one read about or discuss quarks? Strangely, the subject of quarks came up on three separate occasions during the New Year's vacation period. The first time was listening to my 13-year-old son telling me that an atom was the smallest particle of matter. I corrected him, reciting a list of what's inside an atom that could be subdivided into smaller elements. This led to a discussion of electrical force, Thomson's bottled lightning experiments that identified electrons, his discovery of the proton, etc.

My son didn't really believe me because his science teacher had told him.... So I laughingly offered to bet him that the smallest element was called a quark, and that there are up quarks, down quarks, strange quarks, charmed quarks, as well as anti quarks. The gauntlet was quickly picked up. "I'll bet you an Atari game cartridge against a hockey game," he responded. I agreed, but more about this later.

Later that evening, I read an article in *Scientific American* (December 1980) on "Cosmic Asymmetry," attracted to it by my growing interest in astronomy and because we'll be picturing a sophisticated telescope on next month's cover. And there was a discussion and many illustrations relating to quarks that are thought to make up each proton and neutron, bound together by gluons. What a coincidence, I thought.

The next day, I continued reading a book, *Fantastic Journeys* by Mark Hunter. Surprise! I reached the beginning of a dozen pages that discussed quarks, written in layman terms. I learned that two American scientists, Murray Gell-Mann and George Zweig, concluded in 1963 that hadrons were not fundamental particles because there were too many of them. They postulated that there were more basic particles, which Gell-Mann named "quarks," a word he recalled from *Finnegans Wake*. (James Joyce created the name for something that is real but cannot be seen.)

Moreover, I discovered that there was a fifth quark, named a bottom quark, that halted decay. And since basic elements come in pairs, there should be a sixth quark that has not yet been identified. Furthermore, with that many quarks, it's likely that there are many more. If so, scientists say that quarks are not the smallest particles. Interestingly, one American physicist, Leon Lederman, who predicted the existence of the fifth quark, speculated that maybe there are no elementary particles at all and that every particle has smaller parts. Perhaps the hunting of the sixth quark will be concluded when a new particle accelerator that will produce collision energies exceeding 270 GeV (G = 1 billion) is built. A few are now under construction.

Triumphantly showing my son the book that described quarks, I learned that I had not actually won the bet, owing to my naivete in dealing with smaller matter, whether quarks or my son. He calmly informed me that there was no bet at all since we didn't shake hands on it.

Art Salsberg

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"No one else gives you as many functions in a handheld DMM.

Now you can move up to Fluke."

We've got great news for people who've been holding out for a high quality, high performance DMM at a moderate price: Fluke's new nine-function model D 804 is now available at select electronics supply stores.

With a suggested list price of only $229* and features you won't find in any other handheld DMM, the D 804 is an exceptional value. Here's why.

Logic level and continuity testing: A real time-saver for troubleshooting passive circuits in pcb's, cables, relay panels and the like. The D 804 has a switch-selectable audible tone and visual symbols to indicate continuity or logic levels.

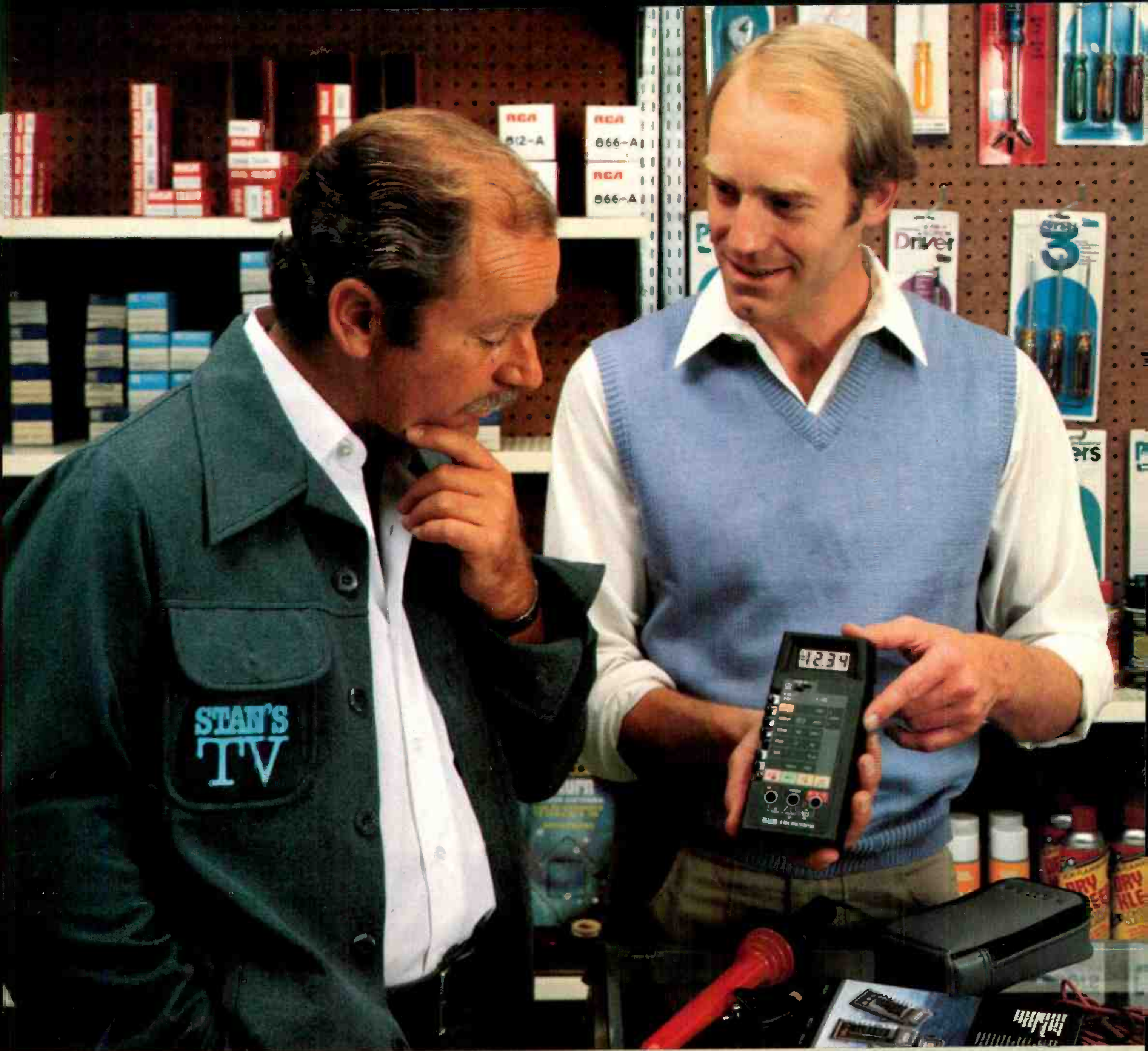
Direct temperature readings in °C: Used with any K-type thermocouple, the D 804 delivers fully-compensated readings in °C from -20°C to +1265°C, for checking heating and refrigeration systems.

Peak hold feature captures transients: A short-term memory in the D 804 captures and holds peak readings.

And more: 0.1% basic dc accuracy, conductance, 26 measurement ranges, battery, safety-designed test leads and a one year parts and labor warranty. A full line of accessories is also available to extend the measurement capabilities of your DMM.

Ask your dealer about the powerful, versatile D 804 and the rest of Fluke's new Series D line of low-cost digital multimeters.

From the world leader in DMM's. Now we've designed one for you.



*Suggested U.S. list price

For technical data circle no.

If your dealer doesn't carry Series D Multimeters yet, call this number. We'll be happy to tell you who does. 1-800-426-9182

FLUKE®

CIRCLE NO. 24 ON FREE INFORMATION CARD

LETTERS

New Battery-Charger Use

I recently had what appeared to be a "dead" car battery and, in trying to locate the trouble, discovered an unexpected use for my "Battery Charger" (January 1981, p 66.). When the LED lights up on TRICKLE charge but not on FULL charge position of *S1*, it is indicating an open battery element or a corroded battery post. If the LED is much brighter on FULL than on TRICKLE, either the battery is fully discharged or there is a short. In my case, the problem turned out to be an open battery element.—*Cass Lewart, Holmdel, NJ.*

BSEE vs BET

In "They're Wooing You in Electronic Land!" (January 1981), I was appalled at the statement, "There are proposals out at the IEEE to eliminate calling BET graduates 'Engineers,' but they do indeed perform as engineers at work." I worked very hard for 5 years to receive my BSEE, while every BET I knew was only learning how to be a 4-year technician. I have noted that the BETs I've worked with perform their duties like technicians not engineers. I believe many companies are using BETs because they can be paid less that BSEEs and there is a shortage of the latter. It is also advisable for companies to call as many employees engineers as possible for proposal writing purposes. This is reducing the integrity of the true engineering profession. The IEEE proposal will uphold that integrity.—*Gregory D. Gogates, Pittsburgh, PA.*

Cordless Phone Confusion

In "PE Examines Cordless Telephones" (December 1980), the last two paragraphs about the Pathcom phones on page 23 are confusing. To quote, the next-to-last paragraph says, "All Ez Phones offer full duplex and answer/originate operation." Then, the first sentence of the next paragraph says, "Pathcom's two economy systems are the Model 8501/8511 full duplex answer-only and Model 8400 simplex push-to-talk systems. . . ." Which are they—answer/originate or answer only?—*Gary A. Ditges, Lansing, KS.*

The Ez Phones are Models 8502/8510 and they have answer/originate operation. The Models 8501/8511 and 8400 are not in the Ez Phone line and are answer only.—Ed.

No Professional Amplifiers?

In "PE Tests Eight Audio Power Amplifiers" (January 1981), why were no standard professional models included? As a professional musician and technician, I own and work with pro recording and sound reinforcement equipment. Anyone serious enough about his stereo system to be willing to spend $600 to $1600 on a power amplifier should be made aware of amps such as BGW, Crown, and Crest—to name a few. These amps come in standardized packages, can be mistreated electrically with no damage, and some were undoubtedly used to mix the records played on your home system.—*Eric Wenocur, Columbia, MD.*

The consumer orientation was intentional. In fact, when we tested a Crown Amplifier (March 1980), we chose the consumer version. We have nothing against professional amplifiers, but we feel that the extreme ruggedness designed into them is overkill for domestic applications.—Ed.

Solar Controller Kit Info

We have received numerous requests for information concerning the Wolfway Solar Controller Thermostats as described in your New Products of January 1981. Our product information pamphlet can be obtained by sending $1.00 (refundable with order) to Wolfway Product Consultants, Inc. R.D. #1, Box 1135, Tamaqua, PA 18252. All models and kits may be ordered via that pamphlet directly.—*R. M. Hollenbach, Tamaqua, PA.*

NEW PRODUCTS

Additional information on new products covered in this section is available from the manufacturers. Either circle the item's code number on the Free Information Card or write to the manufacturer at the address given.

Radio Shack Line Printer

Radio Shack's Line Printer IV is a proportionally spaced high-density dot-matrix impact printer designed for use with the TRS-80 microcomputer. The printer can also be set up to produce 80 or 132 fixed-space characters per 8" line. Both upper- and lower-case letters are available in all three printing modes. Special characters available include the grave accent, braces, back slash, and caret. True underlining, subscripting, superscripting, enlarged characters, bold facing, and forward and reverse line feed are also available. Print density is 10 or 16.7 monospaced or 8.2 to 24.6 proportionally spaced characters per inch, and print speed is 50 characters per second or 22 lines per minute. The printer accepts roll, pin-feed, 9½" fan-fold, or single-sheet plus two carbons paper. Size is 15" x 11" x 5" and weight is 12 lb. $999.

CIRCLE NO. 91 ON FREE INFORMATION CARD

Shure Cartridge/ Headshell Combo

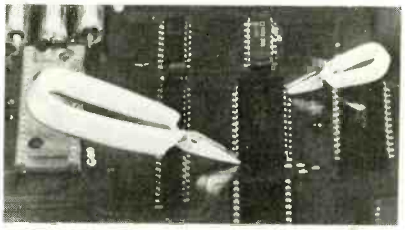
Shure has expanded its M97 Era IV phono cartridge line with the M97ED-AH integrated cartridge/headshell assembly. The AH indicates that the M97HE cartridge comes already mounted in a universal four-pin headshell that is compatible with many leading tonearms. The integrated design is said to offer 4 to 6 grams of total weight reduction compared to separate cartridge and headshell combinations. The cartridge features a nude-mounted hyperelliptical diamond stylus, viscous-damped dynamic stabilizer, telescoped stylus shank, and Shure's "Side Guard" stylus protection. Recommended tracking force range is ¾ to 1½ grams. $120.

CIRCLE NO. 88 ON FREE INFORMATION CARD

Deluxe Scope Curve Tracer

Daltec Systems' Expand-A-Scope connects to the horizontal and vertical inputs of a scope and provides nine reference standards against which the traces of resistors, capacitors, diodes, zeners, and other components can be compared. Current through a component under test is 5 mA maximum. The dual mode allows comparison of unknown components against known ones. An impedance/voltage/current display permits the comparisons, while an audible tone is used for continuity testing of circuits under 10 ohms. $250. Optional test probes, $15. Address: Daltec Systems, Inc., P.O. Box 157, Onondaga Branch, Syracuse, NY 13215.

Heat-Sink Clamps



Six new heat-sink clamps designed to facilitate the soldering of delicate electronic components have been produced by Desco Industries. The clamps reportedly are made of beryllium copper and have parallel-jaw construction. Two sizes, with overall lengths of 1.5" and 2.5", respectively, are available. Finger grips are plastic coated. The clamps are available with either chrome plating for resistance to wetting or chrome plating and a Plastisol coating for resistance to wetting and increased heat-dissipation characteristics. Prices range from $1.98 each to $2.70 each. Address: Desco Industries, Inc., 351 F Oak Place, Brea, CA 92621.

Noise Filter For Videotape

The Model DNF-1201A Burwen noise filter from KLH is claimed to dramatically reduce tape hiss encountered when playing videotapes through hi-fi systems. The filter operates on the principle of selective suppression of noise, having its greatest effect on quiet passages by automatically reducing high-frequency response. The device is rated to provide between 5 and 14 dB of tape hiss reduction. It is also rated to deliver a frequency response from 10 to 20,000 Hz ±0.5 dB maximum, with a dynamic range of 96 dB. Installation in a VCR/hi-fi system is via the tape-monitor jacks on the latter and the audio output jack on the VCR. Pushbutton controls on the DNF-1201A allow selection of maximum, minimum, or medium noise reduction. A sensitivity control and LED readout are also provided for calibration. $379.

CIRCLE NO. 92 ON FREE INFORMATION CARD

Teac Cassette Deck

Teac's new Model V-9 stereo cassette deck features a new two-head, three-motor transport mechanism and a unique spectrograph metering system. Assigned to each channel is a series of six color-coded peak-indicating lamps that display recording or playback levels. The transport's drive mechanism is controlled by IC logic, without the need for solenoids. Other features include one-touch selection of bias and equalization (the V-9 accepts all modern tape formulations, including metal), Dolby noise-reduction circuitry, a timer control for use with an optional timer unit, and REC MUTE. $399.

CIRCLE NO. 89 ON FREE INFORMATION CARD

Simplified Port Switching

Inmac's T-Switch permits a computer user to switch two 24-signal lines without switching all cables. According to the company, an all-purpose asynchronous null modem ensures compatibility between the communicating devices. The T-

Magnavision® is Gourmet Video.

Video for people who know and love video.

Simulated TV picture.

If you seek the ultimate in your electronic gear, Magnavox has a bright idea for you called Magnavision. It is Gourmet Video for the video gourmet.

A picture that's clearer than tape and less costly, too.

Magnavision is an advanced LaserVision™ videodisc player. Its optical laser scanner, a videodisc and your TV set team up to give you a picture that's amazingly sharp and clear.

Even better, the Magnavision picture remains this good even after thousands of viewings. That's because there is no direct contact between our laser and the disc. Unlike your phonograph, Magnavision doesn't use a needle.

The hearing's as good as the seeing.

Magnavision is designed to be played through your home stereo system so you hear what you see in full high-fidelity stereophonic sound. And since there is no disc wear, the Magnavision sound stays crystal clear, playing after playing.

Studio-like controllability puts you in command of the action.

Now the real fun begins. You not only watch and hear Magnavision. You play with it, too. Reverse, Slow Motion, Still, Fast Forward, Search, Numerical Index, Stereo Sound. Only LaserVision systems like Magnavision let you watch and play so many different ways.

Watch what you want whenever you want.

With Magnavision, you have a complete library of MCA DiscoVision® programming to choose from. Blockbuster movies like *The Electric Horseman*. Classic films like *The Bride of Frankenstein*. Cooking lessons by Julia Child. Documentaries from Jacques Cousteau. How-to-do-it tennis, golf, swimming and crafts. Music, concerts, cartoons, the arts and NFL football.

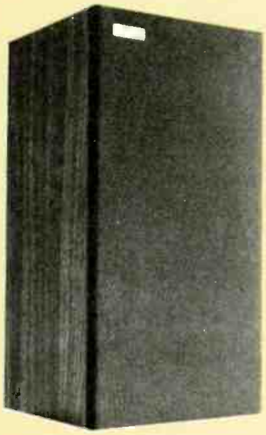
Discover Gourmet Video today. Call toll-free 800-447-4700 for the Magnavision dealer nearest you. In Illinois, call 800-322-4400.

CIRCLE NO. 38 ON FREE INFORMATION CARD

MAGNAVOX

The brightest ideas in the world are here to play.

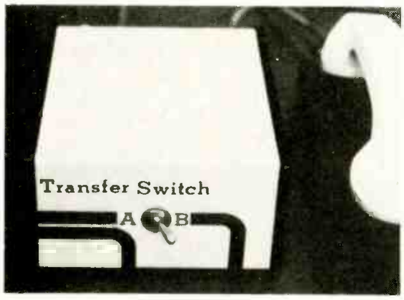
Ditton Two-Way Speaker System



The Ditton 130 is a two-way acoustic-suspension speaker system from Celestion Industries. Its 8" woofer and dome tweeter are said to offer increased efficiency and wider dispersion over previous Ditton models, plus better octave-to-octave balance. The HF 1001 tweeter is designed to have greater power-handling ability than its predecessors, while a new low-mass PVC surround on the woofer is said to provide lower distortion and greater efficiency than would be possible with a neoprene surround. Technical specifications: 75 to 20,000 Hz ± 3 dB anechoic frequency response; 8 ohms impedance; 10 watts minimum driving power required; 87.5 dB SPL for 1 watt input at 1 meter. Size is 19"H x 9¾"W x 9"D, and weight is 17 lb. $200.

CIRCLE NO. 93 ON FREE INFORMATION CARD

Switch features three A-800 Series 25-pin female connectors, and the common ground is not switched. All contacts are

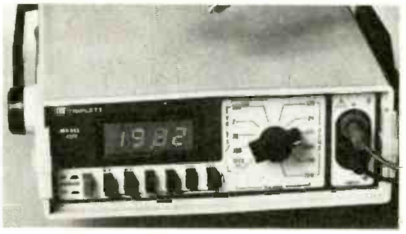


reported to be gold-plated. $175. Address: Inmac, Dept. 1025, 2465 Augustine Drive, Santa Clara, CA 95051.

Kantronics Communications Filter

The Varifilter from Kantronics is claimed to provide optimum reception results from communications equipment without ringing, oscillating, or instability. Frequency and bandwidth can be varied to peak one signal or notch an interfering signal and it works with CW, SSB, and AM signals. Bandwidth is variable from less than 30 Hz to greater than 1 kHz, while frequency range is from less than 150 Hz to beyond 3 kHz. Once set, bandwidth remains constant regardless of changes in frequency-range setting. A tuning "eye" lets you see when a desired signal has been filtered out. The filter's built-in power supply is switchable for 117- to 230-volt ac operation. For maximum convenience, the Varifilter can also be powered from a 12-to-18-volt dc source. $139.95. Address: Kantronics, Inc., 1202 E. 23 St., Lawrence, KS 66044.

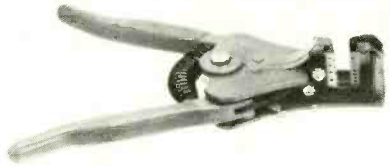
Triplett True RMS DMM



The Model 4200 digital multimeter from Triplett Corp. features true rms conversion for improved measurement of complex ac signals. It features a 3½-digit LED display, ±0.2% typical accuracy, and 32 ranges for measuring ac and dc voltages and currents and resistance. Other features include: pushbutton function selection, single range-selection switch, auto-zero and auto-polarity in the voltage and current modes, and r-f shielding. The instrument is fuse overload protected to 1000 volts on all ranges. Priced at $270, the DMM comes with safety test leads, and combination carrying handle and bench stand. Available options include: high-voltage probes, miniature clips, 30-amp dc current shunt, clamp-on ac ammeter, and simulated-leather carrying case.

CIRCLE NO. 94 ON FREE INFORMATION CARD

O.K. Wire Stripper



O.K. Machine and Tool's new Model ST-300 manual wire stripper has an adjustable stop built into it to allow consistent wire-strip lengths. Designed to accommodate 14- to 22-gauge solid or stranded wire, it is reported to be able to strip almost any type of insulation—including Kynar, vinyl, polyethylene, rubber, etc.—in current use. The tool is designed to remove up to ¾" of insulation in a single motion, without damaging or nicking the wire. $9.95.

CIRCLE NO. 95 ON FREE INFORMATION CARD

Interactive Video Interface

The CAVI (Computer Assisted Video Interface) Model 400 from BCD Associates is a single-board video tape controller for

"Smart" Bearcat Scanner

Electra's Bearcat 350 scanner radio can display with words or abbreviations the source of messages being received on each of its 50 channels, using up to eight characters per channel. The same fluorescent display will also indicate exact received frequency when a button is pushed to put the radio into the numeric mode. In this case, frequencies are displayed to four decimal places to accommodate the new uhf-T band assignments. A second fluorescent display indicates the channel number being received and any special features actuated. Seven-band coverage includes low and high bands, uhf, uhf-T, 2-meter and 70-cm amateur FM bands, and the entire AM aircraft band. Other features include selectable scan speed, priority, direct channel access, automatic up/down search, and manual step search, plus automatic squelch and a function that permits automatic activation of an alarm or recorder when calls are received on channels of special interest. $600.

CIRCLE NO. 96 ON FREE INFORMATION CARD

Video Review® knows a bright idea when it sees one.

Simulated TV picture. Simulated wood cabinet.

Video Review magazine tests a lot of sophisticated video products.

They get to see virtually every make and type of color TV receiver.

Which makes their selection of Magnavox as their standard TV receiver pretty impressive.

"We thought the Magnavox picture quality and resolution were superb."

"Ever since *Video Review* began testing products," says the magazine, "we've been looking for a top quality, 19-inch TV set that might serve as a standard of reference for all of the other products we test....video cameras, video cassette recorders, video cassettes.

"We thought the Magnavox picture quality and resolution were superb, and that off-the-air sensitivity was also extremely good.

"Major VHF channels were received with uniformly accurate color fidelity. This receiver produced superior color pictures even when using its own indoor VHF and UHF antennas."

"The special tuning features and remote control capabilities of the Magnavox receiver are awesome."

"The tuning system is purely electronic and totally digital," they continue. "There is a fine tune switch and a memory lock button. If any channel is received mistuned, the user simply fine tunes up or down in frequency by holding the button, and when perfect tuning has been achieved, the button is released and the memory lock button is depressed once.

"Nearby is Magnavox's Videomatic feature. Depressing this button activates the electronic eye for automatic brightness adjustment, color adjustment circuits and automatic fine tune."

"...unusually good for any receiver."

Overall, *Video Review* rated the Magnavox 9.5 or better (out of a possible 10.0) on Video Quality, Reception Sensitivity, Color Fidelity, and Video Resolution and Fidelity. As they put it, "...unusually good for any receiver."

We can only add that once you see a Magnavox color TV at your Magnavox dealer, we think you'll agree.

For Magnavox color TV specifications, write Magnavox Consumer Electronics Company, Dept. 700, P.O. Box 6950, Knoxville, Tennessee 37914.

MAGNAVOX

The brightest ideas in the world are here to play.

CIRCLE NO. 39 ON FREE INFORMATION CARD

Apple II computers. It can be used to control industrial type VHS, Beta, and 3/4-inch video recorder/players without modifications to the computer or VTR. By counting pulses from the tape control track, the system hardware/software permits precise video tape positioning. The unit contains a video audio switcher to allow alternate display of computer-generated or taped video on a single monitor. BASIC software allows searching for the beginning of a video scene, and play until the end of that scene. The Computer Assisted Instruction (CAI) software is available on a separate diskette. This program allows persons with no computer expertise to create and modify CAI lessons and video tape logs. CAVI is $495, CAI $295.

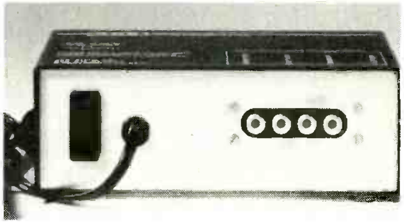
CIRCLE NO. 97 ON FREE INFORMATION CARD

Zenith "Smart" Terminal

Zenith Data Systems' Model Z19 is a Z80-controlled "smart" data terminal whose special deflection system is designed to create smaller on-screen spot size for sharper resolution. The terminal's 12" CRT displays 24 lines by 80 upper- and lower-case (with true descenders) characters and has a 25th user-status line. The keyboard is laid out in standard typewriter format and is supplemented by a separate numeric keypad. Video features permit complete control, and direct cursor control permits users to move anywhere on the screen for corrections and editing. Interfacing with a computer is via a standard RS-232 port, at baud rates from 110 to 9600. Compatibility with the DECOVT52 Digital Electronics terminal can be accomplished from the keyboard, an outside computer, or an interior switch. $995.

CIRCLE NO. 98 ON FREE INFORMATION CARD

Ace Audio Infrasonic Filter



Ace Audio's Model 4000-X24 infrasonic filter is designed to reduce or eliminate infrasonic noise from warped records, off-center spindle holes, turntable rumble, and tonearm mass/stylus compliance resonance effects. The device's circuitry employs a combination of active Bessel and passive filter sections to maintain the lowest possible phase shift. Ace Audio states that each 4000-X24 is individually hand calibrated to improve accuracy. Distortion is rated at 0.002% at 2 volts output, and response is down 3 dB at 20 Hz (ultimate slope 24 dB/octave). $148.50.

CIRCLE NO. 99 ON FREE INFORMATION CARD

30-Channel Cable TV Converter

The ETCO AE047 converter makes all cable-TV channels from 2 to the super band suitable for viewing on the uhf portion of a TV receiver. The converter can be used with remote control systems or manual uhf selection. The converter can also be used with a VCR to regain programmability when video recording from the cable system. It comes with matching transformer and power supply. $39.95.

CIRCLE NO. 100 ON FREE INFORMATION CARD

ENTERTAINMENT ELECTRONICS

Life with Video Discs

THERE is probably still time to be the first on your block with a videodisc player—if you want to be. Magnavox and Pioneer have just put their laser-scanned disc players into more or less national distribution, and they'll still be a novelty in many areas. Even if someone beats you to the punch, you can still be first with an RCA "CED" disc player or a Japanese-developed "VHD" player, both of which are due by about the time you see this. I had a Magnavox for test about a year ago and have the Pioneer player here right now. They're fun to have. But whether you'll find them worth buying will depend on as many personal factors as technical ones.

Why have a videodisc that just plays programs when you can get a tape deck that records them, too? It's really the same question as "Why have a phonograph when a cassette recorder is available?" and the answers are just about the same. Like the phonograph, the videodisc can give you the best reproduction available. For example, I've gotten resolution better than 300 lines (horizontal) from a much-played laser-scanned video test "record," while the best I've seen on recent VCRs was about 250 lines. The disc picture was also far freer of snow and other noise, and there was no color smear, a common fault with tape. Of course, there is *some* noise and loss of detail. In fact, a really good broadcast or cable signal would give a better picture. I confirmed that by comparing a broadcast test pattern with that from my video test disc.

When it comes to sound quality, the laser-scanned video disc (the only type we've worked with to date) runs rings around the VCR and may even beat what comes off the air. The audio signal is stereo, with enough separation for bilingual use, as well. Stereo-sound VCR's are just now appearing (Akai's is the only one I know) and stereo TV broadcasting must await an FCC decision.

What's more, all the special effects work better on the disc than on a VCR. Still-frame, for example, is free of jitter, blur, and noise bars. Speeds range from normal down to a slow-motion 12 frames per minute (1/150 normal), and there are two fast modes—one at three times normal speed for reviewing or previewing a portion of the program) and one that zips through the entire disc in less than 30 seconds. All functions operate as smoothly and cleanly as normal play, and in both forward and reverse.

The videodisc frame counter puts the ones on VCR's to shame. Instead of an arbitrary four-digit number half-hidden behind a little window, there's a five-digit number on the screen (when you want it there) that identifies every one of the more than 50,000 frames on each side. On the Pioneer (but not the Magnavision), you can even punch in the frame number and have the player find it for you. Some discs have chapter numbers to help you find sections rather than frames. They can even carry signals that stop the player at each chapter's end. (Frame-by-frame access is coming to home VCR's, though.)

Otherwise, videodisc has much the same advantages and disadvantages compared to tape as the phonograph does. Disc software is cheaper to manufacture than prerecorded tapes, and access to stored information is the much faster random rather than sequential.

But if the videodisc shares the phonodisc's advantages, it has its major disadvantage as well: reliance on program material from outside sources, rather than on user-made recordings. That's important for two reasons: First, since the phonograph preceded tape, there was already a vast library of recordings available when the latter hit the scene. Videodisc is a Johnny-come-lately, and most of what's available is on tape, not disc. Second, with three incompatible disc systems contending for market share, the odds are against picking the one that will survive.

If you could make your own discs, that would be a small problem. If a video tape system becomes obsolete, there will still be enough demand to keep blank tapes available for years—suppliers can sell the same blanks to everyone, regardless of their tastes in programming. But once a disc system dies, don't expect suppliers to produce new program discs indefinitely.

How will the two new systems—RCA's CED and the Japanese VHD—compare? RCA's disc will initially have only monophonic sound. This is not as much of a drawback as some critics claim, I suspect, since so little video material with stereo is yet available. It also won't allow still-framing and some of the other fancy features of the laser disc. On the other hand, there are reports that the VHD disc will require some extra "frame-store" circuitry to do still-framing. And the long-play (CLV) laser discs, which have 60 minutes per side instead of the standard (CAV) discs' 30, don't allow still-framing, frame-number display, triple-speed play or frame-number search. (There is a counter readout, but it shows minutes and seconds rather than frames.)

Projected costs for both CED and VHD are lower than the laser disc's. RCA says its CED disc players will sell for $500; presumably, the rest (from Zenith, Hitachi, Radio Shack and others) will cost about the same. On the VHD side, Sansui (which just announced a player for later in '81) says the cost will be "at least $200 less than laser disc players," in other words about $550-$600. But discounts are available already, here and there, even with just two laser players on the market; with more competition, more price cuts are likely.

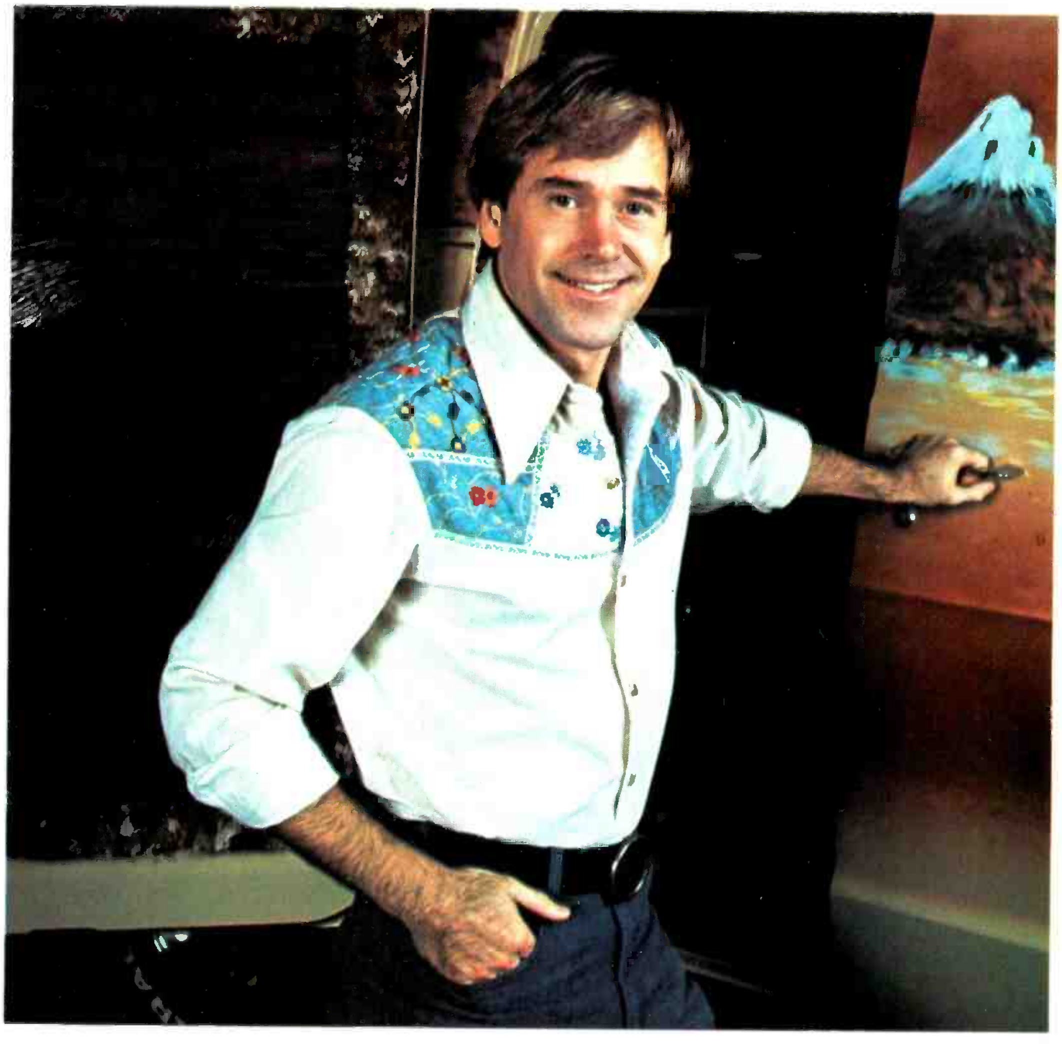
There's no telling how VHD and CED discs will compare with the laser disc for reliability. The laser-system disc seems the most long-lived, on paper (no physical disc contact, for one thing), but it has had problems. Early discs, on early players, would occasionally loop back to repeat a segment of the program, or stop altogether. There have been rumors of a high rejection rate at MCA's disc plant, and dealers have reported as many as one-third of their discs being returned. But disc production techniques have now improved (the return rate is now "almost as low as audio discs," says Magnavox), and Magnavox has modified its new players and those already in the field to eliminate the problem. A new laser-disc plant is rising in Japan, for Universal-Pioneer (the Pioneer player's actual manufacturer); if it lives up to the Japanese reputation for quality audio disc pressing, there should be no further problems.

How do the Magnavox and Pioneer players compare? Quite closely. I used them several months apart, so I can't say for sure that there was any difference in performance between the two. My Magnavox (an early, unmodified one) did sometimes skip into a loop on one specific disc side, and my Pioneeer doesn't seem to have that problem. The Pioneer does have some extra features, though, such as the random-access system, a clever remote control (wireless, but with a wired option, in case it uses the same signal frequencies as your TV set), and a rear-panel jack for a potential digital-audio disc decoder.

That digital-audio output raises another idea that should intrigue computer enthusiasts. Estimating from the bit content of digital audio, a half-hour disc should hold about 150 megabytes, roughly the same as a 14-inch hard disc (allowing for redundant bits and the like). Track-to-track access would be a bit slower than disc systems designed for computer use, but a worst-case access time of about 30 seconds, on a data store that big, would still be acceptable, especially for hobbyist applications. Coming up, though not soon, are laser-disc systems that can record as well as play. That would turn the videodisc into a cross between hard disc and super ROM, with more capacity than most

(Continued on page 20)

You gotta shop around.



When you do, you'll probably pick CIE. You can't afford to settle for less when it comes to something like electronics training that could affect your whole life.

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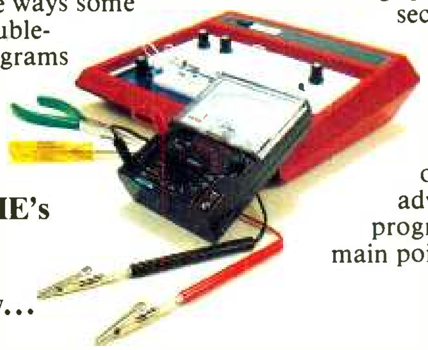
This is the next big important question. After all, your career will be built on what you can do—and on how well you do it.

Here are ways some of CIE's troubleshooting programs help you get your "hands-on" training...



With CIE's Personal Training Laboratory... you learn and review the basics—perform dozens of experiments. Plus, you use a 3-in-1 precision Multimeter to learn testing, checking, analyzing!

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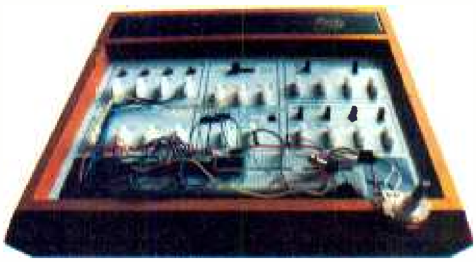
When you get your Digital Learning Laboratory you'll be into digital theory—essential training today for anyone



who wants to keep pace with the state of the art of electronics in the eighties. With CIE's Digital Lab, you'll be applying in dozens of fascinating ways the theory you've learned. For example, you'll compare analog and digital devices. You'll learn to make binary to decimal conversions and to work with semiconductor devices and circuits. You'll see how digital equipment is vital in today's exciting, growing fields such as security where digital theory provides the brains for space-age alarm and protective devices.

Of course, CIE offers even more advanced training programs, too. But the main point is simply this:

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More than half of CIE's courses prepare you for the government-administered FCC License exam. In continuing surveys, nearly 4 out of 5 CIE graduates who take the exam get their Licenses!

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PE-34

(Continued from page 14)

microcomputer users ever dream of.

Digital audio discs will probably be using that output long before computers are. But don't be too sure. The one laser-based audio disc system I've seen concrete proposals on is Philips' Compact Audio Disc. It uses the same technology but is incompatible with the current video disc players. Should the industry choose that (and Sony is already backing it), the digital audio outputs on the Pioneer video player won't be much use—which Pioneer admits: "We don't know where the industry is going—nor does anybody else—but we wanted to leave as many options as possible open . . .," says Pioneer's John Talbot.

If all this leaves you a bit confused, you're not alone. So are the manufacturers. Sansui, for example, while announcing its VHD disc player (with provision for VHD-compatible AHD audio discs which have three digital sound channels plus still pictures), also announced that it's conversant with both RCA's CED videodisc system and the Philips Compact Disc audio system, and could produce either (or both) if the market seemed to warrant it. —*Ivan Berger*

New Sonic Hologram

THAT the Carver Sonic Hologram is now available separately as Model C-9 for a suggested retail price of $279 is news, but not news that would normally make this column. What's chiefly of interest is that the new model incorporates newly revised circuitry meant to overcome some of the limitations of the early version.

First, solipsism has been banished; you can listen to the new hologram along with friends. The cross-fed, delayed signal has been recalibrated so that, in addition to a central position that receives an intense holographic image, there are two flanking positions where the image is almost as good. Flipping a switch optimizes the unit once again for a solitary, centrally located listener.

Second, frequency response has been improved. The comb filtering that is the inevitable consequence of mixing delayed and undelayed versions of the same signal has been reduced, according to Carver, to where the ripple is on the order of 1 dB. Also, the unintended bass boost introduced by the earlier circuit has been removed.

Listening tests essentially confirm Carver's claims for the C-9. Bass is better, and when the device is set to produce a wide listening area, seating position seems almost noncritical. The effect is at times startling. It is easy to sit in one of the flanking positions without paying particular attention and be shocked at the piano that (acoustically, at least) seems to have materialized in your living room. The only oddity I observed is some peculiar image shifting when you move your head between, say, a flanking position and the center position. An added bonus is that the new hologram banishes the "in-the-head effect" in headphone listening.

Recently, the new hologram circuit has been included in the C-4000 preamp/control center. Owners of older C-4000s will be pleased to know that a retrofit of the new hologram is available for $65.—*Harold A. Rodgers*

AUDIOPHILE RECORDINGS

By Harold A. Rodgers
Executive Editor

JOHN WILLIAMS: ***The Empire Strikes Back*** (symphonic Suite from the Original motion picture score). National Symphonic Orchestra conducted by Charles Gerhardt. Chalfont SDG 13 (dbx PS-1018). Judging by public acceptance rather than by edicts from musical academia, the suite distilled from a motion-picture score is at least arguably the 20th century's principal invention in musical form. While there are those who would dismiss it as "mass-market" art, film music has been composed by figures as august as Copland and Prokofiev.

This should not be interpreted as an apologia for the music of John Williams for none is necessary. *The Empire Strikes Back* is dynamic, listenable, and even more impressive on its own, freed from visual distractions and sound effects. Williams has obviously absorbed many of the 20th-century musical practices that were once hailed or condemned as "avant-garde" and uses them in a way that is above all accessible and communicative. Yet there is no need for the musical sophisticate to despair, for the work is original and musicianly.

The sound of the disc is worthy of its digital mastering, and the prodigious dynamic range provided via dbx encoding lets the energetic and powerful reading given by the performing forces come through in the listening room.

THE FIRST HIGH GRADE VIDEOTAPE.

Video cassette recorders have changed a lot in the last few years. New features like six-hour recording, slow motion and freeze frame have added a great deal to home recording.

But there's one drawback. To utilize these new features, you must operate your cassette recorder at a slower speed. And this places increased pressure on the videotape, which can cause the magnetic oxide particles on the tape's surface to loosen and eventually fall off. Once this starts to happen, a loss of picture quality isn't far behind.

At Maxell, we've always been aware that a video cassette recorder can only be as good as the tape that goes in it. So while all the video cassette recorder manufacturers were busy improving their recorders, we were busy improving our videotape.

The result is Maxell Epitaxial HG, the first high grade VHS videocassette. In technical terms, there are several significant differences between our high grade and regular videotape.

For one thing, our oxide particles are smaller and more densely packed on the tape surface. Which is why we have a better frequency response and signal-to-noise ratio, especially at the slower recording speeds.

And, because of our unique binding process and calendering system, the oxide particles on Maxell HG stay put. This drastically reduces friction and video recorder head wear. So not only will you get better picture quality, but you'll be able to enjoy it a lot longer.

All in all, no other home videotape can deliver better color resolution, sharper images or cleaner sound than Maxell HG.

So if you own a VHS recorder, please remember one thing. If you want high grade picture quality, you need a high grade tape.

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CIRCLE NO. 40 ON FREE INFORMATION CARD

Audio Product of the Month

CHOSEN BY THE EDITORS OF POPULAR ELECTRONICS

Luxman K-8 Stereo Cassette Deck

Flexible operation and tasteful styling

SOLENOID-OPERATED tape transport controls and full compatibility with metal tapes as well as conventional formulations are included in the two-head, single-motor K-8 cassette deck from Luxman. Among its operating conveniences are fast-responding fluorescent peak level indicators, light-touch transport control buttons, timer-controlled operation in both recording and playback modes, and several automatic play/rewind functions. The tape index counter is a highly legible, three-digit fluorescent display. Microphone inputs can be substituted for the line inputs (but not mixed with them), and unwanted noises can be deleted by muting the recording temporarily without stopping the tape.

The Luxman K-8, with a suggested retail price of $499, is housed in a wood-grain veneered cabinet with pale gold-colored panel and knobs and measures 17¼" W × 11¼" D × 4¼"H. Its weight is 13.2 lb. A plug-in remote-control accessory is available for $100.

General Description. Access to the cassette well is gained by pushing a button at the upper left of the front panel. Most of the cassette, which is back-lighted, can be seen through the transparent door while in operation. If Luxman cassettes are used, it is possible to minimize azimuth error from a tape made on another machine by adjusting tape skew with a small screwdriver through a hole in the cassette door.

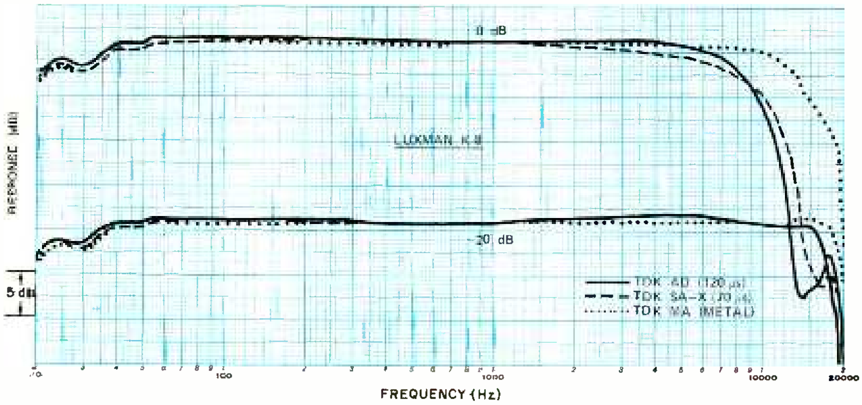
Tape-transport controls are flat "feathertouch" buttons that operate solenoids through logic circuits. These enable switching from any mode to any other without use of the STOP button. The tape normally does halt before changing speed or direction, but that happens automatically. It is possible to make a "flying start" recording while playing a tape, by holding in the PLAY button and pressing the RECORD button.

Each time the recorder is turned on, the counter resets to 000, unlike mechanical index counters. Manual reset can be accomplished by pressing a small button. Another button activates the memory circuit, which causes the tape to stop at a 000 index reading when in rewind mode. Arrows near the index numerically indicate tape motion.

The level indicators are a pair of blue, fluorescent 12-segment horizontal lines. Each channel is calibrated from −20 dB to +5 dB (the segments are solid below 0 dB and outlines above 0 dB). When the deck is set for metal tape, the range of the display is extended to +8 dB.

Two three-position lever switches select bias and equalization. Each has positions marked NORM, CrO_2, and METAL. Basic bias settings can be altered by ±10% via a center-detented vernier control. The switch for the Dolby noise reduction system has an OFF and two ON positions, one of which engages a MPX filter to remove any 19-kHz pilot carrier that might remain in the audio from an FM tuner. Recording levels are adjusted by two concentric controls coupled by a slip clutch, and a single knob sets the playback output level. Another three-position switch selects MIC or LINE inputs or a spring-loaded REC MUTE position that kills the signal to the record head. This does not remove the incoming signal from the line outputs or affect the readings of the level indicator. Front-panel microphone jacks (for medium impedance dynamic microphones) are provided, with a headphone jack.

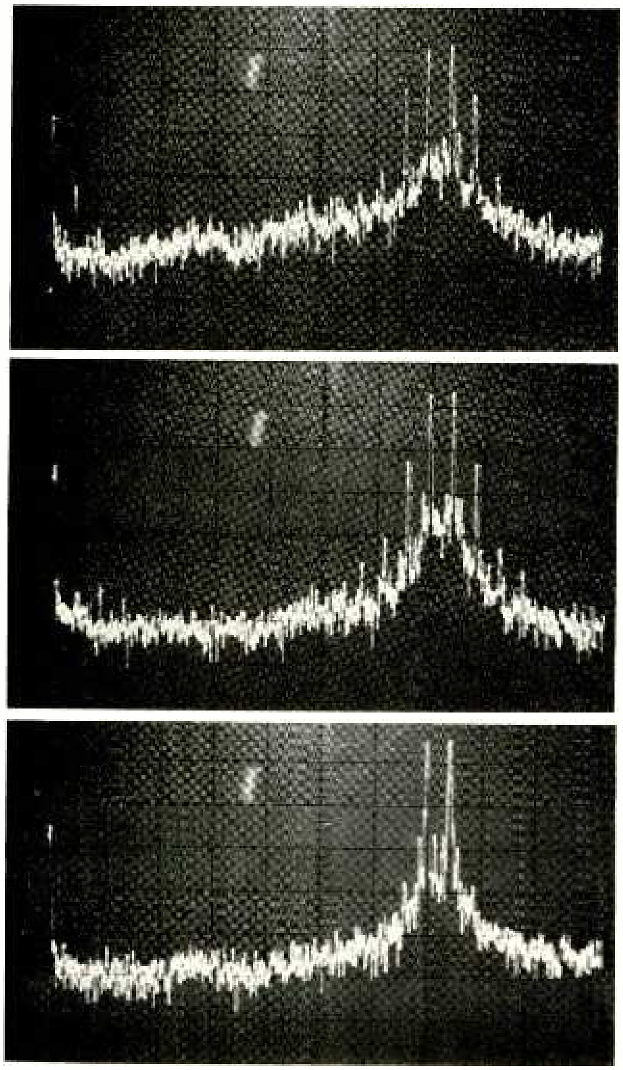
Automatic operation under timer control is possible using a small rotary knob switch. It chooses between normal operation, timer-controlled playback, timer-controlled recording, and three automatic modes: PLAY, REWIND, and REPEAT. Touching the REWIND button when PLAY has been selected causes the tape to rewind to its beginning (or to 000



Frequency-response curves for three different types of tape.

if the MEMORY button is engaged) and go into play automatically. The REWIND position causes the tape to rewind automatically when it reaches its end, stopping either at 000 or its beginning. The REPEAT mode is similar except that play begins again when the beginning reference point has been reached.

Sendust record/play and erase heads are used in the K-8 along with a direct-coupled recording amplifier—an unusual touch in a cassette deck. "Analogue switches," presumably solid-state devices such as FETs, are used for various control functions. With these, the leads routed to front-panel controls handle only dc signals and cannot degrade the audio.



Spectrum-analyzer photos of two-tone IM distortion tests. Input signal consisted of equal amplitude tones at 14 and 15 kHz, each at a −16-dB level. Top to bottom are results on TDK AD, TDK SA-X, and TDK MA tapes.

Specifications of the K-8 include record/playback frequency response (±3 dB) from 30 Hz to either 15,000, 18,000, or 20,000 Hz (normal, CrO_2 and metal tapes respectively). The corresponding S/N ratios (with Dolby) are 60 to 65 dB. The rated flutter (wrms) is 0.055%.

Laboratory Measurements. Lacking specific recommendations—other than an implication that Luxman tapes (not widely available) were suitable—we measured record/playback frequency response with a number of tape formulations. For NORMAL (normal bias, 120 µs EQ) tape, we used TDK AD and OD, Maxell UD-XL I, and Fuji FX-I. The CrO_2 (high bias, 70 µs EQ) tapes were TDK SA-X, Maxell UD-XL II, and Fuji FX-II, and metal tapes were TDK MA, Maxell MX, and Fuji Metal.

Although good results were obtained with all the tapes, our curves suggested that the recorder had been set up for TDK tapes, and we used them for our subsequent testing. All the others gave a slightly drooping high-end response, suggestive of a slight overbias. The BIAS FINE control was found to vary response above 10 kHz by about ±1 or ±2 dB, enough to flatten out the response curves from the Maxell and Fuji tapes. Measurements were made with this control centered.

Response with TDK AD was within ±2 dB from 20 to 16,500 Hz at −20 dB, with the 0-dB curve dropping off above 7,000 Hz to intersect the −20 dB curve at 12,500 Hz. OD tape was close but not quite as good at high frequencies. TDK SA-X delivered a response, within ±0.5 dB from 37 to 17,000 Hz and −3 dB at 20 and 18,500 Hz. Intersection of the 0-dB and −20-dB curves occurred at 13.8 kHz. Metal tape (TDK MA) was almost identical in response to SA-X (±0.5 dB from 40 to 17,500 Hz), but its dramatically better high-frequency characteristics were demonstrated by the fact that the 0-dB curve was still 12 dB above the −20-dB curve at 20 kHz.

Playback equalization was measured with TEAC 116SP (70 µs) and TDK AC-336 (120 µs) test tapes. Data from both lay within ±1 dB over the full range (40 Hz to 10,000 or 12,500 Hz respectively). Dolby tracking was superb. From −20 dB to −40 dB, the Dolby system affected the response curves by less than 1 dB at any frequency in a record/playback measurement. The MPX filter gave a flat response to about 12,000 Hz, rising to a +1.5 dB peak at 14,500 Hz and cutting off sharply. By 17,000 Hz, output was down more than 25 dB, and was negligible at higher frequencies.

For a 0-dB recording input, a LINE signal of 76 millivolts or a MIC signal of 0.17 millivolts was required. Overload of the MIC inputs occurred at a rather low 16-millivolt input. Playback output from a 0-dB signal was between 1.14 and 1.3 volts, depending on the tape being used.

DISCWASHER® AUDIOSCIENCE™ SERIES

Record Care, Part 2: A Record Life Study

How long will your phonograph records last?

How many times can you safely play records without degrading sound quality?

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Scanning electron microscopy clearly shows the need and contribution of both record cleaning and stylus care.

Exhaustive research shows that with proper record/stylus care, an entire "life span" of 200 play events will not damage record surface quality or fidelity. (Most albums are played a total of 50 times or less.)

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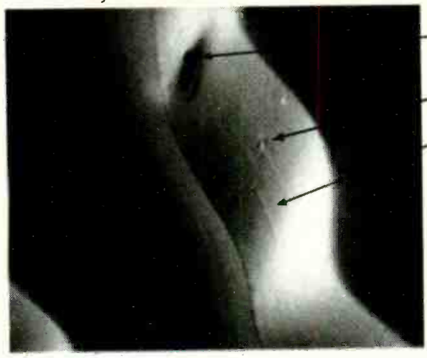
200 Plays Without Record Cleaning

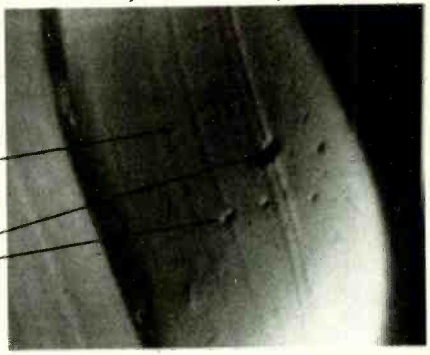


Pit from dust abrasion.

Ground-in microdust.

Prominent dust abrasion.

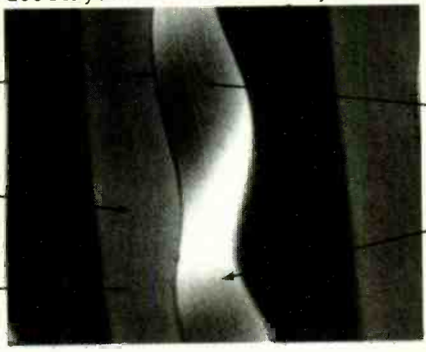
200 Plays Without Stylus Care



Prominent stylus path from abrasive-coated diamond face.

Vinyl particles welded by contaminated upper area of stylus.

200 Plays With Record and Stylus Care



Results of D4 Record Care:

Clean central radius due to capillary attraction of D4 Fluid into D4 pad fabric.

Microdust-free stylus path due to exclusive D4 "spiral fiber" particle holding.

No wall-slurry of "lubricant" products.

Results of SC-2 Stylus Care:

Reduced wall abrasion due to uncontaminated diamond face.

Cleaned stylus leaves no welded-in particles.

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CIRCLE NO. 17 ON FREE INFORMATION CARD

Playback distortion (third harmonic of a 1,000-Hz signal) at 0 dB input was about 0.8% with AD and MA and 1% with SA-X. Reference distortion of 3% required an input of +5 dB with AD and MA, and +4 dB with SA-X. The S/N relative to those levels, with CCIR/ARM weighting and Dolby on, was about 68 dB for AD and SA-X, and about 65.5 dB with MA.

The effect of tape type on distortion is shown in the spectrum-analyzer photos from two-tone IM distortion tests. Using an input signal consisting of equal amplitude tones at 14 and 15 kHz, each of them at a −16-dB level (so that their combined peak was equivalent to a −10-dB sine-wave input), playback output was displayed on the 0-to-20,000-Hz scan of the analyzer. TDK AD gave the lowest output from the two high-frequency tones, with the third-order IM products at 13,000 and 16,000 Hz suppressed by only 10 to 11 dB. The second-order difference component, at 1,000 Hz, was down 53 dB relative to the recorder's 0-dB level. TDK SA-X gave reproduced tone levels 3 to 4 dB higher than AD tape, and its IM products were about 16 to 17 dB below the tones. The 1,000-Hz distortion product was at −64 dB. Although TDK MA produced playback test tones only 1 or 2 dB higher than SA-X, third-order distortion products were down a full 33 dB. The 1,000-Hz product was about the same as with SA-X, and may well represent the distortion of the playback amplifier rather than tape nonlinearity, which normally creates only odd-order distortion products.

The level indicators responded instantaneously to program peaks or short tone bursts, and a standard Dolby level tape gave a +1-dB indication on playback (the Dolby calibration mark was at 0 dB). Crosstalk from right to left channel at 1,000 Hz was −55 dB, and headphone volume was excellent, even with high-impedance phones. Tape speed was 1.8% fast, and in the fast-wind modes, a C-60 cassette was moved from end to end in 75 to 81 seconds. JIS flutter (wrms) was 0.05% and the weighted peak flutter was ±0.08%. Except for a single component at 30 Hz, most of the flutter was below 15 Hz.

User Comment. To judge the quality of a cassette deck audibly, we record interstation hiss from an FM tuner at various levels and compare the playback to the sound of the original. Even slight high-frequency tape saturation will cause a pronounced dulling of the sound in a playback, so that few recorders give accurate playback when noise is recorded at 0 dB (and many cannot do it at −20 dB). In our tests, tapes used behaved just about as their measured performance would suggest. TDK AD was nearly perfect at −10 dB, but had noticeable dulling of the extreme highs at 0 dB. At 0 dB, TDK SA-X matched the performance of AD at −10 dB, and MA was essentially perfect at 0 dB.

It must be realized that these levels were true peak readings, which gives the K-8 a tactical advantage over other machines that use slower, average-reading meters. If one were to record at a 0-dB indicated level with such meters, the peaks would be considerably higher and would cause more high-frequency tape saturation.

On the basis of our listening tests, the Luxman K-8 is capable of true high-fidelity performance. Dubbed program material coming out of it sounds just like what went in, although some types of live material can exceed the recorder's capabilities or overload the mic inputs.

In use, the deck is an unalloyed pleasure. Minor or rarely used controls are located on the front panel, but with very small knobs that avoid a cluttered appearance while preserving operational flexibility. The styling, thus, is at once tasteful and functional. Such niceties as the flying-start recording capability, the REC MUTE, and the automatic and timer operated modes help to distinguish this unit even more.—*Julian D. Hirsch*

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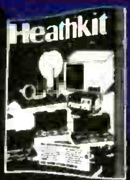

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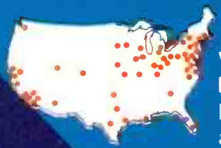

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Popular Electronics Tests
the Pioneer Model VP-1000 Videodisc Player

LaserDisc system connects directly to TV receiver and offers remote control with pause and freeze-frame

GATHER up 65 integrated circuits, 188 transistors, a 2-kilovolt helium/neon laser, precision lenses, and a two-speed turntable motor, put them all together in an attractive tan and walnut plastic package weighing 38.6 lb, and you have Pioneer's marvelous videodisc player. It uses a laser optical system licensed by N. V. Philips and is designed to play videodiscs of the MCA DiscoVision and now 3M labels.

Pioneer's system offers all the features available with the Philips/Magnavox player plus a full-feature remote-control system, pause and freeze-frame capabilities, and on-screen display of both chapter and frame numbers.

The player connects directly to the vhf antenna terminals of any TV receiver and optionally to the inputs of a stereo amplifier. Any disc can be played without interruption from beginning to end in a one-button operation, or any desired portion of a disc can be played simply by keying in its chapter (and/or frame) number. You can also fast scan or play back in slow motion in either direction. Sound reproduction can be in full stereo or in mono left or mono right. Finally, the two-speed player offers up to 30 minutes viewing time per disc side in standard play or up 60 minutes per side in continuous nonstop extended play.

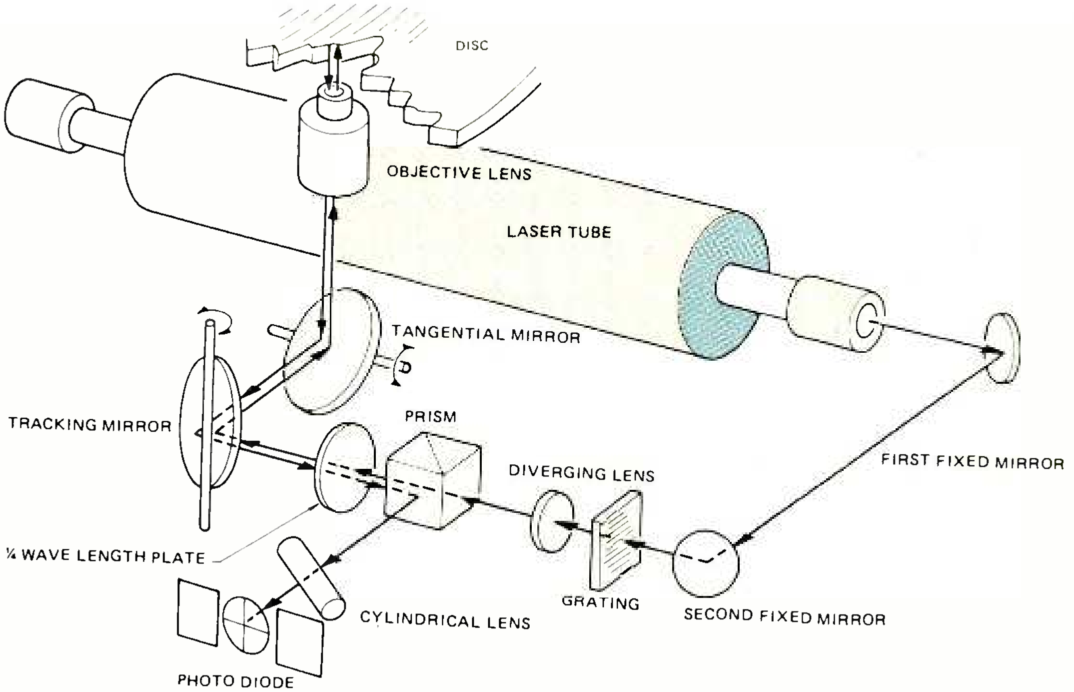

Fig. 1. Diagram showing the path of the laser beam as it is reflected on to the disc and back again to photo diode.

Housed in an attractive tan and walnut-grain plastic enclosure, the player measures 21⅝"W x 16"D x 5⅝"H and weighs 38.6 lb. Suggested retail price for the player is $749. The optional Model RU-1000 remote-control unit lists for $50.

General Description. Audio and video information are encoded on the disc as a series of microscopic indentations laid down in a spiral. The segment of the spiral scanned in one disc revolution is called a track and represents one video frame. Tracks are separated from one another by only 65 millionths of an inch (1.6 micrometers), but they contain all required intelligence for 8.1 MHz composite video, in addition to dual-channel (practically no crosstalk) sound. Each track is 0.4 micrometer wide. The discs have a surface of reflective material and a transparent outer casing. Minor scratches on the transparent layer do not degrade reproduction. Current prices for single recordings are $5.95, and those for multi-record albums range from $15.95 for older releases to $24.95 for more recent feature films.

When the player operates, red light emerges from the laser as a linear cone to the first and second fixed mirrors (Fig. 1). These change its directions and adjust the optical axis to the desired position on the grating. There, the beam's center is split into several parts, of which two are used to read tracking signals while the center, or zero-order, beam reads the FM and focus signals. The other residuals around the circumference are at lower energy levels and have no effect.

The three remaining beams now enter the diverging lens where they converge again on a focal point and continue as a pencil of rays into a prism that passes P-polarized, or parallel, light, but rejects S-polarized, or perpendicularly polarized, light. The ¼-wave plate following adds a 90° phase lag and changes the polarization to circular. Tracking and tangential mirrors then take the beams to the objective lens, where the pencil of rays is focused as an extremely fine spot on the signal (reflective) surface of the disc. A focus servomechanism keeps this spot constantly aligned with the disc's signal track.

Light impinging on millions of disc pits is reflected back through the objective lens, the path-altering tangential and tracking mirrors, and the ¼-wave-length plate. Once more there is a 90° phase lag, producing a total 180° phase alteration from the starting phase, and linearly P-polarized parallel light again emerges through the prism, with S-perpendicular light excluded. Light beams, thereafter, reach the cylindrical lens and the photo diode; and it is the photo diode that transforms the optical information into electrical signals.

The same signals also contain information from the FM focus and tracking beams (Fig. 2). When radial beams A and C are identical in value, they are on proper track and the zero-order beam is precisely on center. But when these two first-order beams are not equivalent, a difference output develops and is used by the tracking servo to correct the tracking mirror. The tangential mirror, whose changing angles derive from the video circuits, will correct any errors in disc revolutions, distortions, and concentricity. The laser and all optics are mounted on a motor-driven slide assembly that passes beneath the video disc as playback proceeds.

(Text continues on page 40)

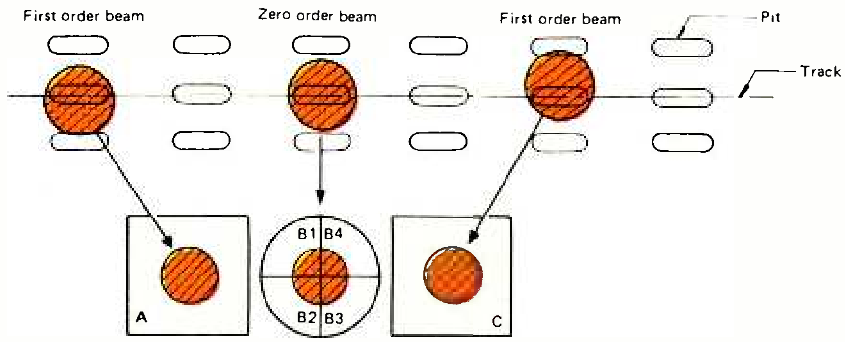

Fig. 2. Optical information is converted into electrical signals for the audio, video, and tracking systems.
(Figure 3 is on page 34)

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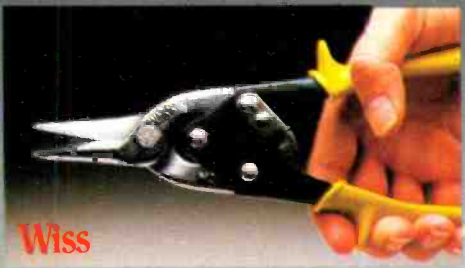

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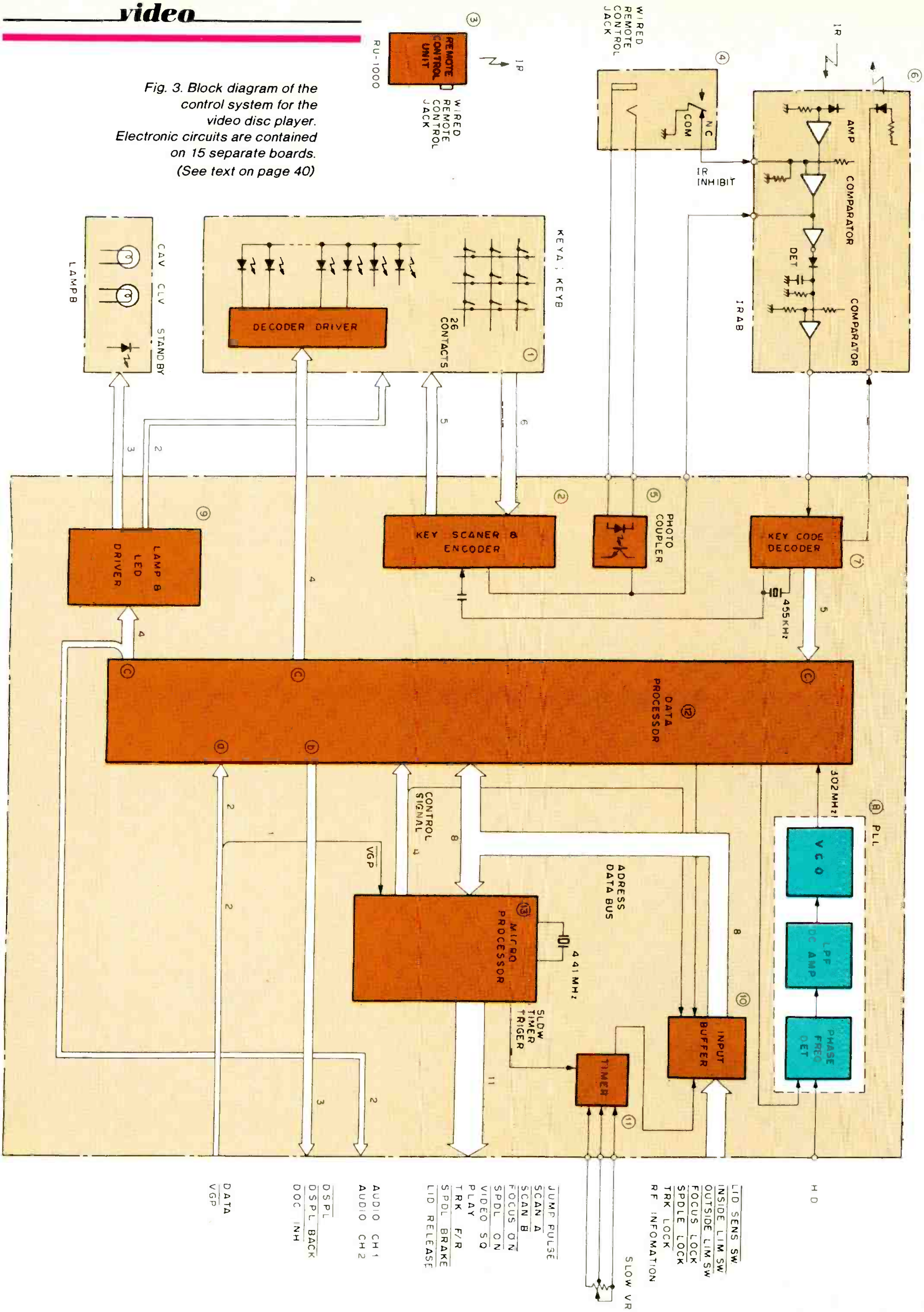

Fig. 3. Block diagram of the control system for the video disc player. Electronic circuits are contained on 15 separate boards. (See text on page 40)


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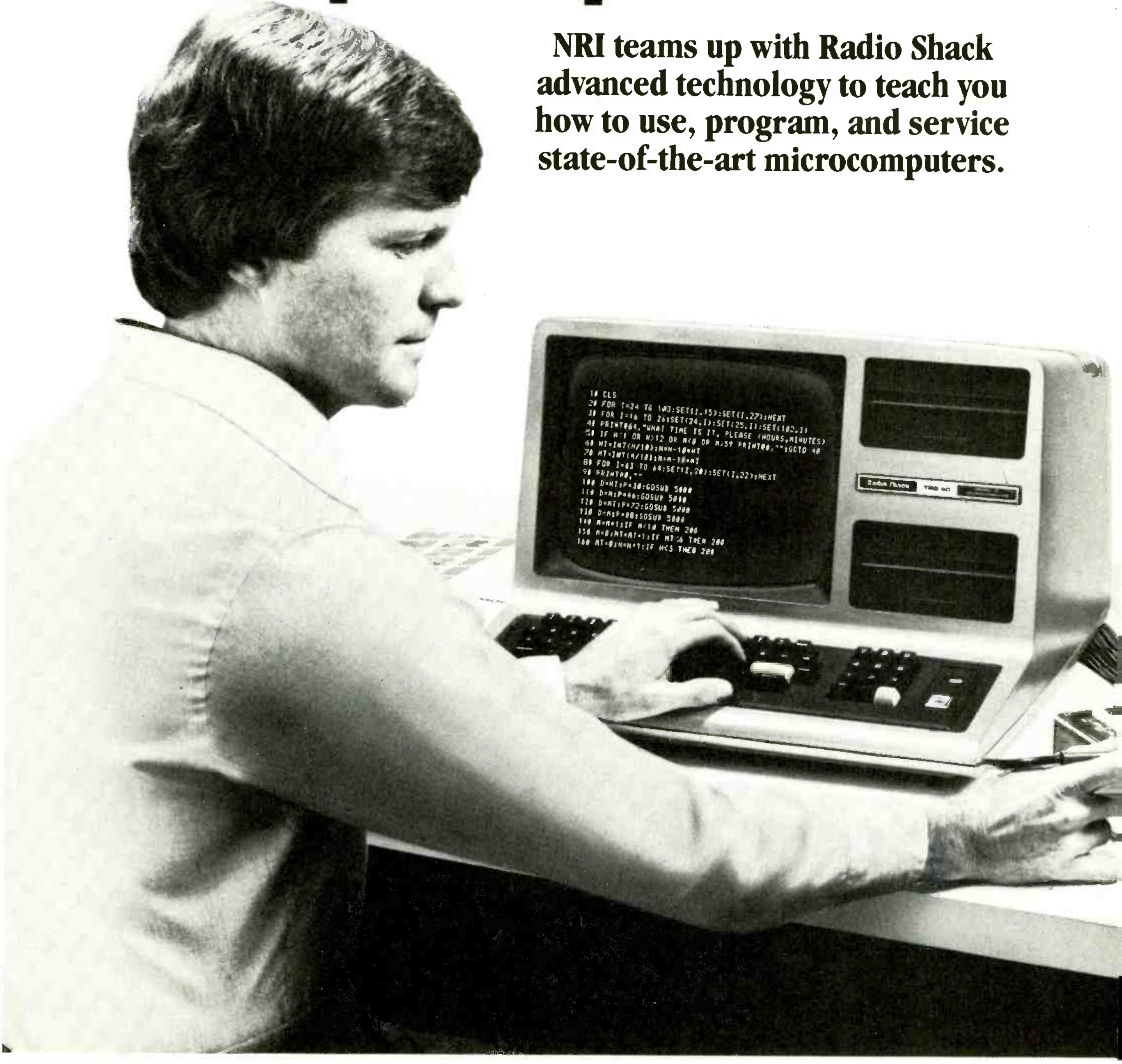

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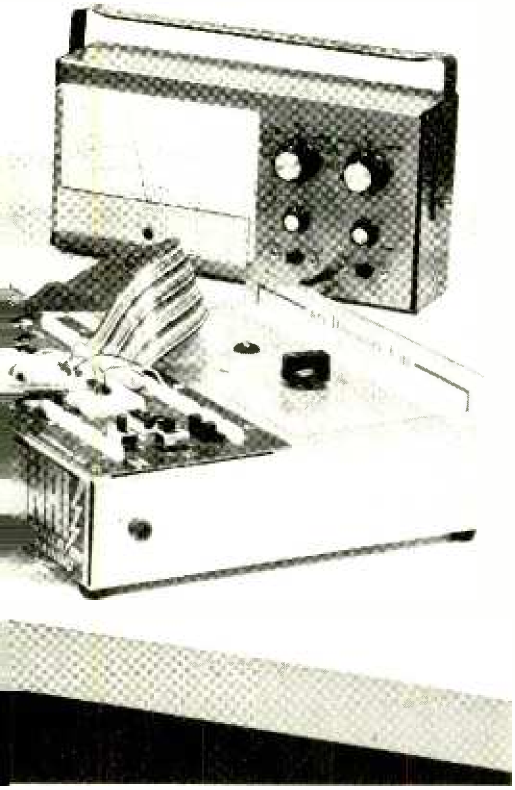

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(TRS-80 is a trademark of the Radio Shack division of Tandy Corp.)

(Continued from page 32)

The two-speed turntable motor operates at a constant 1800 rpm on standard play or 600 to 1800 rpm on extended play. Separate CAV (constant angular velocity) and CLV (constant linear velocity) LEDs indicate which type of disc is being played. Freeze-frame capability is possible only with CAV discs. In the fast-forward mode, one track is jumped at the end of each field, and a still picture results when the same track is repeated. In the search mode, hundreds of tracks are skipped.

Electronics for the VP-1000 are contained on what appear to be 15 separate divisions or boards having such identifications as VDEM, AUDB, SPDL, FTSB, LOGB, KEYA, etc., meaning video, audio, spindle and drives, focus tracking, logic for tracking, and key control, respectively. Schematics and wiring diagrams, along with adjustment instructions, are liberally contained in a 139-page service manual, which is both well-written and nicely illustrated. All mechanical sections are shown as exploded illustrations in reasonable 3D. There are also flowcharts for troubleshooting as well as a few logic diagrams.

The Control System (Fig. 3, p. 34) comprises KEYA, KEYB, IRAB, LAMP, and CONT boards, including a microcomputer arrangement that controls the playback modes and helps monitor operation of the entire video disc system. The RU-1000 remote control, with its wired remote control jack, can be used either through the IRAB sensor and amplifier as a completely wireless infrared remote control or plugged into the remote control jack and on to the photo coupler as a *wired* remote unit when noise is a problem. An IR inhibit grounds and defeats the IR remote function when the control is not used. Observe, however, that the photo coupler and key scanner/encoder will function with the N.C. COM plug at the rear of the receiver either in or out.

Upon command, the key scanner and encoder convert the signal into 10-bit serial pulse-code modulation (pcm), which is impressed on a 38-kHz carrier and transmitted back to IRAB and the input comparator. IRAB picks up these wired or wireless remote signals, detects and modifies their waveforms, then passes them to the key decoder. The 10-bit pcm code from IRAB is decoded into a 5-bit parallel binary code for the large data processor. A 455-kHz oscillator serves as clock.

On the other side of the data processor is a phase-locked loop with a 3.02-MHz clock that generates timing frequencies for character dots of the frame number display and uses an external horizontal drive (HD) signal to synchronize frame and chapter numbers on its slave TV screen with horizontal sync. Inputs to the data processor are from the input buffer, microprocessor and data VGP (external).

Through the input buffer, data enters the microprocessor from the lid sensor switch, inside/outside limit switch, and focus and spindle lock, along with r-f information. It also has a control bus

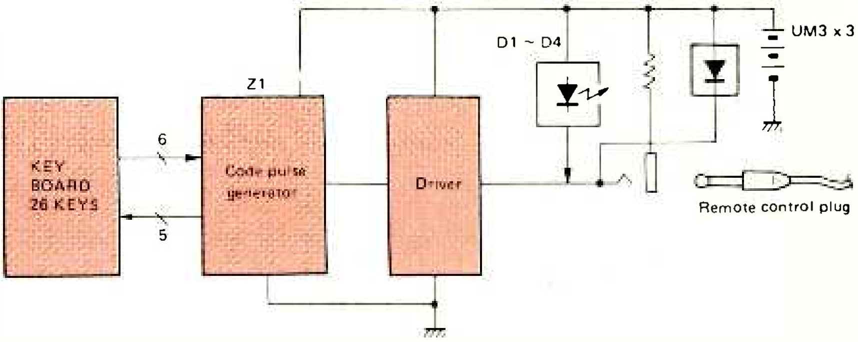

Fig. 4. Block diagram of the remote control unit. It can be wired direct or use infrared transmission.

from the slow mode VR timer and its shunt potentiometer. The microprocessor is an 8-bit unit with a two-kiloword master program stored in memory. The data processor also governs the decoder driver lamp and LED readouts as well and off/on signals for audio Ch. 1 and audio Ch. 2.

Signal transfer for player to TV receiver occurs after the 2.3-MHz channel 1 (left) and 2.8-MHz channel 2 (right) have been limited and detected, mixed and applied to the output radio frequency (r-f) modulator or pcm jack on the rear. Manual switching selects either stereo or Ch. 1 or Ch. 2 outputs. The video signal is separated from audio on the VDEM board by bandpass filtering and demodulation, then transferred to a rear VIDEO OUT jack on the player as well as the AM video modulator. Included are sync, color burst, and dropout protection. (The latter provides a means of covering up dropouts caused by dust and scratches on the disc, and appearing as gaps in the FM waveform. A seriously defective line of video is replaced by a previous line so that any signal interruption becomes virtually unnoticed.) The r-f modulator now processes audio and video by combining them on a regulation carrier (channels 3 or 4, in this instance), applying the result to the television receiver.

Remote control is (so far) the VP-1000's big exclusive feature. Its 26 keys deliver 30 different commands to the overall system using a 455-kHz ceramic vibrator matched to a similar oscillator on the key decoder. They duplicate virtually every command on the player itself except REJECT/OPEN and POWER on/off. There are search keys, chapter and frame displays, left/right audio buttons, chapter and frame, pause and play, in addition to still/step, slow, scan, and 3 X fast—the last four in either forward or reverse.

Serial pcm from the code pulse generator passes through a transistor driver (Fig. 4) on to the four LEDs. These consume approximately 1 ampere of peak current and, along with the 455 kHz oscillator, are not operational until some command key is pushed. Transmissions consist of 10-bit words. Each pulse string is generated by 10 clock pulses at the 38-kHz carrier frequency.

Advantages over the competition in this system include the remote control, two control buttons for frame and chapter digital locations rather than one, separate CAV (standard play) and CLV (extended play) lighted indicators, digital keys used in the search mode for frame and chapter location, the PCM jack on the back, and direct antenna and TV connections rather than a separate connector box. Unit operation seems also to be somewhat less mechanically and electronically noisy, although this can vary from sample to sample.

(Continued on page 42)

MODEL VP-1000 VIDEODISC PLAYER LABORATORY DATA

Parameter	Measurement
Video carrier:	−52.7 dBm
Audio carrier:	−61.7 dBm
S/N ratio for both carriers:	50 dB
Usable video bandpass:	≃4 MHz
Usable audio bandpass (−20 dB):	≃80 kHz
Power supply varied from 95 to 130 V ac with equipment operating satisfactorily.	
Operating power consumption:	71 W

Note: dBm 50 to 75 ohms conversion, decrease reading by 5.72 dB. Also, dBm = dBV − 10log Z + 30; where Z, in this instance, = 75 ohms. Test equipment used: Tektronix 492 and 7L5 spectrum analyzers and Sencore PR57 Power-rite.

"It's about time America gave REACT its full support"

Robert G. Paul, *President*
The Antenna Specialists Co.

the antenna specialists co. announces a major new REACT support program to help keep our highways safe.

"For more than 19 years, hundreds of thousands of REACT volunteers have been contributing their time, their energy and their own money to provide vital emergency communications services to the public.

"Over 80 million Americans have benefited directly from REACT's CB radio handling of emergencies and calls for assistance. Last year, for example, REACT responded to over *one million automobile accidents — one every 29 seconds, 24 hours a day.*

"There is no finer expression of the American way of helping each other than REACT—and it deserves more than token support.

A REACT team for every community...

"As successful and effective as REACT is, its capacity to grow and expand its services has until now been limited. REACT should be expanded drastically. It should implement important new public service programs it cannot now afford. Increase its service to cover *every community in the nation.*

"Even though REACT services are entirely free to the public, it costs a lot of money to organize, train and operate thousands of REACT teams. While some individuals and companies, including ours, have regularly made contributions each year to help support REACT, the simple truth is that REACTers themselves still pay over 70% of this cost.

It's time America and the CB industry paid their dues!

"As a citizen and motorist, I am constantly reassured on the highway, knowing that REACT is listening. And as the nation's largest manufacturer of CB antennas, we are grateful for the support we have received through the years from the CB community. Now we are determined to return that support ...to pay *our* dues.

"Some months ago I directed our people to find a way for our company to help REACT in a major way. They came up with a super program, which I have approved and which has the 100% support of all A/S employees:

1. the antenna specialists co. will provide massive direct financial assistance to REACT.

Very soon we will be introducing a brand new, professional quality mobile CB antenna. We believe it will be the best performing CB antenna available.

For every single one of these new antennas purchased during the entire year 1981, A/S will donate a dollar to REACT. This activity alone should generate tens of thousands of dollars in new income to expand REACT. But that's only the beginning...

2. the antenna specialists co. will help increase REACT membership by funding and producing special programs:

We will sponsor and advertise nationally a first quarter REACT membership drive to bring in new members and form new teams. Cash awards will be made directly to REACT teams achieving the greatest increases in membership...and to REACT Councils helping to establish the most new teams in a state. This is only the first of several special support programs of this type planned for 1981.

In addition, every CB product package shipped from our factory will carry a brochure describing REACT and its importance to highway safety.

3. the antenna specialists co. will exert all possible influence to encourage additional, important industry support for REACT.

"Our company has budgeted a major effort for 1981 in direct contributions, advertising support, national publicity and special action programs.

"We hope and believe our leadership and commitment will encourage other manufacturers, distributors, dealers and foundations to join this movement...to make REACT even stronger, to bring its outstanding services to every corner of the nation."

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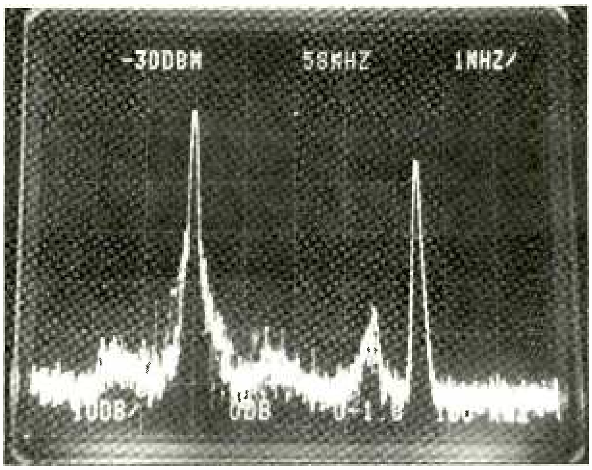

Fig. 5. Spectrum analysis shows output signal on channel 3 with video carrier on left and audio on right. The S/N of 50 dB is excellent.

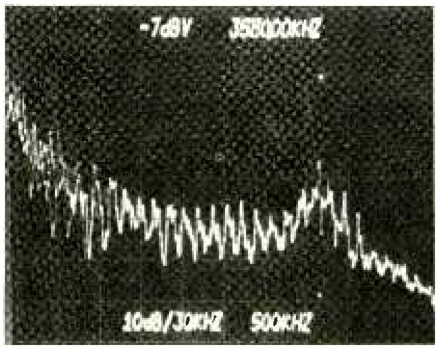

Fig. 6. Baseband video fills 5-MHz spectrum analyzer "window."

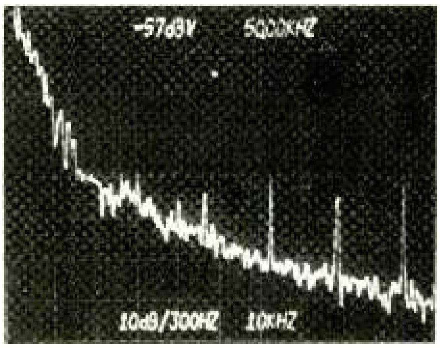

Fig. 7. Audio bandpass extends over 80 kHz with drop of 20 dB.

(Continued from page 40)

Evaluation. Lab tests usually involve oscilloscope and voltmeter readings. But here you have r-f carriers in addition to baseband video and audio outputs, and that requires spectrum analyzers. Furthermore, the usual 50-ohm impedance analyzer input must be matched to the 75-ohm output of the discplayer, and that results in an addition of 5.72 dB. Nonetheless, absolute levels are not nearly as important in this analysis as relative levels, so a rounded 6 dB difference in scale reading for Fig. 5 really won't matter much. For instance, the video carrier reading of −45 dBm becomes −51 dBm after correction for the 75-ohm termination.

But the important points are the position of this carrier with respect to the audio carrier and the S/N ratio. Here, the channel 3 video carrier rests at 61.25 MHz and the audio at 65.75 MHz, right where it should be. The audio carrier is slightly less than 10 dB below the video carrier, which is close to what we found on a broadcast signal.

Neglecting a few spikes about the video and audio carriers, the S/N ratio is about 50 dB, considerably in excess of the claimed 42 dB. The tallest voltage excursion next to the audio carrier is the 3.58-MHz color burst at −40 dB relative to video.

In the second spectrum analyzer photo (Fig. 6) baseband composite video from the player's output jack was evaluated. Beginning at zero reference on the left, the trace shows, once more, a slight rise around the 3.58 MHz color information, and then a gradual tail-off at 5 MHz. As you can see, the remainder of the waveform, taken during disc operation, is remarkably clean.

Good reports are also forthcoming about the audio output. Here, we're looking at a 100-kHz window, of which some 20 kHz is reference, but the remaining 80 kHz is surprisingly uniform with only a 20 dB drop. The spikes you see at 15-kHz intervals in Fig. 7 (and don't hear) are TV horizontal flyback pulses picked up by the lightly-shielded coaxial connector between player and analyzer. Audio connected to a stereo receiver sounded reasonable, as long as there was good quality stereo sound available for reproduction.

One thing you'll have to be careful about is software quality control. Good discs give positively superb results, but not all of them are good. You'll have to pick and choose carefully. In short, try before you buy!

If there's a negative remark to be made about the VP-1000 player, it's minor: the lid to the turntable section is a little stiff to open. Otherwise, this tastefully styled and nicely engineered product performed exceedingly well. From where we sit, the videodisc is for real and here to stay.—*Stan Prentiss*

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1000's of ready made programs availble for "educational" and "scientific" applications?	Yes	Yes
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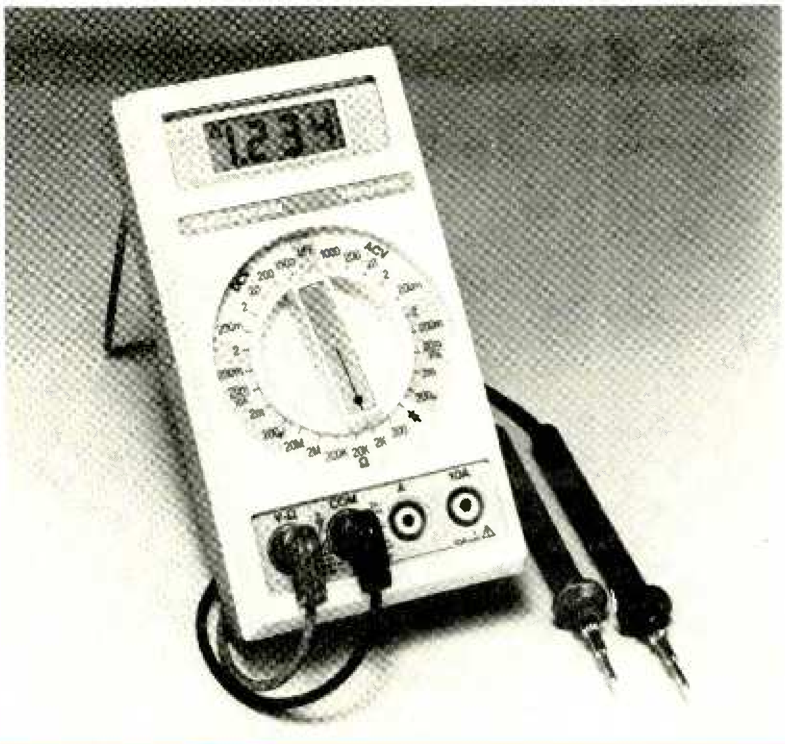

Beckman Tech 310 Digital Multimeter

THE Beckman Tech 310 Digital Multimeter is designed for both bench and field use. Its features include: large (½" high) LCD display capable of indicating to 1999; autopolarity with either a (+) or (−) displayed; automatic decimal point placement; overrange indication; 29 ranges with seven functions accessed by a single rotary switch; Insta-Ohms, a quick-continuity indicator; 10-amperes ac/dc measuring capability; up to 6-kV transient-voltage protection; semiconductor protecting test voltage; an approximate 2000-hour (about two working years) battery life when using an alkaline battery; and the capability of withstanding a 6-foot drop in accordance with MIL-T-28800. Accuracy is guaranteed for one year.

The Tech 310 measures 6.85" long x 3.65" wide x 1.8" thick and weighs one pound. Suggested retail price is $140.

General Description. One interesting feature of the Tech 310 is that the LCD display, function/range switch, and the safety test lead connectors are submerged below the case rim to save them from damage if the instrument is dropped and happens to land face down. Four recessed safety test lead connectors provide the common, volts/ohms, 2-ampere, and 10-ampere inputs. The only control on the instrument is a large-handled rotary switch that not only turns the Tech 310 power off, but selects function and range. (Power is automatically applied when the switch is placed in any function position.) Each alternate function is displayed in a darker shade than the ones on either side, making the switch easy to read. The six functions can be selected by placing the pointer on the switch center bar to ACV (ac volts), ACA (ac amperes), ohms or diode test, DCA, and DCV.

The DCV function provides five ranges from 200 mV to 1500 V. Accuracy is ±0.25% reading +1 digit; input resistance is 22 megohms; normal-mode rejection is greater than 60 dB above 49 Hz; common-mode rejection is greater than 160 dB up to 1500 V; and overload protection is 1500 volts dc or peak ac on any range.

The ACV function provides five ranges from 200 mV to 1000 V with an accuracy of ±0.75% reading +3 digits from 45 Hz to 2 kHz; ±1.5% reading +5 digits from 2 to 5 kHz; and ±2.5% reading +9 digits from 5 to 10 kHz. The conversion technique uses average sensing, calibrated to display rms value of sine wave. Input impedance is 2.2 megohms, shunted by less than 75 pF on all ranges, and overvoltage protection extends to 1000 volts ac (1500 V peak) or 250 V dc above 450 mV on the 200-mV range.

The DCA and ACA provide six ranges from 200 μA to 10A full scale with an average accuracy of ±1% reading +1 digit. The voltage burden is 250 mV on the 200-μA to 200-mA ranges, and 700 mV on the 2- and 10-ampere ranges. Overcurrent protection is provided by a 2-ampere fuse on the 2-A range and the circuit is protected to 20 amperes on the 10-A range.

There are six resistance ranges from 200 ohms to 20 megohms full scale with the Insta-Ohms continuity indicator (a Greek omega) coming on within 100 ms of a test lead short. Test current ranges

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Plainfield, New Jersey

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The above instrument has been checked and calibrated against our working standards which are traceable to the National Bureau of Standards. All specifications were found to meet those set forth by the manufacturer. The metrology procedures utilized conform to and satisfy the requirements set forth in MIL-C-45662A.

NBS REPORT NUMBER GUF 9155. s/n 39.362 ES1035 NBS# 219833 Dated 11/27/78

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TEST PERFORMED BY Szyszko DATE OF TEST 9-29-80

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A basic rule in electrical measurement states that test equipment must be *at least* one order of magnitude (10X) better than the system under test. Otherwise, the test data may be a series of artifacts.

Most of the new bench instruments using the latest in semiconductor technology are capable of accuracy exceeding that of laboratory instruments of several years back. To check the new instruments, "super" test gear is required. Besides being quite expensive, such "super" instrumentation must be calibrated against parameters directly traceable to the National Bureau of Standards (NBS) at regular intervals.

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The electronic capabilities of Lockheed's IML include:

- dc voltage from 1 μV to 30 kV, ±0.0001% to ±0.01% accuracy.
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- alternating current from 1 mA to 30 A, ±0.01% to ±0.1% accuracy.
- resistance from 100 μohm to 10 Gohms, ±0.0005% to ±0.1% accuracy.
- capacitance from 0.001 pF to 10 μF, ±0.0001% to ±0.01% accuracy.
- inductance from 0.1 nH to 1000 H, ±0.001% to ±0.1% accuracy.
- frequency from 0.001 Hz to 26 GHz, ± 2 parts in 10^{-11} accuracy.
- attenuation to 18 GHz to 100 dB, ±0.02 dB to ± 1.0 dB accuracy.
- audiometrics ISO, ASA, ANSI specifications, 20 Hz to 40 kHz, 0 to 140 dB, ±0.2 dB.
- Q to 75 MHz, ±2%.
- standing wave ratio to 12.4 GHz, ± 1% (swept technique).
- ratio: ac to 10 kHz, 1:1 × 10^{-7}, ±0.00005%; dc ±0.0001%.

from 2.5 mA on the 200-ohm range to 25 nA on the 20-megohm range. Accuracy is better than 1% +1 digit. Maximum open-circuit voltage is 0.5 volt on all ranges except low-power ohms, where it is 250 mV. Overload protection extends to 300 volts dc or rms ac on any of the ranges.

The diode test function has a range from 0 to 2 volts (to indicate forward bias diode voltage), with a resolution of 1 mV, accuracy of ±0.25% reading +2 digits, test current of 5 mA, and an overload protection of 300 V dc or rms ac.

The instrument rests on two "feet" and a strip on its rear side. Both the feet and the strip, like the bottom of the tilt stand, are skid-proofed.

Comments. The Tech 310 was checked by Lockheed Electronics Co. Inc., Plainview, NJ, against standards traceable to the National Bureau of Standards. After tests, the lab issued a certificate testifying that the unit met specifications in all respects.

After several weeks of bench and field service, including at least two unscheduled "drop tests," the instrument showed no signs of mechanical or electrical damage. The case is easily cleaned using mild detergent and warm water.

Few meters in the Tech 310 price range can be used to measure CMOS currents less than 100 μA. The Tech 310 did this easily and was found useful down to 100 nA. The Insta-Ohms feature was very handy for checking wiring and pc board foil patterns for continuity, especially since it is not necessary to wait for the meter to "settle down."

Another convenient feature is that with overrange conditions, the display shows an unambiguous OL instead of a blank or flashing display used in other DMMs.

One valuable use of the 310 is in testing unknown diodes or transistors. When the test leads are connected across a junction (in or out of circuit), the display indicates the forward voltage drop, quickly identifying a germanium or silicon device. The range extends high enough to measure the forward voltage drop of a LED, which may be a volt or more. If the OL display comes on with both orientations of the test leads, the junction is open. If the display is zero in both orientations, the junction is shorted. The addition of a couple of resistors (shown in the manual) enables measurement of transistor beta. This is of great value when matching transistors are required by a circuit.

Even capacitors having a value greater than 0.01-μF can be checked. The 310 does not indicate value, but will show whether or not the capacitor is shorted or accepting a charge.

The ac voltage ranges can be used to measure decibels. In the 200-mV range, measurements from −10 to −40 dB (0 dB = 1 mW into 600 ohms) can be made. The manual indicates the conversions when using the 2-to-1000-volt ac ranges.

A number of options are available for the 310. These include both a vinyl and deluxe carrying case, a 50-kV high-voltage probe, and r-f probe good to 200 MHz, an ac current clamp rated to 200 amperes, and a kit of test leads and assortment of tips for a variety of testing applications.

We found the 310 slightly bulkier and heavier than some portable DMMs, but it will still fit into a jacket pocket. The LCD display is very readable from several feet away, the large jet-black digits being in sharp contrast to the silvery background. In its price range, the Tech 310 offers a well-chosen balance of features and performance that would be very hard to improve on.—*Leslie Solomon, Senior Technical Editor.*

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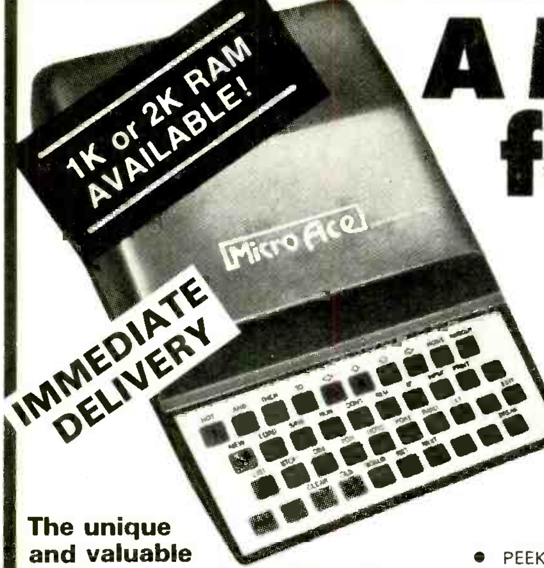

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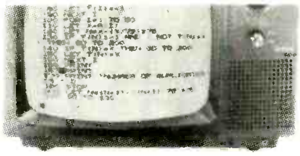

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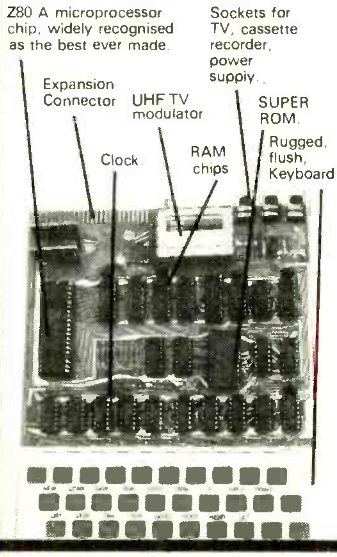

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COMPUTER BITS

By Carl Warren

Good Grief! More Conversion

IN THE last few issues, I have discussed conversion techniques for the BASIC language. As a result, I've received a number of letters in the mail and notes on MicroNet. Many of these asked about *The BASIC Handbook*, by Dr. David Lein, which I had mentioned in passing in a previous column. The book is 360 pages long and is very concise in its presentation of the various syntaxes used in numerous BASICs. You can obtain it from just about any B. Dalton Pickwick Bookstore or by contacting the publisher directly: Compusoft Publishing, 1050 Pioneer Way, Suite E, Dept. C-1, El Cajon, CA 92020 (Tel: 714-588-0996). The price is $14.95 plus $1.35 for mailing. When you write or call, be sure to give the department number.

Those of you who are really serious about doing BASIC translation will want to get a copy of: "Interdialect Translatability of the BASIC Programming Language," by Gerald L. Isaacs. This is ACT Technical Bulletin No. 11. Order it from the Research and Development Div., American College Testing Program, Box 168, Iowa City, IA 52440. Written in 1972, the Bulletin covers various concerns in translation. Two years ago, it cost $4.50; but it may be more now, so write to them for the cost.

A letter of particular interest to me came from Harvey Cowell, of Angola, IN, who pointed out that he recognized the importance of conversion principles for the Apple and TRS-80 but felt cheated since nothing was said about the North Star system.

Harvey, your point is well taken. Systems like North Star did exist long before the others, and you deserve your due. So, here goes.

To Translate to North Star. The version of North Star BASIC to be discussed is Release 5, introduced at the end of 1978. Although numerous BASICs preceded North Star, this version became one of the more serious attempts that was made at designing a business-oriented language.

In its original form, North Star BASIC was an upgraded version of a Tiny BASIC published in *Dr. Dobbs Journal*. Gradually, this BASIC was upgraded to take advantage of the sophistication that was built into the North Star operating system.

Some software experts consider North Star BASIC difficult and poorly structured. However, this may be the beauty of it. Although I'm a proponent of structured design of an application and, to a degree, of structured programming, I feel their constraints make them difficult for the novice to use. There are no such constraints with North Star.

An example of the power of the BASIC and good planning was demonstrated in a program called WHATSIT (Wow, How Did All That Stuff Get In There), developed by a company called Computer Headwear in early 1978. This particular program made extensive use of the ability of North Star BASIC to locate specific points in a record within a file and set pointers. Interestingly, WHATSIT proved that a very high-level data-base management system could be implemented on a microcomputer in BASIC.

Getting Down to Cases. The PRINT statement in North Star BASIC is an output function and works basically the same as in any BASIC. A program line such as:

PRINT "NORTH STAR BASIC"

will produce an output to the screen of: NORTH STAR BASIC. The double quotes are used to inform BASIC that this is a string expression.

Now if you want to drive the same message out to the printer, you must let North Star BASIC know that. To do this, you employ the use of the pound sign (#). For example, to output to the printer:

PRINT #1, "MESSAGE"

would cause the printer to print the message. If you leave out the device number, which can be from 0 to 7 (0 is usually the default), the output goes to the CRT.

The TRS-80 Level II BASIC uses LPRINT; for example, LPRINT "MESSAGE." If you typed PRINT #1, in the same BASIC, it would assume that you want to perform some input to disk buffer #1.

The eight possible devices you can communicate with on the North Star system include the disks and you can address them by device number. The number that you enter (0-7) represents the port address. (They call it the pseudo port since it only points to the actual port location in the memory map.) The way you emulate this in the TRS-80/Microsoft BASIC is to use the OUT function and an argument representing the value of the port in decimal. Thus OUT (26) would send data (one byte at a time) to the port designated by 26_{10} (1A in hexadecimal).

North Star BASIC lets you perform this I/O without worrying about actual address or port designators.

A Way to POKE. The POKE function allows you to put information into memory. North Star has the same function but calls it FILL. Both POKE and FILL work the same way. You enter the function, a memory location, and the byte you want to put there. For example:

POKE 65535, A

and

FILL 65535, A

Both do the same thing—putting byte A into location 65535.

The inverse of POKE and FILL, is PEEK and EXAM. These functions allow you to examine at a given memory location. North Star uses the word EXAM to mean "let's look at a memory location." To convert this:

EXAM 65535, A

is equal to

PEEK 65535, A

Not all the functions are as easily understood or translated. For example, the North Star function TYP(e) allows you to determine what type of data item is going to be found in an open disk file. A numeric item would produce a 2, a string 1, and, if the end of the file is reached, a zero. This is a *disk* function and not a *real* function of BASIC—it is an *extension*. To use this function you have to decide what you are looking for. If you want to detect the end of file mark, you write:

IF TYPE (*n*) = 0 THEN xxx where n is the number of the open file and xxx is the line to branch to. If you are doing a *read* and you want to ensure that you are *read*ing the right data into the correct variable (either string or numeric), then you can set up a test. For example:

```
10 IF TYP(1) = 1 THEN 20
20 READ #1, S$
```

This says: if the next data item on file #1 is a string, read it into the string variable S$. A numeric test is handled the

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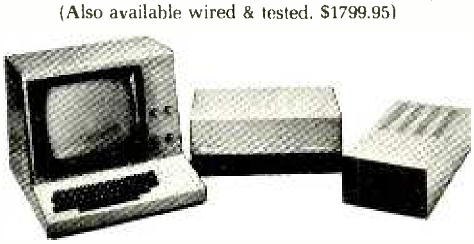
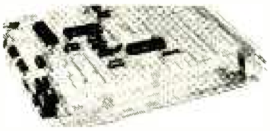


Full 8" disk system for less than the price of a mini (shown with Netronics Explorer/85 computer and new terminal). System features floppy drive from Control Data Corp., world's largest maker of memory storage systems (not a hobby brand!)



Level "A" is a complete operating system, perfect for beginners, hobbyists, industrial controller use. $129.95

Level "A" With Hex Keypad/Display.

LEVEL "A" SPECIFICATIONS

Explorer/85's Level "A" system features the advanced Intel 8085 cpu, an 8355 ROM with 2k deluxe monitor/operating system, and an advanced 8155 RAM I/O . . . all on a single motherboard with room for RAM/ROM/PROM/EPROM and S-100 expansion, plus generous prototyping space.

PC Board: Glass epoxy, plated through holes with solder mask. • **I/O:** Provisions for 25-pin (DB25) connector for terminal serial I/O, which can also support a paper tape reader . . . cassette tape recorder input and output . . . cassette tape control output . . . LED output indicator on SOD (serial output) line . . . printer interface (less drivers) . . . total of four 8-bit plus one 6-bit I/O ports. • **Crystal Frequency:** 6.144 MHz. • **Control Switches:** Reset and user (RST 7.5) interrupt . . . additional provisions for RST 5.5, 6.5 and TRAP interrupts onboard. • **Counter/Timer:** Programmable, 14-bit binary. • **System RAM:** 256 bytes located at F800, ideal for smaller systems and for use as an isolated stack area in expanded systems . . . RAM expandable to 64K via S-100 bus or 4k on motherboard.

System Monitor (Terminal Version): 2k bytes of deluxe system monitor ROM located at FØØØ, leaving ØØØØ free for user RAM/ROM. Features include tape load with labeling . . . examine/change contents of memory . . . insert data . . . warm start . . . examine and change all registers . . . single step with register display at each break point, a debugging/training feature . . . go to execution address . . . move blocks of memory from one location to another . . . fill blocks of memory with a constant . . . display blocks of memory . . . automatic baud rate selection to 9600 baud . . . variable display line length control (1-255 characters/line) . . . channelized I/O monitor routine with 8-bit parallel output for high-speed printer . . . serial console in and console out channel so that monitor can communicate with I/O ports.

System Monitor (Hex Keypad/Display Version): Tape load with labeling . . . tape dump with labeling . . . examine/change contents of memory . . . insert data . . . warm start . . . examine and change all registers . . . single step with register display at each break point . . . go to execution address. Level "A" in this version makes a perfect controller for industrial applications, and is programmed using the Netronics Hex Keypad/Display. It is low cost, perfect for beginners.

HEX KEYPAD/DISPLAY SPECIFICATIONS

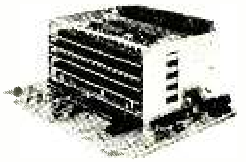
Calculator type keypad with 24 system-defined and 16 user-defined keys. Six digit calculator-type display, that displays full address plus data as well as register and status information.

LEVEL "B" SPECIFICATIONS

Level "B" provides the S-100 signals plus buffers/drivers to support up to six S-100 bus boards, and includes: address decoding for onboard 4k RAM expansion selectable in 4k blocks . . . address decoding for onboard 8k EPROM expansion selectable in 8k blocks . . . address and data bus drivers for onboard expansion . . . wait state generator (jumper selectable), to allow the use of slower memories . . . two separate 5 volt regulators.

LEVEL "C" SPECIFICATIONS

Level "C" expands Explorer/85's motherboard with a card cage, allowing you to plug up to six S-100 cards directly into the motherboard. Both cage and card are neatly contained inside Explorer's deluxe steel cabinet. Level "C" includes a sheet metal superstructure, a 5-card, gold plated S-100 extension PC board that plugs into the motherboard. Just add required number of S-100 connectors.



Explorer/85 With Level "C" Card Cage.

LEVEL "D" SPECIFICATIONS

Level "D" provides 4k of RAM, power supply regulation, filtering decoupling components and sockets to expand your Explorer/85 memory to 4k (plus the original 256 bytes located in the 8155A). The static RAM can be located anywhere from ØØØØ to EFFF in 4k blocks.

LEVEL "E" SPECIFICATIONS

Level "E" adds sockets for 8k of EPROM to use the popular Intel 2716 or the TI 2516. It includes all sockets, power supply regulator, heat sink, filtering and decoupling components. Sockets may also be used for 2k x 8 RAM IC's (allowing for up to 12k of onboard RAM).

DISK DRIVE SPECIFICATIONS

- 8" CONTROL DATA CORP professional drive
- LSI controller
- Write protect
- Single or double density
- Data capacity 401,016 bytes (SD), 802,032 bytes (DD), unformatted
- Access time: 25ms (one track)

DISK CONTROLLER/ I/O BOARD SPECIFICATIONS

- Controls up to four 8" drives.
- 1771A LSI (SD) floppy disk controller.
- Onboard data separator (IBM compatible)
- 2 Serial I/O ports
- Autoboot to disk system when system reset
- 2716 PROM socket included for use in custom applications.
- Onboard crystal controlled
- Onboard I/O baud rate generators to 9600 baud
- Double-sided PC board (glass epoxy.)

DISK DRIVE CABINET/POWER SUPPLY

- Deluxe steel cabinet with individual power supply for maximum reliability and stability.

ORDER A COORDINATED EXPLORER/85 APPLICATIONS PAK!

Beginner's Pak (Save $26.00!) — Buy Level "A" (Terminal Version) with Monitor Source Listing and AP-1 5-amp Power Supply: (regular price $199.95), now at SPECIAL PRICE: **$169.95** plus post. & insur.

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Special 8" Disk Edition Explorer/85 (Save over $104!) — Includes disk-version Level "A", Level "B" two S-100 connectors and brackets, disk controller, 64k RAM, AP-1 5-amp power supply, Explorer/85 deluxe steel cabinet, cabinet fan, 8" SD/DD disk drive from famous CONTROL DATA CORP. (not a hobby brand!), drive cabinet with power supply, and drive cable set-up for two drives. This package includes everything but terminal and printers (see coupon for them). Regular price $1630.30, all yours in kit at SPECIAL PRICE: **$1499.95** plus post. & insur. Wired and tested, only **$1799.95.**

Special! Complete Business Software Pak (Save $625.00!) — Includes CP/M 2.0, Microsoft BASIC, General Ledger, Accounts Receivable, Accounts Payable, Payroll Package, (regular price $1325), yours now at SPECIAL PRICE: **$699.95.**

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- ☐ **Level "B" (S-100) kit** . . . **$49.95** plus $2 post & insur
- ☐ **Level "C" (S-100 6-card expander) kit** **$39.95** plus $2 post & insur
- ☐ **Level "D" (4k RAM) kit** . . **$69.95** plus $2 post & insur.
- ☐ **Level "E" (EPROM/ROM) kit** . **$5.95** plus 50¢ p&h
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same way. The problem associated with this is not so much converting it to another form, but trying to figure out when to replace a specific function in another BASIC with TYP. If you have a situation where you want to find the end of a file, you would have something like this in TRS-80/Microsoft BASIC:

```
10 OPEN "I", #1, "STUFF.DAT"
20 IF EOF(1) THEN 50
30 INPUT #1, A
40 . . . .
50 . . . .
```

What we are saying here is, if you detect an End of File Marker (EOF) which is a 1A, then go do something else on line 50. Otherwise, READ in the data. What the EOF does is return a (−1) if the end is reached and is true, or a (0) if data is available (false).

The EOF function is used with sequential files, and can't be used to detect the end in a random file. You do that by knowing how much you can put out on a disk then use LOF (Last Output File mark).

Testing for the data value, numeric or string, in TRS-80 BASIC isn't as simple as doing a TYP test in North Star. Here you have to be a little inventive. To demonstrate:

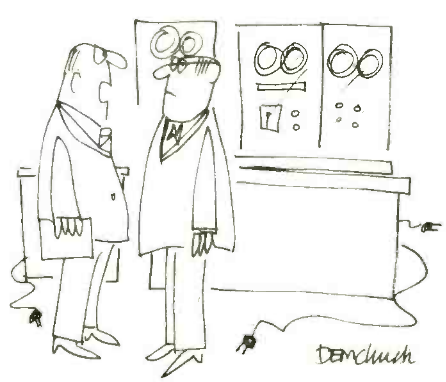
```
10 OPEN "0", 1, "STUFF.DAT"
20 PRINT #1, 1 : REM identify data as numeric
30 PRINT #1, N : REM output actual data
40 . . . .
```

To input it again:

```
10 OPEN "I", 1, "STUFF.DAT"
20 INPUT #1, N : REM check for identifier
30 IF N = 1 THEN 50 : REM if numeric get rest
40 INPUT #1, N$ : REM otherwise read alpha data
50 INPUT #1, D
```

What occurs is a simple test for a condition to determine whether or not the data was a string or numeric in nature. And, depending on the results, read it into the correct variable type. Unfortunately, this takes memory and is simplified using the TYP function.

By now it should be obvious that translation, while not trivial, can be achieved if you sit down and analyze the problem. ◇



"In shutting down the machines, Mr Simms, you don't just pull the plug!"

COMPUTER SOURCES

By Leslie Solomon
Senior Technical Editor

Hardware

S-100/C Bus. The Model IOP I/O processor, used with the S-100 bus incorporates a Z-80A, 16K of RAM and up to 32K of PROM. It can be used stand-alone or as a satellite processor on the S-100 bus. It can also be used to interface the S-100 to peripherals via a new bus, called "C-bus," which operates independently of the S-100. To the host processor, the IOP appears as two output and two input ports, whose base addresses are switch selectable. The IOP can interrupt the host with a preprogrammed interrupt vector. A daisy-chain connector is used for prioritizing the interrupt. $695. Address: Cromemco Inc., 280 Bernardo Ave., Mountain View, CA 94043 (Tel: 415-964-7400).

Multi-User I/O. The INO-288 Multi-User Serial I/O Board was designed for S-100 systems where up to 8 additional serial I/O ports are required. The device is also available with four channels expandable to 8. All ports are fully programmable, using the 8251A programmable communication interface. Each port supports RS-232C with full handshaking, and can operate asynchronously or synchronously with 16 selectable baud rates, and can be interrupt driven. $435 for 4-channel version, $715 for 8-channel version (less the personality boards). Address: Measurement Systems and Controls, 867 North Main St., Orange, CA 92668 (Tel: 714-633-4460).

Hardware Catalog. Called "The Engineers Guide to Microcomputing Packaging," this brochure covers plug-in prototype boards, racks, and accessories for S-100/IEEE 696, Apple II, Pet, Expandamem, Super-kim, STD bus, Motorola Exorciser, Rockwell AIM, TI980, DEC LSI-11, PDP-8, Heath H-11, Intel SBC 80, and National BLC Series 80. Address: Vector Electronic Co., 12460 Gladstone Ave., Sylmar, CA 91342 (Tel: 213-365-9661).

Low-Cost EPROM Programmer. One of the most useful items for any serious computer user is a means of permanently saving important programs. The low-cost EPROM Programmer kit consists of a finished pc board and full documentation. The completed programmer connects to a parallel port and the programming verifies that the EPROM is erased and programmed with new data, checks that the data is correct, and allows transfer of data to system RAM. Documentation is available for 6800, 6809, 8080/8085/Z80, and 6502 in the near future. Specify processor when ordering. $15. Address: Micro Technical Products, 814 W. Keating Ave., Mesa, AZ 85202 (Tel: 602-839-8902).

Apple Printer Interface. The Model 7728 Printer Interface enables an Apple II to operate the Integral Data Paper Tiger, Okidata Microline 80, Microtek MT-80P, MPI 88T, as well as Centronix printers. An on-board ROM provides all driver firmware. Users who choose to develop their own drivers may replace the ROM with RAM. The 7728 resides in any Apple slot, and supports the interface daisy chain, and daisy chain pass through. The interface includes an 8-bit data output bus, four status inputs, data strobe and acknowledge handshakes, and printer reset signal. $119.95. Address: California Computer Systems, 250 Caribbean Dr., Sunnyvale, CA 94086 (Tel: 408-734-5811).

OS Light Pen. A deluxe version of the Lewis Computer System light pen kit features a coiled cord and Kwik-disconnect plug. It is designed for use with

Ohio Scientific computer systems. $29.95. Address: Faragher Associates, Inc., 7635 West Bluemound Rd., Milwaukee, WI 53213 (Tel: 800-558-0870).

Music Sweetener. This device is a low-pass filter designed to improve the quality of commercial and home-brew music synthesizers. It attenuates unwanted high-frequency sampling noise four times better than an audio system treble control. The device is connected between the music peripheral and the audio system. $39.95 plus $2 shipping/handling. Address: Newtech Computer Systems Inc., 230 Clinton St., Brooklyn, NY 11201 (Tel: 212-625-6220).

Atari Memory. The Mosaic 32K RAM Board can be used to add 32K of memory to both the Atari 400 and 800 systems. It enables the 400 owners to use disk drive. With the additional 32K of RAM, Atari owners can use disk drives and large data arrays while operating in the high-resolution graphics mode. Address: Mosaic Electronics, Box 748, Oregon City, OR 97045.

S-100 EPROM Board. The MB8A 1K-16K EPROM board provides sockets for up to sixteen 2708 EPROMS. The board can operate in 1K increments and the Magic Mapping features allows overlaying RAM and ROM at the same address in any desired increment. Address: SSM Microcomputer Products, 2190 Paragon Dr., San Jose, CA 95131 (Tel: 408-946-7400).

Winchester Systems. The C2-D from Ohio Scientific is the same as their C2-OEM system with an 8" Winchester hard disk, and comes with 52K RAM, serial I/O, bootstrap and diagnostic firmware, and single 8" floppy drive. Software includes OS-65U small-business operating system and 9-digit Microsoft BASIC. Optional software includes WP-2 word processor, OS-DMS data base manager and information management system, OS-AMCAP small business acounting package, PASCAL, FORTRAN, and assembler/editor. $6,795. The C3-D system uses the triple processor Challenger III with an 8" Winchester. It incorporates 52K RAM, serial I/O, bootstrap/diagnostic firmware, 8" floppy disk-drive, OS-65A DOS, and 9-digit Microsoft BASIC. Optional software is similar to that for the C2-D system. The machine also runs OS-CP/M complete with assembler/editor, BASIC, FORTRAN, COBOL, and compatible software. $7,600. Address: Ohio Scientific, 1333 South Chillicothe Rd., Aurora, OH 44202 (Tel: 216-831-5600).

Software

Dictionary for CP/M. WordSearch, a program that can be used with WordStar and other CP/M compatible word-processing systems, will help the user produce material free from misspelled words. The "unknown" words are identified by the program as both a list of words or in context of the original text. Words not found in the library are added on command. Word libraries can be tailored to handle special vocabulary requirements. $195. Address: Key Bits Inc., Box 592293, Miami, FL 33159.

AMI Pascal. Designed for the Intel MDS, Motorola Exorciser, TI 990/4, Tektronix 8002A, and AMI Phoenix systems, the AMI-Pascal compiler runs under the AMIX operating system and supports such practices as top down, structured, and modular programming. It includes extensions for business programming as well. Separate modules written in assembly language or FORTRAN-77 can be linked. It produces threaded code for use with the resident runtime library of AMIX and can be used for algorithm design and debugging. It requires 48K, dual disks, and CRT terminal. $275. Address: American Microsystems, Inc., 3800 Homestead Rd., Santa Clara, CA 95051 (Tel: 408-246-0330).

Decathalon Game. Written for the TRS-80 and Apple machines, Olympic Decathalon is a skill game that encompasses 10 events: 100-meter dash, long jump, pole vault, discus throw, shot put, 400-meter dash, 110-meter hurdles, 1500-meter run, high jump, and javelin throw. Each event is accompanied by animated graphics. Players use a combination of keyboard controls. One to eight players may compete. Cassette version for the TRS-80 requires 16K, disk version requires 32K; Apple disk version is upcoming. $24.95. Address: Microsoft Consumer Products, 400 108th Ave., NE, Suite 200, Bellevue, WA 98004 (Tel: 206-454-1315).

Medical Business Package. Apple Business Package V, for the medical profession includes the procedures normally handled by office receptionist, accounts receivable secretary, insurance clerk, and lab technician. It can also be used to analyze personal investments. Five modules are incorporated. These cover patient records, appointment schedules, private patient billing, insurance claims, internal bookeeping and audit, and statistical analysis. $450. Address: CompuSoCo, 25251 Via Roble (Box 2325), Mission Viejo, CA 92690.

Apple Bowling. The Bowling Data System for the Apple II provides accurate record keeping and report generation for bowling leagues. It is designed for up to 40 teams, with up to six bowlers per team. For each team, a cumulative record of total pins, games won and lost, total points, high series, etc., is maintained. This information is also maintained for each bowler, as well as high game, handicap, and other data. A season average is also produced, listing each bowler in descending order by average. Requires 32K, Applesoft in ROM, one disk, and an 80-column printer. $79.95. Address: Rainbow Computing Inc., 9719 Reseda Blvd., Northridge, CA 91324 (Tel: 213-349-0300).

Editor/Assembler. EDAS 3.4 is a text editor and assembler for the TRS-80 Models I and III. It provides text editing facilities with a command syntax identical to the BASIC editor, and provides text block move, global change with line range directive, string search, and line scroll. Assembler options include ability to suppress source and symbol table listing, generate object code, and output the assembled code directly to memory or diskette. The assembler features direct assembly from

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disk; 14-character symbolic labels; concatenated constant declarations for octal, decimal, hex, binary and string constants; paged listings with page, title, subtitle and space psuedo-ops; sorted symbol table; and direct assembly to memory. $82. Address: Misosys, 5904 Edgehill Dr., Alexandria, VA 22303 (Tel: 703-960-2998).

EE Programs for TRS-80. Designed for electrical engineering calculations, the E3M Fault Current program uses per-unit calculation and permits an unlimited number of bus voltage levels, panels, and branches. Three-phase symmetrical voltage and fault currents are calculated at any point with or without line voltage drop. Files include characteristics of oil-filled and dry transformers, circuit breakers, switches and all common copper and aluminum busways, wire, and ducts. All varieties of mixed resistive and reactive loads are accepted. The EM5 Lighting Design program calculates the number, spacing, and location of luminaires for a desired level of illumination in up to 100 rooms. Thirty or more projects can exist, and all pertinent data is made available. Address: R.S. McClintock, Box 430980, Miami, FL 33143 (Tel: 305-666-1300).

Deathmaze 5000. Written for the TRS-80, Level II 16K machine, this program is a three-dimensional adventure based on activities within a five-story building. All you have to do is try to get out alive. Address: Med Systems Software, Box 2674, Chapel Hill, NC 27514.

Word Processor. Written in 8080 machine language and designed to run under CP/M, Spellbinder word processor includes automatic word wrap, print formatting, proportional spacing, screen editing, justification block text manipulation, insertion, deletion, typeovers, search and replace, and emphasis/special characters. It also provides mailing list/label, sort/merge, text/merge and legal numbering functions. The user can create special Macro Programs to fit any individual need. Address: California Pacific Computer Company, 2601 Blackburn, Davis, CA 95616. (Tel: 916-756-2921).

OSI Software. HEXDOS 2.3 is a disk operating system designed for use with ROM BASIC. Requiring only 2K, HEXDOS supports a real-time clock, named disk files, trace and single stepping, tone generator, multiple data files, editing, program chaining, interactive disassembler, etc. $27.50. FOCAL-65 for the 6502 allows programs 2 to 3 times more compact than similar BASIC programs. It has 9-digit floating-point arithmetic, and string-handling, all in 8K. $49.50. Address: The 6502 Program Exchange, 2920 West Moana, Reno, NV 89509. ◇

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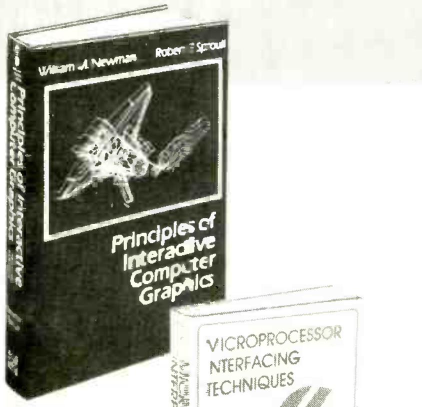

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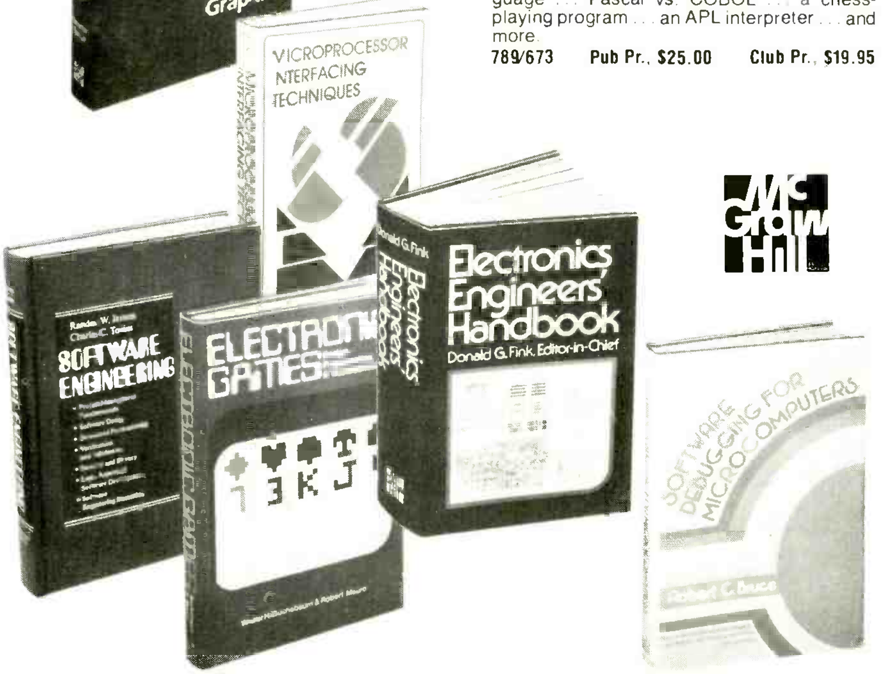

AUTOMATIC DATA PROCESSING HANDBOOK. Edited by The Diebold Group. *976 pp., 269 illus.* Written by a staff of internationally recognized authorities on ADP, this comprehensive handbook explains systems, programming and the languages, communications processes, and the design and installation of today's computers.
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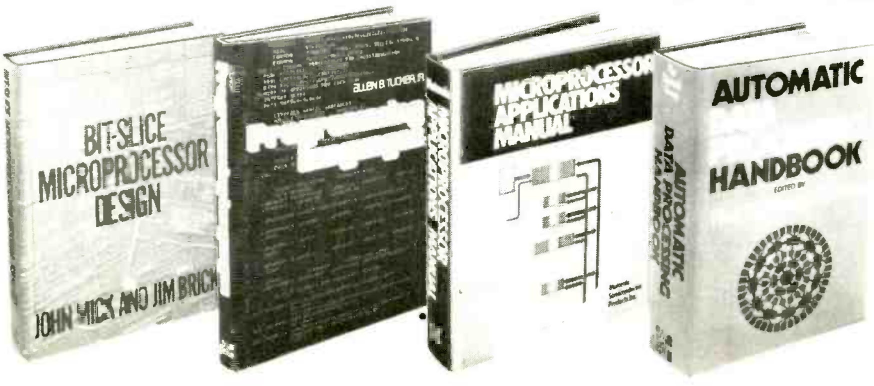

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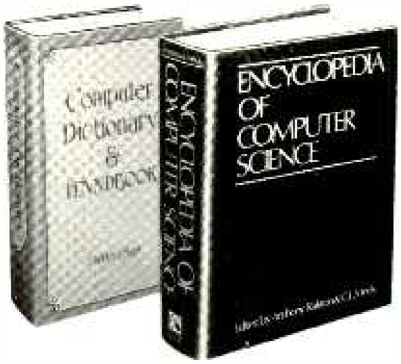

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Popular Electronics
MARCH 1981

BY GEORGE LEON

BEEP! A LOOK AT POCKET PAGERS

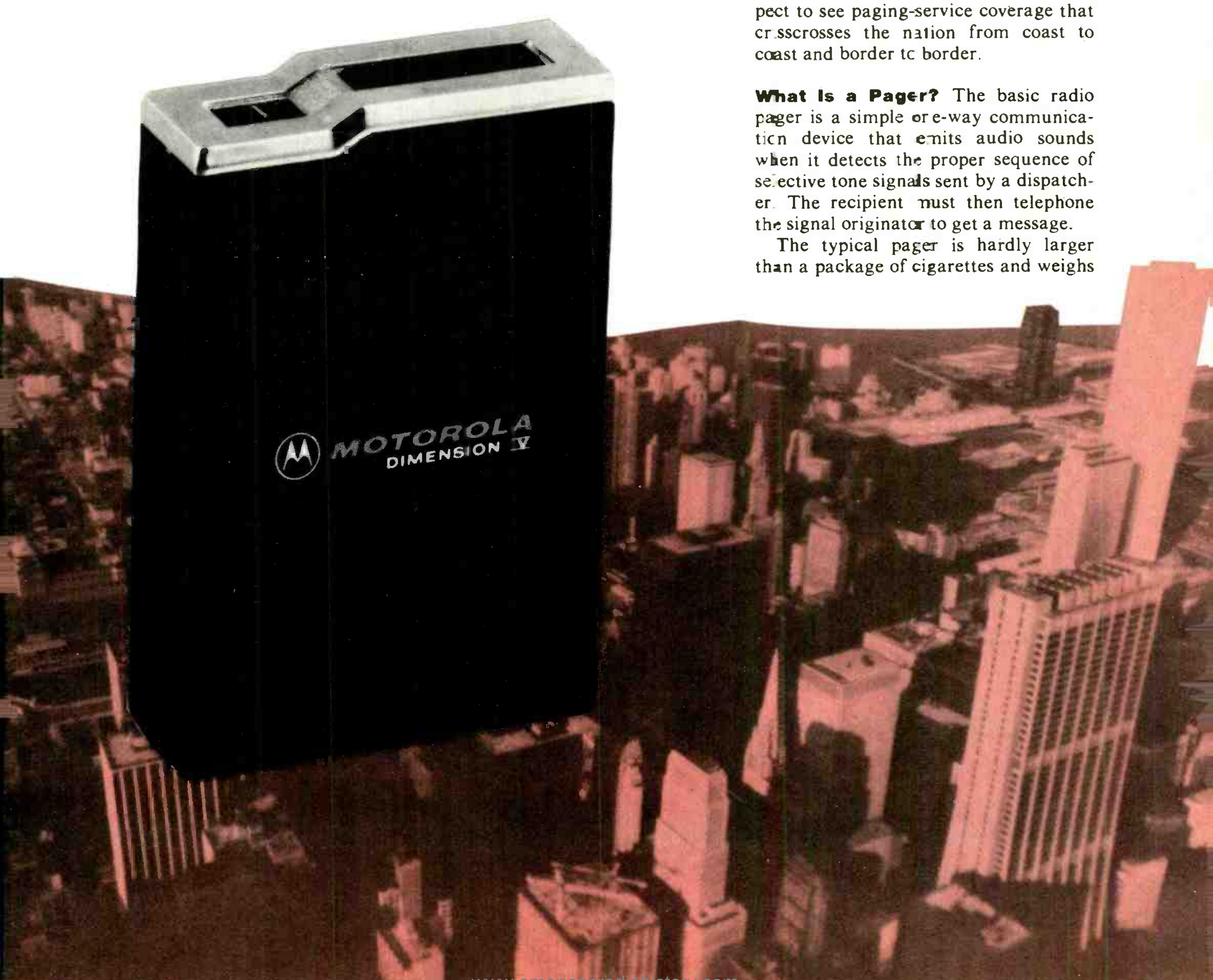
How these lightweight, pocket-sized radio devices can keep you as close to home base as the nearest telephone

MELODIC audio beeps from a pocket-size, battery-powered paging receiver are alerting perhaps one-million subscribers in the U.S. to call their office or home. And the numbers are growing dramatically as more and more people become aware of the convenience and modest cost of radio pagers.

New types of pagers are constantly being developed to increase convenience and reliability and to meet new demands of subscribers. Many paging companies are combining their services to provide the subscriber with wider-ranging coverage. Already, with some services, it has become possible for the subscriber to travel from one city to another without a break in coverage. At least one paging network offers New York-to-Los Angeles coverage even now; its success has prompted others to follow suit. In the very near future, therefore, we can expect to see paging-service coverage that crisscrosses the nation from coast to coast and border to border.

What Is a Pager? The basic radio pager is a simple one-way communication device that emits audio sounds when it detects the proper sequence of selective tone signals sent by a dispatcher. The recipient must then telephone the signal originator to get a message.

The typical pager is hardly larger than a package of cigarettes and weighs



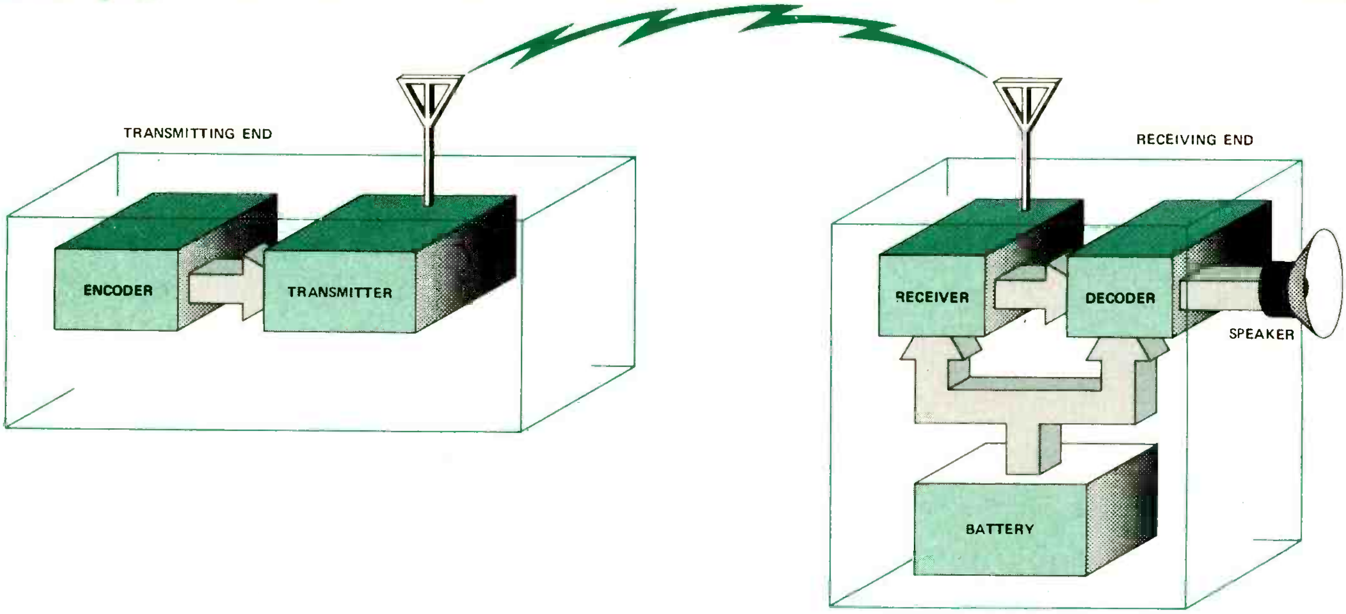


Fig. 1. Block diagram of a basic paging system made by Motorola.

4 to 6.5 ounces, including battery. Therefore, it's easy to carry it in a jacket pocket or clipped to a belt.

Unlike a pocket radio, a radio pager has selective tone circuits built into it, allowing only the person or persons being paged to receive the audio alert. Though all pagers in a given network and on the same frequency band intercept a transmitted call signal, only the pager with the appropriate call code is keyed, and only his audio circuit is activated. The beeper operates until the wearer presses a reset button.

To send out the proper code, the originator of a call must dial on an ordinary telephone a seven-digit number that's unique to the particular radio pager. This accesses the paging service, where automatic equipment generates the proper call code. One can also rent equipment from the telephone company that requires only pressing a button to automatically send the tones over the air. The call between the originator and the paging company providing the service is billed as a regular telephone call.

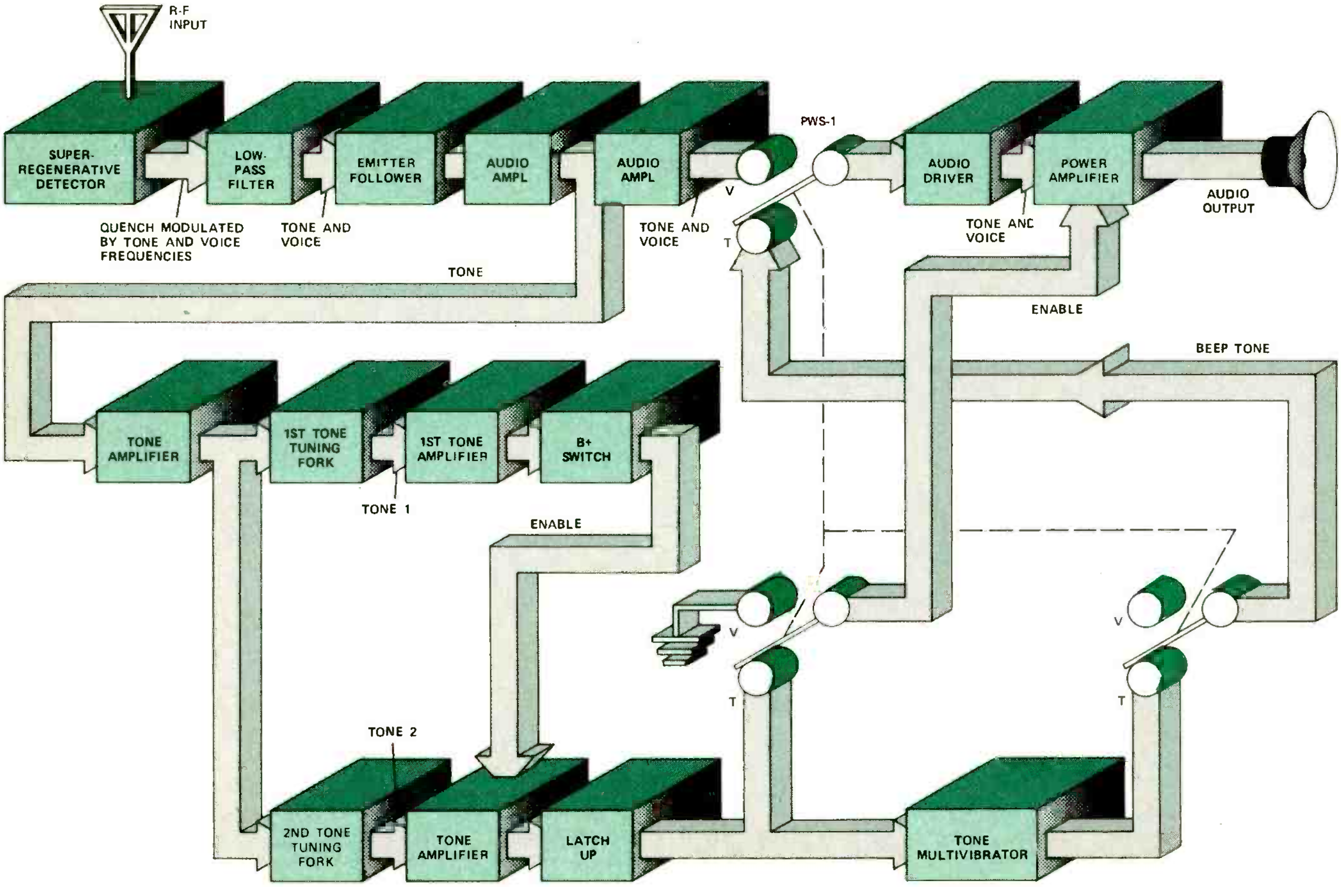


Fig. 2. Operational diagram of Model R-2 Receiver made by Bogen Div. of Lear-Siegler.

TABLE I—CODE CHANNEL TABLE

First Digit of Code	Second Digit of Code	Third Digit of Code
1	1 thru 0: Ch. 11 thru 20 (1st Tone)	1 thru 0: Ch. 26 thru 35 (2nd Tone)
2	1 thru 0: Ch. 11 thru 20 (2nd Tone)	1 thru 0: Ch. 26 thru 35 (1st Tone)
3	1 thru 0: Ch. 21 thru 30 (1st Tone)	1 thru 0: Ch. 36 thru 45 (2nd Tone)
4	1 thru 0: Ch. 21 thru 30 (2nd Tone)	1 thru 0: Ch. 36 thru 45 (1st Tone)
5	1 thru 0: Ch. 11 thru 20 (1st Tone)	1 thru 0: Ch. 36 thru 45 (2nd Tone)
6	1 thru 0: Ch. 11 thru 20 (2nd Tone)	1 thru 0: Ch. 36 thru 45 (1st Tone)
7	1 thru 0: Ch. 11 thru 20 (1st Tone)	1 thru 0: Ch. 46 thru 55 (2nd Tone)
8	1 thru 0: Ch. 11 thru 20 (2nd Tone)	1 thru 0: Ch. 46 thru 55 (1st Tone)
9	1 thru 0: Ch. 21 thru 30 (1st Tone)	1 thru 0: Ch. 46 thru 55 (2nd Tone)
0	1 thru 0: Ch. 21 thru 30 (2nd Tone)	1 thru 0: Ch. 46 thru 55 (1st Tone)

Most radio pagers currently in use are tone-only devices that indicate to the wearer that he's being paged by sounding a tone. A new variation of the pager, however, provides both tone and voice paging capability. As its name implies, the tone-and-voice pager beeps to alert its wearer that a voice message follows.

For situations in which a subscriber must routinely call either of two locations—a doctor might call his office or his hospital—there is a pager designed to respond to either of two call codes. Each code combination sounds a distinctly different beep alert.

Another model unobtrusively alerts its wearer by using a vibrating action rather than a beep tone. This type can be worn where a beep tone might prove indiscreet. More important, the vibrating beeper is suitable for environments where ambient noise might drown out a beep tone.

While most paging is directed to individuals, a few situations require a group of people to be alerted simultaneously. To meet the demands of, say, volunteer fire departments or emergency medical teams for simultaneous paging, manufacturers have developed the "group-call" pager. Similar to standard tone-alert pagers, group-call pagers generally have a unique call code to permit individual alerts and a second call code shared by every pager in the group. Of course, each group has its own group-call code so that only its members will be alerted.

Radio pagers exist that are even more sophisticated. Among these are two models, developed by Multitone Electric Co., that offer numeric displays in addition to audible alerts and are no larger than an ordinary tone-alert model. Appropriate coding by the paging service will activate a numerical sequence specified by the originator of the message. The displayed numbers can be assigned meanings, such as what telephone number to call, what job is to be performed next, etc.

Radiofone Corp., one of the larger paging service organizations, has also been working with pager manufacturers on two models that may eventually permit alphanumeric messages to be displayed. One would display the number of the caller; the other, now being readied for field testing, will be able to receive a message of up to 50 words that would appear line by line.

TABLE II—CHANNEL FREQUENCY TABLE

Channel	Frequency (Hz)
11	2704
12	2612
13	2523
14	2437
15	2354
16	2274
17	2196
18	2121
19	2049
20	1980
21	1912
22	1847
23	1784
24	1723
25	1664
26	1608
27	1553
28	1500
29	1449
30	1400
31	1352
32	1306
33	1261
34	1219
35	1177
36	1137
37	1098
38	1061
39	1025
40	990
41	956
42	923
43	892
44	862
45	832
46	804
47	776
48	750
49	725
50	700
51	676
52	653
53	631
54	609
55	588

Technical Details. A radio pager is capable of receiving and decoding signals radiated from a call-service transmitter, but has no transmitting facilities of its own (Fig. 1).

Besides a radio transmitter, which is obviously necessary, the transmitting section includes an encoder, whose purpose is to generate the unique call (tone) frequencies for any desired pager in the network. The encoder contains a crystal-controlled tone oscillator. Voice output, when used, is fed to the transmitter via a preamplifier module.

The information given in Tables I and II, taken from the Reach Electronics manual, will help show how the encoder selects a specific pager within a network. Assume that the pager to be contacted is keyed to respond to the call code 324. Start by locating the number 3, the first digit of the code, in the left column of Table I. In the second column of row 3, the numbers 1, 2, 3, . . . 0 correspond to channels 21 through 30. Therefore, the second digit of the call code (2) corresponds to channel 22. In the third column of row 3, the last digit of the call code, 4, corresponds to channel 39. We can now determine from the selected channels what tone frequencies must be transmitted to activate the beeper with the call code 324.

Referring now to Table II, it is seen that channel 22, specifying the first tone frequency, corresponds to 1847 Hz. Similarly, channel 39 indicates that the second call-tone frequency is 1025 Hz. Once these two tone frequencies are determined, a timer circuit is necessary to space the tones very precisely. For example, in the GE paging system, the first tone is sent for one second, followed by 180 ms of silence before the second tone is sent. In this system, signalling tone frequencies must be within ±2% of the bandwidth, and the on-time of each tone must be precise.

To obviate problems of intelligibility with voice transmissions, voice-synthesis circuits are used in some transmitters. The final radio transmitter and antenna are fairly conventional.

Receiving circuitry is conventional except that the pager also contains a decoder (Fig. 2). The first stage is typically a superregenerative circuit that detects and amplifies all incoming r-f signals in the receiver bandpass. Detection is also accomplished by this stage. Output from the detector is a high quench frequency in the audio range, with a low-frequency tone or voice signal superimposed on it. Low-pass filtering removes the quench frequency, after which the tones are separated and analyzed by narrow, crystal-controlled bandpass filters. Finally, if the filters "recognize" the audio-frequency code tones, an audio driver and power amplifier are energized.

Radio pagers generally are assigned to operate in only one of four frequency bands, depending on the type of service the subscriber requires. The low vhf band from 30 to 50 MHz is usually used for on-site coverage of a facility, such as a factory or construction site. For wider coverage, one might choose a pager designed to operate on the high vhf band between 132 and 174 MHz. For even greater coverage, usually obtained through the use of multiple antennas at the call service's facility, a uhf pager that operates between 406 and 420 MHz would prove to be a better choice. Finally, when signal saturation is desired on floors of buildings and in basements in metropolitan areas where there are many tall buildings, a uhf pager that operates in the 420-to-512-MHz range would be required.

Until last year, these were the only bands available for paging services. In mid-1980, however, Motorola announced the availability of a tone-and-voice pager designed to operate at 800 MHz. The new Dimension IV pager from Motorola operates in the 851-to-866-MHz band and is available to only those subscribers who qualify for their own frequencies. This pager is said to be compatible with existing 800-MHz base-station (call-service) equipment and encoders.

Highly efficient integrated circuitry has reduced power demands to where a single AA-size mercury battery will keep a pager operating for almost seven weeks. This eliminates the bulky, heavy nickel-cadmium batteries used in early pagers and the need for daily recharges as well. Higher-efficiency circuits are only a part of the battery long-life story. New circuits such as those used in the Multitone and Motorola pagers automatically switch off the major portions of the pager's circuit in the absence of calls, switching them on again when there is an incoming call.

What Paging Costs. Most radio-call companies offer a choice of two plans for their paging services. Under one plan, a monthly charge is levied and includes rental of the pager, handling of calls, and maintenance. Prices under this plan vary according to range of coverage and the number and types of pagers rented. The general range is from $13.50 to $18 per month per pager.

The second plan is designed for the subscriber who wishes to purchase his pagers outright. Cost is about $200 each. In this case, the cost of service including handling of calls and maintenance, ranges from $5 to $8 per month per pager. Again, the exact figure depends on the number and type of pagers being used.

Range of coverage varies from service to service. For example, Beep Communication Systems, Inc. (New York City) offers coverage from Albany and surrounding cities, down through Pennsylvania and parts of Delaware. Radiofone Corp., also in the East, covers about 20,000 square miles and was the first paging-service company to offer coast-to-coast service, connecting New York, Chicago, and Los Angeles via Western Union's Westar satellite. By linking up services in various cities with shared frequencies and exchanging access numbers, a group of paging companies can provide subscribers with a large "umbrella" under which the pager wearer can travel from city to city without loss of service. The most common coverage appears to be 30 to 75 miles.

Considering the modest cost and service, it's small wonder that radio paging has become so popular. The prestigious "beep" has even been known to get one a better table in a restaurant. ◇

BINARY, OCTAL AND HEXADECIMAL NUMBERS

How to understand and apply the three basic numbering systems in computer programming

BY FRED BLECHMAN

MICROCOMPUTER users often need to understand and apply number systems other than the familiar decimal system. The most popular of these is the hexadecimal (base 16) system, with octal (base 8) and binary (base 2) following close behind.

This article will help clear up some of the mysteries regarding these various systems and show how to convert decimal numbers to any of the bases and vice versa. A BASIC computer program that performs hex/decimal conversions is also given.

The Number Systems. Tables I through IV are designed to help you learn how the familiar decimal system relates to the binary, octal, and hexadecimal systems.

The values associated with the digits of decimal, binary, octal, and hexadecimal systems are given for the first four places in Tables I-IV. In each case, the left-hand column gives the number (or letter) "code" for that system. The other four columns contain the *decimal numbers* that represent each code location. Since decimal numbers are common to all tables, once you learn how to use these tables you can convert from one number system to another using the equivalent decimal number. The hexadecimal system requires more digits than can be expressed by the characters 0,1,2,3,4,5,6,7,8,9, so the first six letters of the alphabet are added. The full set is thus 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F. While FFFF may be an odd-looking expression, it is a valid number in the hexadecimal system.

Using these tables takes some explanation, so let's start with Table I, the Decimal Number System. The decimal code column shows the familiar digits 0-9. Now look at the far right (Column I) which also reads vertically from 0 to 9; ten digits in all. Our base, then, is 10. These numbers are actually the numbers 0 to 9 times the zero power of the base 10. Column II shows each of the Column I digits multiplied by the base, 10, raised to the first power. Column III shows each of the Column I digits multiplied by 10^2, or 100; column IV shows each multiplied by 10^3, or 1000.

Suppose you wanted to know the decimal *number* for decimal *code* 6037. This is a 4-digit number, which means we'll use all four columns in the table. The first or most significant digit is 6. Look down the left-hand "Decimal Code" column to 6 and go to the right to Column IV, where you find 6000. Call this the decimal value of Column IV. The next most significant digit is 0. The Column III value for Decimal Code 0 is 0. The next significant digit of 6037 is 3. In Column II, the decimal value for Decimal Code 3 is 30. The last or least significant digit, 7, is seen to equal 7 in Column I for Decimal Code 7. Now simply add the Column I through Column IV values (6000+0+30+7) and you have 6037 (the hard way!).

You can also work backwards—that is, find the decimal *code* for a given decimal *number*. Suppose the decimal number is 2408. Start by finding the *largest* number in the table that is *smaller* than the decimal number 2408. That would be 2000 in Column IV for Decimal Code 2. Therefore, the first decimal digit is 2. Now, subtract 2000 from 2408, leaving a remainder of 408. Again, find the *largest* number in the table *less than* 408. The number is 400, in Column III, for decimal digit 4. Now, the remainder of 8 (after subtracting 400 from 408) *bypasses* Column II and we find the *exact* value, 8, in Column I at Decimal Code 8. This generates *two* decimal code numbers, a 0 for Column II and an 8 for Column I. The result: a decimal code of 2408.

The Binary Number System. Table II shows the Binary Number System, using the same tabular approach as shown for the decimal system. Since the binary code consists of only two digits, 0 and 1, the columns use a base of 2. That is, Column I (far right) is 2 to the zero power, times the digit. Column II is 2 to the first power, Column III is 2 to the second power, and so forth. Binary code 0 is 0 in all columns (since zero times anything is zero).

Suppose you had a 4-bit binary code 1011. Starting with Column IV and adding the values wherever a binary code of 1 appears for that column, you have 8+0+2+1 equals 11 in decimal. Going the other way—that is, starting with a decimal number and determining the binary code—use the largest-number subtraction technique described previously. Suppose you needed the binary code for decimal 14. You'd have a "1" for Column IV. Then, subtracting 8 from 14, you have 6 as a remainder. Column III has a 4, so you have a "1" for Column III, and a remainder of 2 (6−4), which is an *exact* match with Column II. That gives you a binary code of "1" for Column II, and "0" for Column I. The end result is that decimal 14 equals binary 1110.

The Octal Number System. Table III shows the Octal Number System using our familiar format. Since the base number is 8 this time, all the columns are powers of 8. For example, the 256 in Column III is 4 times 8 to the second power (4×8^2), which equals 4 times 64, or 256. The table is used exactly the same way as the previous tables. Octal code 4273 is equal to decimal 2048+128+56+3, or 2235 decimal. Going the other way, 3273 decimal is equal to 6311 *octal* (3273−3072−192−8−1=0).

The advantage of octal is that a 3-bit binary number (such as 110, 101, etc.), can be represented as a single octal digit, since a 3-bit binary number can only range from 0-7. For example, binary 110 would be octal 6; binary 101 would be octal 5. Thus, a long binary number of 12 bits could be broken up into 4 groups of 3 bits each, and represented by 4 octal digits.

The Hexadecimal Number System. Now we arrive at "Destination Hex," where we computer users wanted to go all along. Actually, there are good reasons why hexadecimal numbers are so popular in computing. Most computers use binary 8- or 16-bit "words," 8-bit "bytes" and 4-bit "nybbles" internally. One hexadecimal character can represent a 4-bit nybble, two hex characters an 8-bit byte, and four hex characters a 16-bit word! Thus, hex code provides a reasonable "middle-ground" between the binary code the computer actually processes and the decimal code we humans like to use.

Table IV shows the tabular approach, and a simple BASIC program is also shown. Either will convert from hex to decimal or decimal to hex for the range of 0 to 65535 or 0 to FFFFh. (An h or H is often added to a hexadecimal number to indicate the type of code.)

Look at Table IV, Hex Code column. Since the base for hexadecimal code is 16, we use single-character letters to represent the 10,11,12,13,14 and 15 codes.

The table is used exactly like the previous ones. Thus, 3CB6h is equal to 12288+3072+176+6 or 15542 decimal. Going the other way, 32650 decimal equals 7F8Ah (32650−28672−3840−128−10=0).

BASIC Hex/Decimal Conversion Program. Although the program is self-prompting and requires no programming knowledge to operate, you may be interested in how it works. A fair understanding of TRS-80 Level II BASIC language statements and functions is assumed.

Lines 5 to 40 introduce the program and print the conversion limits and "menu" on the screen followed by a blank line. Line 50 asks which way you want to go—decimal-to-hex or hex-to-decimal. You enter a 1 or 2 and line 60 sends you to either line 100 or line 500. Assume you typed and entered a "1." Then M equals "1" and you continue at line 100. (Note that line 60 could also be: IF M=2 GO TO 500). For simplicity, error-trapping is not used, and if you enter *any* number but "2" you'll be at line 100 which clears the screen and tells you how to return to the "menu" or exit the program. Line 110 asks for your decimal number for variable N. Line 111 traps numbers over 65535, and line 112 checks if N is zero for return to menu.

Line 115 sets the value of A equal to N, and also sets counter variable X to zero. Line 120 starts a "countdown" by subtracting 4096 (which is 16 to the third power) from A. Line 130 looks at the result to see if it is less than zero; if it is, then 4096 is added, the variable Z is set to the value of X and the program branches to a subroutine, lines 1000-1060. We'll get to that later.

If, however, line 130 is bypassed because A is zero or larger, then line 140 adds 1 to the value of X and sends the program back to line 120 for another subtraction of 4096.

What's happening here is that the computer is counting down from the top of Column IV of Table IV. Each time it repeats line 120, it is adding to the hex code by 1 (X increases by 1). Finally, when line 130 finds A is less than zero, the value of X is the hex code for the most significant digit. The subroutine starting at line 1000 then defines the value of this digit.

Suppose you enter the decimal number 32650 for N in line 110. Lines 120

TABLE I—THE DECIMAL NUMBER SYSTEM

Decimal Code	IV	III	II	I
	$10^3=1000$	$10^2=100$	$10^1=10$	$10^0=1$
0	0	0	0	0
1	1000	100	10	1
2	2000	200	20	2
3	3000	300	30	3
4	4000	400	40	4
5	5000	500	50	5
6	6000	600	60	6
7	7000	700	70	7
8	8000	800	80	8
9	9000	900	90	9

TABLE II—THE BINARY NUMBER SYSTEM

Binary Code	IV	III	II	I
	$2^3=8$	$2^2=4$	$2^1=2$	$2^0=1$
0	0	0	0	0
1	8	4	2	1

and 140 will subtract 4096 seven times until, on the eighth time, the result is −118. The variable X has been advanced by line 140 seven times so it has a value of 7. Line 130 now sees that A is less than zero, so 4096 is added, making A equal to 3978. Variable Z is set equal to 7 (the present value of X) and we move to line 1000.

Line 1000 sees that the value of Z is less than 10, so it sets string-variable X$ equal to STR$(X), the numerical value of X in string form. This allows X$ to be a number or a letter. Here, X$ is equal to a string value of 7.

Lines 1005-1050 are ignored, since Z is equal to 7, and line 1060 returns the program to the latter part of line 130, where the branching took place. The next statement sets E$ to the value of X$, for later use. Then the program is directed to line 145.

Line 145 sets variable B equal to the last value of A, which is 3978 in our example. Then X is reset to zero. Now lines 150-170 subtract 256, inspect for a value less than zero, and count, in the same manner as lines 120-140. After 16 subtractions, B has a value of −118. Line 160 catches this, adds 256 to bring the value of B up to 138, sets Z equal to 15, and branches to line 1000.

Lines 1000-1040 are ignored, since Z equals 15. However, line 1050 is satisfied and X$ is made equal to the letter F. Line 160 then makes F$ equal to F.

Similary, lines 175-200 determine the third hex code, which in the example turns out to be 8, with the final value of C equal to 10. The subroutine at line 1000 sets X$ equal to a string value of 8, and line 190 makes G$ equal to 8.

Line 210 takes the remainder (C in line 190, with a value of 10 in our example) and lets variable D equal this value. It now sets Z equal to D and again goes to line 1000. Since our example has Z equal to 10, line 1000 is ignored, but line 1005 sets X$ equal to the letter A. Lines 1010-1050 are ignored, line 1060 returns the program to the end of line 210 and H$ is set to a value of A.

In memory we have E$ equal to 7, F$ equal to F, G$ equal to 8 and H$ equal to A. Line 220 skips a line on the screen and prints out 7F8A and line 225 prints a message reminding you to ignore leading zeros. Then line 230 sends the program back to line 110 for another decimal number after printing a blank screen line.

Hex-To-Decimal Conversion. If you had indicated, as a response to line 50, that you wanted hex-to-decimal conversion by typing and entering a "2," the program would branch to line 500. The screen is cleared, two blank lines are printed, followed by the menu/exit message and a blank line. Line 510 prints a prompt asking for the hexadecimal value, V$. If you enter zero, line 511 returns the program to the menu. Suppose you type in 45FD. Line 512 makes sure this is a 4-character string by adding leading zeros if necessary. Line 520 extracts the rightmost character of V$ and makes X$ equal to it. In our example, this would make X$ equal to D. Now the program branches to a subroutine starting at line 2000.

Line 2000 looks at X$ to see if it has a value less than A. Since numbers come before letters in the computer's pre-programmed ROM value sequence, the letter D allows the program to "fall thru" to line 2030. Since X$ *is* equal to D, this program line now makes the variable Z equal to 13. Lines 2040 to 2060 are ignored, and line 2070 returns the program to the branching point, the end of line 520. Variable D is made equal to Z, which is currently 13.

Line 2060 is a simple error-trap to keep you from entering any letters beyond F, since they would be invalid in hex code.

Line 530 looks at the third character in X$, which is an F in our 45FD example. The subroutine sets the value of Z to 15 in line 2050 and the end of line 530 makes C equal to 15 times 16 or 240.

Line 550 finds the second character in X$ to be 5. The subroutine catches this value in line 2000 as being less than A, and sets Z to the *decimal* value of 5. (VAL(X$) converts a string value to a numerical value.)

The end of line 550 makes B equal to 5 times 256, or 1280. Similarly, lines 560 and 1000 take the first character (4) of X$ and makes A equal to 4 times 4096, or 16384. Notice that A,B,C and D are all now numerical values, and can be added together. Line 600 does this and prints the result. In our example, 45FD equals 16384 plus 1280 plus 240 plus 13, for a result of 17917 decimal. Line 620 goes to line 510 for another hex number. Line 999 is just good form to identify the beginning of a subroutine, but could be omitted.

Other Number Conversion Programs. While the program given here is simple and can be entered from your

TABLE III—THE OCTAL NUMBER SYSTEM

Octal Code	IV	III	II	I
	$8^3=512$	$8^2=64$	$8^1=8$	$8^0=1$
0	0	0	0	0
1	512	64	8	1
2	1024	128	16	2
3	1536	192	24	3
4	2048	256	32	4
5	2560	320	40	5
6	3072	384	48	6
7	3584	448	56	7

TABLE IV—THE HEXADECIMAL NUMBER SYSTEM

Hexadecimal Code	IV	III	II	I
	$16^3=4096$	$16^2=256$	$16^1=16$	$16^0=1$
0	0	0	0	0
1	4096	256	16	1
2	8192	512	32	2
3	12288	768	48	3
4	16384	1024	64	4
5	20480	1280	80	5
6	24576	1536	96	6
7	28672	1792	112	7
8	32768	2048	128	8
9	36864	2304	144	9
A	40960	2560	160	10
B	45056	2816	176	11
C	49152	3072	192	12
D	53248	3328	208	13
E	57344	3584	224	14
F	61440	3840	240	15

NUMBER CONVERTING PROGRAM

```
5 REM * COPYRIGHT FRED BLECHMAN 1980 *
10 CLS
20 PRINT:PRINT:PRINT:PRINT"          NUMBER CONVERTER PROGRAM"
25 PRINT"        (MAXIMUMS: 65535 DECIMAL, FFFF HEX)"
30 PRINT:PRINT"(1) DECIMAL TO HEX CONVERSION
40 PRINT"(2) HEX TO DECIMAL CONVERSION
50 PRINT:INPUT"WHICH DO YOU WANT, 1 OR 2?";M
60 ON M GOTO100,500
100 CLS:PRINT:PRINT:PRINT"ENTER 0 FOR MENU, BREAK TO EXIT....":PRINT
110 INPUT"WHAT IS THE DECIMAL NUMBER (65535 MAX.)";N
111 IF N>65535 PRINT"ABOVE 65535 LIMIT! TRY AGAIN...":GOTO110
112 IF N=0 GOTO10
115 A=N:X=0
120 A=A-4096
130 IF A<0 THEN A=A+4096:Z=X:GOSUB1000:E$=X$:GOTO145
140 X=X+1:GOTO120
145 B=A:X=0
150 B=B-256
160 IF B<0 THEN B=B+256:Z=X:GOSUB1000:F$=X$:GOTO175
170 X=X+1:GOTO150
175 C=B:X=0
180 C=C-16
190 IF C<0 THEN C=C+16:Z=X:GOSUB1000:G$=X$:GOTO210
200 X=X+1:GOTO180
210 D=C:Z=D:GOSUB1000:H$=X$
220 PRINT:PRINT"THE HEXADECIMAL VALUE IS: ";E$;F$;G$;H$
225 PRINT"(IGNORE LEADING ZEROES....)"
230 PRINT:GOTO110
500 CLS:PRINT:PRINT:PRINT"ENTER 0 FOR MENU, BREAK TO EXIT...":PRINT
510 INPUT"WHAT IS THE HEXADECIMAL VALUE (FFFF MAX.)";V$
511 IF V$="0" GOTO10
512 V$=RIGHT$("0000"+V$,4)
520 X$=RIGHT$(V$,1):GOSUB2000:D=Z
530 X$=MID$(V$,3,1):GOSUB2000:C=Z*16
550 X$=MID$(V$,2,1):GOSUB2000:B=Z*256
560 X$=LEFT$(V$,1):GOSUB2000:A=Z*4096
600 PRINT:PRINT"THE DECIMAL NUMBER IS";A+B+C+D
620 PRINT:GOTO510
999 END
1000 IF Z<10 THEN X$=STR$(Z)
1005 IF Z=10 THEN X$=" A"
1010 IF Z=11 THEN X$=" B"
1020 IF Z=12 THEN X$=" C"
1030 IF Z=13 THEN X$=" D"
1040 IF Z=14 THEN X$=" E"
1050 IF Z=15 THEN X$=" F"
1060 RETURN
2000 IF X$<"A" THEN Z=VAL(X$)
2005 IF X$="A" THEN Z=10
2010 IF X$="B" THEN Z=11
2020 IF X$="C" THEN Z=12
2030 IF X$="D" THEN Z=13
2040 IF X$="E" THEN Z=14
2050 IF X$="F" THEN Z=15
2060 IF X$>"F" PRINT"ERROR!! NO LETTER GREATER THAN F! TRY AGAIN...":GOTO 510
2070 RETURN
```

keyboard in 15 to 20 minutes and stored on cassette or disk, it is limited to hex/decimal conversions and to only four hex characters. Several other cassette programs with more flexibility can be obtained from the following sources:

(1) "BASECONV/BAS" converts any number with a base between 2 and 16. No known limit to number size. Excellent, fast, easy to use. $3.95, postpaid, if payment with order. International Data Services, 340 West 55th St., New York, NY 10019. Phone: 212-757-8046.

(2) "Number/Base Converter" will add, subtract or convert numbers of any base between 2 and 16. No known limit to number size. Very flexible. $6.95, postpaid. Demi-Software, P.O. Box 570, Lynbrook, NY 11563.

(3) "Programmer's Converter" has three programs: Base Calculator converts numbers with bases 2 through 16 and performs calculations, including fractions; Hexadecimal/Decimal Training not only performs conversions but includes a teaching/testing program; Number Base Conversions converts decimal, binary, octal and hexadecimal numbers from zero to FFFF, and displays all four values simultaneously. $9.95 plus $1 shipping. Instant Software, Peterborough, NH 03458.

(4) "HEX-DEC Converter" provides hexadecimal-to-decimal or decimal-to-hexadecimal conversions "in memory" up to 65535 decimal or FFFF hex. It can be used during the writing of a BASIC program by using SHIFT-D to convert from decimal or SHIFT-H to convert from hex. The answer appears on the screen and the program returns to BASIC. Very handy. Uses less than 256 bytes of reserved upper memory. $6.95 postpaid. J. Lindsly, 8106 Quailwood Ct., West Chester, OH 45069.

For $2 postpaid, you can receive a BASIC *listing only* (no cassette) of a "number Conversion Program" that converts decimal, hex, octal and binary numbers in the range of zero to FFFF. Dean R. Zimmerman, 444 North Grove Drive, Alpine, UT 84003. ◇

BY JAMES BARBARELLO AND EDWIN IRIYE

Inexpensive, accurate instrument measures inductance from 1 microhenry to 1 henry as well as capacitance

BUILD THE

Reactance Measuring Set

NOW you can measure the inductance of coils and loudspeaker windings without resorting to expensive laboratory instruments. The Reactance Measuring Set (RMS) presented here will measure inductance from 1 microhenry to 1 henry, using any multimeter as a readout device. Furthermore, capacitance from 1 picofarad to 1 microfarad can be determined.

Accurate, stable, and easy to build, the RMS project uses a measurement technique based on the relationships between currents flowing through and voltages appearing across reactive components. The resulting measurements are not influenced by any effective or internal resistances of the components under test. Moreover, the RMS can be aligned without using a precision reference standard. As a bonus, it can function as a crystal-controlled frequency standard. No batteries are needed, thanks to the presence of an internal, line-powered supply.

Measuring Reactors. The voltage drop across a pure inductance is directly proportional to the rate at which the magnitude of the current flowing through it changes with time. Mathematically, this is expressed by the differential equation: $v = L\,di/dt$. If a current that has a constant rate of change flows through the inductor, the voltage drop across it will be constant. Similarly, if the waveform of the current that flows through the inductor is a triangle, the resulting voltage is a square wave.

The current that flows through a pure capacitance is directly proportional to the time rate of change of the voltage across it ($i = C\,dv/dt$). If a voltage with a constant rate of change is applied across the capacitance, a current of constant magnitude flows through it. Similarly, if the waveform of the voltage that is applied across the capacitor is a triangle, a square-wave current flows through it.

Now let's look at a block diagram of the RMS (Fig. 1). A triangle-wave voltage source is the heart of the measurement circuit. It drives both a voltage-dependent current source and a buffer/voltage-to-current converter stage. The former generates a triangle-wave current which is applied to an inductance whose value is to be determined (L_X). If a value of capacitance is to be measured, a triangle-wave voltage is applied across the component under test (C_X). Conversion of the current through the unknown capacitance into a voltage by the latter stage means that a voltage is applied to the demodulator stage via *S3B* whether an inductance or a capacitance is being measured.

Two basic parameters of the signal generated by the triangle voltage source must be closely controlled if accurate measurements are to be obtained—its amplitude and its period. An agc stage monitors the peak-to-peak amplitude of the triangle voltage source's output and generates a control signal to suppress undesirable variations. To keep the period of the voltage source's output stable, a crystal-controlled clock and a series of frequency-divider stages are employed. The output of this portion of the RMS is a square-wave voltage whose frequency is determined by the setting of RANGE switch *S1* and which governs the frequency (and hence the period) of the triangle voltage source's output.

When the component under test is driven by the triangular test signal, a complex voltage is presented to the RMS demodulator stage. This waveform comprises a square wave, which is due to the reactive portion of the impedance of the component under test, and an added, triangle wave which is due to the resistive portion of the impedance of the component under test. (An ideal reactor contains no resistance, but practical inductors and capacitors do.) To prevent any resistive element of the component from influencing the measurement, the triangle-wave portion of the signal presented to the demodulator is averaged out.

The demodulator responds only to the square-wave portion of the signal applied to it and generates a dc output voltage. A scaling amplifier processes this voltage and presents a dc level to the output terminals of the RMS. This level, which is monitored by means of an external dc voltmeter, is scaled so that the voltage reading represents the actual value of the reactor under test.

About the Circuit. The schematic diagram of the RMS appears in Fig. 2. A quartz-crystal oscillator comprising *Q1, Q2, Q3* and their associated passive components generates a 2.0-MHz output signal. This signal is conditioned and its frequency divided by a factor of two by flip-flop *IC1B*, which provides a 1.0-MHz square wave to decade dividers *IC2* through *IC5*. One of the five decade-counter output frequencies (1 MHz, 100 kHz, 10 kHz, 1 kHz or 100 Hz) is selected by *S1A* to drive the active voltage divider comprising *R7, R18* and *Q14*. The divider is part of the agc stage.

Capacitor *C4* couples a portion of the driving signal to the triangle-wave generator comprising *Q5, Q6,* and *Q7* and their associated passive components. This circuit is a bipolar constant-current source which alternately charges and discharges the triangle-generating capacitor selected by *S1B* that is appropriate for the frequency selected by *S1A*. The triangle-wave voltage that appears across this capacitor is monitored by that portion of the agc circuit comprising *Q13, Q14, IC7* and their associated passive components.

The input signal to this portion of the

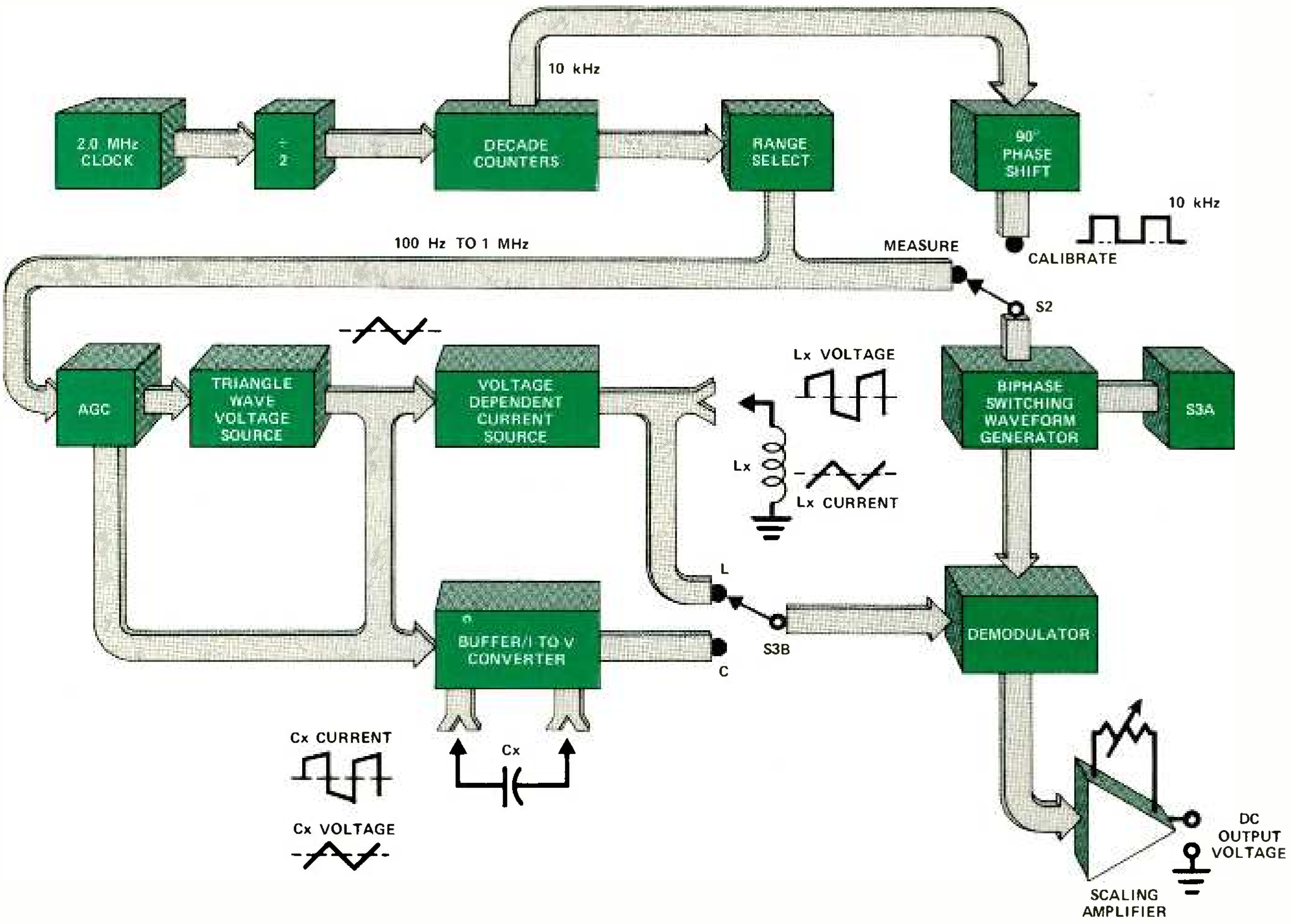


Fig. 1. Block diagram of the Reactance Measuring Set. A measurement is performed by synchronous demodulation of the square-wave voltage that appears across the component being tested.

agc stage is first buffered by *Q13* and then peak-detected by *D5* and *D6*. This detected signal is then filtered and compared by *IC7* to a reference provided by voltage divider *R21R22*. The output of *IC7* is the bias applied to the gate of *Q14* that determines the channel resistance of the FET. As a result, the amplitude of the crystal-derived square wave provided to the triangle-wave voltage source is maintained such that the amplitude of the triangle-wave voltage signal remains constant.

Owing to possible differences in device and circuit parameters, an imbalance between the charge and discharge cycles could result. This would in turn cause a net buildup in charge across the triangle generating capacitor, eventually leading to saturation. A modified phase inverter comprising *Q5*, *R10*, *R20*, *R24*, *R26*, and *C36* is utilized to prevent this. The out-of-phase (180° phase-shifted), voltage that appears at the collector of *Q5* is ac-coupled and added to the in-phase, dc-coupled voltage that appears at the emitter of *Q5*. Any tendency for the dc voltage to build up (as a result of differences between the parameters of complementary transistors *Q6* and *Q7*) will automatically change the bias of both *Q6* and *Q7* to stabilize the circuit.

The output of the triangle-wave generator drives both the voltage-controlled current source and the buffer/voltage-to-current converter. The voltage-controlled current generator comprises *Q8*, *Q9*, *Q10*, and their associated passive components, and is similar to the triangle-wave generator. It converts the voltage waveform to an out-of-phase (180° phase-shifted) current which is applied to the inductor to be measured. When the component under test is so driven, a square-wave voltage whose amplitude is directly proportional to the inductance appears across it.

The buffer/current-to-voltage converter (*Q12*, et al) is a common-base amplifier with an extremely low input impedance. From the viewpoint of a capacitor whose value is to be measured, the node *R29Q12* emitter is effectively at ground. Therefore, the magnitude of the current flowing through the capacitor under test depends only on the capacitance and the voltage waveform applied to it. The output impedance of *Q12* is very high, like that of a constant-current source, and the collector current of *Q12* is therefore a replica of the transistor's base current. This arrangement allows the capacitor to "see" an effective ground and simultaneously allows *Q12* to monitor the current flowing through the capacitor under test. The square-wave collector current of *Q12* gives rise to a corresponding square-wave voltage drop across *R34*. This square-wave voltage is buffered by *Q13* and presented to the synchronous demodulator via *S3B*.

The square-wave voltage passed by *S3B* is synchronously demodulated by *IC8*. Synchronous demodulation requires the reference signal supplied to the demodulator to be in phase with the signal from the component under test. However, the square wave generated by the buffer/current-to-voltage converter is 180° out of phase with respect to the voltage generated across an inductor under test. To compensate for this, in the inductance-measuring mode, the reference signal supplied to the demodulator is inverted by NAND gate *IC9C*. The triangle-wave voltage source provides the required 90° phase shift to ensure that the signal generated by the component under test is in phase with the reference signal.

Details of the synchronous-demodulation process follow. The square-wave voltage passed by *S3B* is simultaneously provided to two of the four bilateral switches in *IC8*. During the positive portion of the square-wave input, the signal flows from the input of bilateral switch A (pin 1) to the output of that switch (pin 2). This happens because the reference signal applied to switch A's CONTROL input (pin 13) is positive. During this interval, the phase-inverted signal applied to the CONTROL input of bilateral switch B control is negative. This causes the input-to-output channel resistance of switch B to become very high. On the negative portion of the square-wave input, switch B turns on and switch A turns off. Therefore, the negative portion of the input square wave appears at the output of switch B (pin 3). The two switch outputs are summed and scaled by *IC6*.

Calibration of the RMS does not require precision inductors and capacitors. A resistor of specific value serves as the calibrating component. Transistor *Q4* and flip-flop *IC1A* generate a 10-kHz square wave shifted 90° in phase with respect to the signal that appears at the output of counter *IC3*. During calibration, the signal generated across the calibration resistor, which is connected to the terminals to which the component under test is normally attached, and the output of *IC1A* will be in phase. This allows the demodulator to produce a specific output voltage. The calibration procedure will be described later.

Power for the circuit is provided by the supply shown schematically in Fig. 3. The power supply utilizes IC voltage regulators to produce the ±12 volts dc required by the circuit. A grounded (three-wire) line cord is used for safety purposes. The ±6.8 volts supplied to *IC8* and *IC9* are derived by zener diodes *D7* and *D8*. Because *IC8* and *IC9* must generate bipolar output voltages, this lower supply potential was selected so that the 15-volt maximum differential supply-voltage rating of the CMOS devices would not be exceeded.

Construction. Use the full-size etching-and-drilling guide shown in Fig. 4 to make a printed-circuit board, and mount all the fixed resistors shown in the parts placement guide given in Fig. 5. Next, install the diodes, transistors, ICs and jumpers and capacitors.

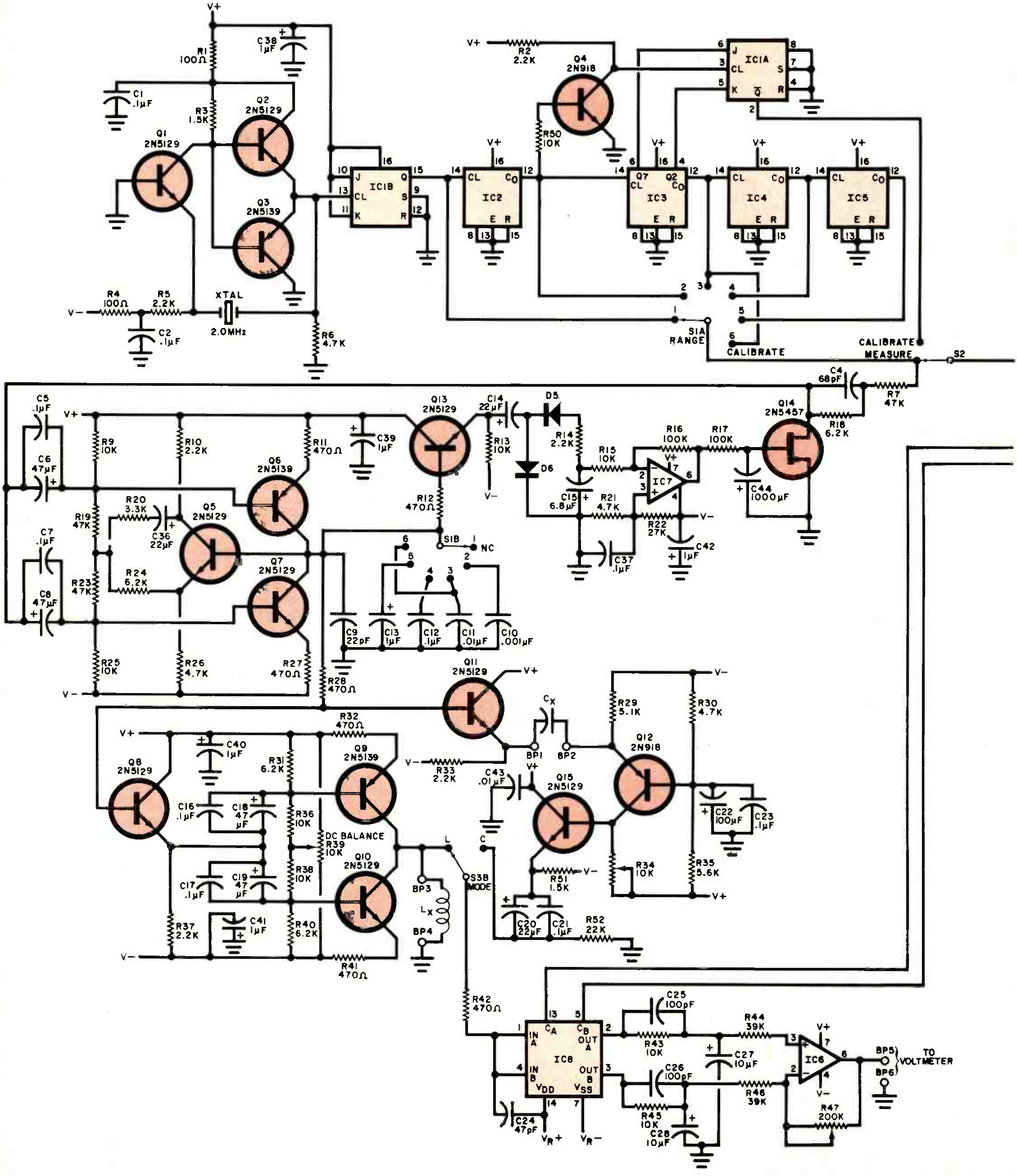
When all on-board components have been mounted, wire rotary switch *S1*. In the authors' prototype, *S1* was mounted above the board using stiff, solid-conductor wire and capacitors *C10* through *C13* to give mechanical support. We connected one lead of each capacitor to the pc board. Without shortening the leads, the free end of each capacitor was soldered to the appropriate switch lug. Next, we connected pc-board points *S1B2* through *S1B5* to the corresponding terminals of *S1* using stiff, solid-conductor wire. Wire lengths equalled lengths of the capacitor leads soldered to lugs on the opposite side of *S1* so that switch was supported securely above the pc board. Finally, we connected the rotors of *S1* to appropriate pc foil pads.

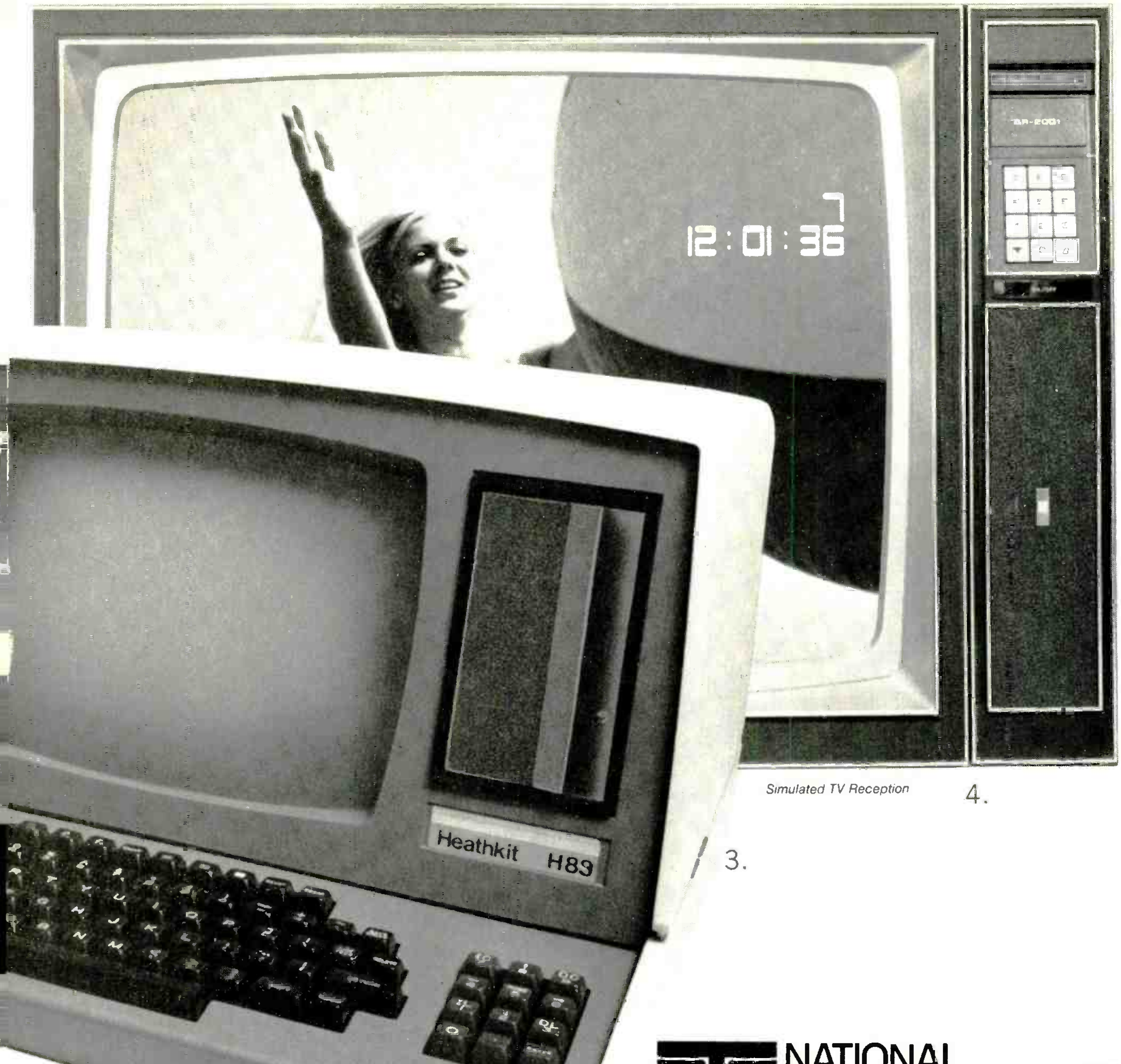
You might choose another method of mounting *S1* above the pc board. In any event, once the rotary switch has been interconnected with the board, make the necessary connections between the printed-circuit board and the remaining switches, *LED1*, and binding posts *BP1* through *BP6* using suitable lengths of stranded hookup wire. Then interconnect lugs 3 and 6 of *S1A* and *S1B*. Transformer *T1*, the fuseholder for *F1*, power switch *S4* and the line cord should be interconnected and mounted in the project enclosure so as to fit in the large pc-board cutout. Once the transformer has been mounted, the secondary leads of *T1* can be connected.

The enclosure should be machined as necessary to accept all switches and binding holes should be drilled to allow easy adjustment of trimmer potentiometers *R34*, *R39* and *R47* after final assembly. When all switches and binding posts have been installed and connected to the rest of the circuit, the pc board can be mounted in the enclosure using standoffs and suitable hardware.

Calibration. Begin by soldering two lengths of stranded hookup wire to the lugs of a 1000-ohm, linear-taper potentiometer so that it will act as a variable resistor. The use of a multiturn potentiometer will simplify matters, but a standard potentiometer can be employed. Utilizing a 3½-digit multimeter, adjust the potentiometer for a resistance of 856 ohms ± 1%.

Taking care not to disturb the setting of the potentiometer, disconnect its leads from the meter probes and connect them to binding posts *BP3* and *BP4*. Apply power to the project, place *S1* and *S2* in their CALIBRATE positions and *S3* in its L position. Switch the multimeter to its dc-volts operating mode and connect its probes to binding posts *BP3* and *BP4*. Adjust trimmer *R39* for a meter reading of 0 volt. Next, remove the probes from *BP3* and *BP4* and connect them to *BP5* and *BP6* and adjust trim-





Simulated TV Reception 4.

3.

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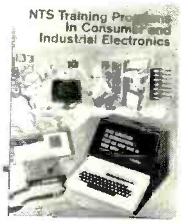

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(Continued from page 71)

behaving nonlinearly. Occasionally, it is desirable to dc bias the inductor under test. This can be done by placing a dc milliammeter across the L_X terminals prior to connecting the inductor, and adjusting DC BALANCE potentiometer *R39*. This potentiometer controls the bias of complementary transistors *Q9* and *Q10* and allows them to provide to the inductor under test a dc bias of up to 5 mA.

To make accurate measurements of inductances less than 10 μH, it is best to use a differential technique. Wind or find a coil whose inductance is approximately 30 to 50 μH (exact value not critical). Measure its inductance and record it for reference purposes. Next, connect the low-value inductor to be

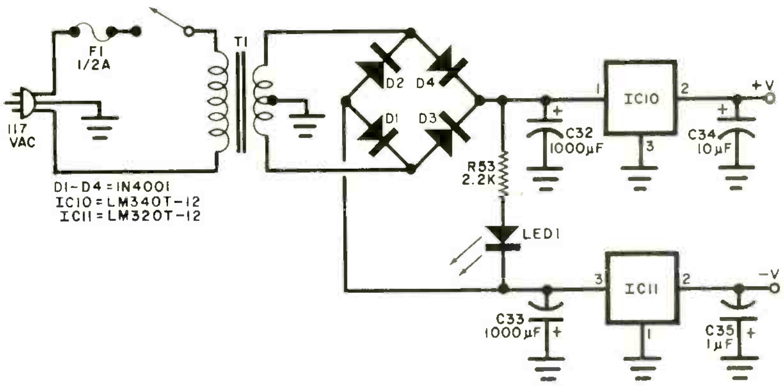


Fig. 3. Schematic diagram of the power supply which furnishes the bipolar 12 volts dc required by the circuit.

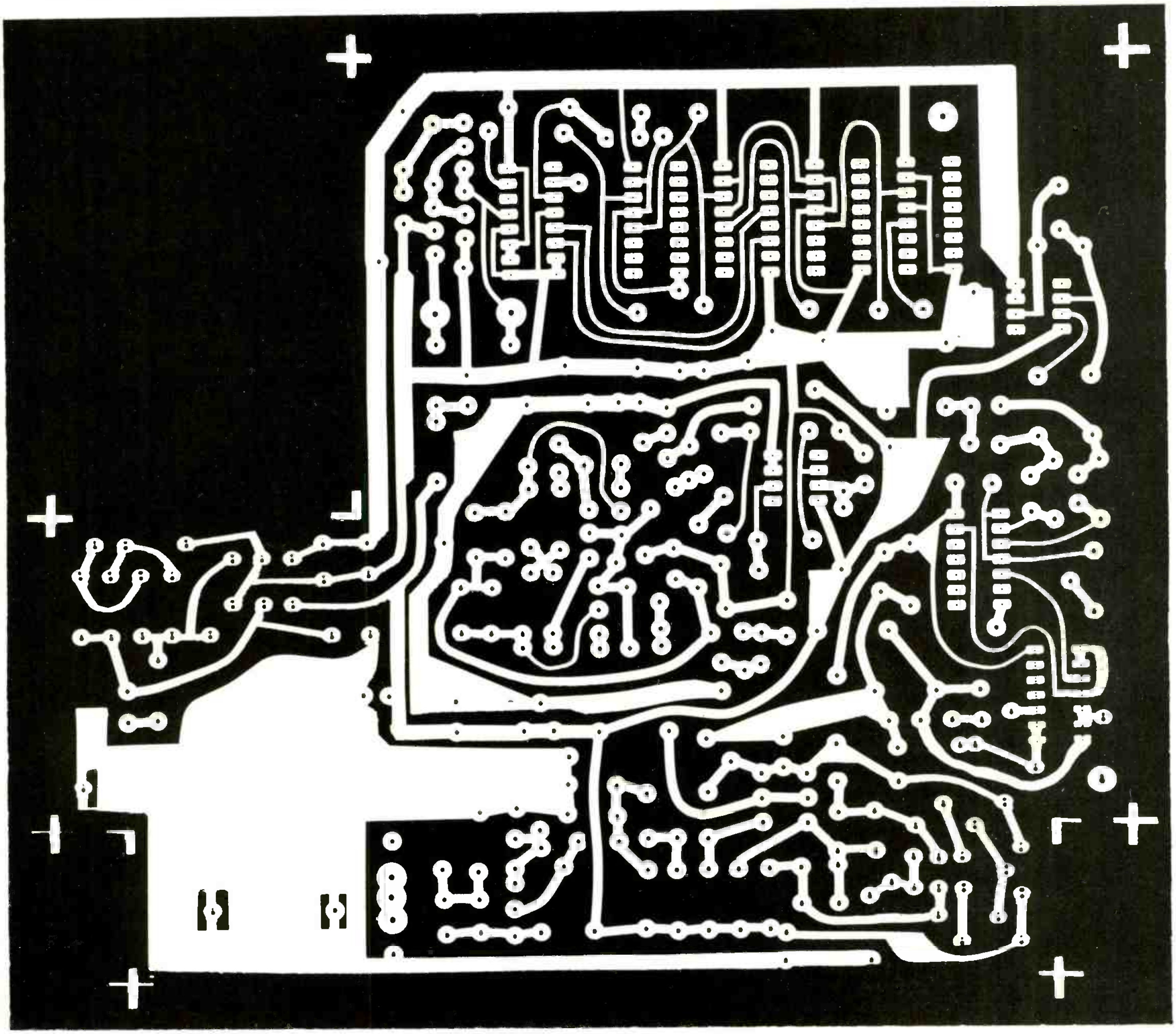


Fig. 4. Full-size etching and drilling guide of the project printed-circuit board.

mer $R47$ for a reading of $+10$ volts. This completes the calibration of the inductance-measurement function.

Fashion a capacitance-calibration network by connecting one lead of a 10-μF nonpolarized electrolytic capacitor to one side of a 2000-ohm, linear-taper potentiometer that is wired to act as a variable resistor. If a nonpolarized electrolytic capacitor is not available, use two 10-μF, 16-volt tantalum or aluminum electrolytic capacitors connected back-to-back (negative plate to negative plate) instead. Solder a short length of stranded hookup wire to the free lead of the nonpolarized capacitor and another to the uncommitted side of the potentiometer. Connect the probes of the multimeter across the potentiometer and set the meter to read resistance. Adjust the potentiometer for a reading of 1200 ohms $\pm 1\%$. Remove the ohmmeter probes.

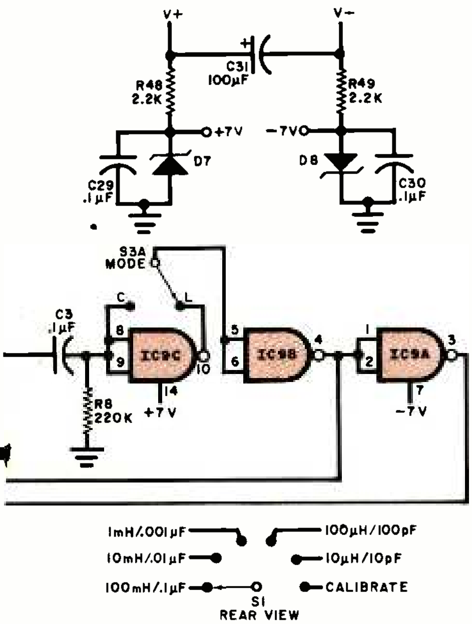
Taking care not to disturb the setting of the potentiometer, connect the leads of the capacitance-calibration network to binding posts *BP1* and *BP2*. Set the multimeter to read dc volts and connect its probes to *BP5* and *BP6*. Set the multimeter to read dc volts and connect its probes to *BP5* and *BP6*. Apply power to the project, place switch *S3* in its C position, and place *S1* and *S2* in their CALIBRATE positions. Adjust *R34* for a meter reading of $+10$ volts. This completes the calibration of the capacitance-measurement function.

Using the RMS. The equivalent circuit of a typical inductor (Fig. 6) contains shunt capacitance and series resistance as well as inductance. Thus, the frequency at which an inductance measurement is performed can influence the reading obtained. Therefore, it should be as close to the actual frequency the inductor will "see" in use as possible. The RMS test frequencies were chosen to meet this requirement for typical applications. Relatively low-value, air-wound coils are generally used in high-frequency applications where stability is important. Ferrite-core inductors are often employed when small size is important. They are usable from dc to approximately 100 MHz, depending on the ferrite mix employed in the manufacture of the core.

In a core inductor, the magnetic characteristics of the core, which include hysteresis and saturation, should be considered, especially if the core has high permeability. Such a component's effective inductance can be affected by the amplitude of the applied signal and any dc bias current flowing through it. Under test conditions, the peak signal voltage applied across L_X is approximately three-tenths of the project's dc output voltage. Under normal conditions, the RMS will apply no dc bias to the inductor under test and will not apply a large enough signal voltage to cause a typical core to saturate.

If inductance-value variation caused by the test signal is suspected, switch to the next higher inductance range. A large increase in measured inductance suggests that the core might have been

(Continued on page 76)



PARTS LIST

BP1 through BP6—Binding posts
C1,C2,C3,C5,C7,C16,C17,C21,C23,C29, C30,C37—0.1-μF, 50-V disc ceramic capacitor
C4—68-pF, 50-V disc ceramic capacitor
C6,C8,C18,C19—47-μF, 16-V, radial-lead electrolytic capacitor
C9—22-pF, 50-V disc ceramic capacitor
C10—0.001-μF, 50-V, 20%, Mylar or monolithic ceramic capacitor
C11,C43—0.01-μF, 50-V, 20%, Mylar or monolithic ceramic capacitor
C12—0.1-μF, 50-V, 20%, Mylar or monolithic ceramic capacitor
C13,C35,C38 through C42—1-μF, 16-V, 20% tolerance tantalum capacitor
C14,C20,C36—22-μF, 16-V, radial-lead electrolytic capacitor
C15—6.8-μF, 16-V, radial-lead electrolytic capacitor
C22—100-μF, 16-V, radial-lead electrolytic capacitor
C24—47-pF, 50-V disc ceramic capacitor
C25,C26—100-pF, 50-V disc ceramic capacitor
C27,C28—10-μF, 16-V, radial-lead electrolytic capacitor
C31—100-μF, 50-V, radial-lead electrolytic capacitor
C32,C33,C44—1000-μF, 25-V, axial-lead electrolytic capacitor
C34—10-μF, 16-V tantalum capacitor
D1 through D4—1N4001 rectifier
D5, D6—1N914 or 1N4148 silicon switching diode
D7,D8—6.8-V, 1-W zener diode (1N5235 or equivalent)
F1—½-ampere fast-blow fuse
IC1—CD4027 J-K flip-flop
IC2 through IC5—CD4017 decade counter
IC6, IC7—μA741CV operational amplifier
IC8—CD4016 quad bilateral switch
IC9—CD4011 quad 2-input NAND gate
IC10—LM340T-12 +12-volt regulator
IC11—LM320T-12 −12-volt regulator
LED1—Red light-emitting diode
Q1,Q2,Q5,Q7,Q8,Q10,Q11,Q13,Q15—2N5129 npn silicon transistor
Q3,Q6,Q9—2N5139 pnp silicon transistor
Q4,Q12—2N918 npn silicon transistor
Q14—2N5457 n-channel JFET
The following, unless otherwise specified, are ¼-W, 10%, carbon-composition fixed resistors.
R1,R4—100 Ω
R2,R5,R10,R14,R33,R37,R48,R49,R53—2.2 kΩ
R3,R51—1.5 kΩ
R6,R21,R26,R30—4.7 kΩ
R7,R19,R23—47 kΩ
R8—220 kΩ
R9,R13,R15,R25,R36,R38,R43,R45,R50—10 kΩ
R11,R12,R27,R28,R32,R41,R42—470 Ω
R16,R17—100 kΩ
R18,R24,R31,R40—6.2 kΩ
R20—3.3 kΩ
R22—27 kΩ
R29—5.1 kΩ
R34,R39—10-kΩ, linear-taper trimmer potentiometer
R35—5.6 kΩ
R44,R46—39 kΩ
R47—200-kΩ, linear-taper trimmer potentiometer
R52—22 kΩ
S1—Two-pole, six-position rotary switch
S2—Spdt toggle switch
S3—Dpdt toggle switch
S4—Spst toggle switch
T1—25.2-V, 300-mA, center-tapped step-down transformer
XTAL—2.0-MHz quartz crystal
Misc.—Printed-circuit board, IC sockets or Molex Soldercons, fuseholder, line cord, sutable enclosure, strain relief, pc standoffs, suitable hardware, hookup wire, solder, etc.

Note—The following are available from BNB Kits, 72 Cooper Avenue, West Long Branch, NJ 07764: Kit of parts including all components and etched and drilled printed-circuit board but not including enclosure, No. RMS-1, for $129.95 postpaid in U.S.; etched and drilled printed-circuit board only, No. RMS-PC, for $21.95 postpaid in U.S.A. New Jersey residents, add state sales tax.

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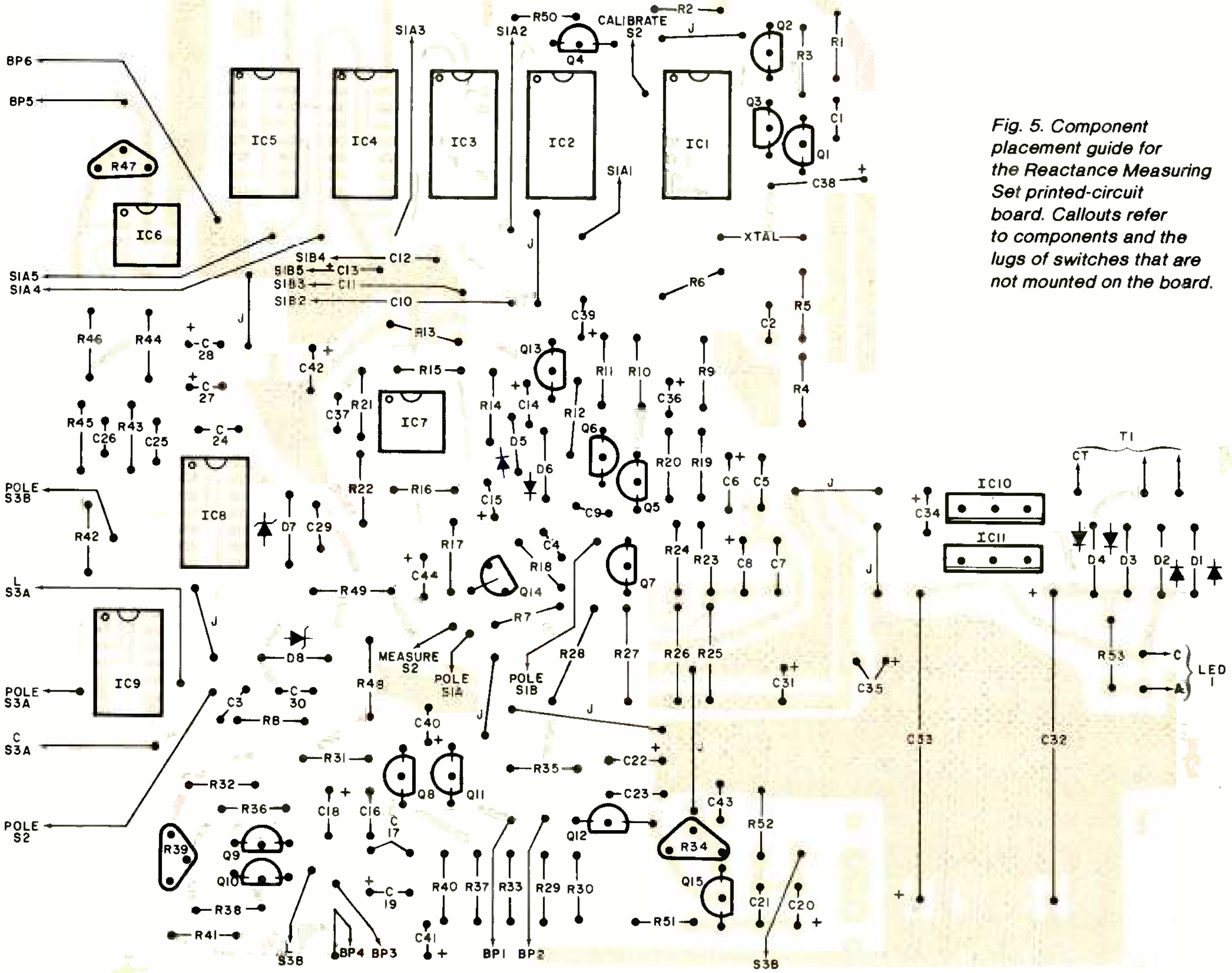


Fig. 5. Component placement guide for the Reactance Measuring Set printed-circuit board. Callouts refer to components and the lugs of switches that are not mounted on the board.

measured in series with the reference inductor and measure the inductance of the series combination. Subtract the recorded inductance of the reference inductor from this new value. The remainder is the value of the unknown. If reasonable care is taken, this technique will yield good results and offer resolution to 0.1 μH. Keep in mind, however, that, at such low levels of inductance, the proximity of a metallic object, your body, or the effects of mutual inductance can significantly influence measured values.

The equivalent circuit of a typical capacitor is shown in Fig. 7. Although practical capacitors whose values lie within the measurement range of the RMS more closely approach the ideal than inductors do, it is worth noting two of their peculiarities.

During the charge/discharge cycle, a portion of the applied charge is retained by the dielectric. This *dielectric absorption* increases with frequency and reduces a component's effective capacitance. It is generally not separately specified but lumped with other loss components.

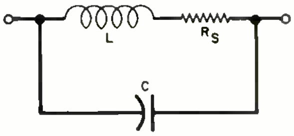


Fig. 6. The equivalent circuit of a typical inductor contains inductance, series resistance and shunt interwinding capacitance.

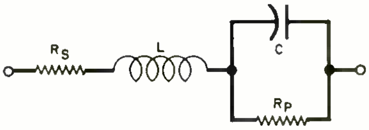


Fig. 7. The equivalent circuit of a capacitor consists of the capacitance and parallel leakage resistance in series with lead and foil-winding inductance and lead resistance.

Capacitors, too, have self-resonant frequencies. This is due to stray inductances contributed by foil windings and lead inductances. The self-resonant frequency is really a figure of merit. If the frequency at which the measurement is performed is near the self-resonant frequency, misleading data will result.

The RMS will provide sufficient accuracy for most applications. If you have an inventory of bargain-basement capacitors, you might notice that the voltmeter reading will not settle or will appear to drift. Either condition indicates that the capacitor is unstable and should be used only in the most noncritical applications. To measure small values of capacitance, the use of a differential measurement technique similar to the one described for inductors is recommended. Measure and record the value of a reference capacitor of about 30 to 50 pF. Then place the unknown capacitor in parallel with the reference capacitor and measure the capacitance of the combination. Subtract the previously recorded reading from this new reading. The remainder is the value of the unknown. Due to the good linearity of the RMS within its useful range, this method will yield an accurate reading with resolution of 0.1 pF. Keep in mind that proximity effects can have great influence on measurements.

If the value of the capacitor under test is completely unknown, always start measurement at a range which is much higher than a reasonably expected value. The RMS can give a misleading capacitance reading in an extreme overrange condition.

Another Use. The RMS can be a handy frequency standard. The crystal oscillator and its associated divider stages will provide five decade-related frequencies from 100 Hz to 1 MHz (on the 100 mH/volt to 10 μH/volt ranges, respectively). For example, to use the RMS to provide marker frequencies spaced 100 kHz apart on a shortwave radio, place switch *S1* in its 100 μH/VOLT position and connect an 800-μH inductor to *BP3* and *BP4*. Couple the inductor to the r-f input stage of the receiver by placing it closer to that portion of the receiver enclosure directly above that stage. If the strength of the marker signals is too great, decrease either the value of the inductor or the coupling between it and the receiver.

Basic accuracy of the RMS is conservatively rated at ±5% of its *reading*, except on the lowest range, where the accuracy is approximately ±10% of the reading. Therefore, if a 3½-digit DVM is used with the RMS, on the project's lowest range, measurements will be resolved to the nearest 0.1 pF or 0.1 μH. Reliance should be placed, however, only on the two most significant digits displayed. The differential-measurement technique will permit resolution to 0.1 pF or 0.1 μH with the 10% accuracy of the lowest range. Accuracy could be improved if you have access to precision (±0.1%) inductors and capacitors, but, as a practical matter, such accuracy is rarely needed.

The RMS permits fast, convenient, and unambiguous measurement of inductance and capacitance over a wide range of values. Understanding its limitations and the nature of components it measures, you will find it a valuable addition to your test bench. ◇

BUILD A HIGH-PERFORMANCE PHONO PREAMPLIFIER

BY JOHN ROBERTS

Features low noise and distortion and allows choice of cartridge types

ALTHOUGH the phono preamp is often taken for granted, it has a critical and difficult job to perform. The preamp must boost signals on the order of a few millivolts or less to usable levels and, at the same time, compensate for the preemphasis applied to the recorded signals. A further task is to form an appropriate interface with the phono cartridge.

To perform adequately, a preamp must obviously have low noise and low distortion. The circuit must also offer accurate equalization and good input characteristics. To many circuit designers, these requirements are contradictory, resulting in designs in which one or more aspects of phono-preamplifier performance are compromised.

To circumvent some of these compromises, the design given here (Fig. 1) combines high-slew-rate BiFET op amps with discrete devices to form an "instrumentation amplifier" input stage. For fixed-coil pickups (moving-magnet, moving-iron, and similar designs), with their relatively high impedance and signal levels, a low-noise, n-channel, JFET device offers noise performance equal to the best bipolar op amp and an input impedance many times higher. Moving-coil pickups, which have low output impedances and levels, are coupled to ultra-low-noise pnp transistors for noise performance ten times better than the best bipolar op amp with comparable input impedance.

About the Circuit. With the exception of input devices and first-stage gain, the fixed- and moving-coil versions are almost identical (Fig. 2). The cartridge output is applied to the circuit's differential input stage and is amplified by 30 dB (60 dB in the MC version). Any undesired, common-mode signals pass through unamplified. The following stage, a differential-to-single-ended converter, adds the oppositely phased signal components and subtracts the common-mode components. This provides excellent rejection of unwanted signals.

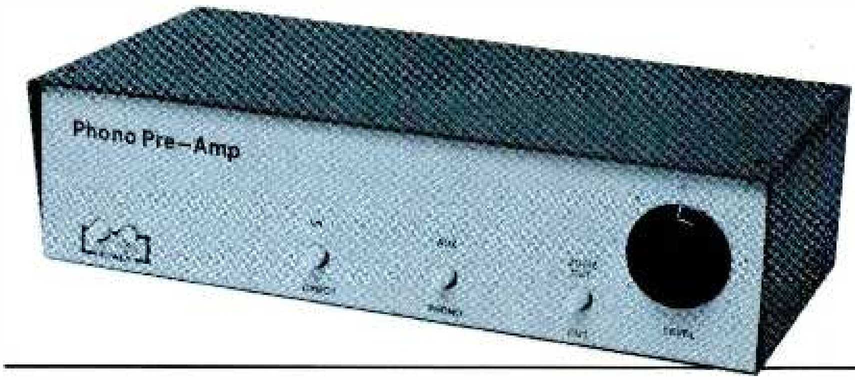
The next stage, containing the playback equalization, is built around a precision deemphasis network. Preemphasis and complementary deemphasis are specified by the Recording Industries Association (RIAA) as a set of time constants. The lowest pole (the frequency at which rolloff begins) in playback response is given as 3180 μs, corresponding to 50 Hz ($f = 1/2\pi T$, where T is the time constant). Below 50 Hz, response is flat. Above this frequency, it falls at −6 dB/octave until the frequency corresponding to the next time constant, at 318 μs (500 Hz). From 500 Hz to the frequency corresponding to the smallest time constant, 75 μs (2122 Hz), response is again flat, rolling off above 2122 Hz at −6 dB/octave. The original standard only specified response from 30 to 15,000 Hz, but it was recently extended to cover 20 to 20,000 Hz.

No problem is caused by the extended high-frequency response (most designers had been doing this all along), but maintaining flat response to 20 Hz limits the amount of attenuation in the 5-10-Hz warp region. To counter this, the International Electro-Technical Commission (IEC) has proposed a fourth time constant of 7950 μs (−3 dB at 20 Hz) be added to the RIAA playback standard (see "Build a Disco Mixer," POPULAR ELECTRONICS, September 1978). The −6-dB/octave rolloff starting at 20 Hz that would result attenuates warp signals and, to a slight extent, some of the program material as well (−1 dB at 40 Hz). To date, the proposal has not been accepted by the RIAA. This preamp adheres to the RIAA standard, but offers the IEC characteristic as a switch-selectable option.

To reduce warp and infrasonic signals and still maintain flat response down to 20 Hz, a 2-pole active high-pass filter, tuned to 10 Hz has been added. Below 10 Hz, the response rolls off at −12 dB/octave. When the IEC time constant is switched in, the resulting response falls at −18 dB/octave below 10 Hz. A ±1-dB trimmer built into the filter allows gain adjustment between the channels for proper balance.

Up to this point in the chain, the signal has been amplified 34 dB (at 1 kHz). An additional 16 dB of gain is subsequently provided for more than is necessary to meet the nominal RIAA gain standard (40 dB at 1 kHz). Some benefit accrues from the fact that this gain is adjustable. High-output cartridges are provided with 6 dB more of overload margin, and low-output cartridges can be amplified up to 10 dB more.

A high-level buffer and selector switch just before the volume control allow a line-level signal to be introduced past the phono equalization/gain stages. This capability facilitates several possible interconnections with an existing system. The project can drive the power amp directly, with the existing control preamp feeding the AUX input. Alternatively, the project can drive a line-level input of the existing preamp, with the



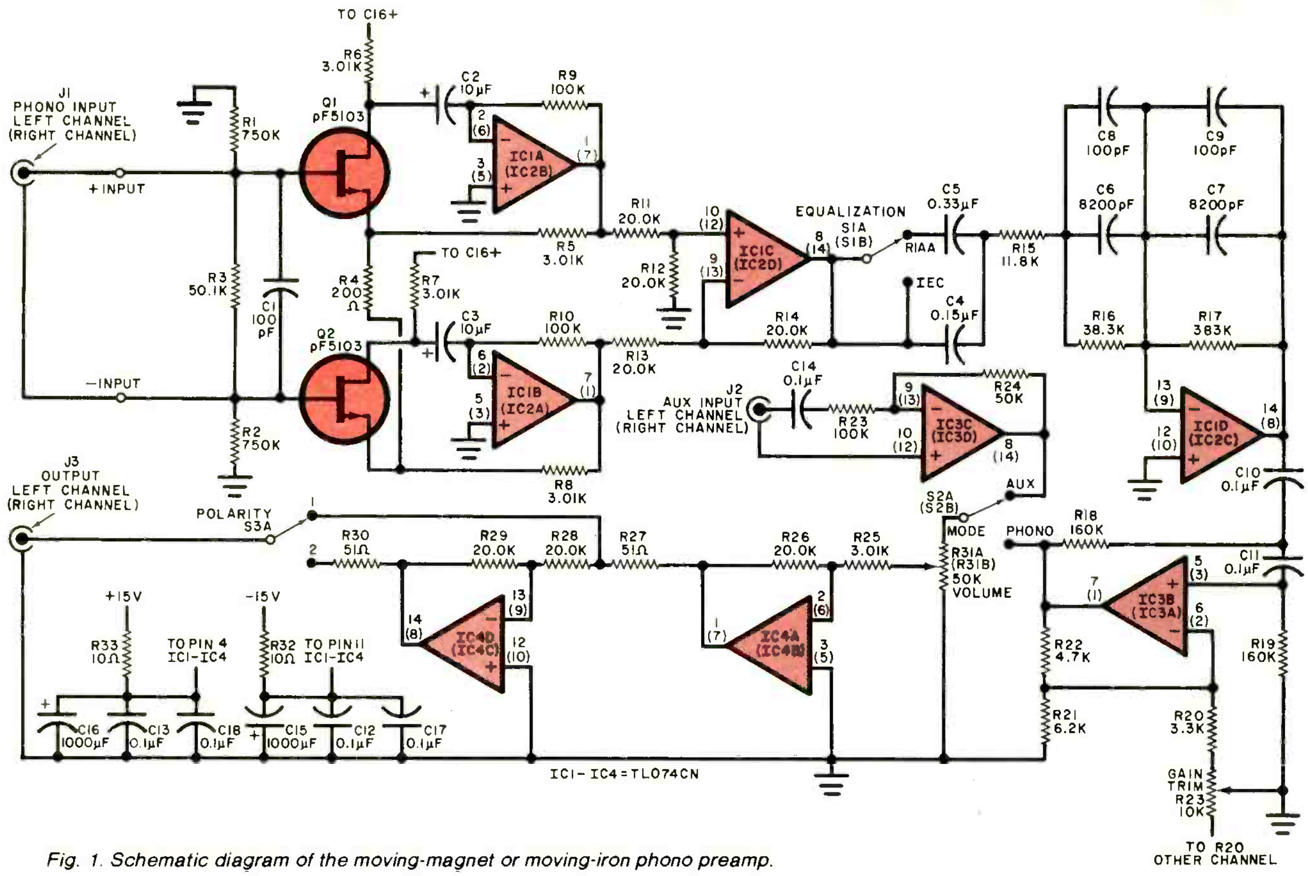


Fig. 1. Schematic diagram of the moving-magnet or moving-iron phono preamp.

PARTS LIST

(Unless marked by a *, two of each component are required for a stereo preamp.)

C1,C8,C9—100-pF, 5% polystyrene capacitor

C2,C3—10-µF, 50-V radial-lead aluminum electrolytic capacitor

C19*—Same as C2 and C3, but used in moving-coil preamp only.

C4—0.15-µF, 10% Mylar film capacitor

C5—0.33-µF, 10% Mylar film capacitor

C6,C7—8200-pF, 1% polystyrene capacitor

C10,C11,C14—0.1-µF, 5% Mylar film capacitor

C12*,C13*,C17*,C18*—0.1-µF, 50-V disc ceramic capacitor

C15*,C16*—1000-µF, 50-V radial-lead aluminum electrolytic capacitor

IC1* through IC4*—TL074CN quad BiFET operational amplifier

J1,J2,J3—Phono jack (J1 must be an insulated jack)

Q1,Q2—Matched pair of pF5103 low-noise JFETs (moving-magnet/iron version of the project)

Q1,Q2—2SB7375 very-low-noise pnp silicon BJT (moving-coil version)

The following, unless otherwise specified, are ¼-watt, 5% tolerance, carbon-film fixed resistors.

R1,R2—750 kΩ

R3,R24—50.1 kΩ, ⅛-W, 1% metal-film

R4—200 Ω

R5,R6,R7,R8,R25—3.01 kΩ, ⅛-W, 1% metal-film

R9, R10—100 kΩ

R35*—same as R9 and R10, but used in moving-coil preamp only

R11,R12,R13,R14,R26,R28,R29—20.0 kΩ, ⅛-W, 1% metal-film

R15—11.8 kΩ, ⅛-W, 1% metal-film

R16—38.3 kΩ, ⅛-W, 1% metal-film

R17—383 kΩ, ⅛-W, 1% metal-film

R18,R19—160 kΩ

R20—3.3 kΩ

R21—6.2 kΩ

R22—4.7 kΩ

R23*—10 kΩ, pc-mount, screwdriver-adjust, linear-taper potentiometer

R27,R31—51 Ω

R31*—50 kΩ, B-volume-taper, panel-mount dual potentiometer

R32*,R33*—10 Ω

R34*—33 kΩ

S1*, S2*, S3*—Pc-mount push/push dpdt switch

Misc.—Printed circuit board, standoffs, suitable metallic enclosure, hookup wire, shielded cable, suitable hardware, hum shield, solder, etc.

KIT AND PARTS AVAILABILITY

The following are available from Phoenix Systems, 91 Elm St., Manchester, CT 06040 (Tel: 203-643-4484): complete kit of parts, including enclosure but not the optional phono-cartridge input loading network, for the moving-magnet or moving-iron phono preamplifier, No. P-10-MM, for $99.00; complete kit of parts, including enclosure but not the optional phono-cartridge input loading network, for the moving-coil phono preamplifier, No. P-10-MC, for $99.00. Also available separately are: complete kit of parts for the optional phono-cartridge input loading network, No. P-10-IL, for $10.00; etched and drilled main printed-circuit board, No. P-10-PB, for $10.00; ST-4-28 power transformer, No. P-10-T, for $6.50; pair of matched, low-noise 2XpF5103 JFETs, No. P-10-FETS, for $5.00; etched and drilled power-supply printed-circuit board, No. P-10-PSB, for $4.00; dual 50,000-ohm, B-volume-taper potentiometer, No. P-10-DP for $2.50; TL074CN quad BiFET operational amplifier, No. P-10-OA, for $2.50; very-low-noise 2SB7375 pnp bipolar junction transistor, No. P-10-BJT, for $2.00; 8200-pF, 1% tolerance polystyrene capacitor, No. P-10-PCAP, for $1.00. If total is under $10.00, add $1.00 for handling. All prices postpaid in continental U.S. Connecticut residents, add 7½% tax.

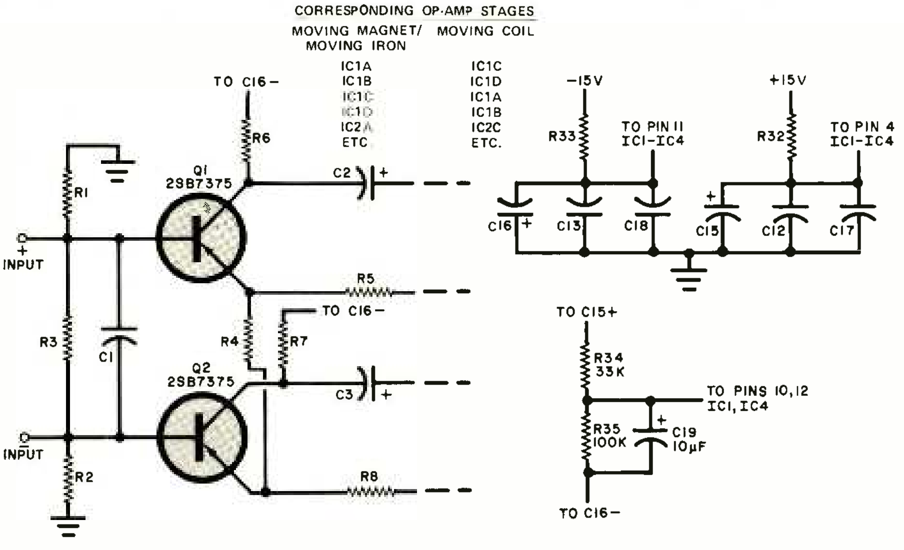


Fig. 2. Partial schematic shows changes required to convert the circuit of Fig. 1 into a moving-coil phono preamp.

phono preamp's AUX input providing the existing preamplifier's line-level input that would otherwise be lost.

The final stage, a polarity inverter, is partly a concession to those who insist that the absolute polarity of musical waveforms be maintained and partly to facilitate experiments to test their hypothesis. As there is no way to ensure that the polarity of a signal radiated by a speaker matches that of the original acoustic signal, there is a 50/50 chance that the switch will be in the right position. You can try both positions and see if you hear a difference. (I have never found any.) The schematic of a power supply for the preamp is shown below in Fig. 3.

For a phono cartridge to deliver the performance its designer intended, it should be loaded with the proper combination of resistance and capacitance. The preferred method is to solder resistors and capacitors of appropriate values directly across the preamp inputs, but this makes changing loading to suit different cartridges a major chore. The task is simplified by an optional, switchable input load (Fig. 4) that can be adjusted in 25-pF steps. The DIP switch specified has gold/gold contacts. (It is a good idea to exercise the switch once every year or two.)

To determine the correct load capacitance, refer to the manufacturer's literature. Subtract from this the fixed capacitances already present in your system, including those of the tonearm and hookup cables. That of typical shielded cable is 25 to 30 pF/ft. Low-capacitance (CD-4) cable has somewhat less. Next, add the input capacitance of the preamp. (The fixed-coil version has about 110 to 115 pF nominal.) If the total fixed capacitance is close to what is required, you can make up small differences by substituting cables or, if this isn't enough, by changing the value of *C1*. But don't eliminate *C1* entirely.

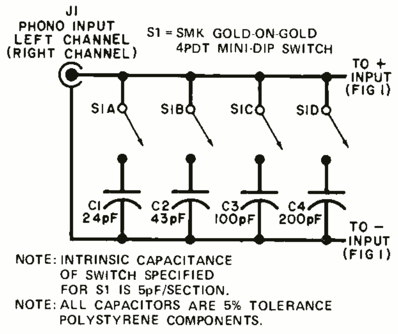


Fig. 4. Schematic diagram of the optional, switchable input load.

Once you have calculated the system's total fixed capacitance, record it to save trouble in the future. Finally, subtract the fixed capacitance from the required capacitance and, if necessary, switch in enough to make up the difference. Note, however, that the loading network is intended for fixed-coil cartridges only.

Construction. It is preferable to use a pc board (Figs. 5, 6, and 7). Component layout (Figs. 8 to 11) is similar for the moving-coil and fixed-coil configurations, but there are changes in power-supply connections and IC, transistor, and polarized-capacitor orientation. Rather than design two different pc boards, we can take advantage of the symmetry of the TL074 op amps and rotate them 180 degrees when reversing the power supplies. Take care to follow the appropriate parts-placement diagram closely. Note that *Q1* and *Q2* are JFETs in the fixed-coil circuit and BJTs in the moving-coil preamp. Be sure to

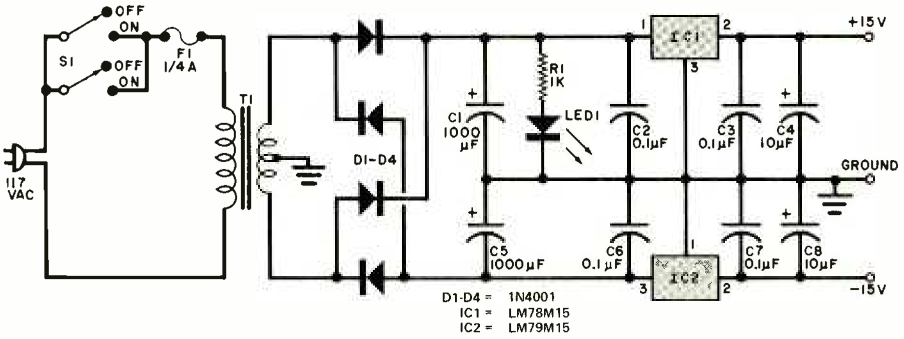


Fig. 3. Schematic diagram of the supply that can be used to power either the moving-magnet/iron or moving-coil phono preamp.

POWER SUPPLY PARTS LIST

C1,C5—1000-μF, 35-V, radial-lead aluminum electrolytic capacitor
C2,C3,C6,C7—0.1-μF, 50-V disc ceramic capacitor
C4,C8—10-μF, 25-V radial-lead aluminum electrolytic capacitor
D1 through D4—1N4001 rectifier
F1—¼-ampere fast-blow 3AG-type fuse with pigtail leads
IC1—LM78M15 +15-V regulator
IC2—LM79M15 −15-V regulator
LED1—Light-emitting diode
R1—1000-ohm, ¼-W, 5% fixed carbon-composition resistor
S1—Pc-mount, push/push dpdt switch
T1—28-V, 250-mA, center-tapped pc-mount transformer (Signal Transformer No. ST-4-28 or equivalent)
Misc.—Printed circuit board, standoffs, line cord, strain relief, hookup wire, metal shield, solder, suitable hardware, etc.

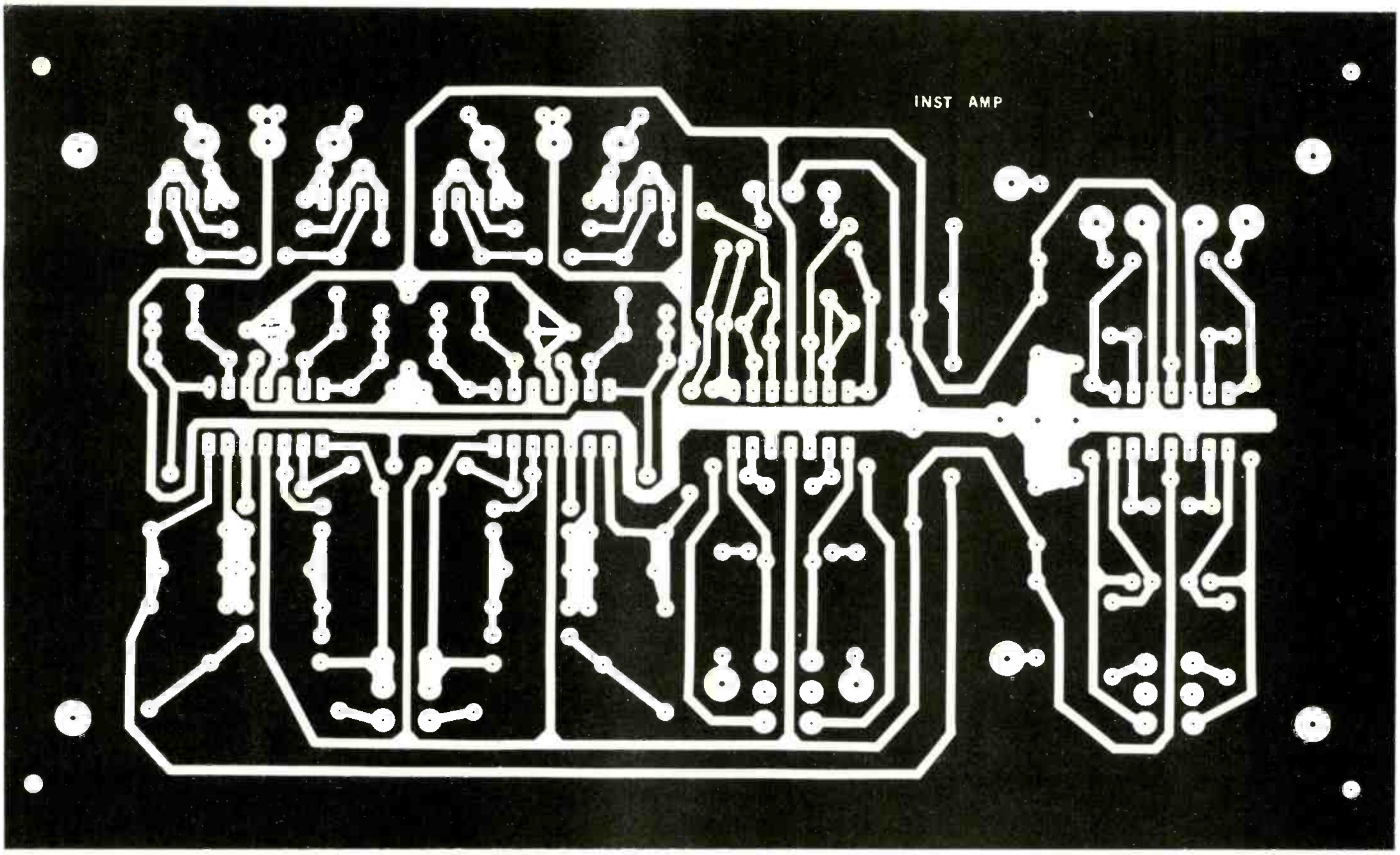


Fig. 5. Full-size etching and drilling guide for the project's main pc board.

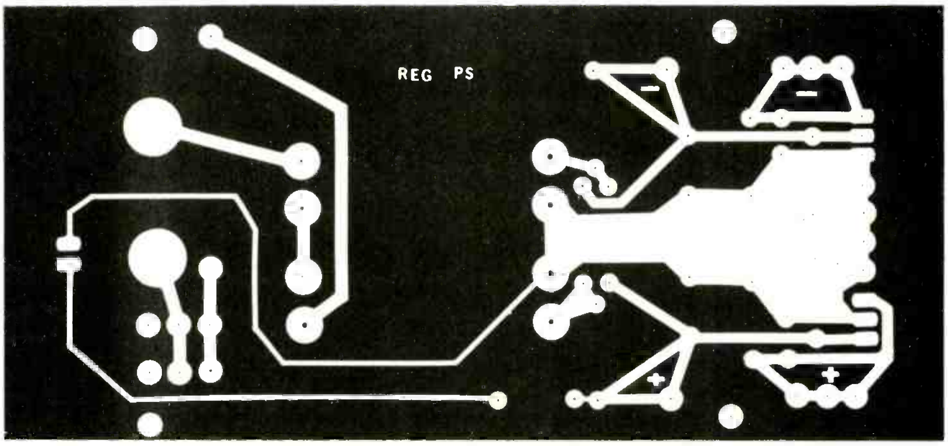


Fig. 6. Full-size etching and drilling guide for the power supply's printed circuit board.

use a hum shield on the end of the main board next to the power supply board as shown in the photo. The shield can be made of a piece of 1/32-inch aluminum stock 2 1/4" x 4" with one side folded and drilled for mounting in existing holes on the board.

JFET and BiFET op amps are not as sensitive to static discharge as MOS devices. However, recent research has shown that all components can be damaged by static so reasonable caution should be exercised. When assembling the optional input-load board, be sure to have capacitor markings facing up. You can then read them easily when changing loading. The banded end of a polystyrene capacitor denotes its outside foil plate and should be connected to ground to suppress hum.

The input-load board should be mounted inside the preamp's metallic enclosure near the phono input jacks. Use insulated jacks or, better yet, hard-

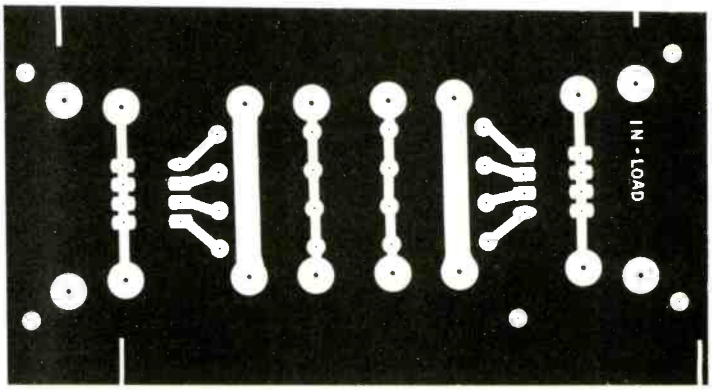


Fig. 7. Etching and drilling guide for the optional input load.

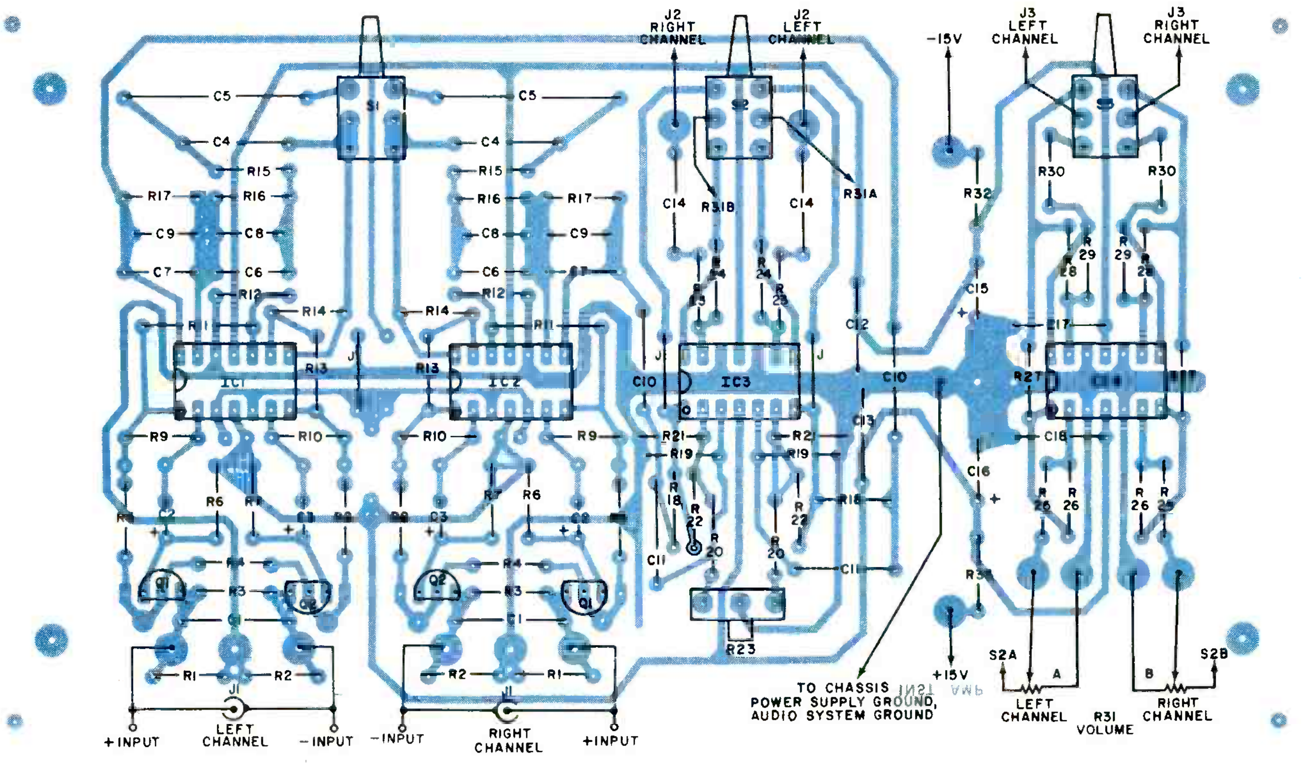


Fig. 8. Component placement guide for the main printed-circuit board.

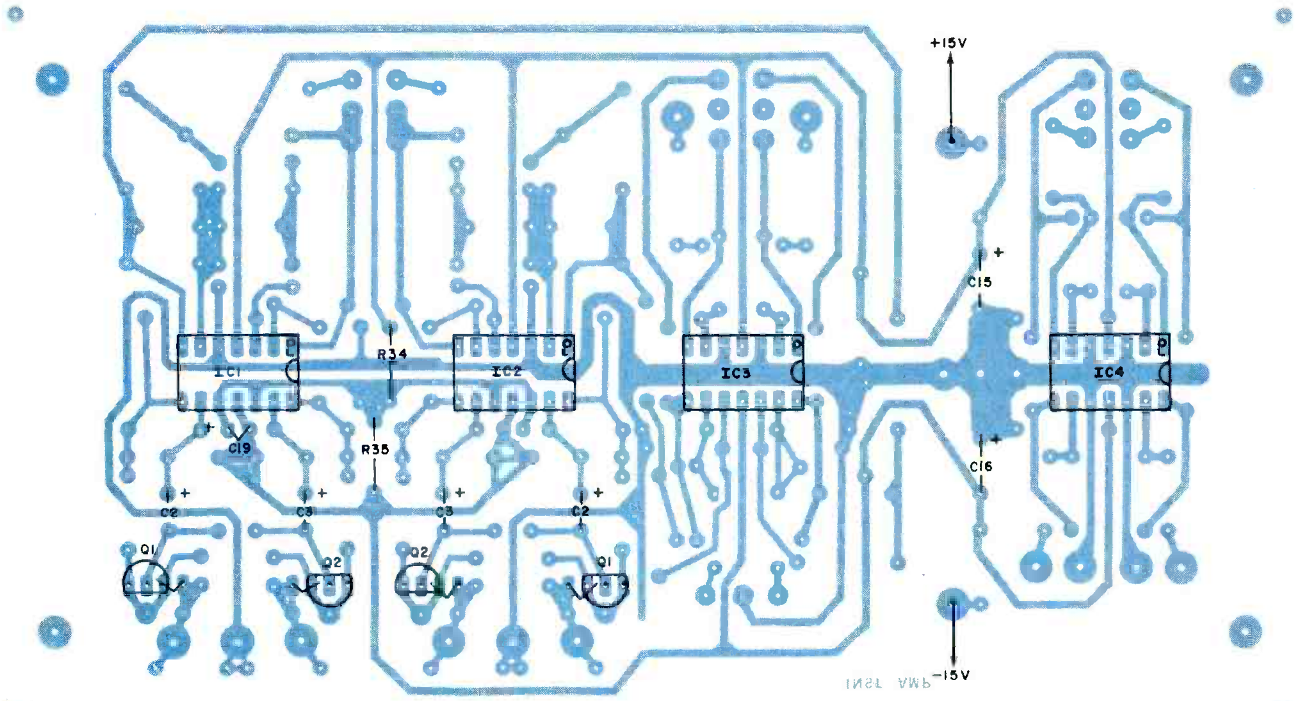


Fig. 9. Component placement guide reflects changes with respect to Fig. 8. that must be made for assembly of a moving-coil phono preamp.

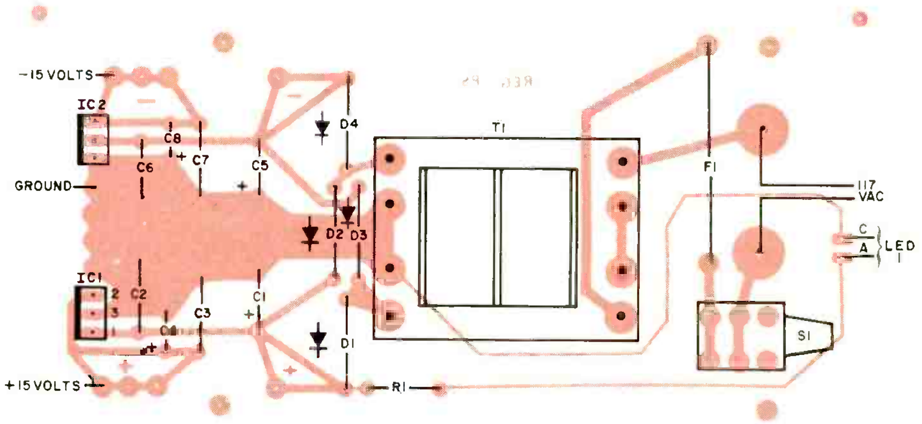


Fig. 10. Component placement guide for the power supply pc board.

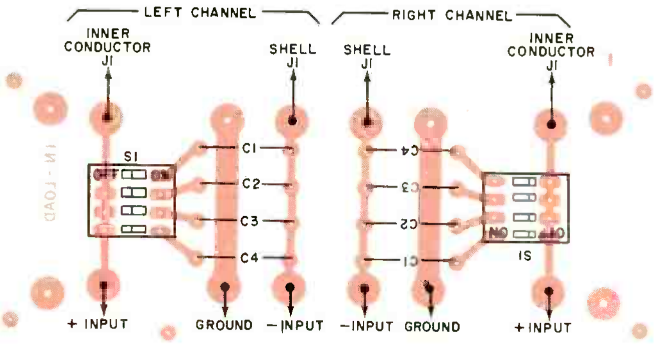
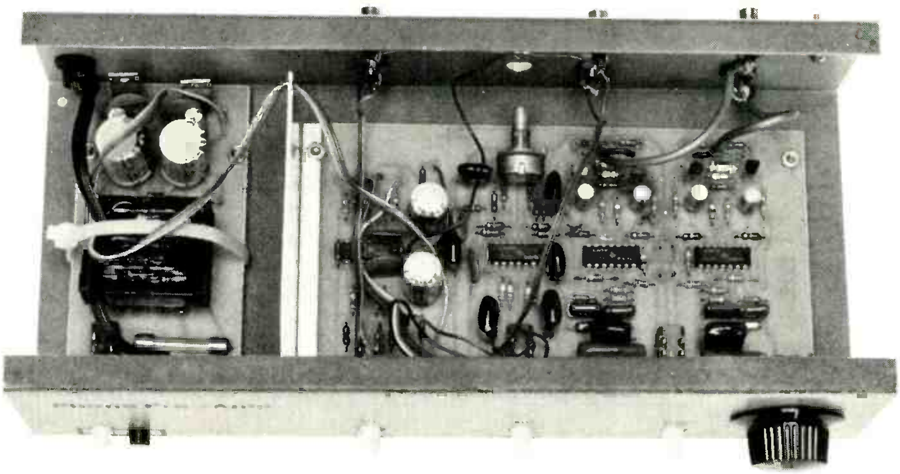


Fig. 11. Component placement guide for the optional, adjustable capacitive phono-cartridge loading network.



Photograph of the author's prototype reveals construction details and the presence of a metal shield between the main and power-supply pc boards.

wire quality phono cables directly to the board. Be sure to include a ground terminal connected to both the metallic enclosure and the ground bus. The turntable ground lead will be attached to this terminal.

Use. Connection of a phono preamp into an audio system is straightforward and will not be reviewed here. Remember, though, to balance the right and left outputs of the cartridge by adjusting *R23* for equal levels from both channels while playing a monophonic disc. If you include the input load board, take the time to adjust it as well. Having completed these steps, you can enjoy your system secure in the knowledge that your phono preamp is close to the state of the art. ◇

BUILD AN

AUTOMATIC LINE VOLTAGE REGULATOR

When your line voltage nosedives, this circuit gives a 6-volt boost

BY HERBERT ELKIN *

DO YOUR lights go dim, does your TV picture shrink and lose brightness, or are your ac appliances acting as though they're just plain tired? You may be living in an area subject to "brownouts" (low power-line voltage), and the solution to your troubles could well be some form of voltage regulation.

The automatic line voltage regulator described in this article will automatically raise power-line voltage by about six volts whenever it drops below a preset level. When the line voltage returns to normal, the compensation automatically drops out. (See Fig. 1.)

Circuit Operation. Filament transformer *T1* is connected with its 6.3-volt secondary in series with the primary so that the two voltages add. Relay *K1* taps an output from the primary alone or from the combined windings. The remainder of the circuit senses the output voltage and sets (or resets) *K1* to switch the extra winding in or out as needed.

As can be seen from Fig. 1 and the waveforms of Fig. 2, capacitor *C1* follows the swings of the fraction of the power-line voltage developed across the *R2* portion of voltage divider *R1-R2*. Potentiometer *R2* is adjusted so that the peak voltage across *C1* just reaches the firing level of neon lamp *I1* when the voltage across *R1-R2* reaches the level where automatic compensation is not required. The neon lamp breaks down and applies a positive pulse to the gate of *SCR1*, causing the SCR to turn on and hold relay *K1* in the position that directs the normal line voltage to the output. The SCR, then turns off when the power-line voltage passes through zero. The neon lamp fires on each positive half cycle, allowing its glow to be used as a "normal" line voltage indication. During the negative half cycles, diode *D1* clamps *C1* to circuit ground, thus keeping the neon lamp "off" and preventing the negative pulse from being applied to the SCR gate.

Because its drive switches on and off at power-line frequency, relay *K1* would normally "chatter". Capacitor *C4*, connected across the relay coil, prevents this problem as it charges when the SCR fires to provide both filtering (due to rectification of the ac voltage by *SCR1*),

*Loral Electronic Systems, Yonkers, NY.

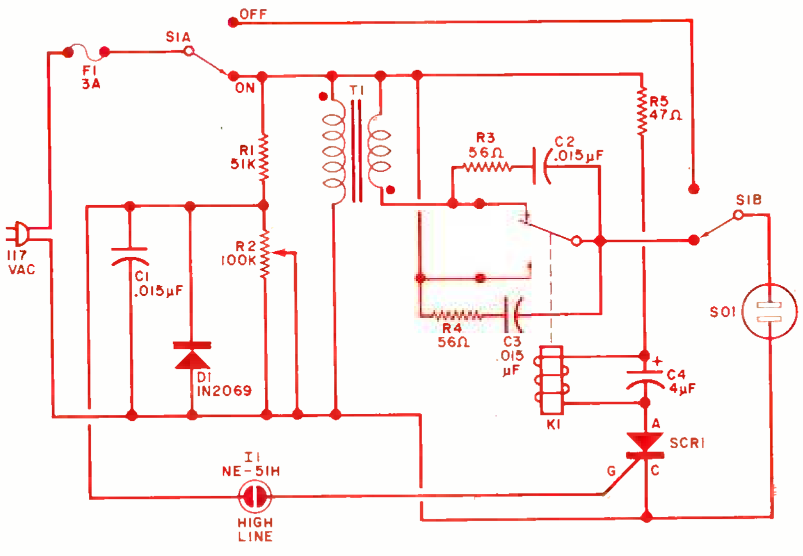


Fig. 1. When line voltage drops, K1 adds the 6.3-V secondary of T1 in series with the line to raise the output at SO1.

PARTS LIST

C1,C2,C3—0.015-µF, 400-volt ceramic capacitor
C4—4-µF, 250-volt electrolytic
D1—1N2069, 1-ampere, 200-PIV rectifier
F1—3-ampere, slow-blow fuse with holder
I1—NE-51H neon lamp assembly (Dialco 95-0463-0931-211 or similar)
K1—2pdt, 48-volt, 2500-ohm relay (Sigma 62R2-48DC-SCO or similar)
R1—51,000-ohm, ½-W, 10% resistor
R3,R4—56-ohm, ½-W, 10% resistor
R5—47-ohm, ½-W, 10% resistor
R2—100,000-ohm, multi-turn pot.
S1—2pdt switch
SCR1—4-ampere, 200-PIV silicon controlled rectifier
T1—6.3-V 3-A, filament transformer
Misc.—Ac receptable (SO1), terminal strip, suitable enclosure, spacers, mounting hardware, etc.

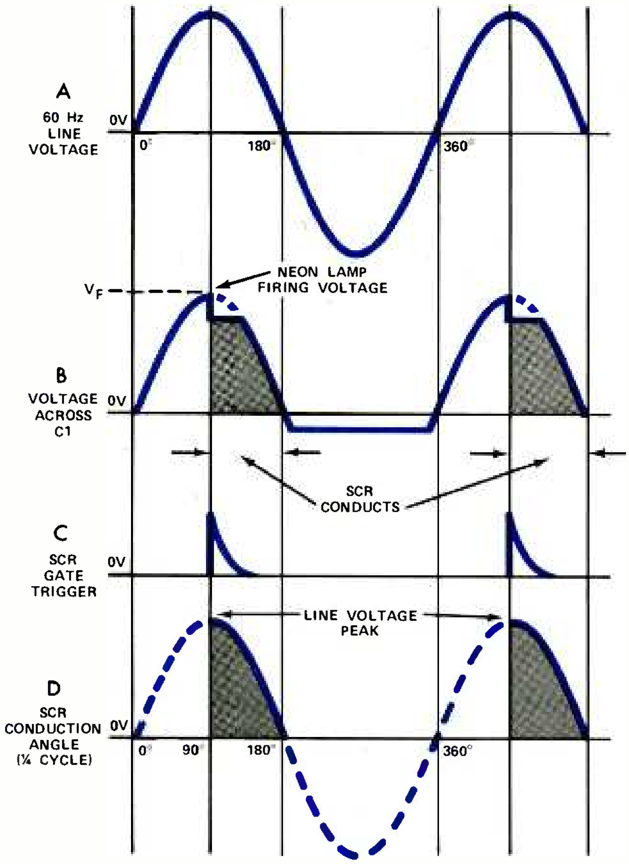
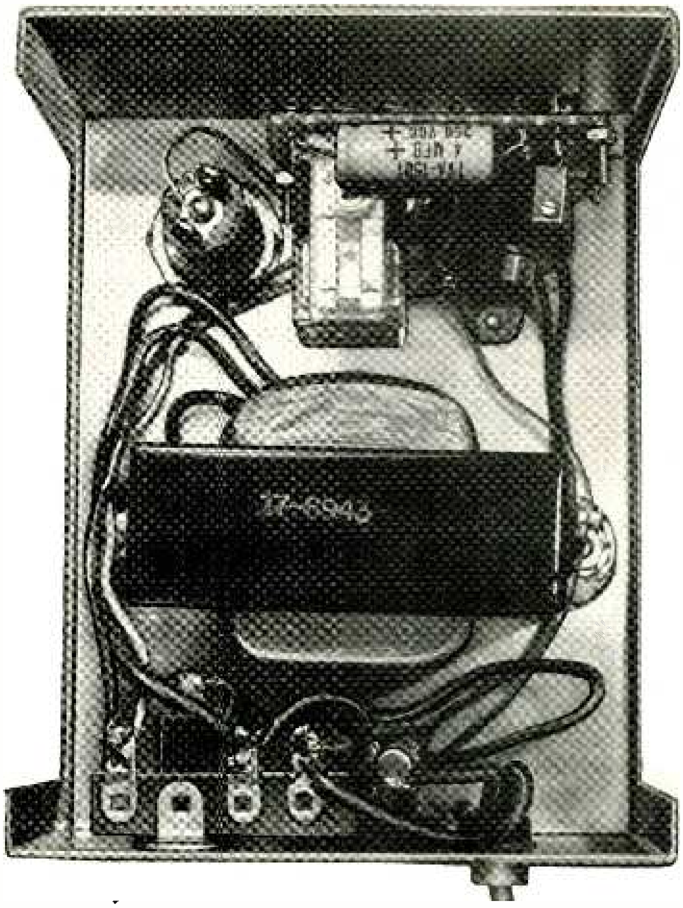


Fig. 2. Waveform at (A) is line voltage; (B) is voltage across C1; (D) is SCR conduction angle.



Interior photo of the prototype regulator. Components can be mounted on pc or perf board.

and relay-coil holding current when the SCR is off.

The networks consisting of *R3-C2* and *R4-C3* form arc-suppression circuits to minimize relay contact pitting, while *R5* limits SCR surge current to a safe value. Using the parts shown in Fig. 1, appliances drawing up to 350 VA can be controlled. For higher power, a larger transformer and a relay with heavier contacts can be used. Make sure that fuse *F1* is a slow-blow type to accommodate any turn-on surge currents. To bypass the compensation circuit, switch *S1* can be set to OFF.

Construction. With the exception of transformer *T1*, output socket *SO1*, neon lamp assembly *I1*, and on/off switch *S1*, all components can be mounted on a small pc board—or a perf board, using point-to-point wiring. The board can be mounted in any type of enclosure that can accommodate all of the components. The line cord exits through a grommetted hole.

A terminal strip with *nongrounded* lugs must be used for the transformer leads and ac power connections. If a metal enclosure is used, it is important that it be isolated from *both* sides of the power line to prevent a shock hazard.

The windings of *T1* can be phased using the setup shown in Fig. 3. Temporarily connect one secondary lead to one side of the primary as shown. Very carefully (to avoid shock), measure and note the voltage appearing across the transformer primary alone. This is the line voltage. Then measure the voltage across the combined primary/secondary and note that it is 6.3 volts higher. If the voltage indication is *less* than the noted line voltage, phasing is incorrect. Exchange the two secondary leads and repeat the above test. When the combined voltage is higher than the line voltage, you know that the transformer leads are properly phased.

Calibration. To adjust the low-voltage trip point, a source of variable line voltage is required. (A Variac or similar device will do.) Adjust the power-line input for 110 volts—or whatever voltage you wish the relay to trip at—and connect an ac voltmeter across the contacts of *SO1*. Vary potentiometer *R2* until neon lamp *I1* glows and note that as this happens the relay is activated, which means that the voltage is not boosted, and the ac voltmeter across *SO1* registers 110 volts.

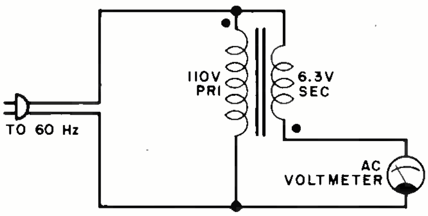


Fig. 3. Meter should read 6.3 V above line with transformer connected as shown.

Carefully rotate *R2* until the neon lamp just extinguishes and the relay deenergizes. The ac voltmeter across *SO1* should move up to approximately 116.3 volts. Slowly increase the input voltage level until the neon lamp lights and note that the ac voltmeter indicates about 112 volts. Set the trip point wherever you want it to occur.

In Conclusion. This project represents a simple, inexpensive way to provide some compensation for low powerline voltage. Its regulation is somewhat coarse, but is sufficient for most home appliances. Note that, since relay *K1* interrupts power briefly while switching in the booster winding, the circuit may not be suitable for use with sensitive devices such as computers or digital clocks. ◇

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SOLID-STATE DEVELOPMENTS

Magnets, Bubbles and Garnets

By Forrest M. Mims

MAGNETIC recording tapes and disks provide the cheapest form of mass data storage available. In addition, unlike most semiconductor memories, they offer nonvolatile data storage. That is, information can be retained indefinitely without the need for electrical power.

The biggest drawback of conventional magnetic recording media is that physical movement of the medium with respect to the head or the head with respect to the medium is required to write data onto and read data from the medium. Thus, drive motors are required. These consume considerable amounts of electrical power and result in relatively slow read-write access times.

The drawbacks of conventional magnetic media are obviated by the use of a new, motionless medium in which the data, not the medium, moves. The latter is a thin synthetic ferrite or garnet film containing microscopic magnetic domains which can act as information carriers and which are free to move throughout the crystal. Normally, the domains are serpentine in shape. Under the influence of an external magnetic field, however, the domains become constricted. When the strength of the field is increased to a certain threshold, the domains become cylinders having diameters of 2 to 30 micrometers.

Magnetic domains such as these can be seen through a microscope. When viewed on end, they appear like small circles, hence their popular name *magnetic bubbles.*

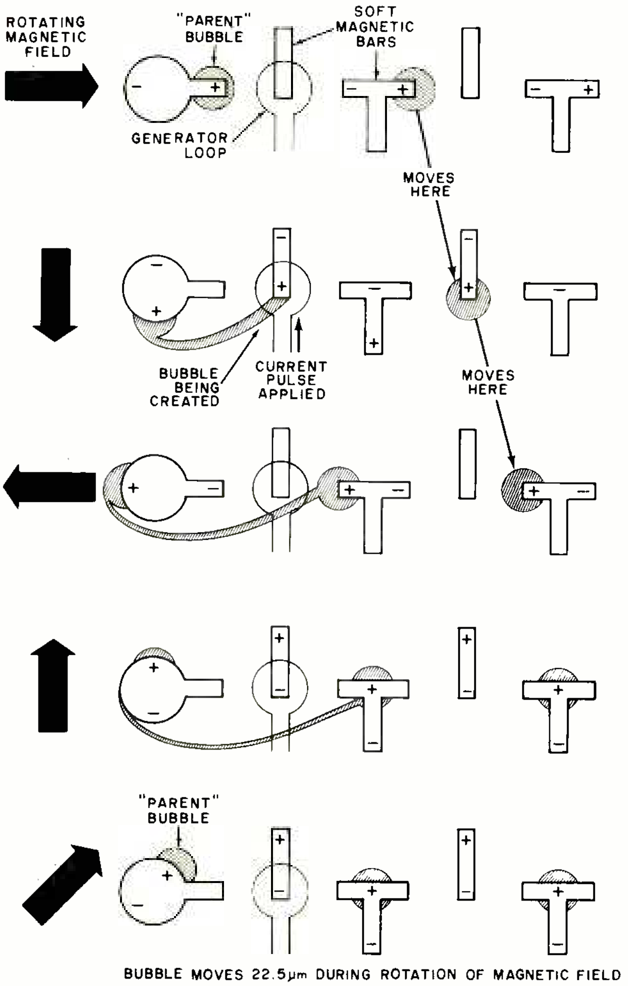


Fig. 1. A bubble, once established, is moved around between soft magnetic bars by rotating magnetic field at left.

Advantages of Bubble Memories. When compared to disk memories, magnetic bubbles offer the advantages of smaller size and no moving parts. The absence of moving parts eliminates the need for periodic maintenance, ensures much higher levels of reliability and provides faster access times. Bubble memories can be cheaper than disk systems in some applications, and price reductions are possible.

Semiconductor memories are faster, easier to interface and smaller than bubble memories. But they are *volatile* and lose their data if power is removed. Bubble memories retain data without the need for electrical power. They may also provide greater storage capacity at less cost than some semiconductor RAMs.

How They Work. Andrew H. Bobeck, a scientist at Bell Telephone Laboratories, discovered magnetic bubbles in 1967. He found that magnetic bubbles can move through their garnet matrix much like air bubbles move through water. Place a magnetized needle on the garnet, and it will attract a cluster of bubbles. Move the needle, and the cluster will follow, perhaps attracting additional bubbles along the way. The bubbles in the cluster retain their integrity and don't merge into one large bubble. Each bubble is actually a microscopic magnet and therefore tends to repel its neighbors.

Many ways have been devised to use magnetic bubbles in shift-register type memory systems. A typical memory consists of a ferrite or garnet film which has been epitaxially grown on a crystalline substrate such a gadolinium gallium garnet (GGG). A ferrite-bearing alloy is then deposited in a repetitive pattern on the upper surface of the bubble-containing film.

The metal patterns guide the bubbles through the garnet film in an organized fashion. Various patterns have been used. One consists of tiny bar- and T-shaped elements. Another consists of miniature chevrons. These elements are converted into miniature magnets by the action of an external magnetic field. When the field is rotated, a bubble between two chevrons or between a bar- and a T-shaped element is repelled toward the adjacent element. If the field continues to rotate, the bubble will continue to move along the pattern of elements as shown in Fig. 1.

A bubble generator is required to enter data into a bubble memory. One type of generator consists of a metal disk deposited on the garnet film adjacent to bar and T-shaped elements. A small bump protrudes from the disk. When a rotating magnetic field is applied, a domain is generated adjacent to the disk.

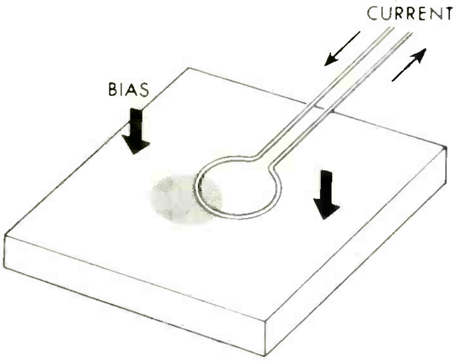


Fig. 2. Pictorial representation of a magnetic loop bubble generator.
(Courtesy Texas Instruments)

As the field rotates, the domain rotates around the circumference of the disk until it arrives at the bump. The domain is then pulled toward the adjacent elements. The magnetic attraction from the elements then pulls a bubble from the domain, and the bubble proceeds to move along the elements.

This kind of bubble generator supplies a continuous stream of bubbles. To write binary data into the memory in the form of logic ones (bubble present) and logic zeros (bubble absent), a *loop generator* (Fig. 2) can be used. This is simply a very small loop formed on the garnet through which a pulse of current is passed to generate a bubble.

Bubbles are erased by a *bubble annihilator* or, as they are sometimes known, a *bubble eater*. The annihilator sets up a magnetic field which neutralizes any bubbles in its vicinity.

Bubbles can be detected optically or by a magneto-resistive element applied to the garnet. The presence of a bubble under the detector lowers the detector's resistance. The resulting increase in current through the detector is processed by a sense amplifier.

Practical Applications. Several years ago, Texas Instruments became the first company to manufacture integrated bubble memories on a commercial basis. In the TI memories, the rotating field is provided by two orthogonal coils mounted above the bubble-containing garnet film. The field is rotated by means of integrated-circuit coil drivers which apply alternating current levels to the two coils. A permanent magnet installed under the substrate provides the magnetic equivalent of a dc bias which preserves the bubbles even when all current is removed from the driving coils.

This permits the bubbles to be stored indefinitely.

Bell Laboratories is experimenting with bubble-memory speech playback units for such computer-generated messages as, "The number you have reached has been disconnected." One unit stores 270,000 bits, enough for a few minutes of speech.

In 1977, TI became the first company to introduce commercial products containing magnetic bubble memories. The products are data terminals, each with a storage capacity of 20K bytes that can be expanded to 80K bytes. Data stored in the terminal's memory can be accessed within 15 milliseconds. Compare this with an access time of from seconds to minutes for terminals with a cassette-tape data storage.

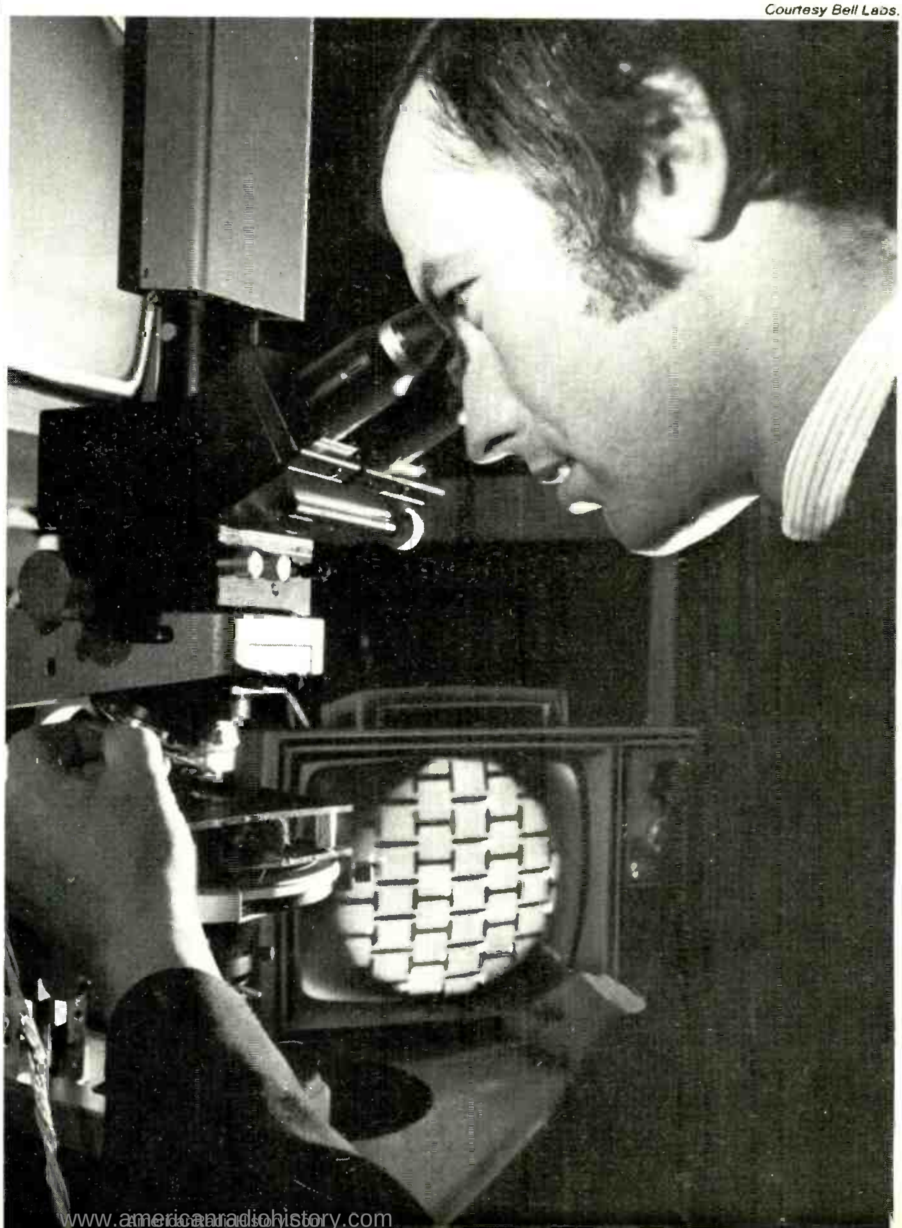
Texas Instruments sells a 92K-bit magnetic-bubble memory kit for $191.00. The kit includes a 92,304-bit bubble memory installed in a 14-pin dual-in-line package containing both one permanent and two orthogonal-coil magnets. The bubble-containing film is imprinted with 144 circular shift registers, each of which contains 641 bit positions. These registers are called *minor loops*. They are all connected to a *major loop* which provides such control functions as bubble generation, replication and annihilation. The bubble detector is also in the major loop.

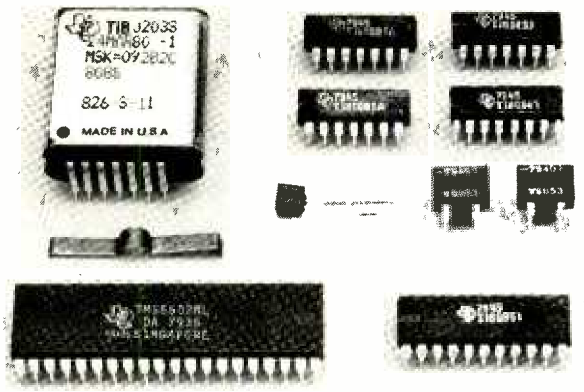
The major/minor loop arrangement greatly speeds up the memory's access time. It also improves production yield because defective minor loops can be ignored by the external access circuitry.

Defective loops occur due to the ultrafine geometry of the metalized elements. As many as 13 of the minor loops in a TI bubble memory can be defective without affecting the memory's storage capacity. The hexadecimal addresses for the defective loops are printed on the memory's package. An external PROM can be loaded with the addresses of good loops only so that the addresses of the defective loops can be ignored.

In addition to the bubble-memory chip itself, the TI kit includes a sense-amplifier chip, two coil-driver chips and

Scientist observing the movement of magnetic bubbles through a microscope.
Courtesy Bell Labs.





Magnetic bubble memory kit from Texas Instruments.

a thermistor for temperature compensation. A function-driver chip to control bubble generation and annihilation is also included, as are a timing chip and a controller chip. A single pair of timing and controller chips will drive up to ten bubble-memory chips.

The TI kit does *not* include a printed circuit board, but TI sells several different assembled single-card, bubble-memory systems. These 4.5-×-6.5-inch cards contain from one to four 92K-bit bubble memories and provide 11.5K, 23K, 34.5K or 46K bytes of storage. These systems are compatible with several commercially available microprocessor and microcomputer boards, but their cost is higher than disk memories offering greater storage capacities. The 11.5K-byte version, for example, is $650. The 46K-byte board sells for $1,215.

Prices for bubble memories and bubble memory products will probably fall in the future as this new memory technology begins to take over applications now dominated by cassette tape and floppy disks. In the meantime, the still more-expensive bubble memories can be used in applications where tape and disk drives are simply too slow. The Texas Instruments 92K-bit bubble memory, for example, has a data rate of 50 kilobits per second and an average access time of only 4 milliseconds.

Bubble memories can also be used to advantage when compact size and small weight are required. The TI memory weighs less than an ounce (25 grams total) and occupies only 1.25 square inches of board space. And, of course, it has no moving parts and produces no annoying acoustic noise.

Further Reading. Many articles about bubble memories have appeared in technical magazines since 1970. For a complete listing, look up the subject in the various guides to periodical literature available at most libraries.

For detailed information about TI's bubble memories, request a copy of the booklet *TIB0203 Magnetic Bubble Memory and Associated Circuits* from a TI distributor, or write to Texas Instruments, Inc., Inquiry Answering Service, Box 225012, M/S 308 (Attn: TIBK090), Dallas, TX 75265.

New Chips. Remote-control enthusiasts will be interested in a new pair of encoder/decoder chips available from Signetics (811 East Arques Avenue, Box 409, Sunnyvale, CA 94086). The NE5044N encoder chip can be programmed to handle from three to seven information channels. The NE5045N is a seven-channel decoder chip which accepts either positive or negative serial inputs and provides parallel outputs.

For simpler applications, the NE5046N, a two-channel decoder chip, is available. This chip provides the same 0.3 percent linearity as its more complex counterparts.

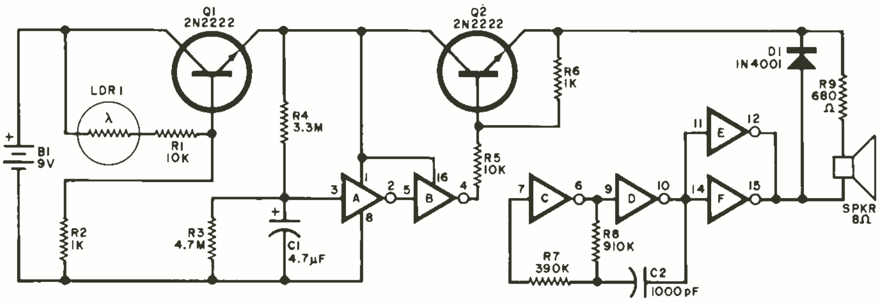
In addition to remote control of appliances and toys, these new chips can be used in data-transmission applications. I don't know single-quantity prices for these new chips, but the 100-quantity price is $2.16 for the NE5044N, $1.99 for the NE5045N and $1.08 for the NE5046N.

The voltage comparator offers a straightforward way to detect whether a voltage is greater or less than a specified level. Silicon General (11651 Monarch St., Garden Grove, CA 92641) has taken the comparator a step beyond its usual abilities in developing the SG1542, a new chip that provides a 200-milliampere output when an overvoltage condition occurs. The output can be used to trigger an external SCR crowbar to terminate the overvoltage condition.

The SG1542 also provides outputs for a warning device and indicators of both in-tolerance and out-of-tolerance conditions. If desired, an external capacitor can be added to provide a predictable delay between the detection of the overvoltage and the triggering of the crowbar protection. The chip includes an internal 2.6-volt reference source and has a 4.5-to-40-volt operating range. Cost in 100-unit quantities is $4.00. ◇

HOBBY SCENE

By John McVeigh, Technical Editor



Open-Humidor Alarm

Q. *I hope you can help me with a problem. My roommate has an irritating habit of removing cigars from my humidor and forgetting to replace the lid. I really hate to smoke dried-out cigars. Can you publish the schematic of a small circuit that will produce an audible signal after it has been exposed to light for more than a few seconds?—Steve Resnick, Spring Valley, NY*

A. The circuit shown schematically in the figure should help keep your cigars fresh. I designed it around the CD4009 CMOS hex inverting buffer. When the lid is lifted off the humidor, the resistance of cadmium-sulfide photocell *LDR1* decreases dramatically and permits sufficient base current to flow into *Q1* to cause the transistor to conduct. This allows *C1* to charge and hex inverter *IC1* (*A* through *F*) to draw current from the battery. When *C1* has charged to slightly more than half of the supply voltage, the output of inverter *A* switches from logic 1 to logic 0 and the output of inverter *B* from logic 0 to logic 1. Pass transistor *Q2* begins to conduct.

In the meantime, the astable multivibrator comprising inverters *C* and *D* and their associated passive components has begun to oscillate at approximately 1000 Hz. The output of the oscillator is applied to inverters *E* and *F*, whose inputs and outputs are connected in parallel. The outputs of these inverters are switching back and forth between logic 0 and logic 1 at a rate determined by the astable multivibrator. Once pass transistor *Q2* has begun to conduct, the inverter outputs can sink current through *R9* and the dynamic speaker to ground during the logic-0 portions of the output cycle. This causes the speaker to emit an audible alert.

It takes about 12 seconds for the circuit to start beeping. That should be enough time for your friend to select the stogie of his choice, but the interval can readily be lengthened or shortened by increasing or decreasing, respectively, the time constant in the delay portion of the circuit (for example, by increasing the value of capaciter *C1*).

Nonsmoking readers can probably find other applications for this circuit, such as an open-refrigerator-door alarm. It can be built using a small piece of perforated board, which could also provide mechanical support for the 9-volt transistor battery and the miniature dynamic speaker. ◇

EXPERIMENTER'S CORNER

By Forrest M. Mims

Programmable-Gain Amplifiers

HOW would you like to control the volume of a radio or gain of an amplifier with a series of switches instead of a knob? Or, better still, how would you like to perform this and other, similar functions digitally, perhaps under microprocessor or computer control? If so, read on!

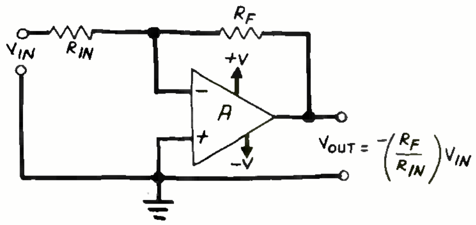


Fig. 1. An inverting operational amplifier.

The Operational Amplifier. Figure 1 shows a straightforward inverting amplifier built around a standard operational amplifier. The voltage gain of this circuit is the quotient of the value of the feedback resistor(R_F) divided by the value of the input resistor (R_{IN}).

The gain of the amplifier can be altered by varying the values of R_{IN} or R_F or both. In practice, it's usually best to keep R_{IN} fixed because changing it alters the amplifier's input impedance.

Potentiometers are customarily used when it's necessary to make either R_{IN} or R_F variable. Unless expensive ten-turn or detented potentiometers are used, this makes accurate changes in gain difficult. The output of the amplifier must be monitored with an oscilloscope or digital voltmeter while the adjustment is made.

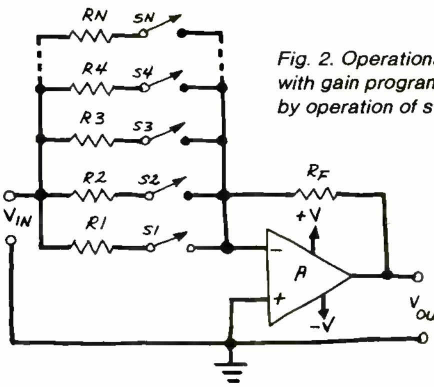


Fig. 2. Operational amplifer with gain programmable by operation of switches.

One way to provide selectable fixed, and therefore repeatable, gain settings is to use a parallel network of resistor/switch pairs as shown in Fig. 2. By preselecting the resistor values, any desired gain setting can be achieved by simply closing the appropriate switch. If R_F and $R3$ in Fig. 2 are 10,000 and 1,000 ohms respectively, then the voltage gain will be -10 when only $R3$'s switch is closed. The polarity of the gain figure is negative due to the fact that the amplifier operates in the *inverting* mode.

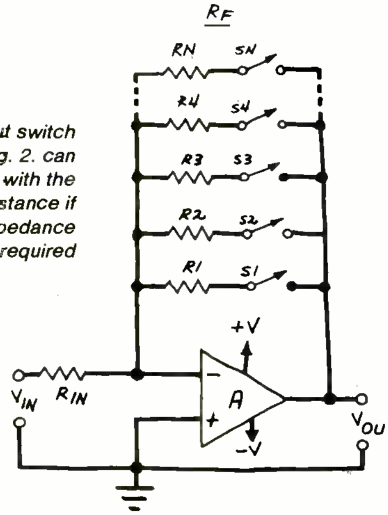


Fig. 3. The input switch network of Fig. 2. can be interchanged with the feedback resistance if constant input impedance is required

The input network and R_F can be interchanged (Fig. 3) if a constant input impedance is required. In this case, if R_{IN} is fixed at 10,000 ohms and $R4$ is one megohm, the voltage gain will be $-1{,}000$ when only $R4$'s switch is closed.

Simplified Programming. As more gain settings are required, the circuits just presented become impractical because more and more resistors and switches become necessary. One way to reduce circuit complexity while greatly increasing the number of available gain steps is to replace the custom-selected resistor network with a binary-weighted resistor network. Figure 4 shows a four-level network connected in place of R_{IN}

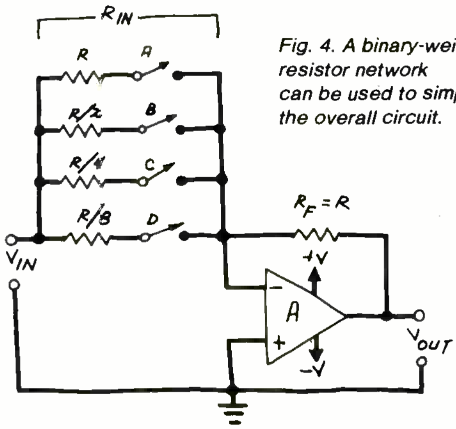


Fig. 4. A binary-weighted resistor network can be used to simplify the overall circuit.

in an op-amp circuit. Closing various combinations of switches will provide gains of each integer from 1 to 15. The previous circuits would require fifteen resistor/switch pairs to provide this same number of gain steps.

More resistors and switches can be added to provide progressively more gain steps. Eight resistor/switch pairs, for example, will provide 255 gain steps!

It's helpful to understand the operation of the binary-weighted resistor network in Fig. 4. Although its input network has four levels, we can understand how it works by referring to the simpler, three-level version shown in Fig. 5.

First, remember that the total resistance of two or more resistors in parallel is the reciprocal of the sum of the reciprocals of the individual resistors, or $R_{TOTAL} = 1/(1/R1 + 1/R2 + 1/R3 \ldots + 1/RN)$. Knowing this, we can make a table that shows the resistance given by each of the eight possible switch combinations. In this table, a zero represents an open switch and a one a closed switch.

Switch C	Switch B	Switch A	Resistance
0	0	0	----
0	0	1	R
0	1	0	R/2
0	1	1	1/(1/R + 2/R) = R/3
1	0	0	R/4
1	0	1	1/(1/R + 4/R) = R/5
1	1	0	1/(2/R + 4/R) = R/6
1	1	1	1/(1/R + 2/R + 4/R) = R/7

As you can readily see, the seven switch combinations give seven different resistances of descending value. We can make practical use of this table by assigning a value to *R*. If, for instance, *R* is 40,000 ohms, we obtain:

Switch C	Switch B	Switch A	Resistance
0	0	0	----
0	0	1	R = 40,000
0	1	0	R/2 = 20,000
0	1	1	R/3 = 13,333
1	0	0	R/4 = 10,000
1	0	1	R/5 = 8,000
1	1	0	R/6 = 6,666
1	1	1	R/7 = 5,714

You can verify the accuracy of this table by actually calculating the value for each step. You should arrive at the same result, whether you divide each of the integers 1 through 7 into 40,000 or use the formula for the total resistance of resistors in parallel.

Now that you know how the binary-weighted resistor network works, let's assume that it's connected as the input resistance in a straightforward inverting amplifier like the one shown in Fig. 1. If R_F is made equal to *R*, then the amplifier will have switch-programmable gains ranging from −1 to −7 in equally spaced increments.

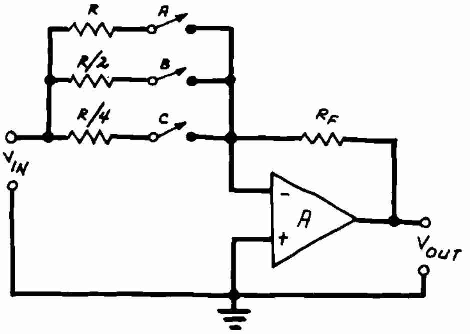


Fig. 5. Three-level binary-weighted input network.

It should now be obvious to you how the circuit shown in Fig. 4 provides a switch-programmable gain of from 1 to 15. Add another resistor-switch pair to the network and the available gain will range from −1 to −31. The use of eight resistor-switch pairs results in switch-programmable gains from −1 to −255.

This method of programming the gain of an op amp has a few disadvantages of which you should be aware. One is that the value of the resistor in the most significant switch position becomes progressively smaller as the number of resistor/switch pairs is increased. This places a practical limit on the maximum number of resistors that can be added since the maximum available (open-loop) gain of the op amp cannot be exceeded.

The second disadvantage also concerns the most significant switch position and is of more importance. Since the resistance of the most significant resistor is much less than that of the least significant switch position, its tolerance is much more critical. For best results, one-percent or closer tolerance resistors should be used.

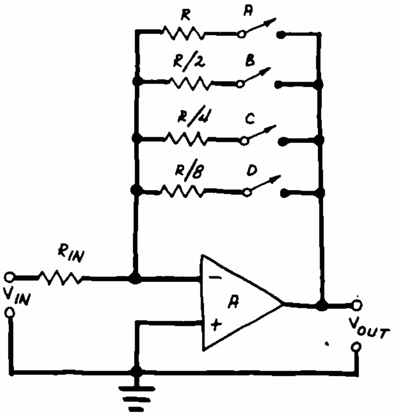


Fig. 6. Using a binary-weighted resistor network in the feedback circuit.

Thus far, we've considered the use of the binary-weighted network as the input resistance. Of course, the network can also be used as the feedback resistance as shown in Fig. 6. The advantage of this configuration is that the amplifier's input impedance remains constant for the various gain settings. However, the disadvantage is that the uniform, stepped gains of the previous circuit are not available. If R_{IN} is 1 ohm, for example, the gains range from −5,714 to −40,000. This circuit thus does not provide uniformly incremental gains, but it does give plenty of range for such an application as audio amplification.

Adding Digital Control. A straightforward way to provide digital control of the circuits that have been presented is to replace the conventional, manual switches with CMOS analog switches. Figure 7 shows how to use a CD4066 to replace all four mechanical switches in the circuit of Fig. 4. Keep in mind that the "on" resistances of the four analog switches in the CD4066 should be subtracted from the values of the input-network resistors to calculate the actual gains such a circuit would provide.

Barry B. Woo of Fluke Automated Systems, Inc. has written an excellent paper on various methods of adding digital control to a programmable-gain amplifier. His paper, "Digitally Programmable Gain Amplifiers with Arbitrary Range of Integer Values," appears in the *Proceedings of the IEEE* (July 1980, pp. 935-936). You can find this journal at most well-stocked technical libraries.

The circuit shown in Fig.8 is adapted from Fig.2(c) of Mr. Woo's paper. It is a noninverting amplifier which provides positive gains of the integers 1 to N. Various CMOS analog multiplexers can be used in this circuit.

Other Applications. The emphasis in this column has been amplification, but the techniques which have been presented can be used to implement such interesting applications as a digitally controlled potentiometer with no moving parts. Other applications include analog-to-digital and digital-to-analog conversion.

You might want to explore some of these applications on your own. If so, you might also want to experiment with an interesting alternative to the binary-weighted resistor networks described here. The *R-2R* network requires more resistors, but it uses only two resistor values and is more tolerant of resistance variations.

The *R-2R* network was the subject of the July 1978 "Experimenter's Corner." It is also covered in a very useful book by Sol Libes entitled *Fundamentals and Applications of Digital Logic Circuits* (Hayden, 1975). Mr. Libes gives a concise treatment of the subject, complete with circuits, on page 136.

Reader Letters. Most of the letters addressed to this column request custom circuit designs or technical information. The number of requests makes it simply impossible for me to fulfill them. Of course, I will try to respond to questions having general interest by means of this column.

A few letters describe circuits built by creative experimenters. Such is the case with 17-year old Antonio Frederico de Cesaro of Porto Alegre, Brazil. Antonio's letter described a solid-state phototransistor/LED video camera and display he has assembled.

The camera portion of Antonio's project is an array of phototransistors which are scanned by a counter. A simple network of NAND gates and inverters places the sampled outputs on a single line which goes to the display cirucit. The display circuit includes an input amplifier and a second scanning system. The counter of the display scanner is driven by the

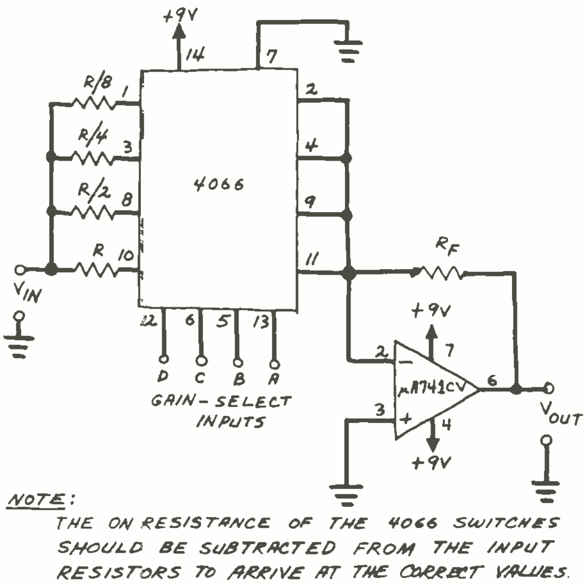


Fig. 7. How to use a CD4066 to replace mechanical switches.

same clock which strobes the camera's phototransistors so the two units are synchronized. Therefore, LEDs corresponding to the phototransistors in the camera glow when the phototransistors are illuminated. A brightness control is included in the circuit.

Antonio has provided a sketch of a more advanced version of the circuits he has already built. He also reports that he is working on various other LED-array projects, and he expressed interest in the LED oscilloscope projects published in this column some time ago.

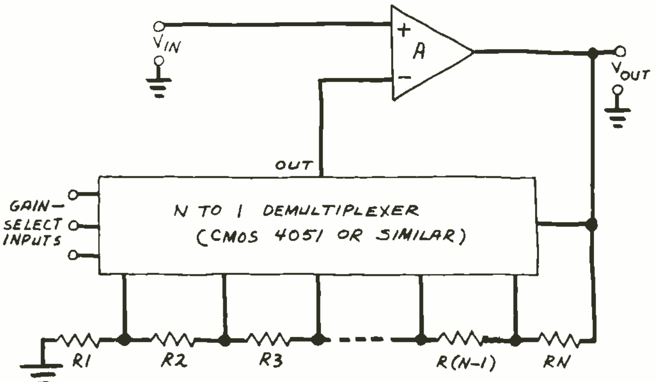


Fig. 8. A digital programmable-gain noninverting amplifier.

Michael J. Geydoshek of Newton, NJ wants to make a ten-minute countdown timer for his sailboat. That's not a big problem. Even adding a seconds display is no problem in view of the watch and clock chips (and modules) now available. The catch is that he requires ". . . a large enough display to be seen clearly at 10 feet on a sunny day." The best solution here is to use a large-format liquid-crystal display and a standard watch or clock module. LED displays wash out in even *moderate* sunlight!

A.A. Aikin of Lansing, MI wonders if optical fibers can be used in a public-address system. Sure! However, the use of fibers will have no effect on acoustical feedback. The feedback is caused by speaker-microphone coupling and has nothing to do with whether copper wire or glass fiber couples the mike to the amplifier or the amplifier to the speaker or both.

Many readers have asked for technical information on subjects ranging from laser gyroscopes to ultrasonics. Some readers report they have been unable to locate certain technical journals and magazines I have cited.

Readers living in remote areas will always have a difficult time finding technical publications. But most readers live within 50 miles of a university or public library which should contain many of the most important technical periodicals. I urge you to take advantage of such libraries by visiting them as frequently as is possible. Electronics is such a fast-moving field that it's essential to read the latest technical periodicals to find out what's happening.

I live near a liberal arts college which has only a limited number of technical publications in its library. Therefore, I visit a large university about once each month. This university has more than a dozen separate libraries, including *one each* for engineering and physics. I spend about a full day and 80 or more nickels (for the copy machine) each time I visit these libraries!

If you will invest some time in investigating the technical libraries in your area, you will probably find you are within a reasonable distance of at least one and perhaps more. If so, take advantage of them. ◊

DX LISTENING

By Glenn Hauser

Shortwave Broadcasting and the FCC

A NEW shortwave station is due on the air this fall. After considerable delay, the Federal Communications Commission finally granted a license for shortwave to *WRNO* (FM), New Orleans, LA. The station will start off using one 100-kilowatt transmitter with antennas beamed for Europe and, not incidentally, the eastern U.S. on the way, at 1600 to 0800 GMT. Unlike present U.S. private shortwave stations, this one will operate commercially with a rock music format. No doubt the U.S. broadcasting industry will be watching this closely to see whether it proves profitable. If it does, there could be a spate of similar applications.

Not, however, if Charles Ferris has his way. In announcing the grant, the FCC chairman in his lame-duck period expressed his personal reservations about privately controlled external broadcasting. He felt that only the U.S. government should have the privilege of broadcasting abroad, to ensure that foreigners would be exposed only to official policy (i.e., via the *Voice of America*). This is essentially the same argument the FCC used for many years while a freeze was imposed on shortwave broadcast applications.

Interestingly, the Billy Graham Evangelistic Association had an application in the mill for much longer than *WRNO*, and the FCC licensed it at the same time to build a shortwave outlet in Hawaii; however, there had been reports that the B.G.E.A. had already given up the project.

There are already four private shortwave stations licensed by the FCC and on the air—*WYFR, KGEI, WINB,* and *KTWR* (Guam). It's hard to see why only these organizations should be allowed to broadcast on shortwave if others want to and are qualified. Chairman Ferris cited an obscure 1948 law which prohibits the government from monopolizing shortwave broadcast frequencies as the reason why the *WRNO* application could not be denied, as he is believed to have preferred.

Although shortwave bands are undeniably overcrowded, the "shortage" of frequencies should not be taken as a serious reason for disallowing further U.S. SWBC operations. The bands are due to be expanded, and hardly any other country lets the frequency shortage stop it from broadcasting on shortwave.

Unfortunately, organizations capable of furnishing a real programming alternative from the U.S., such as National Public Radio, have shown no interest whatsoever in external broadcasting.

The FCC has also been encouraging more and more short-range local radio stations, at the expense of "clear" channels and increased interference to all. Yet, at the same time it was granting the *WRNO* and B.G.E.A. applications, the agency was cracking down on at least three small broadcasters who had been operating on shortwave. These examples were not lost on other pirate operators, as the word spread. With the FCC's get-tough attitude, some voluntarily stopped broadcasting while others resorted to random and irregular appearances on the air.

Meanwhile, the Central Intelligence Agency's name cropped up again in connection with shortwave broadcasting. In an early November 1980 column, Jack Anderson reported that Pres. Carter's national security advisor, Zbigniew Brzenski, was actively considering abolition of the Board for International Broadcasting as an obstacle to the CIA's renewed control of *Radio Free Europe* and *Radio Liberty*. And an unconfirmed report propagated by Marxist elements in Cuba, Nicaragua and Grenada said that another Caribbean island, Antigua, had granted the *Voice of America* permission to build another relay station there (though it would hardly seem necessary, with VOA's good coverage of Latin America direct from the U.S., in contrast to the BBC's and the Voice of Germany's, who, though not mentioned in the report, already operate via Antigua). However, the VOA relay is reported to be on mediumwave only. This was seen as cover for a CIA plot against the eastern Caribbean. There is, of course, no direct and official connection between the VOA and the CIA in American terms.

Country by Country. Ecuador. Station *HCJB* has responded to positive listener reaction by inserting more airings of a mostly nonevangelical quarter-hour show announced in English by a genuine Ecuadorian, "Música del Ecuador." It's not clear how many original programs there are per week, and which airings are repeats of which others. GMT days and times are: Sunday 0145 on 15355, 9745; 0815 on 9745; 1930 on 21480, 17790 and 15295. Monday 2345 on 15350. Tuesday 0915 on 9745. Wednesday 0515 on 11915, 9745, 6095; 0800 on 9760, 11835. Thursday 0945 on 11900, 9745, 6130. Friday 0330 on 15155, *dx listening*

11915, 9745; 0500 on 11915, 9745, 6095. Most of these are also on 26020.

The Ecuadorian government has issued three stamps marking *HCJB*'s semi-centennial this year, and the station was offering listeners a first-day cover at $2.50—but supplies may have been exhausted by now. By the way, collecting stamps dealing with broadcasting is an interesting topical specialty. There are more such stamps than you might think.

Argentina. *Radio Argentina* has reorganized its external services so that English is now aired at 0100 to 0130 GMT on 11710.

Dominican Republic. *Radio Clarín* returned to the air in December on 11700, mostly on weekends and holidays in the afternoons and evenings Rudy Espinal was back too, with an English hour, "This is Santo Domingo," Saturday and Sunday at 2200, a highly flexible time.

Egypt (*to* rather than *from*). Astute DX-listeners sometimes scoop official monitoring services such as the *BBC*'s. Ernie Behr, Kenora, Ont., discovered an Arabic-speaking clandestine on 9670 on the air daily at 1900-2000, with the ID, "Saut ul-Shaab ul-Misri," which proved to be the anti-Sadat *Voice of the Egyptian People*, previously reported to have disappeared from the air. This frequency brings to mind Malta, where, when relations are sufficiently warm, Libya has been allowed to use the Cyclops transmitter built by *Deutsche Welle*; but its actual site is not known for sure.

Faroe Islands. This isolated Danish possession in the North Atlantic has no shortwave broadcasting, but it's conceivable the station *Utvarp Föroya* on 531 kHz might make it to North America, at Monday-Saturday sign-on of 0715 GMT. Only slightly more improbable as a DX target is an American forces station on U.S. channel 2, which did not appear in references, but was picked up by European TV-DXers, and finally traced to here. It's likely rather low-powered. There are also three FM stations of *Utvarp Föroya*, on 89.85, 94.25 and 97.5 MHz, which could bounce off the aurora or reach North America via multiple-hop sporadic-E skip. The two "split" frequencies are a give-away to those who can measure them. The full schedule, per the *World Radio-TV Handbook*, is Monday-Friday 0715-0915; 1200-1300 (Wednesday to 1400), 1830-2020 (Thursday & Friday to 2110); Saturday 0715-0915, 1200-1600, 1830-2305; Sunday 1400-1915. You can prepare for the rather remote eventuality of Faroe DX by familiarizing yourself with the sound of the Faroese language. The only Faroese broadcast on shortwave is a weekly 5-minute newscast, Fridays at 1445 from *Radio Norway*, currently on 21730, 21655 and 15345 (March and April: 21730, 17795, 15175). Why this is carried out by Norway rather than the Faroes' parent country of Denmark is not clear. (This is followed at 1450 by a daily North Atlantic weather summary—in Norwegian; this is also carried at 2255, 0055 and 0255 GMT on the same frequencies we list for Sunday/Monday English 65 minutes later.) The only other Faroese-language broadcast we know of is from *Trans World Radio*, Monaco, Monday at 2230-2245 GMT (which is also Faroe Islands local time), on the 1,200,000-watt 1467-kHz outlet, easily heard in North America with receivers of good selectivity (and without locals on 1460 or 1470), though at this hour there's enough darkness to eastern North America only at midwinter.

Ghana. Facilities at *R. Ghana* continue to deteriorate, but the station is ever-optimistic. All but one external-service frequency (6130) have been off the air for years, yet the station still sends listeners its imaginary schedule, with a P.S. to that effect. Bill Taylor in Pennsylvania received such a communication. But even before it came, he got an unsolicited pen-pal request from a Ghanaian who must have intercepted his letter at the post office. Such things have been happening for some time in Ghana and other African countries. And Ruth Hesch in New York received a domestic-service schedule from *GBC* showing that transmitters for three more frequencies were off the air—3350, 4980 and 5990 kHz.

Israel. Despite its small size, this country has adopted a 5-digit postal code system like U.S. zip codes. *Israel Radio* has been announcing its Jerusalem address with the code 91010, so lots of mail bound for Jerusalem is likely to take a side trip to Duarte, California. *Israel Radio* is also trying a second slow-scan television test February 15 around 2020 GMT on 9425, repeated GMT the 16th at midnight 0020 and 0220 on 11637 and other frequencies.

Mexico. Some small shortwave stations have made comebacks after several years of inactivity. *R. Universidad San Luis Potosi*, on 6045, and *R. Mil*, Mexico City, on 6010, were reported by Horacio Hinojosa Arce.

Spain. There have been reports that Spanish foreign radio will be dropping its English broadcasts this year in order to save a few pesetas.

Publication. *A DXer's Technical Guide* is a well-done 98-page softbound book compiled by members of the mediumwave group International Radio Club of America. It contains reviews of numerous receivers, accessories, antennas, and articles on modifications and many other topics. Much of this is applicable to shortwave as well as mediumwave. It's $5 ppd. payable to IRCA, P.O. Box 17088, Seattle, WA 98107.

Free Information Sheet. To help you become an "insider" in the DX-listening subculture, we've compiled a source listing of many other publications, organizations and programs about shortwave and DX listening. It's yours, only if you send a long SASE to: Glenn Hauser, University Radio WUOT, Knoxville, TN 37916. ◇

PROJECT OF THE MONTH

Transistorized Light Flasher

By Forrest M. Mims

A TRANSISTORIZED light-flasher circuit for model rockets played a key role in the development of the Altair 8800, the POPULAR ELECTRONICS hobby-computer breakthrough project of January 1975.

In 1969, H. Edward Roberts, Stanley Cagle, Robert Zaller, and I formed a company to manufacture and sell a commercial version of my model-rocket light flasher. I wanted our company to have a name using the initials M., I., and T. because, at the time, the Massachusetts Institute of Technology was an important center of model-rocket research activity. Stan came up with Micro Instrumentation and Telemetry Systems, or M.I.T.S.

Eventually, M.I.T.S. was simplified to MITS, and we made telemetry transmitters, light flashers, and a lightwave communicator. The company also manufactured calculators and test equipment—which led to the conception of the Altair 8800 by Ed Roberts. I left MITS in 1970 to become a full-time freelance writer and my first article was about the flasher that was to become MITS's first product.

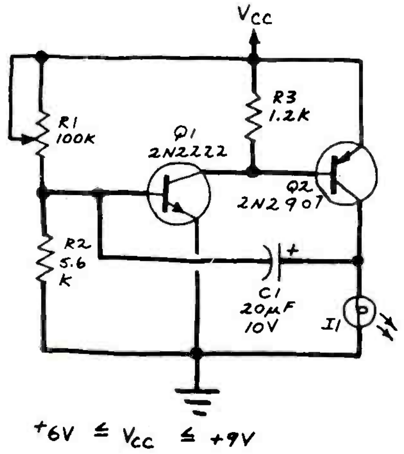


Fig. 1. Schematic diagram of miniature transistorized light flasher.

Figure 1 is the schematic diagram of the circuit, commonly referred to as a regenerative amplifier, that was responsible for both MITS and my present profession. When lamp *I1* is off, *Q2* must be cut off. Since *Q1* controls the behavior of *Q2*, *Q1* must also be cut off. The voltage divider *R1R2*, however, supplies enough base drive to turn *Q1* on, which in turn causes *Q2* to conduct. When *Q2* conducts the lamp is connected directly across the power supply.

Now, *C1* begins to charge through *Q2* and *R2*. At some point, enough charge has accumulated in *C1* to turn *Q1* off. This, in turn, cuts off *Q2* and the lamp darkens. When the lamp is dark, *C1* keeps *Q1* cut off while the capacitor discharges through *R2* and the lamp. When *C1* has discharged completely, *Q1* is biased into conduction by *R1R2*. This turns on *Q2* and the lamp, and the cycle begins again.

The circuit is easily assembled on a miniature circuit board measuring only about one-half inch square. Potentiometer *R1*, which controls the flash rate, can be any standard trimmer. The lamp should be a low-voltage bulb such as the No. 122, No. 222, or a similar, miniature incandescent pilot lamp.

Peak currents of two or more amperes flow through the lamp's filament, so the filament will glow much more brightly than normal. If operated continuously at such current levels, the filament would be quickly destroyed. This does not occur, however, because the flasher circuit supplies current pulses lasting only tens of milliseconds in duration.

Actually, the circuit has broad applications. The flash is bright enough to be an effective personal warning light for cyclists and pedestrians at night. For such uses, you can build the entire circuit inside a plastic automatic lamp housing.

For model-rocket applications, install the flasher in a transparent payload capsule, preferably with the battery mounted *below* the flasher circuit. This keeps the rocket's center of gravity from moving too far forward. It also prevents the comparatively heavy battery from pressing against the flasher circuit during the acceleration phase of the flight.

I hope you enjoy experimenting with this flasher circuit. It may not impact on your career the way it did on mine, but it will certainly brighten up your life! ◊

OPERATION ASSIST

If you need information on outdated or rare equipment—a schematic, parts list, etc.—another reader might be able to assist. Simply send a postcard to Operation Assist, POPULAR ELECTRONICS, *1 Park Ave., New York, NY 10016. For those who can help readers, please respond directly to them. They'll appreciate it. (Only those items regarding equipment not available from normal sources are published.)*

Hartman Marine model 3059 transistor radiotelephone. Need schematic and service information. Dana Willis, 1057 Kingstown Rd., Peace Dale, RI 02883.

Heathkit model #PS-3 variable voltage regulated power supply. Schematic and operating manual needed. Mike Strawser, 315 Spring St., Saline, MI 48176.

Triumph model 841 oscilloscope. Need operating manual and schematic. Ronald Weagley, 2304 Stumptown Rd., Lancaster, PA 17601.

Heathkit model HX-10 "Marauder." Need owner's manual. Stuart Ballinger, 57 S. Clinton St., Poughkeepsie, NY 12601.

RCA model TMV-97-B oscillator. Schematic and information needed. Russell Sandman, 560 Forest Hills Blvd., Waverly, OH 45609.

Lafayette model HA-700 communications receiver. Need schematic and/or photocopy of manual. Gary Liebisch, Rte. 8, Quailridge, Spartanburg, SC 29303.

Hallicrafters model S 38E AM/SW receiver. Need operation and alignment manuals. John Moret, 1260 Larpenteur Ave. W., Apt. 311, St. Paul, MN 55113.

Gertsch model RT-7 radio transformer. Need schematic and instruction manual. Bill Schweber, Instron, 100 Royall St., Canton, MA 02021.

Concord model MTC-21 b/w video camera. Need schematic, manual and troubleshooting information. C. Schram, 1317 Cassland Ct., San Jose, CA 95131.

Stromberg-Carlson model #84 all-wave receiver. Need schematic, parts list and any available information. Judy Simeneta, 139 Ediston St., Pontiac, MI 48058.

Wards Airline model 62-329 receiver. Schematic and operating information needed. Susana Halpine, 10 Florence St., Worcester, MA 01610.

Kyoritsu model K-1400 volt/ohm milliammeter. Need service and operation manual. Faizan Haider, Box 1133, Islamabad, Pakistan.

Precision model E-200C, Serial #28817 signal generator. Need audio oscillator transformer. J. F. Tremitiere, 5 Austin Rd., Yardley, PA 19067.

Electronic Assistance Corp., model CG-75 ultrasonic cleaner. Schematic, parts list and manual needed. R. K. Beamer, 565A Washington Ave., Nutley, NJ 07110.

Ballantine model 420 calibrator; **Sylvania** model 216 RF generator. Need schematics and operator's manuals. R. M. Smith, 3188 Rumsey Dr., Ann Arbor, MI 48105.

Grundig model TK830/U tape recorder. Need parts and schematic. Ken Scheuring, 1200 Kimberly Dr., Valdosta, GA 31601.

Hickok model 217 semiconductor analyzer. Schematic and operation manual needed. Glenn Martin, 242 Cabbel Dr., Manassas Park, VA 22110.

Allen B. DuMont Laboratories, Inc. type 350-R cathode ray oscillograph. Need manuals. Don Bolton, 1418 Perkins Ave., Richland, WA 99352.

Concord model CR-50 AM/FM stereo receiver. Need schematic and operation manual. George J. Van Houten, 26 Delaware Ave., Paterson, NJ 07503.

RCA model WO-33A oscilloscope. Manual and/or schematic needed. Ed Herbert, 410 N. Third St., Minersville, PA 17954.

Gregory Mark XXX bass amp. Transformer, coil ratings or schematic needed. Kelly McRobb, 178 Tim Tam Terrace, West Seneca, NY 14224.

Jackson model CRO-2 oscilloscope. Need manual and schematic. George W. Cunningham, 10 Park View Ct., Biddeford, ME 04005.

Dumont model 5890-B6 deviation meter. Need schematic and operating manual. Keith Birdwell, 58 Rambler Rd., Hutchinson, KS 67501.

Dumont type 403 oscilloscope. Need schematic and operating manual. Joe Tokarz, 4054 Sheffield Ave., Hammond, IN 46327.

Siltronix 1011D radio. Need frequency counter. Dennis Marion, 5922 O'Brian, Corpus Christi, TX 78413.

Philips type G.M.3125 NR 1735C oscilloscope. Need data, schematic and manual. Taisto E. Ylonen, SF-02200 Espoo, Finland.

Superior Instrument Co., model TV-11 tube tester. Need roll chart for latest type tubes. J. W. Corrigan, 7963 Rockhill, Houston, TX 77061.

Bogen BT-25 P.A. amplifier. Need manual and schematics. Chip Sams, 109 Windy Circle, Brondon, FL 33511.

Motorola model H21-10 portable radio. Need schematic and parts list. Gary Hedge, 3526 Johnson St., High Point, NC 27260.

RCA model B870910 shortwave radio. Need schematic. Bob Boehnke, 3011 Antioch Road, Perry, OH 44081.

Hitachi model SU-86 16" B/W TV. Need picture tube 440 BFB4. Joseph Hauswirt, 16 Jones St., Worcester, MA 01604.

Hewlett Packard model 3311A generator. Need owner's manual, service manual, calibration instructions, parts list, and schematic. Shawn E. Baker, 1448 Cardinal Drive, W. Columbia, SC 29169.

Gretsch Safari ac/dc guitar amplifier and **Amplifier Corporation of America** Haynes Bass King II instrument amplifier. Need schematics. David Calhoun, Rt. 2, Box 111, Mt. Olive, MA 39119.

Edison receiver model R6. Need schematic and service information. Gilbert Fontenot, 1575 Longfellow Dr., Beaumont, TX 77706.

Hallicrafters model S-34C shortwave receiver. Need operation manual, schematic, and service manual. J. Geissinger, Box 196, Mt. Gretna, PA 17064.

Super Pro 5 metal detector. Schematic needed. W. G. Eslick, 2607 E 13th, Wichita, KS 67214

Commander model 860 generator. Need schematic and operation manual. Albert Dillon, Jr., Box 27, Prichard, WV 25555.

Pentron model PR-66 President reel-to-reel recorder, serial #15454-J. Need schematic and service manual. Jim Arbuthnot, 212 Erie, South Haven, MI 49090.

Masterwork audio system model 2017, serial #F617-646. Need schematic and selector switch. P. Tan Zenith Radio Corp., 11000 Seymour Avenue, Franklin Park, IL 60131.

RCA radio receiver model CRV46152. Need schematic and manual. T.G. Lucas, 7830 Melbourne Rd., Indianapolis, IN 46268.

Monarch stereo tuner amplifier model SAT-460X. Need schematic of output amplifier and power supply. Robert N. McEntire, 323 Tram Road, Columbia SC 29210.

Precision model 650 tube tester. Need adapter cable P/NAD-65 and cable pin PAA. A. Horowitz, 3518 W. 228th St., Torrance, CA 90505.

Heathkit model AR-15 receiver. Need assembly and checkout data. Tom Chichester, Box C-42, Cinnaminson, NJ 08077.

National model NC46 receiver. Need schematic. Floyd Williams, 121 N. 59th St., Philadelphia, PA 19139.

Clarion AM/FM model 36-300, serial #TT1985 stereo. Need schematic and operation manual. John T. Barber, 501 N. Halagueno St., Carlsbad, NM 88220.

Superior Instruments Co., model 670A ohm meter. Need any available information. M.W. McMahon, 3327 S. Northern, Independence, MO 64052.

General Electric model CRO-3A oscilloscope. Need schematic end operating manual. Gary L. Smith, 10956 S.W. 63rd St., Portland, OR 97219.

Eico model 425 oscilloscope. Need schematic and voltage chart. Nick Meale, 7316 Richmond, Cincinnati, OH 45236.

Allied Radio Ten-2 CB unit. Need schematic and manual. Paul R. Lewis, 1317 Kingston Ridge Road, Cary, NC 27511.

Superior Instruments model 76 CR bridge and signal tracer. Need schematic and manual. Jim Wicks, 1970 Cedar #A, Long Beach, CA 90806.

Zenith model F2040W2 B/W TV. Need schematic diagram. Arvind Sant, 141-35 78th Ave., Flushing, NY 11367.

Galaxy III transceiver. Need schematic. **Plectron** model Sentry 21 and model 77 tone generator. Need schematic and owner's manual. Phillip R. Lofton, 349 Quinn Road, Collierville, TN 38017.

Fisher Model A-192 (Allegro) stereo. Need schematic. Norman Cizek, 1212 Kinne Street, East Syracuse, NY 13057.

Ballantine model 320 voltmeter and **Hewlett Packard** model 206A audio signal generator. Need service manuals and schematics. P. Young, 16W761 White Pines, Bensenville, IL 60106.

Sears programmable scanning radio, model 9343639. Need operation manual and schematic. Gene H. McGurrin, 21 Brookview Dr., Macedon, NY 14502.

EMC models 204, 205 and 209 tube tester. Need set up chart. Walter C. Fletcher, 6139 S. Kenwood Ave., #404, Chicago, IL 60637.

Marantz model 4270 receiver. Need owner's manual and schematic. William J. Byerly, 111 Westchester Place, Apt. D-6, Slidell, LO 70458.

Tektronix model 315D and 561 oscilloscopes. Need manuals and schematics. Bob Carpenter, 2435 Cherry Hill Road, Culpeper, VA 22701.

Digital Concepts clock chip # DCC7302N used in clock kit. Need to know where chip can be purchased. S.S. Siter, 488 Marshall St., Paxton, MA 01612.

KLH model 27 receiver and model 4 speaker, **Tandberg** model 64 tape recorder and **Dynaco** Mark IV amplifier. Need service manuals, operating manuals and specifications. Stephen H. Shenefield, 4501 Arlington Blvd. #220, Arlington, VA 22203.

Sansui model Eversonic 23 CB. Need schematic. Paul R. Lewis, 1317 Kingston Ridge Rd., Cery, NC 27511.

Standel Company model Artist XX amplifier. Need schematic and operational manual. H.A. Singer, Rd. 1, Box 148, Jamesburg, NJ 08831.

Accurate Instruments Co., model 257 tube tester. Need parts list. Larry R. Cook, 362 East South St., Richland Center, WI 53581.

The Voice of Music model 20247 stereo receiver. Need manual and schematic. Jeck Arnold, 3013 Fulton St., Berkeley, CA 94705.

Masterwork model M-812 tape recorder. Need operation manuals. Dwayne Dyals, 1214 Labelle St., #118, Jacksonville, FL 32205.

Grundig model TK400Uz tape recorder. Need schematic. C. Bargel, 452 N.E. 39th St., Miemi, FL 32205.

Futterman model H-3 and H-3A power amplifiers. Need schematic diagrams and any other available information. Richard A. Matthews, 20 West 84th St., New York, NY 10024.

Commercial Trades International # MCB23176900 voltmeter. Need service manual and schematic. Mary V. Saunders, 304 4th Avenue, Jerome, ID 83338.

7400

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SN7460N	.20			SN74390N	1.49
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74LS04	.35	74LS107	.45	74LS197	1.19
74LS05	.35	74LS109	.45	74LS221	1.19
74LS08	.29	74LS112	.45	74LS240	1.95
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74LS21	.35	74LS136	.49	74LS251	1.49
74LS22	.35	74LS138	.89	74LS253	.99
74LS26	.35	74LS139	.89	74LS257	.89
74LS27	.35	74LS151	.89	74LS258	.99
74LS28	.35	74LS153	.89	74LS260	.69
74LS30	.29	74LS154	1.75	74LS266	.69
74LS32	.35	74LS155	1.19	74LS273	1.95
74LS33	.59	74LS156	1.19	74LS279	.75
74LS37	.45	74LS157	.89	74LS283	1.09
74LS38	.49	74LS158	.99	74LS290	.99
74LS40	.35	74LS160	1.15	74LS293	.99
74LS42	.89	74LS161	1.15	74LS298	1.25
74LS47	.89	74LS162	1.15	74LS352	1.29
74LS48	1.15	74LS163	1.15	74LS353	1.29
74LS49	1.15	74LS164	1.25	74LS365	.75
74LS51	.29	74LS165	1.25	74LS366	.75
74LS54	.29	74LS168	1.19	74LS367	.75
74LS55	.29	74LS169	1.19	74LS368	.75
74LS73	.45	74LS170	2.49	74LS373	1.95
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MAN 6630	C.A.—orange ± 1	.560	.99	HDSP-3401	C.A.—red	.800	1.50
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CMU 5031	RV4NAY SD - 503A	50K
CMU 1041	RV4NAY SD - 104A	100K
CMU 1052	RV4NAY SD - 105A	1Meg

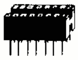
$1.35 each
3/4 Watt @ 70°C
15 turn pot. Linear taper Printed circuit mount

Part No.	Part No.	Part No.
830P-50ohm	830P-5K	830P-100K
830P-100ohm	830P-10K	830P-200K
830P-500ohm	830P-20K	830P-500K
830P-1K	830P-50K	830P-1Meg
830P-2K		

LOW PROFILE (TIN) SOCKETS

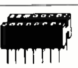
	1-24	25-49	50-100
8 pin LP	.17	.16	.15
14 pin LP	.20	.19	.18
16 pin LP	.22	.21	.20
18 pin LP	.29	.28	.27
20 pin LP	.34	.32	.30
22 pin LP	.37	.36	.35
24 pin LP	.38	.37	.36
28 pin LP	.45	.44	.43
36 pin LP	.60	.59	.58
40 pin LP	.63	.62	.61

SOLDERTAIL STANDARD (TIN)



	1-24	25-49	50-100
14 pin ST	.27	.25	.24
16 pin ST	.30	.27	.25
18 pin ST	.35	.32	.30
24 pin ST	.49	.45	.42
28 pin ST	.99	.90	.81
36 pin ST	1.39	1.26	1.15
40 pin ST	1.59	1.45	1.30

SOLDERTAIL (GOLD) STANDARD



	1-24	25-49	50-100
8 pin SG	.39	.35	.31
14 pin SG	.49	.45	.41
16 pin SG	.54	.49	.44
18 pin SG	.59	.53	.48
24 pin SG	.79	.75	.69
28 pin SG	1.10	1.00	.90
36 pin SG	1.65	1.40	1.26
40 pin SG	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100
8 pin WW	.59	.54	.49
10 pin WW	.69	.63	.58
14 pin WW	.79	.73	.67
16 pin WW	.85	.77	.70
18 pin WW	.99	.90	.81
20 pin WW	1.19	1.08	.99
22 pin WW	1.49	1.35	1.23
24 pin WW	1.39	1.26	1.14
28 pin WW	1.69	1.53	1.38
36 pin WW	2.19	1.99	1.79
40 pin WW	2.29	2.09	1.89

1/4 WATT RESISTOR ASSORTMENTS – 5%

ASST. 1	5 ea.	10 Ohm 12 Ohm 15 Ohm 18 Ohm 22 Ohm 27 Ohm 33 Ohm 39 Ohm 47 Ohm 56 Ohm	50 pcs.	$1.95
ASST. 2	5 ea.	68 Ohm 82 Ohm 100 Ohm 120 Ohm 150 Ohm 180 Ohm 220 Ohm 270 Ohm 330 Ohm 390 Ohm	50 pcs.	$1.95
ASST. 3	5 ea.	470 Ohm 560 Ohm 680 Ohm 820 Ohm 1K 1.2K 1.5K 1.8K 2.2K 2.7K	50 pcs.	$1.95
ASST. 4	5 ea.	3.3K 3.9K 4.7K 5.6K 6.8K 8.2K 10K 12K 15K 18K	50 pcs.	$1.95
ASST. 5	5 ea.	22K 27K 33K 39K 47K 56K 68K 82K 100K 120K	50 pcs.	$1.95
ASST. 6	5 ea.	150K 180K 220K 270K 330K 390K 470K 560K 680K 820K	50 pcs.	$1.95
ASST. 7	5 ea.	1M 1.2M 1.5M 1.8M 2.2M 2.7M 3.3M 3.9M 4.7M 5.6M	50 pcs.	$1.95
ASST. 8R		Includes Resistor Assts. 1-7 (350 pcs.)		$10.95 ea.

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INTERSIL

Part No.	Function	Price
7045IPI	CMOS Precision Timer	14.95
7045EV/Kit*	Stopwatch Chip, XTL	22.95
7106CPL	3½ Digit A/D (LCD Drive)	16.95
7106EV/Kit*	IC, Circuit Board, Display	34.95
7107CPL	3½ Digit A/D (LED Drive)	15.95
7107EV/Kit*	IC, Circuit Board, Display	28.95
7116CPL	3½ Digit A/D LCD Dis. HLD.	18.95
7117CPL	3½ Digit A/D LED Dis. HLD.	17.95
7201IDR	Low Battery Volt Indicator	2.25
7205IPG	CMOS LED Stopwatch/Timer	12.95
7205EV/Kit*	Stopwatch Chip, XTL	19.95
7206CJPE	Tone Generator	5.15
7206CEV/Kit*	Tone Generator Chip, XTL	9.95
7207AIPD	Oscillator Controller	6.50
7207AEV/Kit*	Freq. Counter Chip, XTL	11.10
7208IPI	Seven Decade Counter	17.95
7209IPA	Clock Generator	3.95
7215IPG	4 Func. CMOS Stopwatch CKT	13.95
7215EV/Kit*	4 Func. Stopwatch Chip, XTL	19.95
7216AIJI	8-Digit Univ. Counter C.A.	32.00
7216CIJI	8-Digit Freq. Counter C.A.	26.95
7216DIPI	8-Digit Freq. Counter C.C.	21.95
7217IJI	4-Digit LED Up/Down Counter	12.95
7218CIJI	8-Digit Univ. LED Drive	10.95
7224IPL	LCD 4½ Digit Up Counter DRI	11.25
7226AIJL	8-Digit Univ. Counter	31.95
7226AEV/Kit*	5 Function Counter Chip, XTL	74.95
7240IJE	CMOS Bin Prog. Timer/Counter	4.95
7242IJA	CMOS Divide-by-256 RC Timer	2.05
7250IJE	CMOS BCD Prog. Timer/Counter	6.00
7260IJE	CMOS BCD Prog. Timer/Counter	5.25
7555IPA	CMOS 555 Timer (8 pin)	1.45
7556IPD	CMOS 556 Timer (14 pin)	2.20
7611BCPA	CMOS Op Amp Comparator 5MV	2.25
7612BCPA	CMOS Op Amp Ext. Cmvr. 5MV	2.95
7621BCPA	CMOS Dual Op Amp Comp. 5MV	3.95
7631CCPE	CMOS Tri Op Amp Comp. 10MV	5.35
7641CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7642CCPD	CMOS Quad Op Amp Comp. 10MV	7.50
7660CPA	Voltage Converter	2.95
8069CCQ	50ppm Band—GAP Volt Ref. Diode	2.50
8211CPA	Volt Ref/Indicator	2.50
8212CPA	Volt Ref/Indicator	2.50

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74C

74C00	.39			74C195	1.59
74C02	.39			74C221	1.95
74C04	.39			74C240	2.25
74C08	.39	74C106	.75	74C244	2.25
74C10	.39	74C107	1.89	74C373	2.49
74C14	.75	74C151	2.95	74C374	2.59
74C20	.39	74C154	3.95	74C901	.89
74C30	.39	74C157	2.25	74C903	1.15
74C42	1.39	74C160	1.69	74C911	10.95
74C48	1.95	74C161	1.60	74C912	10.95
74C73	.79	74C162	1.49	74C915	1.69
74C74	.79	74C163	1.69	74C917	10.95
74C85	1.95	74C164	1.59	74C922	5.49
74C86	.99	74C173	1.39	74C923	5.75
74C89	6.95	74C174	1.39	74C925	7.50
74C90	1.29	74C175	1.39	74C926	7.50
74C93	1.29	74C192	1.69	80C95	.79
74C95	1.59	74C193	1.69	80C97	.79

LINEAR

LH0002CN	6.85			NE570N	4.95
LM10CLH	4.50			LM702H	.79
LM11CLH	4.75			LM703CN	.89
LH0070-OH	6.05	LM340T-5	1.25	LM709N	.29
TL071CP	.79	LM340T-12	1.25	LM710N	.79
TL072CP	1.39	LM340T-15	1.25	LM711N	.79
TL074CN	2.49	LM341P-5	.75	LM723N	.69
LH0082CD	35.80	LM341P-12	.75	LM733N	1.00
TL082CP	1.19	LM341P-15	.75	LM739N	1.19
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LH0094CD	36.80	LM342P-12	.69	MC1741SCG	3.00
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LM317T	1.75	LM381N	1.95	LM2002T	1.49
LM317K	3.95	LM382N	1.79	LM2677P	2.05
LM318CN	1.95	LM384N	1.95	LM2878P	2.25
LM319N	1.25	LM386N-3	1.19	LM2896P-1	2.25
LM320K-5	1.35	LM387N	1.45	LM3189N	2.95
LM320K-12	1.35	LM389N	1.35	LM3900N	.69
LM320K-15	1.35	LM392N	.69	LM3905CN	1.25
LM320T-5	1.25	LF398N	4.00	LM3909N	1.15
LM320T-12	1.25	LM399H	5.00	LM3914N	3.95
LM320T-15	1.25	TL494CN	4.49	LM3915N	3.95
LM323K-5	5.95	TL496CP	1.75	LM3916N	3.95
LM324N	.99	NE510A	6.00	RC4136N	1.25
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LM331N	3.95	NE531H	3.95	RC4194TK	5.95
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LM340K-5	1.35	LM565N	1.25	75138N	1.95
LM340K-12	1.35	LM566CN	1.95	75450N	.89
LM340K-15	1.35	LM567V	1.25	75451CN	.39

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

Value	1-9	10-99	100+	Value	1-9	10-99	100+
10 pf	.08	.06	.05	.001µF	.08	.06	.05
22 pf	.08	.06	.05	.0047µF	.08	.06	.05
47 pf	.08	.06	.05	.01µF	.08	.06	.05
100 pf	.08	.06	.05	.022µF	.09	.07	.06
220 pf	.08	.06	.05	.047µF	.09	.07	.06
470 pf	.08	.06	.05	.1µF	.15	.12	.10

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022mf	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

+20% DIPPED TANTALUMS (Solid) CAPACITORS

.1/35V	.39	.34	.29	1.5/35V	.41	.37	.29
.15/35V	.39	.34	.29	2.2/35V	.51	.45	.34
.22/35V	.39	.34	.29	3.3/25V	.53	.47	.37
.33/35V	.39	.34	.29	4.7/25V	.63	.56	.45
.47/35V	.39	.34	.29	6.8/25V	.79	.69	.55
.68/35V	.39	.34	.29	15/25V	1.39	1.25	.95
1.0/35V	.39	.34	.29	22/6V	.79	.69	.55

MINI. ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
.47/50V	.16	.14	.10	.47/25V	.15	.13	.12
1.0/50V	.19	.16	.12	.47/50V	.16	.14	.13
3.3/50V	.17	.15	.11	1.0/16V	.15	.13	.12
4.7/25V	.18	.15	.11	1.0/25V	.16	.14	.13
10/25V	.18	.15	.11	1.0/50V	.17	.15	.14
10/50V	.19	.16	.12	4.7/16V	.15	.13	.12
22/25V	.19	.16	.12	4.7/25V	.16	.14	.13
22/50V	.24	.20	.18	4.7/50V	.17	.15	.14
47/25V	.25	.21	.19	10/16V	.15	.13	.12
47/50V	.29	.25	.23	10/25V	.16	.14	.13
100/25V	.28	.24	.22	10/50V	.17	.15	.14
100/50V	.41	.37	.34	47/50V	.25	.21	.19
220/25V	.39	.34	.33	100/16V	.21	.17	.14
220/50V	.49	.45	.41	100/25V	.25	.23	.21
470/25V	.54	.49	.45	100/50V	.37	.34	.31
1000/16V	.79	.69	.61	220/16V	.25	.21	.19
2200/16V	.89	.79	.69	470/25V	.35	.31	.27

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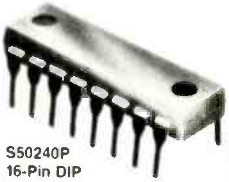

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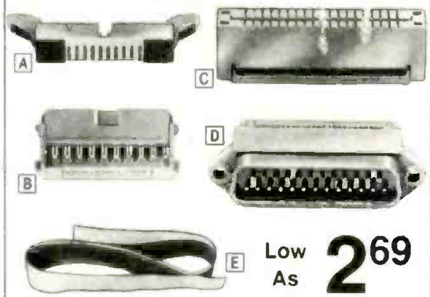

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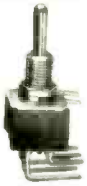

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For 1½ to 6VDC. Typical no-load RPM: 3550. Long leads for easy hookup.
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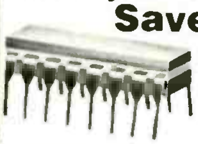

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MM5290-055/4116. Lots of memory in a 16-pin DIP! Requires ±5, +12VDC. Prime. Buy now and save!
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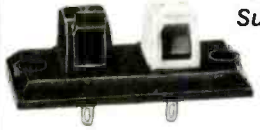
Ideal for Speakers, Power Supplies



1.19

Deluxe terminals with lever release. Color-coded. 2⅛x15/16".
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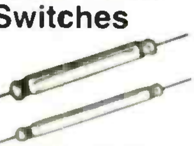

Hermetically sealed in glass. Contacts close when magnetic field is present. Gold-plated contacts rated 500 mA, 125VAC. 275-1610 .... 1.98

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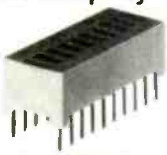
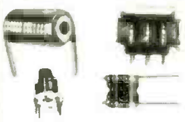


Companion to our LM3914 and LM3915 display driver ICs. Ten LEDs in a 20-pin DIP. With data!
276-081 .... 3.79

Pack of 100 Coils, Inductors & Chokes



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RF, IF and PC-mounts. Nice to have on hand.
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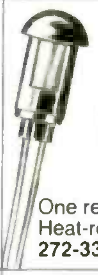
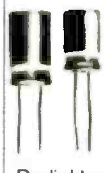
Bright 12-Volt Snap-in Lamps



NEW 1.69 Pkg. of 2

One red, one green. Long life. Heat-resistant housings. Leads.
272-331 .... Pkg. of 2/1.69

Pack of 10 PC Electrolytics



Save 30% Reg. 3.95 **2.77** Pkg. of 10

Radial leads. Two each of most-used values: 4.7, 10, 22, 47 and 100 µF. Rated 35WVDC.
272-1035 ..... Pkg. of 10/2.77

Bright Red Flasher LED

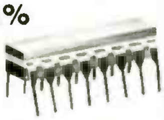
1.29

CMOS Timer IC and LED in One Package!

5 Hz flash rate really gets attention. Ideal for displays, even electronic jewelry. 276-036 .... 1.29

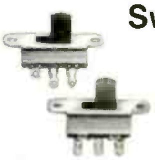
Adjustable Rhythm Generator Chip

Save 33% Reg. 6.59 **4.44**



Build an electronic percussion device! Six combinable patterns. 16-pin DIP with data.
276-1785 .... Sale 4.44

Twelve Assorted Switches



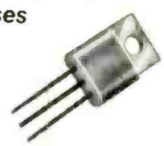
1.98 Pkg. of 12

May include slide, rocker, push-button and momentary types rated up to 3A, 125VAC.
275-1601 .... 1.98

Heavy-Duty SCRs

TO-220 Cases

Low As **99¢**



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200V. 276-1067 .... 99¢
400V. 276-1020 .... 1.19

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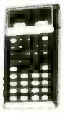

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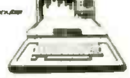

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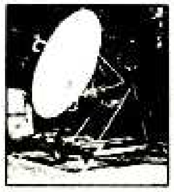

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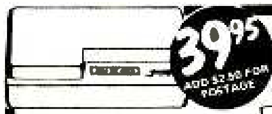

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KOSS CM 1020

No three bandpass loudspeaker system currently available offers the benefits of the Koss CM 1020. Its dual ports improve cabinet tuning and structural stability. And its 10-inch woofer provides a 3db gain in efficiency, as well as flat response over the lower bandpass. In addition, the CM 1020 uses a 4½-inch midrange driver to capture all the energy and presence of this critical bandpass. And the CM 1020's unique 1-inch dome tweeter produces the highest energy output and lowest distortion of any tweeter currently available. Indeed, the Koss CM 1020 is the 3-bandpass loudspeaker system you really have to hear to believe.

KOSS CM 1030

The Koss CM 1030 represents the ultimate in 4-bandpass loudspeaker systems. It includes a 10-inch woofer, mass aligned dual port system, a parallel midrange system with two 4½-inch drivers, and both a tweeter and a 1-inch treble tweeter that feature a unique acoustic transformer. Each has been carefully and specifically designed to produce the optimum spectral characteristics of their respective bandpass.

Uniting the CM 1030 into a total system that represents the ultimate in loudspeaker technology, is a unique, quasi second-order crossover network. In all, the CM 1030 is so amazing, no other 4-bandpass system even comes close in bass, midrange or high bandpass performance.

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