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APRIL 1979/\$1.25

Dynamic Audio Filter Removes Hiss & Noise
"Morse-A-Word" Alphanumeric Converter, Pt. II
Buying Guide to Computer Input/Output Boards

Build a "True RMS" Voltmeter



Tested
In This
Issue

Realistic SCT-30 Cassette Deck

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How to buy a personal computer.

Suddenly everyone is talking about personal computers. Are you ready for one? The best way to find out is to read Apple Computer's "Consumer Guide to Personal Computing." It will answer your unanswered questions and show you how useful and how much fun personal computers can be. And it will help you choose a computer that meets your personal needs.

Who uses personal computers.

Thousands of people have already discovered the Apple computer — businessmen, students, hobbyists. They're using their Apples for financial management, complex problem solving — and just plain fun.

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What to look for.

Once you've unlocked the power of the personal computer, you'll be

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*Apple II plugs into any standard TV using an inexpensive modulator (not included).



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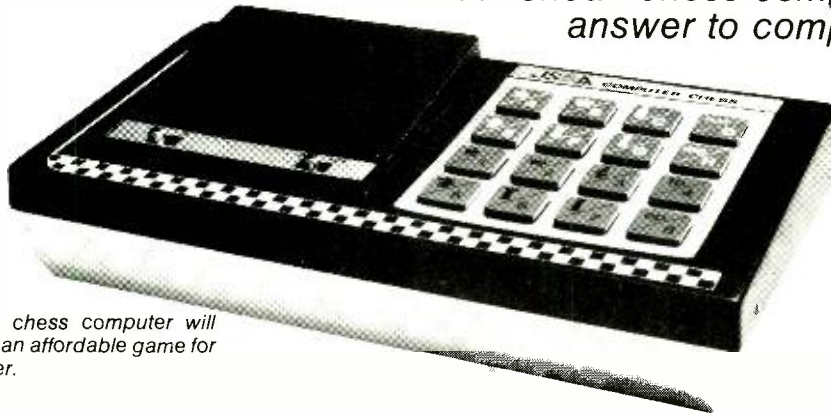
CIRCLE NO. 26 ON FREE INFORMATION CARD



Mr. Karpov and our computer.

Karpov Accepts

*Soviet chess champion agrees to endorse
American chess computer in surprise
answer to computer challenge.*



*The new \$100 JS&A chess computer will
make computer chess an affordable game for
the American consumer.*

Anatoli Karpov is the undisputed World Chess Champion. Last month, JS&A challenged Karpov to play against our chess computer. We offered him \$50,000 and a percentage of each unit we sold if he beat our game.

Karpov rejected our offer and quite frankly, we were at a loss to explain why.

Our concept was simple. If Karpov played against our computer, he would focus world-wide attention on our product. This attention would increase its sales and win or lose, we would sell more computers.

We had to sell more computers. We wanted our unit to sell for \$100 even though units with similar capabilities were selling for up to \$400. But we had to do two things to keep our low price: First, we had to manufacture our unit in Hong Kong where labor costs are very low. Secondly, we had to sell large quantities to keep production costs down.

When we first announced our challenge, the Soviets rejected it. Could Karpov have been afraid to play against it? Or was the circus-like atmosphere that might surround the event not in keeping with the prestige of the coveted world title, even if Karpov won?

Quite honestly, we had no idea. So we asked Karpov for an explanation and got one. Here's what he said:

"I can appreciate your desire to sell the JS&A Chess Computer but you have missed an important point of the entire challenge. It took somebody to program the unit and since I am the world's chess champion, it is highly unlikely that the programmer person could beat me. You Americans have a saying, "Garbage in, garbage out."

Karpov continued, "Your unit is definitely a good product. I played several games at level six and found it to be a challenge even for me. What I like about your unit is that it is priced low enough so that most Americans can afford the unit and this will help promote chess."

The JS&A Chess Computer indeed has six levels of chess. Level one is perfect for beginners. Level six is a real challenge for any Soviet Chess Champion.

LIKE PLAYING KARPov

The system is the perfect way to sharpen your chess skills. It not only has six different skill levels, but if you are playing against the computer at level two and you are beating it, you can switch the unit to level six. It's like having Karpov as your new opponent—right during mid game.

To play against the computer, you enter your move on the unit's keyboard. You then wait until the computer examines all its options and selects its move. You then move the computer's chess piece to correspond with its request as shown on the display. A board layout is provided to show you where each chess piece should be moved.

The JS&A Chess Computer is programmed for such complex functions as castling, pawn promotion and *enpassant*. It also allows you to start in midgame, setting up any situation you choose. This is perfect for those players who wish to examine particularly intricate problems and allows for an infinite number of game variations.

SHARPEN SKILLS

If you already play chess, the JS&A unit provides a new chess dimension. If you haven't played chess, the system is a good way to learn and sharpen your skills.

The JS&A Chess Computer measures only 2 1/8" x 4 7/8" x 8 7/8" and weighs just a few ounces, so if service is ever required you can slip it in its handy mailer and send it back to our prompt service-by-mail center. Service should never be required, but it is reassuring to know that service is an important consideration in this program.

JS&A is America's largest single source of space-age products—further assurance that

your modest investment is well protected.

We suggest you order a JS&A Chess Computer and use it for 30 days. Play against it. Raise or lower the level as you play and watch how the computer's personality can change right in mid game—from a tough competitor to a push over.

Test our level six and see if you'd have much of a chance against the Soviet Champion Karpov. Then, after you've really given it a workout, decide if you want to keep it. If not, you may return your unit within our 30 day trial period for a prompt and courteous refund, including your \$2.50 postage and handling charge. There is no risk. Each JS&A Chess Computer comes complete with instructions and an AC adapter (no batteries are required).

To order our JS&A Chess Computer, send your check for **\$99.95** plus \$2.50 for postage and handling (Illinois residents please add 5% sales tax) to the address below or credit card buyers may call our toll-free number below.

Karpov told us (and this is a direct quote) "I have played all the rest of the American chess computers and find that the JS&A unit is the best value for the dollar. I will accept an offer to endorse the game, however, you can forget about your \$50,000 offer and spend the money on advertising to spread the word."

Thank you, Mr. Karpov. We appreciate your honesty and your generosity and we promise to spread the word.

And you can help us America. Order a JS&A Chess Computer at no obligation, today.

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instrument.

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POPULAR ELECTRONICS



About the cover:

The "True RMS" Voltmeter featured here will at last enable readers to measure "effective" voltages of odd-shaped waveforms without spending considerable monies.

Cover Art by George Kelvin

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Editorial

1979½

The Consumer Electronics Show in Las Vegas this past January revealed what we can expect to be sold in stores during the first half or two thirds of '79. In most cases, products will remain the same as '78 year-end models, judging from what we saw at this giant trade convention. There were exceptions, though, as follows.

At the Jockey Club Hotel, away from the Convention Center mainstream, about 100 smaller audio companies were gathered in hotel suites to display their products. With late and limited publicity as to the existence of this added location, and owing to abominable elevator service, it was a challenge to cover it. But the effort was worthwhile, for here is where one can generally find the design innovator/entrepreneur person and, consequently, learn how a product really works. At one such meeting, I previewed a preamp with an audio hologram function, plus a 200 W/ch "Magnetic Field" power amp housed in a 6¾"-cube chassis, weighing about 12 lb., and tentatively priced at 75¢ per channel-watt. (We'll have a full test report on the prototype Carver Corp. preamp next month.)

At the main show, spread out over some 459,300 sq. ft., personal computer exhibits were clearly in evidence, Ohio Scientific, Apple, APF, and Commodore PET, among them. Bally introduced a new computer language called "Grafix" for expanded functions, while Mattel (yes, the "toy company") debuted its "Intellivision" system. The latter is a programmable game component which is expanded to a "computer" with a mating 64-key keyboard component. Uses prerecorded tapes.

Microprocessors were used for more dedicated applications, of course. For example, Coleco Industries (another "toy company") introduced its ZODIAC™ astrology computer; Comus, its hand-held "C-6 Diet Computer" for computing proper caloric needs according to input information on weight, height, type of exercise, etc. And then we saw—and tried out—Craig's portable M100 Language Translator. It converts English to another language automatically, with the foreign language reading out on a blue Digitron display. Memory capsules (\$25 each) include Spanish, French, Italian, German and Japanese at this time, each with a vocabulary of about 1,500 words. Talking computerized chess games from Boris and Fidelity Electronics astounded many attendees, and for you Contract Bridge and/or Backgammon enthusiasts, there were computer-opponent games exhibited. Texas Instruments' programmable TI 58 and 59 solid-state software libraries impressed me, too.

The car stereo rage was certainly carried over into the CES, with numerous models shown. With one, you can now *feel* the sound as well as hear it owing to a "Bodysonic" amp that makes a seat cushion pulsate as music is played. It's from Pioneer Electronics of America. And from Fosgate is a four-channel 4 x 50W car amp that uses the Tate system.

We listened to a digital audio disc system developed by Matsushita Electric (sounded great!); marketing plans are incomplete, however. And also liked one of the least expensive items at the show, a Discwasher "Hi-Fi Seer" audio illuminator; a small, \$7 flashlight-mirror system with on-off switch that lights up those dark recesses in a hi-fi cabinet.

In the communications field, Nevcom's cordless CM-100 communications microphone, with a three-meter range, worked beautifully. JS&A is marketing it. And writing about cordless, a handful of cordless telephone handsets were exhibited at the show. One of them, Pathcom's "EZ Phone," startled me when an incoming call caused it to ring while in the jacket pocket of the person I was talking to. It operates at 1.6 to 1.8 MHz and 49.8 to 49.9 MHz under Part 15 of the FCC Rules (no license required). About \$170.

Among other interesting products revealed at the show were: "FlexSwitch," a thin, pressure-sensitive membrane that's designed to interface with logic circuitry. A prototype designer's kit costs \$10 (Sheldahl, Electrical Products Div., Northfield, MN 55057.) Another was a portable synthesizer from England, the Tylophone 350-S, that simulates sounds of more than 20 different instruments when sliding a stylus across a 3½-octave keyboard.

With about 811 exhibitors in all, space doesn't permit me to mention all the newly introduced products. But as you can see, 1979½ will be an interesting part-year.

Art Salsberg

POPULAR ELECTRONICS

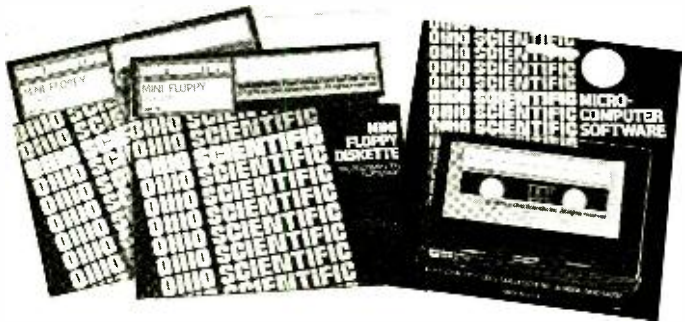
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The C1P MF configuration is very powerful. However, to meet your growth needs it can be directly expanded to 32K static RAM and a second floppy by simply plugging these options in. It also supports a printer, modem, real time clock and AC remote interface as well as the OS-65D V3.0 development oriented operating system.

Or Start with the C1P CASSETTE BASED Computer for just \$349.

The cassette based Challenger 1P offers the same great features of the mini-disk system including a large software library except it has 4K RAM and conservative program retrieval time. Once familiar with personal computers, you'll be anxious to expand your system to the more powerful C1P MF.

You can move up to mini-disk performance at any time by adding more memory and the disk drive. Contact your local Ohio Scientific dealer or the factory today.

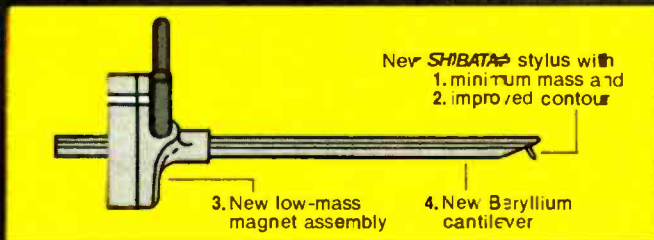
*Both systems require a video monitor, modified TV or RF converter and home television for operation. Ohio Scientific offers the AC-3 combination 12" black and white TV/monitor for use with either system at \$115.00 retail.

All prices, suggested retail.

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Announcing four tiny advances with room-filling benefits!



In the tiny world of the stereo cartridge, microscopic differences in dimensions are all-important. Which is why the extremely low moving mass of the new AT15SS is a major achievement in stereo technology.

For instance, to the best of our knowledge our new stylus is the smallest whole diamond used in series production. In cross-section, it's 36% smaller than our best previous model. It is also nude-mounted to further reduce mass at the record surface. And the square-shank design insures exact alignment with groove modulations.

All this is so small you'll need a microscope like the one above used by many A-T dealers to see the details. If you look very closely you'll also see we've slightly revised the contour of the Shibata tip. The combination of minimum mass and new contour which we call Shibata+ offers outstanding stereo reproduction, especially of the latest high level recordings.

But there's more. Extremely low distortion results from a new ultra-rigid

Beryllium cantilever which transmits stylus movement without flexing. And flatter response plus better tracking is achieved by a new method of mounting our tiny Dual Magnets to further minimize moving mass.

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Note: If you own a current AT15Sa or AT20SLa, you can simply replace your present stylus assembly with a new "SS" stylus assembly to bring your phono system up to date.



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CIRCLE NO. 6 ON FREE INFORMATION CARD

Letters

AUTOMATIC KEYS FOR HAMS

After reading "Control Your Model Railroad With Audio Tape" (November 1978), I thought of another very practical use for the project. It can be used as a keyer for pre-recorded Amateur Radio messages with a ham rig equipped with full break-in capability. The keyer could be used to send a CQ message with perhaps a 20- or 30-second delay before the message is repeated. The conversion is simple: connect a keyer in place of S3 and forget S4 altogether and use the contacts of K1 to key the transmitter. —Brian Torr, Monte Rio, CA.

DISCO MIXER SPECIFICATIONS

For those who are interested, here are the frequency-response and distortion specifications for my "Disco Preamp/Mixer" (September 1978). Phono Section: input impedance, 47,000 ohms and 100 picofarads; input overload 60 millivolts at 1 kHz; playback equalization, IEC ± 0.5 dB; input sensitivity, 4 mV at 1 kHz (for 500 mV output); S/N referred to 5 mV, 87 dB (IHF "A" weighting); THD + N, 0.1% (1 kHz at rated output); IM (SMPTE), 0.09%. High Level: input impedance, 50,000 ohms; frequency response, PA only, -0.4 dB at 20 Hz, 0 dB at 100 kHz, DM, -1 dB at 20 Hz, 0 dB at 100 kHz; IM (SMPTE), PA & DM, 0.003%; THD + N: (at 8 V rms) 20 Hz -0.012%, 2 kHz -0.0018%, 10kHz -0.0035%, 20 kHz -0.0052%; output clipping, 9 V rms; output noise, 92 dB below 500 mV (IHF "A" weighting) (117 dB below clipping). —John R. Roberts.

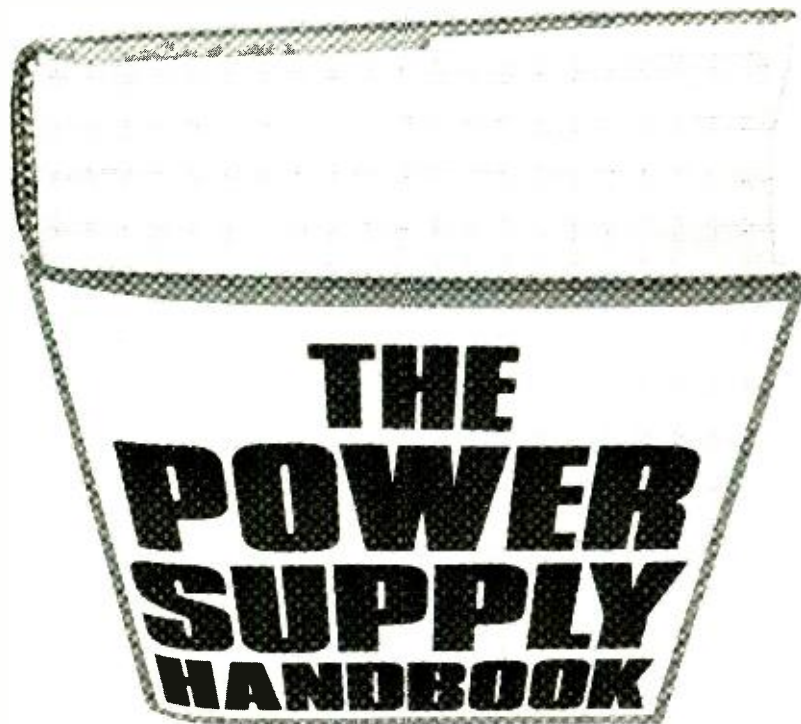
CIRCUIT CHANGE REQUEST

"Build a Digital Darkroom Timer" (August 1978) is really a lifesaver, but I have a request to make regarding its design. Would it be possible to change the circuitry so that the desired exposure time can be entered into the timer via a keypad?—Freddie T. Reitz, Waupun, WI.

We often receive letters in which readers ask us to detail how to make modifications to our published projects. Our response to such requests must be that we do not have the requested information and any attempt to provide this information requires researching that would jeopardize our deadlines.—Ed.

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cuits you can build and modify. Projects like 13V mobile systems, 12V 20A brute supplies, voltage sextuplers for SSB, 115V 60 Hz sine wave inverters, regulated nicad chargers, precision 10,000V DC references, adjustable low-voltage regulated supplies, 117V AC to 24V DC converters, and lots of special-purpose AC supplies. And precisely because this manual is so comprehensive, you'll be able to build PS systems that are as good as any you can buy, systems that meet your specifications.

Probably the most remarkable thing about this volume is the sheer variety and quality of the projects it offers...each one is reliable, pretested, easy to build, and you can construct most of them from inexpensive salvaged or surplus parts. It would have to be a very unusual PS indeed not to be covered in this manual, for here you'll find everything from simple get-the-job-done units to highly refined adjustable supplies. Step-by-step instructions tell you how to put together voltage doublers for MOS LSI, super low-voltage supplies, 78MG voltage regulators, 13V supplies for mobile equipment, 110V 600 Hz inverters,

polarity changers, 12V to 300V converters, solid-state car alternator/regulators, silver-zinc cell battery chargers, zero to 30V lab supplies, simple four-voltage bench supplies, and many more. The projects come with all the data you need to insure flawless no-hitch construction—concise analyses of special circuits, easy-to-follow directions, detailed schematic diagrams, complete parts lists, and special discussions of construction safety precautions.

The scope of this handbook is broad—broad enough to include construction info on tested circuits that'll help you make the most of any power supply you put together—circuits that'll allow you to interface, modify, and test your own PS designs. The authors show you how to construct voltage splitters, IC protection circuits, smoke testers, two-terminal current limiters, voltage limit sensors, active voltage dividers, microfarad multipliers, capacitor rejuvenator-leakage testers, and many, many others. 120 pps., 292 illus. Hardbound. List \$12.95.

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ELECTRONICS BOOK CLUB
Blue Ridge Summit, Pa. 17214

Please open my Trial Membership in ELECTRONICS BOOK CLUB and send my copy of "THE POWER SUPPLY HANDBOOK" ABSOLUTELY FREE! If not delighted, I may return the book within 10 days and have my Trial Membership cancelled. I agree to purchase at least four books during the next 12 months, after which I may cancel my Membership at any time.

Name _____ Phone _____

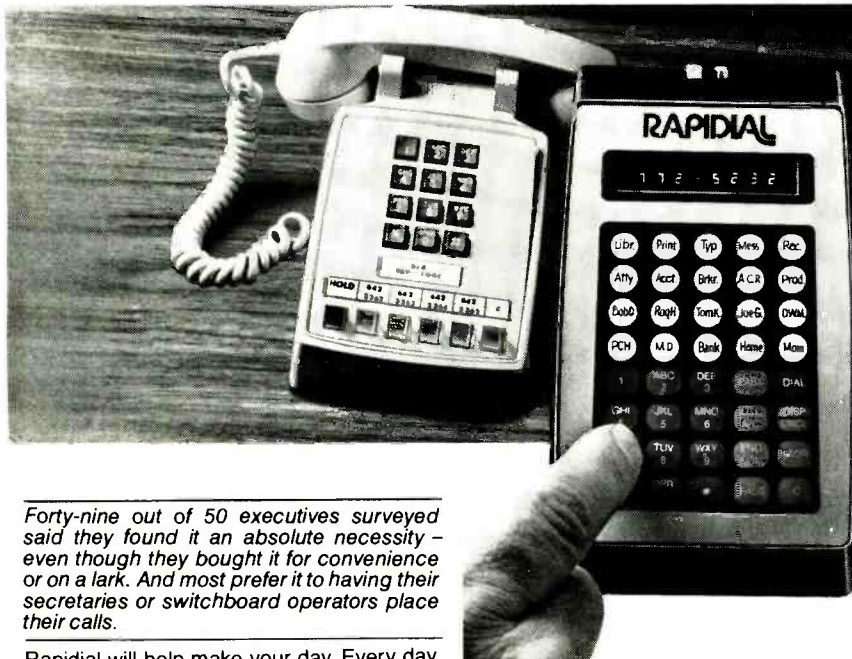
Address _____

City _____

State _____ Zip _____

(Valid for new Members only.) PE-49

CIRCLE NO. 18 ON FREE INFORMATION CARD



Automatic Transmission

Who else wants to save time, trouble and aggravation? At \$99, Rapidial™ is America's lowest priced, best selling automatic dialer.

Forty-nine out of 50 executives surveyed said they found it an absolute necessity—even though they bought it for convenience or on a lark. And most prefer it to having their secretaries or switchboard operators place their calls.

Rapidial will help make your day. Every day. Imagine dialing a number by touching a button. And, then, having the number you are calling ring in a second. (Tell somebody you will call right back, and his phone will ring the instant he hangs up!)

Works with any phone—One line or 10.

Even turns a rotary into a Touch Tone®. F.C.C. approved, manufactured in the U.S. and guaranteed for one full year, Rapidial comes with a plug-in wall jack adapter (4-prong or modular combination) for phones with one or two lines. For permanently installed office phones with up to six lines we have an inexpensive, two-screw "sandwich connector". And for phones with up to 10 lines the phone company will install an RJ35X connection (for a one time charge of about \$30).

Rapidial works on any line of any multiple line phone. It also works with rotary phones. In fact, you can use the Rapidial keyboard to place all your calls with Touch Tone speed and ease.

It's Hands-Free

Rotary or Touch Tone, using the Rapidial keyboard regularly has added advantages. First, it's hands free telephoning. With a built-in type speaker system. You lift the receiver only when you hear someone answer. Second, if the line processed is busy, Rapidial shuts itself off automatically, remembering the number so you can redial at the touch of a button—as often as necessary.

There is no call you can't make. What's more, every call—local, long distance, inter-office, even over seas, is easier and faster. With Rapidial you can store as few or as many as 10 digits (area code and number) in memory. If you have to dial "9" or "1" or both, need the operator, want to access a WATTS line or a PABX system, just touch the extra buttons you need plus the button with the number you're calling.

Bonus Features

About the size of a hand-held calculator, Rapidial sits neatly on your desk next to your telephone. Always ready with no off/on switch to worry about. The numbers in memory are identified on the panel on top. The lower section is the Touch Tone keyboard pad. An LED DISPLAY lets you check any number in memory. The PAUSE CONTROL sets the machine to wait for a dial tone. There's an

© Touch Tone is a mark of A. T. & T. Co.

AUTOMATIC CANCEL button if you change your mind or hit the wrong number. And the BATTERY BACKUP protects the memory in a power failure.

Five Different Uses

For peak operation and maximum efficiency at the lowest cost, Rapidial stores 20 numbers in memory—eliminating wrong numbers and having to stop to look them up. Numbers entered in seconds and changed—any time—by Rapidialing the new number.

Basically it allows you to place frequently made calls yourself in an instant. In far less time, actually, than it would take you to tell your secretary to do it for you. With immediate access to emergency numbers.

Interestingly, our survey unearthed some rather surprising and highly enterprising additional uses.

For example, most executives store *both* their most frequently called numbers, family, friends, clients or customers, service organizations and suppliers... and those important but less frequently called numbers that almost always have to be looked up.

Others use Rapidial mostly for inter-office calls. Since remembering extensions is almost impossible. And it's kind of inconsiderate to have a man get on the phone with your secretary first all the time.

The Memo Caller—or daily telephone organizer—is one of the more intriguing uses we discovered. These men (or their secretaries) program each day's calls. Crossing off the ones that are completed (adding new

ones as necessary). A glance assures you no one's been left out, no call back has been forgotten. And a touch of the button gets you the next man on your list.

Finally, many report leaving the bottom bank of storage cells blank. Reserving them for the flow of calls that always accompanies a special deal or negotiation.

\$20 Less Than Retail... \$50 Less Than The Closest Competitor's.

A repertory—or automatic dialer—from the phone company with 15 numbers costs \$105 to install and \$9 a month plus tax to lease—forever. For \$130 you can get a 16 number dialer—with no keyboard of its own so it's only good for those numbers stored in memory. For \$149.95 you can get a 20 number unit—but it's primarily for the home since a special telephone company installation for any multiple line phone is needed and it's not recommended at all for phones with more than three lines.

Rapidial will sell in stores for \$119.95. But is being introduced by mail for \$20 less. Why? To get as many as possible in use now by the kind of people Douglas Dunhill reaches by advertising in America's most influential publication.

So, you can have the easiest to use, most efficient and versatile unit on the market today for less than anybody else. And without risking one cent!

30 Day Trial

If your Rapidial isn't the executive necessity we described, the home convenience you hoped for, just return it in 30 days for a full refund. And we'll thank you for trying.

The price, including backup batteries and adapter for your wall jack, is just **\$99.00** plus \$2.50 shipping and handling. The Amphenol connection for multiple line office phones is only \$19.95 extra. The adapter for the RJ35X is \$19.95. (For the RJ35X connection itself, for phones with six or 10 lines, call your telephone business office.)

Deduct 10% from the price of the Rapidial on orders for ten or more. Call toll free to charge to your national credit card or send your check to Douglas Dunhill. (Illinois residents add sales tax.) You'll find it a far cry from standard transmission.

CALL 800-621-5554

Illinois residents call 800-972-5858

Douglas Dunhill
INC. AFFORDABLE QUALITY

Dept. 74-2339

Ten Douglas Dunhill Drive, Oak Forest, IL 60452

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CIRCLE NO. 16 ON FREE INFORMATION CARD



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.

Sanyo Bi-amplified Auto Sound

The Sanyo Model FT-1490A is a car in-dash AM/FM/cassette system with bi-amplification. Its tuner has a dual-gate MOS-FET front end, PLL multiplex decoder,



1- μ V FM sensitivity (mono), and 30-to-16,000-Hz response; Dolby noise reduction for FM and tape; loudness contour control; selectable standard/bi-amplification mode; and tape transport with full auto-reverse and auto-repeat, self-draw tape compartment, and locking fast-forward and rewind. Bi-amplification provides separate amplifiers for bass (rated 12 watts/channel) and treble (2 watts/channel). \$199.95.
CIRCLE NO. 86 ON FREE INFORMATION CARD

Antenna Inc. Low-Profile CB Antennas

The Persuader™ is a new line of CB antennas from Antenna Inc. It features a pre-tuned hand-wound loading coil located right in the mounting cup instead of the usual nontunable and low-power printed-circuit assembly generally used in low-profile antennas. This design is reported to

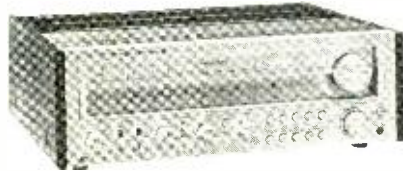


require fewer mechanical and electrical connections and fewer resistive contacts between loading coil and cable terminations. Persuaders are tested at 500 watts of power and rated at 1000 watts continuous. Magnetic mounts are tested at 55 mph. The active radiator element is a 60" (1.5-m) long tapered stainless steel whip. Mounted on the center of a car roof, SWR is claimed to be 1.5:1 or less across all 40 CB channels. A choice of magnetic or trunk-lip mount is available, and mounts come in silver, bronze, black, blue, red, white, and clear. \$34.98.

CIRCLE NO. 87 ON FREE INFORMATION CARD

Realistic High-Power Receiver

The Realistic Model STA-2100 is said to be the most powerful AM/FM stereo receiver ever offered by Radio Shack. It is rated at 120 W/channel minimum rms at 8 ohms from 20 to 20,000 Hz with no more than 0.1% THD. Special features include separate bass, treble, and midrange tone controls, with selectable crossover points on bass and treble; switchable 25- and 75- μ s deemphasis for FM Dolby reception; a multiplex filter, AM signal strength and FM center-channel meters; and dual power meters. Both DIN and phono-type input



and output jacks are provided for use with two tape decks. (One can record from one source while listening to another.) Specifications: 15 to 25,000 Hz \pm 2 dB at 10 watts frequency response; 0.05% IM distortion at 70 watts; 70-dB phono, 75-dB AUX S/N; 1.6- μ V (10.1-dBf) FM sensitivity; 75 dB alternate-channel separation; 52 dB at 1000 Hz FM stereo separation; 0.1% stereo, 0.05% mono FM THD. \$599.95

CIRCLE NO. 88 ON FREE INFORMATION CARD

Mura Wireless Microphone

The Mura Model WMS-49 is a high-power wireless microphone system that contains a matched transmitter and receiver, both of



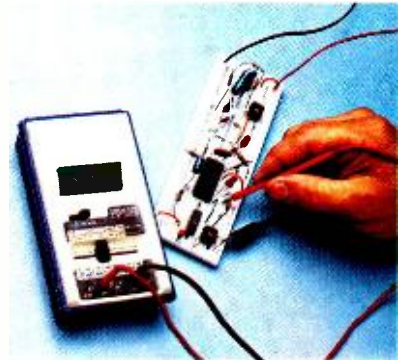
which are crystal controlled. The system operates in the 49-MHz walkie-talkie band where 100-mW output power is permitted without an FCC license. The microphone's

electret element has a rated 30-to-18,000-Hz (no reference given) frequency range. The receiver has a standard phono plug output for connection to a PA or other microphone input and a VU meter to monitor the audio output signal level of the transmitter. A single 9-volt battery is required in the transmitter and the receiver. \$69.95.

CIRCLE NO. 89 ON FREE INFORMATION CARD

Hickok Hand-Held DMM Features LCD Display

The 3½-digit pocket-size Model LX-303 DMM from Hickok Electrical Instrument Co. features a liquid-crystal display for long battery life. Numeric display of the pa-

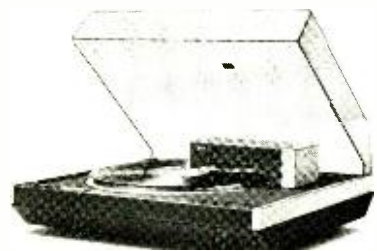


rameter being measured is backed up by automatic polarity and overrange indication. The instrument can measure from 0.1 mV to 1000 V (\pm 0.5% of reading \pm 0.5% full-scale) on dc; from 0.1 V to 600 V (\pm 1% of reading \pm 0.5% f.s.) on ac; 0.01 nA to 200 mA (\pm 1% of reading \pm 0.5% f.s.) on dc; and 0.1 ohm to 20 megohms (\pm 0.5% of reading \pm 0.5% f.s.). Protection is provided to 1000 volts on all dc ranges except the 200-mV range, where it is to 500 V; to 600 V on all ac ranges; and to 120 V on all resistance ranges. \$74.95.

CIRCLE NO. 91 ON FREE INFORMATION CARD

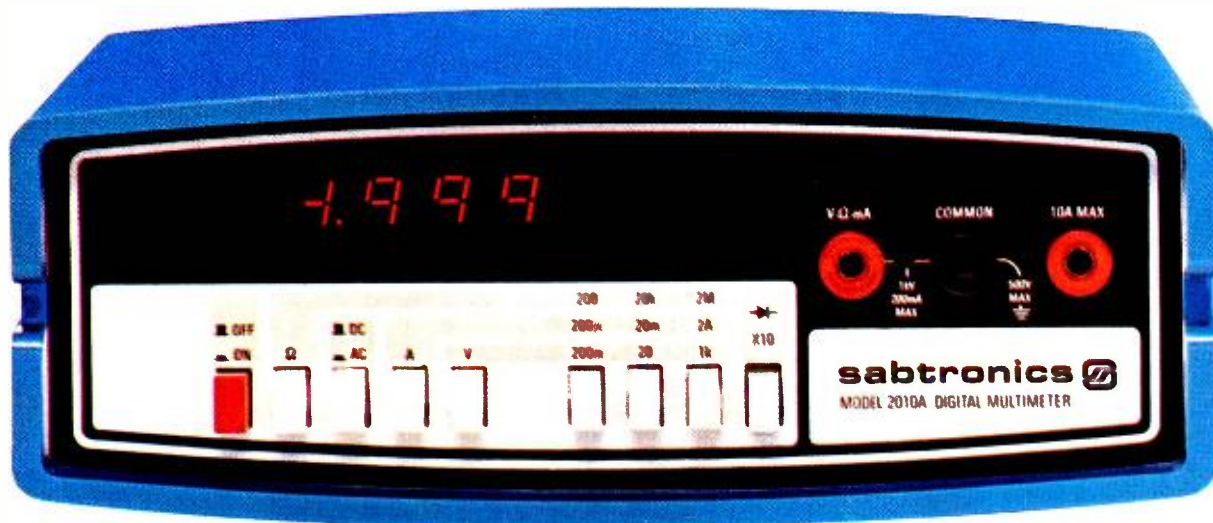
ReVox Direct-Drive Turntable with Tangential Tracking

The B790 turntable from ReVox has no tonearm in the usual sense, but is equipped instead with an optoelectronic servo mechanism to position the cartridge.



ALL NEW AND ADVANCED DMM

by Sabtronics
for only \$89.50



Designed and made in U.S.A.

The new and advanced Sabtronics Model 2010A is absolutely amazing . . . it gives you more performance, features and accuracy at a price no other Digital Multimeter can approach. It is versatile and rugged, for bench and portable use, with laboratory standard accuracy.

Greater Long-Term Accuracy

State-of-the-Art design features include a laser-trimmed decade resistor network and an ultra-stable band-gap reference element to insure long-term accuracy. Basic DCV and Ohms accuracy is 0.1% ±1 Digit, guaranteed for one year. With 31 ranges and 6 functions you can measure AC and DC volts from 100 μV to 1000V; AC and DC current from 0.1 μA to 10 A; resistance from 0.1 Ω to 20 MΩ.

Unique X10 Multiplier Switch

This exclusive feature of the Model 2010A gives you a convenient means of selecting the next higher decade range. The Hi-Lo Power Ohms capability gives you three High-ohm ranges that supply enough voltage to turn on a silicon junction for diode or transistor testing. Measure in-circuit component resistance with three Low-ohm ranges.

Touch and Hold Capability

The optional touch and hold probe allows you to make measurements in hard-to-reach places without taking your eyes off the probe tip. A button on the probe retains the display reading after the probe tip is removed from the test point.

Other Important Features

This quality instrument includes an ACV Frequency Response of 40 Hz to 40 kHz, automatic polarity, automatic zero, automatic decimal point, overrange indication, and overload protection on all functions and ranges. The bright LED display gives readings to ±1999 and is easy to read in dim light or bright light.

Reliability and Performance at Low Cost

The Model 2010A is factory tested, calibrated and is supplied complete with test leads, probes and detailed operating manual. A full compliment of optional accessories is available to increase the versatility of your 2010A DMM. Because you buy factory direct, you get this high-quality, full performance instrument at an incredibly low price of only \$89.50.

Brief Specifications

DC Volts: 100μV to 1000V in 5 ranges
AC Volts: 100μV to 1000V in 5 ranges
DC Current: 0.1μA to 10 A in 6 ranges
AC Current: 0.1μA to 10 A in 6 ranges
Resistance: 0.1 Ω to 20 MΩ in 6 ranges
Diode Test Current: 0.1μA, 10μA, 1mA
ACV Frequency Response: 40Hz to 40kHz
Input Impedance: 10 MΩ on ACV and DCV
Overload Protection: 1200 VDC or RMS on all voltage ranges except 250 VDC or RMS on 100mV and 1 V AC ranges. Fuse protected on ohms and mA ranges.
Power Requirement: 4.5 to 6.5 VDC (4 "C" cells) optional NiCd batteries or AC adapter/charger
Display: 0.36" (9.2mm) Digits reading to ±1999
Size: 8"W x 6.5"D x 3"H (203 x 165 x 76 mm)
Weight: 1.5 lbs (0.68kg) excl. battery

(Batteries not included)

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PLEASE SEND ME THE FOLLOWING

_____	Model 2010A Digital Multimeter(s)	@\$89.50	\$
_____	AC Adapter/Charger(s)	@\$ 7.50	\$
_____	Nickel-Cadmium Battery sets	@\$17.00	\$
_____	Touch-and-Hold Probes	@\$18.00	\$
_____	For delivery in Texas, add Sales Tax		\$
_____	Shipping, Handling and Insurance per unit \$4.00*		\$
			TOTAL \$ _____

Check enclosed Money Order, or bill my Master Charge Visa **Account No.** _____ **Expiry Date** _____

Name _____
Street _____
City _____ **State** _____ **Zip** _____

*Continental U.S. only. AK, HI & PR, \$5.00 Canada, \$6.50, Foreign: \$19.00 Airmail.

PE-4

The platter is turned by a direct-drive servo motor with quartz-crystal speed control at 33 $\frac{1}{3}$ or 45 rpm with speed adjustments of $\pm 7\%$ and a four-digit, seven-segment LED speed readout. The cartridge is carried by a mounting plate of aluminum 4 cm long and weighing a little over a gram. The arm/cartridge assembly is mounted on an overhead carrier mechanism that moves the cartridge tangentially across the face of the record on steel rails. Lateral movement is controlled by a sensing system using an LED light source that advances the cartridge at the groove rate. The company claims that this arrangement eliminates tracking error and noncompliance due to the effective moving mass of a tonearm. The system is supplied with an Ortofon M20E moving-coil cartridge and a brush that automatically cleans the slyus between records. \$799.

CIRCLE NO. 92 ON FREE INFORMATION CARD

CPI CB AM/SSB Mobile

The Model CP-2500 mobile AM/SSB CB radio system from Communications Power, Inc., (CPI) combines the security of a trunk-mounted transceiver module with the

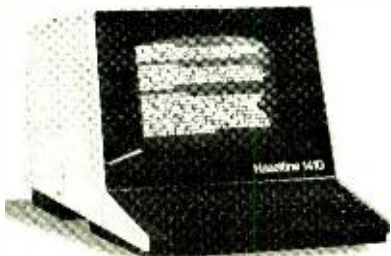


convenience of a dashboard control console. The system's control unit includes a numeric channel display; upper/lower-sideband and AM selector; volume, PA provision, r-f gain, microphone gain, clarifier, and squelch controls. The receiver features a separate, switchable automatic noise limiter and blanker; a logarithmic speech compressor; and front-panel signal strength, transmitter power and modulation meter. An 18' (5.5-m) cable is provided for interconnecting the control and transceiver units.

CIRCLE NO. 93 ON FREE INFORMATION CARD

Hazeltine Video Computer Terminal

Hazeltine Corp. has introduced a new low-priced B&W video terminal for data entry



and data inquiry in a microcomputer system. It features separate numeric keys. The new Model 1410 economy computer terminal is based on the company's 1400 and 1500 video terminals. It operates with a standard EIA RS-232 interface with eight transmission rates (selectable onboard) up to 9600 baud to accommodate all 128 ASCII character codes. A cooling fan is not required and electronic components are mounted on a single printed-circuit board.

CIRCLE NO. 94 ON FREE INFORMATION CARD

Nikko Compact Preamplifier

Nikko has added the ultrathin (2 3/32"H) Beta III PET preamplifier to its professional series of audio components. It uses newly designed FETs throughout its signal circuitry for fast and accurate signal reaction, high S/N characteristics, and extremely



low distortion. Its specifications include: within ± 0.2 dB for the 30-to-15,000-Hz RIAA phono frequency response (10 to 50,000 Hz ± 0.5 dB tuner and AUX); less than 0.004% THD phono at 3 volts tape out (0.005% THD tuner and AUX at 2 volts preamp out); 2 mV phono (110 mV all other) input sensitivity; selectable 22k/47k/100k phono (47k all other) input impedance; 81 dB phono (at 2 mV input), 100 dB tuner and AUX S/N; ± 10 -dB bass and treble tone-control range; 350-mV maximum phono input; 1-volt output 1 and 2 and 100-mV tape 1 and 2 output level; 100 ohms output 1 and 2, 2200 ohms tape 1 and 2 output impedance; 19"W \times 13"D \times 2 3/32"H (48.3 \times 33 \times 5.3 cm); 13 lb (5.9 kg). \$399.

CIRCLE NO. 95 ON FREE INFORMATION CARD

Electra Scanner Includes AM Aircraft Band

Electra Company's "Bearcat 220" is claimed to be the world's first scanning receiver to offer both standard FM Public



Service Band (five vhf-uhf) and AM Aircraft Band reception in a single unit. The crystal-less ac/dc receiver employs pushbut-

ton frequency entry. Frequencies being monitored appear in a lighted numeric display. Up to 20 frequencies can be in any sequence or mix of bands. A priority function alerts the user when a call is received on the priority frequency programmed into the channel-1 location. Channels can be activated in banks of 10, permitting a single button to call up a group of 10 channels. Also, three search operations are provided to locate active frequencies. Other features include selective scan delay, scan speed selection, ac and dc operation, direct access to a programmed channel, and automatic and manual squelch.

CIRCLE NO. 96 ON FREE INFORMATION CARD

MXR Flanger/Doubler

The MXR Flanger/Doubler produces a wide variety of time-delay effects and is instantly switchable between modes. Time delay is 0.25 to 5 ms in the flanging and 17.5 to 70 ms in the doubling modes. Featured are manual control over the delay time; mix control (between dry and un-



delayed signals); sweep controls for width and speed; and regeneration control for added intensity. Many varieties of flanging, hard reverberation, and numerous types of doubling, which include subtle chorus effects, can be produced. The device is rack-mountable and features instrument level inputs and outputs as well as line level inputs and outputs. Voltage-control terminals provide a means for externally controlling the delay and for ganging two units for stereo operation. \$425.

CIRCLE NO. 97 ON FREE INFORMATION CARD

Nihon Nav/Com Receiver

Nihon's COMNI R-1010 is a low-priced version of professional navigation/com-



munication vhf AM air-band receivers. Frequency control is by a PLL frequency synthesizer that tunes across the entire 108-to-135.975-MHz band in 25-kHz steps. Tuning is accomplished with concentric kHz and MHz channel-selector knobs. A five-digit LED numeric display provides frequency readout. Other features include a squelch control and a front-panel head-phone jack.

CIRCLE NO. 98 ON FREE INFORMATION CARD

Hz ± 3 dB on-axis; response drops 3 dB at 15 kHz 90° off axis, and at 10 kHz 180° off axis. Nominal impedance is 4 ohms. Power requirements are 30 watts rms (15 dBW) minimum, 500 W (27 dBW) peak maximum, 100 W (20 dBW) average. Height is 41 $\frac{3}{8}$ ", and the system slopes from 16 $\frac{1}{4}$ " square at the bottom to 8 $\frac{1}{2}$ " square at the top. \$575 each.

CIRCLE NO. 99 ON FREE INFORMATION CARD

Epicure "Trilogy" Speaker System

With its first three-way speaker system, the Model 3.0 "Trilogy", Epicure joins the growing number of manufacturers with enclosures that avoid the conventional box shape. The Trilogy's truncated-pyramid design is claimed to reduce time delay and other sources of distortion, while increasing power-handling capacity. Its rounded cabinet edges are said to eliminate diffraction effects. The Trilogy's 10" woofer crosses over to its separately baffled 6" midrange at 400 Hz; midrange crosses over to a 1" air-spring tweeter at 2600 Hz. Frequency response is rated at 32-20,000

TRS-80 Microcomputer Serial I/O

Electronic Systems has introduced a new accessory for the Radio Shack Model TRS-80 microcomputer—an RS-232 compatible serial I/O that can be used with or without the expansion bus. On-board switching is provided for 110, 150, 300, 600, 1200, and 2400 baud rates; odd, even, and no parity; five to eight data bits; and one or two stop bits. It is available wired and tested as part number 8010C for \$79.95 or in kit form as part number 8010A for \$59.95. The etched and drilled printed circuit board is available separately as part number 8010 for \$19.95.

CIRCLE NO. 100 ON FREE INFORMATION CARD



New Literature

HEATHKIT 1979 WINTER CATALOG

A 96-page catalog describes the latest electronic kits available from Heath Co. Areas of interest include color TV, hi-fi components, amateur radio, test instruments, digital clocks, personal computer systems, and other products for home improvement and family entertainment. New products include a rack-mounted FM/AM stereo tuner, a dc-to-35-MHz dual-trace delayed-sweep oscilloscope, a portable rechargeable fluorescent light, a solid-state heat/cool set-back unit for home energy saving, a precision r-f generator, etc. Address: Dept. 470-170, Heath Co., Benton Harbor, MI 49022.

TRS-80 MICROCOMPUTER REFERENCE HANDBOOK

Radio Shack has published a 108-page book for technically oriented persons with a good working knowledge of digital logic circuits and interest in the TRS-80 microcomputer. It includes technical information and schematic diagrams for both Level-I and Level-II TRS-80 systems. Topics include theory of operation, adjustments and troubleshooting, the outside world (connections to external devices), parts list, etc. The Handbook is available for \$9.95 from participating Radio Shack stores and dealers.

CHERRY KEYBOARD CATALOG

The 32-page Cherry KBC-78 Keyboard Catalog includes custom designed keyboards, a keyboard designer's worksheet, solid-state or gold crosspoint contact keyboards, a complete line of standard keyboards, keyboard switches and molded keycaps. The catalog features diagrams, photos and specifications. Address: Cherry Electrical Products Corporation, P.O. Box 718, Waukegan, IL 60085.

INTRA-FAB EQUIPMENT CABINETS

An eight-page catalog from Intra-Fab describes its line of integrated cabinets specially suited to the needs of the computer hobbyist. Selection information is provided on the construction, assembly, color and sizes of enclosures including Mod-U-Box desktop cabinets, Mod-U-Line and Timberline equipment cabinets, and Mod-U-Rack modular electronic card rack system. Address: Intra-Fab, 660 Lenfest Rd., San Jose, CA 95133.



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Here's your chance to build BORIS, widely regarded as the world's most advanced personal Chess Computer. We have received so many requests from Hobbyists and Kit Builders, that we're offering Him now, for the first time, in Kit form.

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BORIS will keep you on your toes and make each game much more exciting by talking to you with messages flashed from his seemingly-human brain. BORIS will play at a level to teach a child, or let him loose, and he'll keep the attention of a Master.

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Complete Kit—\$175.00. Thousands sold the world over for \$300.00.

All computer parts included for you to enjoy this world famous Chess Computer. Also includes blueprints so you may build your own enclosure!

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CIRCLE NO. 58 ON FREE INFORMATION CARD



Stereo Scene

By Ralph Hodges

THE AUTOMATION OF TAPE

AS RECENTLY as the 1960s, before cassettes were a factor in the serious recordist's life, there was Scotch 111 and then there were other tapes. Scotch 111 was a hoary old product, with a history that descended linearly from the infancy of tape recording in the U.S. Ampex then was trying to get this nation's very first tape recorders into reliable operation.

Not even the 3M Company, 111's creator and manufacturer, would argue that it was an *outstandingly* good tape. There were certainly products available affording much greater potential performance when it was finally discontinued some years ago. But for a long period it reigned as *the* standard tape—presumably because it was fairly consistent and widely available, and because it was the direct evolutionary heir to the first U.S. ventures into magnetic recording. Tape recorders worldwide were adjusted to suit its characteristics, and when you were in doubt as to what tape to use for a particular application, you could almost always fall back on old 111 with a reasonable expectation of getting the job done adequately.

As much as anything else, it was the cassette era that brought an end to Type 111 and its ilk. No longer was there the option of using a higher tape speed or a wider track width to get through the more demanding recording jobs. The format didn't allow such flexibility. And so it was the tape itself that had to improve, and it did—by leaps and bounds. But this progress was exacted at a certain price. Tapes necessarily drifted away from the electromagnetic characteristics of 111, at first gradually and then dramatically. In short order, cassette tape bore only a passing resemblance to its open-reel relatives in terms of recording parameters, and then open-reel tapes be-

gan their own drive toward higher performance, bringing the relatively uncomplicated world of Scotch 111 to an end.

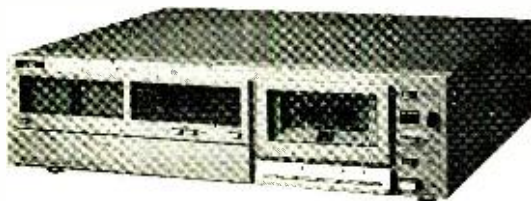
The Problematic Present. When a tape is improved in any significant way—even if the change is something so ostensibly physical as a smoother coating surface, with the magnetic particles themselves left unchanged—it behaves differently with real-world tape machines as an electromagnetic entity. Generally it requires (or at least would benefit from) a different level of recording-bias current, followed by the obligatory touch-up of the record equalization. These are adjustments that require good instruments and a certain amount of technical expertise to accomplish. And they are time-consuming. Buy a handful of tapes from your local retailer, just to find out which brand suits you best, and you may find that all of them require somewhat different bias and equalization, even if they are of the same generic type. Optimizing your machine for each one so that you can evaluate noise levels and other important performance criteria will prove to be a project of considerable proportions.

Then, when you have found your preferred tape and begin to buy it regularly, you will sooner or later come up against a conundrum that isn't talked about much: batch variations. Tape manufacturer X's production run for June is not likely to be identical to the product he offered in March. Very serious recordists buy in quantity from a single batch and resign themselves to readjusting their machines when their supply runs out and a new batch must be investigated.

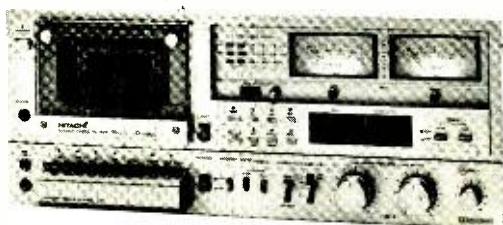
Of course, all of this completely overlooks the plight of the man on the street who cannot readjust his machine. He can only hope that the bias and EQ switches on the deck have enough flexibility to approximate the requirements of the tape. At the same time, he is going to be lured by ever-emerging new tapes claiming unprecedented levels of performance, but completely undefined as far as his machine is concerned. Its available bias and EQ characteristics may suit these tapes or they may not. He can only experiment and hope for the best, or stick to the older product he's always used—not exactly a formula for progress.

The situation can only become more confused. Tape manufacturers routinely trade off one performance characteristic for another they consider more desirable. It's a bit of a gamble, because if they stray too far from the mean characteristics exhibited by the majority of tapes of that generic type they risk missing the market. But at the same time it's a chance to further the technology, and perhaps to open a new market.

Self-adjusting Decks. In short, tape-type accommodation is a dilemma that's been crying for a solution for years. And here it comes, or a good part of it, at least. Following closely on the heels of a few innovative cassette decks incorporating two-tone oscillators that enable you to achieve reasonably flat



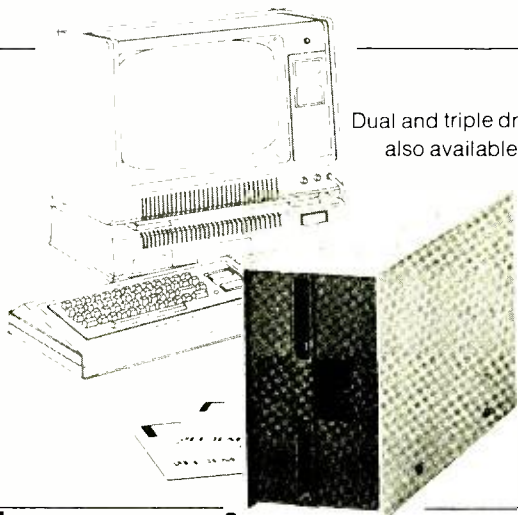
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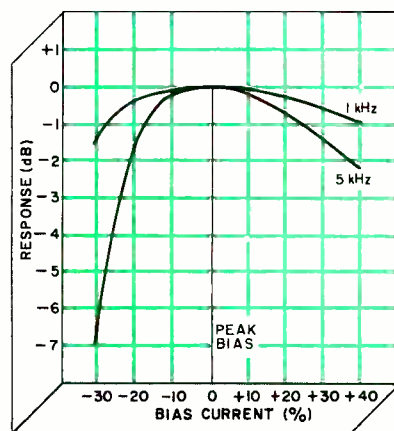
frequency response with virtually any tape (better than nothing, surely), has come a small wave of machines that contain (usually) 4-bit microprocessors that undertake to set bias and equalization automatically through a pre-programmed test sequence. Last month I made reference to the Technics RS-1800, the first open-reel extravaganza (with a price to match, no doubt) that boasts this feature. But the man on the street is more likely to respond to the new cassette decks that will perform the same trick, best exemplified so far by the Hitachi D-5500 and the JVC KD-A8.

Bias is the tricky consideration in this whole business, in large part because the optimum bias level for a tape is controversial. Depending on your criteria, you could adopt a bias level that: (1) maximizes output of the tape at some reference frequency (usually 1000 Hz); (2) minimizes third-harmonic distortion from the tape (for a test frequency of your choice, but often one in the vicinity of 1000 Hz); (3) minimizes modulation noise; (4) minimizes intermodulation distortion in any of a number of two-tone tests; or (5) satisfies any of a number of "ideal" criteria for the relative usable output levels from the tape at low and high frequencies.

Designers of self-adjusting tape decks have decided against incorporating distortion analyzers, the complexity and expense being a bit too much for today's market. Instead, they all aim for maximum output level (MOL) at some specific frequency. Full details are not available in every case, but the Hitachi machine can serve as an example of the approach.

Hitachi chose to set bias for a MOL at 1000 Hz. However, the output vs. bias curve at that frequency exhibits a rather broad peak (see Fig. 1), and the resolution of the microprocessor was deemed inadequate to strike a really definitive bias point. At 5000 Hz the MOL peak is considerably sharper, and

Fig. 1. The more sharply defined optimum bias point at 5 kHz makes that frequency a more suitable choice for bias adjustment.



at the same time output-level variations from the tape (resulting from drop-outs, variations in tape-to-head contact, etc.) are not likely to confuse the adjustment process.

In a study of various representative tapes, Hitachi determined that the bias level giving peak output at 1000 Hz is roughly 33 percent higher than that which gives a 5000-Hz MOL for "normal" ferric-oxide tapes, roughly 25 percent higher for CrO₂ tapes, and 11 percent higher for ferrichrome tapes. With that statistical information, Hitachi was able to create a system that adjusted for MOL at 1000 Hz while actually testing the tape at 5000 Hz. A tape-type switch must still be used to make sure that the right correction factors are introduced.

The JVC machine will take on almost any tape without the need to throw a switch to identify its generic type. On the other hand, the JVC machine presumably doesn't offer the finer degree of resolution possible when the microprocessor is re-



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Fig. 2. A high-quality tape exhibits an almost perfectly flat frequency response after adjustment.

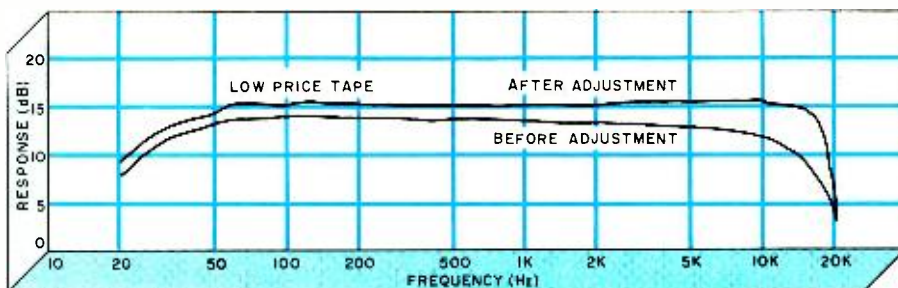
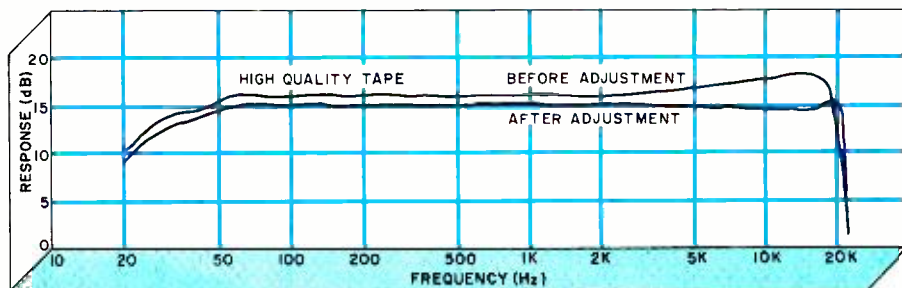


Fig. 3. A low-price tape shows obvious deficiencies in performance, but is much improved in any case after the adjustment sequence.

quired to "search" only a comparatively narrow range of bias-level options.

The "Search." A hunt through various stepped levels of bias is how these machines accomplish their jobs. In at least one case, the bias descends in steps and then ascends; the final level chosen is the average of the MOL's determined by the descending and ascending sequences. The Hitachi deck is a three-head machine and is thus able to present data immediately to the microprocessor. The JVC has two heads and must rewind the tape (which it does automatically as part of the test sequence) before it can play the recorded test signals and "read out" to the control circuits.

A similar hunt takes place during the subsequent automatic adjustment of recording equalization, but EQ is handled with varying degrees of sophistication. The Hitachi system appears to be the most complex, with shelving frequency-response characteristics below 10,000 Hz and peaking characteristics centered at 14,000 Hz. The JVC and Technics systems appear to provide comparatively simple filters with hinge points located somewhere in the midfrequencies. Whether the intricate mechanism that Hitachi has devised will be worth its weight in tape is a question that can be answered only after some serious experimentation with it.

For the cassette decks in this group, it is also necessary—or at least convenient—to provide some means of normalizing a tape's input/output characteristics (sensitivity, in other words), so that the level-dependent noise-reduction systems they have built in will function properly without further fussing by the user. Such facilities have been provided in the JVC and Hitachi decks, and they promise to be a real boon to those who have become disenchanted with noise reduction while being unable to get at the calibration controls that would make it work right. Dolby Laboratories, to name one manufacturer, does not encourage its licensees to provide accessible calibration controls, though some licensees make such provisions. But this policy leaves the user at the mercy of whatever tape he happens to be using—and at the mercy of the person who performed the initial calibration at the factory. (As independent tests have shown, the cassette-deck industry does not always distinguish itself by providing the best Dolby tracking imaginable.)

The Specs. The control circuits in these self-adjusting machines, being digital, cannot offer continuously variable settings. Their search proceeds in discrete steps as governed by their memories. The Hitachi machine provides 96 steps for bias level, obtained through a 4-bit converter and a 3-bit floating-point system. The EQ and sensitivity adjustment functions have 16 steps, each of 0.5 dB. The JVC machine has 32 steps for bias, 15 for sensitivity, and 7 for equalization. These differences are reflected to a certain degree in the specifications for the two machines. With a good tape, the Hitachi is said to maintain a frequency-response tolerance of ± 0.5 dB over much of the audio frequency range. JVC's deck is typically ± 1 dB according to the same criterion. Harmonic-distortion ratings are difficult to compare because of differences in testing.

Suffice it to say that both machines are rated in the range of 1 percent total harmonic distortion for recording levels below those that would cause tape saturation. Figure 2 shows Hitachi's curves for a high-quality tape before and after adjustments for sensitivity and frequency response have been made. Figure 3 presents the same data for an inexpensive tape. (It should be pointed out that there is a substantial price difference between the Hitachi and JVC machines. Final Hitachi pricing has not been announced, but a figure of \$1000+ is anticipated. You'll find JVC's KD-A8 considerably easier on the pocketbook.)

I look forward to a flood of these self-adjusting tape decks within the coming year or so. The technology is here in an affordable format, and the wonders it can perform (refer to Figures 2 and 3 again) have to be just irresistible to someone who takes his tape recording seriously.

When the trend is fully established, there will be no more tape jungle for the consumer to flounder through. He will be able to buy an armload of different manufacturers' cassettes, take them home, and in the course of a civilized, low-pressure evening decide for himself what his brand is going to be, without the worry that a noncompatible machine is making a good tape look bad. By the same token, tape manufacturers will be able to concentrate their full efforts on making a genuinely better tape. It will not be just a *somewhat* better tape that has been compromised a little because it must match the performance and adjustment profile of the tape decks already in the hands of potential customers. \diamond

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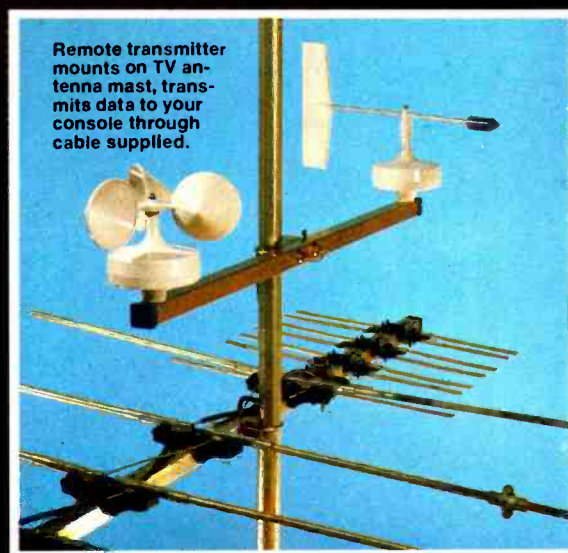


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Julian Hirsch Audio Reports

distortion detection loop and pulse-counting demodulator are featured



THE Model KT-917 FM tuner from Kenwood uses unusual and innovative circuits

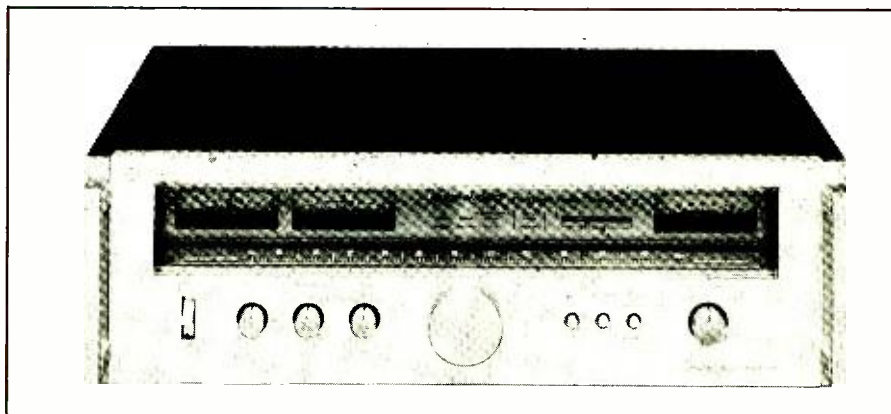
to minimize or eliminate most of the conditions that normally lead to distortion in FM reception. The tuner also features three degrees of i-f selectivity and a multiple tuned circuit front end that gives outstanding interference rejection.

Kenwood has determined that the distortion levels in many FM tuners are unnecessarily high because the user has no means of accurately tuning for minimum distortion. Afc merely corrects for gross tuning errors, and even crystal-controlled synthesized tuning systems cannot guarantee that the pass-bands of the i-f and detector sections are accurately aligned with each other. Kenwood's solution, therefore, was to design a "Distortion Detection Loop" (DDL) system that automatically nulls out tuning distortion. The DDL is used in combination with a highly linear pulse-counting type of FM detector.

The tuner measures 18 $\frac{1}{4}$ " D \times 18 $\frac{1}{8}$ " W \times 6 $\frac{3}{8}$ " H (46.4 \times 46 \times 16.2 cm) and weighs 33.1 lb (15 kg). Suggested retail price is \$1000.

General Description. The tuner has a standard slide-rule tuning dial behind a window that also covers the large and easy-to-interpret meters. Two of these are conventional zero-center tuning and signal-strength meters. A third is a combination meter that can be switched to indicate either deviation or multipath distortion. The signal-strength meter is calibrated directly in 10-dB steps from 0 to 90 dBf. The deviation meter registers peak frequency deviations from zero to 120% of the rated 75-kHz maximum.

Four lights above the dial scale come on separately to indicate when muting is in operation, a stereo signal has been tuned, the tuner has been set for AUTO mono/stereo reception, and the Distortion Detection Loop is in operation. Tun-



The Kenwood Model KT-917 FM super tuner nulls tuning distortion automatically

ing of the Model KT-917 is performed in the same manner as with any conventional tuner, tuning until the zero-center meter is in the center of its scale. The difference here is that a couple of seconds after the tuning knob is released, the DDL system automatically completes the tuning for minimum distortion. Then the DDL indicator comes on.

surface acoustic filters provide superior selectivity

The tuner's muting threshold can be set at either 20 or 40 dBf, or the muting system can be disabled altogether. A horizontal row of lighted green dots above the dial scale increases in length as the tuner's i-f bandwidth control is switched from narrow to normal to wide.

A "quieting control" permits the user to select the tuner's operating mode. In AUTO, either a mono or a stereo broadcast will be heard correctly. With the control set to the STEREO position, the tuner unmutes only for stereo signals. (In this position, if the signal strength drops low enough to make noise a prob-

lem, a multiplex filter automatically blends the left and right channels at the high frequencies to reduce the noise with no appreciable degradation of the stereo image and with no loss in high-frequency response.) All signals received, whether mono or stereo, are delivered to the amplifier in the mono format when the switch is set to MONO.

Pushbutton switches are provided for switching between deviation and multipath distortion display on the dual-purpose meter; dimming the panel lights; and connecting either of two antenna systems to the tuner. The normal A and B antenna connectors are 75-ohm coaxial jacks. The B antenna connector is paralleled by binding posts for a 75-ohm antenna and a 300-ohm antenna. The purpose of the dual antenna inputs is to simplify the orientation of antennas for minimum multipath distortion. By placing the two antennas at suitable angles to each other, one has a choice of two receiving conditions for every station. If the antennas are oriented for minimum multipath distortion on one or more stations, it will often be possible to improve reception appreciably by selecting the appropriate antenna without the cost and inconvenience of a rotatable antenna system.

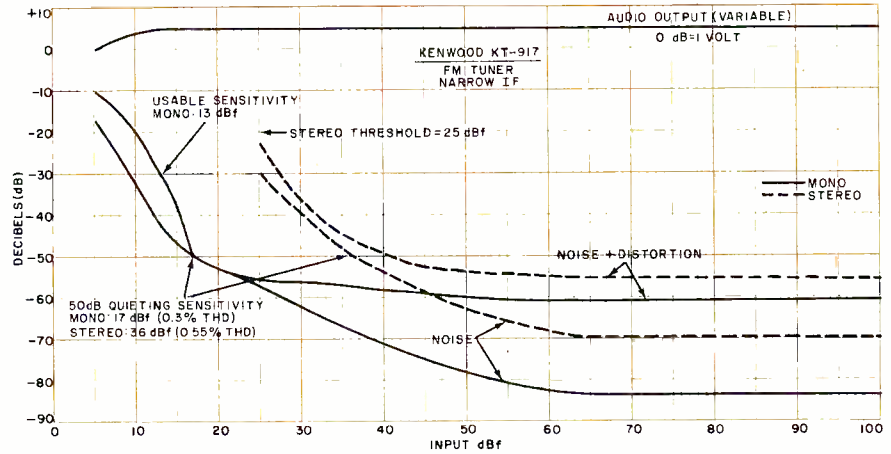
Vertical and horizontal outputs on the rear apron permit an accessory oscilloscope to be connected to the tuner for displaying multipath distortion. There are also separate pairs of fixed and variable-level audio output jacks; a slide switch for changing the deemphasis time constant from the normal 75 to 25 μ s for use with an external Dolby adapter; and a single unswitched ac outlet on the rear apron.

The two MOSFET r-f amplifier stages in the tuner contain a total of seven tuned circuits. Two tuned circuits precede the first amplifier stage, two are between stages, and three couple the amplifier to a four-diode (Schottky) balanced mixer. Although it is complex and expensive, this approach gives the tuner a degree of immunity to overload and spurious-signal generation that is rarely, if ever, found in home-entertainment equipment. The local oscillator is followed by two buffer stages and other circuits. Both the oscillator and the second buffer stage are tuned, and the nine-section tuning capacitor is unique among the tuners we have seen.

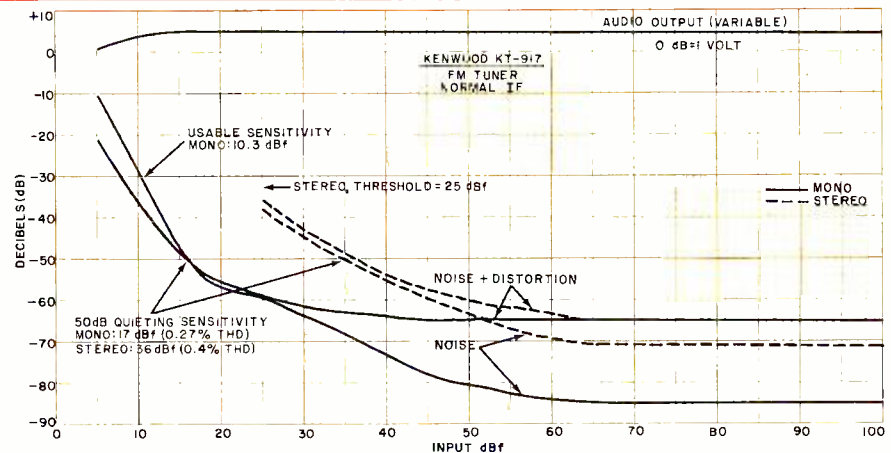
The 10.7-MHz output from the mixer is linearly amplified by a FET stage whose output is then processed for driving the signal-strength and multipath-distortion meters. The distortion meter responds to the amplitude modulation imposed on an FM signal during multipath distortion. The signal is passed through an accurate logarithmic converter before it is applied to the signal-strength meter.

row of green LEDs indicates selected i-f bandwidth

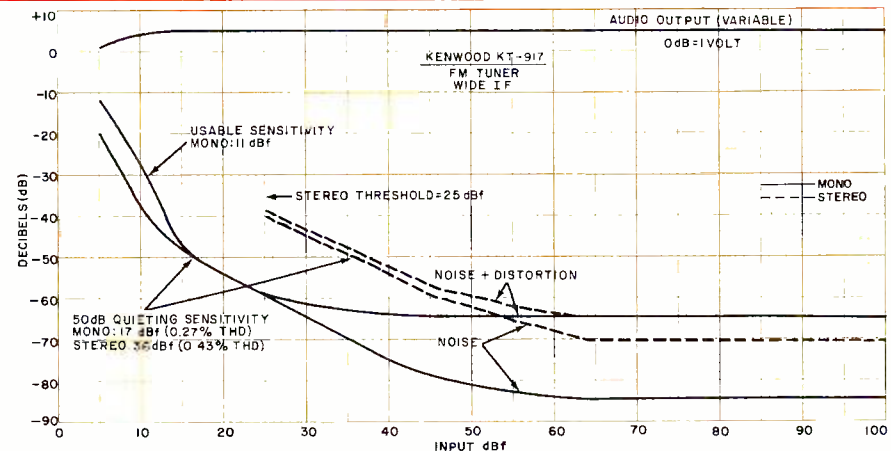
Following the linear i-f amplifier is a series of four surface acoustic filters (SAFs) that give the tuner its selectivity. (The SAFs operate by propagating acoustic waves across a ceramic substrate from an input transducer and receiving the waves in an output transducer that restores them to electrical form.) The SAF has excellent bandpass flatness, steep rejection skirts and good group delay characteristics, which are necessary for low distortion and good separation in stereo reception. Only one filter is used in the WIDE mode, two in NORMAL, and all four in NARROW. Filters coupled by amplifier stages are



Noise and sensitivity curves for narrow selectivity mode.



Noise and sensitivity curves for normal selectivity mode.



Noise and sensitivity curves for wide selectivity mode.

switched in and out by diodes that are operated by dc control signals.

The 10.7-MHz i-f signal is converted to 1.96 MHz and amplified before going to the pulse-counting detector. Following detection, the signal is processed by a sample-and-hold stereo demodulator. The composite stereo signal is sampled at a 38-kHz rate, which is synchronized with the 19-kHz pilot signal, to convert it to left- and right-channel audio signals. Instead of the usual lowpass filter to re-

move 19- and 38-kHz components from the audio outputs (which can effect the flatness of a tuner's high-frequency response), the Model KT-917 has a pilot-canceller circuit in which the regenerated pilot carrier is used to cancel out the 19-kHz pilot signal in the detected output. This extends the tuner's flat audio response to beyond 15,000 Hz, while keeping 19-kHz leakage to low levels.

Laboratory Measurements. Be-

Product Focus

The Distortion-Detection Loop (DDL) in Kenwood's Model KT-917 tuner is a form of amplified afc, but with an important difference. Unlike a conventional afc, which tunes the local oscillator to produce a zero dc output from the detector, the DDL tunes for minimum second-harmonic distortion in the detected signal. This automatically compensates for any asymmetry in the i-f or detector, which is ignored in an ordinary afc system or in a manual-tuning system with the aid of a zero-center tuning meter setup.

Since there is no way to measure the second-harmonic distortion in a complex musical program, the Model KT-917 must supply its own test signal to operate the DDL. How this is done is illustrated in Fig. 1. As in any afc system, the dc local

oscillator control voltage is present. This signal varies the local oscillator frequency through a Varactor diode and is combined with a locally generated 95-kHz signal that also frequency modulates the local oscillator. This is equivalent to having the FM station transmit a 95-kHz sub-carrier at a low level of modulation.

At the output of the tuner's detector, the 95-kHz signal and any harmonics of it are separated from the stereo program by a high-pass filter. In a secondary control loop, the output of the 95-kHz oscillator is passed through an electronically controlled phase-shift network whose output is compared to the phase of the detected 95-kHz signal in Phase Detector #2. This process compensates for any phase shifts that occur in the modu-

lation, amplification, and detection processes, so that the internal 95-kHz signal is exactly in-phase with the detected 95-kHz component.

The phase-corrected 95-kHz signal is passed through a frequency doubler. The resulting 190-kHz signal feeds one port of Phase Detector #1. The other port receives the filtered detector output, which consists of the 95-kHz signal and a small amount of second-harmonic distortion at 190 kHz. The phase of this distortion is a function of the direction of mistuning and its amplitude is proportional to the amount of the tuning error. Hence the output of Phase Detector #1 is proportional to any distortion created by a tuning error, although the second-harmonic distortion level is extremely low (about

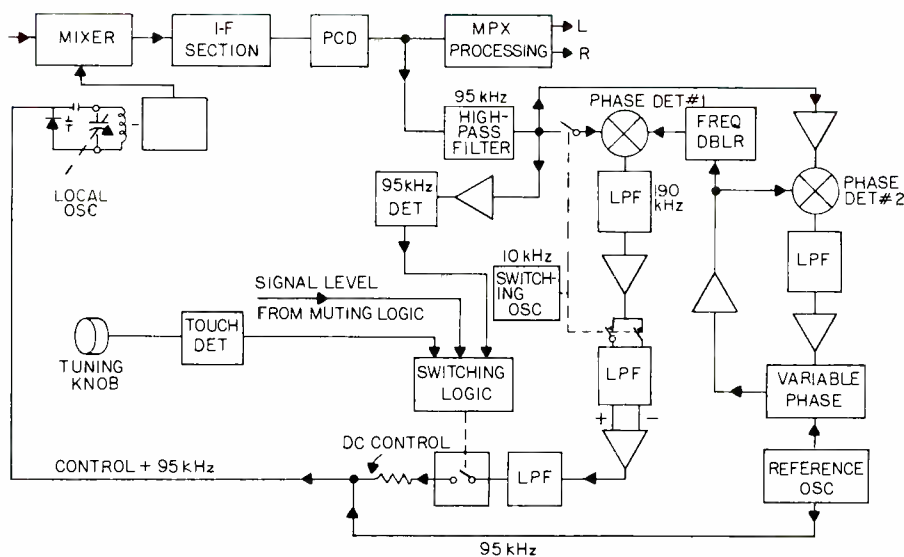
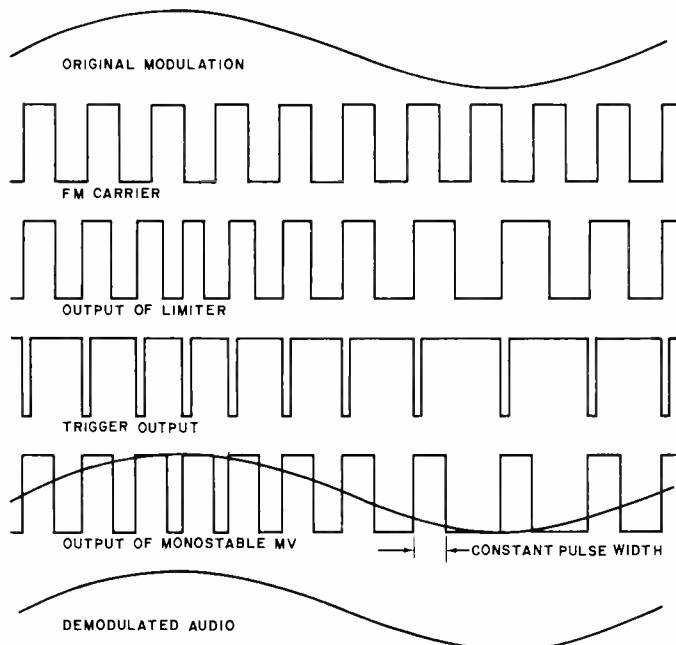


Fig. 1. Block diagram showing operation of the Distortion Detection Loop (DDL)

Fig. 2. Sequence of waveform changes in pulse-count demodulation.



100 dB below normal stereo program levels). A low-pass filter removes higher frequencies from the error signal, leaving a very small dc error voltage. Because of its extremely low level, it is necessary to use a switching (chopper) amplifier to amplify the dc error signal to useful levels without risking any drift that could introduce a tuning error. The phase detector and error amplifier are stabilized against drift by a 10,000-Hz switching signal that operates on the input and output signals to form an effectively direct-coupled high-gain amplifier with virtually no dc drift. After filtering to remove higher frequency components, this error signal is combined with the internally generated 95-kHz signal and sent on to the frequency control diode in the local oscillator.

A three-part logic system disables the DDL until a signal has been tuned in manually. The tuning knob functions as a touch detector. The detected 60-Hz hum is rectified and the resulting dc voltage goes to the DDL logic section. The logic also receives a dc level from the tuner's muting system and another from the detected 95-kHz signal. Unless a signal of sufficient strength and the necessary amount of 95-kHz modulation are present on it and the tuning knob is released, the DDL system is inhibited.

The pulse counting detector (PCD) is another novel circuit feature of the Model KT-917. Pulse counters are not new, having been used for decades for accurate linear FM demodulators in laboratory instruments and other critical applications. Until recently, they were too complex and expensive for use in consumer products, especially at the high i-fs employed in FM tuners. High speed ICs and transistors are now available at moderate cost, making the PCD practical for use in a high-quality FM tuner.

The principle of the PCD is very simple. The FM signal, at the intermediate frequency, is converted to a series of short pulses of constant width and amplitude, which occur at a frequency that is the same as that of the received signal. If the pulse train is clamped to a fixed (or zero) voltage level, its average value ex-

actly follows the modulating waveform of the FM signal.

Figure 2 shows the sequence of waveform changes in the Model KT-917's PCD. The modulated FM signal, after conversion to a lower i-f, is amplitude limited to form a square wave whose zero-axis crossings coincide with those of the input FM signal. Every time the limited waveform goes through the zero-voltage axis in a positive direction, a negative trigger pulse is generated by the trigger circuit. The trigger pulses drive a monostable multivibrator that produces pulses of uniform width and amplitude every time a trigger is received. Since the low and high levels of the pulse train are fixed, the average value of the multivibrator's output follows the waveform of the original modulation. It is only necessary to pass the pulse train through an integrator or low-pass filter to remove the carrier-frequency components and recover the audio.

The advantage of the PCD over a conventional tuned FM detector is illustrated in Fig. 3 (from data supplied by Kenwood). Since it depends on tuned circuits for its operation, the differential gain (the slope of the detector output voltage versus input frequency) changes slightly with frequency. The result is an output voltage that is not exactly proportional to the input frequency and distortion is created. The lower curve shows the almost constant differential gain of the PCD over a very wide frequency range. If the pulses are all identical, the output of the PCD is theoretically perfectly linear over a very wide frequency range.

Aside from its greater circuit complexity, the PCD also delivers an audio output voltage proportional to the deviation as a percentage of the operating frequency of the signal. At 10.7 MHz, a 75-kHz deviation is only 0.7% of the operating frequency, and the output is very low. By converting the 10.7 MHz i-f to 1.96 MHz, the same signal is now deviating 3.8% of the carrier frequency and the output is increased five-fold. This improves the S/N by about 15 dB, as compared to a PCD system operating at 10.7 MHz.

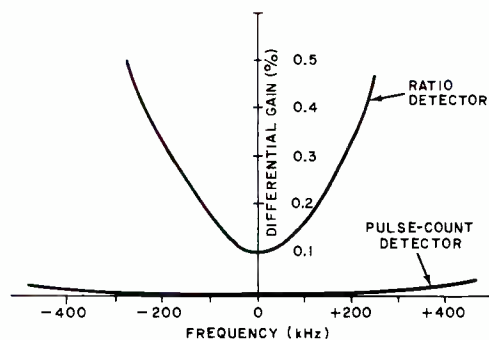


Fig. 3. Differential gain vs. frequency for ratio detector and pulse-count detector showing distortion performance.

cause many of the specifications of this tuner exceed those of good laboratory-grade signal generators, we did not expect to be able to fully confirm Kenwood's ratings. Specially designed or modified signal generators were used by Kenwood during the development of the tuner and to establish its performance ratings. Our tests were performed with a standard Sound Technology Model 1000A FM signal generator.

The measured sensitivity of the tuner was as rated. Measured distortion and noise were essentially those of our signal generator. Only by shutting off the modulation circuits in the generator (CW

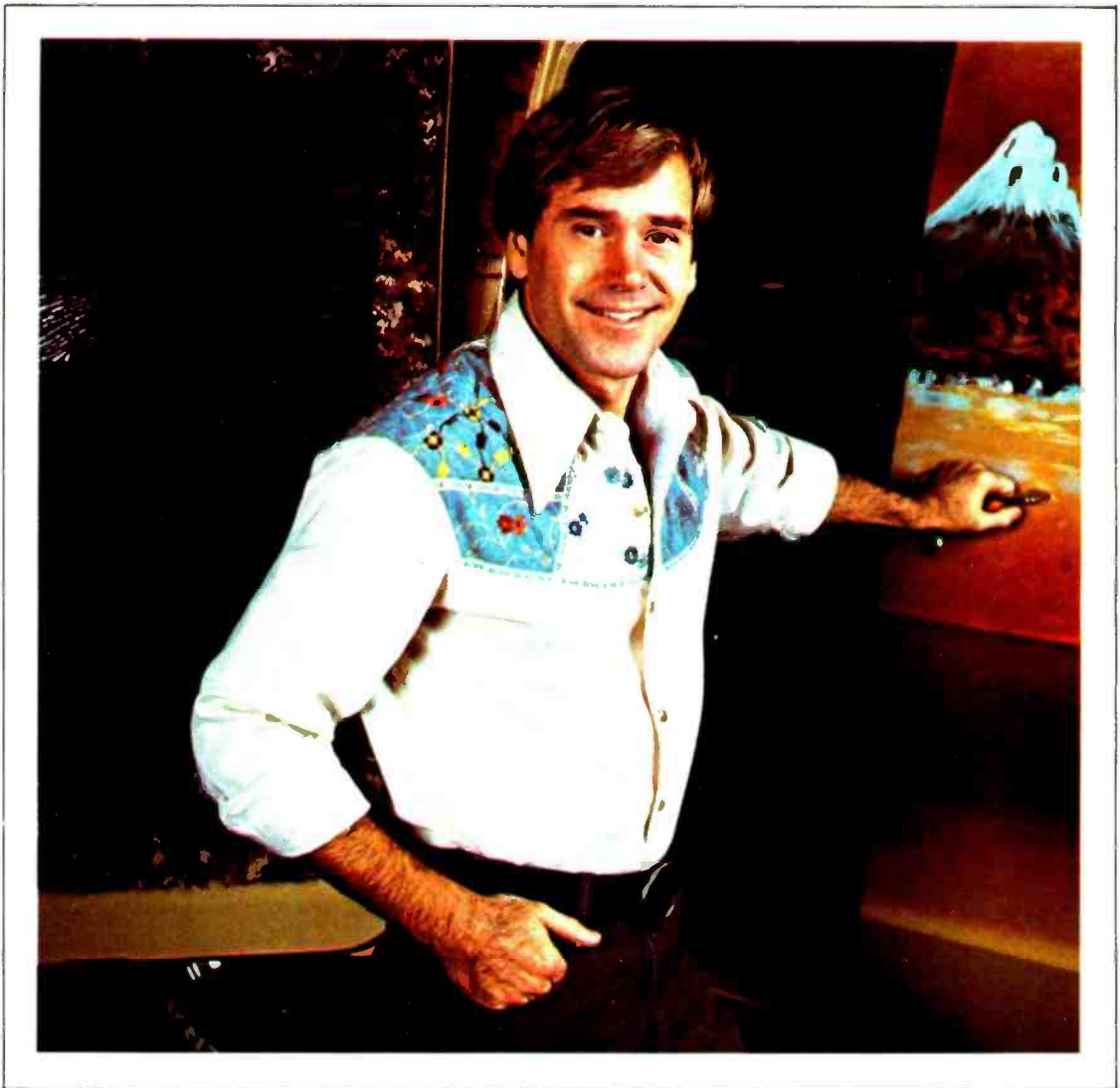
multipath meter is one of very few that is genuinely effective

mode) could we achieve the 84-dB mono S/N reading. Since the modulator was required for a stereo measurement, to supply the pilot-carrier signal, we were limited to approximately the 70-dB range of the generator. For our image-rejection measurement, we used a Boonton Model 202B signal generator, whose maximum output of 200,000 μ V was not sufficient to produce a detectable signal at the image frequency, leaving us with an inconclusive but very impressive measurement of greater than 106 dB.

The only unexpected behavior we encountered when testing the tuner was the relationship of the DDL to stereo channel separation. The DDL worked perfectly and always produced minimum distortion, no matter how the tuning was set when the knob was released. However, when we first measured the stereo channel separation, with the tuning set "dead center," separation was 36 to 43 dB, which is perfectly adequate but somewhat short of Kenwood's claimed 50 to 60 dB. After confirming that the signal generator was correctly adjusted, we investigated further and discovered that releasing the tuning knob when the signal was barely tuned in, just at the point where the muting was overcome, gave much improved readings. We read typically 50 to 55 dB between 30 and 2000 Hz. With wide bandwidth, it exceeded 60 dB between 80 and 160 Hz and decreased smoothly to between 33 and 35 dB at 15,000 Hz. There was little difference in separation between IF BAND switch settings.

(Continued on page 28)

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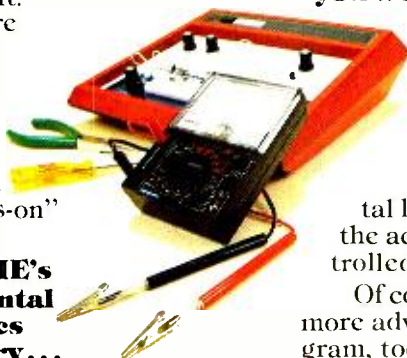
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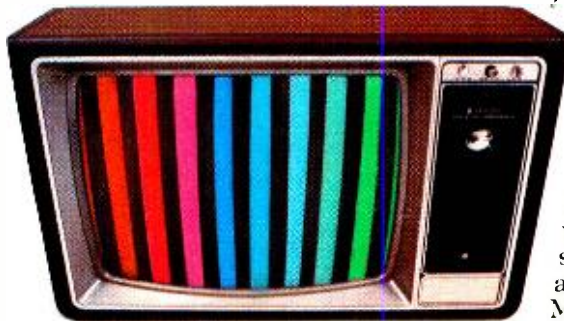


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Performance Specifications

Specification	Rating	Measured
Usable sensitivity (Mono)	10.8 dBf (1.9 μ V)	10.8 dBf (NORMAL) 13 dBf (NARROW) 11 dBf (WIDE)
50-dB quieting sensitivity (Mono)	15.8 dBf (3.4 μ V)	17 dBf
(Stereo)	37.2 dBf (40 μ V)	36 dBf
S/N ratio (Mono)	90 dB	84 dB (unweighted—approx.)
(Stereo)	84 dB	70 dB gen. residual)
Total harmonic distortion (Mono; 1000 Hz)	0.03% WIDE 0.06% NORMAL 0.15% NARROW	0.064% (approx. gen. residual) 0.064% 0.09%
(Stereo; 1000 Hz)	0.04% WIDE 0.09% NORMAL 0.12% NARROW	0.062% (approx. gen. residual) 0.062% 0.17%
CAPTURE RATIO	0.8 dB WIDE 1.4 dB NORMAL 1.7 dB NARROW	0.8 dB/0.73 dB (45/65 dBf) 0.8 dB/0.73 dB 2.1 dB/1.3 dB
Alternate channel selectivity	35 dB WIDE 60 dB NORMAL 60 dB NARROW	44 dB 44 dB 82 dB
Adjacent channel selectivity	N/A	6.3 dB (WIDE) 5.4 dB (NORMAL) 15.5 dB ((NARROW)
Stereo separation (1000 Hz)	60 dB WIDE 55 dB NORMAL 50 dB NARROW	51.0 dB 50.5 dB 54.5 dB
(50 to 10,000 Hz)	50 dB WIDE 45 dB NORMAL 40 dB NARROW	39.5 dB 38.0 dB 35.5 dB
(15,000 Hz)	40 dB WIDE 38 dB NORMAL 33 dB NARROW	33.0 dB 34.5 dB 34.0 dB
Frequency response	10-16,000 Hz +0.2/-0.5 dB	30-15,000 Hz +0.2/-0.3 dB
Spurious response ratio	125 dB	—
Image response ratio	125 dB	Greater than 106 dB
I-f response ratio	125 dB	—
AM suppression ratio	70 dB	70 dB (45 dBf) 73 dB (65 dBf)
Subcarrier product ratio	70 dB	66 dB
SCA rejection ratio	75 dB	—
Output level (1000 Hz, 100% mod)		
Fixed	0.75 V, 60 ohms	Confirmed
Variable	0-1.5 V, 60 ohms	0-1.86 V
Multipath output		
Vert.	0.01 V, 10,000 ohms	—
Horiz.	0.5 V, 3000 ohms	—

(Continued from page 23)

We were struck by the fact that the selectivity was approximately the same in both NORMAL and WIDE bandwidth modes. Our measurement of 44-dB alternate-channel selectivity would be considered marginal for most FM tuners if it were the only one available. However, we never experienced any interference problems using the tuner in New York City, where more than 50 stations can be received. In this area, which is subject to adjacent- and alternate-channel interference, the NARROW mode gave the tuner exceptional selectivity.

Dial calibrations were accurate to within 200 kHz and usually to within 100 kHz. The signal-strength meter indicated within 4 dB of the actual input signal level over its full range. The deviation meter's indications were about 15% greater than the actual deviation, which is of little importance for the meter's purpose. The multipath-distortion meter was one of the very few we have seen that is genuinely effective. Even a slight amount of multipath distortion produced an appreciable indication on the meter during modulation, and a signal without multipath did not cause any detectable pointer movement.

200,000 microwatts was not sufficient to produce detectable image signal

We were unable to use the scope outputs on the rear of the tuner as a multipath or tuning indicator. The reason for this was that the 0.01-volt vertical output was insufficient to produce a useful deflection on several scopes we tried.

User Comment. Since the tuner we tested was one of the first Model KT-917s to enter this country, we have no way of knowing if its unorthodox tuning for maximum stereo separation is inherent or a peculiarity of our test sample. Whatever the case, it is of minor importance, since broadcast stations are required to maintain only a minimum of 30 dB separation and virtually no phono cartridges or records are even that good. Needless to say, the tuner will never degrade the audible separation of the received program.

Operation of the DDL is very effective. With most tuners and receivers, normal tuning errors, even with great care, can

easily degrade a 0.1% distortion condition to 0.3% and even 0.5%. As Kenwood points out, afc is no solution because its operation requires an error voltage that itself introduces a tuning error. The DDL, on the other hand, will give minimum second-harmonic distortion every time, with literally nothing the user can do to mistune the Model KT-917. (On weak signals of less than 25 to 40 dBf, the DDL may not lock on, in which case, the DDL indicator will not light. In any case, signals in this range will have their distortion masked by noise.)

can deliver last measure of performance possible

Basic operation of the tuner was superb! We usually preferred to set the muting threshold at 20 dBf, although one might find 40 dBf preferable in a very strong signal area to eliminate less powerful signals as the band is tuned. (The muting thresholds were very close to the indicated values, measuring 21 and 42

dBf.) The tuning mechanism operates with typical Kenwood smoothness, and the dial calibration was good enough to permit tuning to be set with the power off and, upon turning on the power, to hear the desired station perfectly tuned by the DDL system.

The signal-strength meter is highly informative because it displays the actual received signal levels in a form that can be related to the dBf ratings that appear in manufacturer ratings and our test reports. It is also useful in conjunction with the multipath meter for orienting a directional antenna. An antenna position that yields minimum deflection on the multipath meter and close to a maximum on the signal-strength meter is certainly the best for any given station. We never had occasion to use the deviation meter, which appeared to operate rapidly enough to give a useful indication of peak modulation levels. Although in a few less critical cases the tuner fell short of meeting its published specifications, there were at least as many of the far more important measurements that surpassed specs by wide margins.

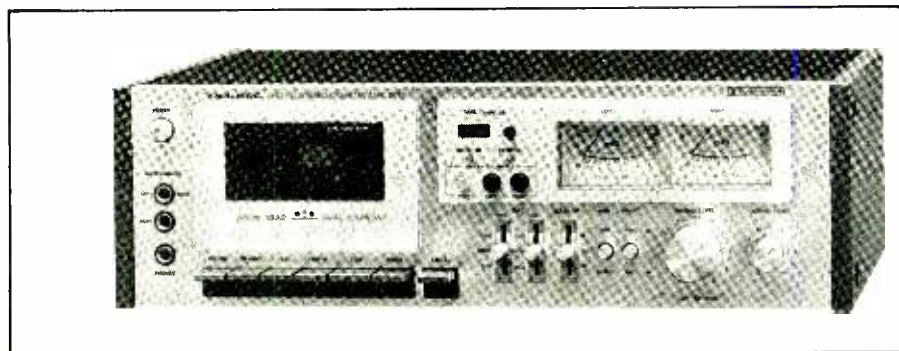
In our opinion, only two i-f bandwidths would have been sufficient for any prac-

tical situation. With both the normal and the wide bandwidths giving virtually identical selectivity, distortion, and separation readings, one of the two was redundant. Our only other criticism is the unreasonably low output from the tuner's vertical scope terminals.

It would be difficult to show that a "super tuner" such as the Model KT-917 actually sounds better than a much less expensive and elaborate tuner on most typical broadcast material. After all, when every characteristic of the tuner is many times better than the corresponding property of the program material, one cannot expect sonic miracles.

The justification for a tuner like the Model KT-917 is that it overcomes the last vestige of human error in tuning and can be depended upon to deliver the last measure of performance possible on every station tuned in. As we see it, this is the rationale for the Model KT-917's existence, and it is a sufficiently convincing argument for those people who depend on FM sources for a substantial portion of their listening pleasure to make the considerable financial investment that this tuner represents.

CIRCLE NO. 101 ON FREE INFORMATION CARD



Three heads and variable bias adjustments are features of the Realistic SCT-30 stereo cassette deck



THE Realistic Model SCT-30 is currently Radio Shack's top-of-the-line cassette

deck. This front-loading, three-head deck has separate Dolby noise-reduction systems for record and playback. Thus, programs can be monitored while recording with the same frequency response and noise level. The Dolby system can also be used to de-

code Dolbyized FM broadcasts with or without simultaneous recording.

The deck has separate bias and equalization switches for ferric-oxide, chromium-dioxide, and ferrichrome tapes. Other features include a dual-capstan tape drive; front-panel Dolby-level calibration control and test oscillator switch; vernier bias adjustment control for matching the requirements of different tape formulations; peak-responding meters; and adjustable "memory rings" that provide reference settings for the recording and playback level controls.

The cassette deck measures 18" W x 10" D x 5¾" H (45.7 x 25.4 x 14.6 cm) and weighs 16.5 lb (7.5 kg). It features walnut-veneer wood side plates and a satin-gold finished front panel. Suggested retail price is \$399.95.

General Description. The Model SCT-30 resembles many other front-loading cassette decks, with its cassette loading well at the left of the front panel. Under the well is the customary bank of levers for operating the transport mechanism. A window in the cassette well door exposes almost the entire cassette to view during operation, and back lighting is provided.

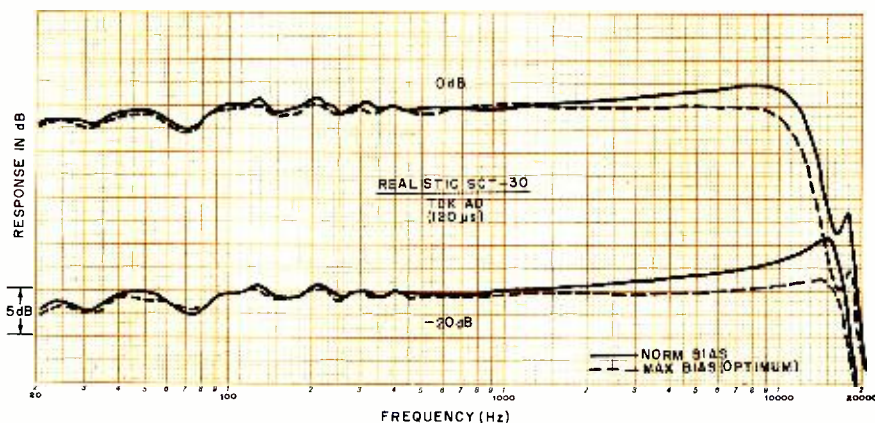
separate record and playback Dolby for true tape monitoring

Bias and equalization for the various tape formulations can be set up with two lever switches. The BIAS switch has positions for CrO₂, ferric-oxide, and FeCr formulations. The EQ switch has corresponding legends for 70, 120, and 70 μ s. (These time constants are for playback; recording equalization is also switched so that the 70- μ s characteristics of the first and third positions of the EQ switch are not identical in their total effect.) A similar switch operates the Dolby system. Its third position is labelled FM, which is used to process audio from an FM station that Dolby-encodes its programs. In this mode, recording-level controls are disabled and the input level is controlled by two screwdriver controls (on the rear apron), using the test tones periodically transmitted by FM stations that use Dolby processing. The FM mode also converts the 75- μ s deemphasis of the tuner's output to the 25- μ s required by the Dolby noise-reduction system.

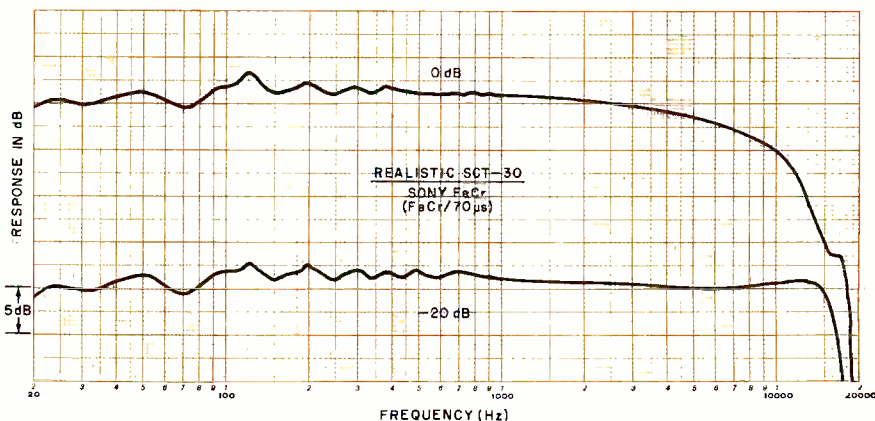
The two RECORD controls are concentric. A plastic ring that surrounds them can be set for conveniently returning to a predetermined gain setting. There is a slight detent at the ring's index mark. The OUTPUT (playback) level control also has a "memory ring."

Laboratory Measurements. For our tests, we used the high-energy ferric-oxide Supertape Gold, TDK's AD and SA, Sony's FeCr, and Memorex's High Bias tapes. The overall record/playback frequency response with any of these tapes was well within the deck's published ratings. In fact, all the tapes performed very similarly to each other when the bias was adjusted according to instructions for each tape. The low-frequency "head ripples" in the response curve were rather low in amplitude, although they extended up to about 700 Hz. They did not reduce the low-frequency response, which was almost flat down to our measurement limit of 20 Hz.

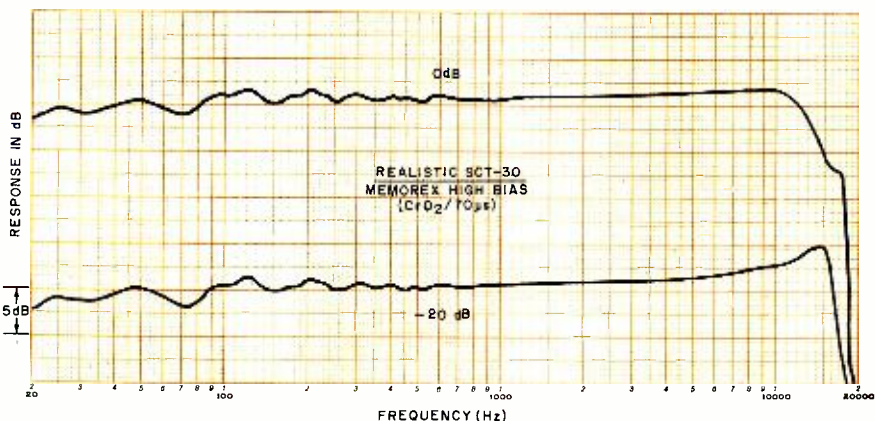
The overall response was typically well within ± 2 dB, referred to the 1000-Hz level, from 20 to 16,000 Hz with all of the tapes at a -20-dB re-



Frequency responses at 0 and -20 dB for TDK AD at normal and maximum bias.



Frequency responses at 0 and -20 dB for Sony FeCr tape.



Frequency responses at 0 and -20 dB for Memorex High Bias tape.

ording level. The deck was slightly underbiased for TDK AD and Memorex High Bias tapes. However, with the bias adjustment set to its maximum limit, both tapes yielded very flat response curves.

Much more impressive than the flatness of the -20-dB response curve was the performance at a 0-dB recording level. With most of the tapes, the response remained flat to about 8000 Hz and did not roll off rapidly until the frequency exceeded 10,000 Hz.

(With TDK SA tape, using CrO₂ bias and equalization, the 0-dB response was flat to 10,000 Hz!) The 0- and -20-dB response curves intersected at 13,500 Hz with Realistic Supertape, but with all other tapes, the 0-dB response was always above the -20-dB curve so that intersection never occurred. This indicates unusual freedom from head and tape saturation—one of the benefits of a good three-head design, since the recording and playback heads can each be de-

signed for their separate tasks. We observed that the Sony FeCr tape revealed more evidence of high-frequency saturation than other tapes, with its 0-dB response rolling off smoothly above 2000 or 3000 Hz but never intersecting the -20-dB curve.

When we measured playback distortion as a function of recording level at 1000 Hz, we received a second surprise. Many cassette decks go into saturation just beyond their 0-dB meter calibrations and distortion rises rapidly before the meter's pointer goes off-scale. The Model SCT-30, however, had to be driven to about +10 dB with most tapes before third-harmonic tape distortion reached the reference 3% level. (With TDK AD tape and the bias set to maximum to flatten out its response, we had to go to +13 dB to reach 3% distortion!) At first, we wondered if the recorded levels were lower than usual, but the Dolby points on the meters were within 1 dB of the correct 200 nW/m flux level for a standard Dolby tape. This means that the Model SCT-30 has a headroom of 7 to 10 dB beyond the Dolby level before the distortion reaches 3%. Therefore, Dolby-encoded FM programs can be recorded with fully effective Dolby operation with no risk of tape saturation and the resulting loss of highs and increased distortion. This is very rare in cassette recorders, most of which cannot be recorded at levels greater than 3 or 4 dB above the Dolby level without excessive distortion.

On most recorders, if the FM Dolby signal levels are adjusted correctly for the Dolby system, with 50% modulation corresponding to a Dolby-level meter indication on the recorder, 100% modulated peaks will be at +6 dB and will almost certainly overload the recorder. The only alternative in most cases is to set the Dolby tone from the FM transmitter (50% modulation) several decibels below the meters' Dolby points, which can degrade frequency response and noise reduction but will not distort. These examples are based on recording the signal without decoding, a theoretically preferable approach. Often, the easiest

playback distortion from 0-dB recorded signal was very low 0.25% to 0.32%

solution is to decode the Dolby-encoded signal and record it in that form at correct levels. We also found that Dolby tracking of the recording and playback circuits of the Model SCT-30 deck was excellent. There was less than 1 dB change in any part of the response from 20 to 15,000 Hz at levels from -20 to -40 dB when the noise-reduction system was operating.

Playback distortion from a 0-dB recorded signal was very low, measuring 0.25% to 0.32% for most tapes and 0.63% with Sony FeCr tape. All of our measurements were below the deck's 0.9% rating. Playback frequency response was within ± 1 dB from 40 to 12,000 Hz with the TDK AC-337 120- μ s test tape and ± 2 dB from 40 to 10,000 Hz with the Teac 116SP 70- μ s test tape.

The unweighted S/N ratio was about 50 dB, referred to a 3% distortion level. With "A" weighting, readings improved to between 53.5 and

55.3 dB, depending on the tape. With CCIR/ARM weighting and the Dolby system switched in, S/N was about 64 dB with ferric-oxide tapes (Realistic Supertape and TDK AD) at normal bias settings. With bias adjusted for flattest response on TDK AD tape, the S/N improved to slightly greater than 66 dB, which is the same reading obtained with TDK SA tape and CrO₂ bias and equalization. The best S/N was measured with Sony FeCr tape, which was an excellent 68.5 dB. Noise increased by 9.2 dB through the microphone inputs at maximum gain.

An AUX input of 85 mV or a MIC input of 0.3 mV was required for a 0-dB reading on the deck's meters. The microphone input overloaded at a rather low 25-mV input. Maximum playback level from a 0-dB recorded signal was about 0.33 volt with ferric-oxide tapes and 0.4 volt with TDK SA and Sony FeCr tapes.

The CCIR or DIN weighted peak flutter with a TDK AC-317 test tape

Performance Specifications

Specification	Rating	Measured
Frequency response (± 3 dB)		
Supertape	30-15,000 Hz	20-16,000 Hz ± 2 dB (ST)
CrO ₂	30-16,000 Hz	20-15,500 Hz ± 2 dB (SA)
FeCr	30-15,500 Hz	20-15,000 Hz ± 2 dB (FeCr)
Overall S/N ratio	61 dB (CrO ₂ , Dolby CCIR weighted)	49 dB (ST) 48.3 dB (AD) 50 dB (SA) 49.5 dB (FeCr) 53.5 dB (ST) 54 dB (AD) 54.7 dB (SA) 55.3 dB (FeCr) 64 dB (ST) 64.3 dB (AD) 66.3 dB (SA) 68.5 dB (FeCr)
		(unweighted)
		(A weighted)
		(CCIR/ARM, with Dolby)
Distortion at 0 VU	Less than 0.9%	0.32% (ST) 0.28% (AD) 0.25% (SA) 0.63% (FeCr)
Crosstalk	Under -60 dB	-42 dB (TDK AC-352 tape)
Wow/flutter	Under 0.06% wrms	0.075% wrms (TDK AC-342) 0.09% wpk
Erase ratio	70 dB	Not measured
Output level	At least 0.55 V	0.33 to 0.40 V for 0 dB recorded signal
Output impedance	10,000 ohms (8 ohms, phones)	Not checked
Input impedance	AUX 100,000 ohms Mic. OK for 500 to 5000 ohms	Not checked
Record bias frequency	105 kHz	Not checked
Fast forward/rewind time	Under 125 s for C-60	96 s

was $\pm 0.09\%$, and the JIS weighted rms flutter was 0.075%. In a combined record/playback measurement, readings were slightly higher. Speed was 0.5% fast. The deck required about 96 seconds to handle a C-60 cassette in both fast forward and rewind. This was faster than the rated time, but still rather slow. The 1000-Hz crosstalk from right to left channel with a TDK AC-352 test tape was -42 dB. The meters had a fast response, with about 15% to 20% overshoot on a 0.3-second tone burst, and a slow decay time that appeared to be on the order of a couple of seconds. Headphone volume was excellent, even with 200-ohm phones.

User Comment. When we compared the sound of interstation FM tuner hiss entering and leaving the recorder, we found the two to be close with all of the tapes we used. It was virtually perfect when the bias was carefully adjusted. In taping FM broadcast programs, we could never hear any difference between the incoming and outgoing signals when we used the monitor button on the recorder or amplifier. Recording levels are

much less critical with this deck than with most we have used. We found it perfectly practical to record with the deck's meters regularly indicating in the range between 0 and $+3$ dB. With the meter pointers often pinned to their right indexes, there was no audible sign of compression, distortion, or loss of highs.

The Model SCT-30 lacks a few frills, such as memory rewind and microphone mixing, neither of which is likely to be missed by most cassette deck users. To compensate for this, the buyer gets one of the very few cassette decks, and possibly the only one at this deck's price, that can decode or record Dolby-encoded FM broadcasts without the risk of distortion and with fully effective Dolby operation. In its sound quality, this deck takes second place to none when recording from records and FM broadcasts. It is more limited for live recording purposes if one wishes truly high-quality results, of course, owing to the cassette medium and, perhaps, to the low-mike overload point.

Handling quality of the deck ranged from fair to good. When EJECT is pressed, the cassette well moves out

in a smooth, cushioned manner. Levers such as FAST FORWARD disengage automatically moments after the end of a tape is reached—a neat feature. The action of the transport lever, though positive and smooth, does have a mechanical latch for locking purposes. Also, the levers are all the same size (except STOP) so, without illumination, one would be hard pressed to control the transport in a darkened room.

The foregoing does not detract from the overall fine value of this deck. Naturally, there are trade-offs to be made for the price. Raw performance is super. Variable bias adjustment; big, well-lighted meters; Dolby monitor; Dolby test-adjust facility; three tape heads; and the like more than make up for some noted shortcomings. And let's not forget the front-load facility, which is a pleasurable convenience, though transport start is delayed somewhat as heads are moved into position. In all, the new Realistic SCT-30 would be a fine addition to virtually any high-quality stereo component system when overall high performance is the overriding criterion.

CIRCLE NO. 102 ON FREE INFORMATION CARD

Denon DP-2500 record player offers direct drive with quartz control and dc braking

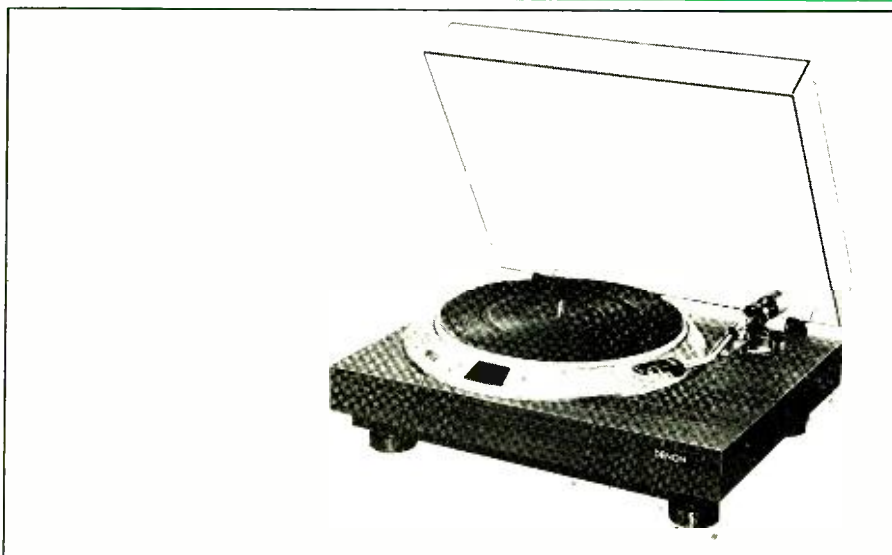


THE Model DP-2500 record player introduced by Denon offers a quartz - controlled

direct-drive turntable and a high-quality tonearm. The single-play, manually operated player is mounted on a 40-mm thick wooden base.

The turntable features an ac motor with bidirectional servo control and dc braking to give it exceptionally fast start-up, speed-change, and shut-down times and very low flutter and rumble. A dynamically damped tonearm reduces the effect of low-frequency tonearm/cartridge resonance. It employs a lightweight rigid aluminum headshell with a four-pin plug-in design. The wood base is sandwiched with a viscous damping material to reduce resonances. The base is covered in a vinyl wood-grain (choice of blond ash or walnut) veneer and comes with a clear-plastic dust cover.

With the dust cover closed, the Model DP-2500 record player measures 19" W \times 16" D \times 7" H (48.3 \times 40.6 \times 17.8 cm) and weighs 26.5 lb (12 kg). Suggested retail price, \$525.



General Description. Like other Denon record players, the Model DP-2500 has its cast-aluminum platter almost entirely above the motor-board and surrounded by a bevelled ring. On the sloping surface of the ring are the turntable controls, including a pushbutton power switch and a green indicator light, a 33 $\frac{1}{3}$ - and 45-rpm speed selector switch, and a momentary-contact button for starting and stopping the turntable. Stroboscope markings under the platter are visible through a window in the control ring.

The ac servo motor that drives the platter is controlled by a quartz crystal oscillator whose operating frequency is about 1.3 MHz. The feedback signal from the platter to the control amplifier is derived from a magnetized band on the inside rim of the platter. On this band are recorded 1000 pulses. A pickup head that resembles the tape head used in a cassette deck senses the magnetic pulses as the platter rotates. The output signal frequency from this pickup at 33 $\frac{1}{3}$ rpm is approximately 500 Hz. It is compared with a similar reference frequency derived from the crystal oscillator after frequency division. Any error between the two signals causes a correcting signal to be generated for the motor.

Denon claims that the 500-Hz speed-sensing frequency is approximately five times the frequency typical of most direct-drive turntables. This helps give the Model DP-2500 a speed stability and freedom from overshoot that surpass the performance of other direct-drive turntables.

The neon lamp that illuminates the stroboscope pattern is driven by a signal derived from the quartz oscillator. Hence, a single stroboscope pattern is used for both speeds. The pattern is stationary during momentary shifts in line-power frequency and phase, which can cause most stroboscope patterns to waver even when platter speed is constant.

The tonearm consists of an S-shaped aluminum tube that is balanced by a threaded counterweight on which the tracking-force scale is located. After the tonearm is balanced, the scale is set to zero and the entire weight is rotated to align the desired force calibration (0 to 2.5 grams in 0.1-gram increments) with a reference mark on the tonearm's tube. Antiskating force can be adjusted while a record is being played. The cueing lever for the tonearm is viscous damped.

Tonearm height is adjustable to accommodate different cartridge dimensions, while remaining parallel to the turntable.

Laboratory Measurements. Although no stylus-positioning jig was supplied with the sample record player, the setup directions state that the stylus should be 50 mm from the mounting reference surface at the end of the tonearm for minimum tracking error. When the stylus was positioned as instructed, tracking error was very low, typically less than 0.25°/in. and a maximum of 0.4°/in. at a 2.5" (63.5-mm) radius.

Calibration of the tracking-force scale was exact after initial balancing of the tonearm according to instructions. The antiskating force had to be set slightly greater than the tracking force for best correction. In our tests, we used an antiskating force of 2 grams at a 1.5-gram tracking force. The cueing mechanism allowed the tonearm to drift considerably outward during descent. When the stylus finally contacted the record's surface, about 12 seconds was repeated.

Effective mass of the tonearm was about 20 grams. Capacitance of the tonearm and signal cables was 90 pF to ground in each channel and 1 pF between channels.

Turntable speed was more accurate than our ability to measure. The platter came up to speed in less than a second, which was about the same time it took for the platter speed to stabilize when switching from one speed to the other. Dc braking stopped the platter completely within two seconds after the OFF button was operated.

isolation was considerably greater than typical direct-drive player

Rumble was somewhat lower than we have observed on most direct-drive turntables, measuring -35 dB unweighted and -64 dB with ARLL weighting. Rumble energy was principally below 5 Hz. The unweighted peak or DIN flutter measured $\pm 0.08\%$ (0.075% wrms JIS). Flutter was mostly below 10Hz.

The extremely compliant base

mounting feet had considerable lateral freedom of movement, making it difficult to measure the isolation from conducted vibration in our usual manner, with vibration applied directly to the feet through small transducers. We determined, however, that the isolation of the Denon mounting system was considerably better than that of the typical direct-drive record player. It was, in fact, comparable to that of many of the better belt-driven players.

User Comment. Although the Model DP-2500 is a no-frills record player, devoid of concessions to automatic play, it shares many of the qualities we have found in Denon's top-priced Model DP-6700 player. Specifically, it is unusually easy to set up. Also, when the tonearm is balanced and the cartridge is positioned according to instructions, tracking force is precisely correct and tracking error is at the theoretical minimum for this size tonearm.

The fast start and stop action of the turntable will be appreciated by anyone who has used an "automatic" turntable that requires one to wait usually 12 to 15 seconds for the tonearm to reach its playing position after turn-on or for completely shutting down after a record has been played. With the Model DP-2500, the start-up, speed-change, and shut-off operations are virtually instantaneous, smooth, and silent.

Since we use different test methods than those employed by Denon, we did not make an effort to compare specs. As evidenced by our standard measurements, the Model DP-2500 is indeed a top-rated performer.

The only thing we found not to our liking was the outward drift of the cueing system during descent of the tonearm. This was in marked contrast to the virtual perfection of every other aspect of the player's design and performance. Of course, the tonearm can be manually handled at all times, which is no great problem in view of its excellent finger lift and balance.

In all, Denon's DP-2500 is a solidly built record player of exceptional quality. It operates smoothly, rapidly, and virtually silently. It should also prove to be relatively free of the acoustic-feedback problems that plague many record-playing installations. And as an added fillip, its appearance has all the indications of top quality.

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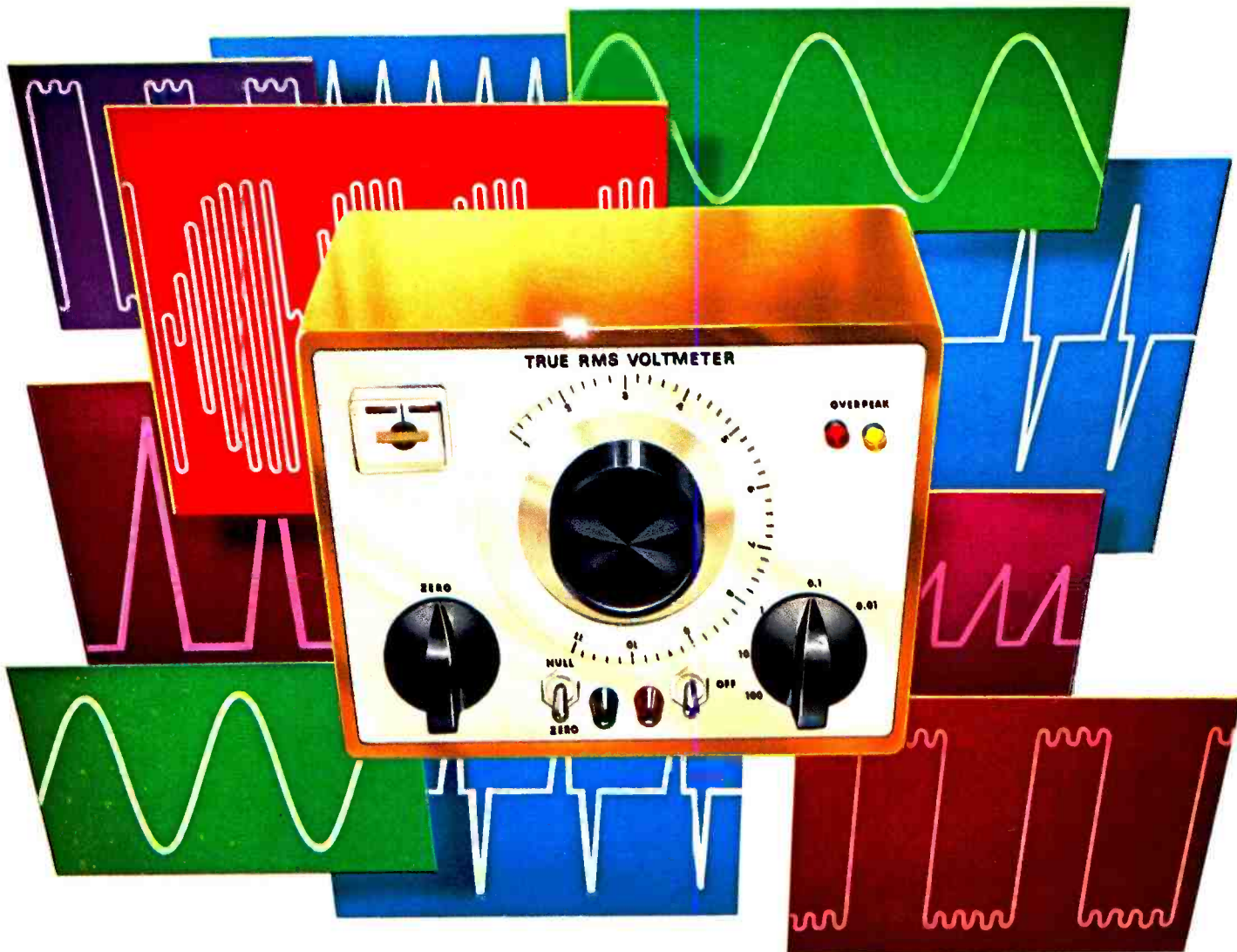
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BUILD A TRUE RMS VOLTMETER

Measures effective
ac voltage rather
than the usual
average values

BY DANIEL METZGER

EVENTUALLY, most serious electronics experimenters find a need to measure the power content of an odd-shaped waveform. This might occur in measuring the output of a class-C amplifier, audio, video or noise signals; power supply inverter waveforms; or just plain power supply ripple.

When the time comes, the experimenter will discover that a standard VOM or DVM simply won't provide true rms readings! An rms voltmeter is needed for this purpose. Unfortunately, this is a rather expensive instrument.

With the plans presented here, however, a true rms voltmeter can be built for only about \$30. To fully understand how this is accomplished, let's first examine what rms means.

What Is RMS? Rms values allow the expression of the average power content of an ac waveform whose instan-

taneous power varies from zero (at the zero crossing) to some high value at the voltage peak. In practice, rms means "equivalent to dc." Mathematically, given a voltage and a resistance, power is calculated as $P = E^2/R$.

The "equivalent-to-dc" voltage for a continuously varying ac voltage must be calculated by squaring the voltage at each instant, averaging the infinite number of instantaneous values produced (taking the mean), and then extracting the square root. Hence, the term Root of the Mean of the Square (RMS).

For anything beyond a simple rectangular waveform, this rms technique involves calculus. For sine waves *only*, it produces $E_{RMS} = E_{PK(SINE)}/\sqrt{2} = 0.707E_{PK}$.

For periodic waveforms that cannot be mathematically expressed, the rms technique requires iterative computer analysis. For completely undefinable

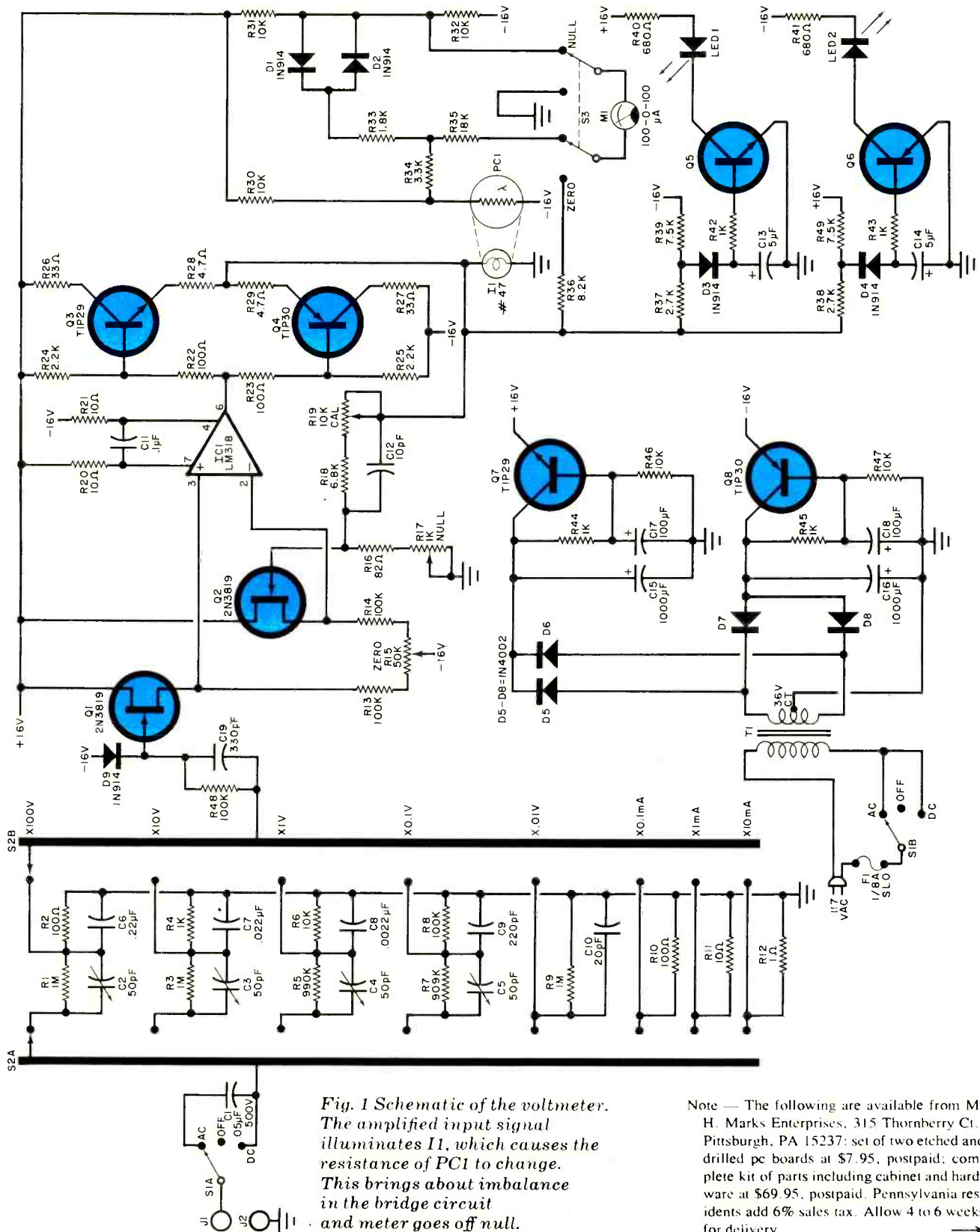


Fig. 1 Schematic of the voltmeter. The amplified input signal illuminates I1, which causes the resistance of PC1 to change. This brings about imbalance in the bridge circuit and meter goes off null.

Note — The following are available from M. H. Marks Enterprises, 315 Thornberry Ct., Pittsburgh, PA 15237: set of two etched and drilled pc boards at \$7.95, postpaid; complete kit of parts including cabinet and hardware at \$69.95, postpaid. Pennsylvania residents add 6% sales tax. Allow 4 to 6 weeks for delivery.

PARTS LIST

C1 — 0.05- μ F, 500 volt capacitor
 C2 through C5 — 50-pF trimmer
 C6 — 0.22- μ F Mylar capacitor
 C7 — 0.022- μ F Mylar capacitor
 C8 — 0.0022- μ F capacitor
 C9 — 220-pF capacitor
 C10 — 20-pF capacitor
 C11 — 0.1- μ F capacitor
 C12 — 10-pF capacitor
 C13, C14 — 5- μ F, 15-volt electrolytic
 C15, C16 — 1000- μ F, 35-volt electrolytic
 C17, C18 — 100- μ F, 25-volt electrolytic
 C19 — 330-pF capacitor
 D1 thru D4, D9 — 1N914
 D5 thru D8 — 1N4002
 F1 — 1/8-ampere slow-blow fuse
 I1 — #47 pilot lamp
 IC1 — LM318 op amp
 J1, J2 — Five-way binding posts, one red (J1), one black (J2)
 LED1, LED2 — Light emitting diode
 M1 — 100-0-100- μ A meter
 PC1 — See text
 Q1, Q2 — 2N3819, MPF102, or similar
 Q3, Q7 — TIP29 or similar
 Q4, Q8 — TIP30 or similar
 Q5, Q6 — Any small-signal silicon transistor
 R1, R3, R9 — 1-megohm, 1%, 1 watt resistor
 R2, R10 — 100-ohm, 1% resistor
 R4 — 1000-ohm, 1% resistor
 R5 — 1-megohm, 1% resistor (try for 990k)
 R6 — 10,000-ohm, 1% resistor
 R7 — 909,000-ohm, 1% resistor (try for 900k)
 R8 — 100,000-ohm, 1% resistor
 R11 — 10-ohm, 1% resistor
 R12 — 1-ohm, 1% resistor
 R13, R14, R48 — 100,000-ohm resistor
 R16 — 82-ohm resistor
 R18 — 6800-ohm resistor
 R20, R21 — 10-ohm resistor
 R22, R23 — 100-ohm resistor
 R24, R25 — 2200-ohm resistor
 R26, R27 — 33-ohm, 1-watt resistor
 R28, R29 — 4.7-ohm resistor
 R30, R31, R32, R46, R47 — 10,000-ohm resistor
 R33 — 1800-ohm resistor
 R34 — 3300-ohm resistor
 R35 — 18,000-ohm resistor
 R36 — 8200-ohm, 1/2-watt resistor
 R37, R38 — 2700-ohm 5% resistor
 R39, R49 — 7500-ohm 5% resistor
 R40, R41 — 680-ohm resistor
 R42, R43, R44, R45 — 1000-ohm resistor
 R15 — 50,000-ohm linear-taper potentiometer
 R17 — 1000-ohm linear-taper potentiometer (see text)
 R19 — 10,000-ohm, trimmer pot
 S1 — Dpdt center-off toggle switch
 S2 — 8-position, 2-pole rotary switch
 S3 — Dpdt switch
 T1 — 36-V CT, 0.1-A transformer (Stancor 8611 or similar)
 Misc. — Suitable enclosure, dial plate and knob for R17, pointer knobs (2), press-on type, mounting hardware, etc.

waveforms such as noise, however, we have to go back to the rms voltmeter.

This may be a good place to observe that the time-honored VOM and most DVMS actually respond to *average* voltage (not rms) on their ac scales. The average value of one half-cycle of a sine wave is 0.637 of its peak value, or 0.901 of its rms value.

The meter scales are calibrated in rms, but this calibration is valid for sine waves only. VTVMs and FET meters generally respond to peak voltages on their ac ranges. Again, the meter scales are calibrated for rms readout on sine waves only. Consequently, a VOM or VTVM can display different and incorrect conclusions about a 25% duty cycle waveform, as illustrated in boxed section below right. Interestingly, most VOMs err in one direction on non-sine waves, while VTVMs err in the other.

The majority of true rms meters operate by electronically squaring and averaging the input signal, or by taking the log of the signal, doubling it, then taking the antilog. Building such a meter is best avoided because of its circuit complexity. The meter discussed here takes the direct approach of amplifying the input waveform and using its large signal to turn on a conventional incandescent lamp. The brilliance of the lamp is sensed by a photocell so that comparisons between ac and equivalent dc voltages can be made. In operation, the amplifier gain is adjusted until the lamp reaches a predetermined brightness, and the rms voltage is then read off a calibrated "gain" control.

Circuit Description. As shown in Fig. 1, resistors R1 through R9 provide voltage divisions by progressive factors of ten while maintaining a 1-megohm input resistance. Capacitors C2 through C10 provide identical division ratios at high frequencies while maintaining an input capacitance of 20 pF. Without these capacitors, the reactance of any stray wiring capacitance would completely swamp the resistive dividers above approximately 50 kHz, resulting in false division ratios. Resistors R10 through R12 are used in the measurement of current.

Source follower Q1 provides an almost infinite input impedance for the amplifier, while FET Q2 provides compensation for variations in Q1 source voltage with temperature. Both Q1 and Q2 should be well matched—zero volts between their sources with the input grounded and control R15 (ZERO) near

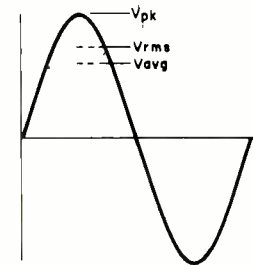
the center of its rotation. Also, the transistor cases should be thermally bonded.

Op amp IC1 has a gain between 10 and 100, depending on the setting of the CAL (R19) and NULL (R17) controls. Capacitor C12 compensates for stray capacitance in the R16-R17 leg, and is selected for good high-frequency response. Components R20, R21 and C11 are required to prevent high-frequency oscillation via power supply coupling. A complementary symmetry voltage follower (Q3 and Q4) provides the high current required by lamp I1.

The sensitive surface of photoresistive cell PC1 is butted to the lamp and secured in place with opaque heat-shrink tubing. The photocell forms one arm of a Wheatstone bridge, with R30-R32 as the other arms. At one particular

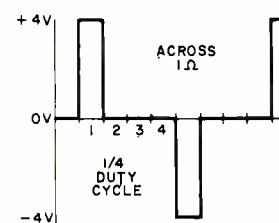
VTVM AND VOM ERRORS

For sine waves:



$$\begin{aligned}
 V_{PK} &= 1.414V_{RMS} = 1.569V_{AVG} \\
 V_{RMS} &= 0.707V_{PK} = 1.110V_{AVG} \\
 V_{AVG} &= 0.637V_{PK} = 0.901V_{RMS} \\
 \text{VOMs read } &1.110V_{AVG} \\
 \text{VTVMs read } &0.707V_{PK}
 \end{aligned}$$

For this rectangular wave:



$$\begin{aligned}
 P_{INST} &= E^2/R = 4^2/1 = 16\text{ W} \\
 P_{AVG} &= 16/4 = 4\text{ W} \\
 E_{RMS} &= \sqrt{PR} = \sqrt{4 \times 1} = 2.00\text{ V} \\
 \text{VOM reads:} \\
 1.110 \times V_{AVG} &= 1.110 \times \frac{1}{4} \times 4 \\
 &= 1.11\text{ V or }2.00\text{ V}_{RMS} \\
 \text{VTVM reads:} \\
 0.707 \times V_{PK} &= 0.707 \times 4 \\
 &= 2.83\text{ V or }2.00\text{ V}_{RMS}
 \end{aligned}$$

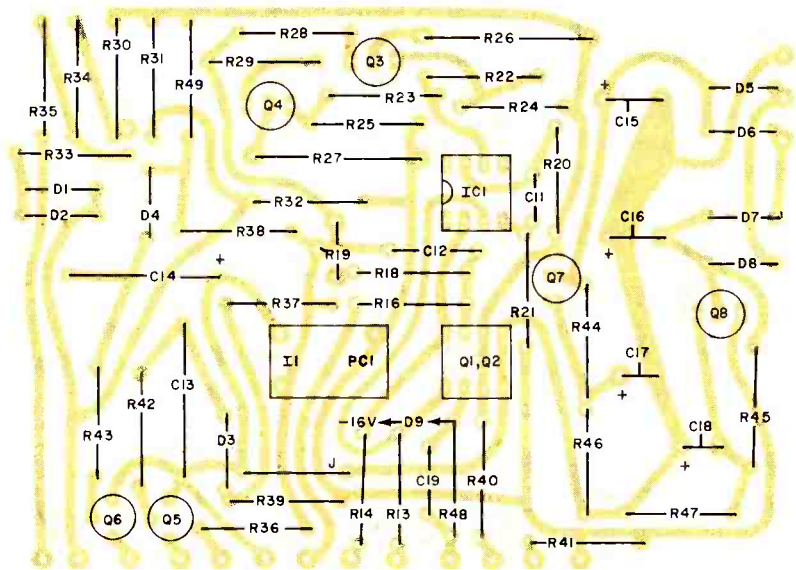
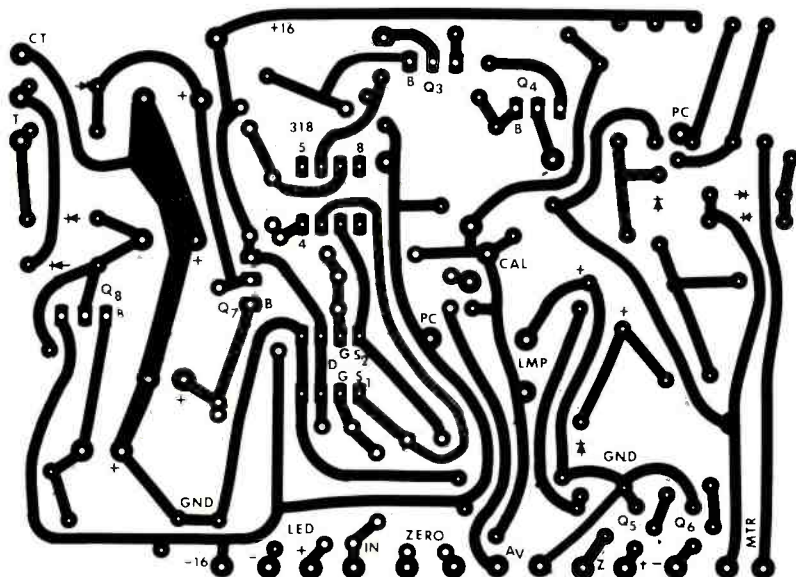


Fig. 2. Actual-size foil pattern for main pc board is at top, component installation immediately above.

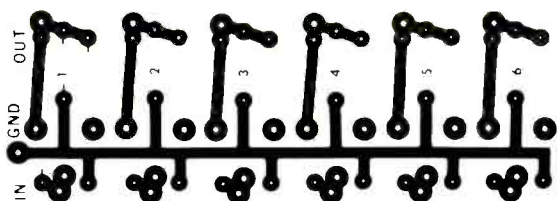


Fig. 3. Components for attenuator can be mounted on board similar to that at left. Only four sections are used in this case.

lamp intensity, the cell resistance will equal 10,000 ohms and meter *M1* will indicate zero. For unbalance currents of about $25\mu\text{A}$, *D1* and *D2* will begin to conduct, shunting the meter with *R33*. This makes it easier to find the null by reducing the meter sensitivity for off-null settings. The meter can be switched to zero out dc voltage at the amplifier output when the input is grounded.

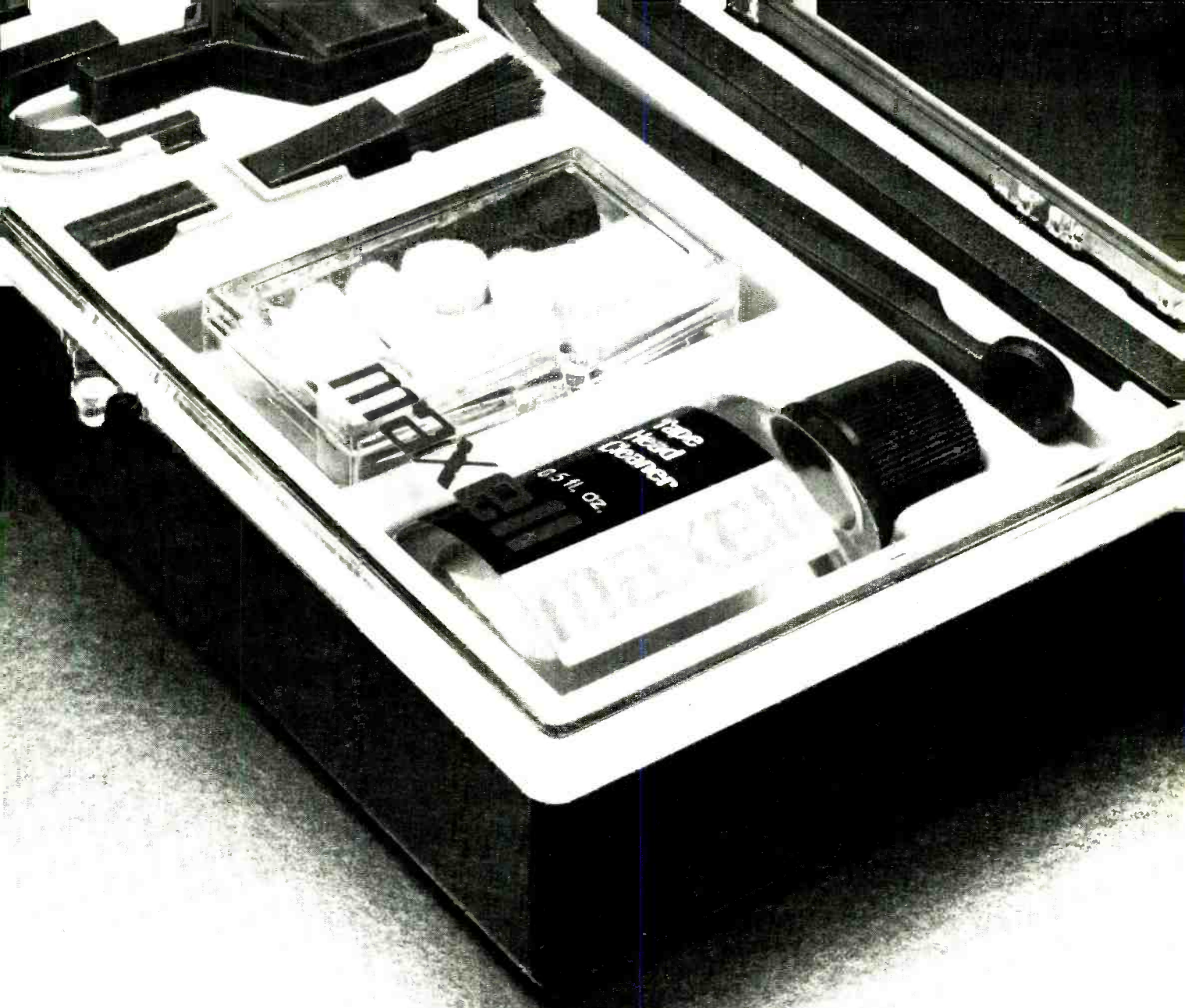
In the prototype, balance was achieved with 2 volts rms (or dc) across the lamp. For sharply peaked waveforms, it is possible that the peak voltage might exceed the approximately 10-volt limit of the amplifier resulting in distortion of the waveform. Diodes *D3* and *D4* detect such peaks slightly before the threshold of distortion, causing the front panel positive (*LED1*) or negative (*LED2*) overpeak indicators to glow.

The power supplies are well filtered by the emitter follower action of *Q7* and *Q8*. Regulation is not required because the differential amplifier and bridge circuits remain balanced in spite of power supply voltage variations.

Construction. Few of the components are critical and substitutions are possible. The NULL potentiometer (*R17*) should be of the highest quality since accuracy of the instrument depends on reading its angular position. Resistors *R1* through *R12* directly affect the accuracy and should be held to $\pm 1\%$. For the voltage dividers, it is the resistance ratio that is important. Ceramic trimmer capacitors hold their values better than compression types and are recommended for *C2* through *C5*. Transistors *Q3* and *Q4* may dissipate as much as 2 watts and must have heat sinks.

Using an LM318 for *IC1* results in a 400-kHz bandwidth. A $\mu\text{A}741$ reduces the bandwidth to about 20 kHz. Any photoresistive cell having a resistance of 10,000 ohms when illuminated by a #47 lamp with 1.5 to 2.5 volts dc applied to it will work for *PC1*.

The bulk of the circuit can be assembled on a pc board using the foil pattern and component layout shown in Fig. 2. The front-end attenuator can be built up on a small pc board like that shown in Fig. 3. Fixed and trimmer capacitors are mounted on the foil side and the resistors on the other. This board supports the first four attenuator elements. (Two sections on this small board will be unoccupied.) Once the components are mounted on the board, the pc assembly can be wired to the appropriate lugs on *S2* with short lengths of hookup wire.



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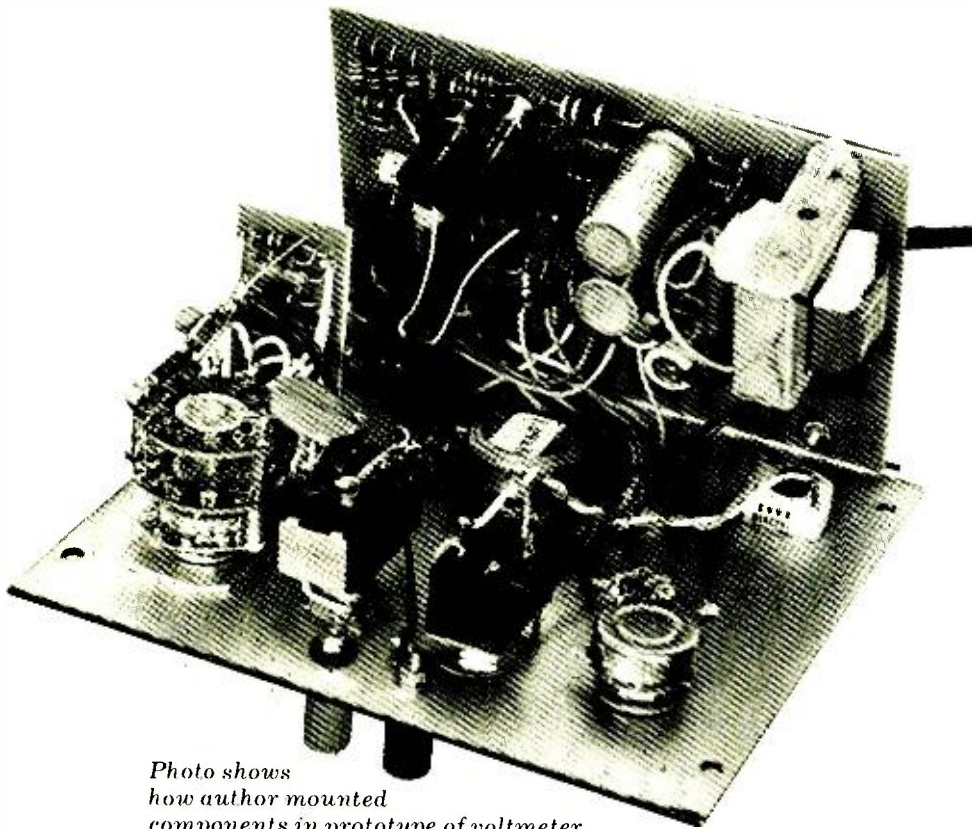


Photo shows how author mounted components in prototype of voltmeter.

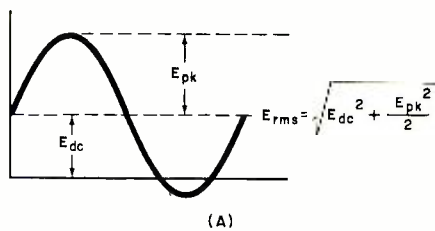
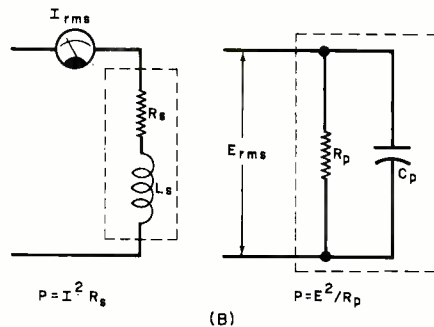


Fig. 4. Rms value of sine wave can be calculated as described in text using diagrams shown here.



Null the meter to read a 60-Hz sine wave someplace on the $\times .1$ range.

Without changing the generator output level, raise the frequency to 50 kHz and adjust $C5$ for a null at the same spot on the dial. Repeat this for $C4$, $C3$ and $C2$ on their ranges. Alternately, the trimmer capacitors can be adjusted for the cleanest 10-kHz square-wave response with a scope probe across $I1$.

Use. Here are some guidelines for using the rms meter.

When there is an ac or combined ac and dc voltage across an unvarying (pure) resistance, the rms value of the voltage can be used to compute the average power in the resistance by the equation $P_{AVG} = E_{RMS}^2/R$.

Similarly, if the rms current through an unchanging resistance is known, then $P_{AVG} = I_{RMS}^2 R$.

Note that unlike many rms meters, the meter described in this article can indicate the rms value of a waveform having a dc component. This dc component cannot be simply added to the rms value of the ac component to obtain the rms value of the total waveform. For sine-wave ac components, the rms value can be calculated as illustrated in Fig. 4. For other waveforms, it's either calculus or the dc-coupled rms meter.

An rms measurement cannot be applied to the calculation of power where the load impedance is partly reactive. However, if the numerical value of the resistive part of the load can be determined, true power can be calculated as shown in Fig. B, since the reactive portion consumes no power.

The rms measurement is also not appropriate for calculating the average power delivered to devices having changing ohmic resistance. Examples of such devices are diodes, SCRs, switching transistors and the plate or collector of a class-C amplifier.

For such devices, measure the average voltage and current for the device and calculate: $P_{AVG} = I_{AVG} E_{AVG}$.

If current flows always in one direction, a VOM on the dc range can be used. If ac is involved, you must use a meter that measures the average absolute (without regard to sign) value of voltage and current.

A VOM or average-reading DVM on the ac range fills this function if the readings are multiplied by 0.901 to change the rms calibration to average calibration. Be wary of such meters on the ac ranges since many of them have upper frequency limits below 1 kHz. \diamond

The four remaining attenuator sections are resistors that can be mounted directly on $S2$.

As shown in the photograph, on the front panel are the meter, two overpeak LED's, $R17$ (NULL), $R15$ (ZERO), $S3$ (NULL/ZERO), $S1$ (AC, DC POWER ON-OFF), $S2$ (RANGE) and input jacks $J1$ and $J2$.

These components can be mounted as desired on the front panel, leaving enough room around $R17$ to accommodate a calibrated dial plate. Press-on type can be used to identify controls.

Calibration. Set the NULL control ($R17$) to its minimum resistance. With

$S3$ at ZERO, connect $J1$ to $J2$ and adjust $R15$ (ZERO) for no meter deflection (center zero).

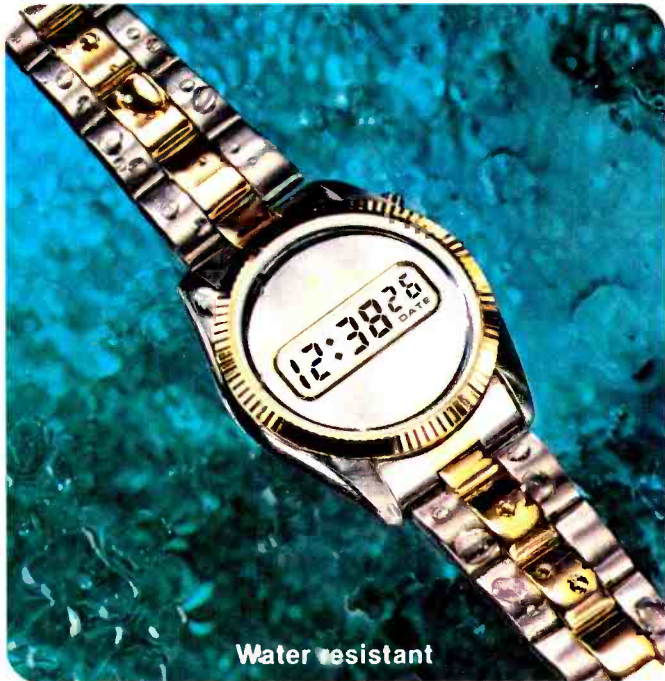
Set $S2$ to the $\times 1V$ position and $S3$ to NULL. Apply an accurate 1-volt dc between $J1$ and $J2$ (positive to $J1$) and adjust the pc board mounted $R19$ for a zero meter indication.

Mark the NULL dial plate with a 1, then apply 2, 3, etc., up to 11 volts dc, zeroing the meter with the NULL control and marking the dial as you go. If desired, you can apply a 60-Hz sine wave of known rms value to verify the "equivalent-to-dc" function.

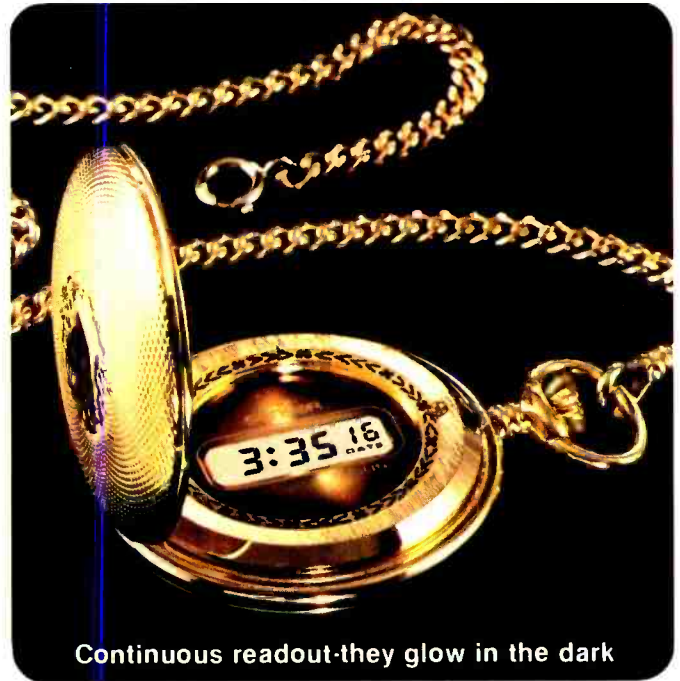
The $S2$ trimmer capacitors can be adjusted with the aid of an audio generator.

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Both watches also feature TriLite™, a new space-age illuminating technique developed by Sensor. Two tiny glass tubes, lined with phosphor, injected with tritium, are sealed permanently by laser beam and mounted behind the digital display. Perpetual interaction between phosphor and tritium emits a constant glow. The soft green light becomes more pronounced as exterior light dims.

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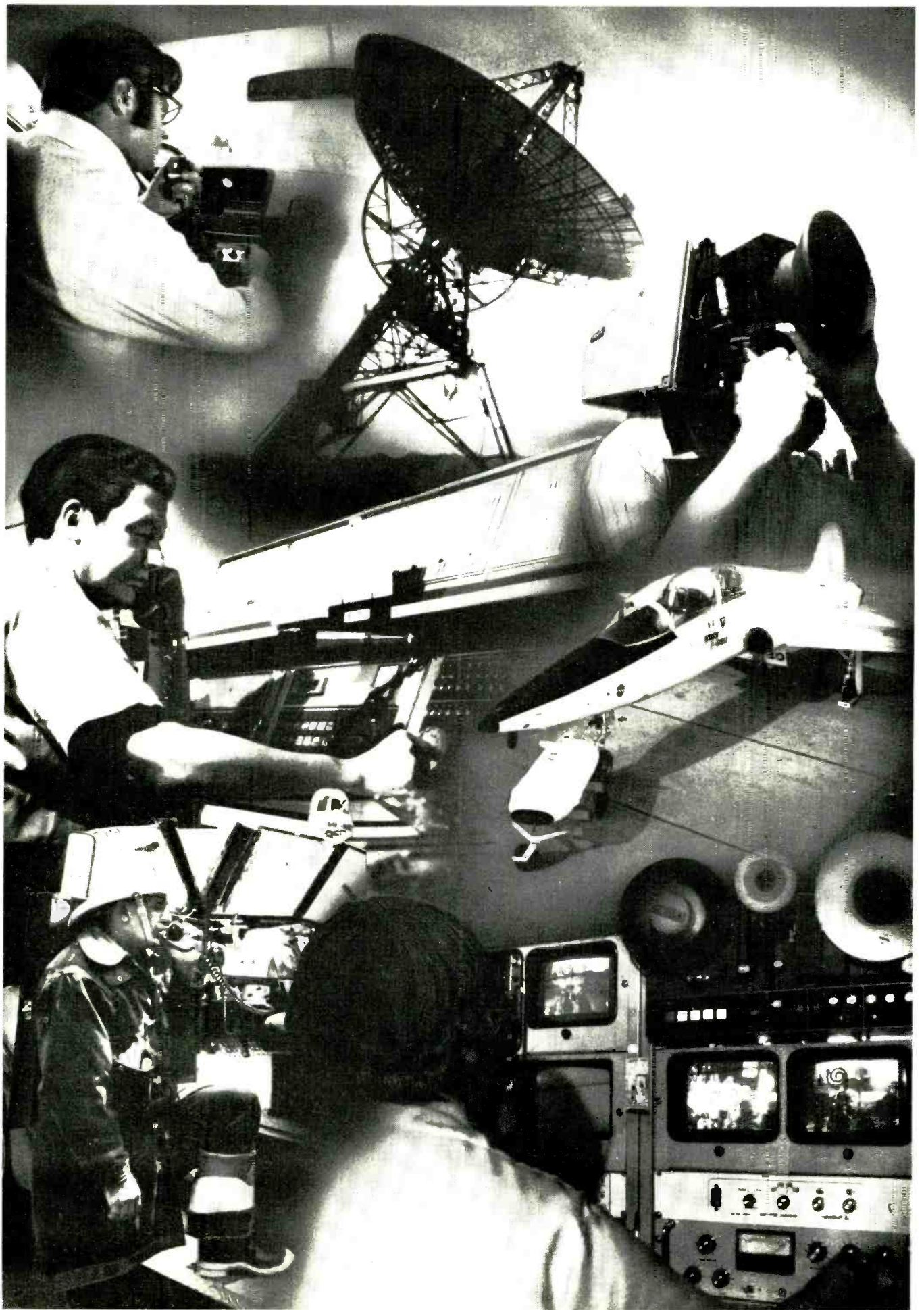
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 CIRCLE NO. 53 ON FREE INFORMATION CARD

Although transmission-line transformers are widely used in front ends of television receivers, there is not much information available about what they are and how they work. It is often assumed that they are just another ordinary transformer that uses a fancy high-frequency ferrite to obtain the desired results. In reality, the only thing in common between transmission-line and conventional transformers is the name. Their operating principles are totally different. In this article, we will explore what a transmission-line transformer is

pare them to the transmission-line transformer we are talking about here.

A simple step-up transformer with a center-tapped secondary is shown in Fig. 1A. Three things are obtained with such a transformer: a step up in voltage at its output, isolation between its primary and secondary, and a secondary that is symmetrical about its center tap. Here we are mainly concerned with the voltage ratio. Another parameter that should be mentioned because it is very important in transmission-line transformers is the impedance ratio.

Another transformer that is very similar to that shown in Fig. 1A, except that the primary and part of the secondary are a common winding, is shown in Fig. 1B. This autotransformer does the same job as the previous transformer, except that there is no isolation between the primary and secondary windings.

Finally, in Fig. 1C is a very simple 1:1 isolation transformer. In this case, the impedance, turns and voltage ratios are all 1:1. The only purpose of such a transformer is to provide isolation between the primary and secondary windings.

DESIGN OF TRANSMISSION-LINE TRANSFORMERS

How coreless transformers can be made from coaxial transmission line

BY ROY HARTKOPF

and how it works. But first let us see how it differs from conventional transformers.

How It Differs. In a conventional transformer, an alternating current in the primary continuously changes the amount of flux in the core, which, in turn, sets up a voltage in the secondary. Disregarding losses, since the amount of flux cuts every turn of both the primary and the secondary, the voltage ratio is directly proportional to the ratio of the turns in the windings. Also, since the action of the conventional transformer depends on the flux generated in the core, the bandwidth and efficiency depend entirely on the core material.

Normal iron cores are useful at frequencies up to a few hundred hertz. Although there are ferrite cores used in the megahertz range, their permeability and efficiency drop off fairly rapidly with increasing frequency. Another factor that comes into play at high frequencies is that the capacitance between the turns of the windings also limits the usefulness of the conventional transformer at megahertz frequencies.

It is useful at this point to examine a few conventional transformers to com-

Suppose that the primary of the transformer shown in Fig. 1A is rated 6 volts and 1 ampere (6 watts). Since we cannot obtain something for nothing, the output, even at 100% efficiency, can never be more than 6 watts. Hence, if the secondary potential is 12 volts, the secondary current can be no greater than 0.5 ampere.

By Ohm's Law, impedance is equal to the voltage divided by the current ($Z = E/I$), where E and I can be ac terms. Therefore, the impedance of the primary in our example is 6 volts/1 ampere, or 6 ohms, while the impedance of the secondary is 12 volts/0.5 ampere, or 24 ohms. Hence, even though the turns and voltage ratios are 1:2, the impedance ratio in our example is 1:4. (The impedance ratio is actually the *square* of the turns ratio.)

Although the schematic symbols shown in Fig. 1B and Fig. 1C can be and often are used for transmission-line transformers, this is where the resemblance between the conventional and transmission-line transformers ends. The first and perhaps most striking difference between the two is that with the transmission-line transformer, the core material is relatively unimportant. Instead of limiting the high-frequency response, the only effect it has is to extend the low-frequency response.

As far as high-frequency response is concerned, the core just does not matter. It could be made out of hard candy and the transformer would still work. A second very important difference is concerned with the number of turns. With the transmission-line transformer, the number of turns has nothing to do with

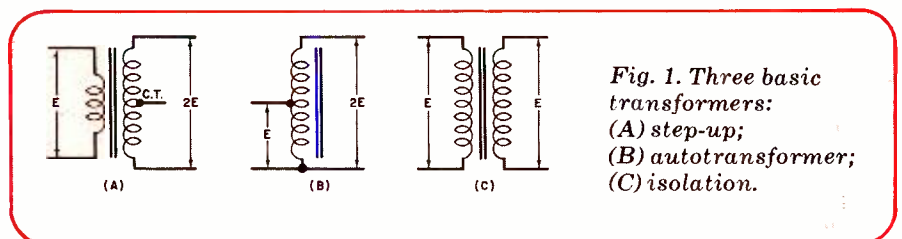


Fig. 1. Three basic transformers: (A) step-up; (B) autotransformer; (C) isolation.

the impedance. Finally, the pains taken to minimize capacitance in a conventional transformer are unnecessary in the transmission-line transformer. The transmission-line transformer uses the capacitance between its windings. In fact, this capacitance is often made as large as possible by twisting together the wires that make up the transmission-line transformer.

Technical Details. The transmission-line transformer is simply a length of transmission line. It is a pair of conductors that are either parallel to each other, twisted together, or arranged coaxially. Of importance is the spacing between the conductors, which must be constant throughout the line's length.

Each conductor in the transmission-line transformer has an inherent inductance. Also, between the wires of a conductor pair, there is an inherent capacitance. It is this combination of continuous inductance and capacitance that gives the transmission line its characteristic impedance. Any type of line can be used for a transmission-line transformer, but if a line is wound on a toroid, parallel or twisted lines are most often used because they are easy to handle and do not get pulled out of shape.

Examples of the characteristic impedances one can expect from various types of lines are as follows: No. 23 PVC-insulated hookup wire twisted at about one turn/inch yields about 150 ohms; 0.040" enameled wire with about eight twists/inch yields about 25 ohms; and 0.040" enameled wires wound side by side, with the turns kept as close together as possible, works out to between 50 and 70 ohms.

The essential condition for the proper operation of a transmission line is that the currents flowing in the two conductors be equal and opposite. Anything that causes an unbalanced current flow will prevent the line from operating properly. Suppose, for example, that a coaxial transmission line is very short and has one leg grounded at each end, as shown in Fig. 2. It is quite possible that there could be a ground current, I_g , flowing through the ground leg in addition to transmission-line current. There are, in fact, many ways in which a short transmission line can have unbalanced currents flowing through its conductors, all of which defeat the effect of the line.

Suppose the short transmission line shown in Fig. 2 were wound to form an inductor, as shown in Fig. 3A. (Its schematic representation is shown in Fig.

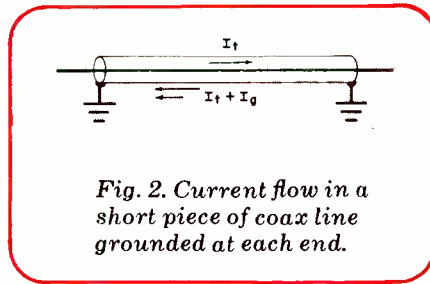


Fig. 2. Current flow in a short piece of coax line grounded at each end.

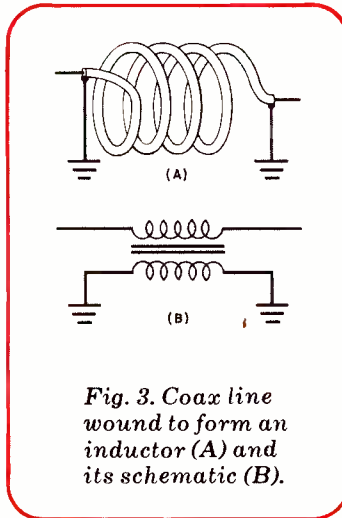


Fig. 3. Coax line wound to form an inductor (A) and its schematic (B).

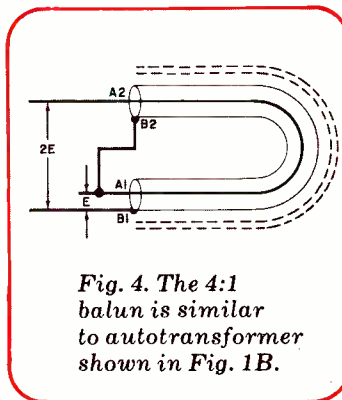


Fig. 4. The 4:1 balun is similar to autotransformer shown in Fig. 1B.

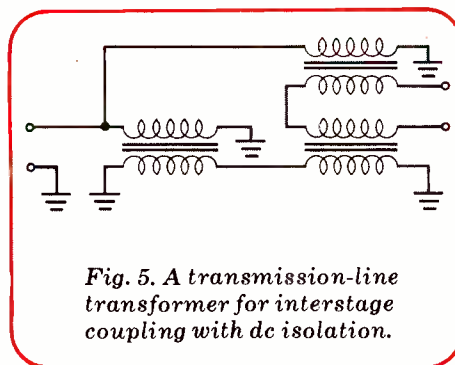


Fig. 5. A transmission-line transformer for interstage coupling with dc isolation.

3B.) Even though one leg is still grounded at each end, the ground current will be impeded by inductive reactance. The transmission-line currents, however, would not be affected here because they are equal and opposite at every point along the line, thus neutralizing the inductive effect of the coil. The actual line length can be short as 1/50-wavelength so no significant phase shift takes place.

If the transmission line were now wound on a ferrite rod or, better yet, a toroid core, it would be even more effective and would produce a higher degree of isolation. As the frequency increases, less inductance would be required to obtain the same isolation effect. Even if the core material is useless at very high frequencies, the isolating effect would still remain.

The autotransformer shown in Fig. 1B has a voltage ratio of 2:1 and an impedance ratio of 4:1. Exactly the same ratios can be obtained with a transmission-line transformer. The principle involved can be readily seen with a coaxial transmission line, as shown in Fig. 4. This is the well-known 4:1 balun (balanced-to-unbalanced) transmission-line transformer. The schematic symbol for the balun transformer would be the same as for the autotransformer of Fig. 1B.

In Fig. 4, ignoring losses, if a voltage is supplied between points A1 and B1, it will appear at points A2 and B2. With point B2 connected to point A1, twice the input voltage would appear across output points B1 and A2. This means that the output impedance would be four times the input impedance and the output would be symmetrical about the A1/B2 junction. In practice, the A1/B2 junction would be connected to the shield of the main coaxial transmission line and would generally be grounded.

There must be a very high impedance to out-of-balance currents between A1 and A2, isolating the two ends from each other. As a rule-of-thumb, this could be at least 50 times the characteristic impedance of the line—2500 ohms for a 50-ohm line. Winding the cable around a toroid is an effective way of getting the required impedance. A special case is the 1/4-wave balun, where isolation is provided by the 1/4-wave effect. However, this is effective only at one frequency, and cannot provide a broadband transformer.

Making a Transformer. Now that you know what a transmission-line transformer is and how it works, let us proceed to make a vhf power transform-

The reasons for giving up analog.

er using a core of audio-frequency material. Just about any type of toroid—ferrite or, better still, one made from flat strip iron rolled up in a coil, such as the type used in dc-to-dc converters—will do.

Wind two lengths of 0.040" enamelled wire onto the toroid. Keep the wires parallel to each other and make each turn touch the previous turn. Do not attempt to crowd too many turns on the toroid. The object is to wind only as many turns on the toroid in a single layer without having the conductors cross each other.

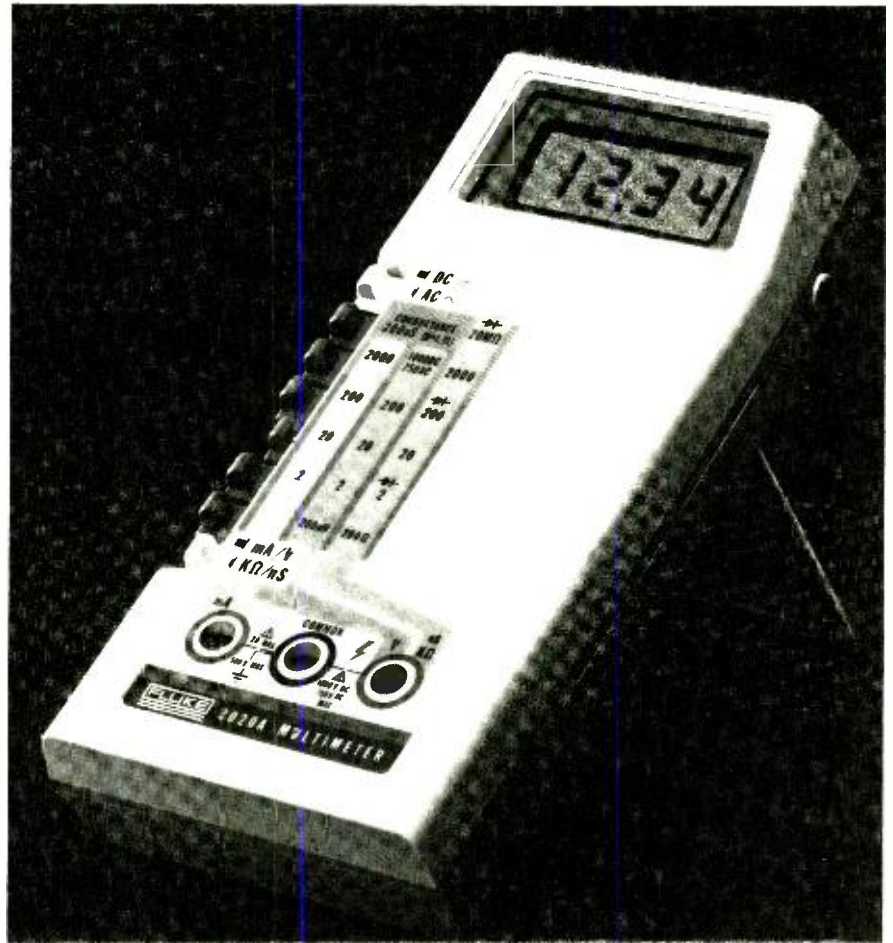
Bear in mind that many toroids have sharp edges and that even ferrite material is often conductive. If the edges cut into the insulation, the wire windings can be short-circuited. If the transformer does not operate as expected, short-circuiting will be the most probable cause since, practically speaking, there is nothing else that can really go wrong with the transformer. After winding your transformer, use an ohmmeter to test the insulation between each conductor and the core and between windings.

The basic transmission-line transformer just fabricated will yield a 1:1 impedance ratio and complete isolation so that it can be used as a balanced-to-unbalanced or, for that matter, any other type of configuration. If we need a 4:1 balun, it is necessary only to connect the ends of the conductors as shown in Fig. 4, without altering the winding.

When necessary, as when using a transmission-line transformer for inter-stage coupling, dc isolation can be obtained by using three transformers, as shown in Fig. 5. Remember that the core is there only to prevent out-of-balance currents. Therefore, if the wire size is small enough and the toroid core is large enough, it is possible to wind all three transformer windings on the same core.

In Conclusion. There is one basic limitation concerning transmission-line transformers. This is that the ratios obtainable are limited to 1:1 and 2:1, and multiples of 2:1 if two or more transformers are used. Also, it can be difficult to obtain the required impedance, particularly with a twisted-pair line.

If you want to build a wideband amplifier and must match, say, a 12-ohm transistor to a 50-ohm output, or make a balanced modulator, or provide really good isolation in a noise bridge, or make a balun transformer for a high-power transmitter, the transmission-line transformer is the way to go. The transmission-line transformer offers a great opportunity for experimenting. ◇



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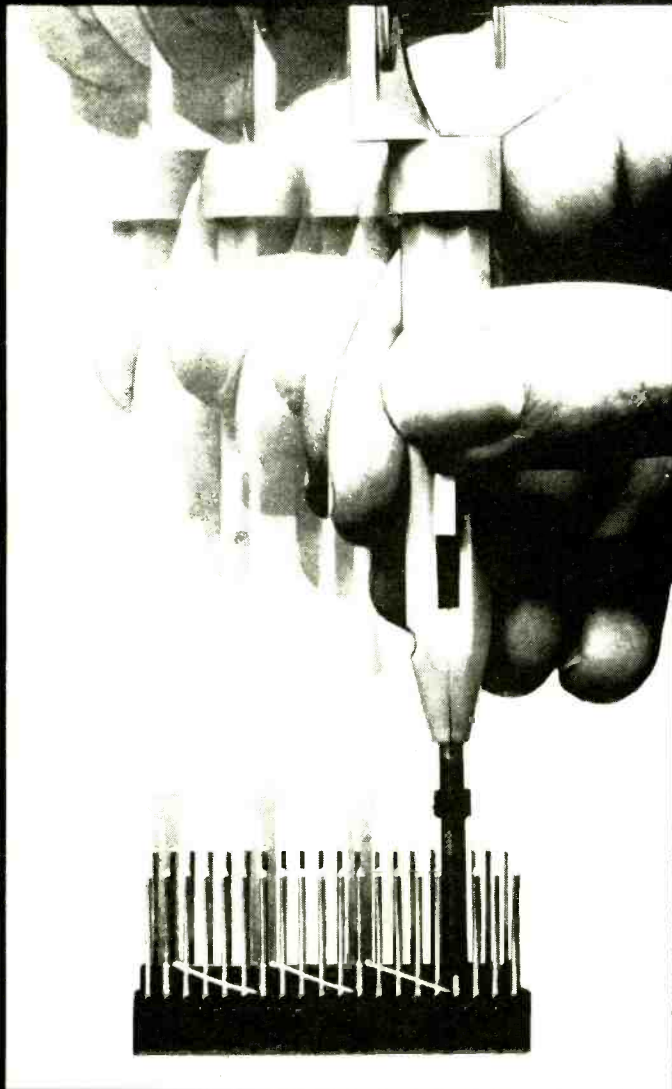
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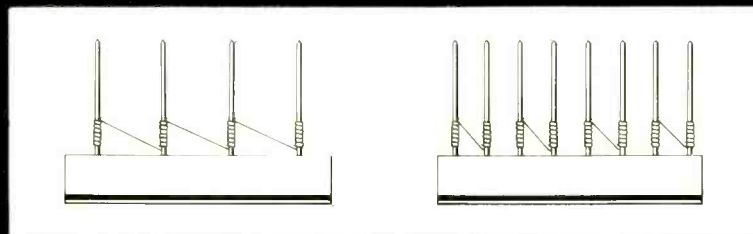
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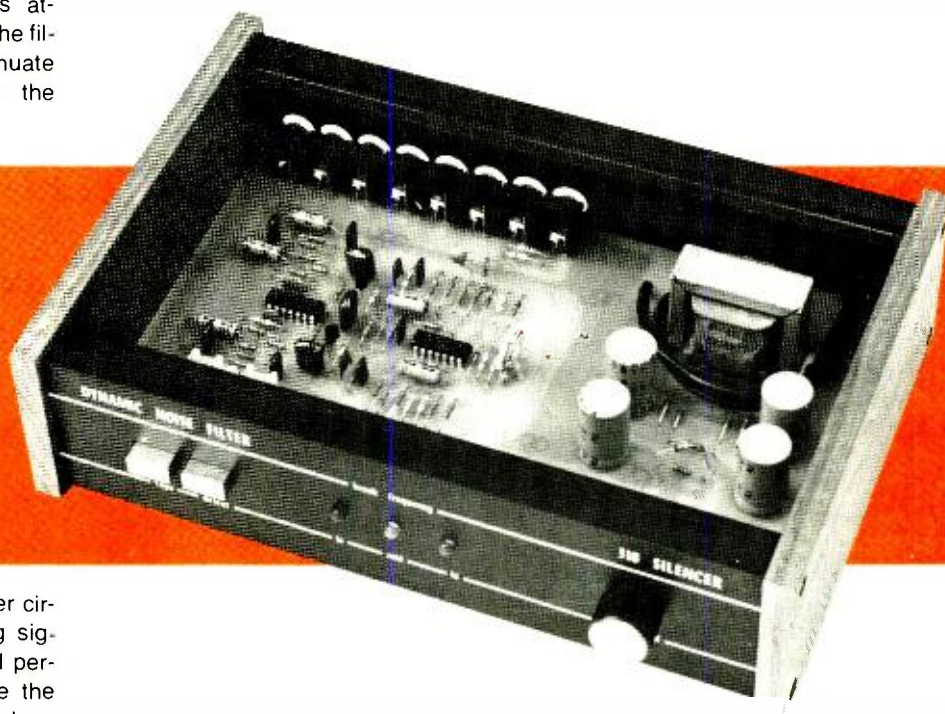
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THE "SILENCER" dynamic noise filter described here can eliminate tape hiss, record-surface noise, and atmospheric radio noise. Consequently, it is an ideal add-on device for stereo hi-fi systems. Moreover, it does not require encoding and decoding.

The device is essentially a voltage-controlled low-pass filter whose cutoff or break frequency is continually changing to accommodate program material and shut out any detracting noise. It only filters when noise and hiss are audible, when program material is at a low level or absent. The phenomenon of masking is utilized. That is, high-level signals mask noise that would be objectionable if program material level were low. When such masking occurs, the whole signal is passed. When there is no masking by program material, however, the filter extends the bandwidth only as far as required by the music. Beyond this, the high-frequency noise is attenuated. The frequency at which the filter begins rolling off to attenuate high-frequency noise is called the "break frequency."

Build a DYNAMIC AUDIO NOISE FILTER



About The Circuit. The silencer circuit constantly analyzes incoming signals for amplitude, frequency, and persistence. These factors determine the bandwidth at any instant, as well as how quickly the variable low-pass filter changes. Attack and release times vary with the music, thus eliminating a "pump and wheeze" effect of noise modulation.

The device has a continuously variable threshold control, with front-panel LEDs calibrated to indicate "Low," "Mid," and "High" break frequencies. The filter's break frequencies vary between 1.5 and 20 kHz with a roll-off slope of 9 dB/octave (maximum). The Silencer is a single-ended stereo device, making it ideal for use with tapes, records, and tuners for playback and record purposes.

The unit connects either in the auxili-

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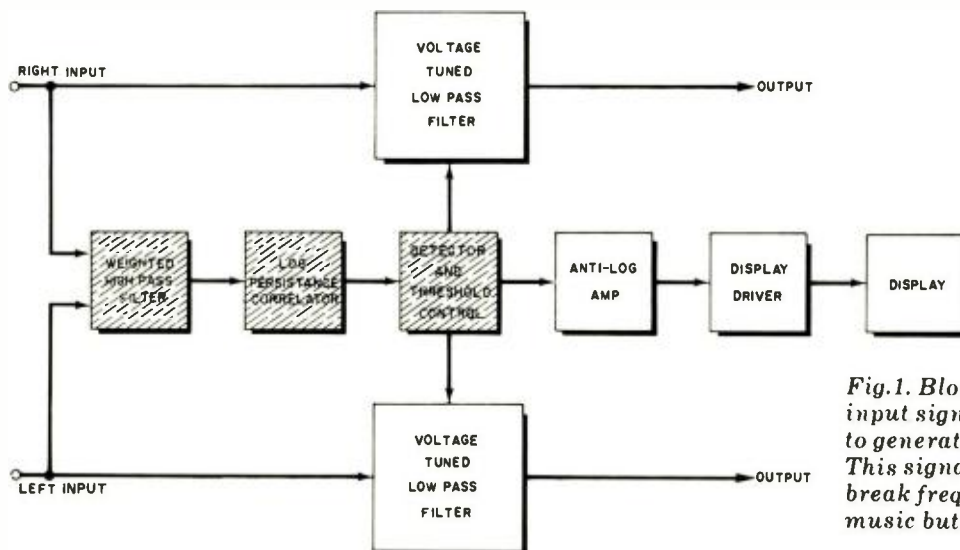


Fig. 1. Block diagram shows how input signals are processed to generate a control signal. This signal governs filter's break frequencies to pass music but attenuate noise.

ary mode or in the tape loop of your audio amplifier. On the back panel are IN and OUT jacks for the tape loop; the front panel also has a TAPE monitor button, and a system DEFEAT.

The block diagram of Fig. 1 shows the functions of the dynamic noise filter. The voltage-controlled low-pass filter is composed of IC1A and IC1B, as shown in the schematic of Fig. 2. (The components to the left of the dashed line make up one stereo channel; only one is shown in the schematic for clarity.) The gain of op amp IC1A is approximately $R3/R5$. At low frequencies, the capacitive reactance of capacitors C4 and C5 is very high, making the output of IC1B look like a low impedance source. The gain of IC1A is then:

$$A = R3/R5 = 10,000 \text{ ohms} / 1000 \text{ ohms} = 10$$

At higher frequencies, however, the impedance of C4 and C5 decreases; IC1B generates an output and bootstraps R5. This bootstrapping effect causes R5 to look larger. Therefore, gain A becomes smaller and the filter attenuates the high-frequency energy.

To vary the breakpoint of the filter, FET Q1 has the ability to shunt the signal at the non-inverting input of IC1B to ground. Figure 3A shows the filter with the FET open and the high frequencies attenuated, while 3B illustrates the filter's action with the FET shorting the signal to ground. The control signal applied at the gate of the FET allows the bandwidth of the low-pass filter to be self-adjusting for any frequency. This allows high-frequency signals and subtle harmonics of fundamental bass frequencies to be passed, while unmasked noise is attenuated.

The circuits represented by the shaded blocks of Fig. 1 are the dynamic analytical controls. They automatically judge the program material, adjust the bandwidth to accommodate it, and change the attack and release times to maximize the masking effect and minimize noise modulation. The control signal is applied to the gate of Q1. It's determined by the (1) spectral content, (2) amplitude, and (3) persistence of the incoming signal.

The spectral content is sensed by the high pass weighting filter, a network made up by R8, R29, R30, R31, C6, C17, and IC2A. This network is driven by the output of IC1B, which actually determines the quiescent operating point of the low-pass filter. Amplitude is determined by threshold control, R27, a 100K-ohm front-panel potentiometer. This pot sets the voltage divider for the positive input to IC2A, and the dc level for IC2A's output. The dc output level determines the quiescent operating point of the FET. The dynamic operation

of the FET is adjusted by the ac control signal, allowing it to follow the program material. The ac component of IC2A's output is determined by sensing the signal's amplitude on the output of IC1B.

The persistence log amp is formed by R33, D2, and C20. It checks the correlation coefficient of the signal, and adjusts the attack and release time of the low-pass filter to minimize any noise modulation problems. Variable attack and release times allow for the most effective masking of the noise.

The anti-log amplifier IC2B also senses the control voltage output of IC2A. This signal is then rectified and filtered by D4 and C21, and is then used to drive threshold comparators IC2C and IC2D. These amps drive the logic network of D5, D6, and D7, which drives the display. The 10K-ohm trimpot, R37, is used to calibrate the LEDs. The red LED indicates a break frequency of 1.5 kHz, the yellow, a break frequency between 1.5 and 10 kHz, and the green that the filter is opening up above 10 kHz.

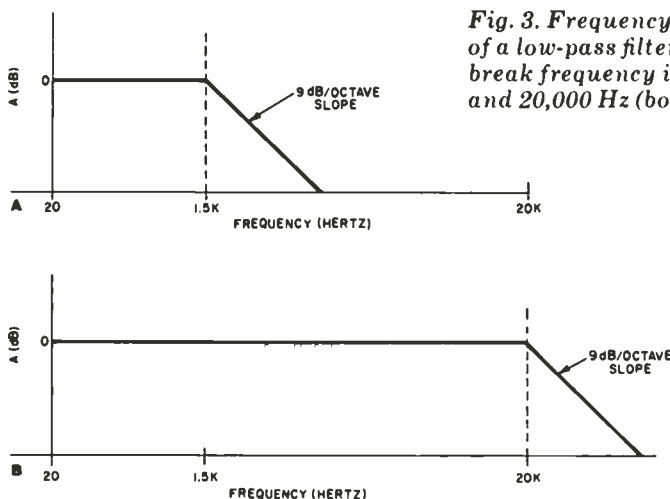


Fig. 3. Frequency response of a low-pass filter when its break frequency is 1500 Hz (top) and 20,000 Hz (bottom).

PARTS LIST

C1, C3, C9, C11, C21—1- μ F 50-volt axial-lead electrolytic capacitors

C2, C10—680-pF disk ceramic capacitors

The following are 100-volt Mylar capacitors:

C4, C5, C12, C13—.022- μ F

C6, C14, C17—.001- μ F

C7, C15, C20—.1- μ F

C8, C16—.01- μ F

C18, C22, C23, C24—1000- μ F 35-volt radial-lead electrolytic

D1—33-volt Zener diode

D2 through D7—IN914 signal diode

D8 through D11—IN4002 rectifier

F1— $\frac{1}{2}$ -ampere fuse

IC1, IC2— μ A4136 quad op amp (Fairchild)

J1-J8—RCA phono jacks

LED1—Red (Fairchild FLV 110 or equivalent)

LED2—Yellow (Fairchild FLV 410 or equivalent)

LED3—Green (Fairchild FLV 310 or equiv.)

Q1, Q2—Matched pair of 2N5458 JFETs.

The following are $\frac{1}{4}$ -watt, 5% tolerance resistors:

R1, R13, R26—47,000 ohms

R2, R14, R35, R43, R44—4700 ohms

R3, R15, R33, R38—10,000 ohms

R4, R16—100 ohms

R5, R17—1000 ohms

R6, R18—39,000 ohms

R7, R19, R45, R46—2200 ohms

R8, R20—15,000 ohms

R9, R21—11,000 ohms

R10, R22, R36, R39, R41—100,000 ohms

R11, R12, R23, R24, R34—1 megohm

R25—22,000 ohms

R28, R32—470,000 ohms

R30—680,000 ohms

R31—130,000 ohms

R40, R42—27,000 ohms

Other resistors and controls:

R27—100,000-ohm potentiometer with switch (CTS FR-GC-XM 450 or similar)

R37—10,000 ohm thumbwheel trimpot

R47, R48—10 ohms, $\frac{1}{2}$ watt, 5% tolerance resistor

S1, S2—DPDT switches

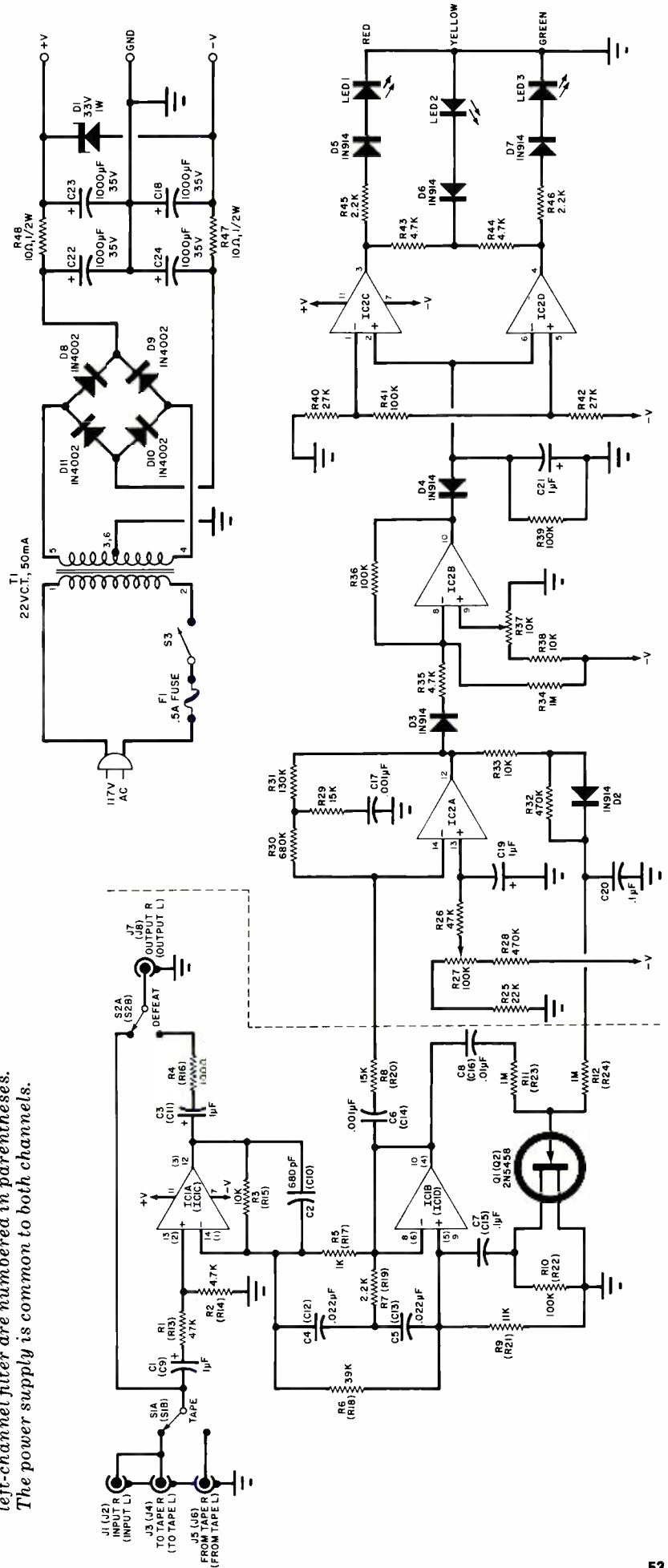
S3—110-V, 2-A switch (part of R27)

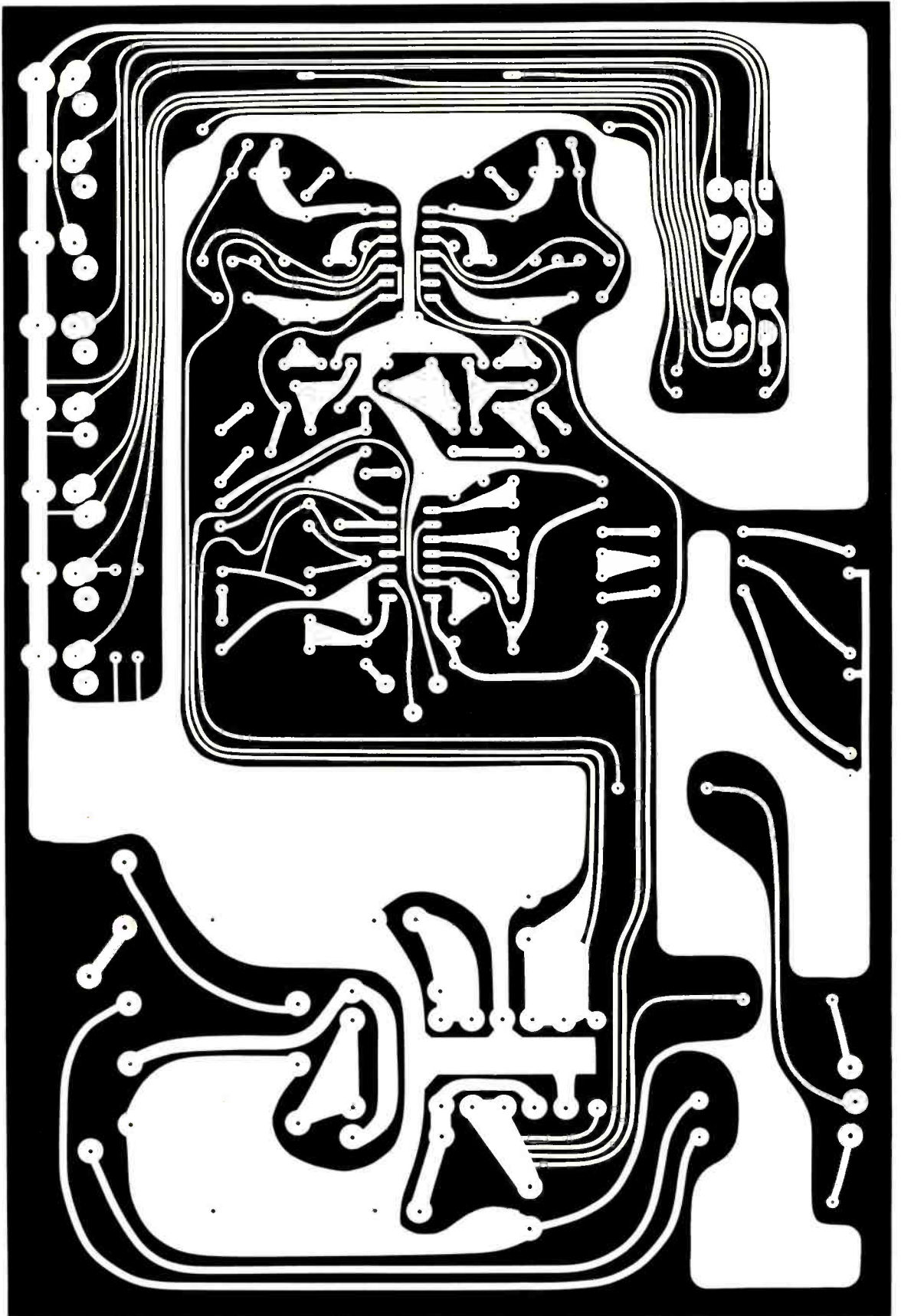
T1—22-volt center-tapped, 50-mA transformer

Misc—Ac line cord, knob for threshold pot, buttons for switches, suitable enclosure, hardware, hookup wire, solder, etc.

Note—The following items are available from Logical Systems, 3314 "H" St., Vancouver, WA 98663 (Tel. 206-694-7905): Complete 318 Silencer kit, including 6063 extruded aluminum chassis and hand-finished black walnut end pieces, \$129.00. Also available separately: Etched and drilled circuit board, \$15.00; individually tested and matched 2N5458 FETs, \$3.50. Washington state residents please add 5% sales tax.

Fig. 2. Schematic diagram. Components of the left-channel filter are numbered in parentheses. The power supply is common to both channels.





A

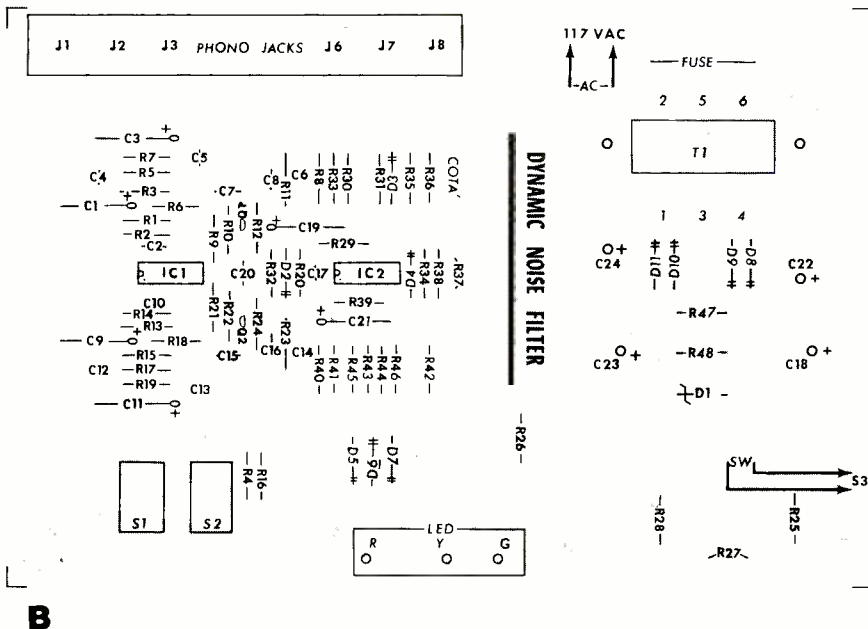


Fig. 4. Actual-size etching and drilling guide for the "Silencer." Board is shown at (A); parts placement at (B).

OPERATING SPECIFICATIONS—"SILENCER"

Hiss Reduction:	15 dB at 10,000 Hz
Max. Filter Slope:	9 dB/octave
Frequency Response:	20 to 20,000 Hz \pm 0.5 dB
Minimum Bandwidth: (Filter Closed)	1500 Hz
Dynamic Range:	Output noise greater than 100 dB below max. output, 20 to 20,000 Hz
S/N Ratio:	Better than 85 dB below 2 V ac output 20 to 20,000 Hz
THD:	Less than 0.1%, at rated output, 20 to 20,000 Hz.
IM Distortion:	Less than 0.01% at rated output 60/7000 Hz mixed 4:1; typically less than 0.005%
Rated Output:	2 V ac into 10,000 ohms
Max. Output:	10 V ac into 10,000 ohms
Input Impedance:	47,000 ohms, single ended
Output Impedance:	100 ohms
Power requirements:	110/120 V, ac 50/60 Hz, 8 W

Note: All measurements made with filter bandwidth open maximum except where specified. (This is the worst-case condition.)

Construction. This unit is most easily constructed using a printed-circuit board. Complete etching and drilling guides are shown in Fig. 4A, with the component guide shown in Fig. 4B. Proper orientation of parts is very important. Take careful note of how FETs *Q1* and *Q2* are mounted as well as op amps, diodes, and electrolytic capacitors. Also observe that the dynamic characteristics of the FETs must be matched. Moreover, when choosing op amps, it is important to make sure that the one chosen for the detection circuit, *IC2*, has an open-loop gain of at least 50 dB at 10 kHz. Op amps in the parts section were chosen for their excellent noise figures.

The unit is designed to fit into a custom aluminum extrusion, held by the eight screws in the wood ends. Any suitable enclosure will work, however. The circuit board itself measures 6" \times 9". The RCA phone jacks, front-panel switches, and threshold pot are circuit-board mounted for ease of construction and minimum noise. LEDs may be circuit-board mounted or attached to your front panel and then wired. If you choose not to use the furnished printed-circuit guides, make sure that the power supply is as far away as possible from the rest of the circuit to eliminate stray hum.

Calibration. Calibration should be done before you fully enclose the unit. To calibrate, connect the noise filter into your amplifier's or receiver's auxiliary or tape input. Find a low-level noise source—an erased magnetic tape would be ideal. If you don't have tape facilities you may use the inside groove of an LP record. Increase the amplifier's gain so you can hear the noise very well.

Start with the Silencer's threshold pot turned fully counter-clockwise and slowly turn the control knob clockwise. You will hear the noise change character and become more objectionable. Return to the position where the noise-content change just begins (listen several times so you will be able to identify this point). With the threshold knob in this position, adjust *R37*, the thumbwheel trimpot, so that the red LED lights. You should adjust the pot so that it is at the point where only a slight adjustment will cause the yellow LED to light.

In conclusion, this easy-to-build noise-reduction system will be a helpful and versatile addition to any stereo hi-fi system, cleaning up signals from any source. \diamond

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The MORSE- A-WORD

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PART TWO: Construction, Alignment, and Use

Construction. The Morse-A-Word is most easily assembled using printed circuit techniques. Three pc boards are required—a main circuit board, display board, and a power supply board. The parts placement guide for the main circuit board appears in Fig. 5. Etching and drilling guides are shown in Fig. 6. Similarly, etching and drilling guides for the double-sided display board are shown in Fig. 7. This board's parts placement guide appears in Fig. 8. Finally, the etching and drilling and parts placement guides for the power supply board appear in Figs. 9 and 10.

When soldering components to circuit board foils, use a low-wattage, fine-tipped soldering pencil and fine solder. Be sure to employ the minimum amount of heat and solder consistent with good connections, and take care not to inadvertently create solder bridges between adjacent foils. The use of IC sockets or Molex Soldercons is recommended.

Assemble the main pc board first.

Start by inserting and soldering the IC sockets and Molex Soldercons. Install the smallest components next, gradually working up to the larger items. For example, start with the 1/4-watt resistors, then install the diodes, the small capacitors and finally the larger capacitors. Be sure to observe the polarities of diodes and tantalum and electrolytic capacitors, and the pin basing of transistors and ICs. The board furnished by the kit supplier has plated-through holes so you need only solder component leads on the bottom side of the board.

Neither the power supply, the display circuits, the sidetone speaker, jacks, CODE and DAH LEDs or the SPEED control are mounted on the main pc board. Insulated wire leads of suitable lengths should be soldered to appropriate points on the pc board now for connection to these components.

Wire the display board next, referring to the parts placement diagram of Fig. 8. Use Molex Soldercons to mount the dual

IEE 1785R LED displays. Make sure the Soldercons are properly aligned before soldering them to the board. This will ensure a good fit for the displays. Resistors, capacitors and IC sockets or Soldercons for the driver ICs should be installed and soldered next. The resistors should be mounted in a vertical position. Notice that there are a number of jumper wires to be soldered to this board. These are used to interconnect the display board and the main circuit board and to support the display board. The jumpers should be made of heavy solid wire, about 1/2" (1.3 cm) long, and bent into "L" shapes so they extend parallel to the board and point downward.

Position the display board perpendicular to the main pc board. Insert the jumper wires connected to the display board through the appropriate holes on the main pc board and push down the display board until it just touches the main board. Check the alignment of the display board and then solder the jump-

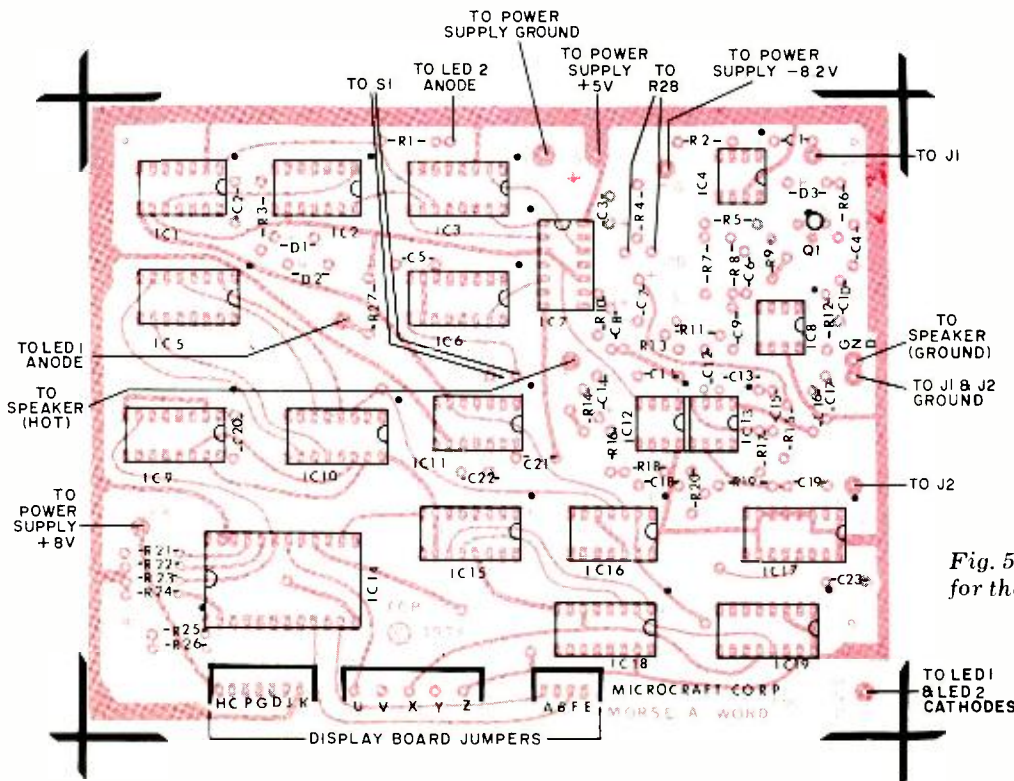


Fig. 5. Parts placement guide for the main circuit board.

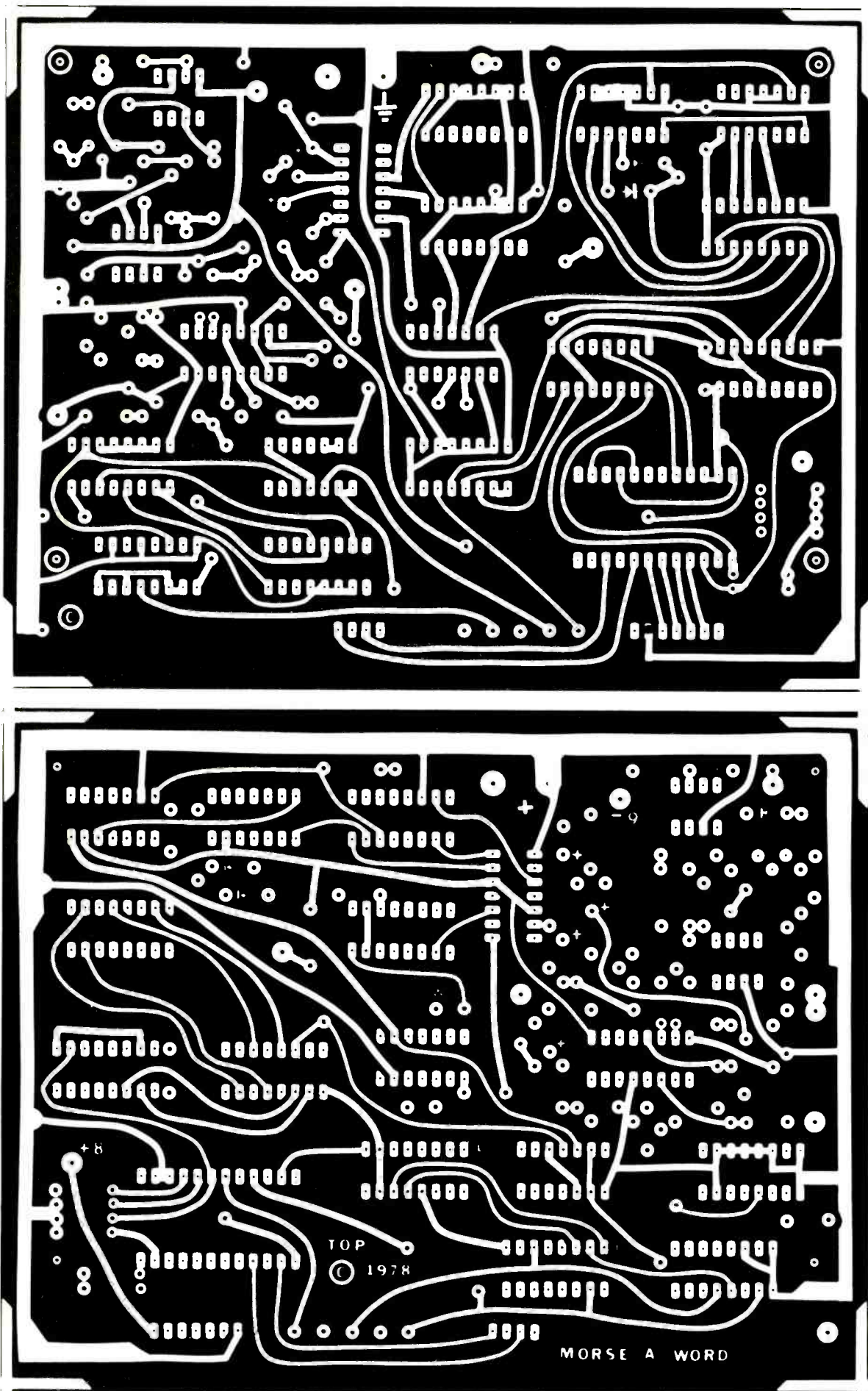


Fig. 6. Actual-size etching and drilling guides for the double-sided main printed circuit board.

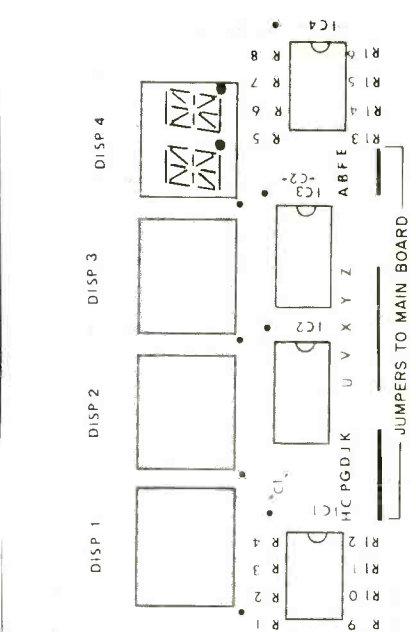
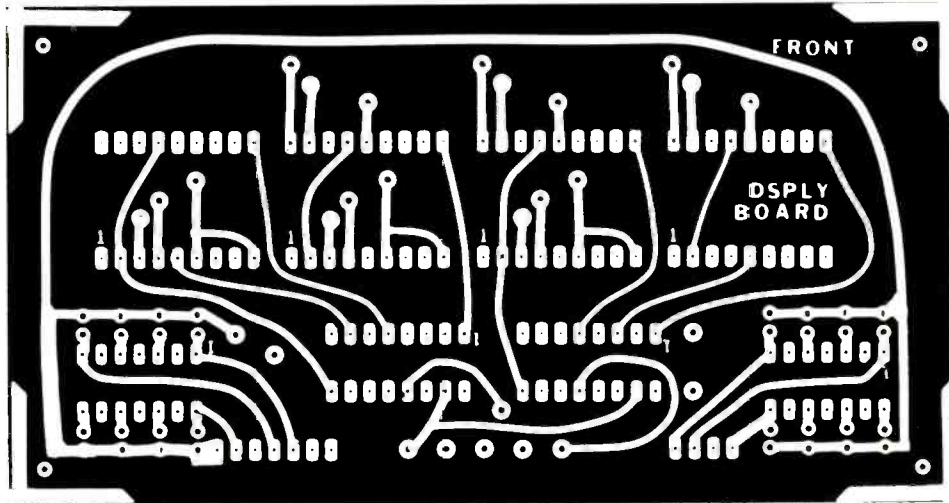
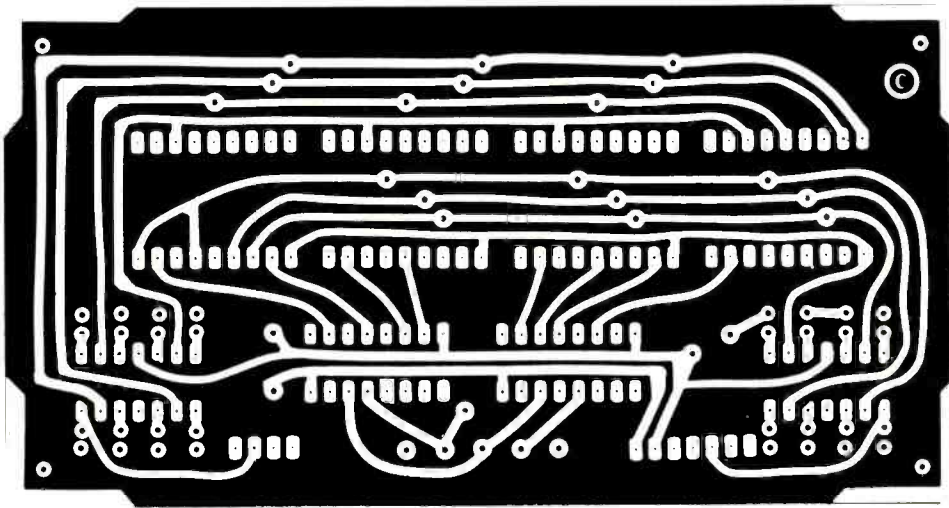


Fig. 8. Parts placement guide for front side of display board is above.

Fig. 7. Actual-size etching and drilling guides for the double-sided display board are at left.

ers to the foils on the bottom of the main pc board. Cut off excess jumper lengths.

For proper Morse decoding, the 1702A ROM must be programmed in accord with Table I. A construction article that appeared in the February 1978 issue of this magazine described a project that allows you to program your own blank ROMs. Some parts distributors will program the 1702A for you if the truth table accompanies your order. The

kit supplier for the Morse-A-Word also offers a preprogrammed ROM.

Install the ICs and the dual-character IEE 1784R LED displays in their Soldercons. Make sure they are correctly oriented and take the usual precautions to avoid bending the leads or damaging the MOS ROM. It is not necessary to have a full eight-character display. Those builders with a tight budget, for example, can install only one dual-

character IEE 1785R LED readout. However, a minimum of two readouts (four characters) is recommended. If fewer than four readouts are used, make sure they are right-justified (installed at the DIS4, DIS4 and DIS3, etc.)

The remaining pc board, that for the power supply, should now be assembled. You will note that the board has space for extra components to be used in another project. These components

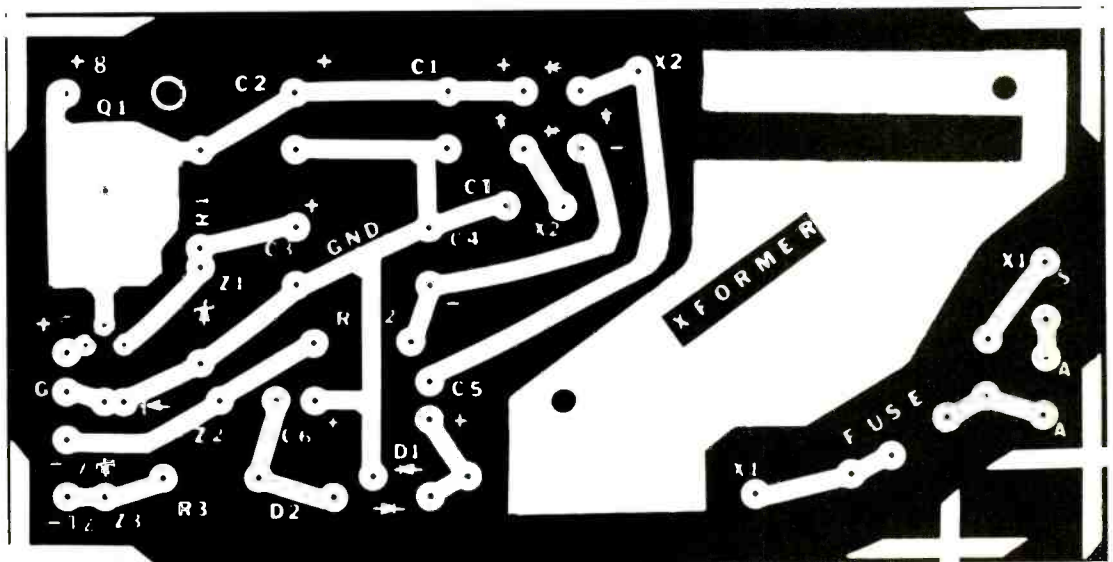
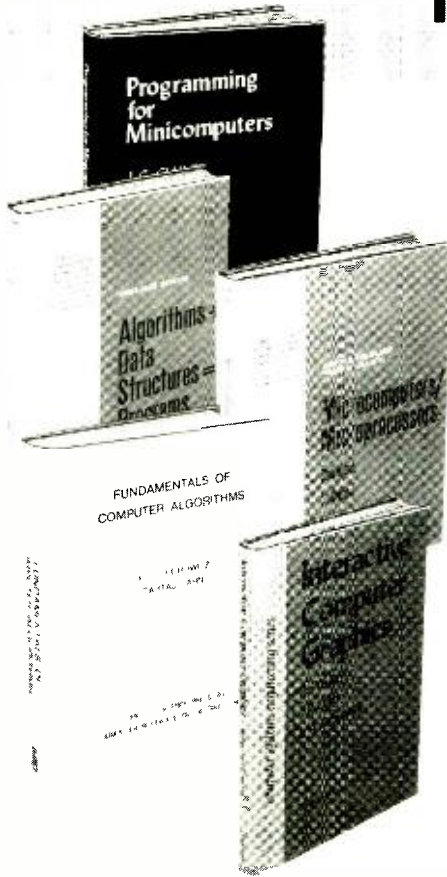


Fig. 9. Actual-size etching and drilling guide for the power supply board.



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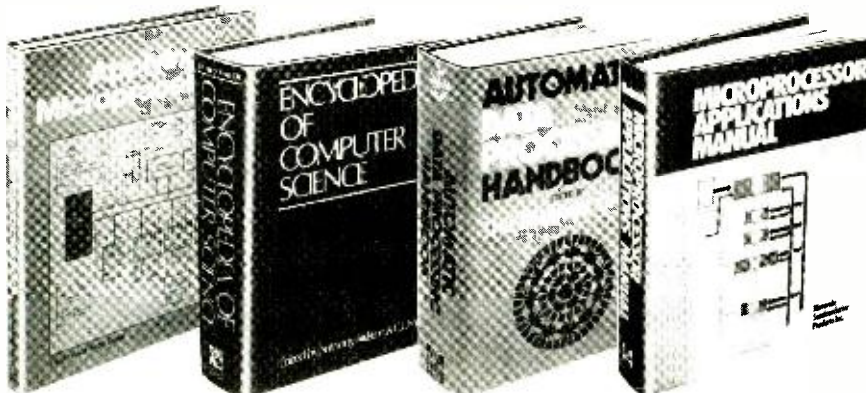
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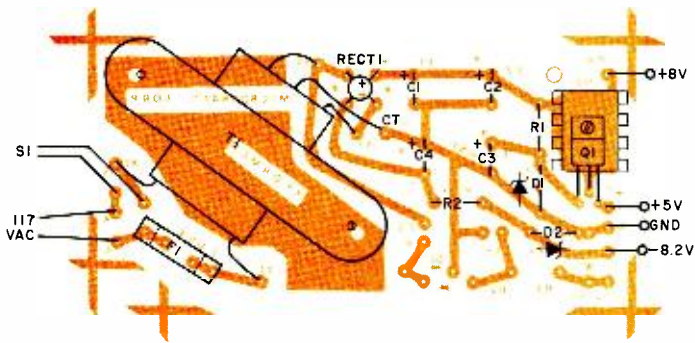


Fig. 10. Component placement for the power supply board shown above.

are not required in the Morse-A-Word and the pc locations for them should be ignored. When you have completed assembly of the board, apply line power to it and verify that the desired voltages are being produced. If the voltages are correct, remove line power and interconnect the supply and main pc boards with suitable lengths of color-coded hookup wire. Then mount the boards in the project enclosure and connect the free ends of the hookup wires already soldered to the main pc board to speaker, jacks, etc. A cutout for the displays must be made on the front panel of the enclosure. This can best be done with a nibbling tool. For those who prefer a prepunched enclosure, one is available from the kit supplier. Display contrast and project appearance will be enhanced by installing a bezel and red filter in the cutout.

Apply power to the project. Several or all of the dual-character displays should start to glow. If they don't, disconnect power and go back and thoroughly check for loose wires, cold solder joints, solder bridges, or incorrect wiring.

Alignment. The center frequency of the bandpass filter and the tone decoder's peak response frequency must be the same if the Morse-A-Word is to function properly. Any frequency between 800 and 2600 Hz is suitable, but the higher frequencies will produce a better circuit response. On the other hand, the higher frequencies tend to be more difficult to tune on a highly selective communications receiver. As a compromise, 1200 Hz was selected as the center frequency of the band-pass filter and the tone decoder.

To align the project, apply a 0.5-volt rms, 1200-Hz signal to the receiver input jack. Connect an ac voltmeter or oscilloscope to the output of the bandpass filter (TP1) and adjust trimmer potentiometer R9 for maximum output. Next, adjust

R20 until a tone is heard in the speaker and the code LED lights. Reduce the input signal to as low a level as possible and repeat the procedure. If a 1200-Hz signal is not available and you have a cassette tape recorder, a cassette tape available from the kit supplier has the necessary tone recorded on it. The tape also includes recordings of sample Morse code messages and selections which can be used for code practice.

The only other adjustment is the setting of trimmer potentiometer R14, which determines the loudness of the speaker output. A low volume setting is

TABLE I
TRUTH TABLE FOR 1702A PROM IC14

Character	Input								Output							
	A7	A6	A5	A4	A3	A2	A1	A0	D8	D7	D6	D5	D4	D3	D2	D1
A	0	1	1	0	1	0	1	1	1	1	0	0	1	0	0	1
B	0	0	1	0	1	0	1	1	0	1	0	0	1	0	0	0
C	0	1	1	1	1	1	0	0	1	1	0	0	0	0	0	1
D	0	0	1	1	0	1	0	0	1	0	0	0	0	0	0	0
E	0	0	1	1	1	0	0	1	1	1	1	0	1	0	0	1
F	0	1	1	1	0	1	1	1	1	1	0	0	0	0	0	0
G	0	1	1	1	0	0	0	1	1	1	0	0	0	0	0	1
H	0	0	1	1	0	0	0	1	1	0	0	0	1	0	0	1
I	0	1	1	1	1	1	1	0	0	1	0	0	1	0	0	0
J	0	0	1	1	1	0	1	1	1	1	0	0	1	0	0	0
K	0	1	1	0	0	0	1	0	0	0	0	0	0	0	0	1
L	0	0	1	0	1	0	0	1	0	1	0	0	1	0	0	1
M	0	1	1	1	1	0	1	0	1	0	0	0	0	0	0	0
N	0	0	1	1	0	0	1	1	0	1	1	0	0	0	0	1
O	0	1	1	1	0	0	1	1	0	1	0	0	0	1	0	1
P	0	0	1	0	0	0	0	1	1	1	0	0	0	0	0	1
Q	0	1	1	1	0	0	1	0	1	1	0	0	1	0	0	0
R	0	0	1	0	1	0	0	0	1	1	0	0	0	0	0	1
S	0	1	1	1	1	1	0	1	1	1	0	1	0	0	0	1
T	0	0	1	1	1	0	1	1	1	1	0	0	0	1	0	0
U	0	1	1	0	0	1	1	1	0	0	0	1	0	0	0	0
	0	0	1	0	1	1	0	1	0	1	0	0	0	0	0	1
	0	0	1	0	1	1	0	1	1	1	0	0	0	0	0	1

recommended to avoid confusion when listening to both the receiver and the Morse-A-Word simultaneously.

Use. The Morse-A-Word is easy to operate. The setting of the front-panel SPEED control (R28) is the only adjustment that must be made, and only a rough setting is required. Keep in mind that the Morse-A-Word has a sensitive input stage, so don't set the receiver audio gain control higher than is necessary. When the receiver is tuned to the center of the filter passband (1200 Hz), you should hear audio from the project's

internal speaker and the code LED should flicker in time with the incoming code. The passband is only about 120 Hz wide, so some care is required when tuning in a signal.

With the signal properly tuned in, adjust the SPEED control so the DAH LED glows only when dahs are sent, and not dits. The alphanumeric readout LED will now display the incoming characters. If word spaces are desired, make sure the WORD SPACE switch is closed. Only a few amateur stations actually send word spaces, so don't expect perfectly spaced copy unless you are tuned to a

V	0	1	1	0	1	1	1	0	0	1	0	0	0	1	0	1
	0	0	1	0	1	1	1	0	0	0	1	0	0	0	0	0
W	0	1	1	0	0	1	0	1	0	1	0	0	0	1	0	1
	0	0	1	0	0	1	0	1	0	1	0	0	0	1	0	1
X	0	1	1	0	1	1	0	0	0	0	1	0	0	1	0	0
	0	0	1	0	1	1	0	0	0	0	1	0	0	1	0	0
Y	0	1	1	0	0	1	0	0	0	0	1	0	0	0	0	0
	0	0	1	0	0	1	0	0	0	0	1	1	0	0	0	0
Z	0	1	1	1	1	0	0	0	1	0	0	0	0	1	0	0
	0	0	1	1	1	0	0	0	1	0	1	0	0	0	0	0
0	0	1	0	0	0	0	0	0	1	1	0	0	0	1	0	1
	0	0	0	0	0	0	0	0	1	1	1	0	0	0	0	1
1	0	1	0	0	0	0	0	1	0	0	0	1	0	0	0	0
	0	0	0	0	0	0	0	1	0	0	0	1	0	0	0	0
2	0	1	0	0	0	0	1	1	1	0	0	0	1	0	0	1
	0	0	0	0	0	0	1	1	1	1	0	0	1	0	0	0
3	0	1	0	0	0	1	1	1	1	0	0	0	1	0	0	0
	0	0	0	0	0	1	1	1	1	1	0	0	1	0	0	1
4	0	1	0	0	1	1	1	1	0	1	0	0	1	0	0	0
	0	0	0	0	1	1	1	1	0	1	0	0	1	0	0	1
5	0	1	0	1	1	1	1	1	1	1	0	0	1	0	0	0
	0	0	0	1	1	1	1	1	1	0	0	0	1	0	0	1
6	0	1	0	1	1	1	1	0	1	1	0	0	1	0	0	1
	0	0	0	1	1	1	1	0	1	0	0	0	1	0	0	1
7	0	1	0	1	1	1	0	0	1	0	0	0	0	0	0	0
	0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	1
8	0	1	0	1	1	0	0	0	1	1	0	0	1	0	0	1
	0	0	0	1	1	0	0	0	1	1	0	0	1	0	0	1
9	0	1	0	1	0	0	0	0	1	1	0	0	1	0	0	0
	0	0	0	1	0	0	0	0	0	1	0	0	1	0	0	1
.	0	1	0	0	1	0	1	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	0	1	0	0	0	0	0	0	0	1	0
.	0	1	0	0	0	1	1	0	0	0	0	0	0	1	0	0
	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0
?	0	1	0	1	1	0	0	1	1	0	0	0	0	0	0	0
	0	0	0	1	1	0	0	1	0	1	0	1	1	0	0	0
/	0	1	0	1	0	1	1	0	0	0	0	0	0	1	0	0
	0	0	0	1	0	1	1	0	0	0	1	0	0	0	0	0
-	0	1	0	0	1	1	1	0	0	0	0	0	1	0	0	0
	0	0	0	0	1	1	1	0	0	0	0	0	1	0	0	0
Space	0	1	1	0	1	1	1	1	0	0	0	0	0	0	0	0
	0	0	1	0	1	1	1	1	0	0	0	0	0	0	0	0
AR	0	1	0	1	0	1	0	1	1	1	0	1	1	0	0	1
	0	0	0	1	0	1	0	1	0	1	0	1	1	1	0	0
SK	0	1	0	0	1	0	1	1	1	1	0	1	1	0	0	0
	0	0	0	0	1	0	1	1	1	0	1	1	0	1	0	0
KN	0	1	0	1	0	0	1	0	0	1	0	0	1	0	0	1
	0	0	0	1	0	0	1	0	0	0	1	1	0	1	0	1
AS	0	1	0	1	1	1	0	1	1	0	1	1	0	1	0	0
	0	0	0	1	1	1	0	1	1	0	1	1	0	1	0	0



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**TABLE II
SOME COMMERCIAL
CW STATIONS
Frequency**

Station	(MHz)	Traffic
NSS	8.090	Weather Bulletins
WSL	8.516	Commercial Press
WAX	8.527	Messages
WCC	8.587	Messages
WCC	8.590	Messages
NBA	8.617	Telegrams
NAM	12.134	Weather Bulletins
NMN	12.720	High Speed CW
NAWS	12.725	Weather Bulletins
WCC	12.926	Messages
WSL	13.026	Messages
NAWS	15.921	Messages
WCC	16.935	Messages

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station such as W1AW which sends machine-perfect code. Invalid Morse characters will be displayed as blanks.

For code practice sessions, connect your telegraph key to the KEY jack and adjust the SPEED control for the approximate sending speed. You can calibrate your SPEED control using the formula: Speed (WPM) = 0.15f. That is, the code speed in words per minute equals fifteen hundredths of the clock frequency as set by the SPEED control.

An excellent source of code material is amateur station W1AW, operated by the American Radio Relay League. The station transmits several code practice sessions each day, as well as ham news bulletins, propagation forecasts and OSCAR bulletins, all in Morse code, on 3.58, 7.08, 14.08, 21.08 and 28.08 MHz, as well as vhf frequencies. For a complete W1AW operating schedule, send an SASE to ARRL, 225 Main St., Newington, CT 06111.

Commercial CW stations that transmit ship-maritime, press, and weather messages are also valuable sources of code practice. Table II is a list of eight shortwave stations that you'll want to tune in if you have a general-coverage receiver. Whether you plan to confine your listening to the ham bands or branch out into the other shortwave frequencies, remember that a good antenna and a sensitive, stable communications receiver play key roles in good CW reception.

One final note—international radio regulations prohibit the disclosure to others of any information gleaned from press or commercial transmissions. Accordingly, it is illegal to pass information so obtained (except that learned from amateur radio or broadcast transmissions) to a third party. ◇

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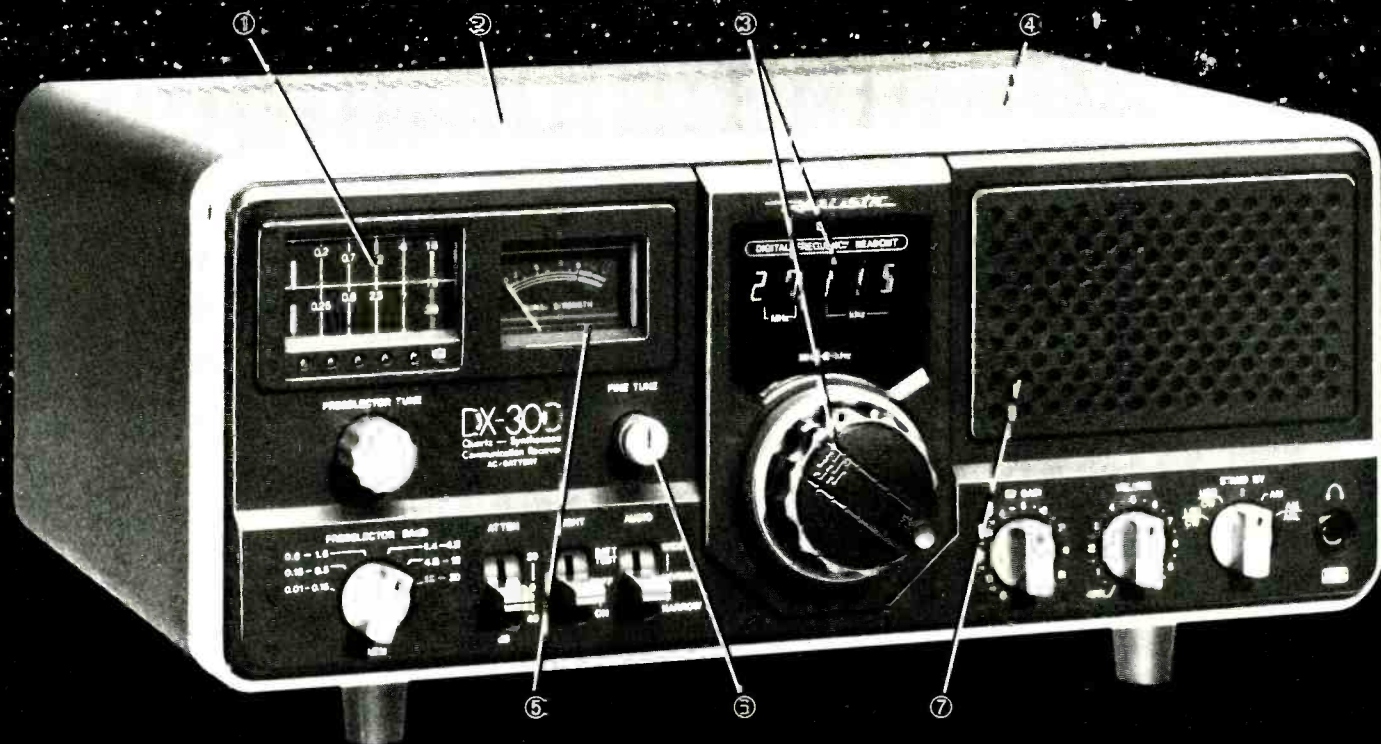
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Make & Model	Price ¹ (\$)	Power required (mA) ²			RAM capacity		Expansion kit size and price	Speed (ns)	Type	Min. addr. block size	Features ³				Remarks
		+8V	+15V	-15V	min.	max.					BS	BB	WS	WP	
S 100															
Advanced Computer															
Prods.															
LOGOS 1	126 (k) 150 (w)				8K	8K	none	450				X	X		Hardware protect in 256-byte to 8K increments, switchable from top of board.
LOGOS 1Z	150 (k) 200 (w)				8K	8K	none	250				X	X		
Base 2															
8KS-B	125 (k) 150 (w)	X			8K	8K	none	500	stat.	4K	X	X	X		
8KS-Z	145 (k) 170 (k)	X			8K	8K	none	250	stat.	4K	X	X	X		250-ns version.
16S-B	285 (k) 310 (w)	X			16K	16K	none	500	stat.	4K	X	X	X		
16KS-Z	325 (k) 350 (w)	X			16K	16K	none	250	stat.	4K	X	X	X		250-ns version.
Central Data															
16K RAM	289 (w)	300	150	20	16K	32K	16K/\$200	450	dyn.	16K					
32K RAM	475 (w)	00	150	20	32K	32K	none	450	dyn.	16K					
CGRS Microtech															
16K RAM	450 (k) 490 (w)				16K	16K	none		stat.						
Chrislin															
CI-S100	390				16K	64K	none	300	dyn.						
	650				32K			300	dyn.						
	825				48K			300	dyn.						
	995				64K	64K	none	300	dyn.						
Computerware, Inc.															
8K Static	146 (w) 186 (w) 350 (w)				8K	8K	none	450	stat.				X		Phantom disable. Phantom disable.
Cromemco															
4KZ	195 (k) 295 (w)	800			4K	4K	none	450	stat.		X		X		Wait states only @ 4 MHz on non-sequential address.
16KZ	495 (k) 795 (w)	800	599	19	16K	16K	none	200	stat.		X				
Digital Micro Systems															
DM16K (w 8K)	35 (b) 275 (k)	2A			8K	16K	8K	350	stat.	4K	X			X	Alpha-Micro DMA compatible; also available as kit less RAM, \$95.
DM16K	35 (B) 465 (k) 495 (w)	2A			16K	16K	none	350	stat.	4K	X			X	
Dynabyte															
MD161	399 (w)	8A		.5A	16K	16K	none	450	dyn.	8K					Transparent refresh DMA compatible.
MS1645	525 (w)	1.6A			16K	16K	none	300	stat.	4K	X				
MS1625	555 (w)	1.8A			16K	16K	none	250	stat.	4K	X				
MS3245	925 (w)	3.1A			32K	32K	none	300	stat.	4K	X				
MS3225	995 (w)	3.8A			32K	32K	none	250	stat.	4K	X				
Electricom															
4020	287 (w)				2K	2Kx9	\$10	250					X		On-board battery, charger and power-state monitor; wire-wrap ribbon-cable or S-100 connection.

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Later we are going to offer you a valuable bribe, if you will test these cassettes, risk free; so read on!

YOUR TIME IS PRECIOUS

Imagine yourself just finishing recording the second side of a 90 minute cassette and horrors, the cassette jams. Tape is wound around the capstan, your recorder may be damaged and you've just wasted 90 minutes of your time and perhaps lost a great recording off FM.

I'm sure this is one experience we all dread, and is one of the main reasons to buy name branded guaranteed tape you can trust.

Enter DAK. We manufacture over one million units of cassette tape each month, and many of our cassettes are used for high speed duplication, which causes more cassettes to fail than any other use.

When we first started, DAK's cassettes failed, just like many others. So we installed over \$20,000 worth of high speed duplication equipment at our factory and set out to design the perfect cassette.

FAILURE

Failure after failure. We substituted, remade, tested and retested the over 20 parts of our cassette, and checked everyone else's cassettes. Finally after over 6 years we positively linked cassette failure or the prevention of failure to the slip sheets, or liners in the cassette.

We were not alone. Scotch, TDK, and several others must have been doing the same research because they have also been coming out with special improved slip sheets.

MOLYSULFIDE

A new chemical named molysulfide, that reduces friction within the cassette several times better than graphite gave us success.

We developed polyester slip sheets with raised spring loaded ridges coated with a unique formulation of molysulfide and graphite.

The tape ran more smoothly than ever before within the cassette. The new formulation is also much tougher than the graphite formulation, so it is extremely resistant to wear.

Static electricity within the cassette was drastically reduced by the low friction, and easily bled off, so its tendency to erase very high frequencies was drastically reduced. A very important consideration for often played tapes.

The molysulfide formulation gives both superior electrical and mechanical performance, thus it has formed the

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No apology We feel that we have equalled or exceeded the mechanical reliability of virtually all cassettes and offer one of the best frequency responses in the industry. Maxell UDXL is truly the Rolls Royce of the industry, and DAK is the 100% US made Cadillac or Corvette!

Price DAK manufactures the tape we sell, you avoid paying distributor and retailer mark ups. While Maxell UDXL 90s may sell for \$3.50 to \$4.50 each, DAK ML90s sell factory direct to you for only \$2.19 each.

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Make & Model	Price ¹ (\$)	Power required ¹ (mA) ²			RAM capacity		Expansion kit size and price	Speed ³ (ns)	Type	Min. addr. block size	Features ²				Remarks
		+8V	+16V	-16V	min.	max.					BS	BB	WS	WP	
Electronic Control Technology															
16K RAM	350 (k) 399 (w)	1.5A			16K	16K	none	450	stat.	16K		X			Spare IC spaces for user circuit.
16K RAM 4MHz	415 (k) 475 (w)				16K	16K	none	250	stat.	16K		X			Spare IC spaces for user circuits.
Electronic Systems															
300	23 (b) 160 (k) 200 (w)				1K			250	stat.				X		Bare-board version includes regulator.
Fire Bird Sales															
16KRB	323 (w)				16K	16K	none	260	dyn.	16K		X			
Franklin Electric															
8KSr	249 (k) 295 (W)	1.2A			8K	8K	none	400	stat.	2K	X	X		X	LED indicators for power OK, board select, write-protect; DIP addr. SW.
8KSh	289 (k) 330 (w)	1.7A			8K	8K	none	250	stat.	2K	X	X		X	
Godbout															
Econoram II	135 (k) 155 (W)	1.5A			8K	8K	none		stat.	4K			X	X	Software write protect w. vector.
Econoram IV	279 (k) 314 (w)	2A			16K	16K	none		stat.	16K				X	Write-protect for 4K blocks.
Econoram V	279 (k) 314 (w)	2A			16K	16K	none		stat.	16K				X	Manual high-8K/low-8K deselect.
Econoram VII	445 (k) 485 (w)	2A			24K	24K	none		stat.	2, 4K, 2, 8K	X			X	Can deselect either 4K/8K pair.
GRE Data Products															
232 8	179 (w)	1.2			8K			400	stat.	8K					Provisions for MWRT and Phantom disable.
232-16	319 (w)				16K			400	stat.	16K	X				
IMSAI															
RAM 4A-4	139 (k) 189 (w)	800			4K	4K	none	500	stat.	4K			X		
RAM 16	449 (k) 499 (w)	500	150	10	16K	16K	none	500	dyn.	4K*	X				*4K block missing with memory-map option.
RAM III-32	895 (w)	360	250	10	32K	32K	none	500	dyn.	4K*	X				As above.
RAM III-64	1695 (w)	360	250	10	64K	64K	none	500	dyn.	4K*	X				As above.
Industrial															
Micro sysys.															
C00232	135				8K	8K		low	stat.						
C00232-HS	150				8K	8K		hi	stat.						
C00282	304				16K	16K		low	stat.						
C00282 HS	343				16K	16K		hi	stat.						
C00360	625				32K	32K		low	stat.						
C00360-HS	689				32K	32K		hi	stat.						
Ithaca Audio															
8KSR	25 (b) 160 (w) 199 (w)	1.4A 1.4A 1.4A			1K	8K			stat. stat. 250	4K 4K 4K	X X X	X X X	X X X	X X X	Software protect/unprotect.
16KDR	35 (b)	1.4A			16K	64K			dyn.						
Jade Computer															
JG8K	25 (b) 126 (k) 150 (w) 140 (k) 160 (w) 170 (k) 190 (w)	2.5A 2.5A			8K			450 350 250	stat. stat. stat.	8K 8K 8K	X X X		X X X		Adapter (\$13) available for use with Motorola D-2 6800 Eval. Kit.
Micro Data Systems															
MD-697 (8K)	179 (k) 199 (w)	1.5A			8K	32K	8K/\$129	450	stat.	16K	X				250-ns option avail.
MD-697 (16K)	308 (k) 348 (w)	1.5A			16K	32K	8K/\$129	450	stat.	16K	X				250-ns optional.
MD-697 (24K)	437 (k) 497 (w)	1.5A			24K	32K	8K/\$129	450	stat.	16K	X				250-ns optional.



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I/O BOARD BUYING DIRECTORY *continued*

Make & Model	Price ¹ (\$)	Power required (mA) ²			RAM capacity		Expansion kit size and price	Speed (ns)	Type	Min. addr. block size	Features ³				Remarks
		+5V	+15V	-15V	min.	max.					BS	BB	WS	WP	
MD-697 (32K)	538 (k) 588 (w)	1.5A			32K	32K	none	450	stat.	16K	X				250-ns optional.
National Multiplex 8K	190 (w)				8K	8K			stat.						
North Star RAM-16	398 (k) 459 (w)	600	400	100	16K	16K	none	250	dyn.	8K					Parity option, \$39 (k), \$59 (w).
Noval 32K RAM	650				32K	32K		2MHz	dyn.	8K					Hardware disable for any 8K block.
Pacific Digital 8KRS (450) 8KRS (250)	150 (w) 190 (w)	2A 2A			8K 8K	8K 8K	none none	450 250	stat. stat.	4K 4K		X X			
Parasitic EconRam II	188 (w)	350	155		8K	8K	none	250	dyn.	4K					"Invisible refresh".
Piceon SuperRam 2	1150 (w)	X	X	X	48K	64K	16K/\$220	2-MHz	dyn.	16K	X				DMA-compatible; uses digital delay lines; software or hardware bank select.
Polymorphic 8K RAM	300 (k)	2.6*						500ns				X			*Standby power, 1.5A @ 2.2V, phantom disable.
Processor Tech. 4KRA 8KRA 16KRA 32KRA	125 (k) 150 (w) 225 (k) 250 (w) 429 (w) 750 (w)	1A 1.9A 800 800			4K 8K 16K 32K	4K 8K 32K 32K	none none none none	460 400 400	stat. stat. dyn. dyn.	4K 4K 4K					
Quay Q80 SMB	235 (w)				8K	8K	none	450	stat.			X	X		Memory protect in 4K blocks.
Seattle Computer 24-101 SCP-16K	375 (w) 425 (w) 425 (w) 475 (w)	1.8A 1.8A 1.4A 1.9A			16K 16K 16K 16K	16K 16K 16K 16K	none none none none	494 294 471 271	stat. stat. stat. stat.	4K 4K 4K 4K			X X		Parallel addressing capability.
Solid State Music MB4 MB 6A MB 7 MR-9 PROM/RAM 80 (k)	91 (k) 165 (k) 175 (k) 449 (k)	1.1A 2.0A 2.0A 550			4K 8K 8K 16K	4K 8K 8K 16K	none none none none	2 MHz 2 MHz 4 MHz 2-3 MHz	stat. stat. stat. stat.	4K 8K 8K 16K		X X X	X X X		Memory protect in 4K blocks. Memory protect to 256- byte blocks; phantom provisions. 4K memory protect, phantom provision. Can intermix RAM and PROM in 256-byte increments; jump on reset or on power-up.
Space Byte 16K	599 (w)	1.6A			16K	16K	--	450/ 250	stat.	4K	X		X		Phantom disable and write protect for each 4K; DMA-compatible.
Thinker Toys EconoRam III SuperRam	159 (k) 149 (w) 299 (k) 334 (w)	240 80 20 2A			8K 8K 6K	8K 8K	none none	471 450	dyn. stat.	4K 4K			X		With Synchrofresh.

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Make & Model	Price ¹ (\$)	Power required (mA) ²			RAM capacity		Expansion kit size and price	Speed (ns)	Type	Min. addr. block size	Features ³				Remarks
		+8V	+16V	-16V	min.	max.					BS	BB	WS	WP	
Trace Electronics															
1600	499 (w)	1.7A			4K	32K	16K/S256	450	stat.		X				DMA-compatible; phantom provision; "Megex tend" can ad- dress to 1M bytes with 4-bit output port.
	599 (w)	1.7A			4K	32K	16K/S356	250	stat.		X				
3200	749 (w)	3.3A			32K	32K	none	450	stat.		X				
	849 (w)	3.3A			32K	32K	none	250	stat.		X				
Vector Graphic															
8Kf	245 (w)	1.8A			8K	8K	none	250	stat.	8K		X		X	Phantom disable, Phantom disable.
16K	485 (w)	1.8A			16K	16K	none	300	stat.	X					
Wameco															
MEM-1	30 (b)				1K	8K		450	stat.	8K			X		
	250 (k)														
	295 (w)														
MEM-2	30 (b)				4K	16K		450	stat.	8K	X		X		
	665 (k)														
	695 (w)														
Xitan															
Z 1h	489 (w)	205	105		16K				stat.	4K	X			X	Write protects each 4K.
D-16	489 (w)				16K				dyn.	4K	X				
D-32	869 (w)				32K				dyn.	4K	X				
K-32	799 (w)	190	250		32K	32K	none	4MHz	dyn.*	32K	X				* -5V @ 15 mA, transparent refresh; 4K block de- selection (switched).
K-48	1099 (w)	190	250		48K	48K	none	4MHz	dyn.*	48K	X				
K-64	1299 (w)	190	250	X	64K	64K	none	4MHz	dyn.*	64K	X				*As above, but 8K deselect.
K-128	2599	190	250	X	128K	128K	none	4MHz	dyn.*	128K	X				*As above, *As above, 16K deselect.

Notes:

- ¹(b)=bare board, (k)=kit, (w)=wired
- ²In amperes, where indicated by "A"
- ³BS=bank select for memory mapping option, BB=battery back up, WS=write-protect, WP=write-protect.
- *See "Remarks" column

Make & Model	Price (\$)	Power required (mA) ²			RAM capacity		Expansion kit size, and price	Speed (ns)	Type	Min. addr. block size	Features ³				Remarks
		+8V	+12V	-12V	min.	max.					BS	BB	WS	WP	
SS-50															
Digital Service & Design															
IND-2114-16K	27 (b)	4.5A			1K	16K		450	stat.	8K	X				
Gimix															
16KWR	495 (w)	1.6A			16K	16K	none	450	stat.	4K	X		X		Software-controllable addressing, disable/en- able, write-protect, register-select.
Midwest Scientific															
RAM-88	225 (k)*	X			8K					8K		X			*Sockets, \$35.
	335 (w)*														
Smoke Signal															
M-16A	379 (w)	1.6A			16K	16K	none	250	stat.	16K					DMA-compatible.
Southwest Tech Products															
MP-M	65 (k)	750			2K	4K	2K/S35	500	stat.						
MP-8M	250 (k)	1A			8K	8K	none	500	stat.						
MP-16	400 (w)	X	X		16K	32K	16K/S250	500	dyn.						

Make & Model	Price ¹ (S)	Power required (mA) ²			RAM capacity		Expansion kit size, and price	Speed (ns)	Type	Min. addr. block size	Features ²				Remarks
		+5V	-5V	±12V	min.	max.					BS	BB	WS	WP	
SBC MULTIBUS															
Chrislin															
CI-8080	390 650 825 995				16K			300	dyn.*						*On-board refresh.
					32K			300	dyn.*						
					48K			300	dyn.*						
					64K			300	dyn.*						
Datacube															
RM-117	1200 (w)	X			16K	1M	use CM118	350	stat.	8K	X		X		Dual-port memory system allows 2 SBC buses to share common memory w. Intel 8086.
CM-118	1250 (w)	X			32K	32K		350	stat.	32K					Usable as stand-alone 32K RAM w. 8K PROM, or as slave memory.
Electronic Solutions															
RAM 4	295 (w)	1.2A			4K	4K	none	400	stat.	4K			X		With battery back-up.
RAM-4L	312 (w)	1.2A			4K	4K	none	400	stat.	4K			X		
RAM-8	395 (w)	2A			8K	8K	none	400	stat.	8K			X		
RAM-8L	428 (w)	2A			8K	8K	none	400	stat.	8K			X		With battery back-up.
National Semiconductor															
BLC-016	784 (w)	1.5A	10	700	16K	16K	none	435	dyn.	16K			X		No wait states with BLC 80/204 CPU.
BLC-032	1292 (w)	3.0A	47	11	32K	32K	none	430	dyn.	16K	X	X	X		
BLC-048	1767 (w)	3.0A	47	11	48K	48K	none	430	dyn.	16K	X	X	X		
BLC-064	2090 (w)	3.0A	47	11	64K	64K	none	430	dyn.	16K	X	X	X		
Xycon															
Xycon 16	684 (w)				16K	32K		250	stat.	8K	X		X		
Xycon 32	1024 (w)				32K	32K		250	stat.	8K	X		X		

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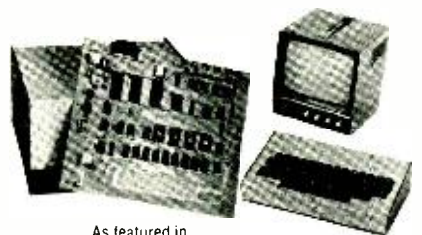
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As featured in
POPULAR ELECTRONICS
EXPLORER/85 shown with Video Monitor and Keyboard/Video Terminal

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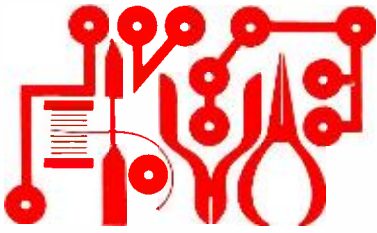
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<input type="checkbox"/> Level "C" S-100 S-Card Expander kit (less connectors), \$39.95 plus \$2 p&h	PHONE ORDERS CALL (203) 354-9375
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Experimenter's Corner

By Forrest M. Mims

THE ANALOG SAMPLE/HOLD CIRCUIT

MICROPROCESSOR enthusiasts are constantly seeking simple ways to interface small controllers and computers with the outside world of analog signals. One well-known analog circuit with many interfacing applications

remains almost constant for an appreciable amount of time.

The op amp is connected as a voltage follower with unity gain. This arrangement permits the charge on the capacitor to be measured by a standard mul-

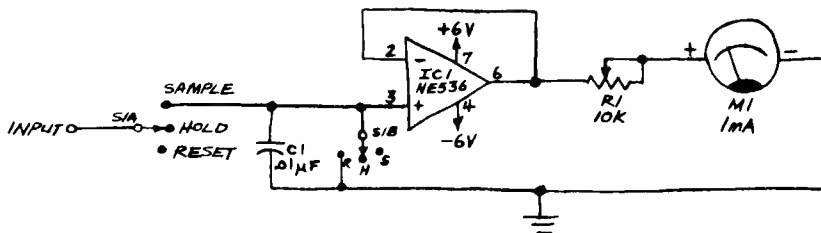


Fig. 1. Schematic of a demonstration sample/hold circuit.

is the op-amp sample/hold (or sample and hold) circuit.

A sample/hold circuit stores in a capacitor the instantaneous voltage present at its input. The stored voltage, which can represent anything from the intensity of light illuminating a photocell to an audio signal, can be converted into digital form by an analog-to-digital converter for processing by a microprocessor. What's more, a sample/hold stage can be used in many different analog applications.

Simple Sample/Hold Circuit. Figure 1 schematically shows a very simple but functioning sample/hold circuit. The key component of the circuit is capacitor C1. When switch S1 is momentarily toggled to its SAMPLE position, the capacitor charges to the voltage present at the input. The charge on the capacitor is monitored by IC1, an op amp with a very high input impedance, which should be an NE536 or similar amplifier with a FET input stage. When switch S1 is released, it returns to its center (off) HOLD position and disconnects C1 from the input of the circuit. Because the op amp's input impedance is very high, the charge stored in the capacitor is effectively trapped and the voltage across C1 re-

timer without significantly altering the amount of stored charge. Connecting a conventional, low-input-impedance voltmeter across the capacitor would, of course, quickly drain the capacitor of its charge. After the magnitude of the voltage sample has been determined, the switch can be momentarily placed in its RESET position to remove the charge from the capacitor and prepare the circuit for a new sample.

It's easy to operate the circuit in Figure 1. Use a 1.5-volt cell to supply the input voltage. With the sample switch closed, adjust calibration potentiometer R1 until the meter reads 0.15 mA, which corresponds to a voltage of 1.5 volts.

You can omit the milliammeter and potentiometer if you prefer to connect a voltmeter directly to the output of the op amp. Because the op amp is connected as a unity-gain voltage follower, the voltage at its output will be identical to that at its input. This does not mean that the op amp is superfluous. To the contrary, it provides the very high input impedance that permits the voltage stored across C1 to be monitored without significant loss.

After you have sampled the input voltage, allow the switch to return to its HOLD position and monitor the meter reading. If C1 is a high-quality, low-loss polystyrene or Mylar unit, the sampled voltage will remain constant for a substantial period of time. Lower-quality capacitors including some ceramic discs will lose their stored charge at a much faster rate, as will be evidenced by a noticeable downward movement of the meter needle.

To increase the circuit's useful storage time, a capacitor larger than the one specified in Figure 1 can be used. But it will require a longer sample interval to charge up to the full input voltage, especially if the sample generator has a significant internal impedance.

Incidentally, if you don't have an NE536 or similar FET-input op amp on hand, you can use a standard 741 for demonstration purposes. You'll have to increase the capacitance of C1 to 1µF or more, because the stored voltage will

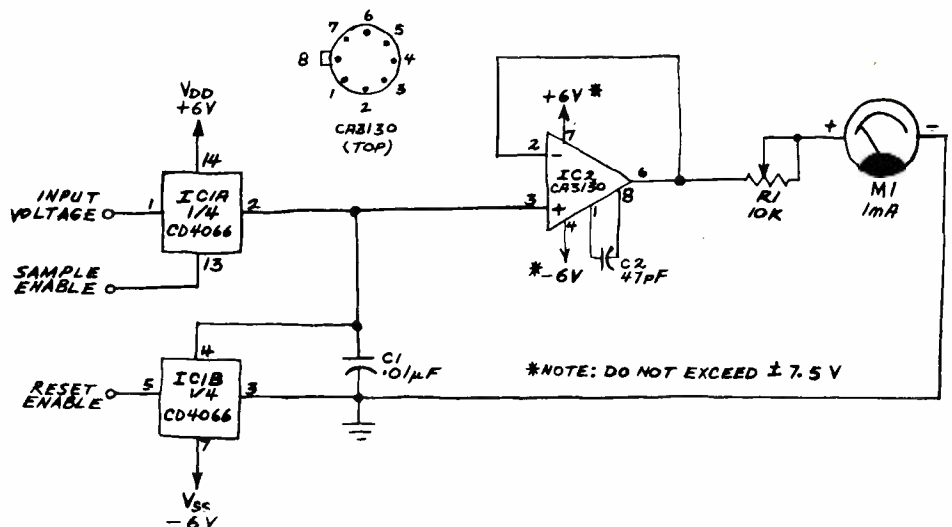


Fig. 2. Digitally controlled sample/hold circuit using CMOS chips. To sample: make sample enable high. To reset: make reset enable high.

be lost much more rapidly than if a FET-input op amp is used, due to the 741's much lower input impedance.

Adding Digital Control. The circuit we have just described is fine for demonstration purposes, but the circuit shown in Fig. 2 is more practical because the sample/hold process is controlled by logic levels instead of mechanical switches. As you can see by comparing the two circuits, the ganged sample/hold/reset switches have been replaced by two of the analog switches in a CD4066 quad analog switch. Furthermore, the NE536 has been replaced by a CA3130 MOSFET-input op amp, but the circuit will work with the 536 as a pin-for-pin replacement without C2.

The analog switch is a newcomer to this column. Like the three-state gate described in the March 1978 issue, the analog switch has an ENABLE input and ports that allow a signal to enter and leave. The analog switch, however, can transmit or block both digital logic levels and analog (variable) voltages. Like a conventional mechanical switch, an analog switch can pass a signal in either direction. Figure 3 shows the equivalent circuit of the analog switch.

The CA3130 op amp is also a new-

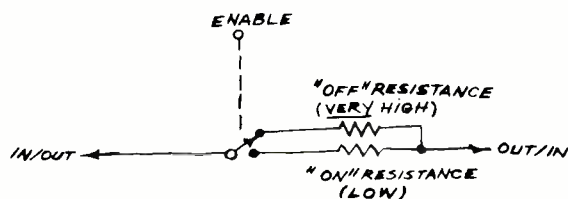


Fig. 3. Equivalent circuit of a basic analog switch.

comer to this column. I'll have more to say about both it and the CD4066 in future columns. Meanwhile, suffice it to say that the CD4066 is one of a family of CMOS analog switches having many fascinating applications. The switches in the CD4066 are *off* when their ENABLE inputs are *low* and *on* when their ENABLE inputs are *high*. The "off" resistance is around 10^{11} ohms, and the "on" resistance is typically 80 ohms.

To sample a voltage with the circuit shown in Fig. 2, the SAMPLE ENABLE input, which is normally kept low, is allowed to go high. The sampled signal level is then stored by C1 until the RESET ENABLE input, which also is normally kept low, goes high. This allows C1 to discharge to ground through IC1B.

If the RESET ENABLE input is again made low, C1 will immediately store the

voltage present at the input if the SAMPLE ENABLE input is still high. Of course, if the SAMPLE ENABLE input is low, C1 will not receive the new sample until the SAMPLE ENABLE input is high. (Ordinarily, both ENABLE lines should not be allowed to go high simultaneously. Otherwise, the signal source output will be connected to ground via a low-impedance path.)

As you can see, there are several operating possibilities for the circuit, each of which can be readily selected by a two-bit logic signal. The factors governing the calibration of the output meter and the selection of C1 are identical to those that apply to the previous circuit.

Applications. The most straightforward application for the sample/hold circuit of Fig. 2 is an analog memory circuit capable of storing a transduced temperature, light intensity, or pressure, or any other analog signal for later processing.

The circuit can also be used as a timer. Replace meter M1 and R1 with a LED and 330-ohm series resistor. The LED will glow until the voltage across C1 drops below the LED's turn-on threshold. Increase the capacitance of C1 for longer time delays. Increasing the magnitude of the sampled voltage up to a

maximum of VDD will also give longer delays.

You can create unusual sound effects by connecting the output of the circuit to a voltage-controlled oscillator such as the 566 function generator or unijunction transistor relaxation oscillator. For a siren effect, connect a high resistance (e.g. 1 megohm) between pin 4 of IC1B and C1. When the RESET ENABLE input is activated, the output voltage will slowly decrease, causing the vco to generate a siren-like sound. The upward wail of the siren is obtained by connecting a second high-value resistor between pin 1 of IC1A and the INPUT VOLTAGE source.

No doubt you will find other applications for both circuits with which we've been experimenting this month. I plan to cover some of those that I have found in a future column. ♦

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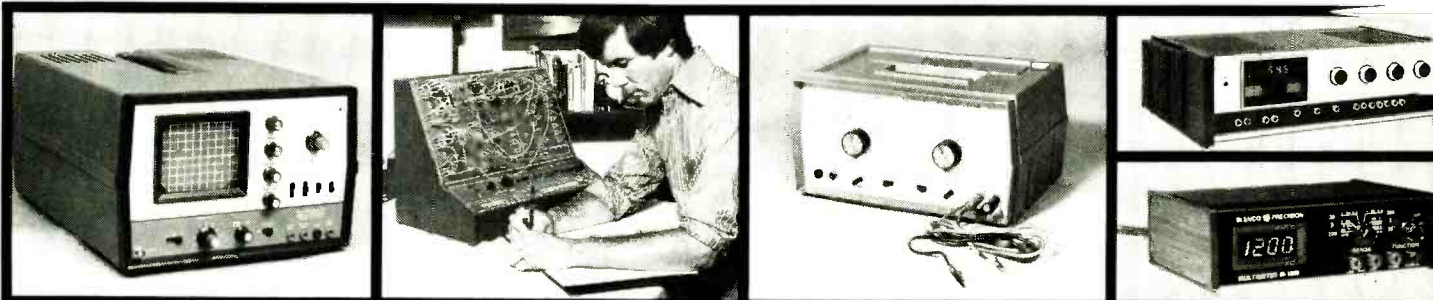
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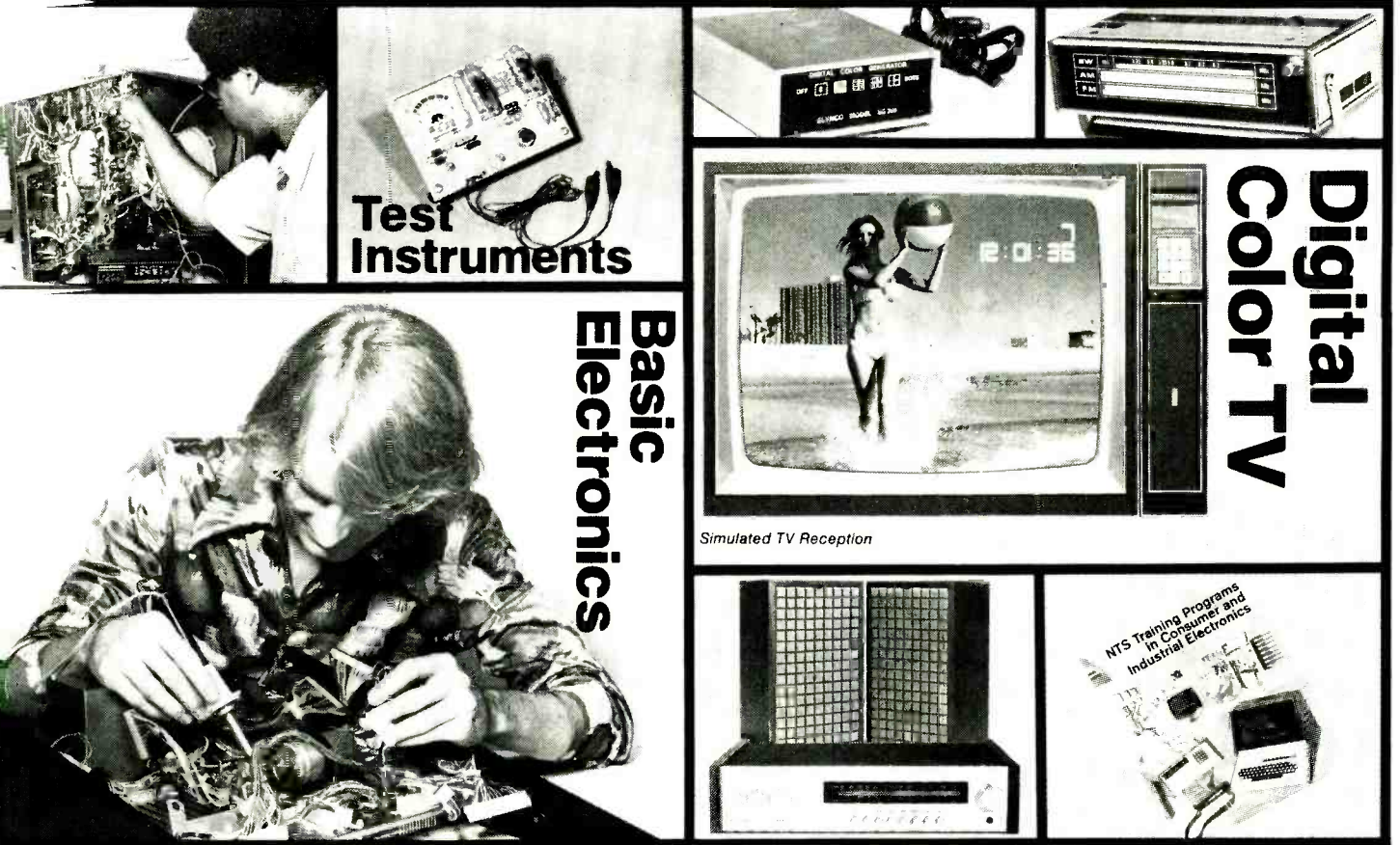
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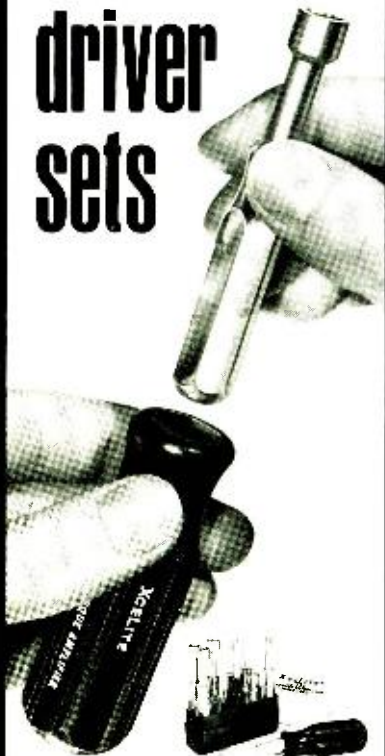
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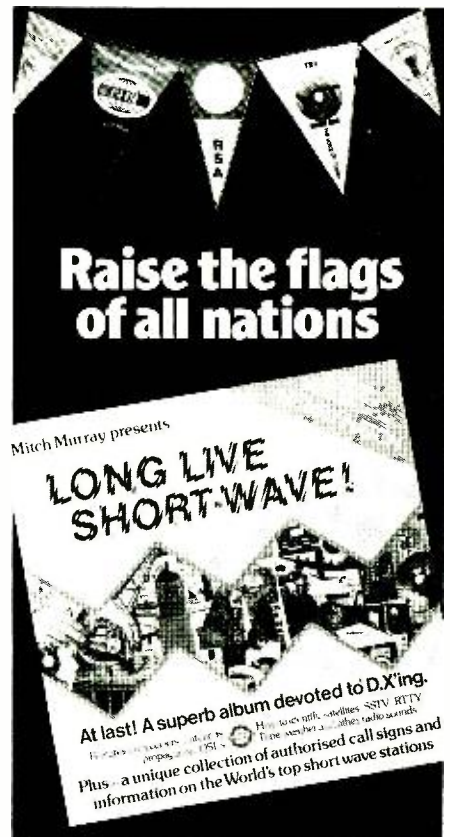
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TIME ¹ EST/CDT	TIME UTC/GMT	STATION	QUAL. ²	FREQUENCIES, kHz ²
4:00-4:15 a.m.	0900-0915	BBC	A	11955, 9640, 9510, 7150, 6195
4:00-4:15 a.m.	0900-0915	R. Japan ⁴	B	9505
4:00-5:00 a.m.	0800-1000	R. Australia	C	9670, 9540
4:00-6:00 a.m.	0900-1100	R. Oman	D	11890
5:00-5:05 a.m.	1000-1005	UN Radio	A	9565, 5955 (Sat.)
5:00-5:30 a.m.	1000-1030	R. Japan	B	9505
5:00-5:30 a.m.	1000-1030	V. of Vietnam	C	12035, 10040, 9840
5:00-sunrise	1000-	R. Australia	B	5995
5:00-6:00 a.m.	1000-1100	AFRTS	A	6030
5:30-6:30 a.m.	1030-1130	Sri Lanka Br. Corp.	C	17850, 15120, 11835 (not all Eng.)
5:55-6:55 a.m.	1055-1155	R. Thailand	C	11905, 9655
6:00-6:15 a.m.	1100-1115	R. Japan	B	9505
6:00-6:56 a.m.	1100-1156	R. RSA	C	21535, 25790
6:00-7:35 a.m.	1100-1235	TWR-Bonaire	A	11815 (Sat, Sun-1220)
6:00-7:50 a.m.	1100-1250	R. Pyongyang	C	11535, 9977
6:00-8:00 a.m.	1100-1300	R. Australia	A	9580
6:00-8:30 a.m.	1100-1330	BBC	A-B	11775, 6195, 5990
6:00-9:00 a.m.	1100-1400	4VEH, Haiti	B	11835, 9770
6:00-9:00 a.m.	1100-1400	AFRTS	A	15430, 15330, 11805, 9700
6:00-9:00 a.m.	1100-1400	VDA	A	11715, 9730, 9565, 6185, 5955
6:00-10:00 a.m.	1100-1500	R. Moscow	B	15150, 11770
6:30-6:45 a.m.	1130-1145	R.R.I. Yogyakarta	C	5046
6:30-9:00 a.m.	1130-1400	CBC Northern Service	B	9625, 6065 (not all Eng.) (from May, 1030-)
7:00-7:15 a.m.	1200-1215	Vatican R.	B	21485
7:00-7:15 a.m.	1200-1215	R. Japan	B	9505
7:00-7:30 a.m.	1200-1230	Israel Radio	C	26095, 21495, 17685, 15540, 15415, 11655
7:00-7:30 a.m.	1200-1230	R. Tashkent	C	9600, 9540, 6025, 5975
7:00-7:45 a.m.	1200-1245	V. of Germany	B	21600, 17765, 15410
7:00-7:45 a.m.	1200-1245	R. Berlin International	C	21540, 15320, 15125
7:00-7:55 a.m.	1200-1255	R. Peking	C	9820, 6995
7:00-11:00 a.m.	1200-1600	HCJB, Ecuador	A	15115, 11745
7:15-7:30 a.m.	1215-1230	V. of Greece	B	17830, 15345, 11730
7:20-7:50 a.m.	1220-1250	R. Ulan Bator, Mongolia	D	12070, 6383 (not Sun)
7:30-7:55 a.m.	1230-1255	Austrian R.	C	21530 (frequent changes)
7:30-8:00 a.m.	1230-1300	R. Bangladesh	D	21670, 15375 (both vary)
7:30-8:00 a.m.	1230-1300	R. Sweden	C	21700
7:30-8:20 a.m. (Sat)	1230-1320	TWR-Bonaire	A	15255
7:30-9:20 a.m. (Sun)	1230-1420	"	"	"
8:00-8:15 a.m.	1300-1315	R. Japan	B	9505
8:00-8:30 a.m.	1300-1330	R. Finland	C	15400
8:00-10:50 a.m.	1300-1550	R. RSA	B	25790, 21535, 17780, 15220
8:00-11:00 a.m.	1300-1600	HCJB, Ecuador	B	17890
8:15-8:45 a.m.	1315-1345	Swiss R. International	C	21570, 21545-SSB, 21520, 15350, 17790
8:30-9:30 a.m.	1330-1430	R. Finland	C	15400 (Sun. only)
8:30-10:00 a.m.	1330-1500	All India R.	C	15335, 11810
8:30-11:00 a.m.	1330-1600	BBC	B-C	21710, 17705, 15400 (from 1430), 15070
9:00-9:30 a.m.	1400-1430	R. Japan	B	9505
9:00-9:30 a.m.	1400-1430	R. Sweden	B	21615
9:00-9:30 a.m.	1400-1430	R. Norway	B	17840, 21730 (Sun only)
9:00-9:30 a.m.	1400-1430	V. Rev. Party, N. Korea	D	4557, 4120
9:00-9:30 a.m.	1400-1430	R. Afghanistan	O	4775
9:00-9:30 a.m.	1400-1430	R. Tashkent	C	9600, 9540, 6025, 5975
9:00-9:45 a.m.	1400-1445	R. Berlin International	B	21540, 15125
9:00-10:00 a.m.	1400-1500	VDA	A	11715, 9565
9:00-10:00 a.m.	1400-1500	V. of Indonesia	C	11789
9:00-11:00 a.m.	1400-1600	AFRTS	A	15425, 15330, 11805, 9700
9:00 a.m.-7:00 p.m.	1400-2400	CBC Northern Service	B-C	11720, 9625 (not all Eng.)
9:30-10:00 a.m.	1430-1500	R. Finland	B	15400
9:30-11:00 a.m.	1430-1600	Burma Br. Ser.	D	5985
9:30 a.m.-5:00 p.m.	1430-2200	UN Radio	A	21670, 15410 (also French; when in session)
10:00-10:15 a.m.	1500-1515	R. Japan	C	9505
10:00-11:00 a.m.	1500-1600	V. of Rev. Ethiopia	D	9615 (frequent changes)
10:00-11:00 a.m.	1500-1600	BBC	B	17830, 11775 (Sat, Sun)
10:00-12:00 a.m.	1500-1700	R. Moscow	B	11770, 9795
10:15-10:30 a.m.	1515-1530	V. of Greece	B	17830, 15345, 11730 (last two, not Tues.)
10:30-11:00 a.m.	1530-1600	Swiss R. International	B	21570
10:30-11:15 a.m.	1530-1615	NSB, Tokyo	C	9595, 6055
10:30-11:30 a.m.	1530-1630	V. of Vietnam	C	12035, 10040, 9840
10:45-11:00 a.m.	1545-1600	R. Canada International	A	17820, 15325 (Mon-Fri only)

11:00-11:15 a.m.	1600-1615	R. Japan	C	9505
11:00-11:15 a.m.	1600-1615	R. Pakistan	C	21590, 17640, 15512
11:00-11:30 a.m.	1600-1630	R. Korea	C	9720, 9640, 7150
11:00-11:30 a.m.	1600-1630	R. Norway	B	21655, 17755, 15345 (Sun only)
11:00-12:00 a.m.	1600-1700	V.O.A.	A	26040, 21485, 17870, 17710
11:00 a.m.-12:09 p.m.	1600-1709	BBC	B	17830, 11775, (Sat, Sun-1745)
11:00 a.m.-1:00 p.m.	1600-1800	AFRTS-Washington	A	15430, 15330, 11805, 9700
11:30 a.m.	-1630	R. Singapore	C	11940 (fade-in time varies)
11:45-12:00 a.m.	1645-1700	R. Canada International	A	17820, 15325
12:00-12:15 p.m.	1700-1715	R. Japan	C	9505
12:00-12:15 p.m.	1700-1715	Vatican R.	B	17900
12:00-1:00 p.m.	1700-1800	HCJB, Ecuador	B	21480, 17865, 15380
12:00-1:00 p.m.	1700-1800	V.O.A.	A	26040, 21590, 21485, 17870, 17710
12:00-2:00 p.m.	1700 1900	R. Moscow	B	9795
12:05-12:55 p.m.	1705-1755	R. France International	B	21620, 21580, 17860, 17850, 17795, 17735, 15425, 15360, 15300, 15210 (from April, 1605-1655)
12:10-12:55 p.m.	1710-1755	BRT. Belgium	C	17735 (1610-1655 from May)
12:45-3:00 p.m.	1745-2000	BBC	C	15400, 12095 (11820 from 1800)
12:45-5:30 p.m.	1745 2230	All India R.	C	11620
1:00-1:15 p.m.	1800-1815	R. Japan	B	9505
1:00-1:30 p.m.	1800-1830	R. Canada International	B	17820, 15260
1:00-1:30 p.m.	1800-1830	R. Norway	C	17755 (Sun only)
1:00-1:30 p.m.	1800-1830	R. Korea	C	9720
1:00-2:00 p.m.	1800-1900	R. Australia	C	11800
1:00-2:30 p.m.	1800 1930	V. of Nigeria	C	15120, 11770
1:00-4:00 p.m.	1800-2100	R. Kuwait	C	12085
1:00-4:30 p.m.	1800-2130	AFRTS-Washington	A	17765, 15430, 15330, 11805, 11790
1:00-5:00 p.m.	1800 2200	V.O.A.	A	26040, 21590, 21485, 17870, 17785, 17710, 15445
1:15-1:45 p.m.	1815 1845	Swiss R International	C	15305
1:15-2:00 p.m.	1815 1900	V. of Revolution, Guinea	C	15310 (varies) (Sun only)
1:15-2:15 p.m.	1815-1915	R. Bangladesh	D	15285, 11765 (both vary)
1:30-1:35 p.m.	1830-1835	UN Radio	A	21670, 19505-SSB, 15410 (Fri)
1:45-2:45 p.m.	1845 1945	Sri Lanka Br. Corp.	C	17850, 15115, 11870
1:45-3:00 p.m.	1845-2000	R. Ivory Coast	C	11920
2:00-2:10 p.m.	1900-1910	R. Tahiti	C	15170, 11825 (exc Sun)
2:00-2:15 p.m.	1900-1915	R. Japan	C	15105
2:00-2:30 p.m.	1900-1930	R. Canada International	A	17875, 15325, 11905
2:00-2:30 p.m.	1900 1930	R. Afghanistan	B	17820, 15260
2:00-3:00 p.m.	1900-2000	B.S.K. Saudi Arabia	C	11770 or 11820 or 11805 (frequent changes)
2:00-3:30 p.m.	1900-2030	HCJB, Ecuador	B	11855
2:00-5:00 p.m.	1900-2200	R. Moscow	B	21480, 17865, 15295
3:00-3:15 p.m.	2000-2015	R. Japan	B	9795, 9490
3:00-3:30 p.m.	2000-2030	V. of Iran	B	15105
3:00-3:30 p.m.	2000-2030	R. Algeria	C	9022 (frequent time changes)
3:00-3:30 p.m.	2000-2030	R. Korea	C	9510
3:00-3:30 p.m.	2000 2030	R. Canada International	C	11860
3:00-3:30 p.m.	2000 2030	Israel R.	A	17875, 17820, 11855
3:00-4:15 p.m.	2000-2115	BBC	C	11655, 9815
3:10-4:50 p.m.	2010-2150	R. Habana Cuba	A	17830, 15260, 6175
3:30-4:20 p.m.	2030-2120	R. Nederland	A	17855
3:30-4:30 p.m.	2030-2130	V. of Vietnam	B	21640, 17810, 11740, 11730
3:50-4:40 p.m.	2050 2140	R. Habana Cuba	C	15012, 10040
4:00-4:15 p.m.	2100 2115	R. Japan	C	17750, 9770
4:00-4:50 p.m.	2100 2150	R. RSA	B	15105
4:15-5:00 p.m.	2115-2200	BBC	B	21535, 17780, 15155
4:15 p.m.-1:30 a.m.	2115 0630	R. New Zealand	A	15260, 6175
4:30-5:00 p.m.	2130 2200	R. Canada International	C	17770
4:30-5:00 p.m.	2130-2200	KGEL, San Francisco	A	17875, 17820, 15325, 15150, 11945
4:30-5:00 p.m.	2130 2200	R. Sofia	C	15280
4:30-5:30 p.m.	2130-2230	R. Baghdad	B	11850, 11750
4:30-6:00 p.m.	2130-2300	V. of Turkey	C	9745
4:30-7:00 p.m.	2130 2400	AFRTS-Washington	C	11955, 9515, 7170, 6185
4:40-5:40 p.m.	2140-2240	V. of Free China	A	21650, 17765, 15430, 15330, 11790
5:00-5:15 p.m.	2200 2215	R. Yugoslavia	C	17890, 15345
5:00-5:15 p.m.	2200-2215	R. Japan	C	9620
5:00-5:30 p.m.	2200-2230	R. Nacional, Venezuela	B	17755
5:00-5:30 p.m.	2200-2230	R. Norway	B	15400 (irregular)
5:00-5:45 p.m.	2200 2245	BBC	C	15175, 11860 (Sun only)
5:00-6:00 p.m.	2200-2300	R. Canada International	A	15260, 11910, 9590, 6195, 6175, 5975
5:30-6:00 p.m.	2230 2300	Israel R.	A	15325, 11860
5:45-6:00 p.m.	2245 2300	BBC	A	15485, 11655, 11620, 9815
5:45-6:00 p.m.	2245-2300	UN Radio	A	15260, 11910, 9590, 9410, 7325, 6195, 6175, 5975
6:00-6:30 p.m.	2300-2330	BBC	A	15225, 11920 (Fri)
6:00-6:30 p.m.	2300 2330	R. Japan	A	15260, 11910, 9590, 9580, 9410, 7325, 6195, 6175, 5975
6:00-6:30 p.m.	2300-2330	R. Sweden	B	17755
6:00-6:30 p.m.	2300-2330	R. Vilnius	C	11705, 9695
6:00-6:50 p.m.	2300 2350	Rdif. Argentina	B	7400, 7360, 7215
6:00-7:00 p.m.	2300-2400	V.O.A.	C	11710 (Mon-Fri)
6:00-7:50 p.m.	2300-2450	R. Pyongyang	A	26895, 25990, 21610, 21460, 17895, 17820
			C	11535, 9977



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6:00-8:00 p.m.	2300-0100	CBC Southern Service	A	5960 (Mon.-Fri.) (2200-2400 from May)
6:00-9:00 p.m.	2300-0200	R. Moscow	B	17720, 15455, 15180, 15140, 12050, 11850, 9760, 9710, 9685, 9665, 9530, 9505, 9490
6:30-7:00 p.m.	2330-2400	R. Finland	C	11800, 9565
6:30-7:30 p.m.	2330 2430	BBC	A	15260, 11910, 9590, 9580, 7325, 6175, 6120, 5975
6:45-7:45 p.m.	2345-2445	R. Japan	B	17825, 15270
7:00-7:15 p.m.	0000-0015	R. Japan	B	17755
7:00-7:25 p.m.	0000-0025	R. Tirana	B	9750, 7065
7:00-7:30 p.m.	0000-0030	R. Norway	C	11870, 9645 (Mon only)
7:00-7:55 p.m.	0000-0055	R. Peking	B	17680, 15520, 15060
7:00-8:00 p.m.	0000-0100	VOA	A	25990, 21460, 17895, 17820, 15205, 11740, 9640, 6130
7:00-8:00 p.m.	0000 0100	R. Sofia	B	9705
7:00-8:00 p.m.	0000-0100	AFRTS-Washington	A	21650, 17765, 15330, 11790, 6030
7:00-9:00 p.m.	0000-0200	Spanish Foreign R.	B	11880, 9630
7:00-9:00 p.m.	0000-0200	R. Luxembourg	C	6090
7:00 p.m.-1:06 a.m.	0000-0606	CBC Northern Service	B	9625, 6195 (not all Eng.) (from May, 0506)
7:15-7:30 p.m.	0015-0030	V. of Greece	B	11730, 9760, 9515
7:15-8:00 p.m.	0015 0100	BRT, Belgium	C	6080
7:30-7:50 p.m.	0030-0050	SODRE, Uruguay	C	11885, 9515 (time varies)
7:30-8:00 p.m.	0030 0100	R. Sweden	C	11905
7:30-8:00 p.m.	0030-0100	R. Prague	C	9630, 6055
7:30-8:00 p.m.	0030 0100	R. Kiev	B	17870, 15180, 12000, 7150, 6020, 5980
7:30-9:00 p.m.	0030-0200	HCB, Ecuador	A	15115
7:30-10:30 p.m.	0030-0330	BBC	A	15260, 11750, 9580, 9410, 7325, 6175, 6120, 5975
7:30-12:00 p.m.	0030-0500	HCB, Ecuador	B	11915, 9745
7:50-8:35 p.m.	0050-0135	TWR-Bonave	B	11925
8:00-8:15 p.m.	0100 0115	R. Japan	B	17755
8:00-8:15 p.m.	0100-0115	Vatican R.	B	11845, 9605, 6015
8:00-8:20 p.m.	0100-0120	RAI, Italy	B	11810, 9575
8:00-8:30 p.m.	0100 0130	R. Canada International	A	17865, 5960
8:00-8:30 p.m.	0100-0130	V. of Chile	B	11890, 11765
8:00-8:45 p.m.	0100-0145	R. Berlin International	C	11805, 9730
8:00-8:55 p.m.	0100-0155	R. Prague	B	11990, 9630, 9540, 7345, 5930
8:00-8:55 p.m.	0100-0155	R. Peking	B	17680, 15600, 15520, 15060, 12055
8:00-9:00 p.m.	0100 0200	VOA	A	15205, 11740, 9640, 6130
8:00-9:00 p.m.	0100-0200	V. of Free China	C	17890, 15425, 15345
8:00-10:00 p.m.	0100-0300	WYFR, Family Radio	A	5985
8:00-10:30 p.m.	0100-0330	R. Habana Cuba	A	11930
8:00-10:30 p.m.	0100 0330	R. Australia	B	17795, 21740
8:00-11:00 p.m.	0100 0400	AFRTS-Washington	A	21650, 17765, 15330, 17790, 6030
8:30-8:50 p.m.	0130 0150	V. of Germany	A	11865, 9605, 9565, 9545, 6100, 6085, 6075, 6040
8:30-8:55 p.m.	0130-0155	Austrian Radio	C	9770, 6155
8:30 8:55 p.m.	0130-0155	R. Tirana	B	9750, 7120
8:30 9:25 p.m.	0130-0225	R. Bucharest	C	11940, 11840, 9690, 9570, 6155, 5990
8:30-9:30 p.m.	0130-0230	R. Japan	B	21640, 17825, 17725, 15195
8:45-9:15 p.m.	0145-0215	Swiss R International	B	11780-SSB, 11715, 9725, 9660, 6135
9:00-9:15 p.m.	0200-0215	R. Japan	B	15105
9:00-9:30 p.m.	0200 0230	R. Canada International	A	9535, 5960
9:00-9:30 p.m.	0200 0230	R. Norway	B	9645, 9550, 6180 (Mon only)
9:00-9:30 p.m.	0200 0230	R. Budapest	B	15220, 11910, 9833, 9585, 6105, 6000 (not Mon)
9:00-9:30 p.m.	0200-0230	R. Warsaw	C	15120, 11815, 9525, 6135, 6095
9:00-9:50 p.m.	0200-0250	R. RSA	B	11900, 9610, 9585, 5980
9:00-9:55 p.m.	0200-0255	R. Peking	B	17680, 15600, 15060, 12055
9:00-10:00 p.m.	0200-0300	R. Moscow	B	17720, 15455, 15180, 15140, 12050, 12010, 11860, 9710, 9665, 9530, 9490
9:00-10:30 p.m.	0200-0330	R. Cairo	B	12050, 9475
9:15-9:30 p.m.	0215-0230	V of Greece	B	11730, 9760, 9515
9:30-9:45 p.m.	0230-0245	R. Pakistan	C	21590, 17830
9:30-9:55 p.m.	0230-0255	R. Tirana	B	9750, 7120
9:30 10:00 p.m.	0230 0300	R. Lebanon	C	11785 (frequent changes)
9:30 10:00 p.m.	0230 0300	R. Sweden	C	11705, 9695
9:30-10:00 p.m.	0230-0300	V. of Chile	B	17800, 11890, 11765
9:30-10:15 p.m.	0230-0315	R. Berlin International	C	11805, 9730
9:30-10:25 p.m.	0230 0325	R. Nederland	A	9590, 6165
9:50-11:00 p.m.	0250 0400	TIFC, Costa Rica	B	5055
10:00-10:15 p.m.	0300-0315	R. Japan	B	15105
10:00-10:15 p.m.	0300-0315	Austrian Radio	C	9770, 6155 (Sun only)
10:00 10:30 p.m.	0300-0330	R. Canada International	A	11845, 9605, 9535, 5960
10:00-10:30 p.m.	0300-0330	R. Portugal	B	11935, 6025 (Mon-0320)
10:00-10:30 p.m.	0300 0330	R. Budapest	B	15220, 11910, 9833, 9585, 6105, 6000
10:00-10:30 p.m.	0300-0330	R. Warsaw	C	15120, 11815, 9525, 6135, 6095
10:00-10:30 p.m.	0300-0330	R. Kiev	B	11860, 9780, 9580, 7400, 7245, 6020, 5980
10:00-10:55 p.m.	0300-0355	R. Prague	B	11990, 9630, 9540, 7345, 5930
10:00-10:55 p.m.	0300-0355	R. Peking	B	17532, 15300, 15060, 12080, 12055, 11685

10:00-11:00 p.m.	0300-0400	RAE, Argentina	C	9690 (Tue-Sat)
10:00-11:00 p.m.	0300-0400	R. Baghdad	C	11935
10:00-11:00 p.m.	0300-0400	UBC, Uganda	B	15325
10:00-11:00 p.m.	0300-0400	R. Moscow	B	12010, 11860, 9710, 9530, 9490, 7205
10:00-11:26 p.m.	0300-0426	R. RSA	B	11900, 9585, 7270, 5980, 4990
10:00 p.m.-12:15 a.m.	0300-0515	R. New Zealand	C	15280
10:00 p.m.-1:00 a.m.	0300-0600	V. of the Voyageur	C	6220
10:00 p.m.-2:00 a.m.	0300-0700	V. of Armenia	A	9670, 5995
10:25-10:30 p.m.	0325 0330	V. of Armenia	B	15180, 12000, 5735 (Sun., Wed, Thu, Sat)
10:30-10:55 p.m.	0330-0355	R. Tirana	B	7300, 6200
10:30-10:55 p.m.	0330 0355	Austrian Radio	C	9770, 6155
10:30-11:00 p.m.	0330-0400	R. Australia	B	17795
10:30-11:15 p.m.	0330-0415	R. Berlin International	B	11970, 11890, 11840
10:30-11:45 p.m.	0330-0445	BBC	A	9410, 6175, 6120 (to 0430), 5975
10:30-11:50 p.m.	0330 0450	R. Habana Cuba	A	11930, 11725
10:30-12:00 p.m.	0330-0500	R. Tanzania	D	15435
10:30 p.m.-1:00 a.m.	0330-0600	R. Habana Cuba	A	11760
10:30 p.m.-12:30 a.m.	0330-0530	R. Moscow	B	17870, 15455, 15140, 12050, 12010, 9780, 9505
11:00-11:15 p.m.	0400 0415	R. Japan	B	15105
11:00-11:15 p.m.	0400 0415	R. Budapest	B	15220, 11910, 9833, 9585, 6105, 6040 (Wed & Sat)
11:00-11:30 p.m.	0400-0430	R. Bucharest	C	11940, 11840, 9690, 9570, 6155, 5990
11:00-11:30 p.m.	0400-0430	R. Canada International	A	9535, 5960
11:00-11:30 p.m.	0400 0430	R. Norway	B	9550, 6180, (Mon only)
11:00-11:55 p.m.	0400-0455	R. Peking	B	17532, 15300, 15060, 12055, 11685
11:00-12:00 p.m.	0400-0500	R. Australia	B	17795, 15320
11:00 p.m.-2:00 a.m.	0400 0700	AFRTS-Washington	A	17765, 11805, 11790, 6030
11:30-11:55 p.m.	0430 0455	Austrian R.	C	5945
11:30-12:00 p.m.	0430 0500	Swiss R. International	B	9725, 6045
11:30-12:00 p.m.	0430-0500	R. Sofia	B	9530
11:45 p.m.-12:45 a.m.	0445-0545	BBC	A	9510, 6175, 5975 (11860 from 0500)
12:00-12:15 a.m.	0500-0515	Israel R.	B	15105, 11655, 11620
12:00-12:15 a.m.	0500-0515	R. Japan	B	9505
12:00-12:30 a.m.	0500 0530	R. Portugal	B	11935, 6025 (Mon-0520)
12:00-1:00 a.m.	0500-0600	R. Australia	C	21680, 17890, 17870, 17725, 15240
12:00-2:00 a.m.	0500-0700	HCJB, Ecuador	B	6095, 9560, 11915
12:15-1:15 a.m.	0515-0615	Spanish Foreign R.	B	11880, 9630
12:22-12:30 a.m.	0522-0530	UN Radio	A	9540, 6055 (Sat)
12:30-12:50 a.m.	0530 0550	V. of Germany	A	11785, 9545, 6185, 6100, 5960
12:30-1:25 a.m.	0530-0625	R. Nederland	A	9715, 6165
12:30-2:30 a.m.	0530-0730	R. Moscow	B	15140, 12050, 12010, 9780, 9505, 7170
12:30-7:05 a.m.	0530 1205	R. New Zealand	C	6105
12:45-1:00 a.m.	0545 0600	UN Radio	A	9540, 6135 (Sat)
12:45-2:30 a.m.	0545-0730	BBC	B	11955, 11860, 9640, 9510, 7150, 6175
12:55-3:35 a.m.	0555-0835	V. of Nigeria	B	15120, 11770, 7255
1:00-1:15 a.m.	0600-0615	R. Japan	B	9505
1:00-1:30 a.m.	0600-0630	R. Norway	B	9645 (Mon only)
1:00-2:00 a.m.	0600-0700	RAE, Argentina	C	11755, 9690, 6120 (Tue-Sat only)
1:00-2:00 a.m.	0600-0700	R. RSA	C	17780, 15220
1:00-4:15 a.m.	0600-0915	R. Australia	B	15320
1:15-1:30 a.m.	0615-0630	R. Canada International	B	11845, 11825, 9655, 9635 6140, 6045 (Mon-Fri)
1:25-3:55 a.m.	0625-0855	V. of Malaysia	C	15295, 12350, 9750
1:30-2:00 a.m.	0630 0700	R. Korea	C	9640
1:30-3:00 a.m.	0630 0800	R. Habana Cuba	A	9525
1:40-3:15 a.m.	0640-0815	R. New Zealand	C	11945
1:45-2:00 a.m.	0645-0700	R. Canada International	B	11845, 11825, 9655, 9635, 6140, 6045 (Mon-Fri)
2:00-2:15 a.m.	0700 0715	R. Japan	B	9505
2:00-4:00 a.m.	0700-0900	R. Australia	B	11740, 9570
2:00-7:00 a.m.	0700-1200	AFRTS Washington	A	9700, 9685, 6155, 6095, 6030
2:07-2:15 a.m.	0707-0715	UN Radio	A	9540, 6135 (Sat)
2:30-2:45 a.m.	0730-0745	UN Radio	A	9540, 6135 (Tue-Sat)
2:30-3:25 a.m.	0730-0825	R. Nederland	B	9770, 9715
2:30-4:00 a.m.	0730 0900	BBC	B	11955, 9640, 9510, 7150
3:00-3:15 a.m.	0800-0815	R. Japan	B	9505
3:30-4:25 a.m.	0830 0925	R. Nederland	B	9715

Explanatory Notes.

1. Times in first column are EST for CDT from April 29). For AST EDT add 1 hour. CST/MDT, subtract 1 hour. MST/PDT, subtract 2 hours. PST, subtract 3 hours. Days of week are in GMT.
2. **Quality.** A strong signal and very reliable reception. B regular reception. C occasional reception under favorable conditions. D rarely audible. These ratings are for locations in the central USA. European and African stations are in general, more reliably received in eastern North America. Asian and Pacific stations are more reliably received in western North America. North American stations are received well except in areas too close to the transmitter site.
3. The information in this listing is subject to press time. However, frequencies and schedules are constantly changing. Listen to "DX Digest" at 1807, 1900 to Europe. Sunday, 0100, 0300, on Monday and 1900 Wednesday to Africa. On R. Canada International for late changes.
4. R - Radio, V.-Voice

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CIRCLE NO. 47 ON FREE INFORMATION CARD



Computer Bits

By Leslie Solomon

LANGUAGE TRANSLATION

MOST OF us remember the various times that Capt. Kirk, in "Star Trek," used a "universal language translator" to communicate with alien life-forms. Well, such a vocal input/output system has not yet come along, but we are getting closer.

Within a period of three weeks, we had the opportunity to try out two "language translators"—the LK-3000 from Lexicon Corp. (8355 Executive Center Drive, Miami, FL 33166) and the M-100 from Craig Corp. (921 West Artesia Blvd, Compton, CA 90220). The translators are similar in operation though there are minor differences.

Both systems resemble pocket-size

calculators and have alphanumeric key-pads, and 16-digit multi-segment displays. The Lexicon uses LED's while the Craig uses fluorescent readouts.

These machines have English as their "base." In operation, an English word is entered on the keyboard, a switch is depressed and both the English and its equivalent in the other language appear in the display. It is also possible to enter the foreign language word and have the display give the English equivalent. Both are provided with about 1500 commonly used words (similar to those little travel books tourists carry), and both also contain 50 or so of the most frequently used phrases. Foreign languages include

French, Spanish, Italian, Portugese, etc., with Japanese, Russian and others coming soon. If an expression is longer than the display, the words will scroll left to allow the message to pass along.

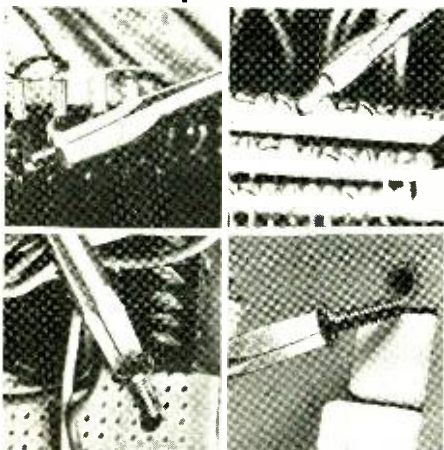
Both machines are provided with plug-in modules that are used to change languages, and are in the \$225 category. They also provide simple calculator operations and can provide a "menu" of the data within their ROM's.

Electronically, both are basic computers in that they contain a processor, some RAM and have their language in ROM. The processor has the usual support circuitry and includes the 16 character display. The M-100, for example, uses a 3870 CPU, features 16K bits of internal ROM (carrying housekeeping and English), and can support 32K or 64K of plug-in ROM carrying the other language and data.

Everything is done in software (actualy firmware) and both use proprietary programs. In both cases, the plug-in ROM will be sold over the counter. (Craig is asking \$25 per language.)

Engineers for both companies refused to speculate on vocal input/output attachments for their devices, so we still have something to look forward to be-

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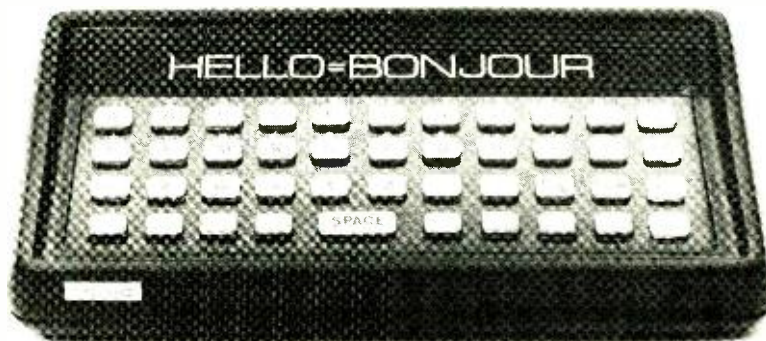
See your dealer or write to:
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Salt Lake City, Utah 84125

CIRCLE NO. 37 ON FREE INFORMATION CARD

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The Lexicon LK-3000 language translator uses LED readouts.



The Craig Model M-100 translator uses a 3870 CPU.

POPULAR ELECTRONICS

fore we can join Kirk in his galactic conversations.

Atari Steps In. After several years of being one of the leaders in making arcade and home video games, Atari Inc. is now offering a pair of personal computers. One is the Atari-400 (approximately \$500) using a 6502 CPU, 8K of RAM and 8K of ROM (expandable to 16K). The keyboard is a 57-key Monopanel with fingertip touch-contact points rather than mechanical keys. The system has upper and lower case, graphics and screen editing functions. Up to 40 characters on 24 lines can be displayed on a conventional TV. Up to 16 colors and 8 luminance levels are provided.

A built-in r-f modulator, set to either channel 2 or 3, conforms to the FCC Type-1 specifications. R-f radiation is kept down by using an extruded metal shield to cover the complete system (under a plastic cover). BASIC is provided. A special I/O connector allows interfacing to the several peripherals Atari intends to provide. Special input jacks, located under the keyboard on the front, allow use of game-playing controllers.

(Continued on page 88)



The Atari-400 personal computer uses a 6502 CPU, 8K of RAM and 8K of ROM. Keyboard is a 56-key Monopanel with touch-control points.

APRIL 1979



Featuring
RCA 1802 COSMAC CPU

Own a powerful home computer system, starting for just \$99.95—a price that gets you up and running the very first night—with your own TV for a video display. \$99.95 ELF II includes RCA 1802 8 bit microprocessor addressable to 64k bytes with DMA, interrupt, 16 registers, ALU, 256 byte RAM, full hex keyboard, two digit hex output display, stable crystal clock for timing purposes, RCA 1861 video IC to display your programs on any video monitor or TV screen and 5-slot plug-in expansion bus (less connectors) to expand ELF II into a giant!

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In fact, not only will you now be able to use a personal computer creatively, you'll also be able to read magazines such as BYTE, INTERFACE AGE, POPULAR ELECTRONICS and PERSONAL COMPUTING and fully understand the articles. And, you'll understand how to expand ELF II to give you the exact capabilities you need!

If you work with large computers, ELF II and the *Short Course* will help you understand what they're doing.

Get Started For Just \$99.95, Complete!

\$99.95 ELF II includes all the hardware and software you need to start writing and running programs at home, displaying video graphics on your TV screen and designing circuits using a microprocessor—the very first night—even if you've never used a computer before.

ELF II connects directly to the video input of your TV set, without any additional hardware. Or, with an \$8.95 RF modulator (see coupon below, you can connect ELF II to your TV's antenna terminals instead.

ELF II has been designed to play all the video games you want, including a fascinating new target-missile gun game that was developed specifically for ELF II. But games are only the icing on the cake. The real value of ELF II is that it gives you a chance to write machine language programs—and machine language is the fundamental language of all computers. Of course, machine language is only a starting point. You can also program ELF II with assembly language and tiny BASIC. But ELF II's machine language capability gives you a chance to develop a working knowledge of computers that you can't get from running only

Write and run programs—the very first night—even if you've never used a computer before!
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(Continued from page 87)

The cassette player used with the system has no volume or tone controls, but does have a tape counter and pushbutton controls. It is also operated by the computer. Digital data is on one track, while audio is carried on the other. Data transmission is 300/600 baud, software controlled. Atari supplies a complete line of software, including many games.

The second system, the Atari-800 (approximately \$1000), has all the electronic features of the 400 and comes with 8K of RAM plug-in expandable to 48K. It too comes with BASIC in ROM. This system can drive up to 4 disks and a printer. Soon to be available are an acoustic modem, a direct telephone adapter, an ac controller, a light pen, voice synthesizer and recognition, and a music synthesizer. Atari also supports this system with a full line of software (interchangeable with the 400). Languages include BASIC and DISK BASIC, with other languages under consideration. They also hope to have an assembler, disassembler and text editor.

Each of the plug-in modules (RAM and operating system) is protected by a plastic enclosure. Details of the 44-pin bus were not available.

The keyboard features 57 full-stroke mechanical keys and four separate function keys. It too has a built-in modulator. Besides its built-in speaker, the 800 also provides TV sound.

The 40-column printer uses dot matrix and standard paper rolls and ribbons. It handles 40 characters per second and one line per second. It contains its own processor. The 800 can handle up to four disks simultaneously. The disk system uses standard 5 1/4" diskettes with 92K per side and also contains its own processor. The various peripherals are "daisy chain" coupled to the single output connector.

TRS-80 S100 Adapter. The 8100, an S100 bus adapter motherboard, plugs into the TRS-80 via a ribbon cable. The 8100 also features 6 slots and card guides, and a second TRS-80 connector allows other TRS-80 devices to be connected at the same time. The new motherboard has optional on-board circuitry and sockets for 16K of dynamic RAM, I/O interfaces for serial and parallel I/O both RS232 and 20-mA loop and an 8-bit parallel I/O port. The basic unit, including the S100 bus interface, one edge connector/card guide set, and manual is \$185 per kit and \$245 assembled. Five connectors/card guides are \$45 as a kit, \$75 assembled. The RAM

support option (less RAM's) is \$45 kit and \$75 assembled, while the I/O option is \$85 kit, \$115 assembled. HUH Electronics, 1429 Maple St., San Mateo, CA 94402 (Tel: 415-573-7359).

Apple Robot. If you have an Apple II, the addition of ROBOT 1, will enable you to control a battery-powered car merely by speaking the words "forward," "reverse," "stop," "left," "right," and "straight". The ROBOT 1 plugs into an Apple slot, and the accompanying program is run. The speech system uses the Heuristics Model 20A Speechlab. The radio link is effective to about 300 feet. The system comes with car, radio-link controller, Apple II peripheral card, preprogrammed demonstration tape and instruction manual. Heuristics, Inc., 900 San Antonio Rd, Los Altos, CA 94022 (Tel: 415-948-2542).

New Computer Clubs. An 1802 user group is now in operation in Finland. Contact: J. E. Nystrom, Ulvilantie 2 C 27, SF-00350 Helsinki 35, Finland.

A new Canadian club has also been reported. Contact: West Coast Computer Society, POB 4476, Vancouver, B.C., Canada V6B 3Z8.

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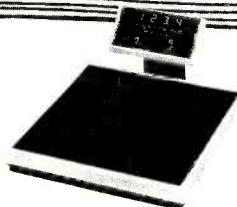


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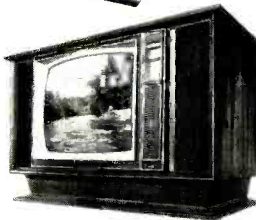
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nel-management system which can produce paychecks, W-2 forms, and reports. MICROINV carries out inventory-control functions, including analysis and order-quantity suggestions. Programs are available for Micropolis or Cromemco 16K BASIC. Packages with listings are \$120 per program; Micropolis II disks, available to package buyers only, are \$10 each. CompuMax Associates, 505 Hamilton Ave., Palo Alto, CA 94301.

North Star Applications Software. Three diskettes of programs (one each financial, mathematical analysis and statistical) from the Osborne book "Some Common BASIC Programs" two game diskettes, one diskette each of backorder, retail sales-report and mailing-list programs using disk data files, and a Northstar DOS for Centronics printers are now available from Arizona and Dallas Byte Shops, or from MicroAge. \$35 per diskette. MicroAge Mail Order, 803 N. Scottsdale Rd., Tempe, AZ 85281.

CP/M Users' Group Programs. For a \$4 annual membership charge, CP/M users can have access to hundreds of programs for \$8 per diskette, with an average of about 17 programs per disk, or 50 cents per program. Program disks available include utility, game, instructional, general ledger, math, monitors, and such languages as BASIC-E, PILOT, ALGOL-M, STOIC, and CASUAL. CP/M Users' Group, 164 West 83rd St., New York, NY 10024.

SC/MP Cross-Assembler for 8080. Systems capable of running the ASM80 macro-assembler for 8080 can now be used to develop programs for the National Semiconductor SC/MP (INS8060). The cross-assembler program, MDSMAC, consists of a set of macros loaded into the host system assembler's macro tables. Paper tape, \$5.00. National Computer Users Group, National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95051.

8080 Development Software and Aids. Tychon, whose principals edit the popular 8080 Bugbooks, also offers two programs and two versions of a programming aid for 8080 users. The TED editor and TAS assembler accept both octal and hex values and yield octal or hex program listings from either input. The package has its own relocater, character string search, and occupies less than 5K. The standard version, with relocater, addressed at 00, is \$35 for a paper tape and manual; it's also available custom-assembled to any address for \$50. Hex or octal listings are \$30 each. DBUG: An 8080 Interpretive Debugger allows programs to be entered, changed, and single-stepped, and displays registers at breakpoints. It resides in 1K. DBUG tapes are \$10, and documentation is \$4.95. DBUG listing book from Howard Sams (order # 21536), 4300 W. 62, Indianapolis, IN 46268; other items from Tychon, Box 242, Blacksburg, VA 24060.

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PROJECT OF THE MONTH

BY FORREST M. MIMS

EXPERIMENTAL SOLID-STATE OSCILLOSCOPE

In the October 1978 Experimenter's Corner I made a brief reference to an experimental solid-state oscilloscope that employs, as a display screen, the 160-element LED array that appeared as the last Project of the Month. Many readers have written requesting additional information, so here it is!

Figure A is the schematic diagram of the experimental scope. In operation, a signal applied to the noninverting input of the 741 op amp is amplified and routed to a flash A/D converter made up of LM339 quad comparators and a 74147 priority encoder. A detailed description of this A/D converter was given in the September and October 1978 Experimenter's Corner columns.

The digital output of the 74147 is a 4-bit

BCD nibble. This nibble, after being decoded by a 74145 1-of-10 decoder, activates one of the ten horizontal rows of LEDs. One of the sixteen vertical columns of LEDs is activated simultaneously by a horizontal scanning circuit consisting of a 555 timer, 74193 4-bit counter and 74154 1-of-16 decoder. The 555 serves as a time base whose sweep frequency is controlled by a 1-megohm potentiometer. The 74193 and 74154 form a 0-to-15 sequence generator that sweeps the sixteen columns of LEDs one at a time.

Because only one row and one column of LEDs are activated at any time, only one LED in the array glows at any single instant. When the sweep rate is faster than 20 or 30 complete scans per second, the individual LEDs merge into a broken line that provides a rough pictorial representation of the positive half of the waveform appearing at the input of the 741 op amp.

Three of the gates in a 7400 quad NAND gate add a simple but very useful trigger feature. When pin 14 of the 74193 is grounded by placing the MODE switch in its FREE RUNNING position, the sweep circuit scans the LED columns continuously. A

careful adjustment of the time base potentiometer will freeze the waveform being displayed. Any drift, however slight, in the incoming waveform will require a readjustment of the time base. Otherwise, the waveform being displayed will move across the screen from left to right or right to left, as it did before the potentiometer was adjusted.

When the MODE switch is placed in its TRIGGERED position, pin 14 of the 74193 is reset (or cleared) to 0000 when an input signal is not present. An input signal with enough amplitude to activate the lowest-order LM339 comparator causes pin 6 of the 7400 to go from high to low. This allows the 74193 to make a complete scan of the display columns.

If the input signal is still present when the scan is completed, another scan is immediately begun. Otherwise, the scope waits for the signal to recur before initiating a new scan. The result is that in the triggered mode the scope automatically locks onto a recurrent waveform, and displays it with its rising portion originating in the first column of LEDs. A LED connected to the trigger gate network indicates when trig-

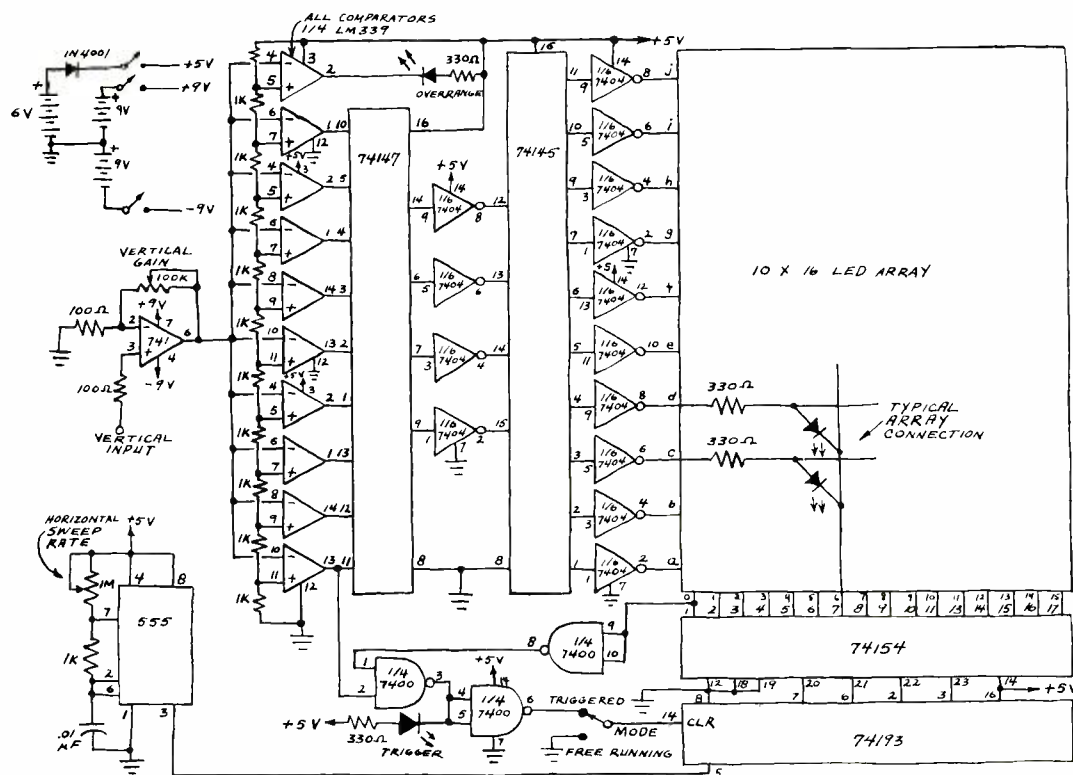


Fig. A. Schematic of a solid-state 10-by-16 LED array oscilloscope.

Project of the Month *continued*

gering is occurring, which might not be known if the gain is set so high as to prevent observation of the waveform.

When the scope is in the triggered mode, the waveform being displayed can be expanded or compressed by changing the horizontal sweep rate. Similarly, the height of the waveform can be increased or decreased by adjusting the VERTICAL GAIN potentiometer. An overrange LED connected to the output of the highest-order LM339 comparator indicates when the gain is too high and the top of the waveform is therefore off the screen.

Although it is considerably easier to assemble the drive circuit than the LED display board described last month, care must be exercised when building it because wiring errors can be very difficult to find. I assembled the prototype driver circuit on the same kind of board used for the display (Radio Shack 276-152 or similar) using wrapped-wire, point-to-point construction. Figure B shows how the major components were arranged on the top side of the board. Note the miniature phone jack that serves as the vertical input for the scope. This jack should be installed from

the front side of the board.

After the components on the board are connected together, connections to the display board, the time base potentiometer, the vertical gain potentiometer and the power supply are provided by soldering wrapping wire to the appropriate copper fingers on the board.

Last month, the bus locations I used on the display board were given. The bus locations used for the remainder of the scope circuit are as follows:

Oscilloscope Circuit	S-44 Socket
-5 volts	1
Ground	2
Overrange LED Cathode	3
Vertical Gain Control	M
Vertical Gain Control	N
Horizontal Sweep Control	S
Horizontal Sweep Control	T
Mode Switch:	
Pin 6 7400	U
Ground	V
Pin 14 74193	W
Trigger LED Cathode	X
-9 volts	Y
-9 volts	Z

Don't feel compelled to use these bus lo-

cations. All of them can be changed so long as they don't interfere with the display bus. It's a good idea to reserve the 1, 2, Y and Z locations for the power supply since these are closest to the two copper strips that traverse the perimeter of the circuit boards. You can use a small file to separate these into four separate strips.

After the scope circuit has been completed, saw off the upper portion of a second circuit board and install a power switch (3PST), trigger mode switch (SPDT), trigger LED and vertical gain and horizontal sweep rate potentiometer. Figure C shows the layout I used to make the prototype. This board becomes the control panel for the scope. Its components should be connected to the appropriate copper fingers in accordance with the bus given above or the one you select.

You'll need to make a card rack or mother board to hold the three boards that comprise the oscilloscope. If you can afford a commercial mother board, great. If not, do what I did and attach three 44-connector sockets with wire-wrap terminals to a couple of wood or plastic rails. Mount the sockets an inch apart from each other. Next,

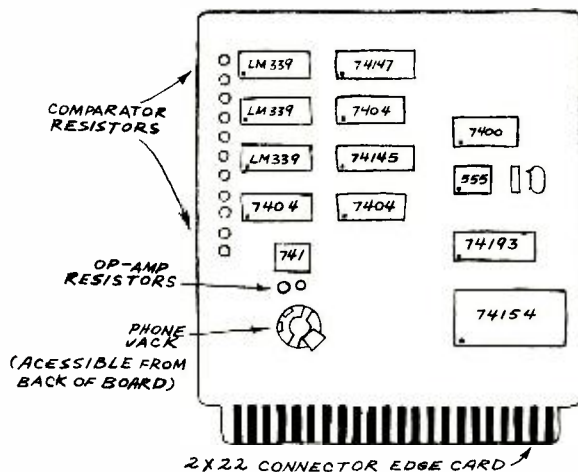
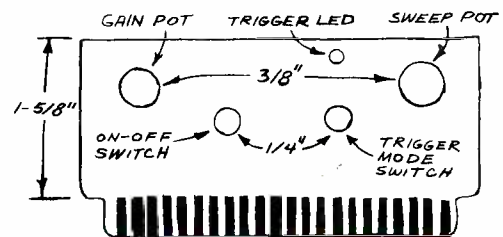


Fig. B. Layout of the major components of the experimental oscilloscope on a 2 x 22 connector edge board.

Fig. C. Prototype layout for the control board for the LED oscilloscope.



connect all the common connectors with wrapping wire. Then insert the scope card in the rearmost socket (ICs facing forward), display card in the center socket and control card in the foremost socket.

The prototype scope is powered by two 9-volt batteries and a 6-volt battery made from four AA alkaline cells in a plastic holder. The batteries are connected to the scope with three battery connector clips.

Before applying power to the circuit, be sure to take the time necessary to retrace all the wiring to make sure you've made no errors. The most common problem in a project using wrapped wiring is overlooked connections, particularly those to the power supply pins of the ICs.

Make a probe for the scope from a length of flexible shielded cable, a miniature phone plug, a test clip and an alligator clip. For initial tests, use a ramp or triangle

Once you have the scope working, you'll be able to display a variety of waveforms after a little practice. Spikes, triangles and ramps are the waveforms best reproduced. Sine waves are slightly distorted by the low resolution of the screen, and the rising and falling portions of square waves are usually very faint. Often several LEDs in a vertical column will appear to be on as shown in Figure D, but it's usually possible to resolve the general waveform being displayed.

Although the resolution of this experimental scope is poor and the design of the vertical section leaves much to be desired, it does demonstrate that a flat-screen, compact oscilloscope can be built. If you build the scope you'll want to spend some time calibrating the vertical and horizontal sections with the help of a voltmeter and frequency generator or a conventional os-

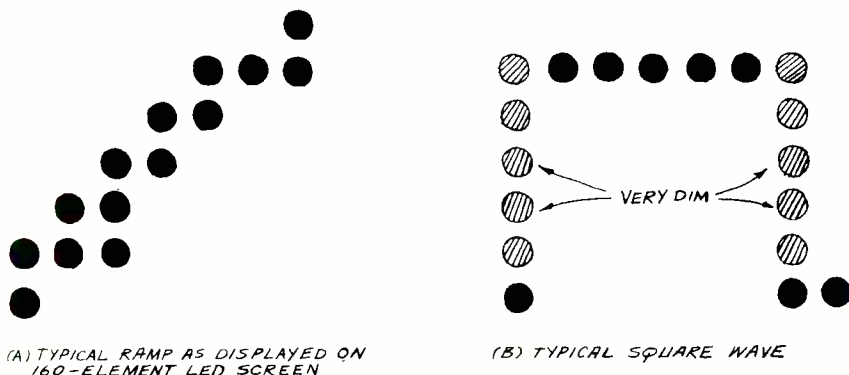


Fig. D. Portions of two waveforms as displayed on 160-element LED display.

wave having an amplitude of up to a few volts and a frequency of a few hundred hertz. Be sure to perform the tests in a darkened room, at least initially, since the LED array will not be as brightly illuminated as a conventional CRT screen.

If the scope fails to respond, make sure that power is being applied properly. Then try changing the gain and time base settings as well as the trigger mode. If the scope still does not work, you will have to troubleshoot the circuit. Hint: Proceed one step at a time. For example, troubleshoot the sweep circuit by beginning at the 555 (is it pulsing?). Then move to the 74193 (is it counting?), etc.

illoscope. You might also want to modify or try to improve the design if you're experimentally inclined. The A/D converter of the vertical section, for example, can be greatly simplified by using a single-chip A/D converter. The sensitivity of the vertical comparator string can be varied by replacing the 1-megohm resistor at the top of the voltage divider with either a fixed resistor having a different value or, better yet, a 1-megohm potentiometer. Similarly, a wide range of sweep rates can be obtained by replacing the single timing capacitor with a group of fixed capacitors of various values, one of which would be selected by a rotary switch. ◇

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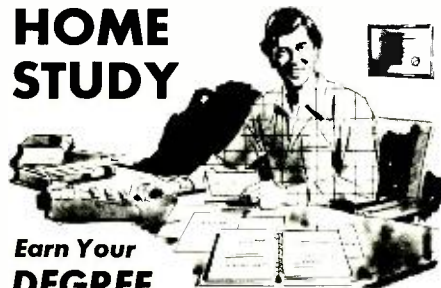
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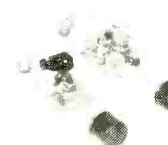
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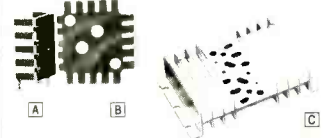
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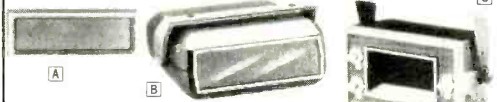
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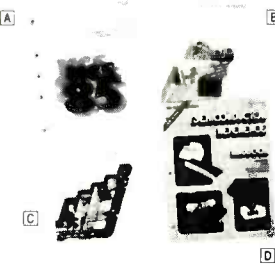
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Electronic Design Corp., Victrola amplifier model 80-12C. Need source for information. W. Wyatt Miller, 305 W. Diamond Ave., Gaithersburg, MD 20766.

Hallcrafters Sky Buddy receiver and RCA R-65/APN-9 receiver indicator. Schematics. Ted K. Wright, 3929 Woodlane, Ft. Worth, TX 76117.

Knight Kit model C22 CB transceiver. Schematic and operating instructions. William Pence, 800 Old Stage Rd., Cave Junction, OR 97523.

National Union Oscillograph Co., type B3-5 oscilloscope. Instruction manual. Bruce W. Miller, Box 21963, Seattle, WA 98111.

Devry Technical Institute combination oscilloscope VTVM from 1959 home study courses. Assembly manual and schematic. D. Moore, Box 83, Main St., Aylesford, N.S. Canada, BOP 1C0.

Sansul model 1000A tuner amplifier. Operating manual and schematic. Paul Shelton, 9004 E. 29th Pl., Tulsa, OK 74129.

RCA CB 2608A, serial #02. Schematic and tube list. F. C. Bergquist, 105 Ellis St., Leesville, LA 71446.

Stromburg Carlson radio model 642A. Schematic and owners manual. James Olin, 720 E. Harbor Dr. S, St. Petersburg, FL 33705.

Precision model 120-volt-ohm meter. Schematic. Alex R. Minelli, 718 Michigan St., Hibbing, MN 55746.

Heathkit model HWA-202-2 tone burst encoder module for HWA-202 two-meter transceiver. Manual or kit. Gary Resta, 20C Tindal Lane, Niagara Falls, NY 14304.

Bradford model WTG-59816 tape recorder. Schematic and any other information. Earl Stephenson, 1956 Minnesota Ave., Columbus, OH 43211.

Lafayette HA 350 receiver. Schematic and instruction manual. Bud Benson, 976 E. Lawson St., St. Paul, MN 55106.

Lafayette KT-320 receiver. Schematic and operating manual. L. T. Switzer, 654 Georgia, Marysville, MI 48040.

Singer model HE8121 television. Schematic, diagrams and operating manual. Charles Peklenk, 12939 Tosca, Houston, TX 77024.

Sonic guitar amplifier. Schematic. Roger Gran, 225 S. 7th St., La Crosse, WI 54601.

Jackson Electric Instrument Co., model TVG-1 TV signal and sweep generator. Schematic and operating instructions. Don Schulteis, 3746 Garfield Ave., Pennsauken, NJ 08105.

Atwater Kent model 60C radio receiver. Schematic, service manual. David G. Ford, 906 Iola, Victoria, TX 77901.

Sprague Teleomike capacitor analyzer model TO-4 and **Heathkit** model AV-3 audio VTVM. Service manuals, calibration data and schematics. E. J. Prado, Box 75591, Los Angeles, CA 90005.

Lafayette model 99-50775 power supply. Schematic needed. David Edlund, 2923 N. Stevens, Tacoma, WA 98405.

RCA model WR-39C TV calibrator. Operation manual. Bob Brandel, Rose Hulman Institute of Technology, Box 927, 5500 Wabash, Terre Haute, IN 47803.

Fairchild channel F system II video game. Schematic. S. T. Stickie, 651 E. Travis Blvd #14, Fairfield, CA 94533.

Radio City Products model 664 VTVM. Schematic and manual needed. H. T. Finch, 6158 Winton, Dallas, TX 75214.

Hammarlund HQ-110A. Operating manual needed. Paul Migliore, N2AKO, 710 Cookman Ave., Asbury Park, NJ 07712.

RCA model MI-11940 tape drive unit. Need service manual or any other information. James J. Julian, 850 Broad St., Teaneck, NJ 07666.

Howard Communications model 460 receiver and **Hallcrafters** model S53A receiver. Manuals and schematics needed. S. Selowentich, 135 Colfax Ave., Clifton, NJ 07013.

Central Electronics, model 20-A multiphase exciter. Schematic and manual. A. McGinnis, WA2DTQ, 55 Patton St., Iselin, NJ 08830.

Hammarlund model HQ200 receiver. Operation manual, schematic and parts list. William A. Unrath, 134 Grove St., Ramsey, NJ 07446.

Hewlett Packard model 400A vacuum tube voltmeter. Need manual and schematic. J. O. Dickinson, 1408 Monmouth Ct. W., Richmond, VA 23233.

Dumont type 208-B oscilloscope. Schematic and operations manual. C. E. McLellan, Box 575, Clarkson, NY 14430.

AN/USM-32 single trace oscilloscope. Schematics, parts list and service manual. Wayne Murningham, 2700 Eaton Rapids Rd., Lot 228, Lansing, MI 48910.

Precision Apparatus Co., Inc. oscillograph series ES-500. Need schematic and parts list. Sgt. M. E. Rudd, P.S.C., Box 944, MacDill A.F.B., FL 33608.

American Trading Corp., model 8P vhf/uhf monitor receiver. Schematic and manual. A. L. Oliveira, 94 Potomaska St., New Bedford, MA 02740.

Concertone series 90 reel recorder. Operation and shop manual. **Dumont** model 304-HR oscilloscope. Need operation manual. Kent Waterman, 3833 20th St., San Francisco, CA 94114.

Philco model 39-85 radio. Schematic and parts list. Tim Floyd, 3113 N. Norfolk St., Indianapolis, IN 46224.

Mallory model 12V multivibrator. Need several for GE radios. Chuck O'Connor, Box 264, Santa Clara, CA 95052.

E.C.I. Courier 50 FM transceiver. Schematic, parts list and operating manual. W. Person, 135 Roe St., Staten Island, NY 10310.

Zenith model G500 6-band transoceanic receiver chassis 5G40. Need schematic and any other information. D. J. Kluth, 503 E. Skillman Ave., St. Paul, MN 55117.

Dumont oscillograph type 304H. Need instructions, service manual and gratulace. Richard W. Schramke, RD 5, Box 164, Tyrone, PA 16686.

Code-A-Phone model 700 telephone answering machine. Schematic and service manual. W. C. Hoar, 1273 N.W. 9th St., Homestead, FL 33030.

Solo Symphonic model 1113 record player. Schematic and parts list. Robert A. Yetman, Rt. 1, Box 200R, Doniphan, MO 63935.

Scott model 222C stereo amplifier. Schematic and repair manual. E. C. Ozag, 823 N. Marion, Oak Park, IL 60302.

U. S. Navy model R-4A/ARR-2 aircraft communications receiver. Jason Spitzer, 437 Carrillo St., Santa Rosa, CA 95401.

Concord model F-140 stereo cassette recorder. Parts list and schematic. Roy P. Swauger, 104 Valley Drive, Bridgeport, WV 26330.

Dumont model 304H oscilloscope and model 264A voltage calibrator. Need operations manual, schematic or any other information. John R. Stephenson, 6057 Pemecia St., Jacksonville, FL 32210.

Hallcrafters model S38 receiver. Need operating instructions and manual. C. E. McLellan, Box 575, Clarkson, NY 14430.

Heathkit model V-7A VTVM. Schematics and operating instructions. **Knight** model KG-680 capacitor checker. Scott Silva, Box 2394, Orcutt, CA 93454.

Supro model S6698 guitar amplifier. Schematic and parts list. W. D. Chupp, 806 "F" Lane, Elkhart, IN 46514.

Concertone model 302-D stereo 4 track tape deck. Need schematic, parts list and repair manual. Bill Szarek, 6515 Spring Rose, San Antonio, TX 78249.

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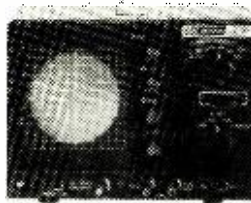
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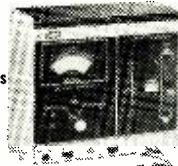
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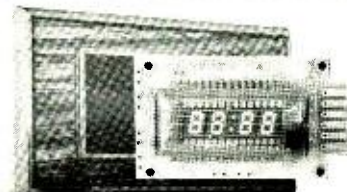
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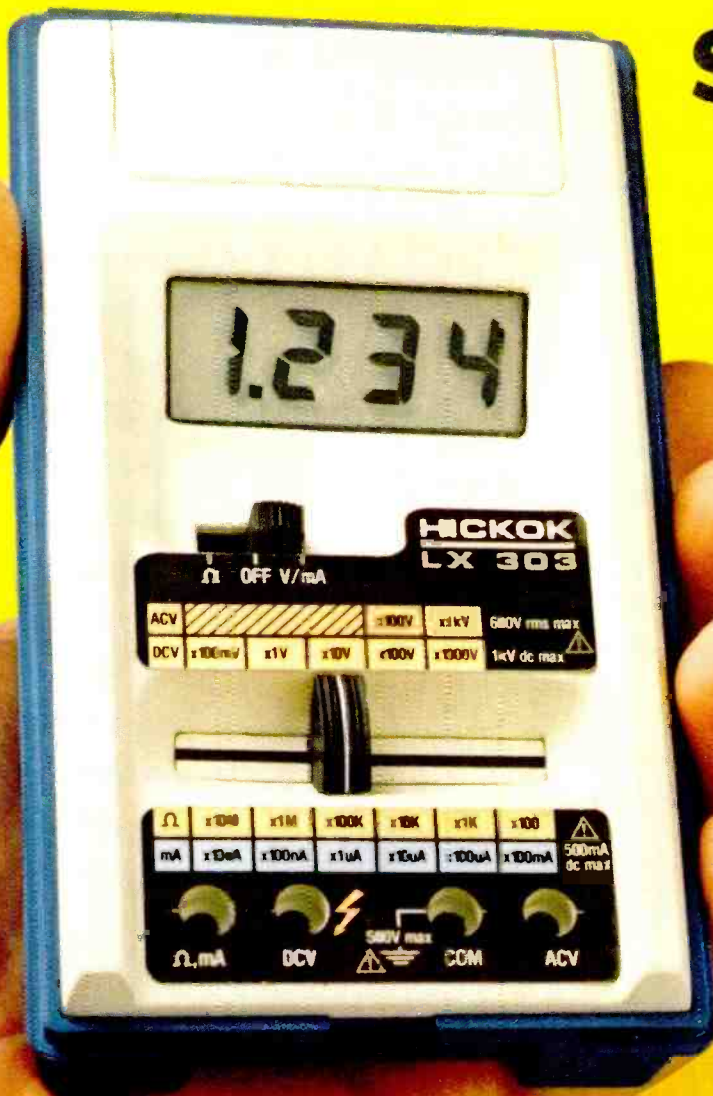
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