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Popular Electronics

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

MAY 1977/$1.25

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- HIRSCH-HOUCK LABS EXAMINES:
  SENNHEISER'S WIRELESS STEREO HEADPHONES
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FOR COMMUNICATION HOBBYISTS

- MORSE CODE ALPHANUMERIC READOUT ON TV
- TESTING KENWOOD'S DIGITAL HAM TRANSCEIVER

HANDS-ON REPORT FOR EXPERIMENTERS

- THE NEW "NO CAMERA" PC BOARD KITS

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MAJOR PROJECT BREAKTHROUGH

THE CATS TO CATCH.

"Roar Power" puts these new 40-channel CB's from Pearce-Simpson out in front. The Lion 40™ and Tiger 40™. Built with all the power and prestige you'll ever need in the CB jungle. As well as some advanced Pearce-Simpson features that command real attention. Like HetroLock™, for zeroing in on the right frequency. Receiv-O-Slide™ tuning for the best reception and superior adjustment of signals (even from "off-freq."sets). And the Lion's bold new LED digital read-out.

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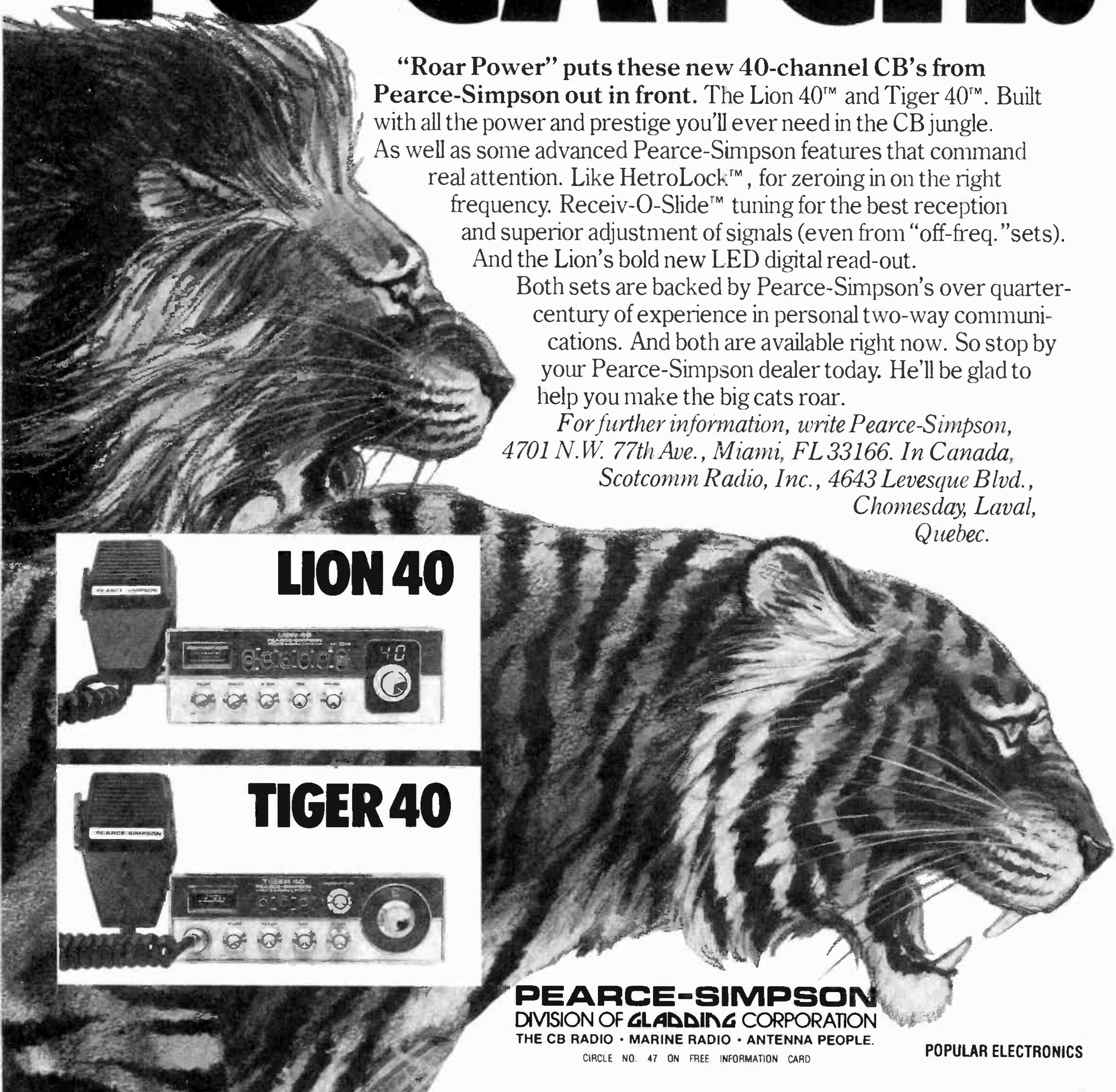
For further information, write Pearce-Simpson, 4701 N.W. 77th Ave., Miami, FL 33166. In Canada, Scotcomm Radio, Inc., 4643 Levesque Blvd., Chomesday, Laval, Quebec.



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MAY 1977 VOLUME 11, NUMBER 5

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ELECTRONIC PRODUCT TEST REPORTS

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Editorial

THE CB CROSSOVER POINT

I felt the pulse of the CB industry this past February at the second annual Personal Communications 2-Way Radio Show, where some 380 manufacturers exhibited their newest CB transceivers, antennas and accessories. It was strong, though beating a little slower than in the recent past. Clearly, the crossover sales point from 23-channel CB transceivers to 40-channel units had not yet been reached in February, although indications are that it will have happened by the time you read this.

A transition period is, of course, a natural state of events, especially when the old and the new are running side by side, with the former sold at spectacular discounts. What we were watching at the PC-77 trade show was "tomorrow," while "today" was having its last hurrah in the marketplace. Making my way through the exhibit hall, I became aware of a few 40-channel misconceptions shared by some dealers and distributors—and perhaps passed on to their customers. Two of them were: 40-channel CB transceivers only produce two watts of r-f output power and they exhibit inferior modulation. Both are fallacious, of course!

Now, really, there is simply no reason why, given good design, expanding a band of frequencies a paltry 150 kHz should influence r-f power output or modulation capability. Sure, a warmed-over 23-channel design that exhibited poor automatic modulation limiting to begin with won't be able to hack it, though passing FCC type-acceptance tests. (These are actually being performed now. The "good old days" of passing tests by submitting paper results to the FCC are over, thankfully). However, we've tested enough new 40-channel rigs to verify that they can provide as much r-f carrier output power and modulation throughout the new, expanded band as the 23's. Moreover, the new rigs are decidedly less prone to overmodulate owing to improved modulation limiters. This means fewer cases of voice distortion and, more important, less splatter to interfere with adjacent channel communication.

Interestingly, the foregoing points were emphasized by a major CB radio manufacturer at a Show press meeting. Furthermore, a spokeman analyzed the signal strength required at the receiver for a standard 10-dB signal-to-noise ratio in a typical urban environment to illuminate another advantage for 40-channel rigs. Assuming a typical receiver sensitivity of 0.5 microvolts for 10-dB (S + N)/N, about 14.5 microvolts of *additional* signal strength is required for the current 23 channels to make the standard due to interference from on-channel users; 15 microvolts more at the receiver is needed to combat adjacent-channel interference, for a total of 30 microvolts. In contrast, the upper new channels require only a total of 1.5 microvolts to receive an intelligible communication, the manufacturer estimated.

As a consequence of the above, the communication range with the upper new channels is estimated to be four times that of the lower 23 channels (30 microvolts/1.5 microvolts = 20 times = 26 dB). Typical area coverage on the new channels (actually, 80% of the upper new ones, since some are still within splatter distance of the original 23) would, therefore, be enlarged about 16 times.

For CB'ers trying to get through during rush-hour traffic, the upper 17's on a 40-channel AM rig might be considered to simulate the effectiveness of single sideband on one of the less popular lower 23 channels. So, though 23-channel transceivers are tremendous bargains (and hard to resist), right now, 40 channels is the way to go to fully appreciate the utility of the citizens band.

Art Salsberg

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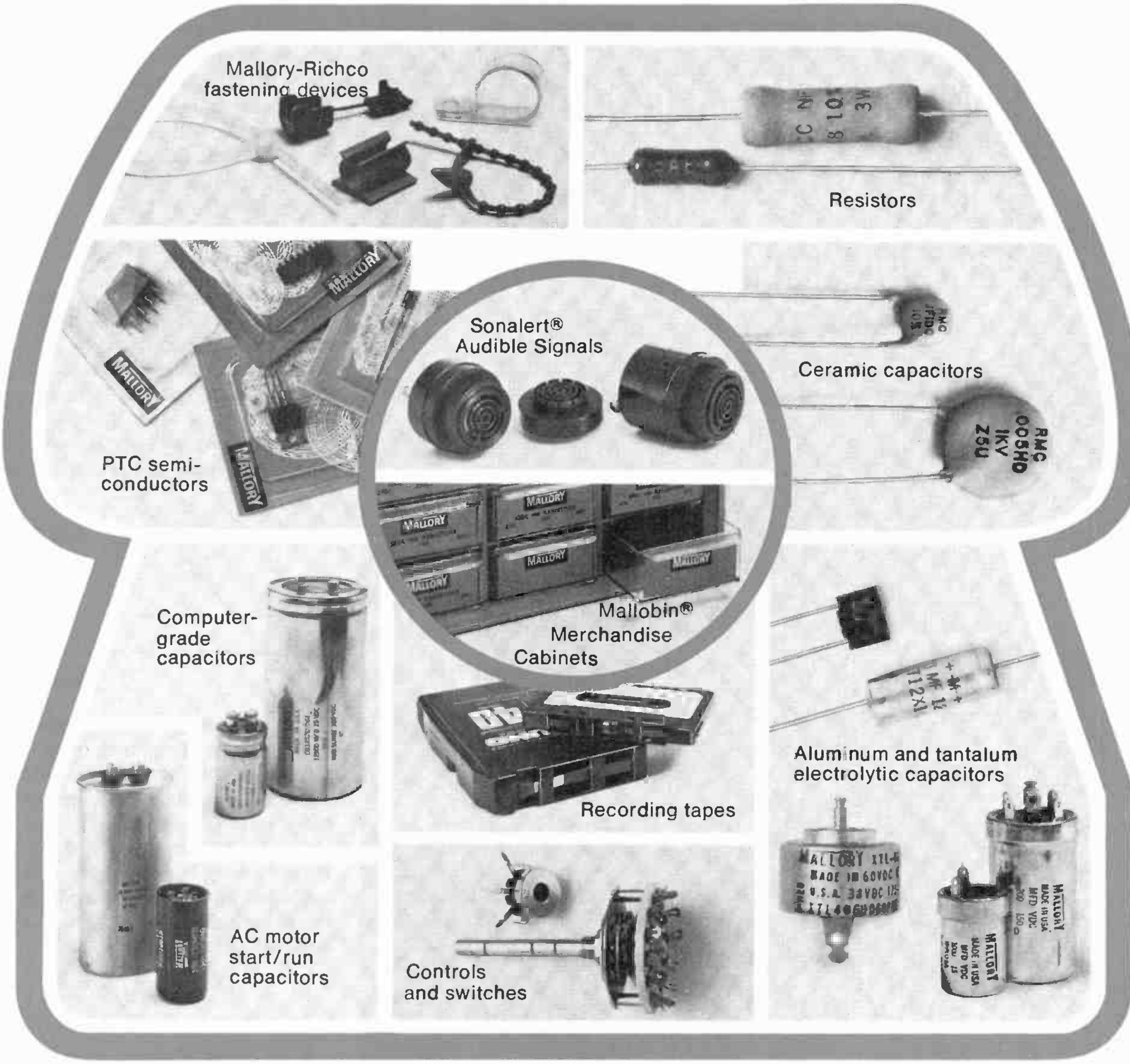

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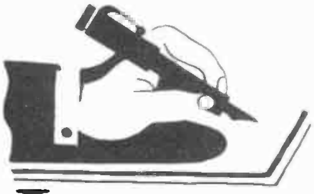


Letters

ABOUT PC ARTWORK

I recently tried, for the first time, GC Electronics' new Lift-It direct-art pc kit and have a few questions I hope you will answer. First, if I attempted to use the Lift-It master to directly expose positive-resist-treated pc blanks, would it work? I fear that the black ink will not have the density required to block out light. Secondly, if the Lift-It artwork would work, what are chances for POPULAR ELECTRONICS to print the pc etching and drilling guides as negative artwork so that one-timers like me could use commonly available negative resist without having to reverse the exposure mask? —*Warren D. White, Berkeley, CA.*

We have used the Lift-It artwork directly to expose presensitized pc blanks with a high degree of success. During our experience, we have not had one instance where the ink was not dense enough to exclude light. (For detailed information about the Lift-It kit and another direct-art kit from Datak, see the feature article in this issue.)

As for printing our pc etching and drilling guides as negative artwork, we have anticipated you. As you can see, beginning in this issue, our pc artwork is now printed in the negative format. We have taken this step because a recent survey revealed that almost all spray-on photoresist available to the hobbyist is the negative variety (although GC Electronics does sell a positive photo-resist). By printing our pc artwork in negative format, readers can save at least one step in the board fabrication process.

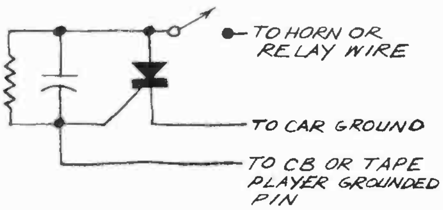
CONSTANT VERSUS VARIABLE

I believe that the explanation of dual-slope analog-to-digital conversion on page 37 of the "Multimeters For Electronics" story (February 1977) is incorrect. The T_1 to T_2 time period is a constant—a specific number of oscillator pulses—not a variable as stated in the text. —*David E. Purdy, Philadelphia, PA*

You're correct. It's the T_2 to T_3 time that's the variable.

SIMPLE TO SIMPLER

The SCR trigger circuit for possible use in protecting CB and other electronic equipment in automobiles shown in the January 1977 CB Scene can be further simplified when applied to CB transceivers. This is particularly true in the case where the rig has a three-prong plug for the 12-volt line and one of the prongs is not used. In my circuit (see below),



note the elimination of the relay. Wire #3 goes to the unused prong of the plug, while the unused contact in the mating female connector goes to ground. Removal of the power cable or physical removal of the CB rig or tape recorder from the vehicle will trigger the vehicle's horn. From actual experience, I can attest that the circuit has paid for itself in value of equipment protected. —*Robert B. McKinley, Jr., Tinton Falls, NJ.*

AMPLIFIER DIAGRAMS SWITCHED

In my article "Classes of Audio Amplifiers" (March 1977), the diagrams for Figs. 5 and 6 have been interchanged. The captions are correct.—*Len Feldman.*

SILENCER PC BOARDS AVAILABLE

Although no source was given for pc boards in my article "Build a Silencer" (March 1977, p 57), they are available from me at the following address: Ronald Miles, Rte. 1, Box 190, Rustburg, VA 24588. Price is $4.60 per board. Virginia residents, add 4% sales tax.

Where do the pros get their training?

Almost half of the successful TV servicemen have home study training and with them, it's NRI 2 to 1.

It's a fact! Among men actually making their living repairing TV and audio equipment, more have taken training from NRI than any other home study school. More than twice as many!

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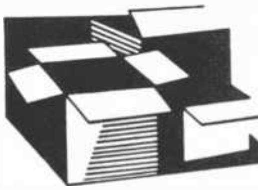


New Products

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

PRESIDENT 40-CHANNEL CB TRANSCEIVER

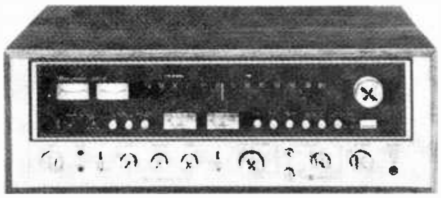
The "Zachary T" 40-channel CB AM base-station transceiver from President Electronics features a new automatic speech compression circuit and a PLL in the frequency synthesizing system. The compressor is designed to provide consistent high-level modulation, while the PLL circuit is said to provide

better on-frequency response than is possible with a conventional synthesizer. Selectivity is rated at −65 dB. Controls include volume, r-f and mike gain, anl (with manual override) and PA/CB switches. Also on the front panel is an S/r-f meter. Back-panel jacks provide for both ac and dc power input, antenna connection, and hookup of PA and external speakers. The earphone and mike jacks are up front. The transceiver also features a LED numeric channel display. $249.95.

CIRCLE NO. 92 ON FREE INFORMATION CARD

SANSUI HIGH-POWER STEREO RECEIVER

Sansui's high-power Model 9090DB AM/stereo FM receiver is rated at 125 watts / channel (8 ohms) minimum rms at no more than 0.1% THD. The power amplifier is direct-coupled throughout, with fully complementary parallel push-pull OCL circuitry. Twin power meters provide convenient output power monitoring. Built in is a Dolby noise reduction system that can be used for both encoding and decoding for full flexibility. The tuner section features a PLL IC multiplex demodulator



that provides improved stereo separation on FM. FM sensitivity is rated at 9.8 dBf (1.7 μV) and capture ratio and alternate-channel selectivity are rated at 1.5 and 85 dB, respectively. A front-panel microphone jack, with its own level control, permits mixing any selected source with the microphone signal for use in PA systems. $750.

CIRCLE NO. 93 ON FREE INFORMATION CARD

CIBCO CB PERFORMANCE MONITOR

A constant CB performance indicator that features light-emitting diodes for easy monitoring of SWR and transmitter output power is available from CiBco Division of Southwest Factories, Inc. The Model CPi II in-line monitor employs a green LED that indicates trans-

mission output of 3.5 watts or more. A red LED comes on when reflected power exceeds a 1.8:1 SWR. (The red LED doubles as a speech modulation indicator.) Indications are produced automatically by pressing the microphone switch. In case of trouble, the red LED flashes an immediate warning. Hence, shorting or theft of the antenna is immediately evident, preventing damage to the output transistors in a CB transmitter. The monitor comes with a PL259 connector for easy installation between transceiver and antenna. $19.95. Address: CiBco Div., Southwest Factories, Inc., 3801 Willow Springs, Oklahoma City, OK 73112.

MICRO-ACOUSTICS PHONO CARTRIDGE

The Model 282-e stereo phono cartridge from Micro-Acoustics has a unique design that is said to enable it to track warped records 25% better than competitive cartridges. It is also said to be immune to the effects of cable ca-

pacitance and not to be tonearm sensitive. The cartridge is fitted with a 0.002 × 0.007 mil elliptical diamond stylus. Frequency response is rated at 5 to 20,000 Hz ±2 dB, tracking force range at 0.75 to 1.5 grams, separation at nominally 25 dB at 1000 Hz (15 dB at 10,000 Hz), and output voltage at 3.5 mV/channel at 5 cm/s peak recorded velocity. Load requirements are not critical and can be anywhere in the range from 10,000 to 100,000 ohms. Similarly, cable capacity is not critical at 100 to 1500 pF.

CIRCLE NO. 94 ON FREE INFORMATION CARD

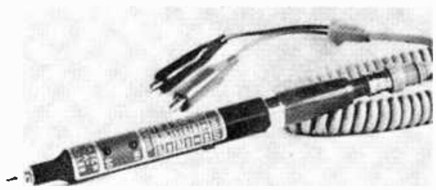
AMI MICROCOMPUTER KIT

American Microsystems, Inc., is offering its S6800 μP in kit form for computer hobbyists. The top-of-the-line Model EVK 200 kit contains all necessary components for complete construction, including a preprogrammed ROM for system monitor and general software utilities. Only a power supply and suitable I/O devices are required for operation. Level-control circuitry, baud-rate generation (50 to 9600 baud), and adjustability are built into the basic board. The CPU is the AMI S6800 eight-bit chip, with an instruction execution of 2 μs and memory access time of 575 ns. The system provides four available interrupt vectors and three types of DMA. A 1-MHz clock provides a 100-μs and 1-ms timer. Also on-board are the I/O interfaces and an EPROM programmer (EPROM device included). $495. (Also available fully assembled as Model EVK 300 for $765.)

CIRCLE NO. 95 ON FREE INFORMATION CARD

AVR LOGIC PROBE

The Catch-A-Pulse logic probe from AVR is compatible with RTL, DTL, TTL, CMOS, MOS, and with microprocessors using 3.5-V to 15-V power supplies. Thresholds are automatically programmed for multi-logic-family operation. The memory circuit for single or



multi-pulse detection resets automatically. LED's indicate high and low levels, open-circuit logic, and pulses. Designed for carrying in a shirt poscket, the probe has a protective cap for the top, and a removable coiled cord. $24.95.

CIRCLE NO. 96 ON FREE INFORMATION CARD

KOSS ELECTROSTATIC STEREOPHONES

The Model ESP/10 electrostatic stereo headphones made by Koss plug into an electrostatic energizer unit that can be operated on as little as 25 watts of continuous power per channel. The energizer, which accommodates two sets of headphones, has semi-

peak-indicating level meters and features an automatic overload device that protects against excessive audio input levels. The LED indicator glows when the protection circuit is activated and shuts off the energizer. Once the protection circuit is activated, it keeps the energizer shut off for 3 to 4 seconds after the excessive level drops to a safe value. $300.

CIRCLE NO. 97 ON FREE INFORMATION CARD

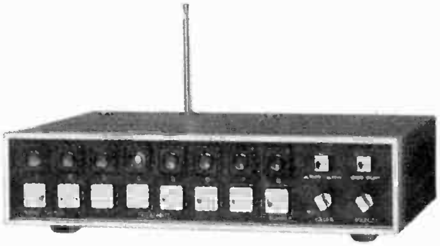
MAYCOM CB MOBILE ANTENNAS IN COLOR

Riotous Red, Lily White, Big Blue, Sand Tan, Cat Black, Down Brown, Grimly Gray, Machine Green, and Yellin' Yellow are the colors of a new line of CB "Colorwhip" mobile antennas from MayCom. The antennas and mounts can be purchased in matching or mixed colors to complement or coordinate with the vehicles on which they are installed. The patented fiberglass whips come in 4′ and 6′ (1.2 and 1.8 m) lengths with top-loaded, helically wound radiators, plastic sheaths, and chrome-plated brass ferrules. Prices are $10.25 and $11.25, respectively. No-drilling Model GW-7 trunk mounts are also available in color for $13.45.

CIRCLE NO. 98 ON FREE INFORMATION CARD

HEATH HIGH-BAND SCANNING RECEIVER

The Model GR-1131 high-band scanner from the Heath Company monitors any combination of eight channels in the "emergency-services" public-safety band between 146 and 174 MHz, including those from the U.S.



Weather Service. The receiver scans each channel, stopping at any that is active, and resumes scanning after the transmission. A priority channel feature checks the channel in which the user is most interested every four seconds and automatically switches to it if there is activity there. Features include channel lockout buttons, lighted channel indicators, automatic/manual channel selection, and a four-pole crystal filter for good selectivity. For crowded areas, an optional eight-pole filter is available. Also featured are a built-in telescoping antenna and provision for an external antenna. Ac or 12-volt dc operation. $89.95.

CIRCLE NO. 90 ON FREE INFORMATION CARD

AMP HAND WIRE STRIPPER

AMP Special Industries Hand Wire Stripper employs front-feed stripping action to make short wires easy to strip. A built-in sensor

THE TERMINAL YOU ASKED FOR

CT-64

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Now you can buy it. The terminal that has all the features that people have been asking us to include. The CT-64 has all the functions that you could want in a terminal and they may be operated by either switches, or through a software program.

All cursor movements, home-up and erase, erase to end of line, erase to end of frame, read on, read off, cursor on, cursor off, screen reversal, scroll, no scroll, solid cursor, blinking cursor, page selection and a beeper to warn you of end of page; all are provided for your use in the CT-64.

You may also switch from upper case only teletype style operation to upper-lower case typewriter style operation. You can reverse the field on individual words to highlight them, or you can reverse the whole screen.

CT-64 is complete with keyboard, power supply serial interface and case. A matching 9 inch monitor with coordinated covers is also available to make a complete system.

CT-64 Terminal Kit	$325.00
MM-1 Monitor (assembled)	$175.00

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You are right, it's just what I have been asking for.

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measures the wire and adjusts the tool for optimum stripping action with minimum hand pressure. The tool is molded of lightweight plastic. Wire and cable up to #12 AWG solid or stranded can be cut and stripped by the tool. Paired wires can be stripped simultaneously. $33. Address: AMP Special Industries, Valley Forge, PA 19482.

KEYBOARD VIDEO INTERFACE

The Merlin keyboard video interface, from MiniTerm Associates, provides ASCII characters (20 lines of 40 characters), high-resolution graphics, and optional monitor and editor functions. The two boards include a DMA controller that permits displaying any part of the computer memory. Also, since the display's starting address is software-controlled, the memory segment displayed can be changed with every screen refresh. Dense graphics will display 2k words of memory as 160H by 100V dots; sparse graphics displays 1k as 80H by 100V. Versions of Merlin for Altair, Imsai, Southwest 6800 and Digital Group computers are available at $249.00 kit plus $34.95 for an optional on-board 2k ROM for the monitor and editor functions.

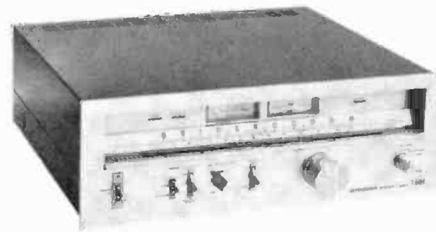
CIRCLE NO. 99 ON FREE INFORMATION CARD

POLYTRON OP AMP DESIGNER TESTER

Designed to help both the beginner and experienced user to experiment with and test circuits containing one or two op amps, the "Dual Op Amp Designer Tester" from Polytron Devices doesn't require any soldering. Components other than op amps can be plugged in. Features include solderless tie points, two 10k potentiometers, four pairs of binding posts, four IC sockets. Model 202 with ±15-V, 100-mA dc regulated power supply is $55; Model 201, using 9-V batteries, is $33. Address: Polytron Devices, Inc., Box 398, Paterson, NJ 07524.

PIONEER AM/STEREO FM TUNER

Pioneer's Model TX-9500II AM/stereo FM tuner has an automatic pilot-signal canceller that minimizes 19-kHz leakage into the audio



section. Featuring both narrow- and wideband operation, it also has a SAW (surface acoustic wave) filter that minimizes adjacent-channel interference. A switch permits using the amplifier/speaker system, minus oscilloscope, to detect multipath reflections as the FM antenna is adjusted. The alternate position of this switch generates a 440-Hz signal every 1.6 seconds (equivalent to 50% FM modulation) for checking the level on a tape deck before recording off the air. Specifications include: 8.8 dBf (1.5-μV) sensitivity in mono; 13.2 dBf (2.5 μV) in mono and 36.1 dBf (35 μV) in stereo 50-dB quieting sensitivity; 77 to 82 dB S/N at 65 dBf; 20 to 15,000 Hz +0.2/−0.5 dB stereo frequency response; and 0.05% to 0.07% distortion in mono at 1000 Hz. $400.

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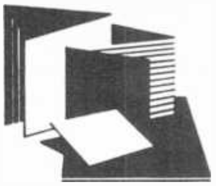


New Literature

VOLTAGE-SURGE SUPPRESSOR CROSS-REFERENCE

A new cross-reference application note, AN504A, for voltage-surge suppressors to protect power semiconductors is available. Over 175 General Electric parts numbers are listed, along with the International Rectifier replacements that are exact mechanical duplicates, including the same power-handling capability. Address: Semiconductor Division, International Rectifier, 233 Kansas St., El Segundo, Calif. 90245.

SEMICONDUCTOR TEST INSTRUMENTS

A 6-page brochure from B&K Precision describes the company's complete line of discrete semiconductor test instruments. Products featured include the Model 530 semiconductor tester with unity-gain frequency measurement up to 1500 MHz. Technical specifications provide data on in-circuit and out-of-circuit tests, applied test currents, indicator, calibration and limiting in-circuit shunt values. Applications for each model are also discussed. Address: B&K Precision, 6460 W. Cortland Ave., Chicago, IL 60635.

GUIDE TO SOLDERING ALUMINUM

A 6-page brochure from Multicore Solders provides information on soldering aluminum. Performance information including a table on the solderability of various wrought and cast aluminum alloys is presented with application and technical data, joint recommendations and soldering techniques. Technical specifications and performance of the company's Alu-Sol 45D are also discussed. Address: Multicore Solders, Westbury, NY 11590.

CB ANTENNA CATALOG

A new catalog SP-4 from Antenna Incorporated describes its line of Citizens Band antennas and accessories. Specifications are provided for each base and mobile antenna with similar styles listed together for easy reference. Replacement parts and accessories are also included. The catalog, Form SP-4, is available from Antenna Incorporated distributors.

VOLTAGE DROP MEASUREMENTS

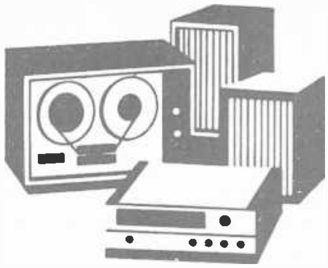
"Forward Voltage Drop Measurements" is the title of Tech Tips 4–6 from Westinghouse. The 3-page article, written to assist in making accurate measurements on power diodes and thyristors that can be used as a quality control check or matching criteria for operating devices in parallel, utilizes a simplified diagram of a test circuit and explains ways to avoid inaccurate measurements caused by pulse widths, duty cycles, peak currents, mounting and measurement techniques. Address: Semiconductor Division, Westinghouse Electric Corp., Youngwood, PA 15697.

EXACT REPLACEMENT GUIDES

Thordarson Meissner, Inc. offers two new cross-reference replacement guides for CB radios and TV sets. "TV Replacement Parts Guide" Form TVPG 9 and "CB Replacement Parts Guide" Form CBRG 2 include 127 new exact electronic replacement products recently made available by the company. Guides are available from Thordarson distributors.

WIRE-WRAPPING AND TOOL CATALOG

Catalog 36G is the new 58-page catalog from O.K. Machine and Tool Corp. which describes its line of Wire-Wrapping tools and machines. Additions to the line, including circuit boards, closures and instrument cases, are described; an illustrated section explains the technology of Wire-Wrapping. Address: O.K. Machine and Tool Corp., 3455 Conner St., Bronx, NY 10475.



Stereo Scene

By Ralph Hodges

THE DECONTAMINATION SQUAD

FOR THE PAST few months (whenever I've remembered to), I've been asking people how they care for their phonograph records. Their replies have been highly individualistic. On the one hand we have the manic camp, systemized to the point where they feel vaguely uncomfortable listening to a record that has not been put through an elaborate cleaning ritual, whether they can hear any noise or not. (I number myself among this group.) At the other extreme are those joyous devil-may-cares who may blow on a disc several times (quite ineffectually, no doubt) as they carry it to the turntable, but otherwise hardly give the matter a thought.

In my circle, almost everyone who takes records seriously owns some sort of cleaning appliance for them. Velvet- or plush-covered pads and specially designed brushes are common (choice of pad or brush seems to depend on intuitive "feel" for the cleaning process), as are Dust Bugs and similar devices. These may or may not be used religiously. I have seen some Dust Bugs so begrimed that their use would probably be a hazard rather than a help to the condition of any decent record, so the benign-neglect approach is not always inappropriate.

Ask the Experts. Why, after all these years, is record hygiene still a matter of guesswork rather than science? The question would be a fascinating one if its answer weren't so obvious. Ask the phono-cartridge manufacturers, whose interest in properly maintained records is readily apparent: "You know, we've always been meaning to look into that. We use the Whatchamacallit, or at least there's one at every testing station, and it seems to do okay. But then again, in the absence of a suitable control sample . . ." Ask the record companies: "All our records are clean and defect-free when they leave the plant, and with reasonable care . . ." In other words, no one—or at least no one who doesn't intend to manufacture a record-cleaning device of his own—has the time to undertake the research necessary. And no wonder, because when you think about it, such a research project turns out to be fairly formidable.

A few hardy types, including some of my eminent colleagues in the press, have made yeomanly attempts to settle the issue in the laboratory. Their tests have generally taken two forms. The first is to play the dirty record, count (somehow) the number and severity of the ticks and pops presumably caused by dirt, then clean the record with the device under test, and play it again to note the improvement, if any. The trouble here is that the very process of playing a record alters its noise content. According to theory, certain dust particles will become embedded in the vinylite material by the stylus pressure—embedded too firmly for removal by any practical cleaning device. Hence the cleaning device under test faces the handicap of working with a record that has already been damaged by being played when dirty. But then, if you go on to play the record several more times, the severity of the "tick" caused by the embedded particle may abate considerably, as repeated passages of the stylus smooth the blight on the groove wall. Play the record with a different stylus and the "tick" may disappear altogether, because the stylus rides lower or higher in the groove.

Testing approach number two involves the visual inspection of the dirty and cleaned record with a high-magnification device such as a scanning electron microscope. Here the problem is that on one hand, you can't be sure that what you do see will cause noise. (Certain particles will be nudged aside or missed by the stylus.) On the other hand, what you can't see may cause noise. (An invisible residue of the cleaning agent may gum the stylus and/or raise the base noise level.) Also, there is the considerable drawback of the time involved in examining the whole record—or even a significant portion of it—with high magnification. And time is critical, because with each passing moment the record acquires a little bit of *new* dust.

Common to both tests are such quandaries as how do you manage to use the cleaning device consistently (most of

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them are hand operated), and how do you establish an adequate control sample of the record. It has been shown repeatedly that "identical" pressings of the same record are far from identical to the stylus and the record-playing environment. According to one theory, the vinylite material of a record takes on a molecular "set" when it is molded, so that the entire disc—or certain random sections of it—acquires a permanent static charge. If the charge distribution varies from pressing to pressing (as it logically should), you have no hope of getting identical pressings.

The Mechanism of Dirty Discs. The laboratory is revealing but not always authoritative about the record-cleaning question. The reported experiences of long-time record users are valuable but difficult to verify. At this point we need a working hypothesis of how records get dirty so that we can consider what *ought* to be done to get them clean again. Surprisingly, there is no universal consensus on the "mechanism" of dirty discs, but here is the theory to which I generally subscribe.

First, there are airborne particles. These settle on the record as they settle on everything, and remain there unless disturbed. Perhaps they are attracted and held in place by some "net" static charge molded into the record. Then there is grosser debris, from the jacket liner or the turntable mat. This is highly visible and hence disturbing, but most of it is too big to penetrate the record grooves and thus is probably harmless. However, its persistent presence suggests that smaller, invisible bits lie within the grooves themselves.

Next comes the record-playing process, which nicely parallels the workings of a Van de Graaff generator. The intimate contact of stylus and groove (much more intimate with the superior tracing and tracking of today's cartridges) builds up some surface voltages on the disc that are probably quite impressive. These are local charges, but they apparently cooperate with any net charges present in various ways. With your record cleaner you can drag a dust particle some inches away from its location on the record surface, only to have it break free and skip back to its precise point of origin.

When the record becomes surface-charged it acts on dust, certain colloids, and anything else available just as an electrophorous acts on a pith ball. The charges give rise to three noise-producing mechanisms. First, they hold dust motes in place where they can be played by the stylus and pounded into the vinyl. No casual puff of breath or swipe of record cleaner will effectively dislodge them. Second, they create noises—sometimes quite alarming ones—in themselves, by freely discharging through the phono cartridge. Cartridges and arms differ in their susceptibility to this, but in a dark room you can often see sparks generated as a record is played, accompanied by loud "bam" sounds through the speakers. In milder cases the static discharges are virtually indistinguishable from noise created by dust contamination.

Third, the colloids attracted by the charges often build up to form a tar-like coating on the grooves that interferes with tracing and ultimately gums up phono styli. The irreplaceable Percy Wilson studied the atmosphere's content of such substances and their effects on discs. Ponder his results for a few minutes and you'll begin to sense the onset of black-lung disease.

On to the Bizarre. More recently, Bruce Maier of Discwasher has documented the effects of fingerprints (always to be avoided) on records, and also raised the subject of certain fungi that subsist on vinylite and that are actually encouraged by the use of some record-cleaning solutions. I was not at all impressed by Dr. Maier's ideas until, several years ago, I visited Singapore, one of the brisker hi-fi markets of today and, being a mere ninety miles from the equator, a miasma of heat and humidity. There, in the home of a prominent audiophile, I saw my first—heaven help us!—*green* record. According to my host, the algae-like growth forms within a few days. He takes his records to the washroom and uses soap and water to combat it. (I noted few other green records in Singapore, so perhaps he was doing something Dr. Maier wouldn't have approved of.)

Getting wet. Many record listeners (Singaporeans excepted) endorse a high-humidity environment as being ideal for the static problem. They place open jars of water beneath their turntables' closed dust covers, or spend a fortune on a large and quiet humidifier. I advise against this. My first reason (another will be discussed later on) is obvious: rust! Back when I could manage long vacations, I summered in a little cottage not twenty-five feet from a quiet seaside harbor. Hardly two years had passed before my tonearm (a cringingly expensive model) began to show characteristic brown stain creeping out of its pivot housing. Most of the arm was aluminum, stainless steel, and/or chrome plated. Unfortunately, the pivot bearings weren't (and few are, for excellent reasons).

Some record-cleaning devices deliberately apply a moisture slick on the record surface and let the stylus plow through that. If there's anything wrong with these appliances (aside from the above) it's hard to detect. In the opinion of some, the stylus cantilever acts as a wick to draw fluid up toward the cartridge. I've never heard anyone complain about this, however. Perhaps what's most suspicious is that the "wet cleaners" tend to remove *all* noise, including that which is molded into the record as groove imperfections. This effect has been ascribed to surface tension, viscosity, and the fact that sound wavelengths are different in water than in air. Or perhaps it's simply a function of the fluid's lubrication. No one seems to know for sure, but a significant number of audiophiles—particularly those with overbright systems—seem to swear by wet playing.

The Author's Approach. I suspected you were interested in my own record-cleaning techniques, and I thought you'd never ask. With the record rotating on the turntable, I begin with an anti-static device such as the Discwasher "Zerostat" pistol, which produces clouds of positive and negative ions when the trigger is squeezed or released. This treatment is simply to release the debris particles being held by static charges, which then can be scooped up by a velvet or plush cleaning pad. (Some claim that such a pad won't scoop unless its bristles are slanted, but my experience suggests that a curvature in the contour of the cleaner accomplishes the same thing as a slanted pile). A little moisture will help the dust particles adhere to the bristles, and I am indebted to a reader for pointing out that open-mouthed breathing on a record will lightly fog it with condensed pure water vapor. So I breathe on the record as I brush.

As the record plays I use a device similar to a Dust Bug, but with a difference. Some years ago, at the height of a very humid summer (remember the objections raised to humidity earlier), I came up against an unaccountable, steady "thththth" sound on a record I knew was intrinsically good and well cared for. What?! Could it be static, encouraged by the high humidity to dis-

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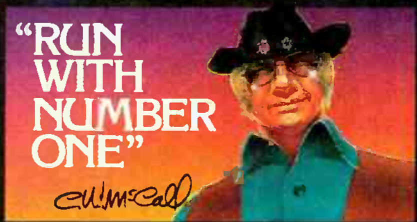

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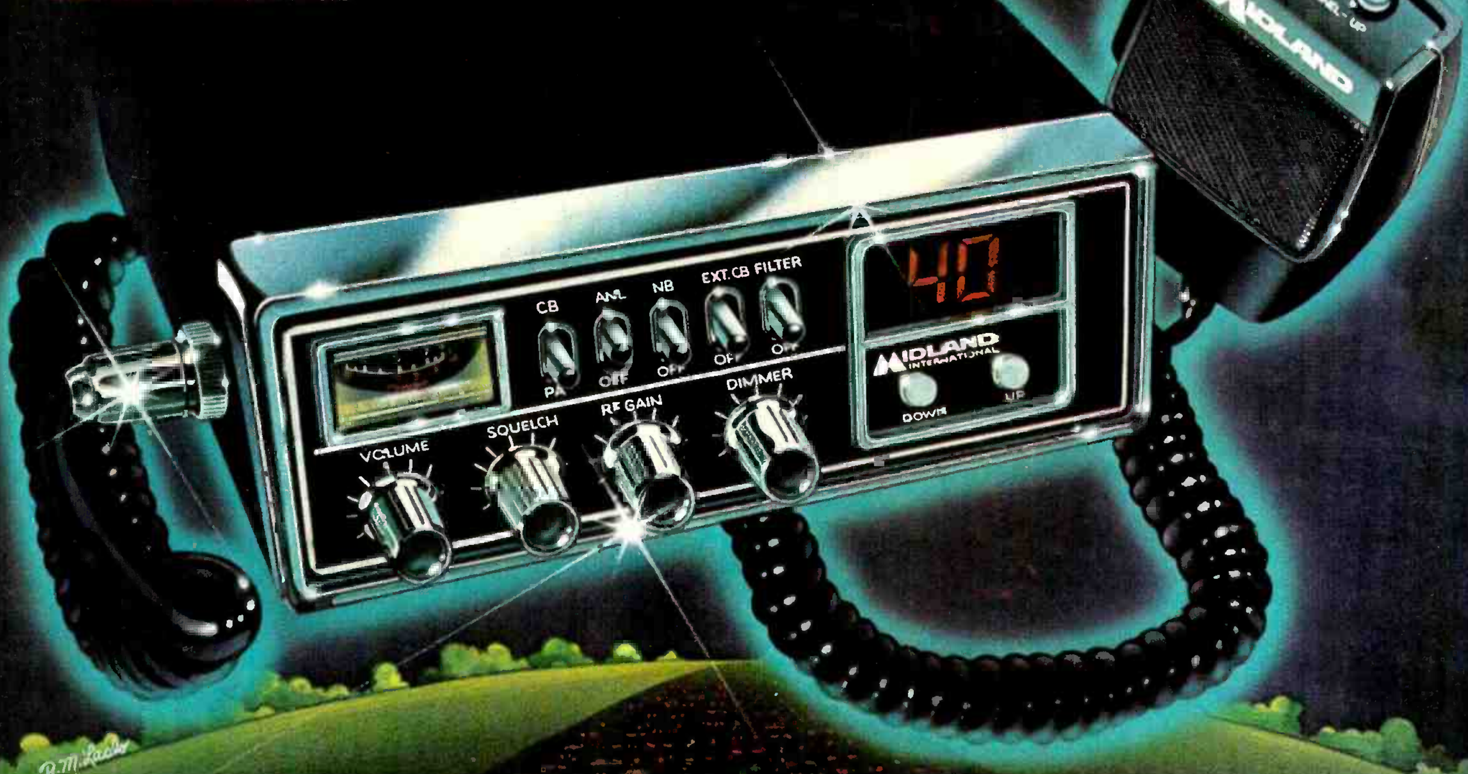

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Shop for these active-living products from Midland International: Medallion Car-Sound Products • Goodwin Sporting Goods • Benchmark Tools • Midland Television • Young World Toys charge through the cartridge in a rather relaxed fashion? Within ten minutes I had acquired one of the record-tracking/cleaning devices that has conductive bristles intended to be grounded at the tonearm or preamp input. To my fascination, I found that the annoying sound disappeared within a few moments of my lowering the bristles to the record surface, and reappeared a few moments after I had raised them. Needless to say, I held onto this contraption, and it has been doing a fine job ever since. This is my idea of how to clean records; I welcome comments.

As long as this article has been, it has left out some pertinent points: the how and whys of stylus cleaning; the efficacy of the new friction-reducing record sprays; the "dust-bug" brushes that come attached to cartridges; the reason some records seem to be more static-prone than others; and the ways in which cartridge/tonearm choice and alignment can effect the annoyance factor of record noise (they can, apparently). I don't have firm responses to any of these (implied) questions, but I do have opinions, which will be forthcoming later on. In the meantime, let me give you several warnings:

(1) Don't rashly buy a record cleaner meant to be used while the record is playing if your turntable has limited torque, as many belt-drive units do. Dust-Bug-type devices are usually okay, but the ones that span an entire LP radius or which are driven off the turntable itself may make it impossible for your record player to get up to speed.

(2) Don't use the turntable's dust cover as a record cleaner. Laboratory tests have shown pretty conclusively that many dust covers provide an excellent path for acoustic feedback. Keep the cover removed or at least raised when you play a record. It is meant only to keep the turntable clean when it is *not* in use, and I don't know of any responsible turntable manufacturer who claims that it is otherwise.

(3) Experiment with anything meant to be applied to a record cautiously. All solvents and even distilled water are suspect with many, although they are beloved by some. When you feel you must evaluate a record-treating substance, dose one half (180 degrees) of a good record with the stuff and leave the other half untreated. At 33 1/3 rpm you should be able to detect the transition from the one side to the other (at 45 rpm things may happen too fast). And be prepared to buy a new record just in case your experiment doesn't work. ◇


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Julian Hirsch Audio Reports

HIRSCH/HOUCK LABORATORIES

HOW HEADPHONES ARE TESTED

MANY PEOPLE are aware, at least in general terms, of some of the effects that room reflections and resonances have on the perceived frequency response of a loudspeaker. For example, the bass response varies widely as one moves about the room, usually being strongest at an opposite wall or corner or close to the woofer, and weakest in the center of the room. High frequencies, on the other hand, are progressively absorbed by room furnishings as one moves away from the speaker. High-frequency level can also change greatly at different angles between the listener and the speaker.

There are ways to circumvent these problems, and even put them to good use, when measuring loudspeaker performance. Most designers, though, choose to test a speaker in an anechoic chamber (a room whose interior surfaces absorb essentially all sound impinging on them, and reflect little or nothing to a microphone placed in the chamber). In this way, the characteristics of the speaker can be determined, free from interaction with its surroundings.

In the case of headphones, the audible results are closely related to the dimensions of the wearer's ear cavity, and the manner in which the earpieces fit the pinna or external ear. These are analogous to the relationship of the room to the loudspeaker. Although anechoic measurements might be possible with headphones, they would be of little practical value since the ear affects the frequency response through the entire audio range.

It is possible to measure headphone response directly on a human head by means of probe microphones inserted into the ear cavity. This is valuable for psychoacoustic and physiological studies, but clearly is of no use to someone wishing to evaluate a headphone. It would be convenient to have a "standard ear," on which any phone could be checked. Even if such an ear were not identical to any specific human ear, it would provide a test bed on which to make comparative headphone measurements.

There are standard artifical ears—several different types, in fact. Some have been shaped to correspond roughly to the external human ear, but others merely present a flat surface to the headphone's ear cushion, with a cavity drilled in the center to expose the end of a calibrated capacitor microphone that simulates the eardrum. This is the basic configuration of the ANSI standard headphone coupler, which we use in slightly modified form for our headphone tests.

The original purpose of the standard coupler was to measure headphone response in the speech frequency range (300 to 5000 Hz). It was recognized that resonances in the coupler cavity would produce severe response changes at higher frequencies. The standard coupler has a 6-cc cavity, simulating the volume of a typical ear. The shape of this cavity is subject to slight modification to suit the particular type of headphone being tested.

Experiments made by Koss Electronics indicated that a good correlation between measured frequency response and the subjective headphone response would be achieved with a slight modification of the shape of the coupler cavity (keeping its volume at the standard 6 cc). The Koss coupler, which we use for our tests, conforms to the 1949 ANSI standard, except for the details of the cavity shape. It is a flat plate coupler into which our test microphone fits snugly. When the headphones are mounted on the coupler stand, the normal tension of the headband provides sealing around the ear cushion of the measured earpiece, equivalent to what would exist with normal wearing.

Although the Koss coupler makes it possible to measure headphone frequency response through the full audible range, it has a few intrinsic high-frequency resonances that make measurements less reliable above 10,000 Hz. Our coupler has been calibrated by Koss, with the aid of a calibrated set of its ESP-9 electrostatic phones. This enables us to check the performance of the test set-up and also provides an absolute calibration of sound pressure level (SPL), since the output of the ESP-9 phones is known at a particular frequency and drive level.

To measure the frequency response of a headphone, it is placed on the coupler and driven from an amplifier whose input is derived from our General Radio frequency-response plotter. The microphone output goes directly to the graphic level recorder input, and the chart reads out directly in dB on the SPL scale (referred to 0.0002 dyne/cm^2). The voltage across the phone is set to a value recommended by the manufacturer (usually in the range of 1 to 3 volts) and a swept response measurement is made using a fast chart speed (25 inches per minute) and moderate pen damping (pen speed, 3 inches per second) to smooth out small variations caused by the coupler.

Distortion is measured at 1000 Hz as a function of applied voltage. The microphone output goes direct-

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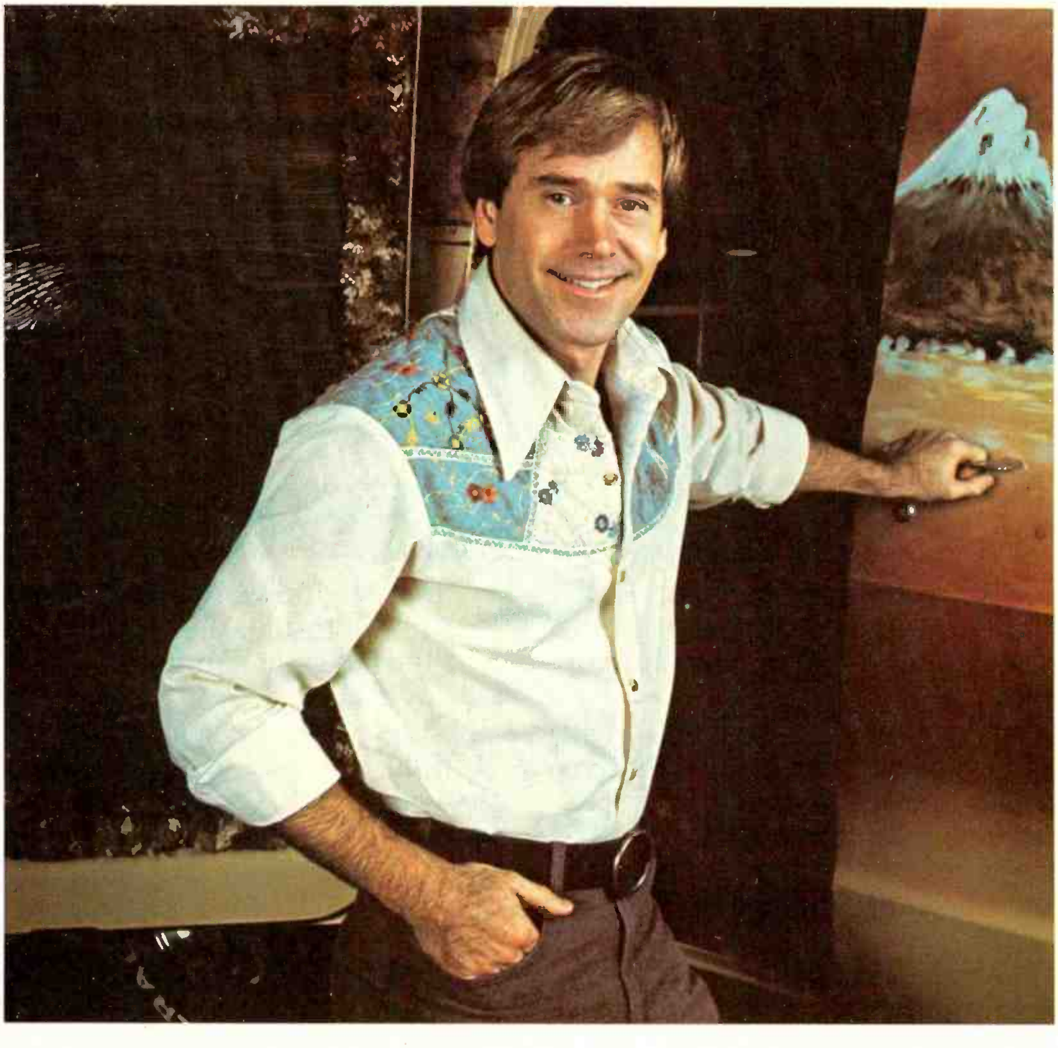

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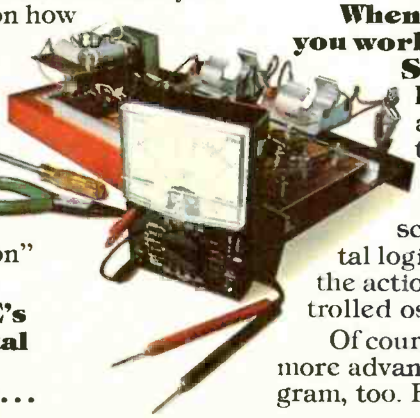

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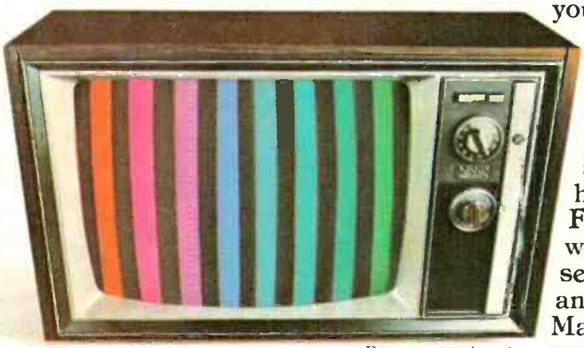

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ly to a Hewlett-Packard 3580A spectrum analyzer, on which all significant harmonic amplitudes can be measured. Impedance is measured by driving the phones through a fairly high resistance and plotting the voltage across them on the chart recorder. The resistance axis of the recorder chart is calibrated against a precision standard decade resistor, substituted for the headphones.

Interpreting the frequency-response curve of a headphone measured in this way is not as easy as we would like it to be. Sometimes the response is relatively flat over most of the audio range, and this is always associated with a phone which has a smooth, natural sound. Sometimes there will be one or more huge peaks (as great as 30 dB in amplitude) in the upper midrange. Such a phone always sounds harsh and unnaturally colored. The difficulty is in the intermediate cases, which comprise the majority of phones. Their response curves often have rather sizable peaks or holes in the range of a few kilohertz. These cannot easily be separated into true headphone response and the coupler response. Many of these phones sound excellent, virtually indistinguishable from some which test much better, while others that are seemingly not too different sound mediocre.

Thus, as with speakers, the only way to buy a headphone is to listen for yourself. With headphones, you have the advantage that the listening room is not a part of the equation, so the phones will sound the same in your home as at the dealer's showroom. Since the physical "fit" of a headphone can be as important as its sound, a personal selection is highly desirable. Test reports can be a guide to those phones that are worthy of your consideration, but response curves should never take priority over the judgment of your own ears.

SENNHEISER MODEL HDI 434 INFRARED HEADPHONES

Cordless headphones provide unfettered personal listening.

HIRSCH-HOUCK LABS REPORT

With these innovative, cordless, stereo headphones, the listener can be free at last from the tether that attached him to the headphone jack. In the past, most attempts at designing cordless hi-fi headphones failed to meet the high quality sound needs of the home listener. The various cordless approaches tried were plagued by poor sound quality, high noise levels, and inability to handle stereo program material. The new Model HDI 434 infrared stereo phones from Sennheiser have solved most of the technical problems.

The Model HDI 434 is actually a headphone "system" that consists of rather large (but lightweight) phones and a separate infrared transmitting unit. No physical connection is needed between the phones and transmitter, nor are there antennas or other appendages on the phones themselves. The only link between the phones and the transmitter is an invisible infrared beam. The transmitter plugs into the headphone jack of any amplifier, tuner, or tape deck.

The infrared transmitter measures 8"W × 3.15"D × 0.7"H (20.3 × 8 × 1.8 cm), and the headphones weigh 13.5 oz (420 g) including battery. Prices: $209 for the Model HDI 434 phones and $184 for the SI 434 infrared transmitter.

General Description. The earcups of the headphones house magnetic open-air drivers. The earcups are designed to provide little or no isolation from external sounds. The semirigid headband has a padded adjustable inner band that rests on the user's head.

On the rear of the right earcup are a pair of slide-type controls for separately adjusting the volume levels in the two earcups. A slide-type switch allows selection of normal stereo listening, channel-A mono through both earcups, or channel-B mono through both earcups. A separate switch controls power to the headphones from its own 9-volt battery. The left earcup has no controls; it houses the battery that powers the phones. A clear plastic on the front edge of the right earcup protects an infrared sensor that picks up the invisible beam radiated by the transmitter.

Across the front panel of the transmitter is a row of 12 light-emitting diodes (LED's) that generate the invisible infrared carrier beam. A separate LED, located at the far left of the panel, is used as the power-on indicator for the line-powered transmitter. The pushbutton power switch is located at the far right of the front panel.

You may have noticed that few turntable manufacturers call your attention to the critical role of the tonearm in record playback. Dual is an exception.

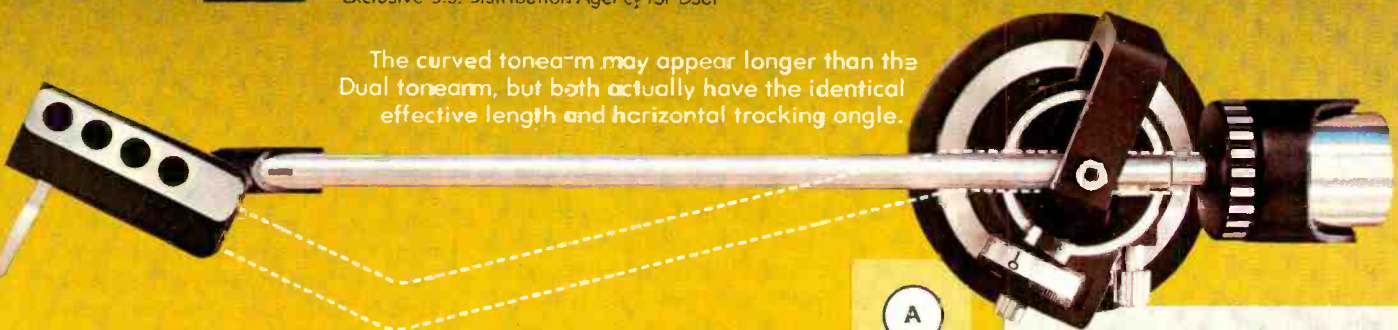
Whatever the shape, materials, or mechanics of a tonearm, the goal is always the same: to maintain the cartridge in the correct geometric relationship to the groove, and to permit the stylus to follow the contours of the groove walls freely and accurately. Wherever the stylus cannot follow the groove undulations, it will gouge its own way. And as we have frequently reminded you, there is no way to repair a damaged record. Every tonearm designer should consider geometry, mass, balance, resonance, bearing friction, and the accuracy and stability of settings for stylus force and anti-skating. However, despite the simple fact that the shortest distance between two points is a straight line, some designers are more concerned with appearance. Hence, the curved tonearm, whose deviations between pivot and stylus simply add mass, reduce rigidity and increase the likelihood of resonance.

Why we want you to know more about tonearms. And why others may not.

Dual engineers have always designed for optimum performance. The essential differences in approach and results are indicated below. You might keep all this in mind when you are considering your next turntable. Chances are you'll want it to be a Dual.

Dual

United Audio Products, 120 So. Columbus Ave. Mt. Vernon, N.Y. 10553
Exclusive U.S. Distribution Agency for Dual



The curved tonearm may appear longer than the Dual tonearm, but both actually have the identical effective length and horizontal tracking angle.

A

B

Actual size of Dual tube (A) and typical curved tonearm (B). For the same effective length, straight Dual tonearm has lower mass and resonance, yet greater rigidity.

Dual 1249. Single-play/multi-play. Belt-drive. Fully automatic start and stop, plus continuous repeat. Mode Selector parallels tonearm to record in single-play; 6% pitch control; illuminated strobe; cue-control viscous-damped in both directions; multi-calibrated anti-skating. Less than $230.

Dual 510. Similar except semi-automatic. Lead-in groove sensor. Tonearm lifts automatically at end of play and motor shuts off. Less than $200.

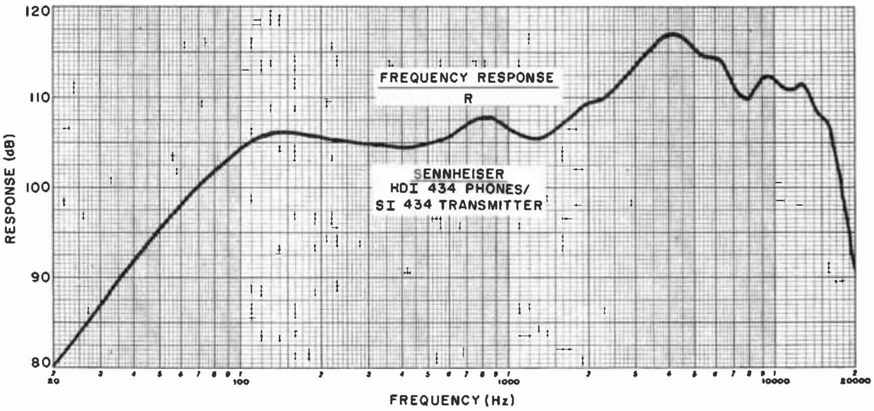
Dual 502. Semi-automatic. Less sensor strobe and pitch-control. Less than $160.

Gimbal-mounted Dual tonearms pivot horizontally and vertically on identical sets of pivot points and high-precision low-friction bearings. Bearing friction: vertical, <0.007 gram, horizontal, <0.015 gram.

Stylus force, applied by long coiled spring around vertical pivot, remains perpendicular to record even if turntable is not level.

Specifications (DIN B): Rumble, >66dB; Wow and flutter, <±0.05%

CIRCLE NO. 4 ON FREE INFORMATION CARD



Overall frequency response of headphones and transmitter.

In operation, the transmitter is placed in a location where its beam will cover the preferred area of the listening room. Then, with the headphone worn in the usual manner, the stereo program is heard just as with conventional headphones. The big difference here is that the listening volume is set by the slide controls on the right earcup.

It is important to have a sufficient, but not excessive, modulation level driving the transmitter. This is accomplished by turning up the volume control of the audio component that drives the transmitter until the glowing LED on the latter suddenly begins to flash, and then backing off slightly until the flashing just ceases. Thereafter all volume level adjustments are made by operating the controls on the phones.

The stereo program is carried over the infrared beam on two subcarrier frequencies—95 KHz for the left channel and 250 kHz for the right channel. The specifications call for a 30-kHz deviation at 1-volt input to the transmitter and 50-kHz deviation at the 1.5-volt maximum allowable input. The headphones contain two FM discriminators that are tuned to the subcarrier frequencies and are capable of demodulating signals with deviations as great as 50 kHz.

The specifications for the phones call for a frequency response of 20 to 20,000 Hz (no tolerance given) with less than 1% THD at 1000 Hz (at an unspecified level) and a maximum output capability of 108 dB SPL. The S/N ratio is rated at approximately 60 dB, and estimated operating life of the standard 9-volt battery is 100 hours.

Laboratory Measurements. We tested the acoustic performance of the phones on a modified ANSI headphone coupler in the usual manner. The transmitter was placed a few feet from the headset and driven directly from our General Radio response plotter. Having determined that a 1-volt drive level to the transmitter resulted in spurious "birdies" at frequencies beyond 12,000 Hz, we reduced the drive to 0.5 volt for the response measurement.

The midrange response was very flat, varying only ± 1.5 dB from 100 to 1700 Hz. The output rose at higher frequencies and was at or above the midrange level all the way up to our measurement limit of about 16,000 Hz. The low-frequency output, as is usually the case with open-air headphones, dropped off at a 12 dB/octave rate below 100 Hz. The midrange SPL was about 105 dB, or 111 dB at the recommended maximum operating level of 1 volt.

The overload indicator glowed at a 1.15-volt input with frequencies of 1000 Hz or lower. Overload occurred at smaller signal voltages at high frequencies, reducing to 0.43 volt at 10,000 Hz and 0.32 volt at 15,000 Hz. The distortion of the acoustic output of the headphone was less than 1% for drive levels up to about 1 volt at 1000 Hz. With the phone's volume controls set to maximum, the distortion increased abruptly above about 1.2 volts. This was apparently due in part to overdriving the headphone amplifiers, since reducing the setting of the volume controls by 10 dB resulted in a more gradual increase in distortion, to 2% at 1.8 volts and 3.4% at 3 volts. Distortion is not a problem when using the phones, since it became appreciable only when the SPL exceeded a very loud 110 dB.

The S/N was measured relative to the output at 1000 Hz with a drive level of 1.15 volts. Wtihout weighting, the S/N was 40 dB, and with CCIR weighting it was 54 dB. The stereo channel separation reduced with increasing frequency, from 40 dB at 100 Hz to 21 dB at 3000 Hz. It remained in the 18-to-21-dB range from 3000 to 15,000 Hz. The electrical impedance of the transmitter input was 100,000 ohms up to about 1000 Hz. It decreased to between 13,000 and 25,000 ohms in the 10,000-to-20,000-Hz range.

User Comment. Considered only as stereo headphones, we would rate these on a par with other Sennheiser phones we have tested. They are excellent, producing a clean, wide-range, transparent sound that could not be distinguished from conventional phones.

The listening volume was most satisfactory, and we heard no background hiss or other noise that was not in the program material. In other words, the

Editor's Note: The listening experience with these infrared phones may differ according to the environment and the placement of the transmitter. For example, using the same new Sennheiser phones in a large (25 ft × 19 ft × 8 ft) wood-paneled listening room in the editor's home, a person standing in front of the transmitter or the headphone wearer did *not* change the sound quality received by the phones when the infrared transmitter was positioned near the corner of the room (a position also tried during Hirsch-Houck tests). Furthermore, in this position, headphone reception was not at all marred by noise when turning a head or even one's back so that the phone receiver's single sensor was facing away from the transmitter. Nor was there any change in sound when a cigarette lighter was flicked, a pipe lighted, or pipe smoke blown by the headphone user. Moreover, the signal-to-noise ratio did not even exhibit an apparent change when the user walked into a hallway off the listening room so that he was *behind* the transmitter. Turning one's head in this area, however, did cause a high level of noise to occur, as did standing under a strong spotlight.

It should be mentioned, as a footnote, that this listening room has angled ceilings emanating from four-foot-high paneled walls and rising to a flat plasterboard ceiling surface. In contrast, Hirsch-Houck's ceiling is constructed with acoustic panels. These differences evidently account for the contrary results in infrared reception. It's obvious that, in the editor's home, the environment enhanced reflections of the infrared beams. As a consequence, the performance of these infrared stereo phones was superb with no reservations whatsoever.

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Ask a trucker about the best antenna team for your CB operations. He knows the Citizens Band. And he knows the performance of Shakespeare's Double Trucker Antenna. Because the men who ride for a living can't settle for anything small-time in their signal power.

Those two solid fiberglass whips stand firmly upright for maximum range and clarity. Perfectly co-phased through Shakespeare's exclusive Diplexer phasing harness. Pre-tested and pre-tuned for the 40 channel band. Delivering the kind of performance true Knights of the Road depend on.

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Shakespeare Company, Antenna Group, P.O. Box 246, Columbia, S.C. 29202. In Canada: Len Finkler, Ltd. Ontario.

CIRCLE NO. 58 ON FREE INFORMATION CARD

S/N of the infrared system was at least as good as that of the FM and commercial phonograph records we used for program sources.

The transmitter evidently radiates a fan-shaped pattern into the room, which does not reflect from room boundaries to any significant extent (unlike ultrasonic remote-control devices, whose output can be "bounced" off a wall to reach around a corner). This means that the phones must be in a direct line of sight with the transmitter, although distance does not seem to be a problem. (We covered 30 feet or more without difficulty.) However, if someone walks between the listener and the transmitter, the signal drops markedly or disappears altogether, delivering a burst of noise like that of an unmuted FM tuner when the signal drops out. Interestingly, a crackling sound occurred when the listener flicked a flint-type lighter, followed by noise when the lighter's flame appeared.

If one turns away from the transmitter, or even to the side so that the left ear is closest to the transmitter, however, a loss of signal is likely to occur. We found this in some ways to be restrictive, although one quickly adjusts to the minor limitation. This occurs because the receiver sensor is on the front of the right earpiece. The answer, it would seem, would be to either place a sensor on each earpiece or mount a single one at the top of the rigid headband to prevent shadowing of the receiver as the wearer moves or turns.

Aside from the above, we were highly impressed with the concept used by these phones, as well as its execution. The system does a remarkably fine job without excessive weight or bulk. True, they are among the most expensive headphones you can buy, but they also do things that no other phones can. One simply has to experience the wonderful feeling of not being tied down to a headphone's umbilical cord to appreciate it. And, the sound is truly superb.

CIRCLE NO. 101 ON FREE INFORMATION CARD

TEAC MODEL PC-10 CASSETTE RECORDER

Portable stereo recorder has performance characteristics of home component types.

HIRSCH-HOUCK LABS REPORT

The Model PC-10 portable cassette recorder is part of Teac's new "Esoteric" line. It is one of the new breed of true high-fidelity portable stereo recorders with all the features and performance quality expected of deluxe home cassette decks. It comes with a separate ac power supply for line operation and can be operated in the field from six D cells that fit within its case.

The recorder measures 11½" W × 9½" D × 3½" H (29.2 × 24.1 × 8.9 cm) and weighs 11 lb (5 kg). Nationally advertised value is approximately $500.

General Description. The recorder features a direct-drive dc capstan motor that is servo-controlled through a phase-locked loop (PLL). This eliminates belts and flywheels; it starts up and brings the transport to final operating speed rapidly. (There is a separate dc motor for the tape hubs.) The PLL motor drive makes the recorder's operating speed relatively independent of supply voltage and temperature, the latter specified over a range of 32° to 140° F (0° to 60° C).

The cassette well is on what would be the top of the recorder when it is placed on a shelf or table. When the recorder is carried over a shoulder via its built-on strap, the cassette well is on the side for convenient loading and unloading. A small lever opens the cassette cover, while a firmer push on the lever ejects the cassette. Located near the cassette well is a pushbutton-resettable index counter.

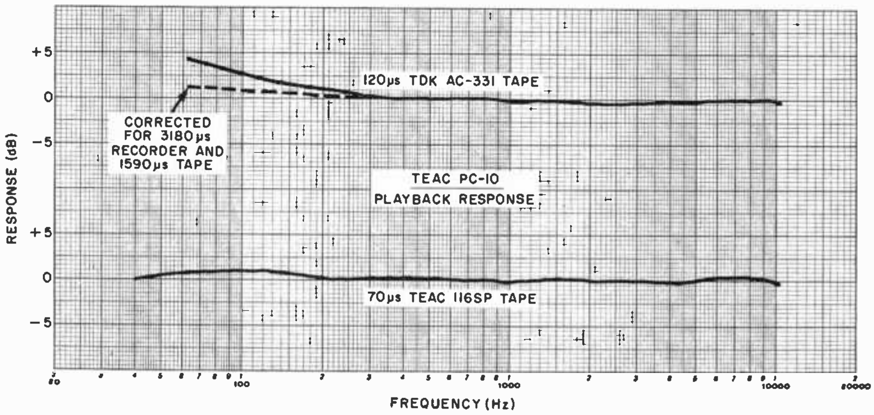
The control panel is dominated by two large VU meters, whose scales are labelled with the standard Dolby level mark at the +3 indexes. Between the meters is a PEAK LEVEL LED that flashes when momentary peaks reach +6 dB. The meters and PEAK LEVEL indicator function in playback as well as in the record mode.

The transport mechanism is controlled by two slide-type levers. The upper lever has STOP and PLAY positions, and next to it is the REC button that must be pressed before going to PLAY if a recording is to be made. The second lever has three positions. The left position is for rewind, center position for off, and right position for fast forward tape motion. Neither lever can be moved unless the other lever is in its stop (center) position. A PAUSE button is located just below the REC button. A red indicator comes on for the record mode.

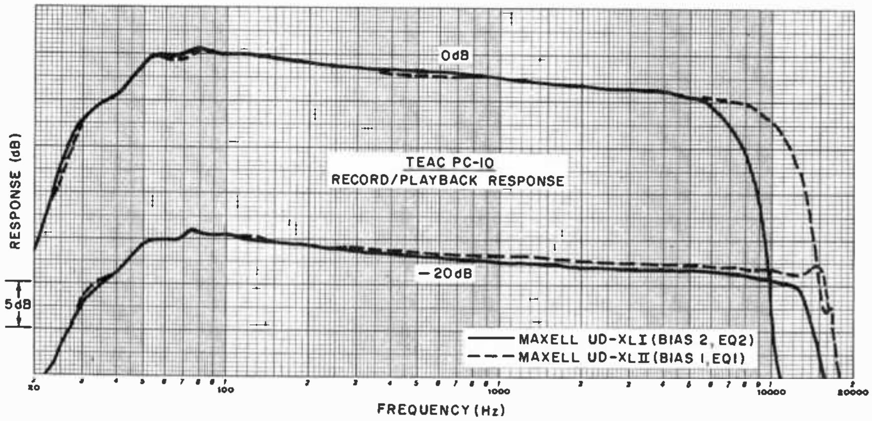
The REC level controls for the left and right channels are concentrically ganged together. The lowest quarter of their adjustment range is marked in white as a warning that input signal levels are excessive if the controls must be set so low. Otherwise, the rest of the scales are in red for the right channel and green for the left channel. A small button below the level controls can be pressed to momentarily illuminate the VU meters or pressed and twisted to lock on the illumination. A similar button connects the right-channel meter to give an indication of battery condition.

Separate BIAS and EQ (equalization) switches are provided for setting the operating conditions to suit most tape formulations. The bias levels roughly correspond to those used with low-noise ferric-oxide and CrO_2 (or the chrome equivalent) tapes. The EQ characteristics conform to the standard 120- and 70-μs curves for these tapes. (The instruction booklet that comes with the recorder lists a number of suitable tapes and recommended switch settings.) The DOLBY NR switch turns on and off the Dolby B noise-reduction system, and the LIMITER switch turns on and off a peak limiter that takes effect at levels over +3 dB.

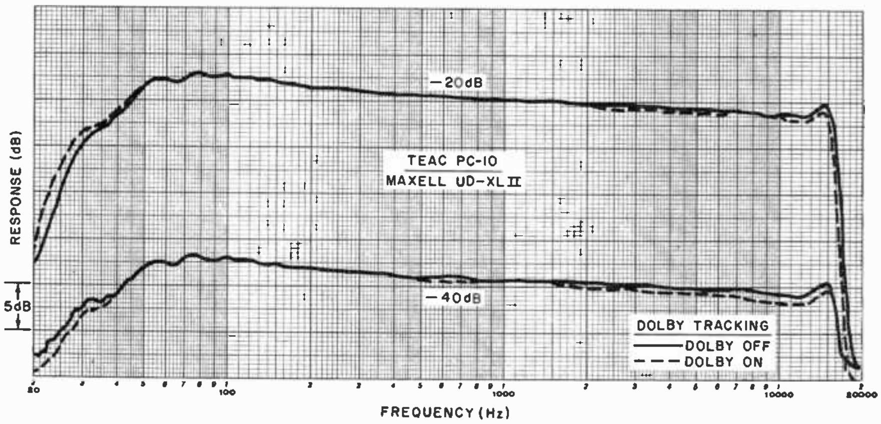
The positions on the MIC ATT switch are labelled 0, 15, and 30 (dB). With this switch properly set, it is possible to record very high sound levels without



Playback frequency response tests using two different types of tape.



Overall record/playback frequency responses at 0 dB and -20 dB.



Response curves showing Dolby tracking error at two levels.

overloading the microphone preamplifier stages.

Set into the right side of the recorder is a well that contains the various input and output connectors, a slide switch for selecting either the microphone or line inputs, playback output jacks, a headphone jack, and a small volume control for the built-in speaker. There is also a jack for connecting the external ac power supply to the recorder.

The published performance specifications of the recorder are similar to those for a better-quality line-operated cassette deck. The recorder can be operated continuously for approximately two hours with six fresh D cells installed.

Laboratory Measurement. We used TDK AC-331 tape with 120 µs equalization and Teac 116SP tape with 70 µs equalization during our playback frequency response tests. In both cases, the response was flat within ±0.5 dB from 150 to 10,000 Hz, with a maximum departure from flatness of only 1 dB at the lower frequencies (which extended, respectively, to 63 and 40 Hz with the two tapes).

Several types of tapes were used to measure the overall record/playback frequency response. The curves obtained with Maxell's ferric-oxide UD-XL I and cobalt-treated ferric-oxide UD-XL II (designed to be used with "chrome" bias and equalization) tapes were typical of the recorder's performance with other high-quality tapes. The frequency response was a nearly straight line that sloped downward with increasing frequency. The total variation was ±3 dB from 35 to 12,500 Hz using UD-XL I tape and from 35 to 15,500 Hz with UD-XL II tape. The principal difference between the two tapes was not in their frequency responses but in their high-frequency saturation characteristics. When the measurement was made at 0 dB instead of the usual −20 dB, the UD-XL II tape delivered a much better high-frequency response.

The tracking error of the Dolby circuits between the recording and playback conditions (they are supposed to be exactly balanced at all levels and frequencies) was excellent. At levels of −20 and −40 dB, there was no more than 1 dB of change in response at any frequency when using the Dolby system.

A line input of 62 mV or a microphone input of 0.22 mV was needed for a 0-dB recording level. The latter increased to 1.6 and 8 mV when the MIC ATT switch was set to its 15- and 30-dB positions, respectively. The microphone overload levels were 82, 550, and 1550 mV in the three positions of the MIC ATT switch. The playback output from a 0-dB recording level varied somewhat with the tape used. The premium ferric-oxide tapes—Maxell UD-XL II and TDK SA—gave about a 0.7-to-0.8-volt output, which roughly corresponds to the rated 0.775-volt output. However, the UD-XL I tape yielded a higher output at 0.93 volt.

The playback distortion from a 0-dB recording at 1000 Hz was 0.63% with UD-XL I and 0.8% with UD-XL II tapes. The 3% THD level was reached with respective recording levels of +6.5 and +5 dB. The PEAK indicator flashed at +5 dB. The recording limiter had no effect at 0-dB or lower levels, but it made a worthwhile reduction in playback distortion when the recording levels were well off-scale on the meters. For example, at +7 dB, with UD-XL II tape, the distortion reduced from 5.3% to 2.1% with the limiter switched in. At +10 dB, the distortion was a still-tolerable 3.5%, but at 20 dB it reached an unacceptable 10%. It is clear that the presence of the limiter is not a justification for entirely ignoring recording levels.

We were pleased to note that the VU

meters were correctly named, at least with respect to their performance. Their ballistics matched the specifications for professional VU meters, with a 0.3-second, 1000-Hz tone burst occurring once per second to give exactly the same meter indication as a continuous tone of the same level.

With UD-XL I tape, the S/N referred to the 3% THD level was 56.5 dB unweighted, 60.5 dB with IEC A weighting, and 56.5 dB with CCIR/ARM weighting (the type preferred by Dolby Laboratories). With the Dolby system switched in, these figures improved to 61, 68, and 66.5 dB. With UD-XL II tape, the S/N was not quite as good, yielding readings of 55 dB unweighted, 59 dB IEC A weighted, and 56 dB CCIR weighted. The Dolby system improved these figures to 56.5, 65.5, and 66 dB. The noise level through the microphone inputs was 14.5 dB greater at full gain but much less with normal settings of the recording gain. Playing a 200-nanoweber/meter standard Dolby level tape provided meter readings within 0.5 dB of the Dolby calibration marks on the meters.

The measured wow was the 0.01% residual of our test equipment and tapes. Unweighted rms and flutter measured 0.145% in both the playback and combined record/playback tests. These figures cannot be compared to Teac's own rating, which was based on a weighted measurement. The transport operated smoothly and reliably and moved a C60 cassette from end to end in about 84 seconds. The crosstalk between stereo channels was −45 dB at 1000 Hz, measured with a TDK AC-352 test tape. All these tests were made using an ac power supply.

User Comment. The overall performance of this recorder is squarely in the class of the better component-type cassette decks used in home hi-fi systems. In fact, with respect to distortion and noise levels, almost perfect playback equalization, and virtually ideal Dolby tracking, this recorder was superior to all but a handful of the component cassette decks we have tested.

Used in a fixed home hi-fi system, the recorder's sound quality and handling convenience left little to be desired. Our only criticism of its operation concerns the eject lever. With the recorder slung over a shoulder, it is very easy to brush against the lever and inadvertently open the cassette door. Otherwise, this fine little recorder offers the best of portable and fixed operation, albeit at a price.

CIRCLE NO. 102 ON FREE INFORMATION CARD

news HIGHLIGHTS

Auto Cigar Lighter Transmitter

It looks like the car's cigar lighter, since it's in the lighter slot. But the "Merc," developed by Mallard Manufacturing, Sterling, IL, is a one-ounce transmitter that, when pushed in just like a cigarette lighter, sends a coded signal that opens a garage door. The Merc (Mallard Electronic Radio Control) is said to work with any door opener on the market, and can be easily unplugged and moved to another car. Since it stays in the lighter slot, it isn't easily misplaced or, since it looks like the lighter, stolen. The Merc transmitter and companion receiver will sell for about $65 together.

Hearing-aid TV Captions

The Federal Communications Commission has given approval to an electronic system for producing captions on TV programs for hearing-impaired viewers whose TV receivers are equipped with the proper decoding accessory. While this gives the nod to manufacturers who wish to make the accessories, it does not require stations to supply the captions. PBS (Public Broadcasting Service) has been experimenting with the system for two years, but opposition has come from the commercial networks who want more time for testing. According to estimates presented to the FCC, the equipment to produce the captions will cost each station $30,000 to $50,000 and encoding the programs is expected to add another $1000 to $3400/hr to production costs.

"Citizens Band" Movie

"Citizens Band," a feature movie about the phenomenon of CB radio and its effect on the lives of some of the people who use it, is being filmed on locations in Marysville and Yuba City in northern California. The Fields Company production for Paramount Pictures release is to be a contemporary comedy-drama about the personal adventures of an interrelated group of characters in Everytown, U.S.A. The movie depicts various uses of CB radio, including heroic rescue operations in highway and air emergencies. All the principal performers who use CB radios in the picture were given CB equipment and operating instructions long before the start of production so that they would become accomplished CB'ers and play their roles authentically.

The "Leap Second" Year

To keep official time in step with the spinning earth, a leap second was inserted into the world's time at the end of 1976. By recommendation of the International Time Bureau in Paris, France, the leap second began on December 31, 1976, at precisely 23:59:60 Universal Coordinated Time. It ended at 00:00:00 on January 1, 1977, making the "leap second" part of 1976, not 1977. This additional second was inserted by all standard time organizations around the world, including WWV, WWVB, and WWVH in the U.S. The 1976 leap second was the sixth since the practice began in 1972, and is required because, in comparison with atomic clocks, the earth is slowing down enough so that the extra second is needed to keep the clocks synchronized to the spin of the earth to within one second.

WWV/WWVH Cutback

On February 1, 1977, the National Bureau of Standards discontinued broadcasts on the less-used frequencies of its two time and frequency radio stations. The affected frequencies are 20 and 25 MHz at WWV (Fort Collins, Colorado) and 20 MHz at WWVH (Kauai, Hawaii). Both stations will continue to broadcast on 2.5, 5, 10, and 15 MHz with no change in radiated power. Radio station WWVB will continue broadcasting on 60 kHz with no changes. Broadcast equipment previously used on the discontinued frequencies will be converted to serve as back-up systems for the remaining frequencies, and will be automatically turned on if the primary transmitters or antennas fail. The NBS also announced that this partial discontinuance of service will be reviewed periodically as changes occur in radio propagation conditions, sunspot activity, etc. If conditions warrant, a resumption of service on the higher frequencies will be considered.

Video Equipment Bright Spot

Frost & Sullivan, a market research organization, has detected many long-term bright spots in consumer electronics, including video tape systems, video discs, video games, and video projection systems. Despite stiff competition from the Japanese and Taiwan manufacturers for the TV receiver market, Frost & Sullivan concludes that the U.S. can dominate the field of video entertainment systems because of its early start and sophisticated circuitry. The video game market, which checked in at $26 million in 1976, is expected to climb to more than $130 million by 1985. There are now more than 70 companies in the field. Video tape systems will be dominated by the Japanese, with a market peaking in 1980 before giving way to video disc systems . . . if the industry agrees to standardization of software and hardware, says Frost & Sullivan.

Marine Guidelines for CB Monitors

The Coast Guard has established guidelines to assist volunteer CB-monitoring groups in relaying boating distress information. The guidelines are required to make sure a message gets through the various relay stations unchanged. The boatman can't reach the Coast Guard directly on CB because the Coast Guard doesn't monitor CB channels, a task left to REACT teams and other CB groups. The Coast Guard needs the following information: name and description of the boat, position, nature of the assistance required, number of persons aboard, radio frequencies available, name of the owner or operator and his home port and telephone number, and the name and phone number of the original contact for confirmation and callbacks.

CIRCLE NO. 28 ON FREE INFORMATION CARD

Clockwise from top: CPU, 9" Video Monitor, Impact Printer, Keyboard, Cassette Storage System with Four Drives.

If you are seriously considering the purchase of a microcomputer system for personal or business use . . . or just beginning to feel the first twinges of interest in a fascinating hobby . . . the Digital Group is a company you should get acquainted with.

For many months now, we've been feverishly (and rather quietly) at work on our unique, high-quality product – a microcomputer system designed from the inside out to be the most comprehensive, easy-to-use and adaptable system you'll find anywhere. And our reputation has been getting around *fast*. In fact, you may have already heard a little something about us from a friend. We've found our own best salesmen are our many satisfied customers.

There's a good reason. Simply, the Digital Group has a lot to offer: state-of-the-art designs, a totally complete systems philosophy, unexcelled quality, reasonable software, affordable prices and the promise that our products will not become rapidly obsolete, even in this fast-moving, high-technology field.

The Advantages

Here are a few specific advantages of our product line:

• We offer interchangeable CPUs from different manufacturers (including the new "super chip" – the Z-80 from Zilog) which are interchangeable at the CPU card level. That way, your system won't become instantly obsolete with each new design breakthrough. The major portion of your investment in memory and I/O is protected.

• Digital Group systems are complete and fully featured, so there's no need to purchase bits and pieces from different manufacturers. We have everything you need, but almost any other equipment can be easily supported, too, thanks to the universal nature of our systems.

• Our systems are specifically designed to be easy to use. With our combination of TV, keyboard, and cassette recorder, you have a system that is quick, quiet, and inexpensive. To get going merely power on, load cassette and go!

• Design shortcuts have been avoided – all CPUs run at full maximum rated speed.

• All system components are available with our beautiful new custom cabinets. And every new product will maintain the same unmistakable Digital Group image.

The Features

Digital Group Systems – CPUs currently being delivered: Z-80 by Zilog, 8080A/9080A, 6800, 6500 by MOS Technology.

All are completely interchangeable at the CPU card level. Standard features with all systems:

- Video-based operating system
- Video/Cassette Interface Card
  512 character upper & lower case video interface (1024 optional)
  100 character/second digitally synthesized audio cassette interface
- CPU Card
  2K RAM, Direct Memory Access (DMA)
  Vectored Interrupts (up to 128)
  256 byte 1702A bootstrap loader
  All buffering, CPU dependencies, and housekeeping circuitry
- Input/Output Card
  Four 8-bit parallel input ports
  Four 8-bit parallel output ports
- Motherboard

Prices for standard systems including the above features start at \$475 for Z-80, \$425 for 8080 or 6800, \$375 for 6500.

More

Many options, peripherals, expansion capabilities and accessories are already available. They include rapid computer-controlled cassette drives for mass storage, printers, color graphics interfaces, memory, I/O, monitors, prom boards, multiple power supplies, prototyping cards and others. Software packages include BASICs, Assemblers, Disassemblers, Text Editors, games, ham radio applications, software training cassettes, system packages and more (even biorhythm).

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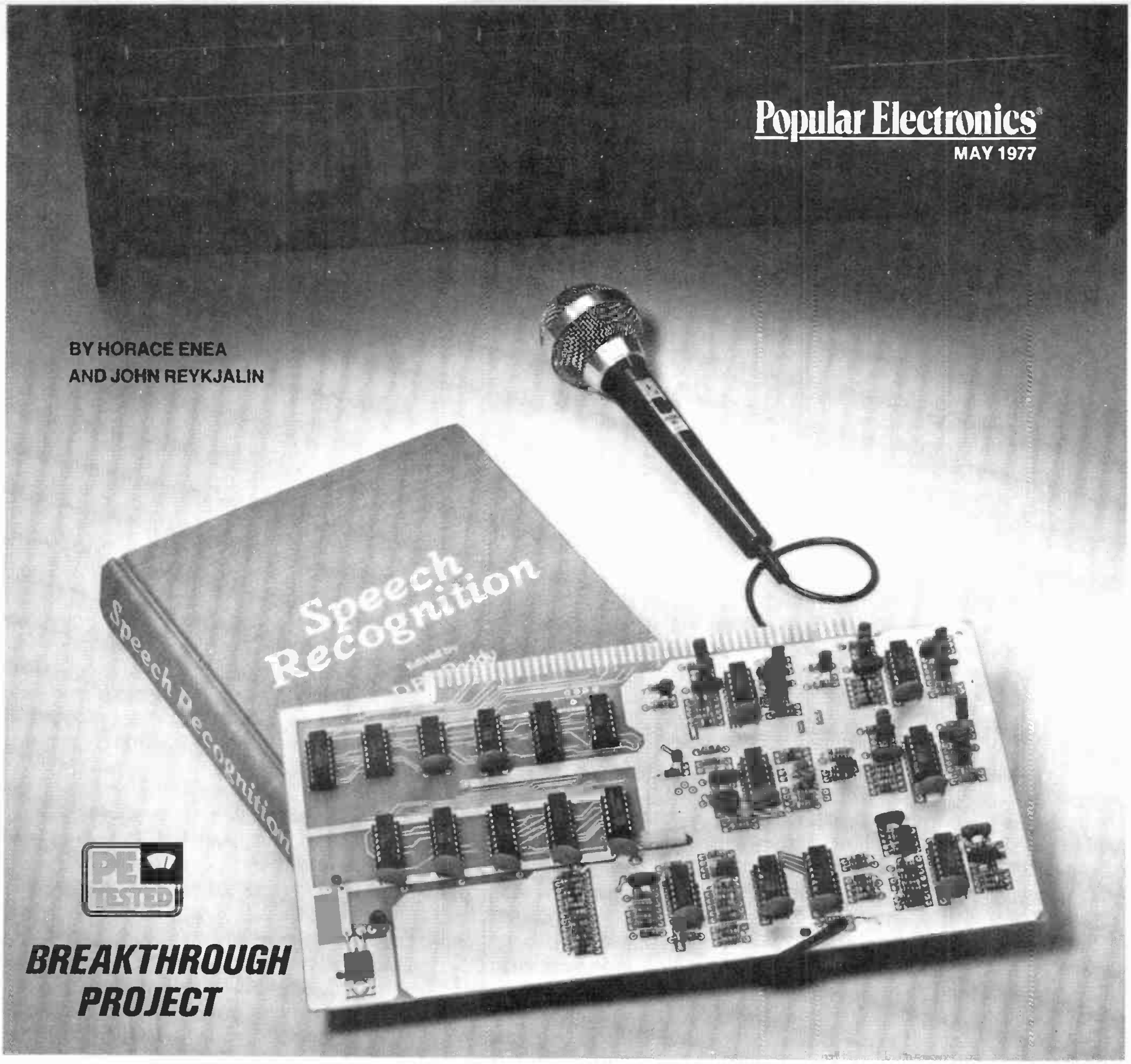
CIRCLE NO. 18 ON FREE INFORMATION CARD

Popular Electronics
MAY 1977

BY HORACE ENEA
AND JOHN REYKJALIN



PE TESTED

BREAKTHROUGH PROJECT

INTRODUCING SPEECHLAB

THE FIRST HOBBYIST VOCAL INTERFACE FOR A COMPUTER!

Now your computer can respond to vocal commands by the simple addition of a $250 single-board unit.

IMAGINE being able to *talk* to your computer and have it respond by way of a hard-copy device or by activating some external appliance! Computer hobbyists can now enjoy this facility by building "Speechlab," a new, low-cost (under $250) computer peripheral. To use it, all one does is plug the single Speechlab pc board into an Altair-bus connector (used by many microcomputer manufacturers), enter a special program, and the computer does the rest. It's a state-of-the-art approach at a moderate cost.

One section of the program allows the user to "train" the computer to accept a vocal input (via a microphone), analyze the spoken word, and create a digitized version that is stored in memory. The second part of the program allows the user to speak to the Speechlab and have the computer generate the output selected for that particular sound.

The vocabulary size of Speechlab is a function of the speech recognition algorithm used and the amount of memory available. For the program used in this article, it is 64 bytes per spoken word.

The unique characteristics of Speechlab open many formerly closed doors. Since Speechlab will operate with any audio input (not necessarily a recognized language), a person who's vocally handicapped can operate almost any number of appliances (TV receiver, stereo system, solenoid-operated door,

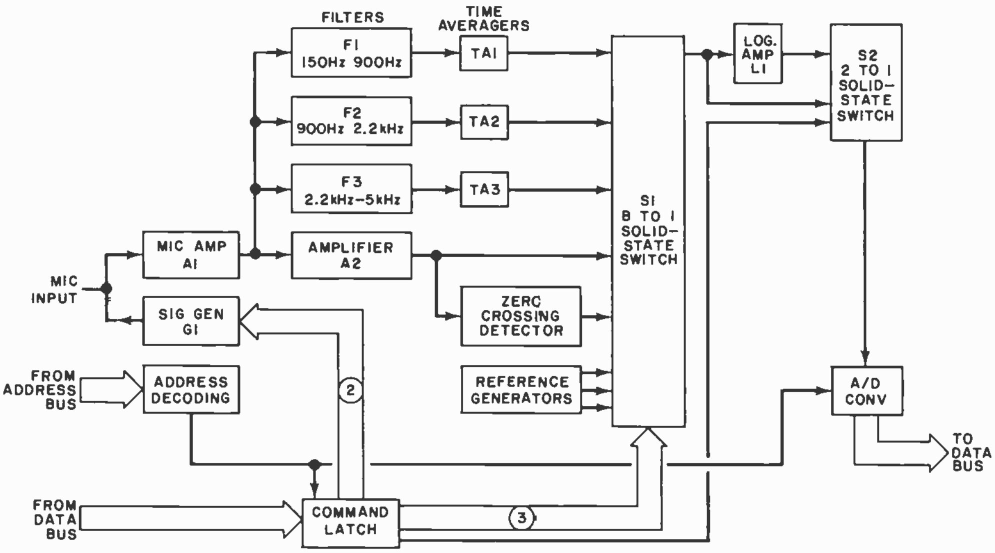


Fig. 1. The mic input is amplified, filtered and applied to S1 along with raw audio, zero-crossing detection, and three reference voltages. Output of S1 is computer selected by switch S2 for digitizing.

etc.) using a repeatable sound such as a grunt. One can use Speechlab, too, as a vocal processor to add spoken commands to many computer games (such as the "Star Trek" game), or enter the world of artificial intelligence and advanced programming.

Circuit Operation. The basic block diagram of Speechlab is shown in Fig. 1. The audio input is amplified by *A1* and applied to three 80-db/decade rolloff band-pass filters *F1, F2,* and *F3*. These filters encompass the ranges of 150 to 900 Hz, 900 Hz to 2.2 kHz, and 2.2 kHz to 5 kHz, respectively. These ranges correspond to the frequency ranges of the first three resonances of the average human vocal tract.

Each filter is passed to a time averager (*TA1, TA2,* and *TA3*) to generate a voltage proportional to the level of the speech waveform within each band.

The amplified audio signal from *A1* is further amplified by *A2* to generate an unfiltered waveform that can swing ±2 volts about a rest level of 2 volts. This signal is also applied to a zero-crossing detector that generates a voltage proportional to the number of times the speech waveform crosses the 2-volt rest level in a given period of time, thus generating a measure of the dominant frequency in the speech signal.

These five voltages—*TA1, TA2, TA3, A2,* and *ZCD*—are fed to solid-state switch *S1* along with three reference voltages used for calibration and self test. A computer output command selects one of these five voltages to be passed through *S1*.

The selected output from *S1* is passed to a second solid-state switch (*S2*), and to a logarithmic amplifier (*L1*) that emphasizes the low-level signal before being passed to *S2*. Switch *S2* can select either the direct output from *S1*, or the output from *L1*, and pass this selected signal to a 6-bit A/D converter where the voltage is converted to a digital value. The output of the A/D converter is fed to the computer data bus.

All operations of the Speechlab are controlled through a single I/O port (address AF_{hex}). As shown in Fig. 2, six bits are used: bit-5 disables the 8-to-1 multiplexer (*S1*), and is used when switching between bands; bit-4 controls signal generator *G1* which is used either to drive the microphone so that it acts like a miniature loudspeaker for prompting during voice input, or to drive the filters and zero-crossing detector during calibration and test; bit-3 selects either linear or logarithmic scaling of the voltage applied to the A/D converter; while bit-2, bit-1, and bit-0 select one of the eight signals from *S1* for A/D conversion.

The input data word contains the 6-bit A/D output in bits 0 through 5, bit-6 is unused and is always 0, while bit-7 is the A/D converter status with a 1 corresponding to busy, and 0 corresponding to finished.

Speechlab is physically configured to occupy one slot in the Altair bus, and the complete schematic is shown in Fig. 3 through Fig. 7.

Construction. The two foil patterns (Speechlab uses one double-sided pc board) are shown half-size in Fig. 8. (Blow up to full size on *film* only.) Component layout is shown in Fig. 9.

All the components are mounted on one side of the board, with all the soldering done on the noncomponent side. Sockets are recommended for all IC's since most of them are MOS-types that may be damaged by improper handling.

Integrated circuits *IC1, IC4, IC7, IC8, IC9, IC15,* and *IC16* should be selected so they are capable of delivering a 4-volt output when using a 5-volt supply. Dual flip-flop *IC14* can be from any manufacturer but Fairchild, as their truth table is somewhat different from the conventional table.

Start construction by installing the voltage regulator (*IC6*), all the discrete components, and the IC sockets—do not install the IC's at this time. Check the board for correct parts installation, and to make sure that there are no solder bridges between adjacent foil traces. Mount the board in an Altair bus connector, and check for the presence of 5 volts at the output of the voltage regulator and at the appropriate socket pins. Remove the board from the computer.

Install *IC2* through *IC5, IC10* through *IC14,* and *IC17* through *IC22*. Install the board back in the Altair bus connector, and turn on the computer. Load the test

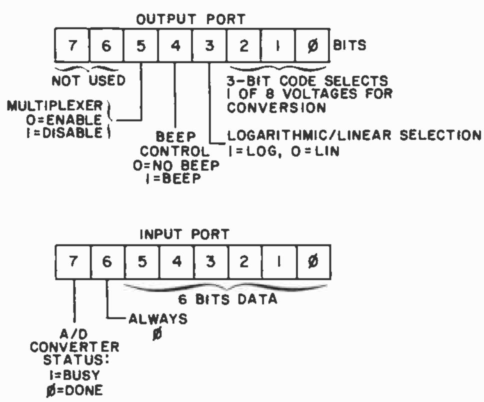


Fig. 2. Input and output port bit configuration.

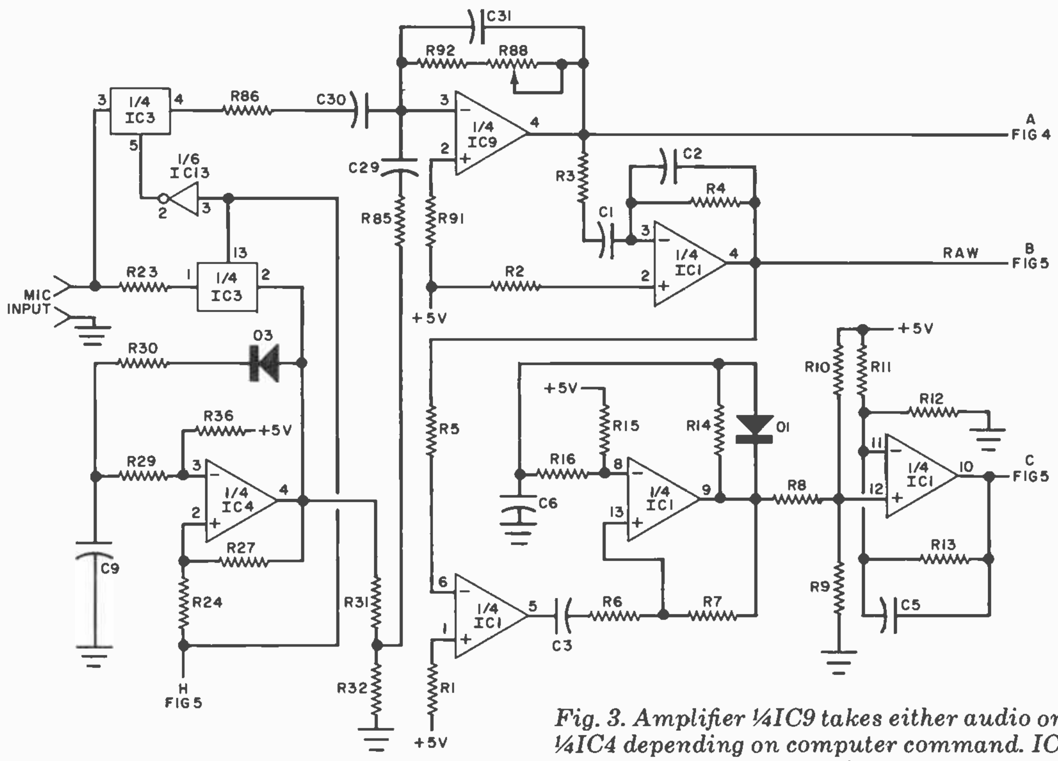


Fig. 3. Amplifier ¼IC9 takes either audio or tone from ¼IC4 depending on computer command. IC1 circuits are used as raw audio amplifier and zero-crossing detector.

PARTS LIST

Unless otherwise noted, the following capacitors are 10% Mylar types, and all picofarad sizes are CM05 types.
C1, C16, C21, C43, C47, C49, C52, C57—0.0047 µF
C2, C31—100 pF
C3, C17, C20—270 pF
C4, C7, C8, C10, C12, C19, C27, C32, C33, C34, C35, C36, C37, C44, C55, C61, C62—0.1 µF, 25-V disc
C5, C14, C18, C24, C54, C60—0.01 µF
C6, C42, C45, C53, C56—240 pF
C9, C40, C48—0.022 µF
C11, C29—47 pF
C13—15 µF, 25 V tantalum
C15, C22, C51, C59—0.0015 µF
C23—0.0022 µF
C25, C26, C28, C38—1 µF
C30, C39, C46—0.047 µF
C41—0.1 µF
C50, C58—0.001 µF
D1, D3 through D6—1N4148 or 1N914 diode
D2—1N746 diode
IC1, IC4, IC7, IC8, IC9, IC15, IC16—LM3900 quad amp
IC2—4051 8-to-1 analog multiplex
IC3—4016 quad analog switch
IC5—LM311 comparator
IC6—78M05 5-volt regulator
IC10—4024 7-stage binary counter
IC11, IC18—74C174 D flip-flop
IC12—4050 hex buffer
IC13, IC22—4049 hex buffer inverter
IC14—4013 (see text) dual-D flip-flop
IC17—74LS30 8-input NAND gate
IC19—8097 three-state hex buffer
IC20—8093 three-state quad buffer
IC21—4001 NOR gate
MIC—Mura DX-121 dynamic microphone (part of stereo set Mura DX-242)
L1—22-µH choke
Unless otherwise noted, the following resistors are ¼-W, 5%
R1—619,000 ohms, 1%
R2—1 megohm, 1%
R3—6810 ohms, 1%
R4—332,000 ohms, 1%
R5—200,000 ohms, 1%
R6,R20,R21—30,000 ohms
R7, R100—3 megohms
R8, R9, R10, R12, R14, R16, R104—1 megohm
R11—910,000 ohms
R13—2.7 megohms
R15, R48—10 megohms
R17,R18—20,000 ohms
R19, R22, R106—10,000 ohms
R23—1000 ohms
R24, R27—1.2 megohms
R25, R34, R39—470,000 ohms
R26, R38—750,000 ohms
R28, R31—100,000 ohms
R29—110,000 ohms
R30—39,000 ohms
R32—47,000 ohms
R33, R41—68,100 ohms, 1%
R35, R96,R102—75,000 ohms
R36—3.9 megohms
R37, R46—357,000 ohms, 1%
R40, R50, R52, R54, R56, R58, R60 R61—10,000 ohms, 1%
R42—12,100 ohms, 1%
R43, R49—4750 ohms, 1%
R44—4320 ohms, 1%
R45, R47—681,000 ohms, 1%
R51, R53, R55, R57, R59—4990 ohms, 1%
R62—274,000 ohms, 1%
R63—7500 ohms
R64, R66, R72, R75—160,000 ohms
R65, R71—12,000 ohms
R67, R70—300,000 ohms
R68—931,000 ohms, 1%
R69—2 megohms
R73—620,000 ohms
R74, R76, R90, R92—62,000 ohms
R77—15,000 ohms
R78, R83, R84—147,000 ohms, 1%
R79, R80, R87—51,100 ohms, 1%
R81,R82,R89—174,000 ohms, 1%
R85—330,000 ohms
R86—680 ohms
R88—100,000-ohm pc trimmer potentiometer
R91—270,000 ohms
R93—249,000 ohms, 1%
R94—4300 ohms
R95, R97, R103, R105—360,000 ohms
R98, R101—820,000 ohms
R99—845,000 ohms, 1%
R107—158,000 ohms, 1%
R108—4700 ohms
R109, R111, R117, R119—82,000 ohms
R110, R116—5100 ohms
R112, R115—180,000 ohms
R113—549,000 ohms, 1%
R114—1.6 megohms
R118—510,000 ohms
R120—6800 ohms
R121—2000 ohms
Misc.—Sockets (one 8-pin, thirteen 14-pin, seven 16-pin), regulator mounting hardware, tie-wrap etc.
Note 1: The following is available from Heuristics Inc., 900 N. San Antonio Rd. (Suite C-1), Los Altos CA 94022 (Tele: 415-948-2542): complete kit of all parts including pc board, sockets, microphone, hardware manual, and 200-page lab manual, SpeechBasic, and assembly language programs at $249. (California residents please add 6½% sales tax.)

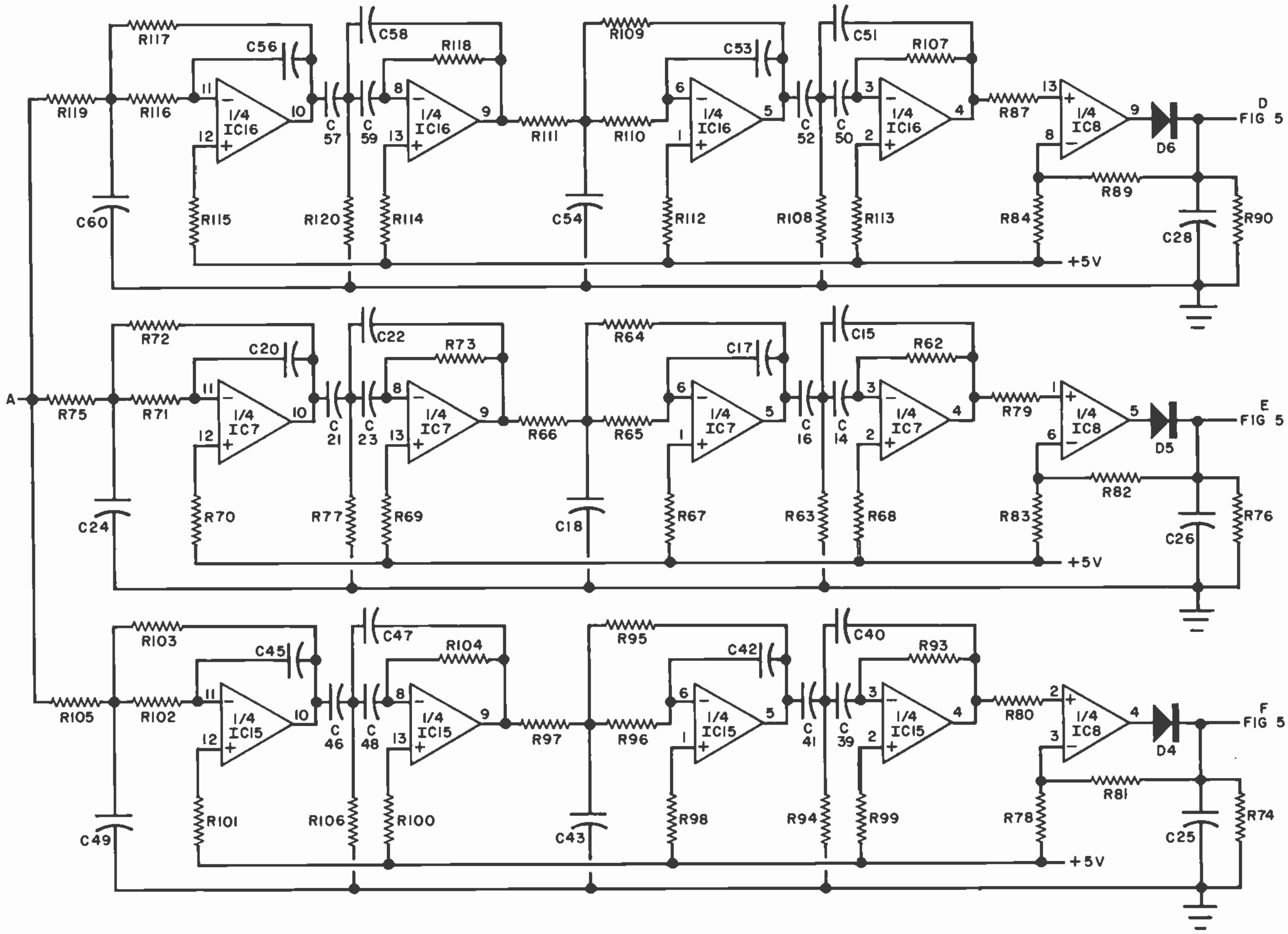


Fig. 4. Three bandpass filters and their associated time averagers. They encompass three ranges corresponding to frequency ranges of the first three resonances of an average human vocal tract.

program of Table I at 100 (hex). *NOTE: all program data in this article is in hex.*

You must jump to your monitor routine at address 0164-0165. Load address 195 with 05 and run the program. This will input the fixed reference voltage levels to the A/D converter and check the signal paths from switch *S1* to the computer data bus.

After running this program, examine locations 200 through 20F, 300 through 30F, and 400 through 40F. Location 200 through 20F should contain 12 ±4, 300 through 30F should contain 24 ±4, and 400 through 40F should contain 36 ±4.

Insert the remaining IC's in their sockets, load location 195 with 10, and run the test program (Table I). This test uses the signal generator (*G1*) to create an input for the filters, amplifiers, and zero-crossing detector, and thereby checks the remaining signal paths on the board and calibrates the microphone preamplifier. After running the program, examine locations 200 to 20F to see if it contains 16 to 18. If not, adjust potentiometer *R88* and rerun the program until these outputs occur.

Calibration and Test Program. The test program (Table I) is a general-purpose calibration, test, and diagnostic program for the Speechlab. It loads at location 100 and requires memory from 100 to 600 for program and data areas. Locations 163-165 should be loaded with a jump to your monitor address so that the program will return control to your monitor after execution. If you do not have a monitor, place a halt at this location.

The program collects four 256-byte buffers of data from four of the eight pos-

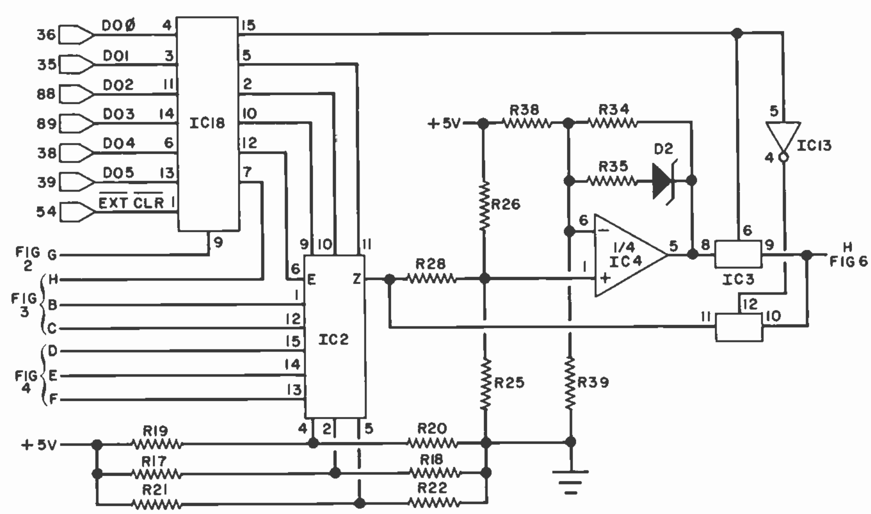


Fig. 5. Command latch (IC18) can activate tone generator and switch S1 (IC2). Op amp (¼IC4) is logarithmic amplifier.

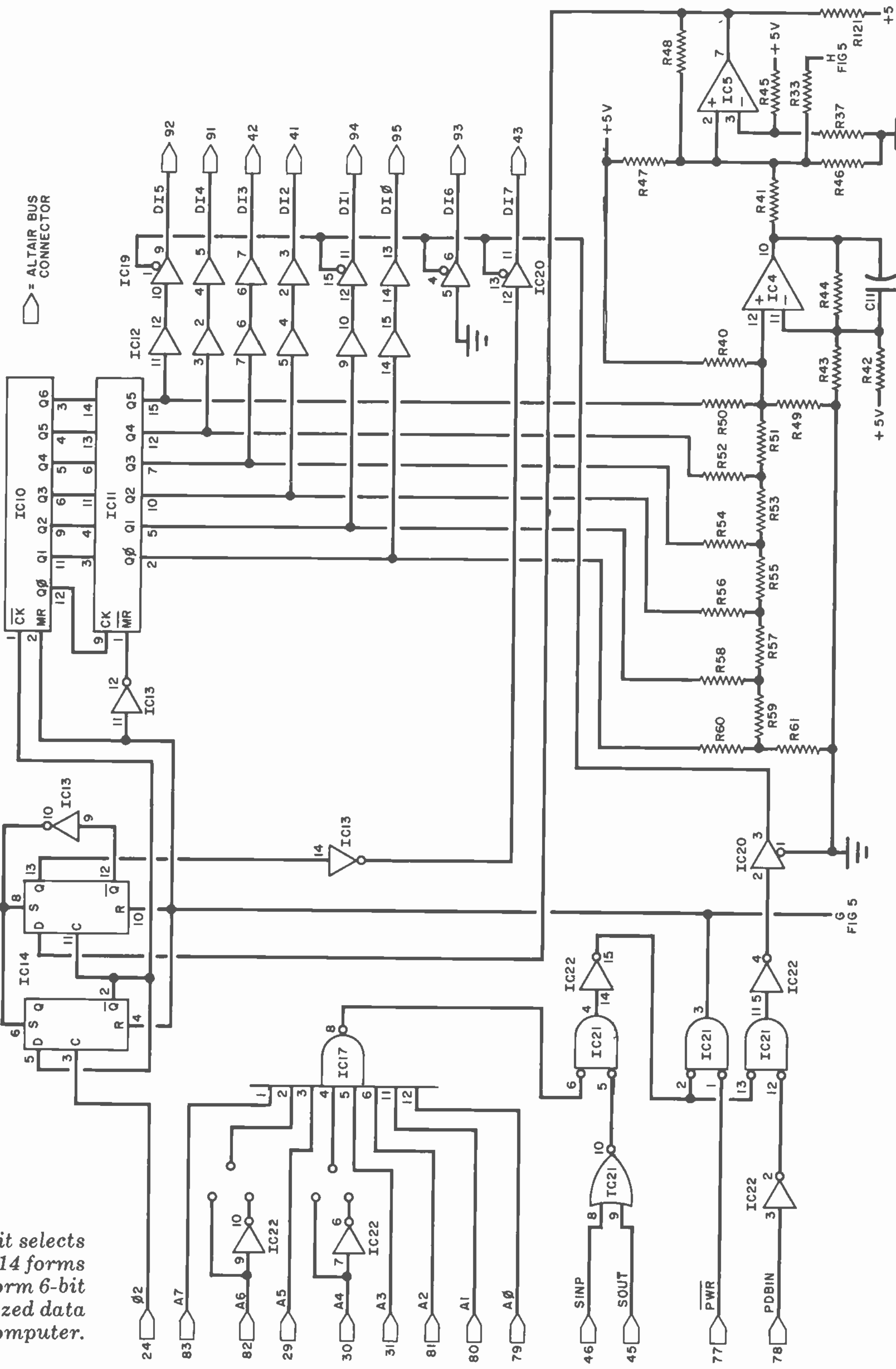


Fig. 6. IC17 circuit selects board address and IC14 forms S2. IC10 and IC11 form 6-bit A/D converter. Digitized data is then passed to computer.

sible inputs to the A/D converter. The first of the four bands is specified by the Test Command word, which also specifies beeper on/off and linear or logarithmic scaling. The next three bands are 1, 2, and 3 greater than specified by the Test Command word. Each band is sampled every five milliseconds until 256 samples have been collected from each of the four bands. Data from the first band is stored in 200 to 2FF, the second band from 300 to 3FF, the third from 400 to 4FF, and the fourth from 500 to 5FF.

For example, if the Test Command word is set to 00, after the test program is run, the four data areas will contain numbers representing the outputs of band-0 (low frequency), band-1 (mid frequency), band-2 (high frequency), and band-3 (zero-crossing detector). Anything that was spoken into the microphone while the program was running, is filtered, converted into a binary number, and stored in the data areas.

If the Test Command word is set to 05, the first three data areas will contain

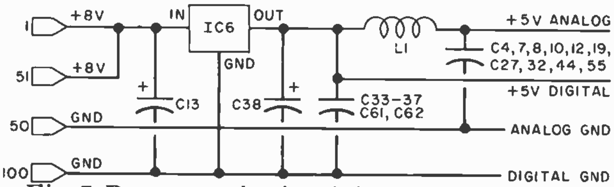


Fig. 7. Power supply circuit is conventional. Note bypass capacitors that are actually mounted between IC power supply pins and ground.

constant numbers corresponding to the three reference voltage levels to the A/D converter on band 5, 6, and 7. This is useful for checking the A/D converter operation and isolating problem areas to one side or the other of the 8-to-1 analog switch *S1*.

If the Test Command word is set to 10, signal generator *G1* is enabled which begins to "beep" the microphone and connects the signal-generator output into the microphone preamplifier *A1*. The four data areas contain data from bands 0, 1, 2, and 3 as when the Test Command word was 00, but the input signal comes from the signal generator rather than from the microphone. This allows calibration of the microphone preamplifier and isolates problems in one of the filter-averager chains.

Adding bit-3 to the command word will cause logarithmic rather than linear data scaling and will isolate problems to the log amplifier or either of the two analog switches comprising *S2*, the 2-to-1 analog switch.

Various combinations of bits in the Test Command word will allow quick calibration and fault isolation, and also provide a quick way to look at raw data from any input through the microphone.

Software. A simple technique for speech recognition of the digits zero through nine with a recognition rate of 90% or better, is shown in the flowchart of Fig. 10. An 8080 program for this algorithm is shown in Table II. The program starts at memory location 0100 and requires less than 4K bytes of storage including table space.

There are two modes of operation—training and performance. During training, speech examples of the digits are read into the microphone and the parameters of the speech input are extracted and placed in the tables. In the performance mode, an unknown utterance is presented and recognized.

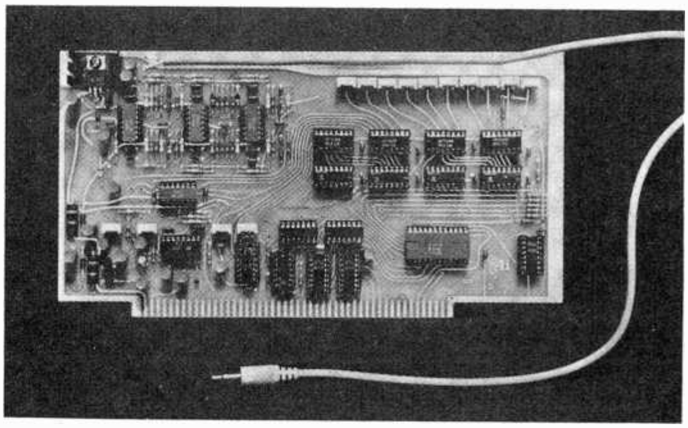
To use the program, enter it into the computer starting at location 0100, and then run the program. The Teletype will respond with "T" (train) or "P" (perform). Type a "T" and the Teletype will respond with "NUMBER?" which can be between 0 and F. Type the digit you desire, and the microphone will emit a "beep" indicating that the speech window is open. When this beep occurs, vocalize the same digit you just typed in. The microphone will beep again to indicate that the speech window is now closed. The machine will then type T or

TABLE I

```
0100                     ORG 100H
0100 =                   START EQU 100H
0100 210002              LXI H,START+100H
0103 228D01              SHLD TEMP1
0106 210003              LXI H,START+200H
0109 228F01              SHLD TEMP2
010C 210004              LXI H,START+300H
010F 229101              SHLD TEMP3
0112 210005              LXI H,START+400H
0115 229301              SHLD TEMP4
0118 3A9501     GO       LDA COMAND
011B CD6601              CALL INPUT
011E 2A8D01              LHLD TEMP1
0121 77                  MOV M,A
0122 2C                  INR L
0123 228D01              SHLD TEMP1
0126 3A9501              LDA COMAND
0129 C601                ADI 1
012B CD6601              CALL INPUT
012E 2A8F01              LHLD TEMP2
0131 77                  MOV M,A
0132 2C                  INR L
0133 228F01              SHLD TEMP2
0136 3A9501              LDA COMAND
0139 C602                ADI 2
013B CD6601              CALL INPUT
013E 2A9101              LHLD TEMP3
0141 77                  MOV M,A
0142 2C                  INR L
0143 229101              SHLD TEMP3
0146 3A9501              LDA COMAND
0149 C603                ADI 3
014B CD6601              CALL INPUT
014E 2A9301              LHLD TEMP4
0151 77                  MOV M,A
0152 2C                  INR L
0153 229301              SHLD TEMP4
0156 CA5F01              JZ STOP
0159 CD7701              CALL DELAY
015C C31801              JMP GO
015F 3E00       STOP     MVI A,0
0161 D3AF                OUT 0AFH
0163 C3XXXX              JMP SYSTEM
0166 F620       INPUT    ORI 20H
0168 D3AF                OUT 0AFH
016A E6DF                ANI 0DFH
016C D3AF                OUT 0AFH
016E DBAF       LOOP     IN 0AFH
0170 17                  RAL
0171 DA6E01              JC LOOP
0174 DBAF                IN 0AFH
0176 C9                  RET
0177 C5         DELAY    PUSH B
0178 3E05                MVI A,5
017A FE00       DEL0     CPI 0
017C CA8B01              JZ RETDEL
017F 0669                MVI B,69H
0181 00         DEL1     NOP
0182 00                  NOP
0183 05                  DCR B
0184 C28101              JNZ DEL1
0187 3D                  DCR A
0188 C37A01              JMP DEL0
018B C1         RETDEL   POP B
018C C9                  RET
C000 =          SYSTEM EQU 0C000H
018D            TEMP1 DS 2
018F            TEMP2 DS 2
0191            TEMP3 DS 2
0193            TEMP4 DS 2
0195 YY         COMAND EQU $
0100 21 00 02 22 8D 01 21 00 03 22 8F 01 21 00 04 22
0110 91 01 21 00 05 22 93 01 3A 95 01 CD 66 01 2A 8D
0120 01 77 2C 22 8D 01 3A 95 01 C6 01 CD 66 01 2A 8F
0130 01 77 2C 22 8F 01 3A 95 01 C6 02 CD 66 01 2A 91
0140 01 77 2C 22 91 01 3A 95 01 C6 03 CD 66 01 2A 93
0150 01 77 2C 22 93 01 CA 5F 01 CD 77 01 C3 18 01 3E
0160 00 D3 AF C3 53 00 F6 20 D3 AF E6 DF D3 AF DB AF
0170 17 DA 6E 01 DB AF C9 C5 3E 05 FE 00 CA 8B 01 06
0180 69 00 00 05 C2 81 01 3D C3 7A 01 C1 C9 9B F7 F0
0190 FE 57 DC 49 E2 A6
?
```

"HANDS ON" EXPERIENCE WITH A *TALKING* COMPUTER

BY LESLIE SOLOMON, Technical Editor



While testing the Speechlab, we borrowed an AI Cybernetic Systems (Box 4691, University Park, NM 88003) Model-1000 Speech Synthesizer ($325, assembled) to see if our microcomputer could "talk" as well as "hear." The Model 1000 is designed to fit into one slot of an Altair bus and delivers its output via an audio cable that can be plugged into any audio amplifier system. The output level is 0.6 volt p-p; impedance is 1000 ohms; and frequency range is 150 to 4500 Hz.

This synthesizer is phoneme-oriented. Accordingly, you can program it to say anything, as opposed to speech synthesizers that have only several words fixed in ROM. Essentially, the Model 1000 is a hardwired analog of the human vocal tract and various portions of the circuit emulate the vocal cords, the lungs, and the variable-frequency resonant acoustic cavity of the mouth, tongue, lips and teeth.

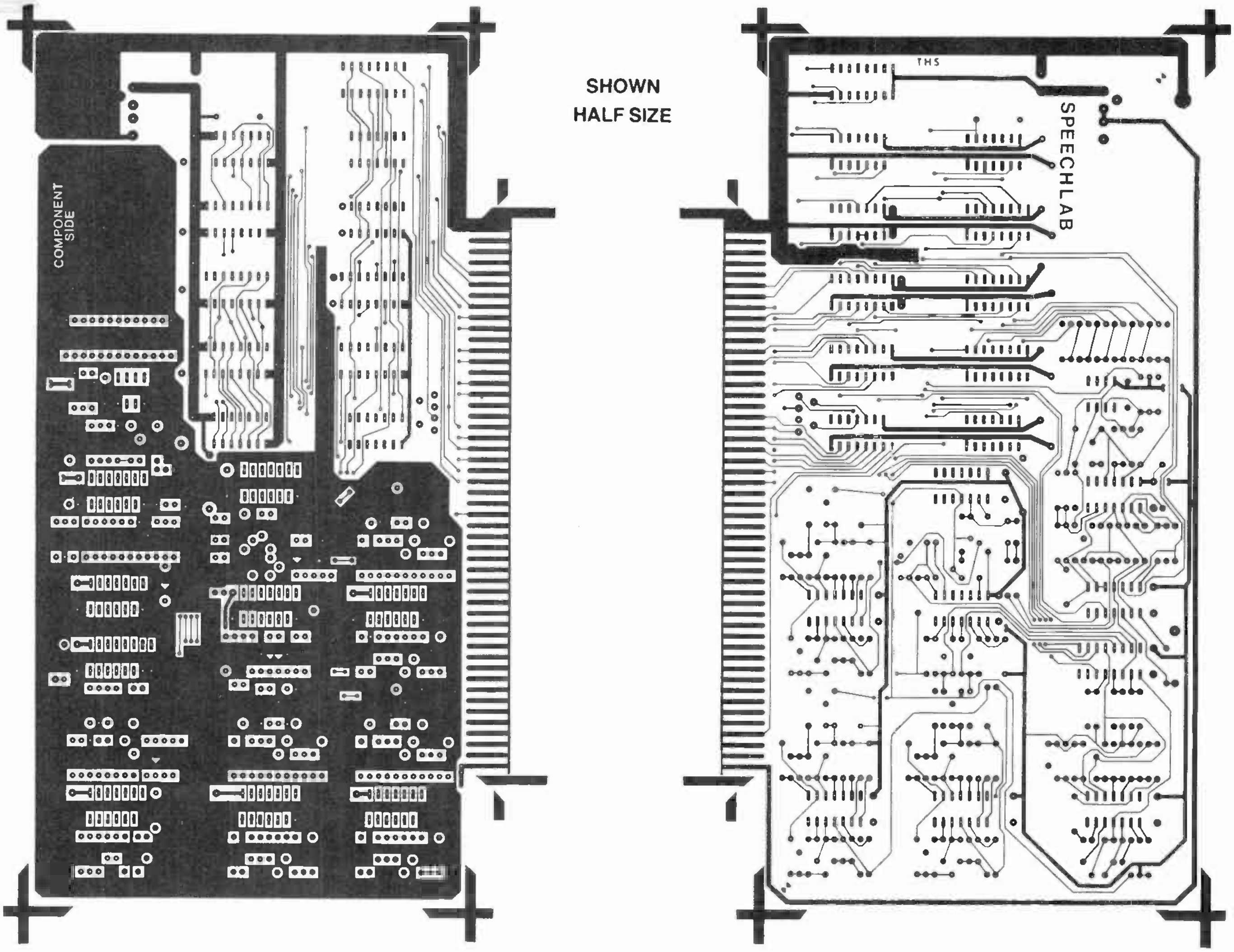


Fig. 8. Etching and drilling guides for pc board are shown half size. Guide at left is the component side. Component layout is in Fig. 9.

P again. You answer with a T, and the process is continued as long as you want. Do not exceed 16 entries with this sample program.

Once you have some vocalized digits in memory, run the program again. This time, when the Teletype asks T or P, answer with a P (for perform). Now, as you *speak* the digits into the microphone, the Teletype will respond by typing that digit. When used in a quiet room, with the same vocalization, this algorithm can be

All the information necessary to perform the synthesis functions are located within a ROM that is accessed by the program. Words and sentences are formed by supplying a string of ASCII characters as would be done when outputting to any port, except that these strings also use some non-alphanumeric characters (i.e., the "+" is used to form "th" as in "thaw" or "earth"). Each ASCII character represents a particular phonetic sound or phoneme. If desired, you can create a program that produces simultaneous printout and "voiceout" of the same string.

The device requires very little software to implement: less than 50 bytes of assembly language or a handful of BASIC statements. The manual accompanying the synthesizer covers speech generation in detail, how it is created, and what is involved. It also illustrates how to "mechanize" speech, with several examples shown.

After working with the synthesizer for a couple of weeks, we found that we have a lot to learn about how humans create speech. After many hours of studying, experimenting, and redoing programs, we made the Model-1000 utter some recognizable sentences. It is not easy, our experience showed, even when one uses the wealth of instructions provided.

Working with a phoneme-oriented speech synthesizer is a little like learning to use a microprocessor. All the logic is there, but programming it properly is another story. Like working with a processor for the first time, one must crawl frustratingly before walking. Slowly, however, the ideas start to percolate. Our computer still talks with a rather heavy "robotic" accent, but we have hopes that someday it will "humanize."

To paraphrase Sam Johnson: "Sir, a computer talking is like a dog walking on its hind legs. It is not done well; but you are surprised to find it done at all." We have a long road ahead to the "HAL-9000," but the first step has been taken.

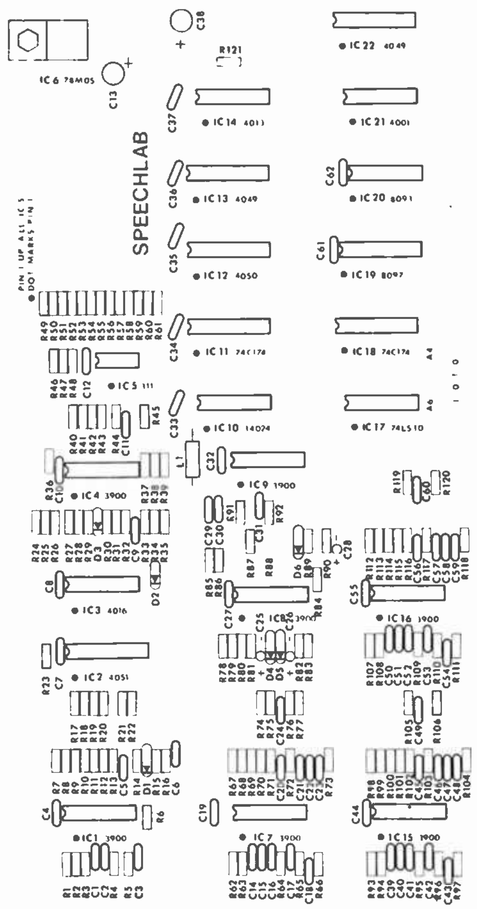


Fig. 9. Component layout for the Speechlab. See etching and drilling guide on previous page.

expected to have a recognition rate greater than 90%.

The program works as follows: the sampling subroutine is entered to obtain a sample of the amplitude every 10 milliseconds in each of the three frequency bands and to estimate the number of zero crossings during each time period. One hundred and fifty samples are collected, allowing up to 1.5 seconds of speech (between microphone "beeps"). A preset threshold is used to find the beginning and end of the word. The duration of the word can now be computed by a simple subtraction. Typically, this duration will be about 400-milliseconds for the digits. The duration time is divided by 16 to select 16 evenly spaced parameters from the three bands and zero-crossing information.

The 64 bytes obtained (16 parameters from each of the four bands) are compared with similar parameters which were collected during the training mode. A summation (running total) of the difference between the 64 parameters of the sample and the parameters of the training "templates" is computed. The totals represent a measure of the difference between the sample and each of the previously stored templates. The template with the smallest difference from the sample is then selected as the answer (output).

The above algorithm, while relatively simple, illustrates many of the basic concepts of speech recognition. A manual supplied with the Speechlab kit contains descriptions of other approaches to speech recognition, along with sample programs to demonstrate the techniques of speech recognition. ◇

TABLE II

0100	31	00	10	CD	5B	03	21	35	0B	CD	3A	03	CD	8F	03	FE
0110	54	C2	1A	01	CD	33	01	C3	00	01	FE	50	C2	2B	01	CD
0120	5B	03	CD	79	01	CD	81	03	C3	00	01	3E	3F	CD	70	03
0130	C3	00	01	F5	C5	D5	E5	CD	5B	03	21	3D	0B	CD	3A	03
0140	CD	DA	03	32	6E	04	3C	47	3A	6D	04	B8	DA	2B	01	CD
0150	5B	03	CD	A3	02	CD	99	01	CD	07	04	3A	6E	04	4F	16
0160	40	CD	F7	02	11	13	07	CD	A3	03	60	69	0E	40	11	C8
0170	06	CD	8C	01	E1	D1	C1	F1	C9	C5	D5	E5	CD	A3	02	CD
0180	99	01	CD	07	04	CD	3D	02	E1	D1	C1	C9	F5	EB	7E	23
0190	EB	77	23	0D	C2	8D	01	F1	C9	0E	00	21	6F	04	CD	F9
01A0	03	FE	06	D2	B2	01	79	FE	96	C2	9E	01	21	44	0B	C3
01B0	9D	02	79	3D	32	08	07	47	CD	F9	03	FE	06	DA	CC	01
01C0	79	FE	96	C2	B8	01	21	4E	0B	C3	9D	02	79	3D	3D	32
01D0	09	07	90	3C	32	C7	06	FE	0A	DA	A6	01	0E	01	CD	F9
01E0	03	FE	06	D2	ED	01	79	FE	0A	C2	DE	01	C9	3A	C7	06
01F0	81	4F	3A	08	07	81	4F	C3	B8	01	21	FF	FF	22	13	0B
0200	3E	00	32	6E	04	3A	6D	04	3D	4F	06	09	C5	79	87	4F
0210	21	15	0B	09	46	23	4E	21	13	0B	56	23	5E	CD	B2	03
0220	DA	2B	02	C1	0D	FA	39	02	C3	0C	02	21	13	0B	70	23
0230	71	C1	79	32	6E	04	C3	24	02	3A	6E	04	C9	CD	64	02
0240	06	00	48	16	40	3E	00	5F	21	13	07	CD	D5	03	CD	75
0250	02	1C	7B	FE	3F	C2	48	02	04	3A	6D	04	B8	C2	42	02
0260	CD	FA	01	C9	3A	6D	04	87	4F	3E	00	21	15	0B	77	23
0270	0D	C2	6E	02	C9	E5	D5	C5	F5	21	C8	06	16	00	19	96
0280	F2	85	02	2F	3C	57	78	87	21	15	0B	4F	06	00	09	23
0290	7A	86	77	D2	98	02	2B	34	F1	C1	D1	E1	C9	CD	3A	03
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02C0	77	23	14	C3	B7	02	3E	0A	CD	E3	02	1D	C2	B5	02	CD
02D0	4B	03	C9	F6	20	D3	AF	E6	DF	D3	AF	DB	AF	17	DA	DB
02E0	02	1F	C9	C5	FE	00	CA	F5	02	06	69	00	00	05	C2	EB
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0310	C9	F5	D5	1E	09	78	47	79	17	4F	1D	CA	2F	03	78	17
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0370	F5	DB	00	07	D2	71	03	F1	D3	01	C9	00	00	00	00	00
0380	00	E6	0F	C6	30	FE	3A	DA	70	03	C6	07	C3	70	03	DB
0390	00	E6	40	CA	8F	03	DB	01	E6	7F	C3	70	03	00	00	00
03A0	00	00	00	EB	09	EB	42	4B	C9	F5	79	93	4F	78	9A	47
03B0	F1	C9	32	0A	07	78	BA	CA	BE	03	3A	0A	07	C9	79	BB
03C0	3A	0A	07	C9	F5	C5	D5	CD	F7	02	09	85	6F	D2	D1	03
03D0	24	D1	C1	F1	C9	CD	C4	03	7E	C9	CD	8F	03	E6	7F	FE
03E0	30	DA	2B	01	FE	3A	DA	F6	03	FE	41	DA	2B	01	FE	47
03F0	3F	DA	2B	01	D6	07	D6	30	C9	AF	C5	06	03	86	23	05
0400	C2	FD	03	C1	23	0C	C9	21	C8	06	22	0B	07	3A	C7	06
0410	4F	16	0A	CD	F7	02	16	10	CD	11	03	26	00	69	22	11
0420	07	21	00	00	22	0F	07	1E	10	D5	2A	0F	07	44	4D	16
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0460	A3	03	60	69	22	0F	07	D1	1D	C2	29	04	C9	10	CD	EF
0B30	DA	0C	FE	02	C2	54	20	4F	52	20	50	3F	00	4E	55	4D
0B40	42	45	52	00	4E	4F	20	53	50	45	45	43	48	00	4F	55
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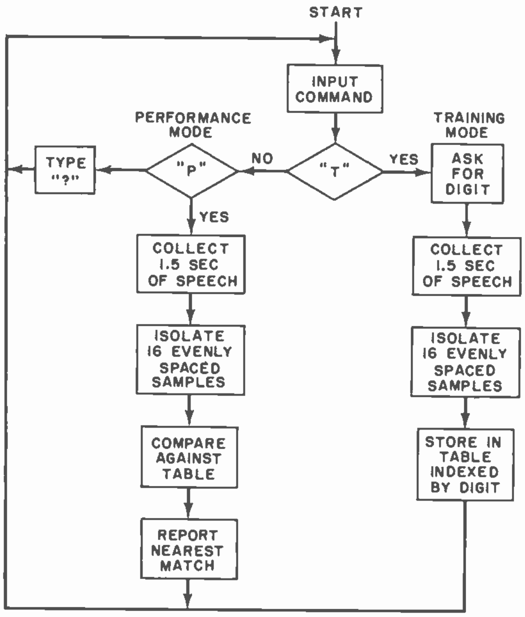
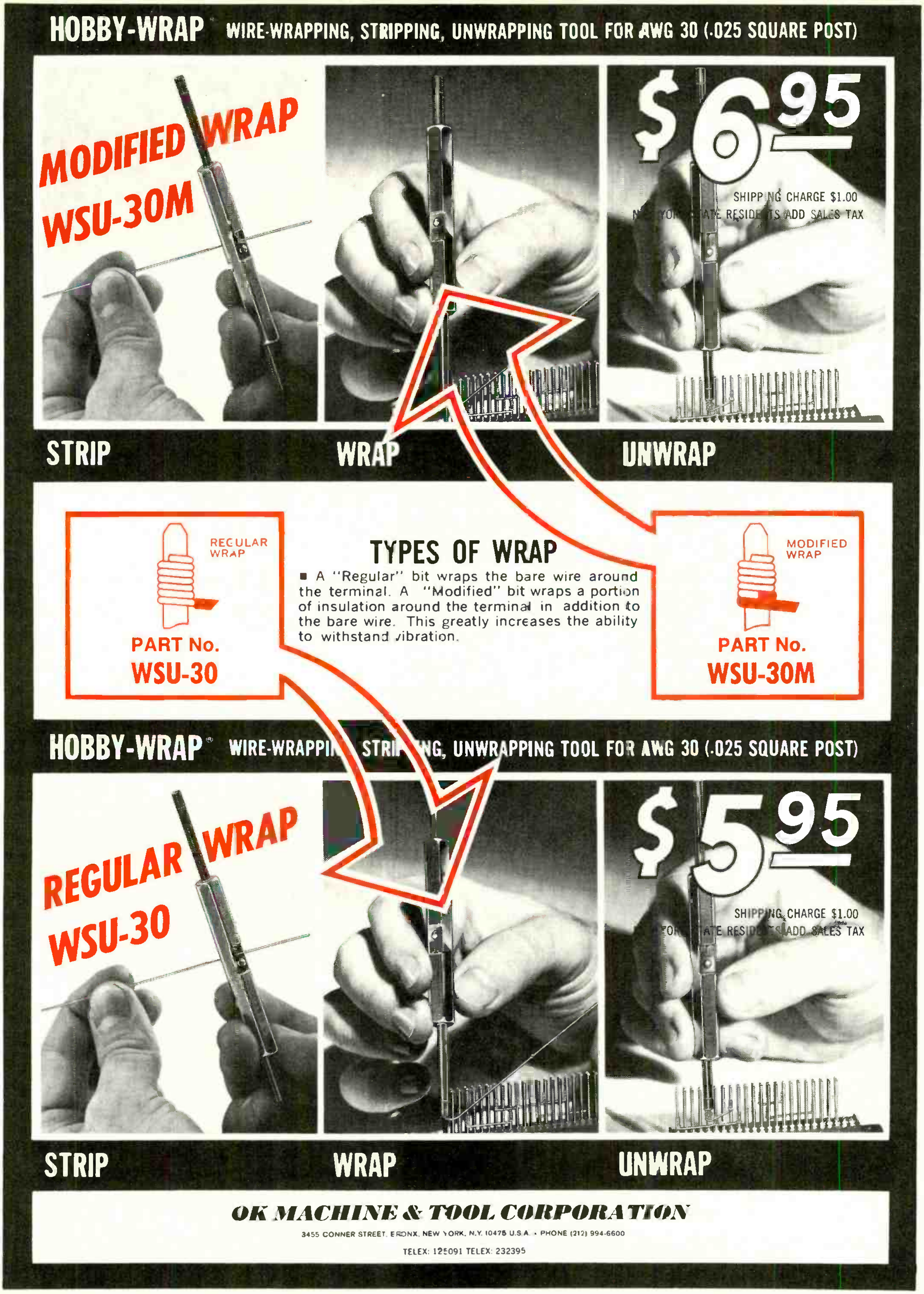


Fig. 10. Flow chart of a simple program that is used to "T" (train) and "P" (perform) a vocal operation. The program is shown in Table II.



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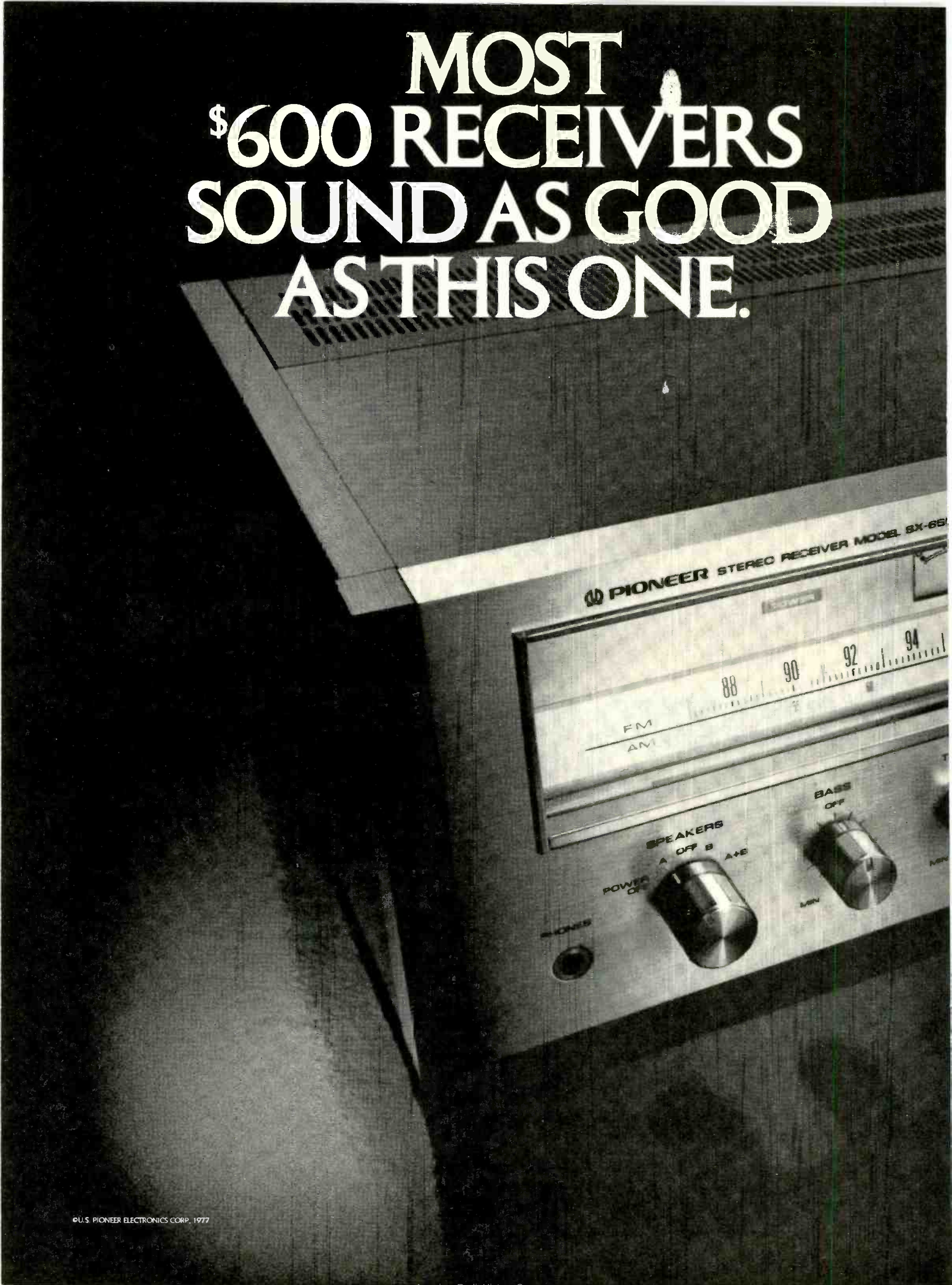
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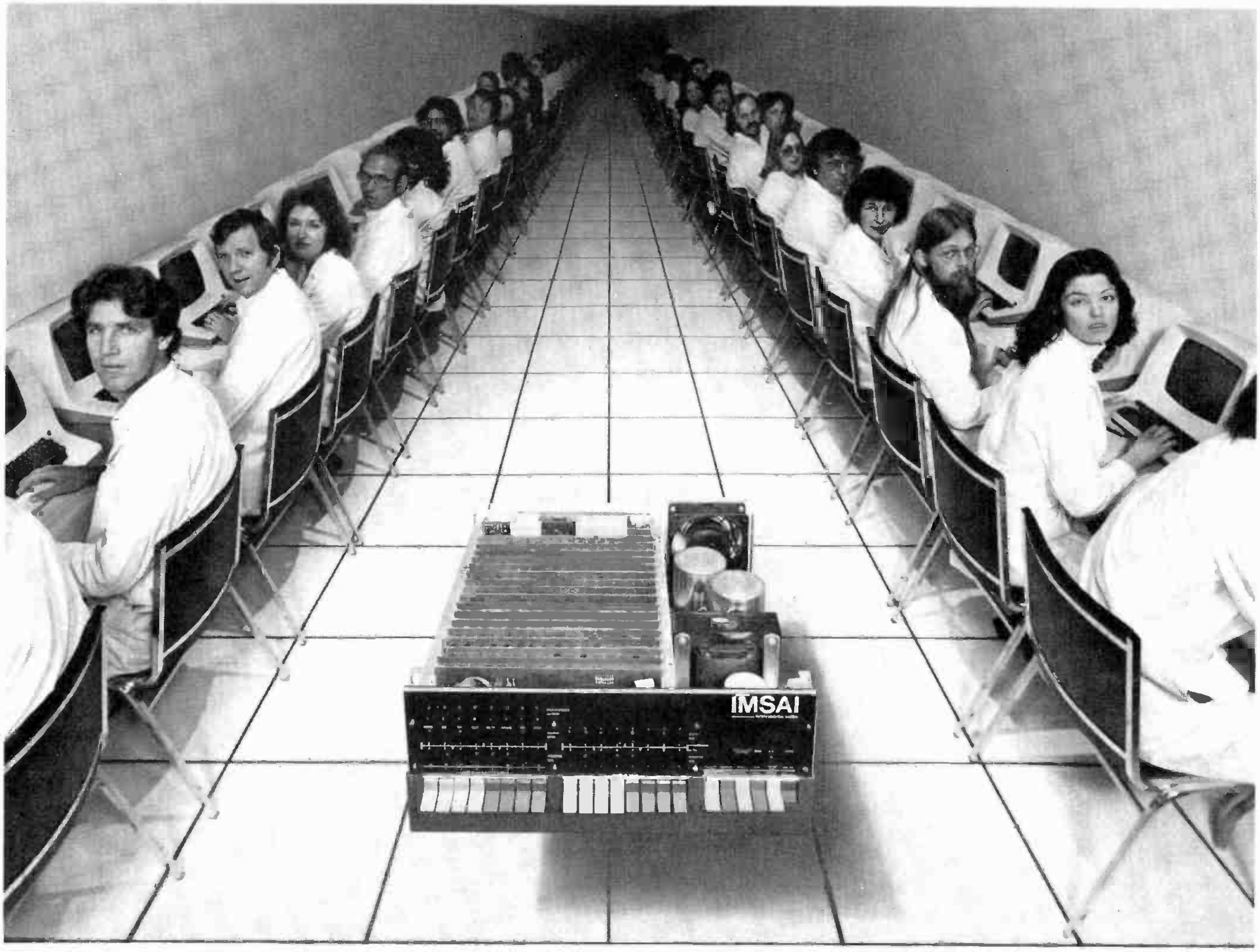
POWER.



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The Megabyte Memory

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Now, IMSAI presents an incredible memory system for micros 16 times more powerful than yesterday's best.

Imagine, a full megabyte of power from sixteen 65K RAM boards.

And, to control all this, the IMSAI Intelligent Memory Manager (IMM), the super control board.

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Plus, preset 16 mapping configurations with protect for high speed transfer or rapid change.

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There's even a real "time of day" clock.

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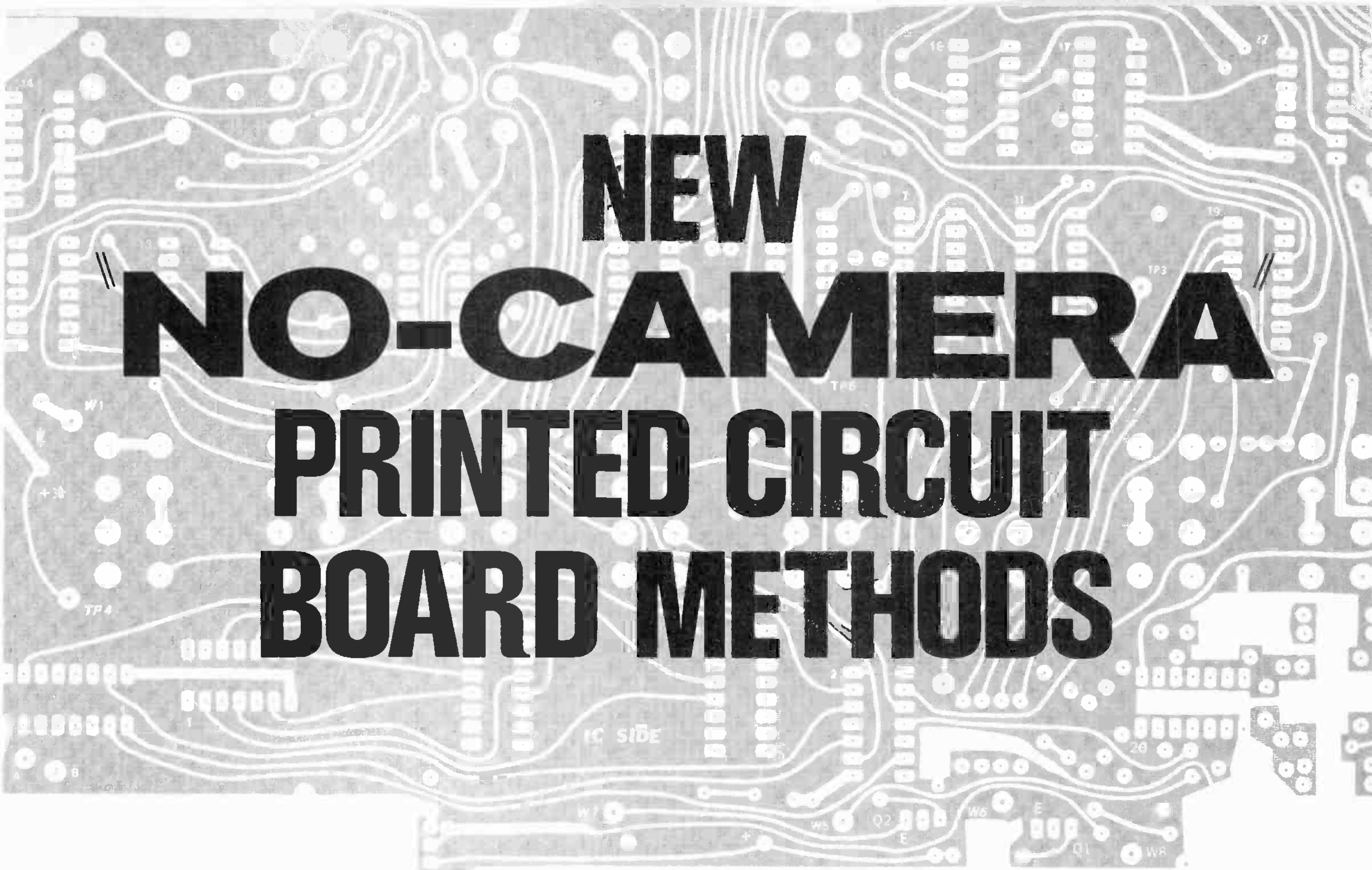


NEW "NO-CAMERA" PRINTED CIRCUIT BOARD METHODS

How to use GC Calectro and Datak kits for making pc boards directly from printed matter.

BY A. A. MANGIERI

YOU CAN now copy pc etching and drilling guides directly from the printed page without using a camera or laying out an artwork master. Two pc kits that can accomplish this dream feat for the electronics hobbyist are now on the market. One of these kits is called "Lift-It" from GC Electronics; the other is Datak's No. ER-4 kit.

The two direct-copy pc kits use different approaches to achieve essentially the same end. The Lift-It technique actually lifts the printed pattern from the page with a paint-on transparent film that has an affinity for the printing ink. The ER-4 technique uses a no-camera photographic process to duplicate or reverse a printed image or a positive or negative transparency, depending on how the copy film is exposed. Either copy method will greatly speed up the artwork portion of a construction project in which a pc board is used.

Kit Lineups. The Calectro No. J4-828 Lift-It kit from GC contains seven chemicals in bottles and cans, three trays, and pc contact film. The chemical lineup includes the paint-on Lift-It film solution around which the kit is built, board-stripping solution, contact film developer, board developer, paint-on resist lacquer, aerosol resist sensitizer, and premixed ferric-chloride etching solution. Two of the trays supplied are aluminum and are meant for the developing processes, while the third tray is plastic and is for etching only.

The only additional items needed for making printed circuit boards with the Lift-It kit are a yellow "safe" light, any of several light sources for exposing the contact film and board, and copper-clad board blanks. All chemicals in the kit come premixed and ready to use.

Datak's No. ER-4 kit uses a unique direct-photocopy process, called Pos-Neg. The kit contains four chemicals, a printing frame with yellow filter, artwork aids (layout film, drafting tape, and direct-etch dry-transfer pc patterns), photocopy film, and two copper-clad pc blanks. The two types of film developer, film fixer, and ferric-chloride etchant are supplied in powder form (to be mixed when needed), while the board developer and photoresist come ready to use.

The only additional materials needed with the ER-4 kit are a photoflood lamp, three glass or plastic trays, and bottles for the home-mix chemicals.

With both kits, you receive complete, detailed instructions on how to use them. In both cases, materials are supplied for making both positive and negative exposure masks for use with presensitized pc blanks (single-sheet original artwork can measure up to 5" by 5").

Note: The two methods are described separately on the following two pages. Methods of transferring from artwork to pc board are given on the final page of this article.

THE "LIFT-IT" METHOD

If you are new to pc techniques and have little or no experience in working with photographic techniques, the GC Lift-It kit may prove to be more convenient to use. There are no photo methods used in making the first film artwork.

Since using the Lift-It method destroys the original published etching and drilling guide, it pays to photocopy both sides of the magazine page on which the artwork appears so that none of the published material is lost. Cut the page from the magazine, trim the artwork to leave about ¼" (6.35 mm) excess on all sides, and tape the artwork flat on a sheet of waxed paper. Paint the Lift-It emulsion over the entire surface of the artwork and allow to dry for 15 minutes. Repeat painting on the Lift-It emulsion and allowing it to dry until six thin, even coatings have been built up. After applying the final coating, allow the emulsion to dry for at least two hours.

When final drying is complete, soak the artwork in warm, soapy water for an hour or more. Remove the artwork from the soaking bath and carefully remove the softened paper from the Lift-It film by rubbing with the tip of your finger. Be careful to avoid tearing, stretching, or deforming the film. If particles of paper prove to be stubborn, return the artwork to the soaking bath for 15 minutes to a half hour. Finally, when all particles of paper have been removed from the film, allow the latter to completely air dry, after which you can apply a coat of the Lift-It emulsion to the ink side of the film. Make this coat as thin as possible.

You can greatly reduce the time to make the first artwork if, after applying the Lift-It emulsion, you dry it under a heat lamp or in a just-warm oven. Arrange the heating to dry the film in 3 to 5 minutes. (The wet emulsion is milky; as it dries, it becomes clear.) Using heat to speed up the drying, you can put the artwork in the soaking bath after 30 to 45 minutes of final drying. To reduce soaking time, tape the artwork, paper side up, to a clean glass plate and place both in the bath. After 10 minutes or so of soaking, cautiously rub the surface of the paper to break up any glaze. Repeatedly rub the paper gently until it begins to roll off in small bits at first and then in larger pieces. If the paper stubbornly adheres to the film, do *not* rub harder; allow additional soaking time and then proceed.

The prepared artwork can be used as is to expose presensitized pc blanks treated with positive photoresist, such as GC's No. 22-232 spray-on positive resist (use only GC No. 22-225 resist developer when using this positive photoresist—not the No. J4-630 board developer supplied in the Lift-It kit).

Positive to Negative. Assuming you are using negative photoresist and have a Lift-It positive, the next step is to make a negative of the Lift-It artwork. To do this, you use the contact film supplied in the kit. The procedure is simple. Working under safe-light conditions, you cut the film to size, place it glossy side up in a contact frame (such as GC's No. 22-280 frame), place over the film the Lift-It positive with ink side down, close the frame, and expose it under cool-white fluorescent light. If you do not have a contact frame, two clean sheets of glass will do. Excellent results are obtained with a pair of 20-watt cool-white fluorescent lamps at a distance of 4" (10.2 cm). Exposure time will first have to be established by exposing segments of a thin strip of the film for ½, 1, 2, and 4 minutes.

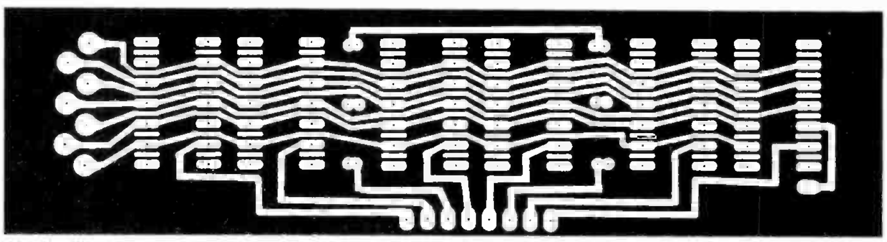
Once you have established the correct exposure time and have exposed the film through the Lift-It positive, switch to safe-light conditions, remove the film from the contact frame, and place it, dull side up, on a clean sheet of glass. Flow onto the film a liberal quanti-

THE "POS-NEG" METHOD

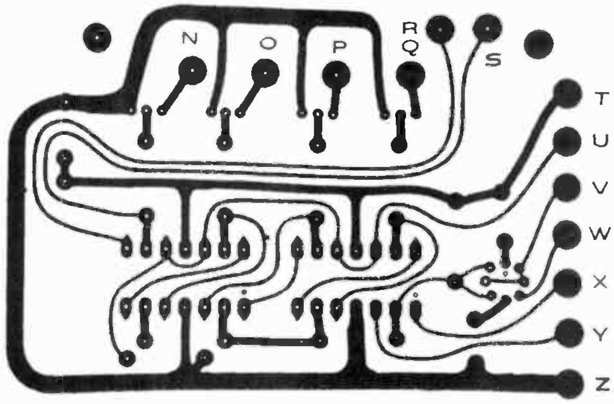
The Pos-Neg method used in the Datak ER-4 kit depends on accurate timing during the exposure of the sensitized film supplied in the kit. Using the Pos-Neg copy mode, you can directly copy the pc etching and drilling guide from the printed page. This results in a film positive that can be used directly to expose positive-resist-sensitized pc blanks.

To use the direct-copy Pos-Neg method, you begin by loading the contact frame (included in the kit) with the printed etching and drilling guide with the artwork facing up, followed by a narrow test strip of the sensitized film with its brown side up, and with the yellow filter on top. The whole is firmly sandwiched together between the contact frame and its top glass.

Next, you expose the test strip in blocks for 30 to 100 seconds at 10-second intervals. After developing and fixing the exposed film strip, you may find only one block satisfactory for your



Typical ER-4 mask.



Mask made using the "Lift-It" process.

ty of contact-film developer. Soak a wad of cotton with the developer and rub gently, in a circular motion, over the entire dull surface of the exposed film. After a minute or two, the areas of the film that were not exposed to the exposing light will begin to dissolve and come away from the film. Continue rubbing until all soft areas of emulsion have been removed. Be as gentle as possible with your rubbing because the emulsion left behind at this point will be soft. When all unwanted emulsion has been removed, rinse the film under gently running warm water and allow to dry completely.

What you should now have is a high-contrast film negative with opaque orange areas surrounding water-clear conductor areas. The details should be as sharp as they are in the Lift-It positive. Carefully examine the film negative for discontinuities and other flaws. You can repair discontinuities by cutting away the appropriate portions of the film with a razor blade or sharp X-acto knife. Pits and other flaws in the emulsion can be repaired with the paint-on resist lacquer in the kit.

Although exposure time is not critical, gross underexposure will result in complete removal of the emulsion. Conversely, gross overexposure might preclude any development at all.

needs. The "good" block will have almost opaque blacks surrounded by a slight brownish haze in the "clear" areas. It is usually necessary at this point to run off another test strip, this time in 3-second steps that span the exposure time of the "good" test block, to determine the exact required exposure time within 3 seconds.

Since the Pos-Neg technique involves both direct and indirect lighting effects, it is quite critical. An accurate enlarger timer to control the on-time of the photoflood light will prove helpful. If you do not have an enlarger timer, you can use a clock with a sweep second hand and manually control the lamp.

At all times, the presensitized film must be in intimate contact with the printed etching and drilling guide. Additionally, there can be no "print-through" in the artwork. If printing on the reverse side of the page from the etching and drilling guide is visible, back the artwork with matte black paper.

The simplest of the photo copying procedures with the ER-4 kit is the duplication of a positive from positive or negative film transparency. Here, again, you must determine the proper exposure time. You load the contact frame with the grey side of the sensitized film up, transparency, and yellow filter on top, and expose in blocks for 20 to 90 seconds in 10-second intervals. After developing and fixing the exposed film, the correct exposure time will be that represented by the block with opaque black areas surrounded by water-clear areas.

Positive to Negative. Two separate exposures of the sensitized film are required to make a positive from a film negative or vice-versa. First, you must determine a "clearing" time. To do this, you load the contact frame with the film test strip with its grey side up and place the yellow filter on top. Then, you expose the strip in blocks for 20 to 90 seconds in 10-second intervals. After this, you develop the film in fresh developer at 68° F (20° C) for 2 minutes, place it in the fixer for 5 minutes, wash it under gently running water, and allow it to dry. The test strip should go from fully opaque black to fully water clear, with one or two intermediate shades. If the first fully clear block was exposed for 60 seconds, the clearing time is 70 seconds, for example. Record the clearing time for future reference.

Now, to reverse your film transparency, you first expose the entire test strip through the yellow filter for the recorded clearing time. Then, remove the yellow filter and substitute it with the film transparency and expose again in blocks for 3 to 21 seconds at 3-second intervals. After developing, fixing, and washing the test strip, select the block that has opaque blacks with water-clear whites. You now know the exposure times for both clearing and copying.

The ER-4 Pos-Neg system sounds more complicated than it really is. Once you gain some experience with it, it will be no more difficult to use than were other "photo" methods used in the past.

FROM ARTWORK TO BOARD

With very little practice, you can easily photosensitize copper-clad pc blanks. The blanks must be flat and free of ragged edges. The best way to deal with a ragged edge is to use a fine steel file to remove copper burrs and fine emery cloth to smooth the edges. Next, thoroughly scour the copper with a steel-wool soap pad until it has a burnished finish and sheds water. Rinse thoroughly and allow to air dry, either at ambient room temperature or in a just-warm oven. Do *not* wipe the blank dry with a towel. The blank is now ready to be sensitized with photoresist.

Go to safe lighting conditions and place the pc blank with its copper side up on a couple of thicknesses of newspaper, thoroughly shake the can of spray resist, and spray a thin, even coating of the resist over the entire copper surface. Dry the resist for an hour at room temperature or for 15 minutes in a just-warm oven. Then inspect your work under safe lighting. If the coating of resist lacquer appears to be too thin, apply a second thin, even coat and again allow to dry. Before taking on a big job, develop a "feel" for the spray technique, using a piece of scrap pc blank.

Finishing Steps. Under safe light, place the sensitized pc blank in the contact printing frame and place the exposure mask on top. Make absolutely certain that the proper side of the mask is in contact with the blank. You can now expose the blank with any of four light sources, detailed in the instructions supplied with the kits. A fluorescent lamp with two 20-watt cool-white tubes at a distance of 4" from the top of the contact frame is suitable. You will have to determine the proper exposure time by trial and error with sensitized scrap pc blank.

Once the blank has been exposed, go to safe lighting and immerse it in the appropriate pc board developing solution and agitate. Remove the blank from the solution promptly when the circuit pattern appears, usually in about a minute or less. At this point, the resist is no longer sensitive to light, and you can switch back to normal lighting. Flush the developed blank under gently running water and allow to air dry at room temperature for an hour or in a just-warm oven for about 20 minutes. At no time before the board is dry should you touch the resist pattern. The pattern will still be soft and easily damaged.

After drying is complete, carefully inspect the pattern for faults and use paint-on resist lacquer or dry-transfer patterns to touch up any breaks. Then etch the blank in pc etching solution. You can speed up the etching time by preheating the etching solution by setting the bottle of solution in hot water until it becomes too hot to handle. Do *not* pour the etchant into a pot and heat it directly on a stove. Pour the etchant into a glass or plastic tray large enough to accommodate the pc blank. Place the blank, copper side down, in the hot etchant and agitate the bath by gently rocking it back and forth. Periodically check the progress of the etching after 20 minutes. When all unwanted areas of copper have been etched away, remove the pc board from the etchant and thoroughly rinse it under running water. Then remove the resist on the copper with pc board stripping solution.

The final step in making a professional-quality pc board at home is to trim the board to size and drill all component-lead and mounting holes. From initial artwork to ready-to-go etched and drilled board, the job should take between five and eight hours, depending on the size and complexity of the board. The boards you make with either of the two kits described here will be indistinguishable from boards made by a professional. ◇

If You're Still Playing Games It's Because You Haven't Seen Our Software Library

This LIBRARY is a complete do it yourself kit. Knowledge of programming not required. EASY to read and USE. Written in compatible BASIC immediately executable in ANY computer with at least 4K, NO other peripherals needed.

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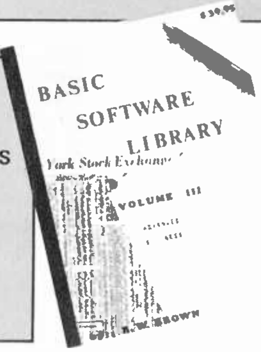

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 CIRCLE NO. 10 ON FREE INFORMATION CARD

Build a Legal In-Flight AIRLINE RECEIVER

Hear pilot-to-control conversations while in-flight with low-cost Varactor-tuned crystal set.

BY CASS R. LEWART

UNTIL NOW, "armchair pilots" wishing to listen to airplane-to-tower communications have had to confine their activities to ground-based monitoring. But the project described here—essentially a vhf crystal set with a small audio amplifier—will allow reception of such conversations when the user is on board an airliner. It will do so *without creating any hazard* to the plane's navigation system. The receiver is easily built, using readily available, inexpensive parts.

About the Circuit. Unlike superheterodyne receivers, whose local oscillators generate signals which can interfere with reception in the 108-to-118-MHz radio-navigation band, this project can be used with complete safety. The heart of the project is a 4-transistor audio amplifier with a built-in speaker, shown schematically in Fig. 1. Power switch *S1* is ganged with *R1*, the volume control. The amplifier draws current from a single 9-volt transistor battery, *B1*.

A few modifications transform this amplifier module into an airline receiver, shown schematically in Fig. 2. The receiver comprises a tuned r-f circuit (*L1*, *C1* and *D1*), a demodulator (*D2*) and the modular audio amplifier. The tuned circuit is unusual in one respect—it uses a voltage variable capacitor or Varactor as the variable capacitance. This diode, when reverse biased over a range of 0 to 9 volts, behaves like a variable capacitor of 5 to 15 pF. Because *C1* is in series with *D1*, the effect of the fixed capacitor is neglible. The combination of *L1*, a small hand-wound coil, and *D1* resonate to provide coverage from 118 through 135 MHz. (Construction details for *L1* are given on the next page.)

A short piece of insulated, stranded hookup wire serves as an antenna. The wire is terminated with a pin or banana plug (*P1*), and is connected to the rest of

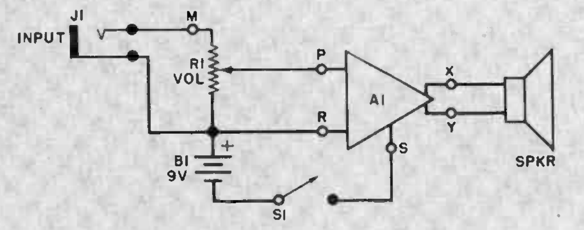


Fig. 1. Simple four-transistor audio amplifier before modification.

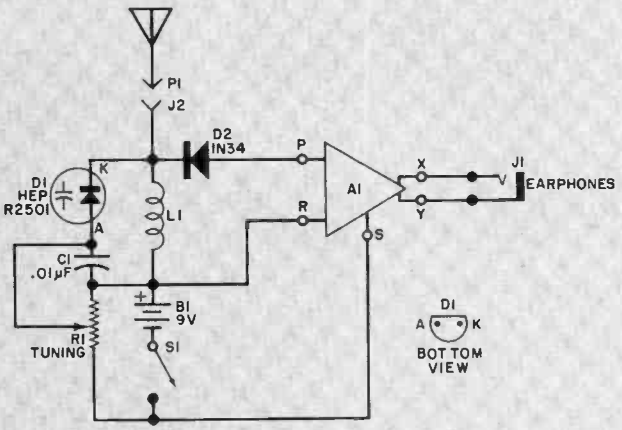
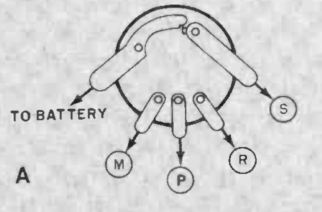


Fig. 2. Schematic of the amplifier with minor additional circuits needed to make airline receiver.

PARTS LIST

A1—Modular Amplifier (Radio Shack 277-1008 or equivalent)
B1—9-volt transistor battery
C1—0.01-µF, 50-V disc ceramic capacitor
D1—5-15-pF voltage-variable capacitance diode (Motorola HEP R2501—do not substitute)
D2—1N34 germanium diode
J1—Miniature phone jack (part of A1)
J2—Pin or banana jack
L1—Five turns of No. 24 enamelled copper wire on a ⅜-inch form, approx. 10 turns per inch
P1—Pin or banana plug
R1—Volume/tuning control (part of A1)
S1—Spst switch (ganged with R1, part of A1)
Misc.— Dynamic earphone (8 ohms), hookup wire, solder, etc.



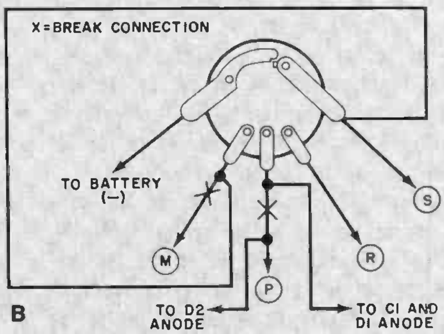


Fig. 3. Unmodified (A) and modified (B) wiring to R1 to convert it from volume to tuning control.

the circuit via *J2*, a pin or banana jack. Signals are thus applied to the tuned circuit, which is resonated by means of *R1*. This potentiometer, which served as the volume control in the unmodified amplifier, functions as a voltage divider to apply variable reverse bias across *D1*.

After the vhf signal has been boosted by the parallel LC circuit, it is demodulated by germanium diode *D2* and applied to the audio amplifier. The output of the amplifier drives a dynamic earphone plugged into jack *J1* (the former input to the amplifier).

Construction of the receiver is greatly simplified by modifying a ready-built audio module and adding a few additional components. In the author's prototype, a Radio Shack 277-1008 amplifier was used. However, other units can be used equally well. The additional components fit in place of the module's speaker.

Start by removing the three small Phillips screws which secure the amplifier pc board to the plastic enclosure. Then remove jack *J1* and unsolder the leads running to it. Raise the pc board and unsolder the leads connected to the speaker. Remove the speaker by softening the glue holding it to the plastic enclosure. Use acetone or nail-polish remover and pry the speaker away with a sharp knife. Then attach what were the speaker leads (points X and Y) to *J1*. Polarity is not important.

Refer to Fig. 3A and 3B for the following steps. Open the pc foil running from the volume control (*R1*) to the amplifier input (point P) and to the input jack (point M) by scraping it off with a sharp blade. Connect the terminal previously running to point M to one side of switch *S1* (point S), which is ganged with *R1*. Solder a wire to the wiper of *R1* and connect the other end to one side of *C1* and the anode of *D1*. Then solder a wire to the pc foil that formerly ran to the wiper of *R1* (on the other side of the break in the foil), and attach the other end of the wire to the anode of *D2*.

Next, drill a hole about 1-9/16" (3.97 cm) from the top of the enclosure on the left side (as viewed from the rear) to accommodate *J2*, the antenna input jack. Mount the jack and secure the pc board to the enclosure with the three small Phillips screws. To form *L1*, wind five turns of No. 24 enamelled copper wire on a ⅜-inch (9.53-mm) form, spaced about 10 turns per inch. Scrape the insulation off the ends of *L1* and position the coil in the speaker cutout of the pc board. Connect *D1*, *D2*, *L1*, and *C1* as indicated in the schematic, using *J2* for mechanical support. Be sure to observe correct polarity for the diodes or you will damage them. Solder all remaining connections.

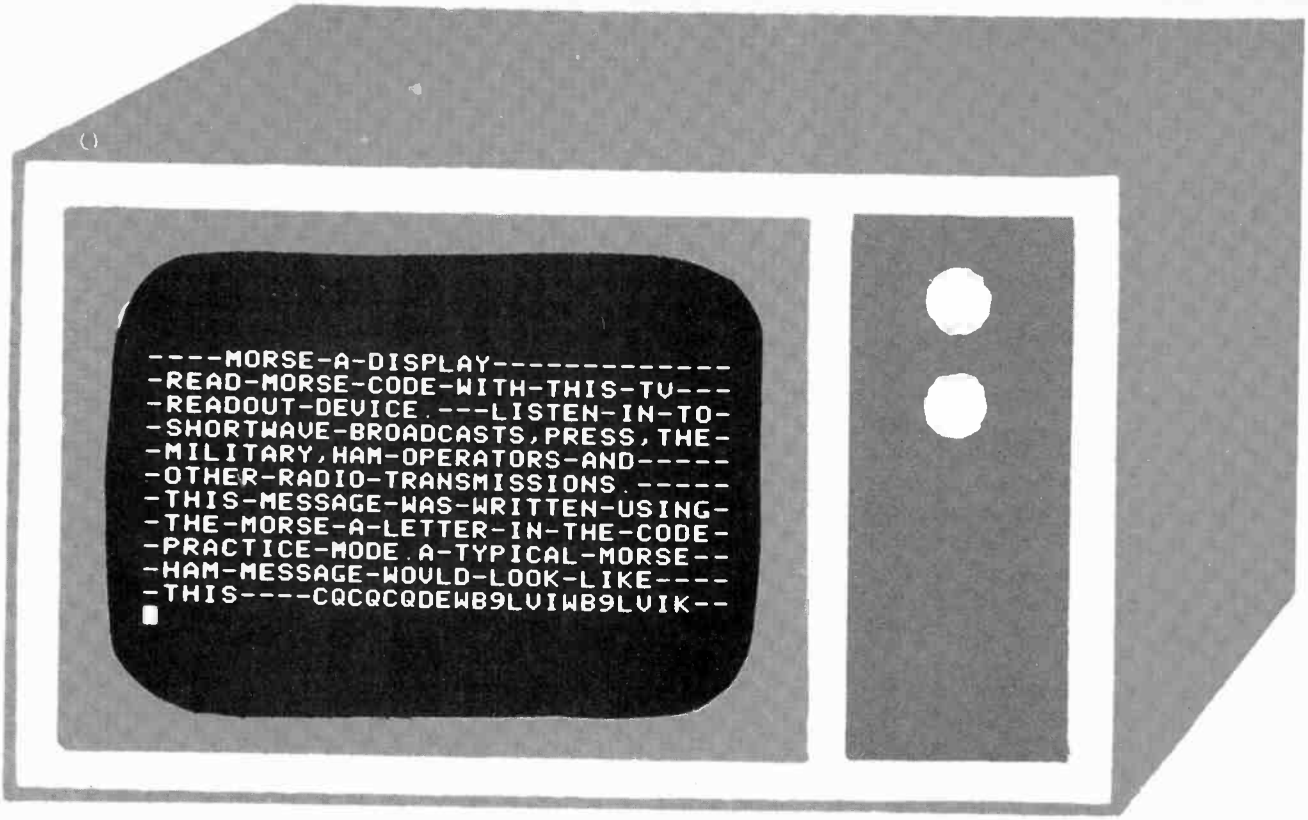
Alignment. The best way to align the receiver is to couple it to a signal generator producing an output at 125 MHz with internal 400-Hz modulation. Connect a small dynamic earphone to *J1* and set the tuning control (*R1*, the former volume control). Compress or expand the winding of *L1* for maximum audio output. If you can't get access to a signal generator with the required output, just go to your local airport. Connect a short (one foot or so) wire terminated with a suitable plug to *J2*, and listen to transmissions from the airport tower. Adjust *L1* for best reception with *R1* at center position.

Operation. The airline receiver is very simple to use. When you are taking a flight, try to get a seat near the window. Attach the antenna wire to the window with a small piece of masking tape, and plug the earphone into *J1*. This will allow you to monitor the pilot's conversations without causing a commotion.

You will not usually know the exact frequencies used by a particular airplane. Airport towers generally transmit and receive below 120 MHz. Other communications can be found anywhere between 120 and 135 MHz. Between takeoff and the time when a plane reaches cruising altitude, its pilot will use several frequencies in succession, communicating with the tower, departure control, and possibly to the particular airline controller. Similarly, the pilot will use several frequencies during the descent.

Each conversation will be brief, lasting only a few seconds. Accordingly, an important characteristic of this receiver is its broad selectivity as compared to that of a superheterodyne receiver. The user can therefore leave the tuning control at its center position. The pilot's transmission will still be heard—even if the tuned circuit is not resonant exactly at the operating frequency. The receiver can be quickly retuned for optimum reception if desired. Another possibility is to continuously tune the receiver back and forth, scanning the band until you can hear the pilot's voice.

When using the receiver, you may try to explain to the stewardess what you are doing in case other passengers think you are using a radio that might foul up airline communications. Your radio is similar to a tape recorder which would be permitted on board. ◇



MORSE CODE AUTOMATIC READOUT ON A TV SCREEN

How to interface the Morse-a-Letter to a "TV Typewriter."

BY GEORGE R. STEBER, WB9LVI

ALTHOUGH the Morse-A-Letter (January 1977) deciphers Morse code signals very effectively, its usefulness is somewhat limited by its single-character LED readout. At higher code speeds, the characters are displayed briefly, straining the operator's ability to copy down the entire text. However, it's easy to interface the Morse-A-Letter to a "TV typewriter." This combination, called "Morse-A-Display," will allow message display in page format—a boon to CW operators and SWL's interested in copying Morse.

Designed with this application in mind, the Morse-A-Letter contains all electronics necessary for converting dits and dahs to TTL-compatible ASCII-6 code. The required interface is simple and straightforward. All features of the original project are retained.

ASCII. Before examining the interface, let's review some basics of ASCII code. This will help us understand how the Morse-A-Letter/TV typewriter team operates. ASCII is a standard 8-bit information code used with most computers and data terminals. It may be used in the parallel (all bits present simultaneously on separate lines) or serial (one bit at a time on a single line) mode. Most systems do not use the eighth bit of the code and it is, therefore, assumed to be a logic one at all times. Some systems, however, use the eighth bit for parity or error testing. The remaining seven bits provide a total of 128 possible characters. Of these, one group of 32 is reserved for the upper case alphabet and a few punctuation marks. Another group of 32 is used for numbers, spacing and additional punctuation symbols. Rarely used punctuation marks and a lower case alphabet are assigned a third group of 32. Finally, the last 32 combinations are assigned as machine or control commands. This group does not actually get printed but is provided to handle hardware operations such as line feed (LF) or carriage return (CR). If only upper case alphanumerics are needed, only the first two groups of 32 codes are required, and only six of the eight bits of the code are used. This diminutive ASCII code is called ASCII-6 and is essentially the code produced by the Morse-A-Letter. No control codes are produced by the Morse-A-Letter, however, so most "housekeeping" operations (line feed, carriage return, etc.) must be performed by the TV terminal. This does not present a real problem, since most TV terminals are programmed to handle

INTERCONNECTIONS

Morse-A-Letter Connector	TV Terminal Connector
A13	Bit 7*
A21	Bit 6
A20	Bit 5
A19	Bit 4
A18	Bit 3
A17	Bit 2
A16	Bit 1
A14	Strobe
A1, A9	Ground

* Optional, see text

these operations automatically in the absence of specific commands.

Interfacing. Almost any TV terminal capable of receiving TTL-level, 7-bit parallel ASCII code can be used with the Morse-A-Letter. Most terminals will work well with the ASCII-6 code without any changes or additions. However, some terminals require the presence of the seventh bit (B7—not to be confused with edge connector location B7) to produce a question mark (?), due to the method used to check control characters. If the seventh bit is required by your terminal, don't despair! It can easily be obtained because B7 is merely the complement of B6 for the 41 valid ASCII characters produced by the Morse-A-Letter. This modification requires a small amount of additional wiring on the Morse-A-Letter circuit board. Fortunately, no additional parts are needed since an unused inverter (actually one half of *IC5*, a 7413 dual NAND Schmitt Trigger) is already "on the board."

To generate bit 7, connect a wire from B6 of the ASCII output (edge connector location A21) to pin 13 of *IC5*. Also, connect a wire from pin 8 of *IC5* to edge connector location A13. This becomes B7 of the ASCII code. Keep in mind that many TV terminals will function adequately with just the ASCII-6 code, so this addition may be optional.

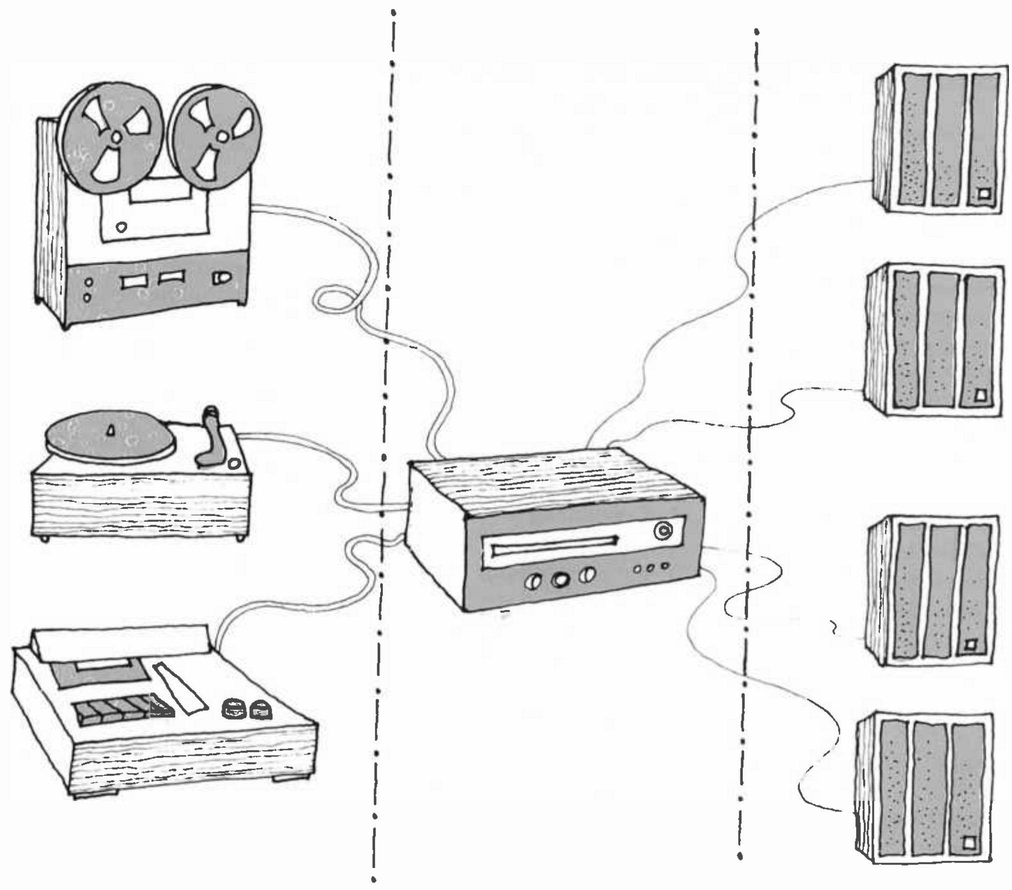
The TV terminal will normally require a "data ready" signal to tell it when an ASCII character is applied to its input connector. This signal is also sometimes referred to as a "keypressed strobe" or "new character" pulse. It is usually a positive going pulse that appears whenever the ASCII character is ready to be entered. The Morse-A-Letter provides this new character pulse in the form of a positive going pulse at edge connector location A14, which is generated every time a new Morse character is received.

A word of caution is in order. If your terminal does not utilize TTL levels at the ASCII input connector and/or requires a negative-going strobe pulse, an additional interface is needed.

As an example of an interface, the Table lists the wiring requirements for interfacing the Morse-A-Letter to the Southwest Technical Products CT-1024 Terminal, which has a TTL-compatible input and a positive strobe line. All that's required is connecting a suitable cable from the appropriate points on the Morse-A-Letter connector to the TV terminal connector. Note that no power supplies or additional electronics are necessary. Most other TV terminals will interface in a similar manner.

Operation. There are no adjustments required for the Morse-A-Display other than the normal code speed adjustment. It will function in either the code practice or the reception mode. Once a signal is properly tuned in, the television display will read out the incoming characters directly on the television screen. Illegal Morse characters willl be displayed as "@." Noisy signals may generate strings of "E"s or "T"s on the screen, but this is normal. Do not expect to view perfectly edited copy since word spaces are rarely sent in Morse code and the Morse-A-Display is not designed to decode them. This is not a serious handicap, however, and with a little practice you will be able to read complete messages from the screen. To copy high-speed Morse, it might be desirable to reduce the Morse-A-Letter's *C9* from 6.8 microfarads to 2.0 microfarads in the original circuit. This reduces noise immunity slightly, but enables copy at code speeds up to 50 WPM or more.

Remember it is illegal to pass information garnered from ship-to-shore, military, or press transmissions to third parties. ◇



HOW TO MATCH HI-FI COMPONENTS

Price tags serve as a good guide to apportioning dollars for each component.

MATCHING hi-fi components of a stereo or four-channel system means that each component must operate compatibly with each other.

For example, your loudspeakers should be efficient enough to deliver satisfactory sound levels—especially in the low bass region—when driven by the amplifier or receiver of your choice. Yet, they should have sufficient power-handling capacity to avoid damage if driven by too much power.

In another sense, compatibility also means that one component should not have substantially better performance than another component in the system. It would be foolish, for example, to have a $300 single-play turntable, $800 receiver, and two speaker systems at $500 each and then add a $19.95 phono cartridge. The latter's electrical/mechanical performance would be well below that of the other components in the system. As a result, one would not get the full performance capability inherent in the better components. Remember that the final reproduced audio will sound only as good as the weakest component link in the system.

One can often ignore electrical and mechanical considerations at the onset of rounding up his choices, however, by viewing compatibility in terms of each component's price tag. Thanks to competition among manufacturers, the quality of each type of component varies almost directly in relation to its price (although exceptions can always be found to virtually any generalization).

Most newcomers to component hi-fi (and some experienced audiophiles, too) have little or no idea of how to apportion their dollars to the various components they plan to buy.

Many audio dealers try to simplify this

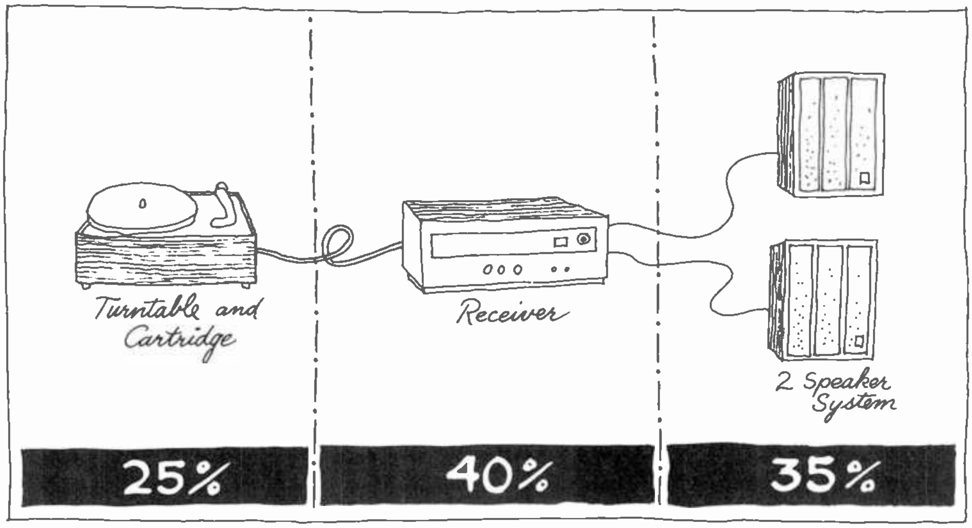


Fig. 1. Apportioning dollars to a stereo receiver/turntable/ speaker system.

problem by "assembling" pre-selected components into a complete system. Such systems usually bear a single price tag and offer significant savings over the prices of the individual components added together. There are both advantages and disadvantages in choosing such a dealer-selected system. Certainly, if the dealer is knowledgeable and reputable, you are at least assured that the components which have been put together in this way will work compatibly with each other—and the savings in making a single purchase from one source are often worthwhile. On the other hand, you may have different ideas about which components you think sound better with which other components. Consequently, your dream system may not be represented by any of the pre-selected groupings offered by the dealer.

In addition, it is common practice for some dealers (but not all) to have loudspeaker systems "custom designed" by local manufacturers who are essentially cabinet makers rather than speaker system designers. Since such speakers are rarely advertised nationally, almost any "suggested retail price" can be assigned

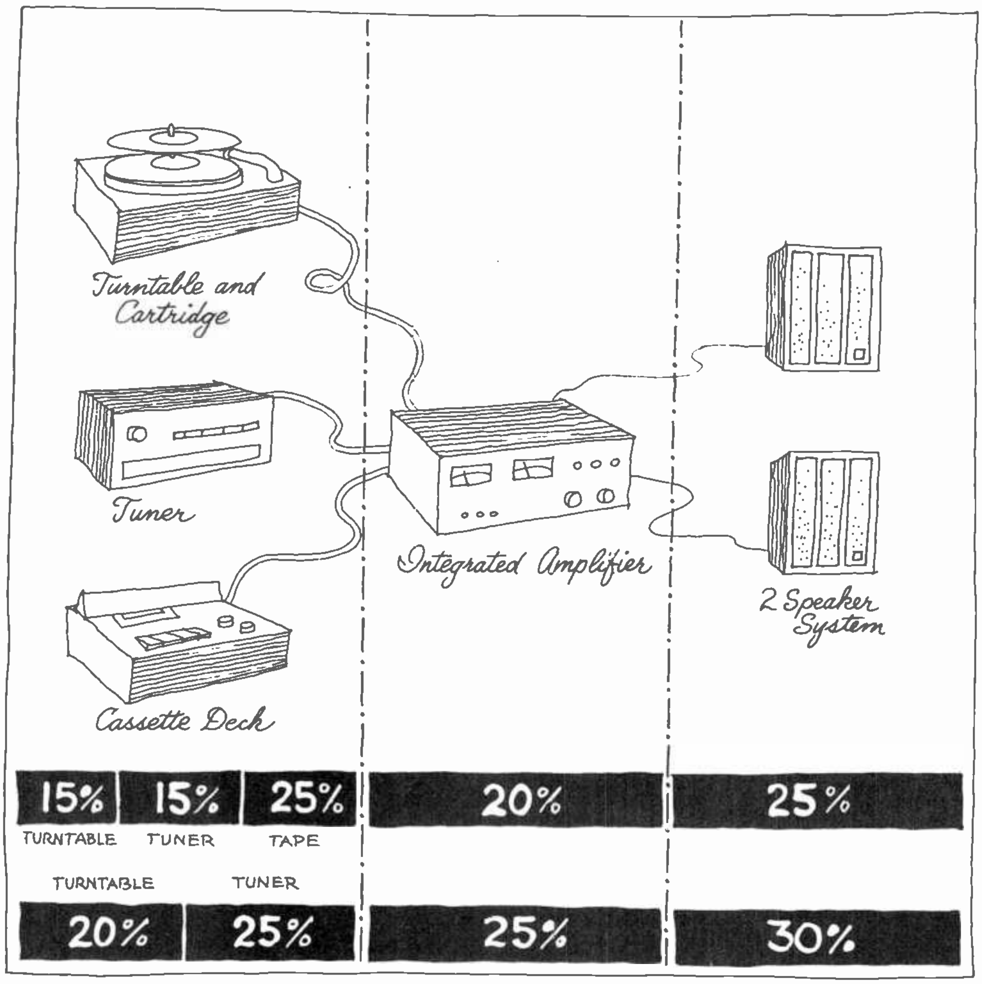


Fig. 2. Percentage of dollars to be spent on components for a system including tuner and cassette deck.

to them. In such instances, the "savings" shown in the final system price tag may actually be the result of reducing these speaker prices to more realistic levels. (This practice is not universal, of course.) What we are suggesting is that each component in such systems be analyzed and evaluated for its own merits and performance—for that is the essence of shopping for components for your own high-fidelity system.

Apportioning Hi-Fi Dollars. By far the greatest number of high fidelity stereo component systems consist of an all-in-one receiver, a turntable system (either single-play or multiple-play) and a pair of loudspeaker systems. This basic layout is shown in Fig. 1. Below it is a typical cost breakdown in percentages of available dollars. As an example, if you have $500 to spend on such a basic system, you might consider a turntable (including the phono cartridge, which is usually purchased separately) selling for approximately $125, a $200 receiver and two speakers for about $87.50 each. There are, of course, no hard-and-fast rules; these are simply rough guidelines. In the system shown, any tape equipment would be considered extra and is not included in the initial percentage breakdown.

Suppose you decided to include a cassette deck as part of your initial hi-fi investment, and that you prefer to have a separate tuner and an integrated amplifier (preamplifier-amplifier combination) instead of a receiver. Your system might then look something like that shown in Fig. 2, with the percentages spent for each component given below. Since such a system is necessarily more expensive than the simpler, 4-piece arrangement, let's start with a budget of $1000. You might spend $150 for a turntable and cartridge, $150 or so for a separate FM/AM tuner, $250 for a cassette deck with Dolby, $200 for an integrated amplifier and perhaps $125 for each of your two speaker systems. If the tape deck is eliminated for the moment, percentages could be reassigned as shown in the lower percentage table.

Quadraphonic systems necessarily cost more than stereo systems of equal quality. In Fig. 3 we have represented a typical quadraphonic system centered around a 4-channel receiver. Again, percentages are shown below for each element of the system. If we assume that you are prepared to spend $3000 for such a system (note that it includes both an open-reel tape deck and a stereo cassette unit) your dollars might be apportioned as follows: $600 for the open-reel deck, $300 for the cassette deck and a similar amount for the turntable/cartridge combination (you will need a cartridge designed to play CD-4 records this time), $750 for the 4-channel receiver and $262.50 for each of the four speakers in the system. If you were to omit the tape decks and had only $2000 to spend, the lower percentage table in Fig. 3 suggests that you might spend $800 on the 4-channel receiver, $200 for each of the four speakers needed, and up to $400 for the turntable/cartridge combination.

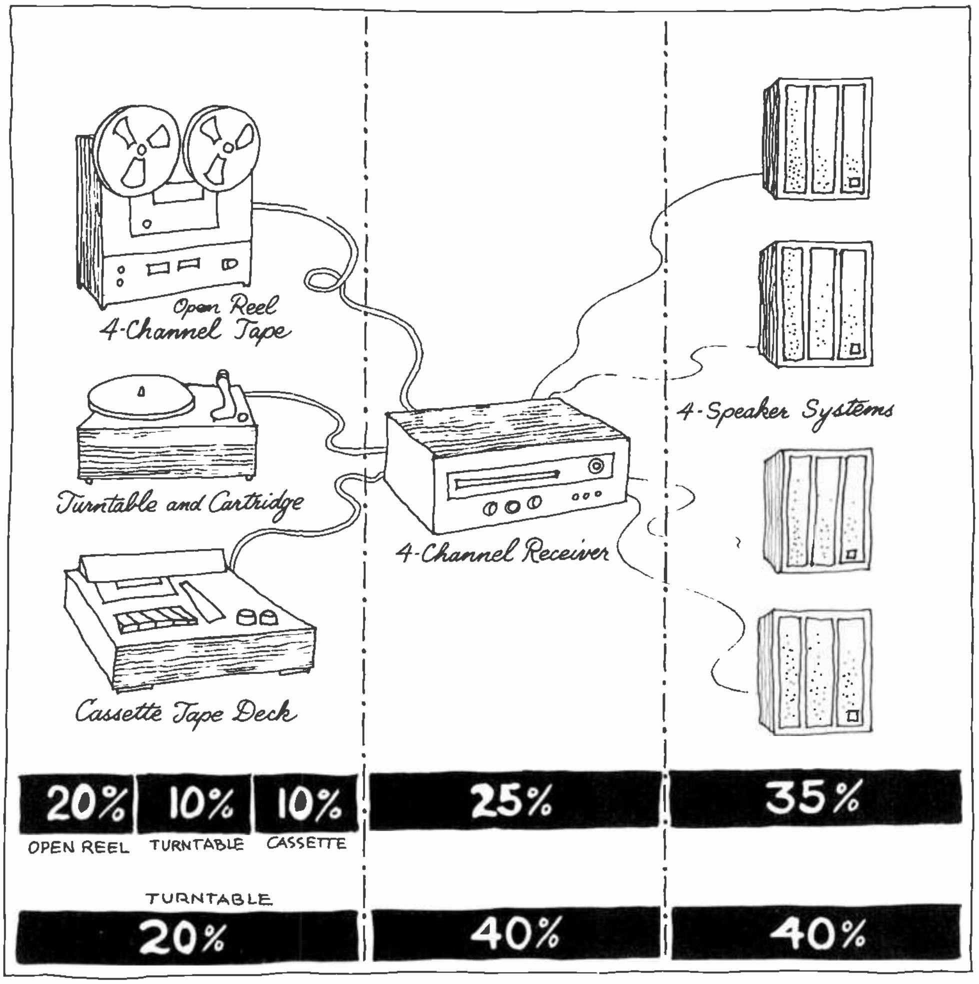


Fig. 3. How dollars should be apportioned for a four-channel system with open-reel and cassette decks.

Specs To Expect. Although specifications are certainly not the only criterion involved in making an intelligent

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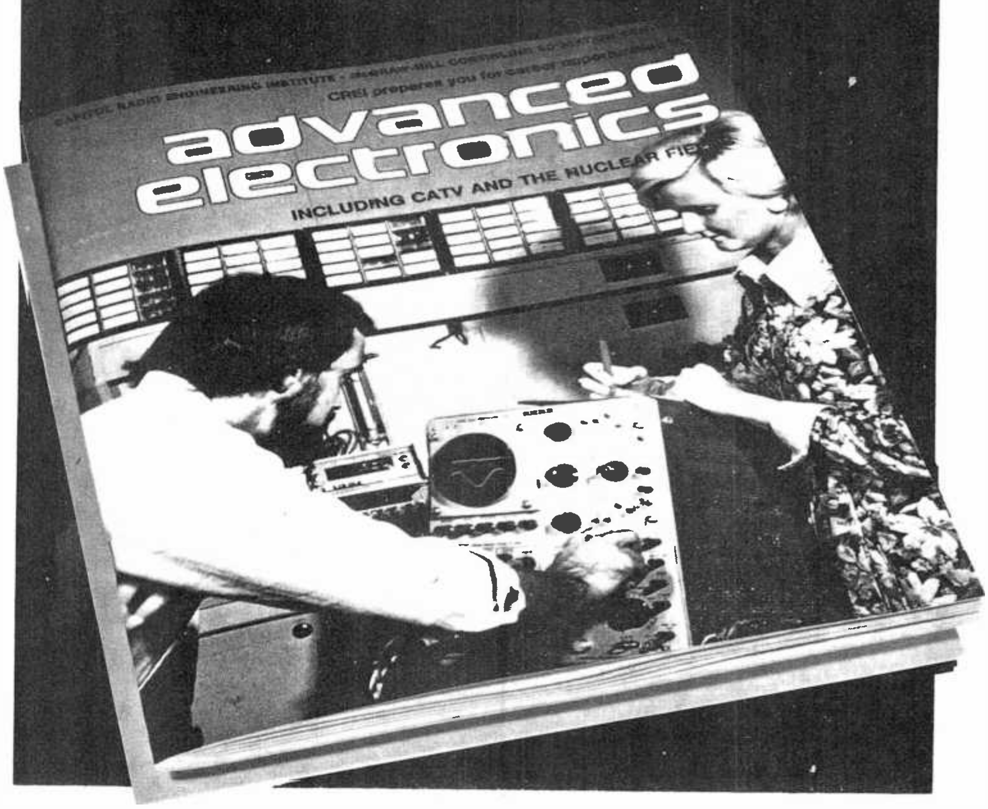

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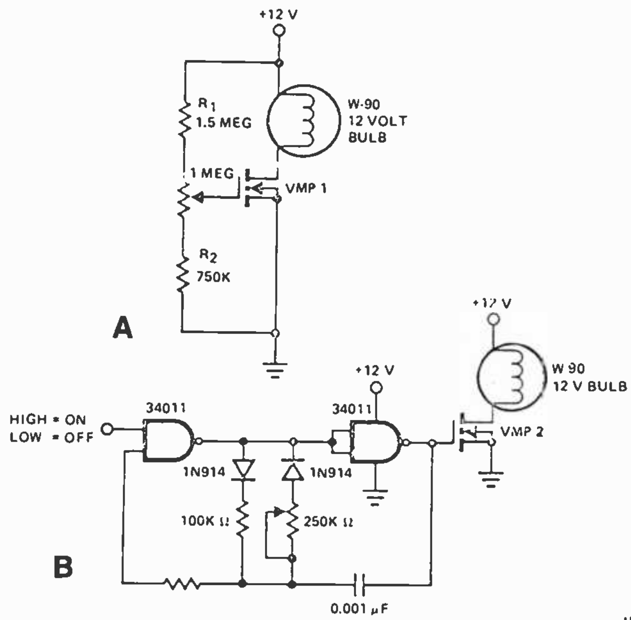

Fig. 3. VMOS light dimmer circuits: (A) Continuous (analog) control; (B) Pulse-width switched type.

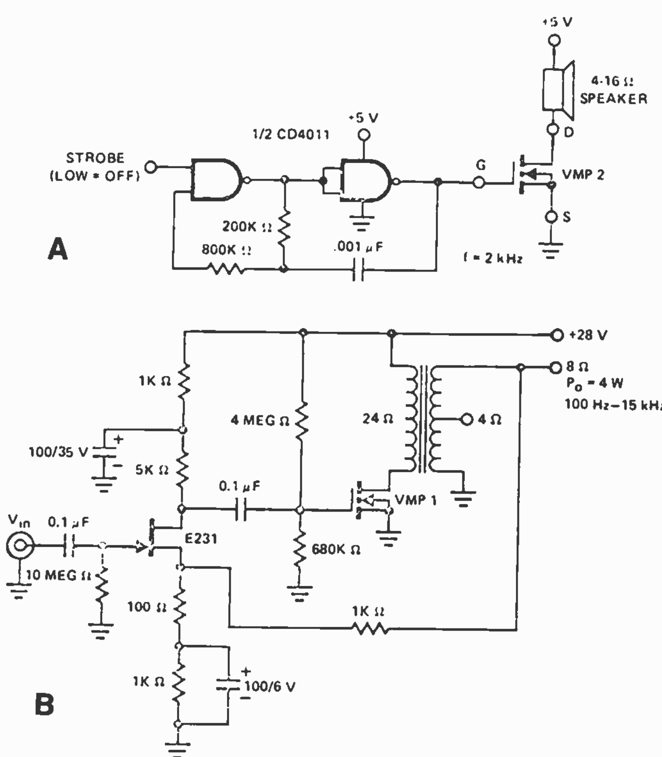

Fig. 4. VMOS audio circuits: (A) Alarm; (B) Class A amplifier.

Two of many possible audio circuit applications for VMOS transistors are illustrated in Fig. 4. The first, Fig. 4A, is a simple sound source which may be used in intrusion and fire alarms or similar projects. The design features a NAND gate oscillator similar to the one used in the second lamp dimmer circuit, with the VMOS transistor serving as a power driver for a PM loudspeaker.

The second, Fig. 4B, employs a single VMOS transistor as a Class A linear power amplifier in conjunction with a JFET preamp stage. Suitable for use in radio receivers, TV sets, record players, intercoms, and low-power PA installations, the circuit can deliver 4 watts to a suitably matched loudspeaker load and has a reasonably flat frequency response from 100 Hz to 15 kHz. Overall distortion is kept to within 2% (at 3 W output) by 10 dB of inverse feedback provided by a 1-k resistor between the output and the preamp's source electrode. A 28-volt dc supply is required.

With their fast switching characteristics, VMOS transistors are suitable for many high-frequency projects. A typical linear vhf amplifier circuit is illustrated in Fig. 5. Designed for operation in the 144-to-146-MHz band, the design may be used in both transmitter and receiver applications. As a transmitter power amplifier, the stage has a minimum power gain of 12 dB and can deliver 5 W PEP at 146 MHz. If used as a receiver r-f preamp, the design can furnish 11 dB gain with a low noise factor of only 2.4 dB. All resistors are half-watt types and the coils are hand-wound, with *T1* consisting of 8 turns of #24 AWG, ⅛-in. diam., close-wound, and *T2* of 5 turns of #24 AWG, ⅛-in. diam., close-wound. In common with most vhf designs, careful layout and proper lead dress during assembly are essential for optimum circuit performance.

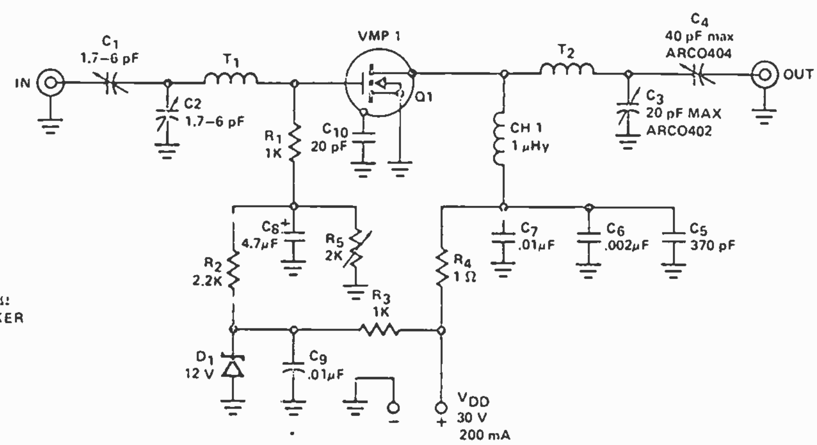

Fig. 5. Vhf linear amplifier using a VMOS transistor.

A further example of the VMOS transistor's versatility is found in the high-power audio amplifier circuit shown in Fig. 6. Of potential interest to audiophiles and more advanced experimenters, the design is suitable for use in high-quality stereo or quadraphonic systems. Capable of delivering 40 watts to an 8-ohm load, the amplifier has an essentially flat closed-loop frequency response (exclusive of the r-f input filter) from 1 Hz to 1 MHz and a slew rate of better than 100 V/μs. Its total harmonic distortion at 1 kHz, full rated output, is less than 0.05%. Featuring a Class AB quasi-complementary push-pull output stage using three parallelled VMOS transistors in each arm, the circuit is described in detail in Siliconix Design Aid DA76-1, *The MOSPOWER™ FET Audio Amplifier.* In addition to the schematic diagram and a suggested dc power supply circuit, the 4-page publication includes pc board and chassis layouts, response curves, signal waveforms, construction and adjustment hints, and a detailed parts list.

Reader's Circuit. Both early and contemporary design concepts are combined in the interesting AM broadcast band receiver circuit illustrated in Fig. 7. Submitted by William J. Wolf (3543 Dubarry Rd., Indianapolis, IN 46226), the circuit features a *reflex* front-end, an IC op amp audio amplifier and a Darlington power output stage. Old timers probably will re-

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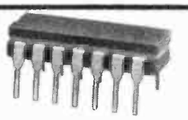

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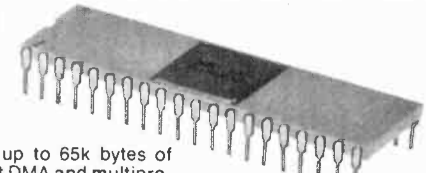

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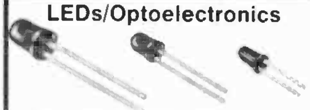

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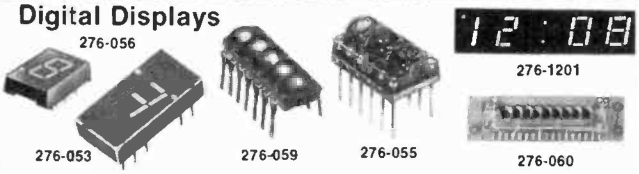

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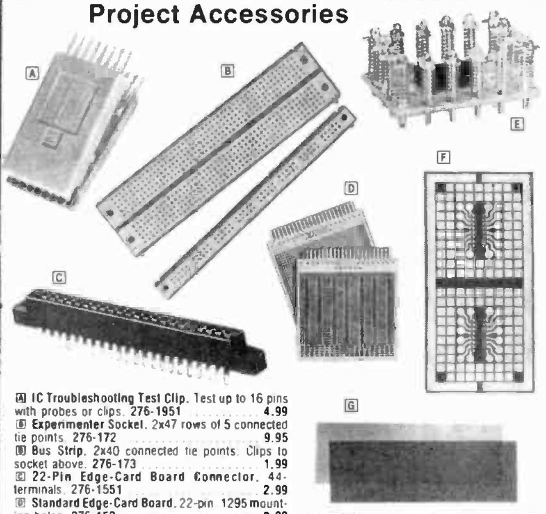

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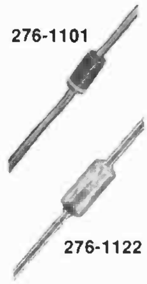

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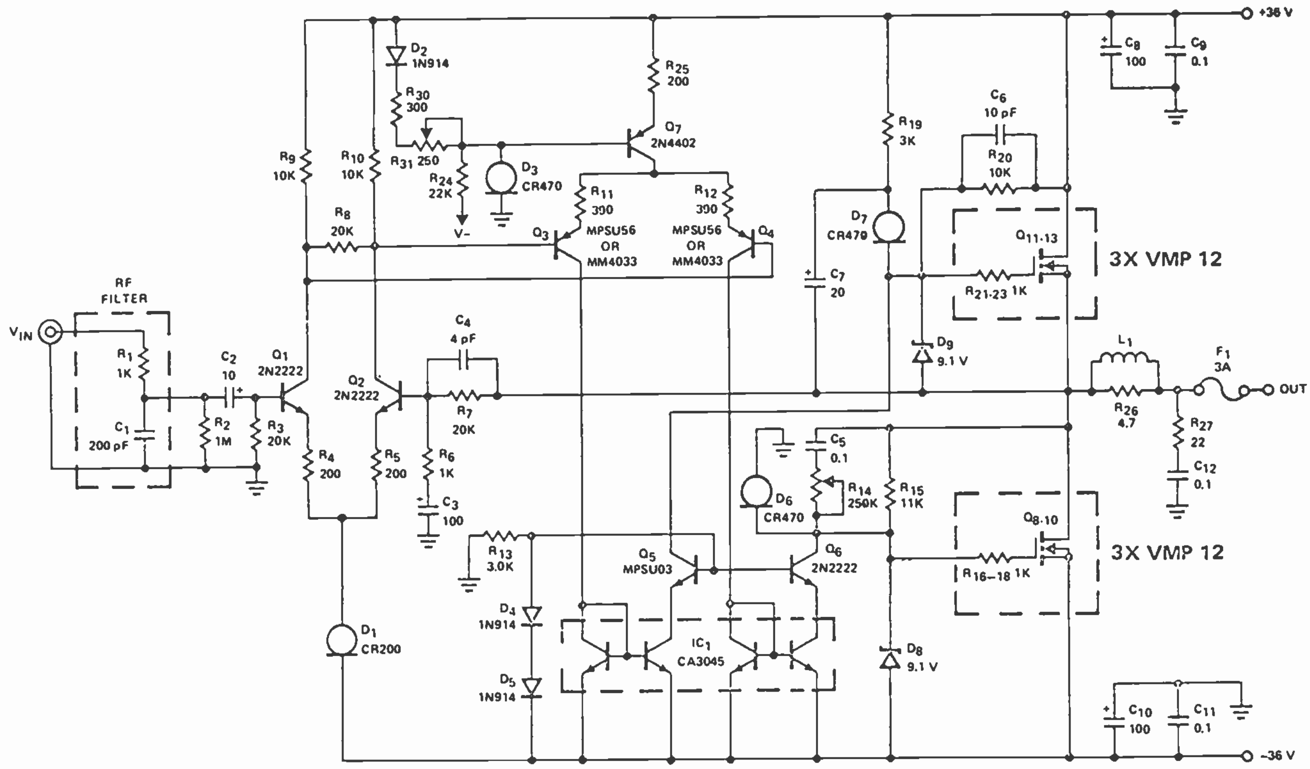

Fig. 6. 40-watt audio amplifier featuring a VMOS transistor output stage.

member the reflex circuit concept with a touch of nostalgia. Popular in the early to middle 50's, when good quality r-f transistors cost as much as fifty dollars each (pre-inflation dollars, at that!), the reflex citcuit permits a single device to amplify two different signals—r-f and audio—*simultaneously*.

In operation, r-f signals picked up and selected by tuned circuit *L1-C1* are applied to *Q1*, serving, initially, as an r-f amplifier. An amplified signal is developed across r-f collector load *L2* and coupled through *C3* to a detector network consisting of *D1, R2, D2* and r-f bypass *C2*. The resulting demodulated (audio) signal *also is applied* to *Q1*, now serving as an audio amplifier and developing an amplified signal across the audio collector load, *T1*'s primary winding. The RFC (*L2*) acts virtually as a short as far as audio signals are concerned. The audio signal is next coupled through gain control *R3* and dc blocking capacitor *C4* to op amp *IC1*, which serves to drive the final power output stage, Darlington connected pair *Q2-Q3*. A PM loudspeaker, shunted by *R9*, serves as the output load. Inverse feedback is provided across the power output and driver stages through *R8* to minimize distortion and optimize overall performance. Reflex amplifier *(Q1)* base bias is furnished through *R1*, the op amp's offset biases through *R5* and *R6* with, finally, the Darlington receiving its base bias directly from *IC1* through current limiting resistor *R7*, bypassed by *C6*. Circuit operating power is supplied by *B1*, controlled by *S1*.

Except for the hand-wound loop antenna coil, *L1*, William has specified standard, readily available components in his design. Transistor *Q1* is a general purpose pnp device similar to Radio Shack's type RS-101, *IC1* is one section of an inexpensive type LM3900 quad op amp, *Q2* and *Q3* are hobby-grade type 2N3055 npn power transistors, and *D1* and *D2* are general-purpose diodes similar to types 1N34 or 1N60. A 2.5-mH RFC is used for *L2*, while *T2* is a small 10-k to 2-k interstage audio transformer similar to Radio Shack's No. 273-1378. Tuning capacitor *C1* is a standard 365-pF unit and all other capacitors are low-voltage disc ceramics except for *C4*, which is a 15-volt electrolytic. The fixed resistors are all one-quarter or one-half watt types. Any standard PM loudspeaker with an 8- or 16-ohm voice coil may be used as the output device. The power switch, *S1*, is a spst toggle, slide or

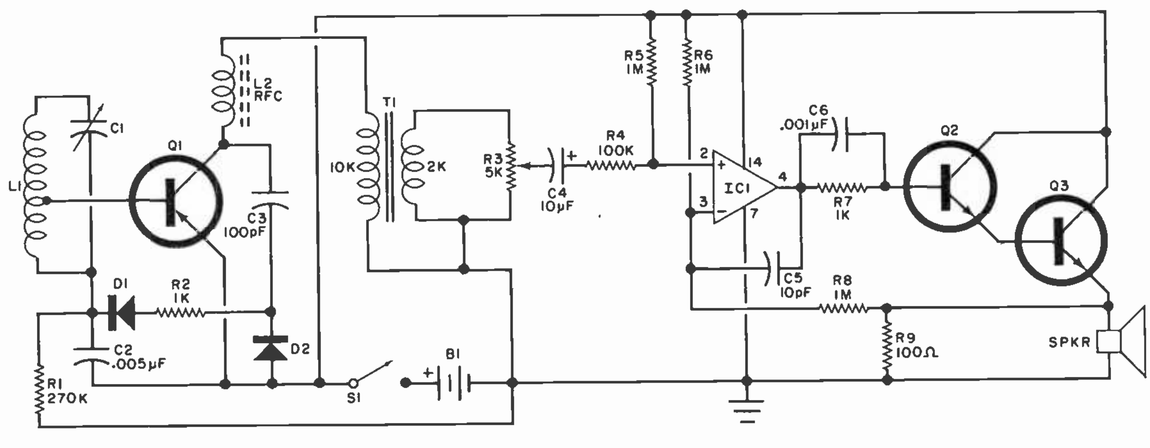

Fig. 7. Broadcast band receiver has reflex front end and IC op amp audio amplifier.

rotary type, with the power pack, *B1*, made up of six series-connected size "C" or "D" flashlight cells. William describes *L1* as a loop antenna consisting of 16 turns of #22 solid copper insulated hook-up wire tapped at 12 turns and close-wound on a wooden frame measuring 10 in. high by 13 in. long by 3 in. wide.

Although neither layout nor lead dress should be critical when duplicating the circuit, good wiring practice should be followed, with signal carrying leads kept short and direct, heat sinks provided for the power transistors (*Q2* and *Q3*), and all dc polarities observed. The reader suggests that the entire circuit, including the loudspeaker and power pack, can be assembled conveniently within the wooden frame supporting the loop antenna. Depending on *Q1*'s individual characteristics, some experimentation with *R1*'s value may be required for optimum performance. Some hobbyists also may wish to experiment with the number of turns on the loop antenna coil or with *C1's* value to obtain coverage of other radio bands. If desired, a multiple tapped coil and suitable selector switch can be provided for multi-band operation.

Device/Product News. Suitable for use in instruments, audio systems, controls, and similar analog applications, a new low-cost dual operational amplifier with a unity gain bandwidth over 2.5 MHz has been introduced by *Motorola Semiconductor Products, Inc.* (P.O. Box 20912, Phoenix, AZ 85036). Designated types MC4558/MC4558C, the new devices are offered in round metal cases as well as in ceramic and plastic 8-pin MiniDIP's. Internally compensated, the new op amps feature a typical large-signal voltage gain of 200 V/mV at 25°C and a CMRR of 90 dB. The two amplifiers within each package are closely matched with respect to both gain and phase, and both are protected against load short circuits.

If your requirements are for a quad rather than dual unit, you should be interested in the RC/RM4156 announced recently by *Raytheon Semiconductor* (350 Ellis St., Mountain View, CA 94040). Supplied in plastic or ceramic 14-pin DIP's, the op amps are short-circuit protected and feature a minimum unity gain bandwidth of 2.8 MHz.

The *Fairchild Camera and Instrument Corp.* (LSI Group, 464 Ellis St., Mountain View, CA 94042) is now offering a new dynamic bipolar 4096-bit random access memory (RAM) designed for operation on a single 5-V dc supply. Two versions of the new RAM are in production. Both are organized as 4096 × 1 bits and have a power consumption of 350 mW active, 70 mW standby, and 500 mW in page mode. The standard 93481 has a maximum access time of 120 ns with a 280-ns cycle time, and a page mode access and cycle time of 75 ns. The faster version, type 93481A, has a maximum access time of 100 ns with a 240-ns cycle time, and a page mode access and cycle time of 65 ns. Manufactured using Fairchild's Isoplanar Integrated Injection Logic process, the new RAM's are TTL compatible and are supplied in standard 16-pin ceramic DIP's.

National Semiconductor Corp. (2900 Semiconductor Drive, Santa Clara, CA 95051) has developed a new single-chip IC containing a pair of monolithic npn transistors matched to within 50 μV of each other. Identified as type LM194, the matched pair has a noise figure so low that it is virtually immeasurable and features a minimum current gain of 500, a current-gain match of better than 2%, a CMRR of better than 120 dB, and a low drift of less than 0.1 μV/°C. With a maximum collector-emitter voltage rating of 40 V and a maximum power dissipation of 500 mW, the LM194 is supplied in a 6-lead TO-5 style metal case. ◇

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Experimenter's Corner

By Forrest M. Mims

USING LED'S AS LIGHT DETECTORS

LIGHT emitting diodes have many applications including status indication, digital readout, signal isolation, and light-beam communication. But did you know LED's can also be used as light *detectors*?

You can easily demonstrate the photosensitivity of a LED by using the simple circuit in Fig. 1. An infrared emitting LED such as the Texas Instruments TIL32 is connected directly to the terminals of a 0–50 microampere meter. This forms a *photovoltaic* circuit, and when the LED is placed near a desklamp or other bright light source, the meter will indicate a photocurrent of at least 10 or 15 microamperes.

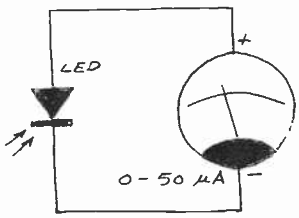


Fig. 1. Simple LED detector demonstration circuit.

Though gallium-arsenide infrared emitting diodes make the best light detectors, visible emitters made from gallium arsenide phosphide, gallium phosphide, and other materials also work. For best results, use LED's with clear encapsulants. Remember that just as LED's emit a narrow spectrum of light, they are sensitive to relatively narrow wavelength bands. Thus a green emitting diode will detect green light better than a red emitter; and infrared emitters will detect infrared far better than visible emitters.

LED's operated as detectors have several very practical applications. For example, an optoisolator can be made by mounting two infrared emitting diodes at either end of a short length of heat shrinkable tubing. The resulting optoisolator can then be used in either direction since the LED's can both emit *and* detect infrared.

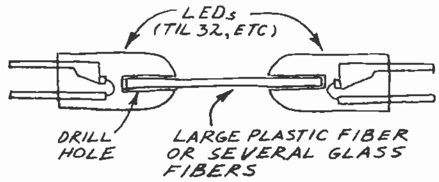


Fig. 2. LED-LED optoisolator using optical fiber coupling.

You can also couple two epoxy-encapsulated LED's with a short length of plastic or glass optical fiber. Just bore a small hole in the top of each LED, using care to avoid striking the chip or its

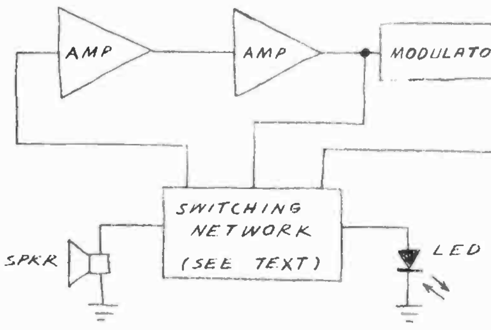


Fig. 3. Block diagram for single LED transceiver.

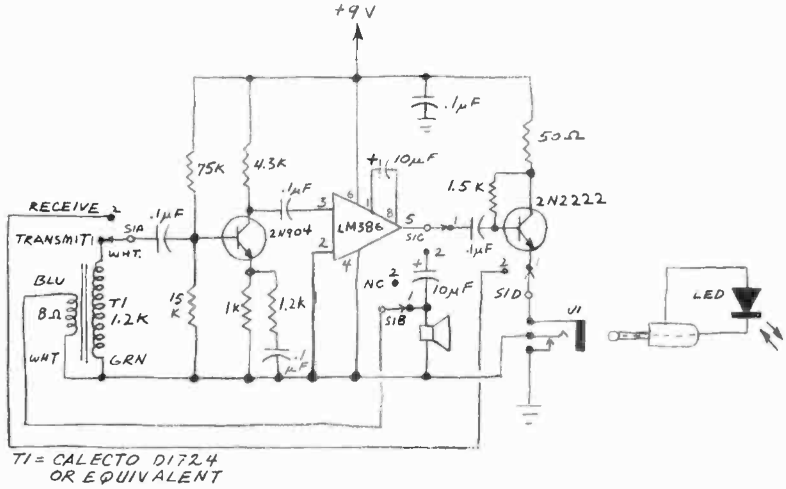


Fig. 4. Schematic diagram of a practical LED-LED transceiver.

upper electrode wire. Then insert some clear epoxy, the fiber, and secure the fiber in place until the epoxy has cured. Figure 2 shows how two LED's are coupled together using this method.

Another possible application for a LED in the detector mode is to monitor the light intensity arriving from the sun or artificial sources at the face of a seven-segment LED display. An unused decimal-point LED could be used as the light detector for a circuit which could automatically control the brightness of the display.

The most intriguing application for LED's operated as detectors lies in the field of light-beam communications. One problem with light-beam communicators designed to operate through the atmosphere is optical alignment. (The *most* perplexing problem, of course, is the atmosphere itself.) Conventional light-beam communicators with separate LED transmitters and photodetector receivers must use two lens systems or complicated optics which allows both to use the same lens or lenses.

LED-LED communicators, however, need only one lens per transceiver. Then when the transmitter of one unit is aligned with the receiver of a second unit, the transmitter of the second unit is *automatically* aligned with the receiver of the first.

A Practical LED-LED Transceiver. The block diagram for a basic amplitude-modulated light beam transceiver using a single infrared LED as both a source and a detector is illustrated in Fig. 3. The circuit consists of a preamplifier, amplifier, LED driver and a switching network to switch the LED from the input of the preamplifier (receive mode) to the output of the driver (transmit mode). Several years ago I described a LED-LED communicator patterned upon this basic design in POPULAR ELECTRONICS ("Communicate Over Light Beams with the First Single-LED Transceiver," March 1974, p. 66). While this transceiver worked quite well, it used a relatively large audio amplifier module.

Figure 4 is the circuit diagram for a more up-to-date LED-LED transceiver made with an LM386 audio amplifier IC. Thanks to the LM386, the new circuit is much smaller and somewhat simpler than the original version. Also, the new circuit incorporates a simplified one-transistor modulator, a single 8-ohm speaker which doubles as a microphone, and a 9-volt battery.

I have assembled a working version of the circuit in Fig. 4 and installed it in a miniature bakelite cabinet measuring 3-1/4" x 2-1/8" x 1-1/8" (8.26 x 5.4 x 2.86 cm). There isn't enough room here to include all the construction details, but here are a few assembly tips: Use a perforated board measuring 2" x 1-15/16" (5.08 x 4.92 cm) to leave room for the 9-volt battery. Remove the upper two corners of the board to make room for the cabinet's cover screws. A 2" speaker fits perfectly in the space between battery and the upper end of the cabinet. All the components except the LED can be installed in a circle on the circuit board around the base of the speaker. The 4pdt switch fits between the upper two cover screw receptacles. Because of the limited space, the switch handle will have to emerge from the side of the cabinet opposite the front of the speaker.

Use a miniature phone jack to connect the LED to the circuit. Besides providing an automatic on-off switch, this will allow you to experiment with various kinds of LED's. It will also let you place the LED some distance from the circuit and simplify experimentation with different lenses.

I've used the transceiver in Fig. 4 for communications through the atmosphere and a fiber optic cable. Results with a 10-meter (32.8') length of glass fiber with an attenuation of a few hundred dB per kilometer were excellent. This cable should soon be available from some of the firms which specialize in experimenters' electronics components. Until then, you can try high-loss plastic fibers or stick to the atmosphere. ◇

Hobby Scene Q&A

By John McVeigh

SUPPRESSING BLOWER HASH

Q. ***I built the CB converter described in the October issue and have installed it in a 1976 Plymouth Fury. However, the blower fan motor (for air conditioning, heating, and defrosting) creates so much static that it is impossible to operate it and the converter simultaneously. I do not have this problem when I use the AM/FM radio "straight through." Can you suggest a filter that will suppress this interference?—W. B. Grandjean, Baton Rouge, LA.***

A. I recommend the installation of 0.25-μF coaxial capacitors across the terminals of each blower motor. The capacitor will act as a short circuit to the r-f hash generated by the sparking at the motor brushes, but will not affect the system from a dc point of view. The capacitors can be obtained from most auto supply houses, and can also be used to silence noisy gauges and sender units. Be sure that the case of the converter and the shield of the antenna lead-in are well grounded.

FM STATION LISTINGS

Q. ***I would like to obtain a listing of FM radio stations. Do you know where I could get one?—Mrs. Don Ginest, Lakin, KS.***

A. As I recall, a very comprehensive list of FM broadcasters is offered by the Worldwide TV-FM DX Assoc., Box 163, Deerfield, IL 60015. Also, there's a listing in *North American Radio-TV Station Guide*, by Vane A. Jones, published by Howard W. Sams & Co.

NIXIE INTERFACE

Q. ***How can I trigger 170-volt Nixie tubes with the 12-to-14-volt "digit enable" pulse from a 5313 clock chip?—LeRoy Lee, Altus, OK.***

A. I think the most inexpensive way to do this is to have the digit enable pulses turn on high-voltage npn switching transistors. These in turn would apply the high voltage to the individual tubes. A suitable transistor is the Motorola HEP S0027. It has a collector-to-emitter breakdown voltage rating of 300 volts, maximum collector current of 500 mA, and a typical cut-off frequency of 50 MHz. However, if you go this route, be sure to include current limiting resistors at the base and collector of each transistor. Of course, some chips provide BCD outputs which can be decoded by suitable IC decoder/drivers. For example, the 7441 is specifically designed for use with Nixies.

TTL VS. CMOS

Q. ***The circuit for the "Westminster Chime" clock (November 1976) uses CMOS IC's. Is it possible to use TTL IC's in place of them, or a mixture of the two?—Murray Voakes, Essex, Ontario.***

A. Although similar CMOS and TTL gates and sequential logic circuits perform the same functions—a CMOS 2-input NAND gate is logically equivalent to a TTL 2-input NAND—there are differences in input and output impedances, drive capabilities, operating voltages, etc. The great advantage of TTL over CMOS is operating speed. However, CMOS has it all over TTL in the areas of power consumption at slow speeds and noise immunity when higher operating voltages are used. In this application, switching speeds are low enough to allow CMOS to run significantly cooler than TTL. This means that a smaller power supply can be used. In fact, CMOS is becoming so popular that several manufacturers are offering MOS devices that have the same pinouts as the 7400 TTL series. This allows one to convert from TTL to CMOS with a minimum of pc board modifications. So I really don't see going TTL or hybrid in this circuit. Surplus CMOS is inexpensive, an all-CMOS design requires no level interfacing, and power supply demands are greatly reduced. As a final note, many CMOS devices are now zener diode "clamped" and won't self-destruct when you touch them!

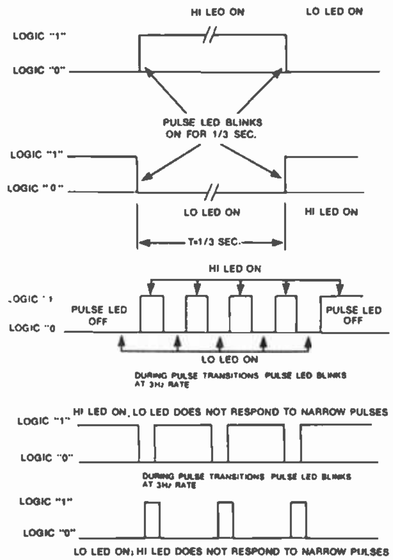
Logic Probe 1 is a compact, enormously versatile design, test and troubleshooting tool for all types of digital applications. By simply connecting the clip leads to the circuit's power supply, setting a switch to the proper logic family and touching the probe tip to the node under test, you get an instant picture of circuit conditions.

LP-1's unique circuitry—which combines the functions of level detector, pulse detector, pulse stretcher and memory—makes one-shot, low-rep-rate, narrow pulses—nearly impossible to see, even with a fast scope—easily detectable and visible. HI LED indicates logic "1", LO LED, logic "0", and all pulse transitions—positive *and* negative as narrow as 50 nanoseconds—are stretched to ⅓ second and displayed on the PULSE LED.

By setting the PULSE/MEMORY switch to MEMORY, single-shot events as well as low-rep-rate events can be stored indefinitely.

While high-frequency (5-10MHz) signals cause the "pulse" LED to blink at a 3Hz rate, there is an additional indication with unsymmetrical pulses: with duty cycles of less than 30%, the LO LED will light, while duty cycles over 70% will light the HI LED.

In all modes, high input impedance (100K) virtually eliminates loading problems, and impedance is constant for all states. LP-1 also features over-voltage and reverse-polarity protection. Housed in a rugged, high-impact plastic case with strain-relieved power cables, it's built to provide reliable day-in, day-out service for years to come.



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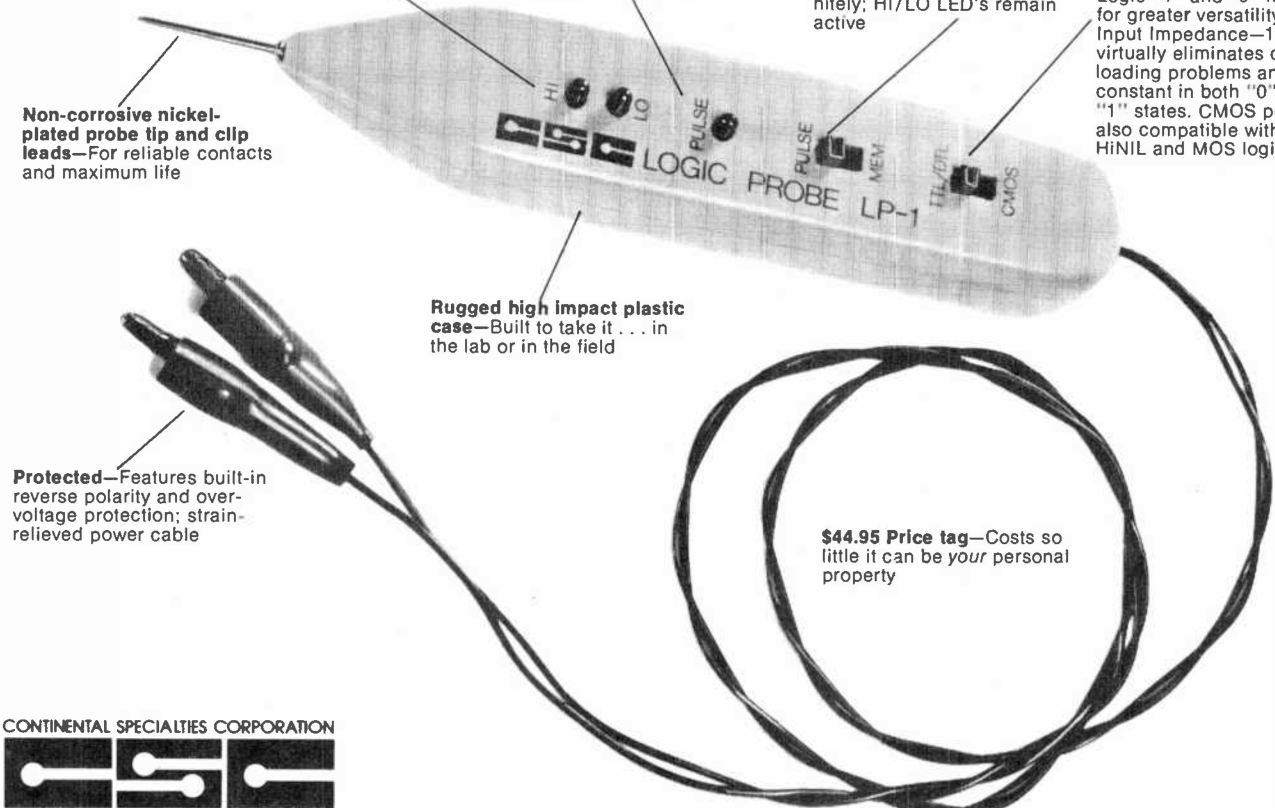

PULSE LED—Lets you know what's going on—and off. Indicates positive *and* negative pulse and level transitions. LP-1 stretches pulses as narrow as 50 nanoseconds to full ⅓ sec. (3Hz pulse rate)

PULSE/MEMORY Switch—PULSE position detects and stretches pulses as narrow as 50 nanoseconds to ⅓ sec. Switch to MEMORY and it stores single shot and low-rep-rate events indefinitely; HI/LO LED's remain active

HI/LO LED's—Display level (HI-logic "1", LO-logic "0") of signal activity at node under test

Logic Family Switch—TTL/DTL or CMOS matches Logic "1" and "0" levels, for greater versatility. High Input Impedance—100K virtually eliminates circuit loading problems and is constant in both "0" and "1" states. CMOS position also compatible with HTL, HiNIL and MOS logic

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Product Test Reports

KENWOOD MODEL TS-820 TRANSCEIVER

All-band hf transceiver has operating versatility and built-in speech processor.

ALTHOUGH Kenwood's new Model TS-820 160 - through - 10 - Meter SSB/CW amateur transceiver physically resembles its popular Model TS-520, the two are very different in terms of circuit design and built-in features. Also, the TS-820 can accommodate an optional digital frequency readout, whereas the TS-520 cannot. Other new features (discussed later) clearly make the new transceiver Kenwood's "top of the line."

The transceiver is housed in a rugged, gray-finished cabinet that measures 13-3/16" D × 13⅛" W × 6" H (33.5 × 33.3 × 15.3 cm). A versatile (110- or 220-V, 50- or 60-Hz) ac power supply is built-in, as well as a small loudspeaker. A handle on the right side of the cabinet provides a means for carrying the 35.2-lb (16-kg) transceiver. The basic TS-820 transceiver is priced at $830. The optional *DG-1* digital frequency readout, which mounts inside the TS-820's cabinet and can be added at any time, is $170. Other options include the *CS-820-20* 500-Hz CW crystal filter ($45), the *DS-1A* dc/dc converter for mobile use ($59), and the *VFO-820* external vfo ($139).

General Description. The transceiver circuitry is solid state, except for a 12BY7A driver and two S-2001A (a pin-for-pin 6146B equivalent) final amplifier tubes. The usual complement of transmitter and receiver tuning controls is provided. The multi-function, switch-controlled meter indicates final amplifier plate current or voltage, relative r-f output, alc circuit operation, compression level from the built-in r-f speech processor, and S units.

When the MODE switch is set to TUN or FSK, power input to the finals is automatically reduced so that the tubes' rated plate dissipation is not exceeded. The r-f speech processor is activated by pulling out the COMP LEVEL/PROC control. The amount of the compression (indicated on the meter) is adjusted by rotating this control.

The transmitter pi network and transceiver preselector controls are grouped together. The PLATE tuning control uses a vernier for easy adjustment. The LOAD control is concentric with a FIX CH switch that selects any one of four crystal-controlled channels in the FIX mode (crystals optional).

The center-detented IF SHIFT control is concentrically paired with the receiver incremental tuning (RIT) control, the latter activated by a pushbutton. The CW CAR level and SSB MIC gain controls are also paired, as are the RF GAIN and AF GAIN controls. An RF ATT push-button switch inserts a 20-dB attenuator at the receiver's antenna input to combat overload and desensitization by strong local signals.

The BAND switch has positions for all amateur bands between 1.8 and 29.7 MHz, as well as JJY/WWV (reception only) on the 15-to-15.5-MHz band. The 10-Meter band is covered in four 500-kHz segments. (There is also a position on the BAND switch labelled AUX, which apparently can be used for operations outside the regular ham bands, although the manual does not mention it.)

The FUNCTION switch is normally left in the VFO position to allow the internal vfo to control the transceive frequency. When set to FIX, both frequencies are controlled by internal crystal oscillators, with up to four frequencies selectable by the FIX CH switch. The VFO:R position uses the internal vfo to control the receiver's frequency, while the FIX:R position puts the receiver under crystal control and the transmitter under vfo control. When either the transmitter or the receiver is on vfo control, the FIX and RMT positions are used with the AUX crystal-controlled channels of the remote vfo to zerobeat the vfo to channel frequency.

A separate HEATER switch is provided to shut off the tube heaters when the transceiver is used for reception only. All VOX controls are mounted on the front panel for ready access. Because the VOX circuit controls the changeover relay on CW (semi-break-in) as well as SSB, it is most convenient to have the DELAY control up front for easy adjustment as conditions warrant.

The large tuning knob operates two circular dial scales, one calibrated at 1-kHz intervals (numbered every 10 kHz), and the other calibrated at 50-kHz intervals and numbered from 0 to 500 every 100 kHz. The dial index can be moved to calibrate the scale against the 25-kHz marker oscillator or WWV. The dial setup uses Kenwood's "mono-scale" kilohertz dial system which fits the full 500-kHz tuning range on a single small dial with 1-kHz calibration intervals. The scale is rotated 10 turns for edge-to-edge coverage of each band segment.

When the optional digital frequency display is installed, as it was on our test model, the fluorescent readout appears in a window above the mechanical dial scales. Above the numeric display are four LED's that indicate when the ATT (attenuator) is on and when FIX, VFO, and RIT functions are active.

A button labelled DH (display hold) permits the numeric display to be "frozen" to store a frequency for quick retuning. When the display is frozen, you can tune about using the mechanical dial. To return to the original frequency, you simply note the counter display, release the DH button, and tune until that number again appears in the display.

The single-conversion receiver has an 8830-kHz i-f. A phase-locked-loop (PLL) circuit gives the benefits of both single and multiple conversion with few of the disadvantages of either. The local oscillator consists of 11 separate bandswitch-selected voltage-controlled oscillators or vco's (one for each band). These oscillators employ varactor diodes. The output of the vco is heterodyned with a crystal oscillator to produce a frequency between 3.33 and 3.83 MHz. The heterodyne oscillator also consists of 11 separate oscillators. The 3.33-to-3.83-MHz signal is then heterodyned with the output of a crystal-controlled carrier oscillator operating near 8830 kHz to generate an output between 5.0 and 5.5 MHz.

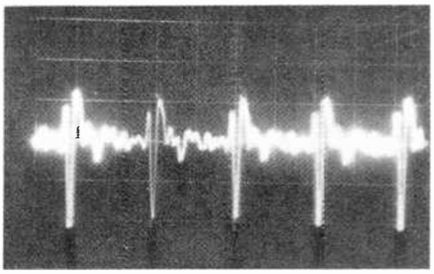
Tuning is by a conventional 5.0-to-5.5-MHz, highly stable and linear Clapp vfo. The vfo's output is compared with a down-converted vco signal by a phase comparator whose output trims the output frequency of the vco. Thus, the vco is phase locked to the 5.0-to-5.5-MHz tunable oscillator to effectively transfer the linearity and stability of the latter to the 10.5-to-39-MHz local oscillator. A phase-lock sensor disables the vco if PLL action fails, preventing off-frequency operation.

There are two separate carrier oscillators. One, controlled by two switchable crystals, operates on SSB transceive and on CW receive. The other functions in the transmit FSK and CW modes, when the receive and transmit frequencies are slightly separated.

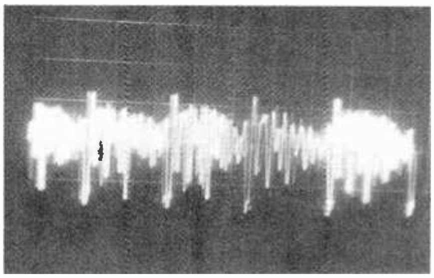
A very useful feature is the IF SHIFT, which allows the i-f passband to be moved approximately ±1.7 kHz without affecting the pitch of the received signal. The IF SHIFT electronically varies the frequency of the carrier oscillator in the PLL system. This causes the vco to move exactly as much as the carrier frequency, resulting in no net change in the relationship between the signal and oscillator frequencies. Because the filter is fixed, the signal is moved through the filter passband.

The built-in r-f speech processor provides up to 50 dB of compression. Here's how it works. The audio input signal is applied to a balanced modulator operating at 455 kHz and is then passed through a filter to remove one sideband. The remaining sideband is compressed—*not* limited—by an agc amplifier. It is further filtered to remove distortion products beyond the desired modulation passband, down-converted to audio, and finally applied to the main balanced modulator of the transmitter.

Some 10 dB of r-f negative feedback is used in the driver and output stages to reduce odd-order IM products by 6 to 10 dB. This makes the signal unusually clean and free from splatter that could interfere with QSO's on nearby frequencies. Alc is also used to prevent driving the output tubes into nonlinearity.



10-W avg. output with sustained "Ahhh" driving transmitter.



Average power increased to 40 W with 20 dB of compression.

The transceiver has a built-in SSB receiver that is always tuned to the transmitter frequency so the operator can monitor his transmitted signal. R-f is sampled just before the driver stage, heterodyned down to audio by a product detector, and injected into the receiver's audio amplifier when the MONITOR switch is on. This is a good way to determine the effects of the r-f processor and to determine how much background noise is increased when compression is introduced.

The optional digital frequency display module counts the frequency to the nearest 10 Hz, then rounds off and displays the operating frequency to the nearest 100 Hz. Accuracy of the display is guaranteed to be 1 ppm/month.

Transmitter Tests. On 80 Meters, a two-tone test resulted in 200 W PEP input to the final amplifiers. PEP output into a 50-ohm dummy load was 115 to 120 W. Key-down CW input power measured 165 W, and CW output 100 to 110 W. On SSB, carrier suppression varied from 53 dB (LSB) to 58 dB (USB). The unwanted sideband was 60 dB down when a 1000-Hz modulating signal was applied. Distortion products measured as follows: third order −32 to −34 dB referenced to the two tones, −38 to −40 dB referenced to PEP; fifth order −56 dB referenced to the two tones, −62 dB referenced to PEP. An audio input of 1 mV at 1000 Hz was sufficient to fully modulate the transmitter on the 7-MHz band.

The r-f speech processor produced some interesting results. A sustained "Ahhh" driving the transmitter to full PEP yielded an average power output of 10 W when no compression was applied. With 20 dB of compression (as indicated on the transceiver's meter), the average power output increased to 40 W. Peak power remained at the same level with or without compression. This translates to a 6-dB increase in "talk power," equivalent to an increase of one "ideal" S unit at the receiving end. This increase is nearly equivalent to switching in a 1000- or 1200-W PEP linear.

Of course, the processor (like all processors) introduced some a-f distortion and degraded the unwanted sideband suppression. At a modulating frequency of 1000 Hz, and at 10 dB of compression, the second harmonic of the modulating frequency was 30 dB down—equivalent to 3.2% of distortion. Unwanted sideband suppression measured 50 dB. At 750 Hz, the second harmonic measured −28 dB (4% distortion) when 10 dB of compression was introduced. The third harmonic (2250 Hz) was 20 dB down (10% distortion), and unwanted sideband suppression measured 30 dB. When a 500-Hz tone was used to modulate the transceiver, the unwanted sideband suppression improved to −35 dB. Finally, when a 400-Hz modulating tone was applied, the second harmonic measured −40 dB (1% distortion) at 10 dB of compression. The third harmonic was 10 dB down (32% distortion), and the unwanted sideband suppression measured 25 dB.

Alc action was very good. Flat-topping simply did not appear, even at maximum alc. Audio response measured (at the 6-dB points) 325-2800 Hz (USB) and 240-2700 Hz (LSB). When the speech processor was used, the response was slightly altered. Maximum VOX release time was approximately one second. When the release was shortened to allow semi-break-in CW keying, no shortened first dot or dash occurred. That is the exception, rather than the rule, among today's amateur rigs!

To check the transceiver's frequency stability (rated at better than 100 Hz/hour after a one-hour warmup and less than 1000 Hz of drift in the first hour after a one-minute warmup), the transceiver was attached to a dummy load and placed in the TUNE mode at 7 MHz, yielding an r-f power output of about 15

RESULTS OF RECEIVER TESTS

Frequency (MHz)	Sensitivity (μV) for 10 dB (S+N)/N		Image Rejection (dB)	I-f Signal Rejection (dB)	Band-to-Band Gain* (dB)
	SSB	CW			
1.8	0.1	0.05	96	100	0
3.5	0.1	0.063	92	90	−3
7	0.08	0.05	86	96	0
14	0.1	0.056	70	92	−3.5
21	0.1	0.063	66	96	−3
28	0.1	0.063	68	96	−1 (+1 dB on 29.5-MHz segment)

*Overall gain—not affecting sensitivity—determined by comparing audio output on each band, referenced to 1.8 and 7 MHz, produced by a given input signal. Variations in band-to-band gain occur below the agc threshold and have no effect above it.

W. The frequency of this output signal was measured by coupling a frequency counter to the dummy load. After a brief stabilization period (much less than the allowable hour), the drift averaged about 96 Hz/hour for the next few hours. The final transmitter test we performed was the measurement of r-f harmonics at the antenna output jack. They were consistently 40 dB below the fundamental.

Receiver Tests. Results of our measurements of sensitivity, image rejection, i-f signal rejection, and difference in band-to-band gain appear in the Table. Note that sensitivity measurements at these very low signal levels are usually accurate to within ±3 dB. However, even within this margin, the TS-820's receiver tested extremely "hot." A 50-μV signal (nominal) was required for an S9 meter reading; a 1-μV signal produced an S2.5 reading. Inserting the r-f attenuator in the input line (by means of the front panel pushbutton) dropped signal levels 20 dB. The receiver incremental tuning varied the receive frequency ± 3000 Hz. Unwanted sideband rejection measured 60 dB at 1000 Hz and 50 dB at 500 Hz.

No crossover birdies were found when signals below 10,000 μV were applied to the input. Internal spurious signals measured 0.2 μV (equivalent) at 21.200 MHz and less than 0.1 μV (equivalent) at 2 and 21 MHz. Two 320-μV signals (−57 dBm, or 70 dB above the SSB sensitivity) spaced 25 kHz apart created third-order IM (intermodulation) products equivalent to the rated sensitivity (0.1 μV for 10 dB (S+N)/N). An undesired 32,000-μV (−17 dBm) signal 110 dB above a 0.1-μV desired signal desensitized the receiver by depressing the desired signal 1 dB. The receiver section was very resistant to blocking (overload). No loss of output level or increase in distortion was detected when input signals of up to 100,000 μV (−7 dBm) were applied.

When the r-f input signal varied from 0.1 to 1 μV (a 20-dB change), the audio output rose 18 dB. When the input signal was raised from 1 μV to 10 μV, the agc came into play and the audio output rose only 1 dB. A 100-dB change in r-f (from 1 to 100,000 μV) caused the audio output to increase only 2 dB. Release time from an S9 signal level to full recovery was approximately 0.75 second when the agc switch was in the FAST position and 4.5 seconds in the SLOW mode.

Nominal overall response—which included the i-f passband and audio responses—measured as follows: 400 to 2150 Hz at −6 dB, 200 to 3525 Hz at −60 dB (USB); 275 to 1850 Hz at −6 dB, 75 to 3300 Hz at −60 dB (LSB); 700 to 1250 Hz at −6 dB, 335 to 1685 Hz at −60 dB (CW). These measurements were made below the agc threshhold. The differences between USB and LSB are easily explained by the fact that the frequency of the carrier oscillator feeding the balanced modulator is deliberately shifted for proper generation of USB and LSB signals. It is the change of the relationship between the skirts of the fixed crystal filter and this carrier oscillator that causes different overall responses in the USB and LSB modes. However, in both modes the unwanted sideband suppression was 60 dB at 1000 Hz and 50 dB at 500 Hz.

The transceiver produced 1.5 W of audio output into 8 ohms. A 1000-Hz sine wave was used for this test, and at the start of clipping total harmonic distortion was less than 2%.

In our final receiver test, we applied a pulse train composed of 0.0005-μs-wide pulses at a 60-Hz rate. This pulse train (at 100 dB above 1 μV/MHz bandwidth) completely obliterated a 3-μV input signal. A 10-μV signal was depressed by at least 10 dB due to agc capture by the noise pulses. However, when the TS-820's noise blanker was activated, normal agc action was restored and undisturbed copy of even *0.1-μV* signals became possible! But the blanker had no effect on low-level pulses (less than 50 dB above 1 μV/MHz bandwidth).

On The Air. With few exceptions, we confined our on-the-air testing to the 7-MHz band. Operation was equally divided between SSB and CW. During the weeks we operated this transceiver, we never felt the need to use our linear.

It seemed as natural to scan the bands with the digital numeric frequency display as it was to observe the position of a dial scale against an index line. Let us assure anyone who is not ready to make the added investment in the digital display that the mechanical dial is accurate to within about 100 Hz of the digital display.

We were pleased to note that the transceiver can be tuned with its own meter, and modulated within the maximum limits defined by its alc meter scale without compromising performance. The front-panel VOX controls proved to be rock stable. On CW, the delay could be set so that the transmitter would drop out between characters below 20 wpm and between words at higher speeds. This is not really QSK (full break-in keying), but it's pretty close! Both the keying and modulation received numerous unsolicited compliments from stations contacted. Only rarely useful on SSB, the IF SHIFT proved to be valuable on CW. It let us move QRM off the skirts of the 500-Hz filter to the point of inaudibility, without changing the pitch of the desired signal.

During our tests, an idling truck blanketed us with ignition noise at S9. Switching in the noise blanker effectively eliminated—not just reduced—the interference! This was a most impressive demonstration, which left us regretting that the blanker could not dispose of types of noise other than impulse noise.

In actual QSO's, we verified that the r-f speech processor gave a one to two S-unit improvement in signal strength. However, the processor does cause some signal distortion. Thus, the processor should be used (and is intended for use) only under conditions that warrant it. Under strong-signal conditions, *all* speech processors impair intelligibility to some degree. On the other hand, when the going gets tough, a good processor like the one in this transceiver can make the difference between contact and no contact.

No sound at all could be heard from the transceiver's cooling fan. The "silent" fan's cooling effectiveness was undeniable, however. After almost two hours of either SSB or CW operation, the cabinet was cool to the touch everywhere except directly above the final tubes, where it was faintly warm.

The TS-820 is certainly a full-feature all-band ham transceiver. The only gripe we do have concerns the top-facing speaker, which managed to lose much of its meager output in our acoustically treated ceiling. For fixed-station operation, the owner would do well to connect an external speaker to the rear-panel output jack.

In sum, the TS-820's versatility and fine performance and the obvious top craftsmanship that has been spent on its design will fill any ham with pride of ownership. If we had to pick the most attractive feature among so many admirable ones, it would be the "digital hold." With this "memory" function, we'll never again fail to return exactly to a QSO frequency after a brief listen off-channel.

CIRCLE NO. 103 ON FREE INFORMATION CARD

MURA MODEL PRX-100 "PRM" CB MICROPHONE

Peak-redistribution modulation effectively increases signal power.

THE MURA PRM microphone contains a conditioning system that redistributes the asymmetrical sharp-peak portions of speech to make the signal more symmetrical. At the same time, it also holds down the peaks to allow the lower-energy components of the signal to be effectively higher in energy than would be possible with a "straight" microphone. This peak-redistribution modulation (PRM) is accomplished electronically by delaying the large sharp-peak components of the signal for minute amounts of time in relation to the lower-energy signals before passing them on to the transmitter's modulator. The result can be an effective *average* modulated signal without adverse distortion.

One of the new PRM microphones for CB use is the push-to-talk Model PRX-100. It has a gain control for setting up the optimum output level for any particular CB transmitter according to the operator's voice amplitude. (The microphone cannot be used with certain CB transceivers on the market. These are detailed by manufacturer and model on the card on which the microphone is packaged.) Operating impedance is 0 to 2500 ohms. Power for the microphone system is obtained from an internal 9-volt battery. Price is $39.95.

Test Results. We checked the Model PRX-100 with the aid of a dual-trace oscilloscope to observe simultaneously the output of the transducer cartridge and the conditioned output signal from the PRM circuit. Asymmetry at the cartridge was demonstrated with the maximum sharp-peak excursions in the positive direction. The conditioned output still produced some asymmetry, but in the opposite direction and to a lesser degree. However, the peak ratios, compared to the in-between lower-energy components, were reduced sufficiently to permit an overall higher average output level which potentially increased the average power of the modulated signal.

We also made comparisons with other microphones and with different voices. We noted that less improvement was obtained when compared to the output of the poorer-quality microphones than was the case with better units. (Lower-quality, less-expensive microphones usually exhibit their best symmetry, with lower positive/negative-peak ratios.) It should be noted that the advantages gained by using a PRM microphone apply mostly to limited-level amplifying or modulating systems in which operation is below the overload or clipping level. Systems that employ clippers or some form of automatic modulation control (amc) generally tend toward symmetry and higher average signal levels.

The polarity and characteristics of the existing microphone, as well as the frequency response or phase shifts in the modulating system, play an important role as to whether or not any significant improvement can be obtained with the use of a PRM microphone with a given degree of maximum modulation.

We noted that the low-frequency response of the microphone was somewhat less than usual. This resulted in a slightly crisper signal for better intelligence under adverse conditions.

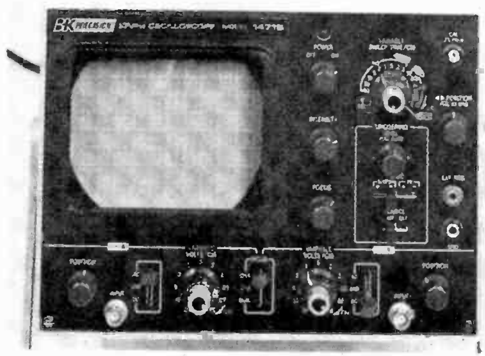
User Comment. In many situations, with the gain control of the microphone set at maximum, the output level can be high enough to severely overload the modulator. This can produce heavy clipping or overmodulation, the latter beyond the signal-handling capabilities of an amc system. Although the use of the microphone can make a signal sound somewhat louder, it may possibly do so at the price of high distortion and excessive adjacent-channel splatter. Therefore, caution should be taken in setting the microphone's gain. This is best done while observing the modulated r-f waveform on an oscilloscope and setting the level control so that the signal does not cause excessive or distorted modulation.

Whether or not a change to this type of microphone will be of benefit in any particular case can be determined by listening to the CB signal under maximum-modulation conditions. (The Model PRX-100 is rated to deliver up to a 4-dB increase in average modulated power, which we confirmed.)

CIRCLE NO. 104 ON FREE INFORMATION CARD

B&K PRECISION MODEL 1471B OSCILLOSCOPE

Has dual-trace and trigger functions desirable in testing modern circuits.



A GOOD general-purpose oscilloscope for servicing and electronics experimenting should have a linear triggered sweep with a broad selection of sweep rates and triggering sources. It should also have two independent traces to permit observation of both the input and output signals of a circuit under test. Moreover, its vertical amplifiers should have sufficient bandwidth and sensitivity to enable the user to work with high-frequency signals with very low and very high amplitudes. The vertical amplifiers should be dc coupled to permit the scope to double as a voltmeter, and both amplifiers should have identical characteristics to permit the instrument to be used for a vector display. Finally, if the scope is to be used in TV servicing, it should have provisions for frame and line sweeps to serve as a vectorscope for chroma alignment.

All of these characteristics can be found in B&K Precision's Model 1471B dual-trace oscilloscope.

The scope measures 16″D × 9.6″W × 7.7″H (40.4 × 24.5 × 19.6 cm) and weighs 18 lb (8.2 kg). Price is $495.

General Details. Each of the vertical amplifiers in this dual-trace solid-state oscilloscope has a bandwidth that goes from dc to at least 10 MHz, risetime of 35 ns, 3% or less overshoot and ringing with a 100-kHz square-wave input, and 1 megohm paralleled by 22 pF input resistance. The deflection factor of the vertical amplifiers is from 0.01 volt/cm to 20 volts/cm in 11 calibrated ranges, fully variable between range settings.

Either amplifier (trace) can be selected separately, or the scope can be operated in the dual-trace (simultaneous display of both channels) mode. In the dual-trace mode, the traces are chopped at a 200-kHz rate at all sweep rates up to 1 ms/cm, while alternate-trace operation is automatically switched in for all faster sweep rates. Channel separation in the dual-trace mode is better than 60 dB at 1000 Hz.

The sweep circuit shared by both

channels can be automatically triggered without an input signal to the scope. The sweep range is from 1 μs/cm to 0.5 s/cm, with full variability between ranges. In addition, the sweep can be magnified 5×, yielding a maximum sweep speed of 0.2 s/cm. There is less than 3% (typical) horizontal linearity distortion.

The switch-selectable sweep triggering can be either internal or external and from the channel in use. (Channel A is selected in the dual-trace mode.) At almost all levels, either the positive or the negative slope of the input signal can be selected to initiate the triggering. Alternatively, the triggering can be automatic. The sweep can be triggered from 20 Hz to better than 10 MHz in the internal mode (1-cm deflection on the CRT's graticule) or dc to 10 MHz from an external trigger signal. A built-in sync separator is provided to permit observation with high stability of any portion of a complex TV waveform.

The horizontal amplifier can be accessed through the channel-B connector on the front panel of the scope and is selected by one position on the sweep speed control when the instrument is in the vectorscope mode. The horizontal amplifier then has a deflection factor of from 0.01 volt/cm to 20 volts/cm, which is the same as that of the vertical amplifier, and a frequency response from dc to 1 MHz.

Intensity modulation on the Z axis is available via a TTL-compatible connector on the rear panel of the scope. A logic low increases trace brightness, while a logic high decreases the brightness. The input resistance to the Z axis is 10,000 ohms.

The scope features a 5" (12.7-cm) flat-screen CRT. Over the face of the CRT is an 8 × 10 cm blue-colored engraved graticule. The bezel that holds the graticule in place can be removed easily to allow insertion of the vector overlay needed for color TV alignment. A 1-volt p-p square-wave source permits checking and calibration of the vertical amplifiers without having to use external sources.

User Comment. The Model 1471B oscilloscope is an excellent general-purpose instrument. Calibration was originally performed with a very accurate external voltage source. After operating the scope for six hours a day over a period of two weeks, we again calibrated the scope and found it to be still "on the head."

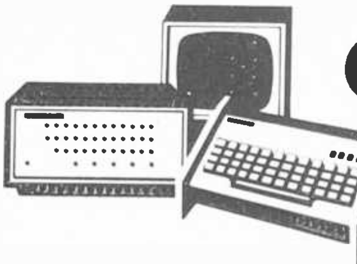
During our in-service tests, we determined that the scope's sync holds up under even very-low-level and relatively high-frequency signals. The trace was steady, and we experienced no trace break-up in the chop mode. The light blue color of the graticule was very easy on the eyes and permitted relatively long term waveform observation without causing optical fatigue.

All controls on the scope are clearly identified, the knobs are shaped and sized for comfortable user "feel," and the controls have positive, smooth action. The combination tilt stand/carrying handle features a solid locking mechanism in both the carry and tilt positions.

During our tests, we used a pair of optional No. PR-31 combination 10:1/direct probes ($25) that proved to be excellent for general-purpose work. They feature miniature spring-loaded clip-tips that enable use in circuits where terminals are very tightly spaced.

If you need fast risetime, extended bandwidth, critical circuit timing, and accurate and stable waveform viewing, the Model 1417B is an excellent choice.

CIRCLE NO. 105 ON FREE INFORMATION CARD



Computer Bits

By Hal Chamberlin

DEBUGGING AIDS

WHAT DO you use your computer's front panel for? Loading programs into memory, monitoring their execution, altering their execution with the sense switches, single-stepping the program to find errors ("bugs"), changing memory locations, and troubleshooting hardware are some examples. Last month, the role of monitor programs such as Motorola's Mikbug in performing routine computer operation tasks was described here. It should have been apparent that the use of a monitor for such functions is far more convenient than using a traditional front panel. But what about non-routine, troubleshooting tasks such as tracing the execution of a new, untried program or locating a hardware malfunction on a new board? Many hobbyists feel that a control panel is indispensable in such situations. Let us examine how monitor software can be used to perform even these "debugging" functions more effectively than a front panel.

Breakpoints. Assume that you have just finished writing a relatively complex program of 200 instructions in machine language and are ready to test it. First you load it into memory, hopefully using a monitor and keyboard. After loading by hand, you save the program on tape just in case it wipes itself out in memory as errant programs often do. Then using the monitor's "G" command you execute the program. Chances are it does not execute properly. In fact, it's probably not even close. At this point debugging begins, which can take considerable time without good debugging tools.

If you have an Altair, Imsai or other front-panel oriented computer you will probably single-step your way through the program in an effort to find out where it goes awry. This means simply that the computer is placed in a single-step operating mode where every operation of the "single-step" switch causes exactly one machine cycle to be executed. Generally, as each cycle is executed, you can see in the console lights the memory or input/output address referenced by the cycle and the data transferred. Additional status lights identify the type of cycle out of about a half-dozen possibilities. However there are many things that the panel lights fail to show. For example, when executing an "add register B to register A" instruction in single-step mode, you will only see the memory address of the instruction and the operation code, 200 in octal. You will not see the contents of register A, register B, or the result of the addition. Even the condition flags such as overflow are hidden from view. Obviously the panel is of limited value if you think the root of a particular bug lies in incorrect register contents or if there is an uncertainty as to what a specific instruction does. If this information is critical (as it often is), you must temporarily modify your program to store the necessary data into memory and then halt so that it may be examined.

Another often encountered difficulty is that single-stepping through a loop a dozen times to catch an error that occurs on the thirteenth iteration can take a long time. If the problem occurs on the 387th iteration it would not even be practical to single-step. Again the program must be temporarily modified to make it halt close to the error condition. Such temporary patches are called "breakpoints."

Many monitors have commands or functions that make inserting and keeping track of breakpoints much easier. A command like "3:213B" might insert a breakpoint at location 213 in page 3 (octal notation). What would actually happen is that the monitor would first look at the indicated address and save whatever was there. Next it would store a CALL instruction in the same location which would transfer control to a "breakpoint subroutine" in the monitor. This monitor

```
                          *      TEST OF DOUBLE PRECISION SUBTRACT

001:000 006 123                  MVI  B,123Q          SET BC TO 123:156 = 21358 DECIMAL
001:002 016 156                  MVI  C,156Q
001:004 026 356                  MVI  D,356Q          SET DE TO 356:312 = -4405 DECIMAL
001:006 036 312                  MVI  E,312Q
001:010 315 000 003              CALL DSUB            DO THE SUBTRACTION
001:013 311                      RET                  RETURN TO THE MONITOR

                          *      DOUBLE PRECISION SUBTRACT REGISTERS B AND C FROM
                          *      D AND E WITH RESULT PLACED IN D AND E

003:000 173               DSUB   MOV  A,E             SUBTRACT LOWER BYTES
003:001 221                      SUB  C
003:002 137                      MOV  E,A             MOVE RESULT INTO E
003:003 172                      MOV  A,D             SUBTRACT UPPER BYTES
003:004 230                      SBB  B
003:005 127                      MOV  D,A             MOVE RESULT INTO D
003:006 311                      RET                  RETURN
```

Fig. 1. Program to be traced.

```
002:232 123  3:0,3:6T        (Command to trace between 003:000 and 003:006
002:232 123  1:0G            (Command to start execution at 001:000

003:000 173  A=312 B=123 C=156 D=356 E=312 H=113 L=002 SP=017:374 FLG=
003:001 221  A=130
003:002 137  E=130
003:003 172  A=356
003:004 230  A=203 FLG=SA
003:005 127  D=203

002:232 123 (next command)
```

Fig. 2. Monitor printout with trace. Underlined portion typed by user.

routine prints the contents of all registers and the condition flags.

Now that the breakpoint is set up, the program would be entered with the normal "G" command. When it got to the "CALL BREAKPOINT" instruction that was inserted, the registers and flags would be printed. After the printout, the monitor would be waiting for another command. When the breakpoint is no longer needed, an "E" command might erase the breakpoint and restore the instruction it saved.

A more sophisticated monitor could allow multiple breakpoints. It would automatically keep track of the instruction displaced by each breakpoint and identify the breakpoint when the registers were printed. A really good breakpoint routine might even execute the saved instruction after printing and then automatically return to the program being debugged. In this case, a breakpoint could not be placed on top of a JUMP or CALL instruction.

A breakpoint routine can also take care of the "error on the 387th loop" problem mentioned earlier. Each time the breakpoint routine is entered, a software counter is decremented. If the counter is not zero, the user program is re-entered without printing the registers. Only when the counter finally does become zero do the registers get printed—thus saving a lot of time and paper. There would, of course, be a command to set the initial value of the counter.

Some microprocessors make the task of implementing a breakpoint facility in a monitor much easier. In the 8080 a normal CALL instruction is three bytes long. When placed in a breakpoint location, the three bytes that were there have to be saved. These three bytes might represent as many as three separate instructions making the "print registers and continue" function very difficult to implement. The 6800 or 6502, on the other hand, has a one-byte BREAK instruction that seems to be custom designed for just this function.

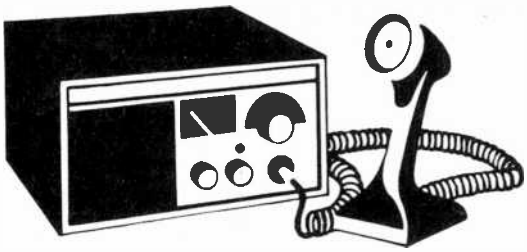
Software Single-Step. Although breakpoint capability in a monitor greatly simplifies the debugging of machine language programs, it is not real single-stepping. A different class of monitor routines called "trace routines" allows the software equivalent of single-stepping. It is interesting to note that some microprocessors are "dynamic" and cannot be stopped to allow the usual hardware single-step function. With these, a trace routine is the only way to get a single-step operation.

Tracing is really equivalent to putting a breakpoint at every instruction in a program. Then when the program is executed, a printout of the location, instruction, and all registers would be given for each instruction executed. This would be exactly equivalent to manual single-stepping with the bonus of a written record of every aspect of the program execution. In a machine with a lot of registers, time and paper may be saved by only printing the registers that have *changed* since the last printout. A useful trace feature in a monitor would allow the setting of *trace limits* so that only the program section of interest would be traced. A fancy trace feature might even allow multiple sets of trace limits with possibly a counter to delay the printing until a specified number of traced instructions has been executed.

How are trace routines actually implemented? One simple method is to use the interrupt feature of the microprocessor itself. With this method, a simple circuit added to the computer is activated to issue an interrupt whenever an instruction is executed. This interrupt would prohibit further interrupts and cause execution of the monitor trace print subroutine. The print routine would not re-enable interrupts until just before it returns to the interrupted program, the one being traced. This prevents the trace print routine from being traced itself. The trace limit feature is implemented by having the trace print routine check if the instruction about to be printed is within the trace limits. If it is not, printing is suppressed and a return to the program is executed. An example is shown in Figs. 1 and 2.

Another method involves *interpreting* the instructions of the traced program rather than executing them. An interpreter is a program that acts just like the microprocessor itself. It literally looks at the operation codes, addresses, and other components of the instruction and, through software, accomplishes the same result as the real microprocessor would have. The purpose of this is that the interpreter program may also store or print detailed information about the instructions it "executes", something the real microprocessor, of course, would not do. This technique requires much more complex software than breakpoints or trace using interrupts does but it has an important advantage. Since the interpreter routine *simulates* the machine, it can also simulate hardware features that the real machine may not have, such as memory protect. While debugging, the simulator would trap any instruction that attempts to jump outside of the protected area as well as any instruction that tries to write into protected memory.

Unfortunately the standard, readily available monitors in read-only memory generally do not have these debugging functions. If anything, a simple breakpoint facility is all that is offered. Specialized monitors, designed primarily for debugging rather than routine operations, on the other hand can probably do everything that has been discussed as well as other handy functions. These monitors are often found in the microprocessor manufacturer's development systems, such as Intel's MDS or Motorola's Exorciser (meaning to "exorcise" bugs) and are quite expensive. However the functions described are not difficult to implement and are certainly worth the effort needed to write them. Club meetings provide opportunities to exchange such software with fellow hobbyists. ◇



CB Scene

By Ray Newhall, KWI6010

UNCLE CHARLIE IS SNOWED-IN

THEY tell us that even the ladies' room at Gettysberg is stacked high with mailbags. The FCC offices there process all Class D (now the "Citizens Band Radio Service") license applications and, between January 1st and 26th, had received more than 832,000 new CB license applications. However, reports are that their computer facility has been working so effectively that expected delays in processing those applications which were properly filed are only two to four weeks. To the FCC's delight, no more than 20% of applications received have included fees, which have to be returned since there is no longer a license charge.

Best estimates are that the FCC will issue more than 990,000 CB licenses in January. That represents an increase of more than 50% above the next greatest month (March 1976). The FCC believes that more than 8,000,000 new CB'ers will go on the air during 1977 and that the total number of licenses issued will exceed 16 million by the end of the year.

Total sales do not appear to account for the flood of license applications received. It appears that many would-be CB'ers are taking advantage of the fee amnesty and are being joined by many others who have been operating without a license. Also, different members of the same family are applying for their own licenses. FCC people tell me that, in many cases, a half dozen or so applications are arriving in the same envelope.

Why Were the Fees Dropped? As most of you know, the FCC handed CB'ers a nice Christmas present by suspending all fees, effective January 1st 1977. That sudden move was not entirely in the spirit of Christmas, however. It was prompted by a court decision ordering the FCC to suspend *all* fees until fee schedules are restructured, based upon the actual costs for issuance of licenses. In fact, they were ordered to refund all fees collected since January 1975, but don't hold your breath in anticipation; the FCC's records on CB licensees do not go back that far in many cases. It is likely that fees will be reestablished again within a few months, and Congress might even pass legislation which permits the Commission to charge fees to help support the enforcement effort.

Some New Developments. When the fourth general meeting of PURAC was adjourned on January 27, it marked the halfway point in the advisory group's two-year Congressional charter. Earlier that morning the meeting was opened with an address by Al Gross, the first licensed CB'er (19W-0001). He recounted all the early efforts to get CB rolling, dating back to World War II. He showed us a pocket-sized walkie-talkie which had been used by the OSS during the war. It was this tiny radio transceiver that convinced the FCC and others that there was a viable future in personal radio communications.

Based on discussions at the meeting, quick FCC action is likely on a proposal by the public safety task group that the four callsign digits, "0911", be set aside for the exclusive use of state-level public service agencies as an emergency-aid callsign. These special calls, a "K" followed by the State's two-letter abbreviation and the four digits "0911," would be issued to any State applying for licensing under the National Emergency Radio Aid (NEAR) program. For example, in Connecticut the NEAR callsign to summon emergency road assistance on channel 9 would be KCT-0911.

The advisory committee was told that the FCC's Office of Plans and Policy would soon release a radio spectrum inventory report which would study areas of the spectrum for future expansion of Personal Radio Services, including:

- A new FM band somewhere between 218 and 225 MHz.
- Future allocation of a portion of the reserved spectrum near 900 MHz.

A new band of FM frequencies at about 220 MHz ("Class E") was first proposed nearly ten years ago; it now appears that it will be considered anew, but prospects are dim for its adoption. In contrast, the possibility of using 900 MHz for distant CB expansion is viewed more optimistically by the FCC. In any event, the FCC pronounced that the recently expanded 27-MHz band ". . . won't be eliminated . . . is here to stay."

Meanwhile, how many CB'ers have considered moving up to the old Class A band around 465 MHz (now redesignated the General Mobile Radio Service)? Here you can use up to 50 watts of power and antenna heights up to 200 feet. Repeaters and automatic phone patches are permitted. It offers nearly all the features now enjoyed by the hams on the 2-Meter band. However, the equipment is several times the cost of present CB equipment.

From the "Future Needs" Task Group, Cary Hershey, a sociologist at Columbia University, made an interesting observation. In response to a question from the floor regarding the damaging effect of Smokey reports by mobile CB units, he said:

> "We have considered the 'Smokey Syndrome' in depth and weighed its negative effects against other factors relating to personal use radio. We have concluded that the sociological advantages to the American public in talking and listening, in direct communication with one another as opposed to all listening only to the media, far outweigh the opportunities offered a minority of criminals using CB to evade the law."

He continued by pointing out that the more inventive law-enforcement agencies have found that the so-called Smokey Syndrome can actually assist their enforcement efforts.

In the area of "Rules Compliance," the committees noted that rules infractions have dropped significantly. They rate the most serious violations as those involving the continued use of "linears" to exceed r-f power output limits and deliberate interference with communications. Though FCC members rate the non-use of callsigns high on their list of violations, the non-FCC members of PURAC tend to down-grade the seriousness of this violation and are examining alternate means of transmitter identification. The primary argument against the Automatic Transmitter Identification Signal (ATIS) involves the management of a data base of information on 30-million or more transmitters. This writer, who is also a data-processing consultant, believes that the FCC will eventually have

ORGANIZATION OF THE PERSONAL RADIO SERVICES, Part 95

Old Class Designation	New Designation	Part 95 Sub-part
Class A	General Mobile Radio Service	A
Class C	Radio Control (R/C) Service	C
Class D	Citizens Band (CB) Radio Service	D
—	All Technical Specifications	E

to bite the bullet and spend the money to do the job properly. It is an expensive operation.

The FCC is determined to make it very risky to operate overpowered rigs. The reason it is so up-tight about external power amplifiers (linears) is because laboratories operating in both the government and private sectors have now determined that more than 60% of all CB-caused TVI results directly from the use of these illegal devices. This is particularly true with the "cheapie" import varieties that are being sold illegally in the United States. They cause all sorts of havoc on frequencies outside of the CB band, and are illegal to manufacture, sell, or even to own in this country. In spite of this, someone managed to slip a packet of sales material onto the FCC reception table at the PURAC meeting! TVI complaints, mostly CB-related, have increased more than ten-fold over the past two or three years.

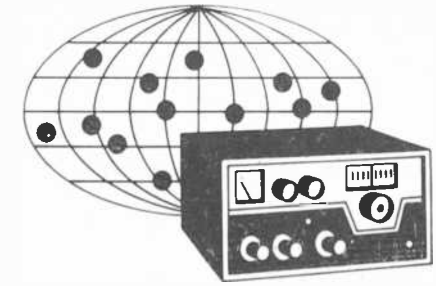
It has now also been determined through extensive field tests that modern TV receivers are less susceptible than was originally thought to fundamental signals. Most TVI occurs under conditions of severe front-end overloading of the receiver, whether caused by an antenna preamplifier or by an extremely powerful CB signal. In a recent field test by the FCC's Field Operations Bureau, where 32 randomly selected CB-related TVI complaints were examined in depth, 63% were the direct result of external power amplifiers used to boost the CB signal well above the legal limit.

Rules Simplification. I have just completed a review of the reorganized version of Part 95, as reported earlier in this column, and I find it a great improvement over the older versions. These should be readily available through the GPO by the time this column is published. The three classes of personal-use radio services have been renamed under the overall designation of "Personal Radio Services" as shown in the Table listing. The 27 MHz CB service (Class D) has been designated the "Citizens Band (CB) Radio Service." All of Part 95 required to be read and understood by a CB operator is contained in *Sub-part D.* This sub-part will be available as a separate publication.

The PURAC efforts to simplify Part 95 are still not complete. Work is already underway to simplify the language as well as the structure. It is expected that this work will be completed and available to the public by late summer 1977.

Legal Problems For CB'ers. As more and more CB'ers go on the air, their legal problems appear to be growing by leaps and bounds. Throughout the country, individual communities are attempting to outlaw CB by the use of local zoning or nuisance ordinances. In Connecticut, for example, there is a statute which was enacted long before CB was authorized making it illegal to operate a radiotelephone in a moving vehicle. Taxis, amateur radio operators, business radio users and commercial radiotelephone are exempted from the law, which appears to leave only CB'ers who can and have been arrested by the State Police. However, there are State Representatives who have pledged to work for the repeal of this law during the current legislative session.

But the number of legal actions which have reached the courts, involving either CB'ers or hams, has increased ten-fold within the past ten years, and a considerable amount of legal precedent is being accumulated. The *Personal Communications Foundation* is a new non-profit legal organization which was formed recently for the purpose of collecting and redistributing all the legal data available on such cases. Its services are free except for the actual cost of reproducing and mailing materials to those attorneys who request it in defense of a personal radio user. If you should have a legal problem, your lawyer may contact them in Lancaster, CA 93534 (805-942-0144). ◇



DX Listening

By Glenn Hauser

Secret Shortwave Stations. If you scan the non-broadcast bands with a good, sensitive receiver for evidence of broadcast programming, you should discover, as we did last fall, a number of tropical-band harmonics in the 18–25 MHz range. Some of them are listed below. As the sunspot count picks up, so should harmonic reception, even up to 31 MHz. Whether you hear the stations listed depends on skip conditions, but there is likely to be less interference on weekends. F_2 propagation peaks around noon, but sporadic E (short skip) can extend into the evening.

In regular out-of-broadcast-band tuning, you'll also find broadcast programs transmitted on SSB. Most feed the remote retransmission sites. Guyana Broadcasting Service is seldom armchair copy on 3.290 or 5.950 MHz, but when they activate 16.454 MHz, listening is easy. Radio Monte Carlo feeds Arabic programs of pop music to its MW relay on Cyprus, via 15.575 or 17.555 MHz frequently heard during the morning in North America. Chilean stations such as Radio Colo-Colo and Radio Cooperativa can be heard on 12.250, 6.6845 or 4.885 MHz at irregular hours.

MHz	Harmonic	Fundamental (MHz)	Station
24.3298	4	6.08245	R. Nacional, Peru
24.024	4	6.006	R. Reloj, Costa Rica
24.020	4	6.005	BBC, Ascension
23.850	2	11.925	Rdif. Portuguesa
23.630	2	11.815	BBC, Ascension
23.610	2	11.805	WYFR, Massachusetts
23.540	2	11.770	BBC, Ascension
19.860	4	4.965	R. Santa Fe, Colombia
19.480	2	9.740	Rdif. Portuguesa
19.328	4	4.832	R. Reloj, Costa Rica
19.210	2	9.605	Deutsche Welle, Antigua
19.100	2	9.550	R. Habana Cuba
19.050	2	9.525	R. Habana Cuba
18.5688	3	6.1896	La Voz de los Centauros, Colombia
18.3456	3	6.1152	La Voz del Llano, Colombia
18.315	3	6.105	La Pantera, Mexico
18.2262	3	6.0754	La Voz del Junco, Honduras
14.835	3	4.945	R. Colosal, Colombia
12.320	2	6.160	Em. Nueva Granada, Colombia

The World Station. Matching its image as the "number one" SW service in English, the BBC also publishes the best program guide, "London Calling." New subscribers to the illustrated free monthly had been turned down due to rising costs. But in April BBC began accepting subscriptions from anyone paying the new charge of $10 per year (630 Fifth Ave., New York, NY 10020). Alternatively, you can consult our fortnightly column, *Short Waves*, in the Roundup section of the Sunday Denver Post.

A few late-April features we can tell you about here: *Theatre of the Air*, Saturdays at 1830 GMT, Sundays at 0030 and 1130, presents Anouilh's "Antigone," Apr. 23/24. *Radio Theatre*, Sun. 1900, Thurs. 1345, Fri. 0030 has James Fairfax plays, "No Holds Barred," Apr. 17/21/22, and "Let's Play Politics," Apr. 24/28/29. Documentaries, Sun. 1709, Tues. 0030, Thurs. 1130 are "The Right Sort of Food," Apr. 17/19/21, and "The Changing Role of the Ambassador," Apr. 24/26/28. And Wed. 1430, Thurs. 0030, Fri. 2030, "One Hundred Years of Recorded Sound," Apr. 20/21/22, and "Shakespeare on Record," Apr. 27/28/29.

DX Programs. Radio Nederland is broadcasting a "Communications System Course" covering radio, TV, radar, navigation and radio astronomy, written by Jim Vastenhoud. Besides broadcasting each lesson two weeks in a row, printed lessons and illustrations are available free. You can still enroll in this course, which began April 7 on the Thursday "DX Juke Box" programs, and continues through the summer. R. Nederland is also celebrating 50 years of SWBC with a special QSL card, and yours truly is celebrating his 10th anniversary as a DX correspondent on the April 21 program. You can also hear our DX report in Spanish, the second Friday of each month on "Espacio DX-ista."

DX listeners are invited to participate in or monitor a ham net discussing all phases of DX'ing and SWL'ing, Wednesdays at 2130 GMT on 7.275 ±0.005 MHz (perhaps an hour earlier by GMT during daylight time). NCS is Charles, WB9NWF. Medium-wave DX'ers exchange tips Monday mornings at 0700 (0600 GMT, starting in May) on 3.900 MHz; listen for Skip, K0SBV, or Ross, W9BG.

The hams also operate a well-organized "intruder watch" designed to expunge non-ham stations from their bands, and qualified SWL's are invited to help. Contact the ARRL Intruder Watch, E. H. Conklin, K6KA, 402 Oliveta Pl., Box 1, La Cañada, CA 91011.

Mark Your Calendar. The International Committee of the Red Cross broadcasts only 4 hours a day, 3 days a week, 6 weeks a year, making its QSL more of a prize than others from Switzerland. Here's the schedule, via SBC on 7.210 MHz, for the rest of 1977: May 23/25/27; July 25/27/29; Sept. 26/28/30; Nov. 21/23/25, at 0600-0700, 1130-1230, 1700-1800, 2200-2300 GMT. The last, and possibly the first, have a chance of being heard in North America this time of year. Mondays are in English; Wednesdays, French/German; and Fridays, Spanish/Arabic.

If you make a point of listening to certain stations on important dates, you may hear extended or special programming. For a starter, try 5.047 MHz on April 27, Togo's National Day. Deutsche Welle is 24 years old on May 3. Liberation Day in Czechoslovakia is May 9, and R. Prague itself marks 54 years on May 18. Cameroun stations on 4.9725 and 5.010 MHz may observe National Day on May 20. Guyana Independence Day is May 26, a good time to check

16.454 MHz. May 31 is Republic Day in South Africa. Tunisia's National Day is June 1, and June 2 is Italy's Day of the Republic. Haiti's 4VEH celebrates 27 years on the air June 2—check 9.770 and 11.834 MHz. FEBC, Philippines is 29 on June 4, while Philippine Independence Day is June 12. Republic Day in Iceland, June 17, just might bring some special transmission on 12.175 MHz. (Dates were compiled by Cees van der Zalm for the Benelux DX Club.) ◇

MAY-AUGUST ENGLISH-LANGUAGE SW B'CASTS by Richard E. Wood

TO EASTERN NORTH AMERICA

TIME-EDT	TIME-GMT	STATION	QUAL*	FREQUENCIES, MHz
6:28 a.m.-8:00 p.m.	1028-2400	**Montreal, Canada (Northern Service)	G	9.625, 11.72 (includes French, etc.)
7:00-7:25 a.m.	1100-1125	Tirana, Albania	F	9.50, 11.865
7:00-9:00 a.m.	1100-1330	Melbourne, Australia	G	9.58
7:00-9:30 a.m.	1100-1330	London, England	G	5.99 (via Sackville), 6.195 (via Antiqua), 11.79 (via Antiqua, tentative by midsummer) 15.07
7:00-10:00 a.m.	1100-1400	**VOA, Washington, USA	G	5.955, 9.73
7:05-8:25 a.m.	1105-1225	Trans-World Radio, Bonaire, N.A.	G	11.815
7:45-8:05 a.m.	1145-1205	**Montreal, Canada	G	9.56, 11.72
8:00-8:30 a.m.	1200-1230	Jerusalem, Israel	G	11.655, 15.10, 15.485, 17.685
8:00-8:55 a.m.	1200-1255	Peking, China	F	11.685
8:10-8:30 a.m.	1210-1230	**Santiago, Chile	F	9.566, 11.81, 15.15
8:15-8:30 a.m.	1215-1230	Athens, Greece	F	15.345, 17.83
		HCJB, Quito, Ecuador	G	11.745
8:30-9:00 a.m.	1230-1300	Stockholm, Sweden	G	15.305
8:30-10:00 a.m.	1230-1400	Trans-World Radio, Bonaire, N.A.	G	15.255 (Sat., Sun.)
8:30-11:30 a.m.	1230-1630	HCJB, Quito, Ecuador	G	11.745, 15.115
9:15-9:45 a.m.	1315-1345	Berne, Switzerland	G	15.14
9:30-10:00 a.m.	1330-1400	Helsinki, Finland	G	15.11
9:30-11:00 a.m.	1330-1500	**London, England	G	15.07
10:00-10:15 a.m.	1400-1415	**Montreal, Canada	G	15.325, 17.74
10:00-10:30 a.m.	1400-1430	Oslo, Norway	G	15.175 (Sun.)
		Stockholm, Sweden	G	15.305
10:30-11:00 a.m.	1430-1500	Helsinki, Finland	G	15.11
11:00 a.m.-12 noon	1500-1600	London, England	G	17.84 (via Ascension), 9.58 (via Sackville Sat., Sun.)
11:15-11:30 a.m.	1515-1530	Athens, Greece	P	11.73, 15.345, 17.83
12 noon-12:15 p.m.	1600-1615	London, England	G	9.58 (via Sackville) 17.84 (via Ascension)
12:00 noon-12:30 p.m.	1600-1630	Oslo, Norway	G	15.175 (Sun.)
12:04-12:56 p.m.	1604-1656	**Paris, France	G	15.20, 15.30, 15.425, 17.72, 17.80, 17.82, 21.62
12:15-2:30 p.m.	1615-1830	London, England	G	9.58 (via Sackville), 15.07
1:00-4:00 p.m.	1700-2000	**Kuwait, Kuwait	F	9.555, 9.58, 11.845
2:00-2:30 p.m.	1800-1830	**Montreal, Canada	G	11.855, 15.325, 17.82
		**Kampala, Uganda	F	15.325 (Tues., Thur., Sat., Sun.)
2:30-3:00 p.m.	1830-1900	**Montreal, Canada	G	11.855, 15.325, 17.82
2:50-4:00 p.m.	1850-2000	**Abidjan, Ivory Coast	G	11.92 (Sun.)
3:00-3:30 p.m.	1900-1930	**Montreal, Canada	G	11.855, 15.325, 17.82
3:00-4:00 p.m.	1900-2000	**Algiers, Algeria	F	11.91, 15.42 (variable)
3:00-6:00 p.m.	1900-2200	**Jeddah, Saudi Arabia	F	11.855
3:30-4:00 p.m.	1930-2000	**Montreal, Canada	G	11.855, 15.42, 17.82
4:00-4:30 p.m.	2000-2030	**Montreal, Canada	G	15.29, 15.325, 17.82
		**Tehran, Iran	F	9.022, (11.77 alternate)
		Jerusalem, Israel	G	9.009, 9.425, 9.815, 11.655, 15.10
4:00-5:00 p.m.	2000-2100	Accra, Ghana	F	11.85 (irregular)
4:00-5:20 p.m.	2000-2120	**Hilversum, Holland	G	11.73 (via Talata)
4:50-5:50 p.m.	2050-2150	**Havana, Cuba	G	11.865, 17.75
5:00-5:30 p.m.	2100-2130	**Brazzaville, Congo	G	15.19
5:00-5:50 p.m.	2100-2150	**Johannesburg, S. Africa	F	5.98, 9.585
5:00-6:00 p.m.	2100-2200	**Brasilia, Brazil	G	15.24 (11.78, 15.245 alternate)
5:15-6:45 p.m.	2115-2245	London, England	G	9.58, 11.75
5:30-6:50 p.m.	2130-2250	Hilversum, Holland	G	9.715, 11.73 (exc. Sun.)
6:00-6:15 p.m.	2200-2215	**Belgrade, Yugoslavia	F	6.10, 7.24, 9.62
6:00-6:30 p.m.	2200-2230	**Montreal, Canada	G	11.855, 15.325
		Oslo, Norway	F	15.175 (Sun.)
		**Caracas, Venezuela	F	15.40 (varies, Mon.-Fri.)
6:00-7:15 p.m.	2200-2315	**Cairo, Egypt	G	9.805
6:00-8:30 p.m.	2200-0030	Ankara, Turkey	G	9.515, 11.88
6:30-7:00 p.m.	2230-2300	Jerusalem, Israel	G	9.435, 9.815, 11.655, 15.10, 15.485
		Moscow, U.S.S.R.	G	7.105, 7.15, 7.355, 7.40, 9.655, 9.685, 11.735, 11.75, 11.87, 12.05
6:30-7:20 p.m.	2230-2320	Johannesburg, S. Africa	F	5.98, 9.585, 11.90
6:45-7:00 p.m.	2245-2300	London, England	G	5.975, 7.325, 9.58, 11.75

6:50-7:10 p.m.	2250-2310	**Santiago, Chile	F	9.56, 11.81, 15.15
7:00-7:30 p.m.	2300-2330	Stockholm, Sweden	G	6.12, 9.695, 11.705
		Moscow, U.S.S.R.	G	7.105, 7.15, 7.355, 7.40, 9.685, 11.735, 11.75, 11.87, 12.05,
		Vilnius, U.S.S.R.	G	9.655, 9.72, 9.745, 11.77 11.90 (Sat., Sun..)
7:00-7:50 p.m.	2300-2350	**Buenos Aires, Argentina	G	11.71 (Mon.-Fri.)
7:30-8:00 p.m.	2330-2400	Helsinki, Finland	P	11.755
		**Radio Clarin, S. Domingo, Dom. Rep.	G	11.70 (irregular)
		London, England	G	5.975, 6.12 (via Antigua, tent. by midsummer) 7.325, 9.58
7:30-8:30 p.m.	2330-0030	Moscow, U.S.S.R.	G	7.105, 7.355, 7.40, 9.655, 9.685, 9.72, 9.745, 11.735, 11.75, 11.77, 1187, 11.90, 12.05
7:45-8:45 p.m.	2345-0045	Tokyo, Japan	F	15.27, 15.30
8:00-8:25 p.m.	0000-0025	Tirana, Albania	G	7.065, 9.75 (varies)
8:00-8:30 p.m.	0000-0030	Oslo, Norway	F	9.645, 11.86 (Sun.)
8:00-8:55 p.m.	0000-0055	Sofia, Bulgaria	G	9.70 (alternate 9.705)
		Peking, China	F	11.675, 11.945, 15.06
8:00-9:00 p.m.	0000-0100	**VDA, Washington, USA	G	6.19, 9.67, 11.83, 11.895
8:00-10:45 p.m.	0000-0245	**Luxemburg	F	6.09
8:00 p.m.-1:06 a.m.	0000-0506	**Montreal, Canada (Northern Service)	F	6.065, 9.625
8:15-8:30 p.m.	0015-0030	Brussels, Belgium	G	9.725
8:30-8:55 p.m.	0030-0055	Prague, Czechoslovakia	F	6.055, 9.74
8:30-9:00 p.m.	0030-0100	Stockholm, Sweden	F	11.955
		Kiev, U.S.S.R.	G	9.60, 9.61, 11.69, 11.735, 12.05
8:30-9:30 p.m.	0030-0130	Moscow, U.S.S.R.	G	7.15, 9.53, 9.655, 9.685
		**Trans-World Radio, Bonaire, N.A.	G	11.925
8:30-11:30 p.m.	0030-0330	London, England	G	5.975, 6.12 (via Antigua, tent. by midsummer) 7.325, 9.51, (via Greenville), 9.58 (via Ascension)
8:40-11:00 p.m.	0040-0300	HCJB, Quito, Ecuador	G	9.56, 11.915
9:00-9:15 p.m.	0100-0115	Vatican, City	G	5.995, 9.605, 11.70
9:00-9:20 p.m.	0100-0120	Rome, Italy	G	9.575, 11.91
9:00-9:30 p.m.	0100-0130	Vilnius, U.S.S.R.	G	7.15, 7.215, 9.61, 11.69, (Sat., Sun.)
		Montreal, Canada	G	9.535
9:00-9:45 p.m.	0100-0145	Berlin, Ger. Dem. Rep.	P	9.73
9:00-9:55 p.m.	0100-0155	Peking, China	G	7.12, 9.78 (via Tirana), 9.94, 11.945, 15.06
		Prague, Czechoslovakia	G	5.93, 7.345, 9.54, 9.63, 9.74, 11.99
9:00-11:00 p.m.	0100-0300	Melbourne, Australia	G	15.32, 17.795
9:00-11:30 p.m.	0100-0330	Havana, Cuba	G	11.725, 11.93
9:00 p.m.-12 mdt.	0100-0400	Madrid, Spain	G	6.08, (alternate 6.065) 11.88 (exp. Sun)
9:10-9:30 p.m.	0110-0130	**Santiago, Chile	F	9.566, 11.81, 15.15
9:30-9:50 p.m.	0130-0150	Cologne, Ger. Fed. Rep.	G	6.01, 6.04 (via Antiqua), 6.075, 9.565, 9.605
9:30-9:55 p.m.	0130-0155	Tirana, Albania	G	6.20, 7.30
		Vienna, Austria	P	6.155, 9.77
9:30-10:25 p.m.	0130-0225	Bucharest, Rumania	F	5.99, 9.57, 9.68, 11.775, 11.94
9:30-10:30 p.m.	0130-0230	Moscow, U.S.S.R.	G	7.15, 7.215, 9.53, 9.685, 9.70 (via Sofia)
9:45-10:15 p.m.	0145-0215	Berne, Switzerland	G	5.965, 6.135, 9.725, 11.715
10:00-10:30 p.m.	0200-0230	Budapest, Hungary	G	6.00, 7.215, 9.585, 9.833, 11.91 (Exc. Sun.)
		Oslo, Norway	F	9.645, 11.86, 15.175 (Sun.)
		Montreal, Canada	G	6.085, 9.535
		Warsaw, Poland	P	6.095, 6.135, 7.27, 9.675, 11.815, 11.84, 15.12
10:00-10:55 p.m.	0200-0255	Peking, China	F	9.94, 12.01, 12.055
10:00-11:20 p.m.	0200-0320	Hilversum, Holland	G	6.165 (via Bonaire)
10:00-11:30 p.m.	0200-0330	Cairo, Egypt	G	9.475
10:10-10:30 p.m.	0210-0230	**Santiago, Chile	F	9.566, 11.81, 15.15
10:15-10:30 p.m.	0215-0230	Athens, Greece	F	9.75, 9.76, 11.73
10:30-10:55 p.m.	0230-0255	Tirana, Albania	G	6.20, 7.30
10:30-11:00 p.m.	0230-0300	Stockholm, Sweden	F	9.695, 11.705
		Moscow, U.S.S.R.	G	7.39, 9.50, 9.53, 9.61, 9.685, 9.70 (via Sofia)
10:30-11:15 p.m.	0230-0315	Berlin, Ger. Dem. Rep.	P	9.73
11:00-11:30 p.m.	0300-0330	Budapest, Hungary	F	6.00, 7.215, 9.585, 9.833, 11.91 (Tues., Fri.)
		Kiev, U.S.S.R.	G	7.39, 9.61
		Lisbon, Portugal	F	6.025, 11.935
		Moscow, U.S.S.R.	G	9.50, 9.685, 9.70 (via Sofia)
11:00-11:35 p.m.	0300-0335	Warsaw, Poland	P	6.095, 6.135, 7.27, 9.675, 11.815, 11.84, 15.12
11:00-11:55 p.m.	0300-0355	Peking, China	G	7.12, 9.78 (via Tirana)
11:00 p.m.-12 mdt.	0300-0400	Buenos Aires, Argentina	G	9.69 (Mon.-Fri.)
		Prague, Czechoslovakia	G	5.93, 7.345, 9.54, 9.63, 9.74, 11.99
11:00-12:25 a.m.	0300-0425	**Johannesburg, S. Africa	F	5.98, 7.27
11:00 p.m.-1:00 a.m.	0300-0500	HCJB, Quito, Ecuador	G	6.095, 9.56, 11.915
11:10-11:30 p.m.	0310-0330	**Santiago, Chile	F	9.566, 11.81, 15.15

11:30-11:55 p.m.	0330-0355	Tirana, Albania	G	6.20, 7.30
		Vienna, Austria	P	6.155, 9.77
11:30 p.m.-12 mdt.	0330-0400	Moscow, U.S.S.R.	G	7.39, 9.50, 9.61, 9.685, 9.70 (via Sofia)
11:30 p.m.-12:30 a.m.	0330-0430	London, England	G	5.975, 6.12 (via Antiqua, tent. midsummer)
11:30 p.m.-12:50 a.m.	0330-0450	Havana, Cuba	G	11.725, 11.76, 11.93
12:00 mdt.-12:15 a.m.	0400-0415	Budapest, Hungary	G	6.00, 7.215, 9.585, 9.833, 11.91 (Tues., Fri.)
12:00 mdt.-12:25 a.m.	0400-0425	Bucharest, Rumania	F	5.99, 6.155, 6.19, 9.57, 9.68, 11.775, 11.94
12:00 mdt.-12:30 a.m.	0400-0430	Oslo, Norway	F	9.645, 11.86 (Sun.)
12:30-1:00 a.m.	0430-0500	London, England	G	6.175 (via Antiqua)
12:50 p.m.-2:00 a.m.	0450-0600	Havana, Cuba	G	11.725, 11.93
1:00-1:15 a.m.	0500-0515	Jerusalem, Israel	G	7.412, 9.815, 11.655
1:00-1:30 a.m.	0500-0530	Lisbon, Portugal	G	6.025, 11.935
1:00-3:00 a.m.	0500-0700	HCJB, Quito, Ecuador	G	6.095, 9.56
1:00-3:30 a.m.	0500-0730	London, England	G	6.175, (via Antigua) 9.51 (via Antigua, tent. by midsummer)

TO WESTERN NORTH AMERICA

TIME-PDT	TIME-GMT	STATION	QUAL*	FREQUENCIES, MHz
4:00-4:15 a.m.	1100-1115	Tokyo, Japan	P	5.99
4:00-5:25 a.m.	1100-1225	Trans-World Radio, Bonaire, N.A.	G	11.815
4:00-6:30 a.m.	1100-1330	London, England	G	5.99 (via Sackville), 6.196 (via Antigua), 11.75 (via Tebrau), 11.79 (via Antigua tent. midsummer)
4:00-7:00 a.m.	1100-1400	**VOA, Washington, USA	G	5.955, 9.73
		**4VEH, Cap-Haitien, Haiti	G	9.77, 11.835
5:00-5:15 a.m.	1200-1215	Tokyo, Japan	P	5.99
5:00-5:30 a.m.	1200-1230	**Tashkent, U.S.S.R.	G	9.60, 11.925
5:10-5:30 a.m.	1210-1230	**Santiago, Chile	F	6.195, 9.566, 11.81, 15.15
5:15-5:30 a.m.	1215-1230	HCJB, Quito, Ecuador	G	11.745
5:30-7:00 a.m.	1230-1400	Trans-World Radio Bonaire, N.A.	G	15.255 (Sat., Sun.)
5:30-9:30 a.m.	1230-1630	HCJB, Quito, Ecuador	G	11.745, 15.115
6:00-6:15 a.m.	1300-1315	Tokyo, Japan	P	5.99
6:30-6:50 a.m.	1330-1350	**Santiago, Chile	F	6.195, 9.566, 11.81, 15.15
6:30-8:00 a.m.	1330-1500	**Delhi, India	F	11.81
7:00-7:30 a.m.	1400-1430	Tokyo, Japan	G	9.505
		**Tashkent, U.S.S.R.	G	9.60, 11.925
7:00-8:20 a.m.	1400-1520	**Hilversum, Holland	G	11.73 (via Talata)
7:00-9:55 a.m.	1400-1655	Manila, Philippines (VOP)	F	9.58 (Closes 1555 Sun.)
8:00-8:15 a.m.	1500-1515	Tokyo, Japan	G	9.505
8:00-9:00 a.m.	1500-1600	London, England	G	17.84 (via Ascension) also 9.58 (via Sackville Sat., Sun.)
9:00-9:15 a.m.	1600-1615	Tokyo, Japan	G	9.505
		London, England	G	9.58, 15.365 (via Sackville), 17.84 (via Ascension)
9:04-9:56 a.m.	1604-1656	**Paris, France	G	15.20, 15.30, 15.425, 17.72, 17.80, 17.82, 21.62
9:15-10.09 a.m.	1615-1809	London, England	G	9.58, 15.365 (via Sackville)
9:42-9:51 a.m.	1642-1651	Hilversum, Holland	G	15.19, 17.775 (Mon.-Fri.)
10:00-10:15 a.m.	1700-1715	Tokyo, Japan	G	9.505
10:00 a.m.-1:00 p.m.	1700-2000	**Kuwait, Kuwait	F	9.555, 9.58, 11.845
10:09-11:00 a.m.	1709-1800	London, England	G	9.58, (via Sackville)
11:00-11:09 a.m.	1800-1809	London, England	G	9.58 (via Sackville), 11.815 (via Ascension)
11:00-11:15 a.m.	1800-1815	Tokyo, Japan	G	15.105
11:00-11:30	1800-1830	**Kampala, Uganda	F	15.325, (Tues., Thur., Sat., Sun.)
		Oslo, Norway	F	11.895 (Sun.)
11:45 a.m.-1:00 p.m.	1845-2000	**Abidjan, Ivory Coast	G	11.92 (Sun.)
12 noon-12:15 p.m.	1900-1910	**Papeete, Tahiti	F	11.825, 15.17 (exc. Sun.)
12:00-12:15 p.m.	1900-1915	Tokyo, Japan	G	15.105
1:00-1:15 p.m.	2000-2015	Tokyo, Japan	G	15.105
1:00-2:20 p.m.	2000-2120	Hilversum, Holland	G	11.73 (via Talata)
1:30-1:50 p.m.	2030-2050	**Santiago, Chile	F	9.566, 11.81, 15.15
1:30-2:00 p.m.	2030-2100	**Kampala, Uganda	F	9.73 (Sat., Mon. Wed., Fri.)
2:00-2:15 p.m.	2100-2115	Tokyo, Japan	G	15.105
2:00–2:30 p.m.	2100-2130	**Brazzaville, Congo	G	15.19
2:00-3:00 p.m.	2100-2200	**Brazilia, Brazil	G	15.24 (alternates 11.78, 15.245)
2:30-3:30 p.m.	2130-2230	**Taipei, Taiwan	F	15.225
3:00-3:15 p.m.	2200-2215	Tokyo, Japan	G	15.105
3:00-3:30 p.m.	2200-2230	**Caracas, Venezuela	F	15.40 (varies; Mon.-Fri.)
3:00-5:00 p.m.	2200-2400	**VOA, Washington, USA	G	17.82, 17.895, 21.61
		Montreal, Canada	F	5.96 (Mon.-Fri.)
3:30-4:00 p.m.	2230-2300	Jerusalem, Israel	G	9.435, 9.815, 11.655, 15.10, 15.485
3:30-4:20 p.m.	2230-2320	Johannesburg, S. Africa	F	5.98, 9.585, 11.90
3:30-5:30 p.m.	2230-0030	Moscow, U.S.S.R.	G	9.635, 9.78, 12.05, 15.14, 15.18, 15.455, 17.72
3:50-4:10 p.m.	2250-2310	**Santiago, Chile	F	9.566, 11.81, 15.15
4:00-4:30 p.m.	2300-2330	Tokyo, Japan	G	15.105
4:00-5:00 p.m.	2300-2400	**Pyongyang, Dem. Rep. Korea	F	11.535, 15.63 (variable)

4:00-4:30 p.m.	2300-2330	London, England	G	6.175, 9.51 (via Sackville), 9.58 (via Ascension)
4:30-5:00 p.m.	2330-2400	**Radio Clarin, S. Domingo, Dom. Rep.	G	11.70 (irregular Mon.-Fri.)
4:30-5:30 p.m.	2330-0030	London, England	G	6.12 (via Antigua tent. by midsummer) 6.175, 9.51 (via Sackville)
5:00-5:15 p.m.	0000-0015	Tokyo, Japan	G	15.105
5:00-6:00 p.m.	0000-0100	**VOA, Washington, USA	G	11.83, 11.895, 15.40
5:30-6:00 p.m.	0030-0100	Moscow, U.S.S.R.	G	9.635, 9.78, 12.05, 15.14, 15.18, 15.455, 17.72
5:30-6:30 p.m.	0030-0130	**Trans-World Radio, Bonaire, N.A.	G	11.925
5:30-8:30 p.m.	0030-0330	London, England	G	6.12 (via Antigua, tent. by midsummer) 6.175 (via Sackville), 9.51 (via Greenville), 9.58 (via Ascension)
5:40-8:00 p.m.	0040-0300	HCJB, Quito, Ecuador	G	9.56, 11.915
6:00-6:15 p.m.	0100-0115	Tokyo, Japan	G	15.105
6:00-6:30 p.m.	0100-0130	Moscow, U.S.S.R.	G	9.635, 9.78, 12.05, 15.14, 15.18, 15.455
6:00-7:00 p.m.	0100-0200	Taipei, Taiwan	F	15.425, 17.89
6:00-8:00 p.m.	0100-0300	Melbourne, Australia	G	15.32, 17.795
6:00-9:00 p.m.	0100-0400	Madrid, Spain	F	6.08, (alternate 6.065), 11.88
6:10-6:30 p.m.	0110-0130	**Santiago, Chile	F	6.195, 9.566, 11.81, 15.15
7:00-7:30 p.m.	0200-0230	Moscow, U.S.S.R.	G	9.635, 9.78, 11.86, 12.05, 15.14
7:30-8:00 p.m.	0230-0300	Stockholm, Sweden	F	9.695, 11.705
		Moscow, U.S.S.R.	G	9.635, 9.78, 11.86, 15.14
8:00-8:15 p.m.	0300-0315	Tokyo, Japan	G	15.105
8:00-8:30 p.m.	0300-0330	Kiev, U.S.S.R.	G	9.58, 9.635, 9.78, 11.86
		Seoul, Rep. Korea	F	11.86
		Moscow, U.S.S.R.	G	9.655, 12.05
8:00-8:55 p.m.	0300-0355	Peking, China	G	7.12, 9.78 (via Tirana), 11.445, 12.055, 15.06, 15.385, 17.735, 17.855
8:00-9:20 p.m.	0300-0420	**Johannesburg, S. Africa	F	5.98, 7.27
8:00-10:00 p.m.	0300-0500	HCJB, Quito, Ecuador	G	6.095, 9.56, 11.915
8:10-8:30 p.m.	0310-0330	**Santiago, Chile	F	6.195, 9.56, 11.81, 15.15
8:20-9:25 p.m.	0320-0425	**TIFC, San Jose, Costa Rica	F	6.035, 9.645, (opens 0300 Sat., Sun.)
8:22-8:28 p.m.	0322-0328	Erevan, U.S.S.R.	G	9.54, 9.735, 11.69, 15.14 (Sat./Tue./Wed./Fri.)
8:30-9:00 p.m.	0330-0400	Moscow, U.S.S.R.	G	9.54, 9.58, 9.635, 9.735, 9.78, 11.69, 15.14, 11.87, 12.00, 12.05, 15.10, 15.21
8:30-9:15 p.m.	0330-0415	Berlin, Ger. Dem. Rep.	F	11.89, 12.00
8:30-9:30 p.m.	0330-0430	London, England	G	6.12 (via Antigua tent. midsummer) 6.175 (via Sackville)
9:00-9:15 p.m.	0400-0415	Tokyo, Japan	G	15.105
9:00-9:30 p.m.	0400-0430	Oslo, Norway	F	6.18, 9.55, 9.645
		Budapest, Hungary	F	6.00, 7.215, 9.585, 9.833, 11.91 (Tue., Fri.)
		Montreal, Canada	G	9.655, 11.765
9:00 p.m.-12:30 a.m.	0400-0730	Moscow, U.S.S.R.	G	9.54, 9.58, 9.635, 9.71, 9.78, 11.69, 11.87, 12.00, 12.05, 15.10, 15.21
9:30-10:00 p.m.	0430-0500	Berne, Switzerland	G	9.725, 11.715
		Sofia, Bulgaria	F	9.70 (alternate 9.705)
9:30-12:30 a.m.	0430-0730	London, England	G	6.175 (via Antiqua)
10:00-10:15 p.m.	0500-0515	Jerusalem, Israel	F	7.412, 9.815, 11.655
		Tokyo, Japan	G	15.105
10:00-10:30 p.m.	0500-0530	Lisbon, Portugal	F	6.025, 11.935 (varies)
10:00-11:20 p.m.	0500-0620	Hilversum, Holland	G	6.165, 9.715, (via Bonaire)
10:00-12 mdt.	0500-0700	HCJB, Quito, Ecuador	G	6.095, 9.56
10:00 p.m.-12:30 a.m.	0500-0730	London, England	G	6.175 (via Antiqua) 9.51 (via Antiqua tent. by midsummer)
10:30-10:50 p.m.	0530-0550	Cologne, Ger. Fed. Rep.	G	5.96 (via Antiqua) 6.10 (via Malta), 6.185, 9.545
11:00-11:15 p.m.	0600-0615	Tokyo, Japan	G	9.505
11:00-11:30 p.m.	0600-0630	Oslo, Norway	P	6.18, 9.645 (Sun.)
		Seoul, Korea	F	9.73
11:00 p.m.-12 mdt.	0600-0700	Buenos Aires, Argentina	G	9.69 (Mon.-Fri.)
11:25 p.m.-1:25 a.m.	0625-0825	**Kuala, Lumpur, Malaysia	G	15.275
11:30 p.m.-12:50 a.m.	0630-0750	**Hilversum, Holland	G	9.63 (via Bonaire)
12:00-12:15 a.m.	0700-0715	Tokyo, Japan	G	9.505
1:00-1:15 a.m.	0800-0815	Tokyo, Japan	G	9.505
1:00-2:20 a.m.	0800-0920	**Hilversum, Holland	G	9.715 (via Bonaire)
1:00-3:00 a.m.	0800-1000	Manila, Philippines (FEBC)	F	11.92
1:00-7:00 a.m.	0800-1400	**Port Moresby, Papia-New Guinea	G	4.89
2:00-2:15 a.m.	0900-0915	Tokyo, Japan	G	9.505
2:30-2:50 a.m.	0930-0950	**Santiago, Chile	G	6.195, 9.566, 11.81, 15.15
3:00-3:30 a.m.	1000-1030	Tokyo, Japan	G	5.99
3:50-4:10 a.m.	1050-1110	**Santiago, Chile	G	6.195, 9.566, 11.81, 15.15

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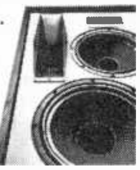

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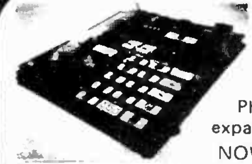

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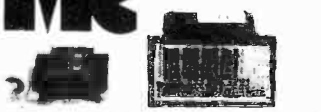
iMC

3½ DIGIT DVM KIT



This 0-2 VDC .05 per cent digital voltmeter features the Motorola 3½ digit DVM chip set. It has a .4" LED display and operates from a single +5V power supply. The unit is provided complete with an injection molded black plastic case complete with Bezel. An optional power supply is available which fits into the same case as the 0-2V DVM allowing 117 VAC operation.

A. 0-2V DVM with Case $49.95
B. 5V Power Supply $14.95

VECTOR WIRING PENCIL
Vector Wiring Pencil P173 consists of a hand held featherweight (under one ounce) tool which is used to guide and wrap insulated wire, fed off a self-contained replaceable bobbin, onto component leads or terminals installed on pre-punched "P" Pattern Vectorbord. Connections between the wrapped wire and component leads, pads or terminals are made by soldering. Complete with 250 FT of red wire **$9.50**

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1/16 VECTOR BOARD

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PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	169P44 062XXXP	4.50	17.00	3.69	3.32
EPOXY GLASS	64P44 062	4.50	6.50	2.07	1.86
	84P44 062	4.50	8.50	2.56	2.31
	169P44 062	4.50	17.00	5.04	4.53
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- 1 - 0
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- Return Key
- Optional Key (Period)
- — Key

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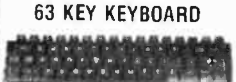
63 KEY KEYBOARD

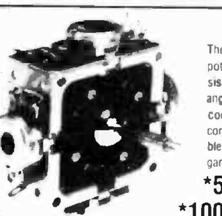


This keyboard features 63 unencoded SPST keys, unattached to any kind of P.C.B. A very solid molded plastic 13 x 4 base suits most applications.

$19.95

HD0165 16 LINE TO FOUR BIT PARALLEL KEYBOARD ENCODER $7.95

JOYSTICK



These Joysticks feature four* potentiometers, that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastics components only at the movable joint. Perfect for electronic games and instrumentation.

***5K Pots $6.95**
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8111	256 x 4	Static	6.95
8599	16 x 4	Static	3.49
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74200	256 x 1	Static	6.95
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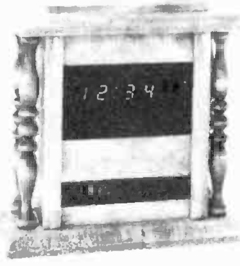

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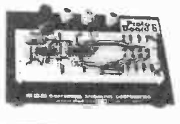

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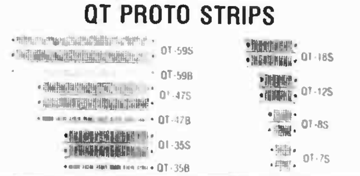

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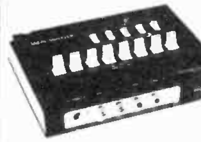

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BRIGHT YELLOW ORANGE .3" LED DISPLAY!

Kit includes case, bracket and all components — complete. Nothing else to buy! 12 Volt NEG GRD
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- SPECIFY BLACK OR IVORY

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Elapsed Timer: Hrs, Mins and Secs
12 or 24 Hr Capacity
Simple Reset - Start Pushbutton Control

Complete kit includes mounting bracket, case and all components, nothing else to buy. Features MM5314 chip. Large .4" LED's. Accuracy better than ± min. per mo. internal battery backup. 12 volt non-polar operation.

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12 or 24 Hour
115 VAC

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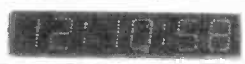

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4 DIGIT KIT $49.95	4 DIGIT ASSEMBLED $59.95
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This clock features big 3½" high digits for viewing in offices, auditoriums, etc. Each digit is formed by 31 bright 0.2" LED's. The clock operates from 117 VAC, has either 12 or 24 hr. operation. The 6 digit version is 27" x 3½" x 1½" and the 4 digit is 18" x 3½" x 1½". Kits come complete with all components, case and transformer.

Specify 12 or 24 Hour When Ordering

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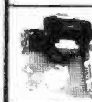
The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols: (HI) - 1 (LOW) - 0 (PULSE) - P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.

$9.95 Per Kit
printed circuit board



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SN7411N	.30	SN7483N	.70	SN74170N	2.10
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SN7437N	.27	SN74122N	.39	SN74191N	1.25
SN7438N	.27	SN74123N	.50	SN74192N	.89
SN7439N	.25	SN74125N	.60	SN74193N	.89
SN7440N	.15	SN74126N	.60	SN74194N	1.25
SN7441N	.89	SN74132N	1.09	SN74195N	.75
SN7442N	.59	SN74136N	.95	SN74196N	1.25
SN7443N	.75	SN74141N	1.15	SN74197N	.75
SN7444N	.75	SN74142N	4.00	SN74198N	1.75
SN7445N	.75	SN74143N	4.50	SN74199N	1.75
SN7446N	.81	SN74144N	4.50	SN74200N	5.59
SN7447N	.69	SN74145N	1.15	SN74279N	.90
SN7448N	.79	SN74147N	2.35	SN74251N	1.79
SN7450N	.26	SN74148N	2.00	SN74284N	6.00
SN7451N	.27	SN74150N	1.00	SN74285N	6.00
SN7453N	.27	SN74151N	.79	SN74367N	.75
SN7454N	.20	SN74153N	.89		

MANY OTHERS AVAILABLE ON REQUEST
20% Discount for 100 Combined 7400's

CMOS

CD4000	.25			74C04N	.75
CD4001	.25			74C10N	.65
CD4002	.25	CD4035	1.85	74C20N	.65
CD4006	2.50	CD4040	2.45	74C30N	.65
CD4007	.25	CD4042	1.90	74C42N	2.15
CD4009	.59	CD4044	1.50	74C73N	1.50
CD4010	.59	CD4046	2.51	74C74	1.15
CD4011	.25	CD4047	2.75	74C90N	3.00
CD4012	.25	CD4049	.79	74C95N	2.00
CD4013	.47	CD4050	.79	74C107N	1.25
CD4016	.56	CD4051	2.95	74C151	2.90
CD4017	1.35	CD4053	2.95	74C154	3.00
CD4019	.55	CD4060	3.25	74C157	2.15
CD4020	1.49	CD4066	1.75	74C160	3.25
CD4022	1.25	CD4069	.45	74C161	3.25
CD4023	.25	CD4071	.45	74C163	3.00
CD4024	1.50	CD4081	.45	74C164	3.25
CD4025	.25	CD4511	2.50	74C173	2.60
CD4027	.69	CD4518	2.50	74C193	2.75
CD4028	1.65	MC14566	3.00	74C195	2.75
CD4029	2.90	74C00N	.39	MC4044	4.50
CD4030	.65	74C02N	.55	MC14016	.56

LINEAR

LM300H	.80			LM1351N	1.65
LM301H	.35			LM1414N	1.75
LM301CN	.35			LM1458C	.65
LM302H	.75	LM370N	1.15	LM1496N	.95
LM304H	1.00	LM373N	3.25	LM1556V	1.85
LM305H	.95	LM377N	4.00	LM2111N	1.95
LM307CN	.35	LM380N	1.39	LM2901N	2.95
LM308H	1.00	LM380CN	1.05	LM3065N	.69
LM308CN	1.00	LM381N	1.79	LM3900N	.55
LM309H	1.10	LM382N	1.79	LM3905N	.60
LM309K	.99	NE501K	8.00	LM3909	1.25
LM310CN	1.15	NE510A	6.00	LM5556N	1.85
LM311H	.90	NE531H	3.00	MC5558V	1.00
LM311N	.90	NE536T	6.00	LM7525N	.90
LM318CN	1.50	NE540L	6.00	LM7535N	1.25
LM319N	1.30	NE550N	1.30	8038B	4.95
LM320K-5	1.35	NE555V	.39	LM75450	.49
LM320K-5.2	1.35	NE560B	5.00	75451CN	.39
LM320K-12	1.35	NE561B	5.00	75452CN	.39
LM320K-15	1.35	NE562B	5.00	75453CN	.39
LM320T-5	1.75	NE565H	1.25	75454CN	.39
LM320T-5.2	1.75	NE565N	1.25	75491CN	.79
LM320T-8	1.75	NE566CN	1.25	75492CN	.89
LM320T-12	1.75	NE567H	1.95	75494CN	.89
LM320T-15	1.75	NE567V	1.50	RCA LINEAR	
LM320T-18	1.75	LM703CN	.45	CA3013	2.15
LM320T-24	1.75	LM709H	.29	CA3023	2.56
LM323K-5	9.95	LM709N	.29	CA3035	2.48
LM324N	1.80	LM710N	.79	CA3039	1.35
LM339N	1.70	LM711N	.39	CA3046	1.30
LM340K-5	1.95	LM723H	.55	CA3059	3.25
LM340K-6	1.95	LM723N	.55	CA3060	3.25
LM340K-8	1.95	LM733N	1.00	CA3080	.85
LM340K-12	1.95	LM739N	1.00	CA3081	2.00
LM340K-15	1.95	LM741CH	.35	CA3082	2.00
LM340K-18	1.95	LM741CN	.35	CA3083	1.60
LM340K-24	1.95	LM741-14N	.39	CA3086	.85
LM340T-5	1.75	LM747H	.79	CA3089	3.75
LM340T-6	1.75	LM747N	.79	CA3091	10.20
LM340T-8	1.75	LM748H	.39	CA3102	2.95
LM340T-12	1.75	LM748N	.39	CA3123	2.15
LM340T-15	1.75	LM1303N	.90	CA3130	1.39
LM340T-18	1.75	LM1304N	1.19	CA3140	1.25
LM340T-24	1.75	LM1305N	1.40	CA3600	1.75
LM350N	1.00	LM1307N	.85	RC4194	5.95
LM351CN	.65	LM1310N	2.95	RC4195	3.25

74LS00 TTL

74LS00	.29			74LS139	1.95
74LS02	.29			74LS151	1.55
74LS03	.29	74LS74	.39	74LS153	1.89
74LS04	.35	74LS75	.69	74LS157	1.55
74LS05	.35	74LS76	.39	74LS162	2.25
74LS08	.29	74LS83	1.15	74LS163	2.25
74LS10	.29	74LS85	2.49	74LS164	1.95
74LS13	.69	74LS86	.39	74LS175	1.95
74LS14	1.25	74LS90	1.25	74LS181	3.69
74LS20	.29	74LS92	1.25	74LS190	2.85
74LS26	.39	74LS93	1.25	74LS191	2.85
74LS27	.39	74LS95	1.95	74LS192	2.85
74LS28	.39	74LS96	1.89	74LS193	2.85
74LS30	.29	74LS107	.59	74LS194	1.89
74LS32	.39	74LS109	.59	74LS195	1.89
74LS40	.39	74LS112	.59	74LS257	1.75
74LS51	.29	74LS132	1.25	74LS260	.55
74LS55	.29	74LS136	.59	74LS279	.79
74LS73	.49	74LS138	1.89	74LS670	2.95

CLOCK CHIPS

MM5309	6 Digit, BCD Outputs, Reset PIN	9.95
MM5311	6 Digit, BCD Outputs, 12 or 24 Hour	4.95
MM5312	4 Digit, BCD Outputs, 1 PPS Output	4.95
MM5314	6 Digit, 12 or 24 Hour, 50 or 60 Hz	4.95
MM5316	4 Digit, Alarm, 1 PPS Output	6.95
MM5318	Video Clock Chip For Use With (MM5841 - $9.95)	9.95
CT7001	6 Digit, Calendar, Alarm, 12 or 24 Hour	5.95

DATA HANDBOOKS

7400	Pin-out & Description of 5400/7400 ICS	$2.95
CMOS	Pin-out & Description of 4000 Series ICS	$2.95
Linear	Pin-out & Functional Description	$2.95

ALL THREE HANDBOOKS $6.95

There is only *one*

James ELECTRONICS

They can try and copy our ad,
BUT
They can't copy our service!

DISCRETE LEDS

.125" dia.			.190" dia.		
XC209	Red	10/$1	XC111	Red	10/$1
XC209	Green	4/$1	XC111	Green	4/$1
XC209	Orange	4/$1	XC111	Yellow	4/$1
XC209	Yellow	4/$1	XC111	Orange	4/$1

.200" dia.			.185" dia.			.200" dia.			.085" dia.	
XC22	Red	10/$1	XC526	Red	10/$1	XC556	Red	10/$1	MV50 - Red	6/$1
XC22	Green	4/$1	XC526	Green	4/$1	XC556	Green	4/$1		
XC22	Yellow	4/$1	XC526	Yellow	4/$1	XC556	Yellow	4/$1	INFRA RED LED	
XC22	Orange	4/$1	XC526	Orange	4/$1	XC556	Orange	4/$1		
SSL-22	RT	4/$1	XC526	Clear	4/$1	XC556	Clear	7/$1	Flat	5/$1.00

SPECIAL * — XC556 Red 100/$8.00 1000/$60.00 — SPECIAL *

DISPLAY LEDS

DL707 DL338

TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 1	Common Anode	270	2.95	MAN 3640	Common Cathode-orange	300	1.75
MAN 2	5 x 7 Dot Matrix	300	4.95	MAN 4710	Common Anode-Red	400	1.95
MAN 3	Common Cathode	125	3/1.00	DL701	Common Anode-red ±1	300	.99
MAN 4	Common Cathode	187	1.95	DL704	Common Cathode	300	.99
MAN 7	Common Anode	300	1.25	DL707	Common Anode	300	.99
MAN 7G	Common Anode-green	300	1.95	MAN 4740	Common Anode-Red	400	.99
MAN 7Y	Common Anode-yellow	300	1.95	DL741	Common Anode	600	1.50
MAN 52	Common Anode-green	300	.99	DL 747	Common Anode	600	2.25
MAN 64	Common Anode-red	400	.99	DL 750	Common Cathode	600	2.49
MAN 74	Common Cathode	300	1.50	DL 338	Common Cathode	110	.50
MAN 82	Common Anode-yellow	300	.99	FND70	Common Cathode	250	.75
MAN 84	Common Cathode-yellow	300	.99	FND503	Common Cathode	500	1.00
MAN 3620	Common Anode-orange	300	1.75	FND507	Common Anode	500	1.00

FACTORY REJECTS ATARI GAME BOARDS

BOARD A — 8½" x 16" — $6.95 ea.
Over 60 each reusable IC's
Misc. Transistors, Resistors,
Diodes, Caps, Crystals, Switch, etc
ONLY 500 EA AVAILABLE

DELUXE BOARD B — 11½" x 16" — $9.95 ea.
Over 100 each reusable IC's
Misc. Transistors, Resistors,
Diodes, Caps, Crystals, Switches, LEDS, etc
ONLY 500 EA AVAILABLE

NEW AY-3-8500-1 TV GAME CHIP

- Score display
- Selectable angles, speed and bat size
- Auto or manual ball service
- Realism sounds
- 6 Games — tennis, hockey, soccer, squash, pelota practice and two rifle games

28 Lead Dual In Line

The circuit is intended to be battery powered. Minimum number of external components required for complete system.

$24.95

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

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

SOLDERTAIL STANDARD (TIN)

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

SOLDERTAIL STANDARD (GOLD)

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$.30	.27	.24	24 pin	$.70	.63	.57
14 pin	.35	.32	.29	28 pin	1.10	1.00	.90
16 pin	.38	.35	.32	36 pin	1.75	1.40	1.26
18 pin	.52	.47	.43	40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

	1-24	25-49	50-100		1-24	25-49	50-100
10 pin	$.45	.41	.37	24 pin	$1.05	.95	.85
14 pin	.39	.38	.37	28 pin	1.40	1.25	1.10
16 pin	.43	.42	.41	36 pin	1.59	1.45	1.30
18 pin	.75	.68	.62	40 pin	1.75	1.55	1.40

Plastic Push Button Switch

- 18 AWG Solid Wire - 5" Long
- .50 (wide) X .60 (high) ⅜-27 Thread
- 8 AMP @ 14 Volt - 1 AMP @ 110 Volt

		1-9	10-Up
J-188-1	Push On-Push Off	.59	.49
J-188-2	Normally Open	.59	.49
J-188-3	Normally Closed	.59	.49

MINATURE TOGGLE SWITCH

JMT-221	DPDT	on/off/on	$1.95
JMT-223	DPDT	on/none/on	$1.75
JMT-121	SPDT	on/off/on	$1.50
JMT-123	SPDT	on/none/on	$1.25

CLIPLITE 8/$1.49

LED MOUNTING SYSTEM
use with XC556 LEDS
Specify Colors — Red - Green - Amber - Yellow

DIP SWITCHES

SPST Slide Action

#206-4 (8 pin dip) 4 switch unit $1.75 ea.
#206-7 (14 pin dip) 7 switch unit $1.95 ea.
#206-8 (16 pin dip) 8 switch unit $2.25 ea.

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

ASST. 1	5 ea.	10 OHM / 27 OHM	12 OHM / 33 OHM	15 OHM / 39 OHM	18 OHM / 47 OHM	22 OHM / 56 OHM	1/4 WATT 5%	50 PCS.
ASST. 2	5 ea.	68 OHM / 180 OHM	82 OHM / 220 OHM	100 OHM / 270 OHM	120 OHM / 330 OHM	150 OHM / 390 OHM	1/4 WATT 5%	50 PCS.
ASST. 3	5 ea.	470 OHM / 1.2K	560 OHM / 1.5K	680 OHM / 1.8K	820 OHM / 2.2K	1K / 2.7K	1/4 WATT 5%	50 PCS.
ASST. 4	5 ea.	3.3K / 8.2K	3.9K / 10K	4.7K / 12K	5.6K / 15K	6.8K / 18K	1/4 WATT 5%	50 PCS.
ASST. 5	5 ea.	22K / 56K	27K / 68K	33K / 82K	39K / 100K	47K / 120K	1/4 WATT 5%	50 PCS.
ASST. 6	5 ea.	150K / 390K	180K / 470K	220K / 560K	270K / 680K	330K / 820K	1/4 WATT 5%	50 PCS.
ASST. 7	5 ea.	1M / 2.7M	1.2M / 3.3M	1.5M / 3.9M	1.8M / 4.7M	2.2M / 5.6M	1/4 WATT 5%	50 PCS.

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$10.95 ea.**

$5.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax

Spec Sheets - 25¢ — Send 35¢ Stamp for 1977A Catalog
Dealer Discount Available — Request Pricing

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PHONE ORDERS WELCOME — (415) 592-8097
All Advertised Prices Good Thru May

WIRE WRAP CENTER

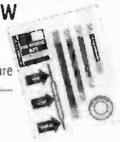
HOBBY-WRAP TOOL-BW-630

- Battery Operated (Size C)
- Weighs ONLY 11 Ounces
- Wraps 30 AWG Wire onto Standard DIP Sockets (.025 inch)
- Complete with built-in bit and sleeve

$34.95
(batteries not included)

WIRE-WRAP KIT — WK-2-W

WRAP • STRIP • UNWRAP



- Tool for 30 AWG Wire
- Roll of 50 Ft. White or Blue 30 AWG Wire
- 50 pcs. each 1", 2", 3" & 4" lengths — pre-stripped wire.

$11.95

WIRE WRAP TOOL WSU-30

WRAP • STRIP • UNWRAP - $5.95

WIRE WRAP WIRE — 30 AWG

25 ft. min. $1.25 50 ft. $1.95 100 ft. $2.95 1000 ft. $15.00
SPECIFY COLOR — White - Yellow - Red - Green - Blue - Black

CUTTER CRIMPER TOOL (CS-8)

- Plier Nose (serrated-jaw)
- Scissors Action Cutting
- 6 Bolt Cutters (4-40, 5-40, 6-32, 8-32, 10-32, 10-24)
- Crimp Stations (7mm Auto — 22-20 to 12-X0 elect.)
- "Up-Front" Wire Cutting
- Scissors Action Stripping (No. 22-20 to No. 10)
- Crimp Stations — insulated (2w-20 to 12-10 elect.)

Actual Size - 8¼" length **$8.50**

Permacel Electrical Tape

- ¾" (wide) X 66 ft. (long) • All weather • Not import

$1.25 per roll — $9.95 per 10 roll package

ZENERS — DIODES — RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3.3	400mm	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N751A	5.1	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N3600	50	200m	6/1.00
1N754	6.8	400m	4/1.00	1N4148	75	10m	15/1.00
1N959	8.2	400m	8/1.00	1N4154	35	10m	12/1.00
1N965B	15	400m	4/1.00	1N4305	75	25m	20/1.00
1N5232	5.6	500m	.28	1N4734	5.6	1w	.28
1N5234	6.2	500m	.28	1N4735	6.2	1w	.28
1N5235	6.8	500m	.28	1N4736	6.8	1w	.28
1N5236	7.5	500m	.28	1N4738	8.2	1w	.28
1N456	25	40m	6/1.00	1N4742	12	1w	.28
1N458	150	7m	6/1.00	1N4744	15	1w	.28
1N485A	180	10m	6/1.00	1N1183	50 PIV	35 AMP	1.60
1N4001	50 PIV	1 AMP	12/1.00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1.00	1N1185	150 PIV	35 AMP	1.50
1N4003	200 PIV	1 AMP	12/1.00	1N1186	200 PIV	35 AMP	1.80
1N4004	400 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR	$1.95
C38M	35A @ 200V	SCR	1.95
2N2328	1.6A @ 200V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC.	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC.	1.95

TRANSISTORS

MPS A05	5/$1.00			PN4249	4/$1.00
MPS A06	5/$1.00	PN3567	3/$1.00	PN4250	4/$1.00
2N2219A	3/$1.00	PN3568	4/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	PN3569	4/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	2N3704	5/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3705	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3706	5/$1.00	2N4409	5/$1.00
2N2484	4/$1.00	2N3707	5/$1.00	2N5086	4/$1.00
2N2906A	4/$1.00	2N3711	5/$1.00	2N5087	4/$1.00
2N2907A	5/$1.00	2N3724	$.65	2N5088	4/$1.00
2N2925	5/$1.00	2N3725	$1.00	2N5089	4/$1.00
2N3053	2/$1.00	2N3903	5/$1.00	2N5129	5/$1.00
2N3055	$.89	2N3904	4/$1.00	2N5138	5/$1.00
MJE3055	$1.00	2N3905	4/$1.00	2N5139	5/$1.00
MJE2955	$1.25	2N3906	4/$1.00	2N5209	5/$1.00
2N3392	5/$1.00	2N4013	3/$1.00	2N5951	5/$1.00
2N3398	5/$1.00	2N4014	3/$1.00	C106B1SCR	2/$1.00
		2N4123	10/$1.00	2N5432	$2.00

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

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

+20% DIPPED TANTALUMS (SOLID) CAPACITORS

.1/35V	.28	.23	.17	1.5/35V	.30	.26	.21
.15/35V	.28	.23	.17	2.2/25V	.31	.27	.22
.22/35V	.28	.23	.17	3.3/25V	.31	.27	.22
.33/35V	.28	.23	.17	4.7/25V	.32	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.36	.31	.25
.68/35V	.28	.23	.17	10/25V	.40	.35	.29
1.0/35V	.28	.23	.17	15/25V	.63	.50	.40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead				Radial Lead			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.15	.13	.10	1.0/16V	.15	.13	.10
4.7/25V	.16	.14	.12	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
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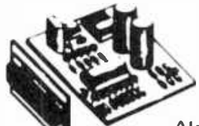

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74LS04	.29	74LS40	.28	74LS109	.39	74LS162	1.02	74LS258	.75
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74LS08	.29	74LS47	.79	74LS113	.39	74LS164	1.02	74LS283	.79
74LS09	.29	74LS48	.77	74LS114	.39	74LS168	1.14	74LS290	.65
74LS10	.28	74LS51	.28	74LS125	.49	74LS169	1.14	74LS293	.65
74LS11	.28	74LS54	.28	74LS126	.49	74LS170	1.73	74LS365	.67
74LS12	.28	75LS55	.28	74LS132	.81	74LS173	1.34	74LS366	.67
74LS13	.47	74LS73	.39	74LS136	.39	74LS174	1.06	74LS367	.67
74LS14	1.02	74LS74	.39	74LS138	.73	74LS175	.84	74LS368	.67
74LS15	.28	74LS75	.53	74LS139	.73	74LS190	1.18	74LS386	.39
74LS20	.28	74LS76	.39	74LS151	.75	74LS191	1.18	74LS670	2.34
74LS21	.28	74LS78	.39	74LS153	.75	74LS196	.86	71LS95	.77
74LS22	.28	74LS83	.79	74LS154	1.10	74LS197	.86	71LS96	.77
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7412	.21	7495	.70	74196	.88	4024	.84	LM340T-8	1.25
7413	.25	7496	.70	74197	.88	4025	.23	LM340T-12	1.25
7414	.89	74100	1.28	74198	1.49	4026	1.68	LM340T-15	1.25
7416	.25	74107	.30	74199	1.49	4027	.40	LM340T-18	1.25
7417	.25	74109	.33	74251	1.09	4028	.89	LM340T-24	1.25
7420	.21	74121	.35	74279	.55	4029	1.14	LM3900N	.88
7421	.25	74122	.44	74365	.67	4030	.23	LM3909N	.69
7423	.35	74123	.61	74366	.67	4033	1.51	MC1456V	1.00
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7426	.25	74126	.40	74368	.67	4035	1.14	MC3302P	1.15
7427	.33	74132	.70	8093	.40	4040	1.14	NE536T	3.24
7428	.28	74141	.88	8094	.40	4041	.79	NE540L	2.04
7430	.21	74145	.70	9095	.67	4042	.79	NE555V	.48
7432	.25	74147	1.63	8096	.67	4043	.70	NE556A	.88
7433	.30	74148	1.30	8097	.67	4044	.70	NE560B	3.83
7437	.25	74150	1.16	8098	.67	4046	1.86	NE561B	3.83
7438	.25	74151	.70	75150	1.16	4049	.40	NE562B	3.83
7440	.21	74153	.65	75450	.88	4050	.40	NE565A	1.25
7442	.53	74154	1.03	75451	.61	4051	1.26	NE566V	1.28
7443	.63	74155	.70	75452	.61	4052	1.26	NE567V	1.36
7445	.70	74156	.70	75453	.61	4053	1.26	uA709CV	.44
7446	.70	74157	.70	75454	.61	4060	1.58	uA710CA	.44
7447	.70	74160	.88	75491	.81	4066	.79	uA711CA	.53
7448	.70	74161	.88	75492	.84	4071	.23	uA723CA	.60
7450	.21	74162	.88	75493	1.09	4072	.23	uA733CA	.75
7451	.21	74163	.88	75494	1.19	4073	.23	uA741CV	.44
7453	.21	74164	.96	82525	2.19	4075	.23	uA747CA	.70
7454	.21	74165	1.15	4000	.23	4081	.23	uA748CV	.49
7459	.21	74166	1.26	4001	.23	4082	.23	uA7805CU	1.25
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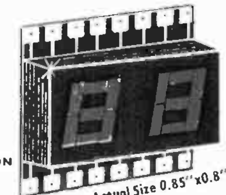

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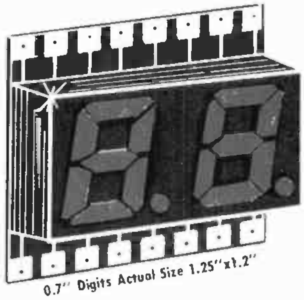
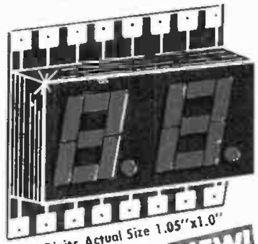


0.7" Digits Actual Size 1.25"x1.2"



0.5" Digits Actual Size 1.05"x1.0"

NEW!

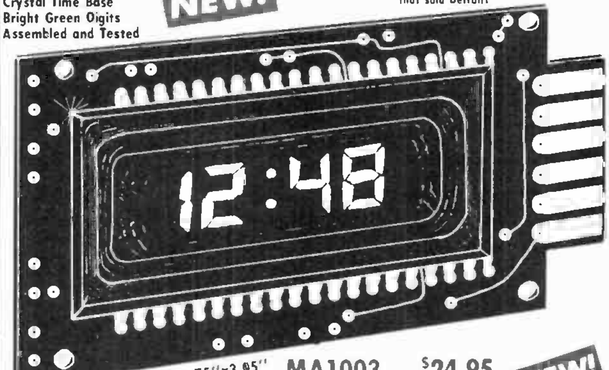
MA1003 CAR CLOCK

NEW — FOR CAR OR BOAT!

12 Hour Only
12 Volt DC
Crystal Time Base
Bright Green Digits
Assembled and Tested

NEW!

The MA1003 bright green flourescent display offers a brilliance that cannot be achieved by LED displays, a feature that sold Detroit!



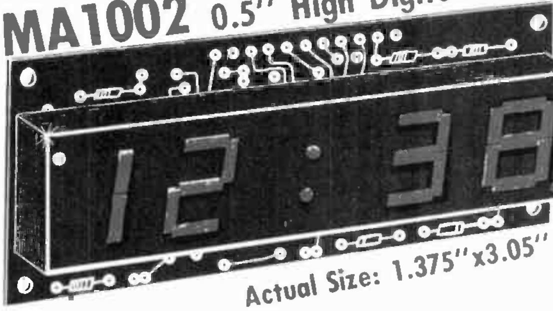
0.3" Digits Actual Size 1.75"x3.05"

MA1003 . . . . $24.95

Includes 3 Push Button Switches

NEW!

MA1002 0.5" High Digits



Actual Size: 1.375"x3.05"

MA1002A 12 Hour AM-PM $10.50
MA1002C 24 Hour $10.50
SPECIAL TRANSFORMER & SWITCHES $3.45

ABOUT OUR CLOCKS

The MA1002 and MA1010 series clock modules by National Semiconductor are fully assembled and tested clocks using a 4 digit LED display and an MOS integrated circuit on the same board. Simply connect switches and our special transformer and you have a fully functioning clock.

The MA1003 clock module is a fully assembled and tested 12 hour clock using a high brilliance green flourescent display and crystal time base making it perfect for car, boat or other portable use. It operates directly from 12 volts DC so no transformer is needed. Our price includes three push button switches for setting the time.

MA1002A	.5" LED 12 Hour AM-PM Clock Module	$10.50
MA1002A SET	Module with Transformer & Switches	$13.95
MA1002C	.5" LED 24 Hour Clock Module	$10.50
MA1002C SET	Module with Transformer & Switches	$13.95
MA1003	12 Volt Car Clock with Switches	$24.95
MA1010A	.84" LED 12 Hour AM-PM Clock Module	$13.00
MA1010A SET	Module with Transformer & Switches	$16.45
MA1010C	.84" LED 24 Hour Clock Module	$13.00
MA1010C SET	Module with Transformer & Switches	$16.45

Double Digit Discounts Save You Even More!

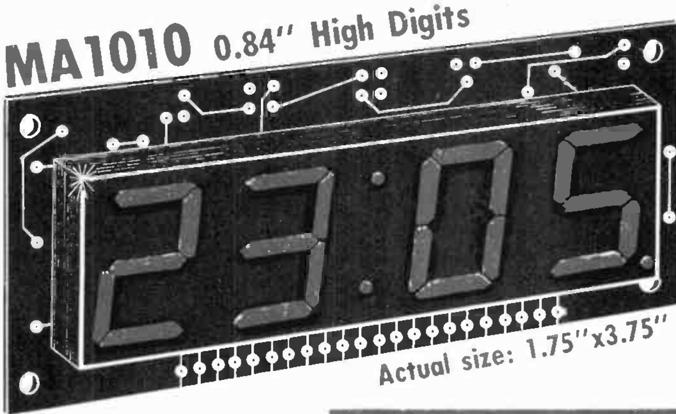
RADIAL ELECTROLYTICS

.47/50V . . .08	.65/10	22/50V . . . 12	1.00/10	330/25V . . 23	1.86/10
1/50V 08	.65/10	100/6.3V . .09	.75/10	470/10R . . 21	1.71/10
2.2/50V . . .08	.65/10	100/10V . . 10	.77/10	470/16V . . 23	1.81/10
3.3/50V . . .08	.65/10	100/16V . . 11	.85/10	470/25V . . 29	2.35/10
4.7/35V . . .08	.65/10	100/25V . . 13	1.10/10	1000/10V . 24	1.96/10
4.7/50V . . .08	.68/10	100/50V . . 21	1.71/10	1000/16V . 29	2.35/10
10/16V . . .08	.65/10	220/10V . . 13	1.08/10	1000/25V . 42	3.33/10
10/25V . . .08	.65/10	220/16V . . 15	1.16/10	2200/10V . 42	3.33/10
10/50V . . .10	.75/10	220/25V . . 21	1.71/10	2200/16V . 54	4.30/10
22/16V . . .08	.67/10	220/50V . . 29	2.35/10	2200/25V . 58	4.67/10
22/25V . . .09	.70/10	330/10V . . 15	1.16/10	3300/16V . 89	7.14/10
		330/16V . . 21	1.66/10		

AXIAL ELECTROLYTICS

.47/10V . . 11	.90/10	33/25V . . . 14	1.15/10	330/16V . . 29	2.35/10
1/30V . . . 11	.90/10	33/50V . . . 19	1.52/10	330/25V . . 32	2.54/10
3.3/35V . . 12	.95/10	47/16V . . . 14	1.15/10	470/16V . . 32	2.55/10
3.3/50V . . 12	1.00/10	47/25V . . . 17	1.30/10	470/25V . . 37	3.00/10
4.7/25V . . 11	.90/10	47/50V . . . 21	1.17/10	1000/10V . 33	2.65/10
4.7/35V . . 12	.95/10	100/10V . . 14	1.13/10	1000/16V . 39	3.15/10
4.7/50V . . 12	1.00/10	100/16V . . 17	1.30/10	1000/25V . 56	4.50/10
10/25V . . . 12	1.00/10	100/25V . . 20	1.55/10	2200/10V . 50	3.96/10
10/50V . . . 14	1.15/10	100/50V . . 29	2.30/10	2200/16V . 62	4.95/10
22/16V . . . 12	1.00/10	220/10V . . 18	1.42/10	2200/25V . 79	6.36/10
22/25V . . . 13	1.05/10	220/16V . . 20	1.55/10	3300/16V . 95	7.63/10
22/50V . . . 17	1.32/10	220/25V . . 29	2.35/10	4700/16V 1.09	8.70/10
33/16V . . . 12	1.00/10	220/50V . . 40	3.23/10	10000/10V 1.15	9.19/10
		330/10V . . 14	1.16/10		

MA1010 0.84" High Digits



Actual size: 1.75"x3.75"

MA1010A 12 Hour AM-PM $13.00
MA1010C 24 Hour $13.00
SPECIAL TRANSFORMER & SWITCHES $3.45

SEND FOR OUR FREE CATALOG

WE STOCK A WIDE VARIETY OF PARTS NOT IN THIS AD PLUS MANY SPECIALLY PRICED BARGAINS!

DATA BOOKS

TTL IC's 595 p.	$4.00
Linear IC's 957 p	$5.00
CMOS 74C 256 p	$3.00
Memory IC's 592 p	$3.00
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Volt. Regs. 128 p.	$3.00
Linear Appl. 1 432 p.	$4.00
Linear Appl. 2 246 p.	$3.00
Audio 196 p	$3.00
MOS/LSI IC's 713 p	$4.00
CMOS 4000 278 p	$3.25
Analog Manual 637 p	$5.95

SLIDE SWITCHES

SPST	.15	1.20/10	10.00/C
SPDT	.19	1.70/10	13.00/C
DPDT	.23	2.00/10	19.00/C

STRANDED HOOK UP WIRE

20 ga PVC	2.50/100'	10.00/500'
22 ga PVC	2.80/100'	11.25/500'
24 ga PVC	2.10/100'	8.50/500'
26 ga PVC	2.10/100'	8.50/500'

50 VOLT DISCS

100 pf	.40/10	3.50/C
220 pf	.40/10	3.50/C
470 pf	.40/10	3.50/C
.001 uf	.40/10	3.50/C
.0022 uf	.40/10	3.50/C
.0047 uf	.40/10	3.50/C
.01 uf	.45/10	3.65/C
.022 uf	.50/10	4.00/C
.047 uf	.70/10	5.60/C
.1 uf	1.35/10	11.50/C

WIRE-WRAPPING TOOL

$5.95

Wraps, Unwraps & Strips 30 ga. Wire

I.C. SOCKETS

8 Pin Solder	.17	1.60/10
14 Pin Solder	.20	1.90/10
16 Pin Solder	.22	2.10/10
18 Pin Solder	.29	2.75/10
24 Pin Solder	.38	3.60/10
28 Pin Solder	.45	4.25/10
40 Pin Solder	.63	6.00/10
8 Pin W-W	.24	2.30/10
14 Pin W-W	.26	2.50/10
16 Pin W-W	.30	2.85/10
18 Pin W-W	.60	5.70/10
24 Pin W-W	.96	9.10/10
28 Pin W-W	1.12	10.00/10
40 Pin W-W	.92	8.75/10

¼ & ½ WATT 5% CARBON FILM RESISTORS

5c each in multiples of 5 per value
$1.70/100 & $12.00/1000 of same value

1 ohm thru 1.0 megohm

HARDWARE

2-56 1/4 Screw	.99/C	7.20/M
2-56 1/2 Screw	.99/C	7.65/M
4-40 1/4 Screw	.55/C	3.60/M
4-40 1/2 Screw	.60/C	4.05/M
6-32 1/4 Screw	.65/C	4.40/M
6-32 1/2 Screw	.75/C	4.85/M
8-32 3/8 Screw	.90/C	5.85/M
8-32 5/8 Screw	.99/C	7.00/M
2-56 Hex Nut	.55/C	3.60/M
4-40 Hex Nut	.55/C	3.75/M
6-32 Hex Nut	.60/C	4.00/M
8-32 Hex Nut	.60/C	4.15/M
No. 2 Lockwasher	.85/C	5.75/M
No. 4 Lockwasher	.45/C	3.00/M
No. 6 Lockwasher	.45/C	3.00/M
No. 8 Lockwasher	.45/C	3.00/M

DOUBLE-DIGIT DISCOUNT SCHEDULE

Merchandise	Discount	Merchandise	Discount
$ 0.00-$24.99	NET	$100.00-$499.99	Less 15%
		$500.00-$999.99	Less 20%
$25.99-$99.99	Less 10%	$1000.00 & Up	Less 25%

Then Add the Standard Charge Below

STANDARD SHIPPING/HANDLING CHARGE

If your merchandise total after discount is between

$ 0.00-$ 4.99	add $2.00	$ 50.00-$99.99	add $0.25
$ 5.00-$24.99	add $0.75	$100.00 & up	No Charge
$25.00-$49.99	add $0.50		

Includes shipping and insurance to USA & Canada

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DIGI-KEY CORPORATION

Box 677, Thief River Falls, MN 56701 218-681-6674

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GOVERNMENT SURPLUS. Buy in your Area. How, where. Send $2.00. Surplus, 30177-PE Headquarters Building, Washington, D.C. 20014.

JEEPS, TRUCKS, Typically from $52.40...Automobiles, Boats, Motorcycles, Airplanes, Oscilloscopes, Tools, Clothing, Sports, Camping, Photographic, Electronics Equipment ... 200,000 Bid Bargains Nationwide Direct from Government ... Low as 2 cents on Dollar! Surplus Catalog and Sales Directory $1.00 (refundable). National Surplus Center, 240 Eastcass-PEL, Joliet, Illinois 60432.

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7401	21	7448	1 15	74122	49
7402	21	7450	26	74123	1 05
7404	21	7451	27	74125	60
7405	24	7453	27	74126	81
7406	45	7454	41	74132	3 00
7407	45	7460	22	74141	1 15
7408	25	7472	39	74150	1 10
7409	25	7473	45	74151	1 25
7410	20	7474	45	74153	1 35
7411	30	7475	80	74154	1 25
7413	85	7482	1 75	74155	1 21
7416	43	7483	1 15	74157	1 30
7417	43	7485	1 12	74161	1 45
7420	21	7486	45	74164	1 65
7422	1 50	7489	2 49	74165	1 65
7425	43	7490	69	74166	1 70
7427	37	7491	1 20	74174	1 95
7428	33	7492	82	74175	1 95
7430	26	7493	82	74180	1 05
7432	31	7494	91	74181	3 55
7437	47	7495	91	74191	1 50
7438	40	7496	91	74195	1 00
7440	21	74100	1 25	74197	1 00
7441	1 10	74107	49	74298	1 30

74L SERIES TTL

74L00	33	74LS04	45	74LS113	98
74L10	33	74LS10	39	74LS138	1 89
74L30	33	74LS20	39	74LS174	2 50
74L42	1 50	74LS51	39	74LS386	5 50
74L86	69	74LS74	65	74S153	2 25
74LS00	39	74LS112	65	74S387	1 95

74H00 TTL

74H00	33	74H11	33	74H53	39
74H01	33	74H20	33	74H55	39
74H04	33	74H21	33	74H73	59
74H05	35	74H30	33	74H74	59
74H10	33	74H40	33	74H76	60

5400 SERIES

5400	1 00	5475	1 50
5404	1 25	5486	1 90
5410	1 00	5493	2 00
5426	1 25	54100	1 80
5473	1 50	54LS04	1 00

C MOS

4001AE	29	4022AE	1 20
4002AE	29	4023AE	29
4007AE	29	4024AE	1 50
4009AE	58	4025AE	35
4010AE	58	4026AE	1 49
4011AE	29	4028AE	1 60
4012AE	29	4029AE	2 90
4013AE	52	4030AE	65
4015AE	1 25	4037AE	4 50
4016AE	65	4040AE	2 40
4018AE	1 10	4044AE	1 50
4019AE	65	4047AE	2 75
4020AE	1 75	4049AE	75
4021AE	1 50	4050AE	75

MOTOROLA CIRCUITS

		MC1741CG	98
MC725P	1 50	MC1804F	98
MC740L	1 55	MC1806P	98
MC790P	1 50	MC1810P	98
MC832P	48	MC2053L	45
MC1004L	1 25	MC3004L	1 32
MC1008L	1 25	MC3006P	1 44
MC1010L	1 25	MC3007P	1 32
MC1011L	1 25	MC3021L	2 15
MC1036L	12 50	MC3021P	2 15
MC1037L	12 50	MC3060L	2 65
MC1352P	1 05	MC3062L	3 00
MC1406CP	3 95	MC4024P	2 20
MC1468L	2 90	MC14501CP	31
MC1469R	2 50	MC14502CP	1 18
MC1510G	8 00	MC14507CP	82
MC1514L	4 50	MC14510CP	2 40
MC1550G	1 50	MC14511CP	2 76
MC1558	4 37	MC14512CP	1 92
MC1595L	6 25	MC14519CG	94
MC1596G	3 31	MC14528CP	1 74
MC1723CG	1 25	MC4044P	4 80

JAPANESE CIRCUITS

AN136	2 90	HA1312	4 05	STKO56	11.35	TA7201P	6 40
AN203	3 75	HA1322	5 20	STK415	11 50	TA7203P	7 00
AN208	4 75	HA1339	5 20	TA7045M	3 50	TA7204P	6 50
AN210	3 10	LA1201	4 25	TA7054P	3 05	TA7205P	6 50
AN211	3 30	LA1364	4 70	TA7055P	5 50	TA78005M	2 50
AN214	4 90	LA1366	6 00	TA7060P	1 85	TA78005P	1 95
AN217	3 30	LA1367	5 90	TA7061P	2 25	TA78012M	2.50
AN229	6 35	LA3301	4 85	TA7149P	4 00	TA78012P	1 95
AN234	5 75	LA4030	4 85	TA7063P	2 25	TA78015M	2 50
AN239	6 50	LA4031P	3 50	TA7074P	4 90	TA78015P	1 95
AN241	3 20	LA4051P	4 65	TA7075P	4 90	TC9100P	12 00
AN245	6 50	TBA8105	3 50	TA7076P	4 55	UPC16C	2 50
AN274	3 95	LD3080	4 00	TA7089P	2 90	UPC20C	5 00
AN277B	3 40	LD3120	3 10	TA7102	5 15	UPC41C	3 95
AN288	4 80	LD3141	2 40	TA7106P	3 25	UPC48C	3 95
AN328	4 05	M5112	5 40	TA7120P	2 20	UPC554C	3 90
AN343	3 90	M5115PR	4 80	TA7120P-C	2 20	UPC563H2	8 00
BA511	3 50	M5155	2 85	TA7122AP	2 30	UPC566H	2 25
BA521	3 95	SG613	5 40	TA7124P	1 85	UPC575C	4 10
HA1158	6 30	STK011	10 50	TA7146P	4 10	UPC1001H2	5 15
HA1159	6 60	STK015	6 50	TA7150P	4 55	UPC1020H	5 50
HA1202	3 10	STK025	12 50	TA7153P	6 90	UPC1025	5 50
HA1306W	5 20	STK032	14 20	TA7200P	6 25		

MISC CIRCUITS

BC184L	60	LM309K	1 95	SN15844N	55
CA3001	75	LM351AN	70	SN15946	55
CA3005	80	LM741CP	40	SN158097N	60
CA3006	1 10	LM1458M	.65	SN72560P	4.50
CA3018	1 60	MFC9020	1 15	SN727410N	85
CA3018A	1 60	MR995A	1 05	SN72741C	45
CA3026	2 15	MSC9967P	1 50	SN72748P	49
CA3035	2 45	N5558	55	UA703C	95
CA3039	1 35	N8598B	5 00	UA709C	40
CA3058	1 90	NE555V	45	USF7733393	2 40
CK707P	45	PA771131	45	995879	6 50
C5134J	1 15	PL994551	45	996079	12 50
C5135J	1 20	RC14370B	35	998979	9 00
C5136	1 25	SC9962P	70	936-5D	1 10
IC3(GE)	1 50	SC9966P	1 25	9313DC	1.20
LM301AN	35	SN15830N	50	93L28DC	2 75

POSITIVE VOLTAGE REGULATORS

LM340K-5	1 95
LM340K-6	1 95
LM340K-8	1 95
LM340K-12	1 95
LM340K-15	1 95
LM340K-18	1 95
LM340K-24	1 95
LM340T0-5	1 75
LM340T0-6	1 75
LM340T0-8	1 75
LM340T0-12	1 75
LM340T0-15	1 75
LM340T0-18	1 75
LM340T0-24	1 75

NEGATIVE REGULATORS AVAILABLE

IC's ON THE MOVE

BBD BUCKET BRIGADE DEVICE
MM3001 19 50 MN3002 11.70 MM3003 9 45
HALL IC DN834 1 25 DN837 1 50
DN835 1.35 DN838(NEW)
SN76001 1 75 SN76002 1.95
PLL02A MIDLAND PHASE LOCK LOOP 12 00

MICROPROCESSOR CHIPS

1404A	3 25	2102	2 50	MM5013	3 25
C1702A	19 95	C2708	95 00	8008	19 95
2101	6 95	C4702A	19 95	8080A	29 95

MK4200 P-11	4096x1 Bit Dymanic Ram	9 95
C5101-3	1024 Bit (256x4) Static C-Mos Ram	4 50
MC14514	4 Bit Latch 4 to 16 Line Decoder	4.25

CALL OR WRITE FOR FURTHER INFORMATION.
SPEC'S AVAILABLE

ELECTROLYTIC CAPACITORS

2 2MF50	AXIAL LEADS	15
3 3MF10	AXIAL LEADS	15
3 3MF10	NO POLARITY	15
10MF25	AXIAL LEADS	15
10MF50	AXIAL LEADS	15
10MF150	AXIAL LEADS	20
25MF35	AXIAL LEADS	15
30MF25	AXIAL LEADS	15
47MF25	RADIAL LEADS	15
47MF50	RADIAL LEADS	20
100MF16	RADIAL LEADS	15
100MF25	RADIAL LEADS	20
500MF50	AXIAL LEADS	60
1000MF35	AXIAL LEADS	65

CARBON RESISTORS

Minimum 5 Pc's Per Value

QUANTITY

PRICING	5-25	30-95	100-495
¼w5%	06	05	04
½w5%	08	07	06

STANDARD RESISTANCE VALUES
OHMS

10	270	820	4 7K	27K
22	300	910	5 1K	33K
47	330	1 0K	6 8K	47K
51	470	1 5K	7 5K	100K
100	510	2 2K	8 2K	330K
150	560	2 7K	10K	1 0M
220	680	3.3K	15K	
240	750	3 9K	22K	

HOBBY SPECIALS

YOU TEST 'EM $AVE BIG MONEY

Power Pac	100 Asst (includes Case T03, T066 T0220, T0202)	$2.99
Transistor/ Diode Pac	100 Asst (includes Case T05, T039, T018, D07, 0041)	$1 99
I C Pac	100 Asst (includes 14 & 16 Pin)	$3.50
Resistor Pac	50 Asst (Assorted values)	$1 50
Mos Fet Pac	10 Asst (many top #'s Case T072)	$0 99
SCR Pac	100 Asst (similar to C103 Series) Case to 92, VR 10-100V, I 400MA IGT 200MA	$4.00

ZENER DIODES
½ & 1 Watt 10% .30 each UP TO 33V.
GREATER THAN 33V CALL FOR PRICING

PACE/PATHCOM PART #'S

130079	4 00	IP20-0123	2 75
1300821	65	IP20-0131	2 50
13-0122	1 75	IP20-0141	3 00
83-0005	2 00	IP20-0142	3.00
83-0007	2 50	IP20-0139	.43
83-0008	2.00	IP20-0154	6.00
83-0015	3.00	IP20-0155	2.50
IP20-0005	3 00	IP20-0161	4 00
IP20-0016	40	IP20-0177	2.75
IP20-0034	85	IP20-0176	2 85
IP20-0037	85	IP20-0191	72
IP20-0045	2 00		
IP20-0073	2.75		
IP20-0093	2 50		

JAPANESE TRANSISTORS ★ CB, AUDIO, INDUSTRIAL

2SA52	60	2SC206	1 00	2SC774	1 75	2SC1173	95	2SD77	1 00
2SA316	75	2SC240	1 10	2SC775	2 75	2SC1175	65	2SD81	3 25
2SA473	75	2SC291	65	2SC776	3 00	2SC1209	55	2SD88	1 50
2SA483	1 95	2SC292	3 00	2SC777	4 00	2SC1213	75	2SD118	3 25
2SA489	80	2SC320	75	2SC778	4 00	2SC1226A	1 25	2SD130	1 25
2SA490	70	2SC352	75	2SC781	3.00	2SC1237	4 50	2SD141	2 25
2SA505	70	2SC353	75	2SC783	1 00	2SC1239	4.00	2SD151	2 25
2SA564	50	2SC371	70	2SC784	70	2SC1243	1 50	2SD170	2 00
2SA628	65	2SC372	70	2SC785	1 00	2SC1293	85	2SD180	2 75
2SA643	85	2SC394	70	2SC789	1 00	2SC1306	4 75	2SD201	1 95
2SA647	2 75	2SC458	70	2SC793	2 50	2SC1307	5 75	2SD218	4 75
2SA673	85	2SC460	70	2SC796	3 15	2SC1308	4 75	2SD235	1 00
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2SA682	85	2SC481	1 85	2SC798	3 10	2SC1318	70	2SD313	1 10
2SA699	1 30	2SC482	1 75	2SC799	4 25	2SC1325	4 95	2SD315	.75
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2SB56	70	2SC536	65	2SC839	85	2SC1384	85	2SD380	5 70
2SB77	.70	2SC537	70	2SC922	55	2SC1409	1 25	2SD389	75
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2N398B	1 50	2N1304	1 25	2N2325	2.00	2N3250	50	2N3904	.16	2N5133	.15
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2N711	.90	2N1613	.30	2N2904	.25	2N3565	.20	2N4124	.16	2N5458	.30
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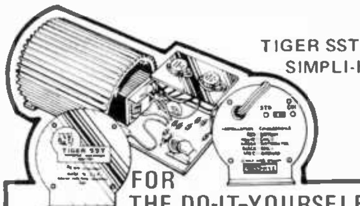

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CD4019	.39	CD4069	.30
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CD4022	.90	CD4076	.99
CD4024	.70	CD4077	.39
CD4025	.19	CD4102	.68
CD4027	.39	CD4116	.39
CD4028	.75	CD4507	.40
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74LS11	.32	74LS155	.90
74LS20	.31	74LS157	1.00
74LS21	.33	74LS162	1.39
74LS22	.33	74LS163	1.39
74LS27	.30	74LS175	1.09
74LS30	.31	74LS193	1.09
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3.3K	ohm	1/4W	47K	ohm	1/4W
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12	120	1.2K	12K	120K	1.2M
13	130	1.3K	13K	130K	1.3M
15	150	1.5K	15K	150K	1.5M
16	160	1.6K	16K	160K	1.6M
18	180	1.8K	18K	180K	1.8M
20	200	2.0K	20K	200K	2.0M
22	220	2.2K	22K	220K	2.2M
24	240	2.4K	24K	240K	2.4M
27	270	2.7K	27K	270K	2.7M
30	300	3.0K	30K	300K	3.0M
33	330	3.3K	33K	330K	3.3M
36	360	3.6K	36K	360K	3.6M
39	390	3.9K	39K	390K	3.9M
43	430	4.3K	43K	430K	4.3M
47	470	4.7K	47K	470K	4.7M
51	510	5.1K	51K	510K	5.1M
56	560	5.6K	56K	560K	5.6M
62	620	6.2K	62K	620K	6.2M
68	680	6.8K	68K	680K	6.8M
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.15	35	.33	6.8	35	.45
.22	35	.33	10.0	16	.42
.33	35	.33	10.0	25	.45
.47	35	.33	10.0	35	.90
.68	35	.33	15.0	20	.45
1.0	35	.33	15.0	35	1.32
1.5	35	.40	22.0	16	.45
2.2	20	.33	33.0	20	1.32
2.2	35	.40	47.0	20	1.53
3.3	35	.42	68.0	16	1.62
4.7	35	.45			

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.0012	1000	.14	.047	250	.15
.0015	1000	.14	.056	250	.15
.0018	1000	.14	.068	250	.15
.0022	1000	.14	.082	250	.17
.0027	1000	.14	.1	100	.17
.0033	1000	.14	.12	100	.18
.0039	630	.14	.15	100	.20
.0047	630	.14	.18	100	.21
.0056	630	.14	.22	100	.23
.0068	630	.14	.27	100	.26
.0082	630	.14	.33	100	.30
.01	630	.14	.39	100	.33
.012	630	.14	.47	100	.36
.015	400	.15	.56	100	.44
.018	400	.15	.68	100	.47
.022	400	.15	.82	100	.54
.027	400	.15	1.0	100	.60
.033	250	.15			

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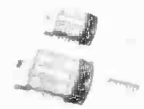

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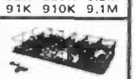

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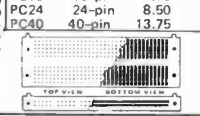

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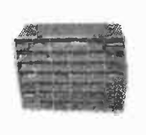

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18 Pin	.28	.27	.26
20 Pin	.34	.33	.32
22 Pin	.36	.35	.34
24 Pin	.37	.36	.35
28 Pin	.44	.43	.42
36 Pin	.59	.58	.57
40 Pin	.62	.61	.60

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8 Pin	.25	.23	22
14 Pin	.27	.25	.24
16 Pin	.30	.27	.25
18 Pin	.35	.32	.30
22 Pin	.70	.65	.60
24 Pin	.49	.45	42
28 Pin	.99	.90	.81
36 Pin	1.39	1.26	1.15
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14 Pin	.35	.32	.29
16 Pin	.38	.35	.32
18 Pin	.52	.47	.43
22 Pin	.70	.63	.57
24 Pin	.70	.63	.57
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36 Pin	1.75	1.40	1.26
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18 Pin	.75	.68	.62
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SN74LS125N	.75	SN74LS375AN	.75
SN74LS126N	.75	SN74LS386AN	.59
SN74LS132N	1.19	SN74LS395AN	1.95
SN74LS136N	.50	SN74LS670AN	2.75

CMOS

CD4000BE	.09	CD4035BE	.99	CD4507BE	.52
CD4001BE	.18	CD4040BE	.99	CD4510BE	1.05
CD4002BE	.13	CD4041BE	.67	CD4511BE	1.25
CD4006BE	.99	CD4042BE	.63	CD4512BE	1.15
CD4007BE	.17	CD4043BE	.45	CD4514BE	2.50
CD4008BE	.80	CD4044BE	.45	CD4515BE	2.50
CD4009BE	.37	CD4046BE	2.45	CD4516BE	1.10
CD4010BE	.37	CD4047BE	2.45	CD4518BE	.90
CD4011BE	.18	CD4049BE	.37	CD4519BE	.79
CD4012BE	.17	CD4050BE	.37	CD4520BE	.79
CD4013BE	.37	CD4051BE	1.15	CD4522BE	1.98
CD4014BE	.89	CD4052BE	1.15	CD4526BE	1.50
CD4015BE	.89	CD4053BE	1.19	CD4527BE	1.50
CD4016BE	.37	CD4055BE	1.29	CD4528BE	1.20
CD4017BE	.94	CD4060BE	1.40	CD4531BE	1.25
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CD4019BE	.42	CD4068BE	.24	CD4555BE	.75
CD4020BE	1.04	CD4069BE	.24	CD4556BE	.75
CD4021BE	.99	CD4070BE	.24	CD4585BE	1.80
CD4022BE	.89	CD4071BE	.24	74C85/40085PC	1.20
CD4023BE	.18	CD4072BE	.29	74C160/40160PC	1.50
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CD4025BE	.17	CD4075BE	.29	74C162/40162PC	1.50
CD4026BE	1.39	CD4076BE	1.05	74C163/40163PC	1.50
CD4027BE	.39	CD4078BE	.24	74C174/40174PC	1.40
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CD4034BE	2.95	CD4502BE	1.15		

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C1702A	(1.5 Microsecond) 256 x 8 EPROM	5.95
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3347PC	Quad 80 Bit Static Shift Register	4.50
3341APC	4 x 64 MOS FIFO 1 MHz Shift Register	4.50
TMS0117NC	Decimal Arithmetic Processor	10.00
LCM1001	Microprocessor Learning Module	149.95
TMS4024NC	64 x 9 FIFO	8.95
TMS4050NL	4K Dynamic RAM Plastic 300NS (18 Pin)	6.95
TMS4060NL	4K Dynamic RAM Plastic 300NS (22 Pin)	6.95
AY5-1013P	8 Bit UART	6.95
SEMI 4804A	4K STATIC RAM 1024 x 4 (450 NS) single 5V supply	14.95
93415PC	1K RAM 40 NS Open Collector	11.00
93425PC	1K RAM 40 NS Tri-State	11.00
AM2901DC	4 Bit Bi-Polar Microprocessor slice	31.50
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AM2905PC	Quad 2 Input Bus Transceiver	8.10
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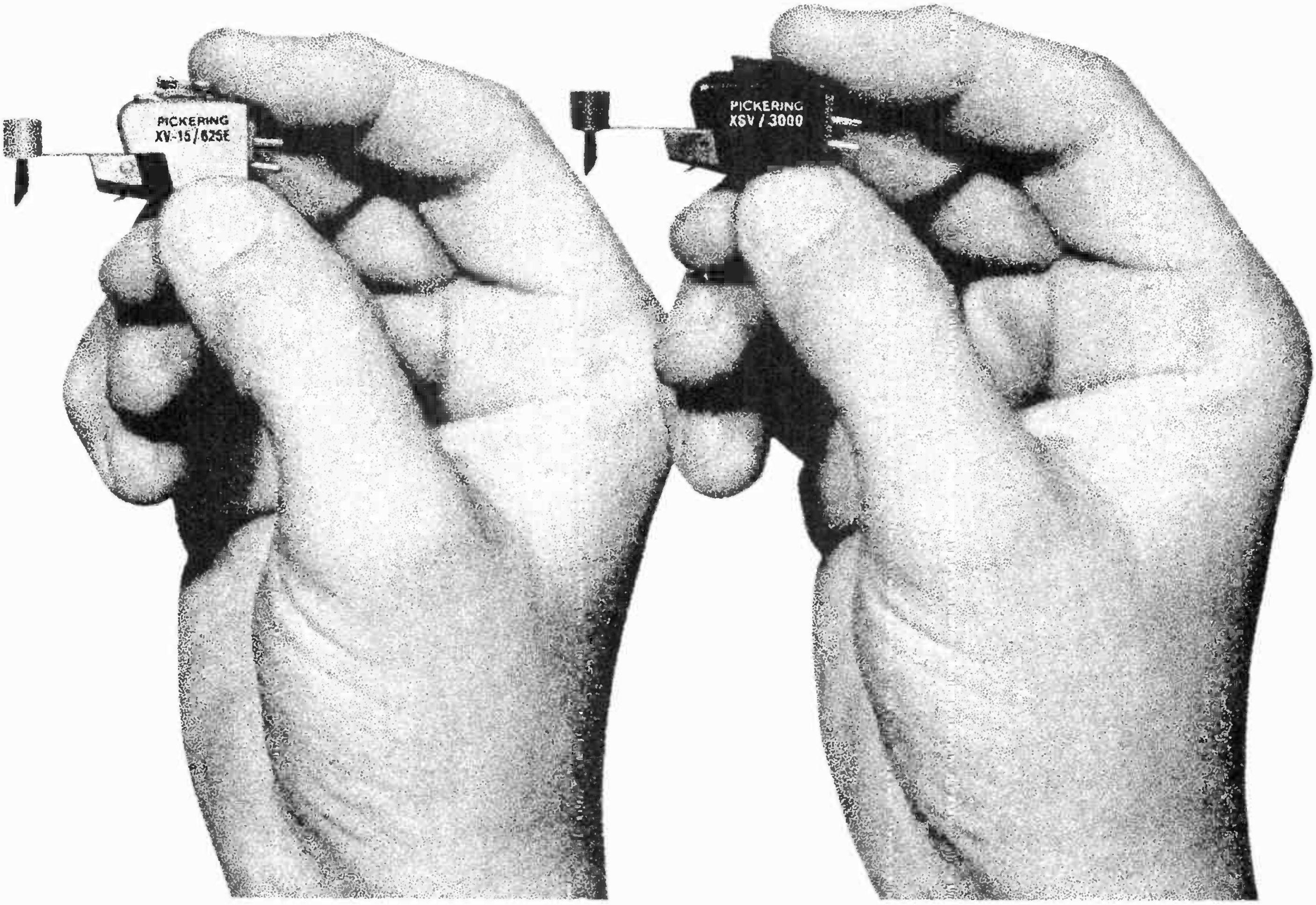

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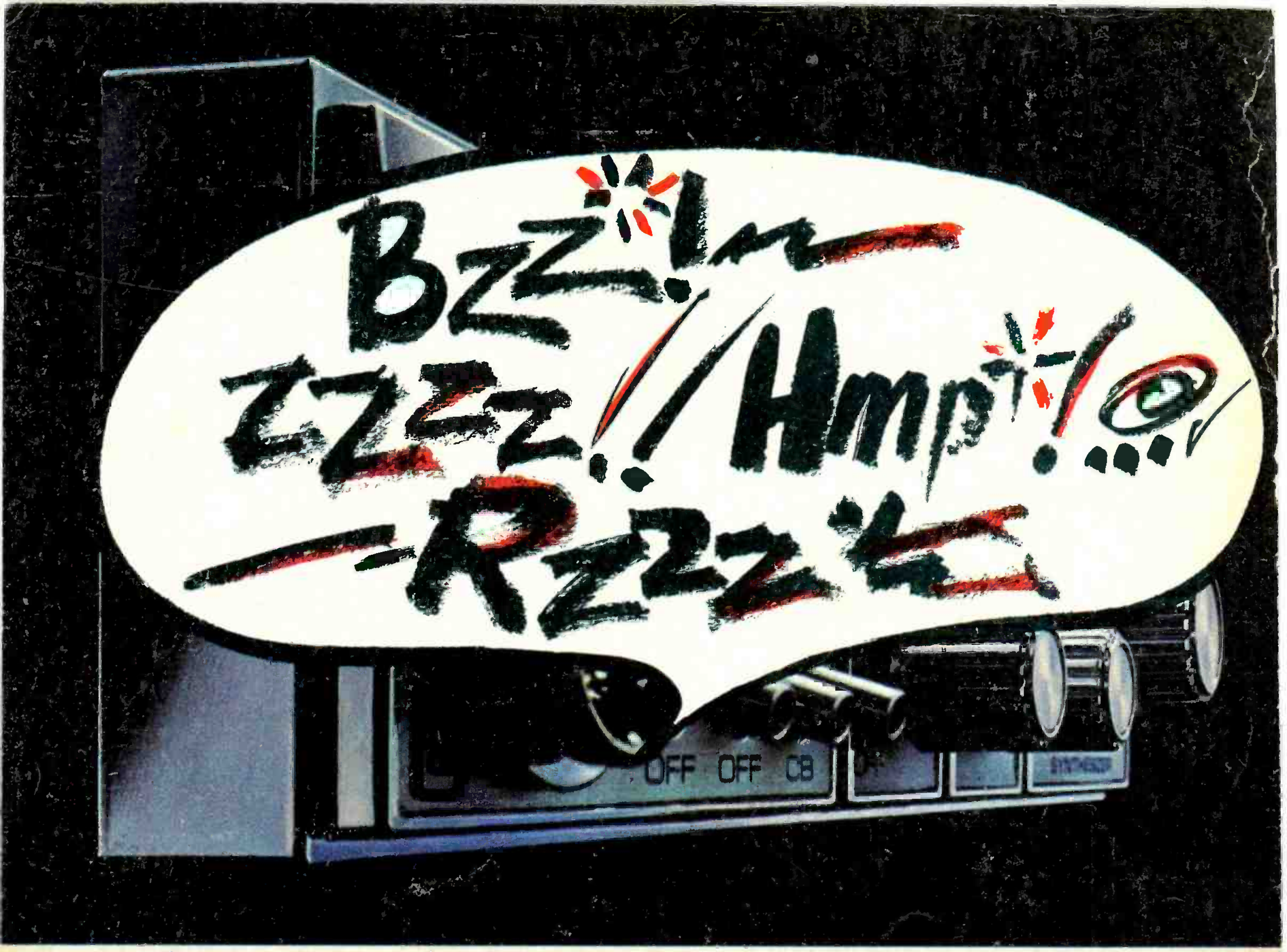

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