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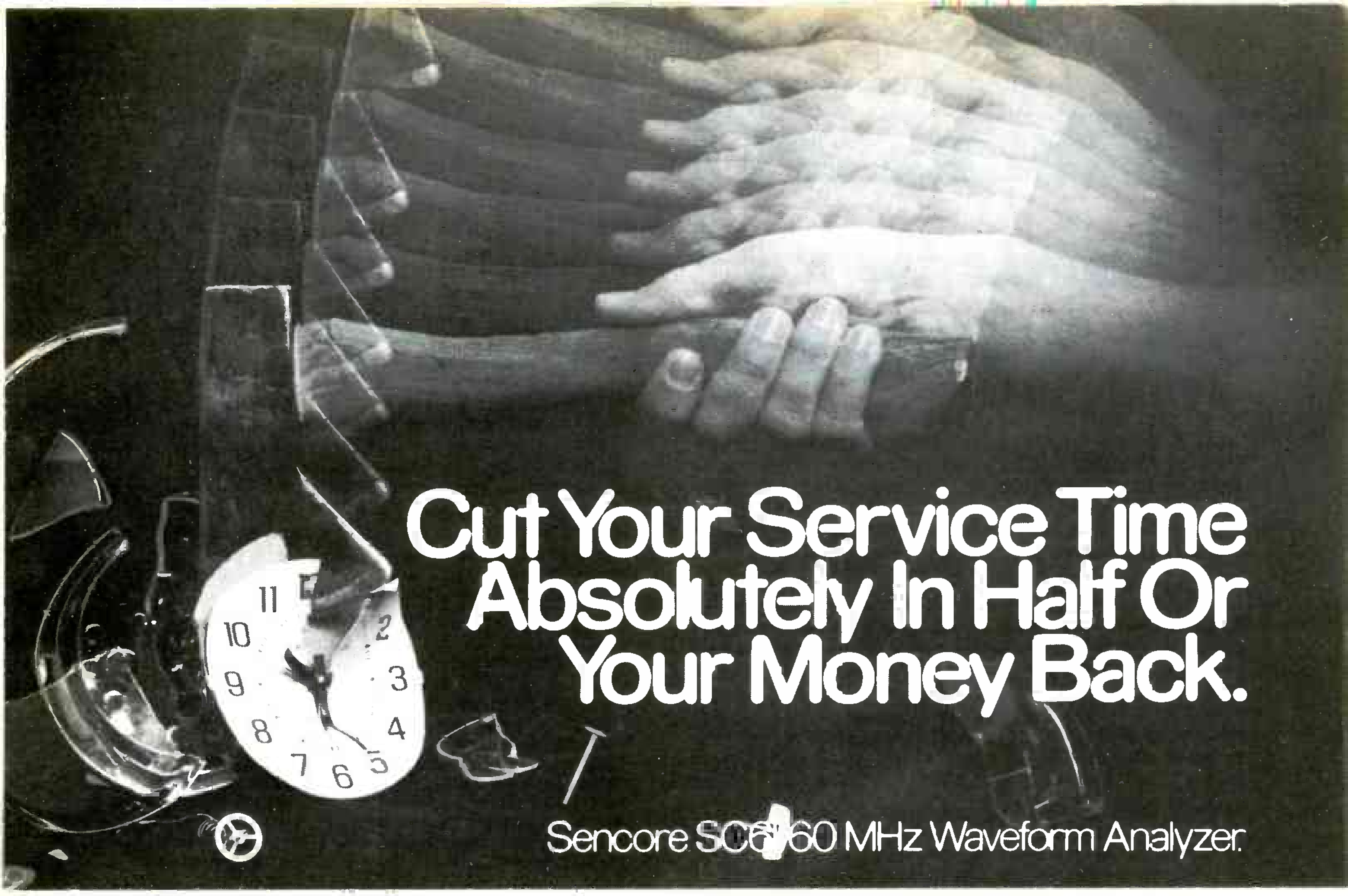


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# Radio-Electronics

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

Electronics publishers since 1908

MARCH 1983 Vol. 54 No. 3



## ON THE COVER

Portable shortwave-receivers with features like microprocessor-controlled PLL tuning and digital readouts, and pocket-sized shortwave receivers with "big"-radio performance, were once just dreams. Both types are now realities, as you'll see in our story on pocket-sized and portable shortwave receivers. The article begins on page 49.

**IF YOU'RE LOOKING for a DVM for your workbench, one of those described here may be for you. Thanks to the use of LSI IC's, the circuits are small and inexpensive to build. The story begins on page 59.**

**EVEN THOUGH MODERN RADIOS are sleek, and are great performers, there's something about the old ones that makes most of us feel nostalgic. Find out how you can restore an old radio's original sound and appearance starting on page 56.**

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# VIDEO ELECTRONICS

**DAVID LACHENBRUCH**
CONTRIBUTING EDITOR

## HIGH RESOLUTION

How do you get 1,000-line resolution out of the 525-line television system? Digitally. Based on word leaking from the labs, the TV set industry here, in Europe, and in Japan is working toward doubling the number of lines a television receiver will convey by means of digital "interpolation"—generating new lines based on the average of the lines above and below them—and eliminating interlace, which wouldn't be necessary in a 60-frame-per-second picture. ITT Semiconductors in Germany has developed an all-digital signal-processing system (see **Radio-Electronics,** September 1982) which could accomplish that purpose, according to its engineers. RCA's principal goal in digital-TV circuitry is the development of a compatible high-resolution system, said William Hittinger, executive VP for research and development, who adds: "We believe it will come in this decade."

In Japan, Hitachi has developed a digital converter to separate the received luminance and chrominance signals, and double the number of scanning lines without a change in transmitter standards; it says that development of a VLSI chip could bring the cost down to the consumer level. Sony also has a digital-scanning system, non-interlaced, which doubles the number of lines by using a 60-frame-per-second picture.

## CABLE COMPUTER

Later this year, your friendly neighborhood cable system may put a personal computer in your home for a few dollars a month, under a plan developed by Time Inc. and Matsushita Electric. Under the arrangement, Matsushita will develop and manufacture a combination teletext decoder and personal computer, to be distributed by cable systems carrying Time Video Information Services teletext transmissions. The decoder-computer would cost cable operators about $150-$200 and they'd rent it to subscribers as part of the $5-$10 monthly fee for teletext service. The same hardware, which probably will have 64K capacity, may also be available for sale through dealers.

## BILINGUAL TV

While most video addicts look forward to multichannel TV sound to bring stereo audio to TV, the networks and some independent broadcasters see other—and perhaps more lucrative—possibilities in the standards now being worked out by an industry committee (see **Radio-Electronics,** January 1983 issue). They have their eye on "SAP"—which stands for "separate audio program," which will be a part of the new sound system, separate from the multiplexed stereo audio system. That separate channel, with a frequency response going out to 8 or 12 kHz (depending on which system is ultimately adopted) probably will get its first use in providing simultaneous dubbed Spanish sound on network shows in areas with large Spanish-speaking populations. Other suggested uses are descriptions of program action for the blind.

## SOUPED-UP PROJECTION

A high-output long-life light bulb may be the key to the future of home projection-TV. General Electric's Lamp Division is working to develop a light source that will free giant-screen home television from the cathode-ray tube. A high-priority effort at GE is the development of a super-bright high-resolution projection system for the home using the principles of its industrial Talaria system, which now sells for $40,000 and up. Unlike most TV projectors, which depend on three cathode-ray tubes to develop light, Talaria uses electron guns to distort the surface of a viscous oil layer. An external light source (xenon lamps are used in the present models) is diffracted by that modulated layer of oil through a lens system and onto the screen. GE officials are hoping to come up with the super-bright home version of Talaria in perhaps two or three years, possibly at a price between $2000 and $3000.

## TEENY TV's

Hot on the heels of Sony's flat-tube Watchman with the 2-inch picture will come a host of other pocket-sized monochrome TV sets. Sinclair's 3-inch flat-tube set is scheduled for sale this year, as are several sets using LCD's instead of picture tubes. Seiko's wrist TV (which has some of its electronics plus battery pack in a pocket box attached to the TV by cable), is now on sale in Japan at about $400. Casio will soon offer a 12-ounce LCD pocket TV at about $200. And by year's end, Sanyo expects to have LCD sets in 3- and 4-inch screen sizes. **R-E**

## New from Zenith!

# Two-way protection from high voltage surges for the appliances and electronics you sell or service!

A brief, high voltage surge – or spike – can occur in any electrical system and, at amplitudes lower than 600V, cause little or no damage.

But at greater amplitudes, a spike can do real damage. And the greater the high voltage surge – resulting from nearby lightning, for example – the greater the risk of harm, especially to solid-state devices.

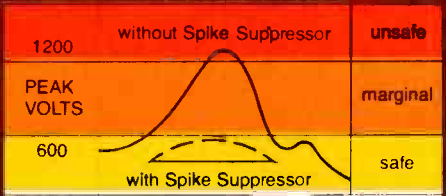
That's why Zenith now introduces the Spike Suppressor: to protect the susceptible TV receivers and household appliances you sell or service from damaging high voltage surges!

And the Zenith Spike Suppressor protects not one, but two ways.

First, the new Zenith Spike Suppressor absorbs most line voltage spikes so only a safe voltage level reaches the protected equipment.

Second, heavy or prolonged voltage surges cause the Zenith Spike Suppressor to cut off power completely for added protection and to signal the need for a replacement.

That's double-duty protection against spikes and reason enough for you to stock and sell the Zenith Spike Suppressor. Your bottom line's another. So call your Zenith distributor now!




In this graph, the solid curve represents the excess voltage or "spike" imposed on an electric system and, represented by the dotted line, the protection provided household appliances as the Zenith Spike Suppressor absorbs the excess voltage and prevents it from surging thru the system.

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# WHAT'S NEWS

## Two RCA satellites for direct broadcast

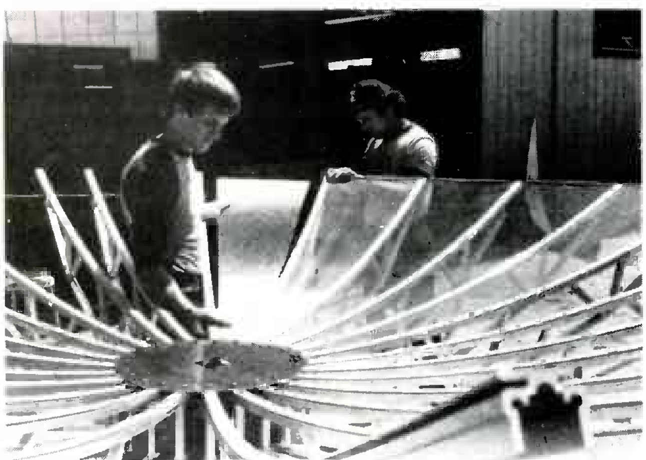
RCA Astro-Electronics has been awarded a contract in excess of $100 million to design and build two direct-broadcast satellites (DBS) for Satellite Television Corporation (STC), a wholly-owned subsidiary of COMSAT (Communications Satellite Corporation).

STC's initial DBS service will use two satellites to serve an area approximating the Eastern time zone of the United States. STC will offer three channels of pay television beamed directly from the satellites—which will be several times more powerful than conventional commercial satellites—to individual homes equipped with 2- to 2½-foot receiving antennas.

## New satellite antenna cuts installation time

An installation-time saving of up to 70 percent is offered by the new KLM 11-foot satellite receiving antenna. That includes installation of the new heavy-duty KLM Polar-Trak mount. The average setup time of the new antenna is 2½ hours, as against the 6 to 8 hours normally required for older antennas. The new antenna is made up of radial rib sections and individual slide-in mesh panels, thus not only reducing setup time but making it shippable in compact cartons via UPS.

The *KLM X-11* delivers 40.5 dB gain at 55 percent efficiency. It has a focal length of 69 inches and a focal-length/diameter ratio of 0.47. Weight is 125 pounds and the wind resistance is up to 100 miles per hour.



**SLOTTED RIBS AND SLIP-IN MESH SECTIONS cut the KLM X-11 installation time by 60 to 70 percent.**

## Advertising aims to educate readers

"A far greater amount of information that explains the expanding array of new electronic products," is the key to attracting the public to more high-class TV receivers and other video products, says Joseph Donahue of the RCA Consumer Products Division.

To that end, RCA is publishing a special magazine, *Living With Video,* as part of its current advertising campaign. It will "help bring the average TV viewer into the expanding video age where TV sets are also sophisticated monitors for use with other video accessories such as games, videodisc players, videocassette recorders, and home computers," says Donahue. *Living With Video* devotes special chapters to the major product categories with a combination of understandable technical information and a series of "Decorating with Video" articles.

## Dialog adds nine new retrieval databases

Dialog Information Services, which claims the world's largest on-line information-retrieval system, has added nine databases to the 150 already in place:

TELEGEN contains information about biology and genetic engineering in over 54,000 records.

BOOKS IN PRINT contains 650,000 records, listing the entire current U.S. book-publishing inventory.

LABORLAW has over 150,000 summaries of decisions on labor relations, fair employment, wages and hours, and occupational safety and health.

PAPERCHEM contains about 160,000 records, produced by the Institute of Paper Chemistry.

ELECTRONIC YELLOW PAGES—CONSTRUCTION DIRECTORY has more than 880,000 records covering all contractors and construction agencies.

WATERNET, the file of the American Waterworks Association, contains 5,000 records from 1971 to date.

BLS EMPLOYMENT, HOURS AND EARNINGS, with 23,000 records, provides numerical data from the U.S. Bureau of Labor Statistics.

CHEMSIS 82+, CA SEARCH, AND CHEMZERO are three databases that list almost 5 million chemical substances.

The price for searching the new databases ranges from $30 to $130 per connect hour—a full record printed off-line costs from 15 to 75 cents, with the majority available for 20 cents.

Literature is available from Dialog Information Services, 3460 Hillview Ave., Palo Alto, CA 94304.

## Computer now responds to anybody's voice

Software that enables a computer to respond to anyone's voice was exhibited in the Mini-Micro section of the recent WESCON convention in Anaheim, CA, by Votan, a leading supplier of computer speech-technology products. The system requires no user training. It recognizes the digits 0 through 9 and eight command words, including "yes" and "no."

Speaker-independent recognition provides a set of statistically sampled utterances of a particular word by a large and varied population base, thus eliminating any need for system training by the operator. Several thousand utterances are collected and analyzed to form a specific word from the population sample. Thus the computer will respond to almost anyone's pronunciation of the digit or command.

Speaker-independent word recognition eliminates time-consuming user training, and allows the untrained public to access data bases or to control equipment, even over telephone lines. Applications such as shopping by phone, voice mail, and banking all become possible simply by picking up the telepone and talking.

Votan believes that the new word-recognition product will be available in original equipment-manufacturers' quantities for less than $2,000.

## Sony starts division to develop business

To match its rapidly unfolding technological developments with potential markets, Sony has announced the establishment of a Business Development Division. According to Sony's president, Kenji Tamiya, the new division "will provide Sony with a complete structure for effectively converting our research and development investments into new business opportunities for the company."

Based at Sony's Operations Headquarters in Park Ridge, NJ, the division will work closely with Sony's research laboratories in Japan and the United States, as well as with selected outside companies. It will concentrate on CATV systems and terminals, receivers for direct satellite broadcasts, subscription TV, videotex, and teletext systems and terminals in the immediate future.

## H.S. grads unqualified for engineering studies

Seventy-five percent of today's high school graduates—no matter how good their grades—just lack the necessary math and science they need to enroll in college engineering courses, reports the Electronic Industries Association (EIA). The Human Resources Council of the EIA blames the situation on "a declining national commitment" to interest high

*continued on page 8*

# WHAT'S NEWS

*continued from page 6*

school students in math and science courses.

The report—available from EIA—gives information on technical education in the United States and its importance to high technology; the balance of supply and demand in various technical fields, and job opportunities in electronics.

The EIA hopes to reach local school systems—who are most important in making decisions about early science and math education—with the report, and is organizing a campaign to do so. "The problem is to be addressed," says EIA president Peter McCloskey, "at the local level with volunteer employees—at all levels—from our member companies."

Copies of the report may be obtained by contacting the EIA Human Resources Council, 2001 Eye St., N.W., Washington, DC 20006 (phone 202-457-4925).

## Self-converging tubes for projection TV

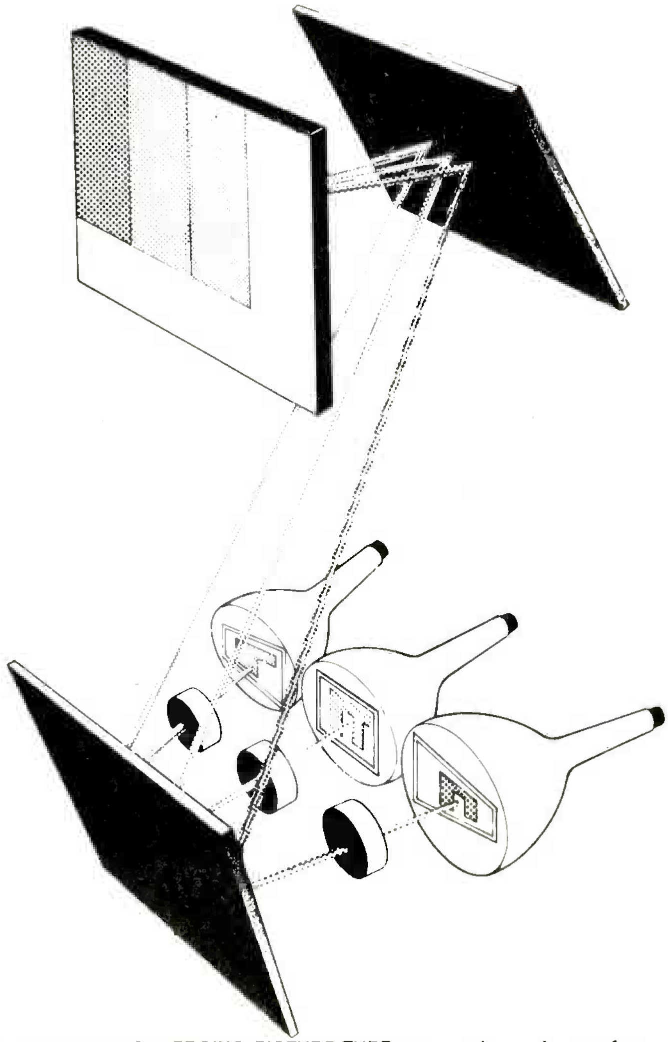
The problem of converging the three images of a color projection TV, formerly attempted with complex electronic circuitry and adjustable consumer controls is now solved, reports Zenith.

The patented solution is in the tubes themselves. In a conventional projection color-TV set, three tubes—red, green, and blue—are mounted side-by-side. Only the middle (green) tube can be aimed squarely at the screen. The others are tilted slightly inward. That distorts their images on the screen, and the picture has to be converged manually.

Zenith's solution was to tilt the faceplates on the red and blue tubes slightly. That distorts the image projected on the screen. The distortion produced by the tilted face place is in the opposite direction to the distortion caused by the off-center mounting of the outside tubes. The two distortions thus cancel each other, resulting in a perfectly "self-converged" picture. Since the correction is built into the tubes themselves, controls and electronic parts are eliminated, and correct convergence becomes automatic.

Another improvement in the new tubes is a special bipotential gun designed to maintain resolution at high brightness levels. In many conventional tubes, the dots of color on the screen tend to "bloom" whenever the tube is driven to provide a bright picture, producing a fuzzy image. Brightness must be reduced before the dots return to normal size.

The new electron gun operates on a fixed DC voltage, and is designed to hold the dots as sharp colored points at high brightness. The result is sharper detail at all levels of brightness.



**THE SELF-CONVERGING PICTURE-TUBE system. Image beams from each of the three tubes follow carefully engineered paths through precision acrylic lenses, which weigh about half as much as glass lenses. The images are then reflected by two glass mirrors that reflect more than 94 percent of the light that strikes them.**

## Bible now published on videodisc

Noting the strong consumer response to such videodisc programs as "The Ten Commandments," RCA has licensed five volumes of *The New Media Bible,* a video translation of the Bible by the Genesis Project. RCA also has options on the additional 27 volumes for use in its videodisc system.

Seth Willenson of RCA Videodisc notes that "The Ten Commandments" has sold about 30,000 copies, which amounts to more than $1 million at retail prices. "We are bringing spiritual values into the home in an historical, realistic, and entertaining way that appeals to all the family," Mr. Willenson said. "To those parents who are concerned about what their children watch on television, the videodisc permits them to select from a wide variety of family-oriented programs."

## Alaskan satellite in orbit

Satcom V, is a 2,385-pound advanced domestic communications satellite that was launched last October. It will provide long-distance communications within the State of Alaska, and between Alaska and the rest of the United States. The craft will also carry the state's rural area, television, and emergency medical networks.

RCA American Communications will operate the spacecraft as joint licensee with the owner, Alascom, Inc., the long-lines carrier for the state of Alaska.

RCA Satcom V is the first all-solid-state communications satellite, and is the first of a series of advanced spacecraft. They will provide up to a 50 percent increase in voice/data capacity over their predecessors, while remaining compatible with present in-orbit Satcom satellites, and with terrestrial facilities.

## New CBS-Columbia group to market software

A new unit, CBS Software, has been formed to develop, license, and market game, education, and home-management software for personal home computers.

Edmund R. Auer, Senior Vice President of the Columbia Group, reports that concurrently with establishment of the CBS Software unit, a license agreement has been signed with K-Byte for the exclusive worldwide marketing and distribution rights to K-Byte computer games, including those that will be developed during the next four years.

CBS Software will initially offer the K-Byte games for the Atari 400 and 800 systems, and is evaluating several other formats for the games.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# EDITORIAL

## Electronics In Medicine

Electronics has a great impact on our day-to-day lives. It places a tremendous amount of information at our fingertips, reduces our day-to-day chores, improves the "quality" of life, and provides a virtually unlimited supply of entertainment right in our living rooms.

In fact, it we stopped to think about it for a moment, we could name many benefits that electronics makes possible. But after we finished, how many of us would have included medicine in our listings.

I'm not thinking of the electronic thermometer, either. Basic research continues to investigate new applications of electronics. For example, researchers are implanting electrodes in the inner ears of deaf people to help them hear. So far, success has been modest—patients hear medium-to-loud sounds only—but progress is continuing. When that technique is perfected, researchers envision a "bionic" ear. Along the same lines, researchers are investigating a technique for attaching an electronic camera directly to the brain; they will be using surgically implanted electrodes.

Researchers are also investigating the effects of electric fields on bone growth. Placing a fracture into an electric field has speeded the healing of bone injuries that have proven to be difficult to mend on their own.

Out of the University of Pennsylvania comes a pair of electric braces that researchers believe will cut in half the time required to straighten teeth.

On a completely different front, a researcher from the University of Florida has developed a device that shatters kidney stones. The patient lies in a bathtub and is subjected to shock waves created by high-voltage discharges. The shock waves are what break up the kidney stones.

And those are just some highlights of the intensive investigation of electronics applications in medicine. The bionic human is no longer just a fictional fantasy and may be children's reading compared to what is still to come. The promise of electronics and its limitations are still somewhere far in the distance and it's going to be a true-life experience as we live through the next few years.

**ART KLEIMAN**
Editor



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## TRACTOR-FRICTION PRINTER $399

This all new COM-STAR deluxe line printer, prints 8½" x 11" letter quality full size, single sheet, roll or fan fold computer paper, labels, etc. 40, 66, 80, 132 columns. Impact dot matrix, bi-directional, 80 CPS. Includes special cable that plugs direct into the VIC-20 printer port — no other costly interface is needed! List $599.00 Sale $399.00.

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Has all the features of the COM-STAR printer shown above, PLUS! 10" carriage 100 CPS, Dot addressable bit image graphics, 2.3 buffer, 18 character sets, 40, 48, 66, 80, 96, 132 columns, prints true descender, super and subscript, underlining. Includes special cable to plug into the VIC-20 printer port. List $699. Sale $499.

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CIRCLE 92 ON FREE INFORMATION CARD

# SATELLITE/TELETEXT NEWS

GARY ARLEN
CONTRIBUTING EDITOR

## NATIONAL BUSINESS TELETEXT

Satellite Network Delivery Corp., a new information-distribution firm, plans to beam teletext-type data and video material throughout the U.S. via a hybrid satellite signal that will be retransmitted by local TV stations. SND's service, due to start in April, will include two primary features: *Business Teletext Network* will carry about 100 medium-speed data channels, and *T-Sat* will use digital technology to send commercials and other video programming to TV stations. The teletext service will use the vertical blanking-interval lines of a satellite transponder; SND plans to use the new North American Broadcast Teletext Standard (NABTS) technology; that is the hybrid format combining French Antiope and Canadian Telidon standards. SND data service won't be formatted as conventional page-by-page teletext frames; rather the data will be "sliced" into 100 channels within the VBI, with data moving at 3,000 characters per second. All transmissions will be addressed and encoded so that only designated customers will have access to the services. At presstime, SND was still negotiating for satellite space; the assumption is that it will find transponder room aboard a Westar bird.

## TWO NEW SATELLITE PROJECTS

NASA is putting new emphasis on two activities that could lead to a sizeable new effort in satellite communications. The Advanced Communications Technology Satellite (ACTS) program will develop multiple-beam satellites that do their own switching, operate in the 30/20-GHz range, and have fixed scanning as well as spot beams. The ACTS birds would also have the capacity to handle system networking and would offer data speeds of up to 500 megabytes-per-second. The ACTS project had been shelved in recent U.S. budget cutbacks, but NASA is trying to bring it back to life, goaded in part by new Japanese activity to develop high-tech satellites of the same type.

The other new NASA effort comes in the dynamic business of mobile communications, hooked into satellite networks. The Mobile Satellite Experiment (MSat-X) would offer thin-route mobile communications for mobile phones and other transportable communications systems. NASA is trying to develop a two-by-four-foot horizontal patch antenna which would cost under $500 and could downlink mobile communications from atop a truck.

NASA is encouraging the participation of private companies in both projects, part of the new effort to develop joint ventures between government and business.

## TELETEXT NEWS BRIEFS

**The National Captioning Institute,** which prepares closed captions using line 21 of the vertical-blanking interval, and British Videotex-Teletext, the U.S. marketing agency which champions U.K.-format teletext, recently demonstrated a hybrid system which decodes line-21 captions into the teletext format. That would permit captions to be sent simultaneously via either system, and would assure that the 60,000 homes now equipped with Sears TeleCaption decoders (a number likely to grow) won't be stuck with obsolete equipment when teletext catches on.

**Time Inc.** has included several novel features in its full-channel satellite-cable teletext service now being tested in San Diego and Orlando. Time Teletext includes an audio soundtrack (primarily background music), stemming from Time's belief that viewers using a TV text service will feel more comfortable if there's an audio factor accompanying the screen images. The Time service also has a sizeable capacity for downloading data; the Zenith decoder used in the test has the ability to allow users to format material in order to retrieve specific information. For example, users can ask for data, such as "movies to be shown on Tuesday," and the terminal will collect and display information (titles, description, ratings) about films featured on that day.

**WGBH-TV, Boston Channel 2,** has begun its "Scoop" teletext experiment, using Antiope technology. The 100-page teletext magazine includes considerable educational and local information and is available at special receivers in public sites, such as libraries and schools.

**More cable TV** teletext services are springing up, among them a sophisticated package delivered by Cablevision Systems in Long Island, NY, developed in cooperation with *Newsday* newspaper. The system uses Telidon graphics and is the precursor of an advanced interactive videotex service which the cable and newspaper companies want to introduce in the near future. The Newsday Channel, due to begin service in April, will include news, weather, advertising, and a daily video newscast. **R-E**

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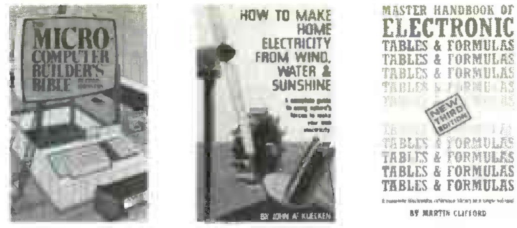


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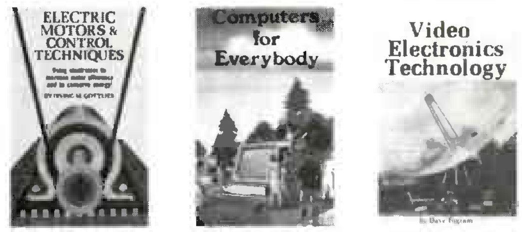


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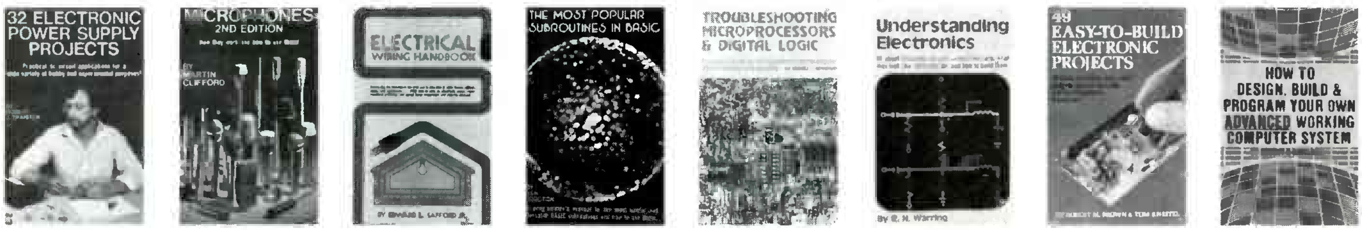


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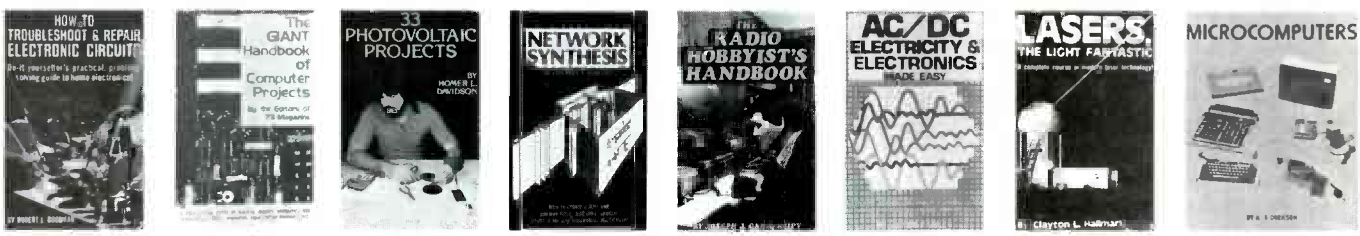


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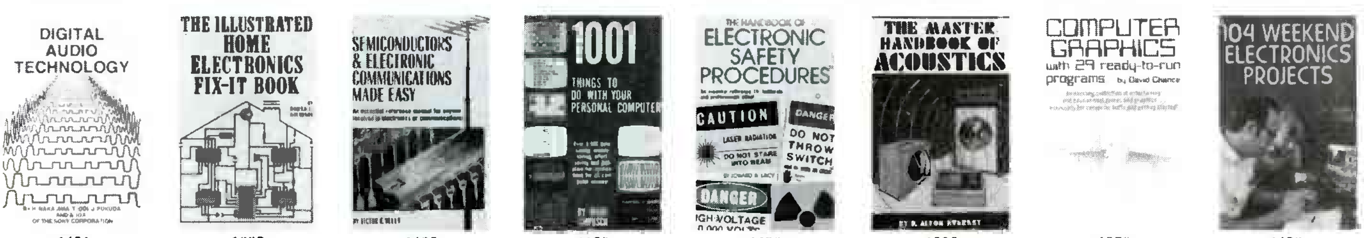


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# VIDEOGAMES

## An exciting new home videogame-system.

**DANNY GOODMAN,** CONTRIBUTING EDITOR

WALK INTO ANY ONE OF LITERALLY MILlions of homes across the country and you're sure to see this familiar sight: the family color-TV hooked up to a videogame console, wires running all over the place, and the family engaged in a "spirited" conversation about whether Dallas or *Missile Command* will be on the screen tonight. That scene soon may be a little less common, however, thanks to the introduction of a self-contained cartridge-programmable videogame called *Vectrex* (see Fig. 1).

That is no ordinary videogame. Made by General Consumer Electronics Corporation (233 Wilshire Blvd., Santa Monica, CA 90401), it features a built-in 9-inch diagonal vector-scanning display monitor. Vector scanning produces razor-sharp outline graphics like those found on arcade games such as *Battle Zone*, *Asteroids*, and (in color) *Tempest*. Screen characters spin or glide smoothly, and the tiniest specks of light serve well as high-resolution laser blasts.

The other type of video-screen imaging, called raster scanning, allows areas to be colored in, but with less resolution. Home TV-receivers are of the raster-scan type.

Vectrex's self-contained design is unique. About the size of a small portable-TV (on its side), the unit simply plugs into any AC outlet. There's a carrying handle built into the top of the case, and one controller panel stows securely in a compartment beneath the screen. The controls on that panel include a small joystick (it's a little too small to allow for comfortable control, however) and a row of four pushbuttons. A speaker, ON/OFF/VOLUME and RESET switches, and jacks for two controller panels are located on the front of the unit, in the compartment under the screen.

Although the monitor is black and white, each game cartridge comes with a color overlay that helps jazz up the display and indicates which controller pushbuttons do what. One game (*Mine Storm*) is "resident" in the unit when you buy it. Most of the 12 cartridges scheduled for introduction this year are space games, including a licensed version of *Scramble*. Other games include *Berzerk*, *Armor Attack*, a 3-D road race, and football.

Essentially a version of *Asteroids*, *Mine Storm* is challenging even for the experienced game player. In fact, most of the cartridges are tough, especially at higher levels—as they are intended to be. In fact, one early reviewer complained that the games were too tough—apparently he hasn't seen what it takes to challenge an arcade video whiz.

This is one system with a lot of potential—interesting game play, coupled with 3-D effects and a very versatile sound package. GCE is already at work on future cartridges. For the avid videogamer, *Vectrex* surely is the one to beat.

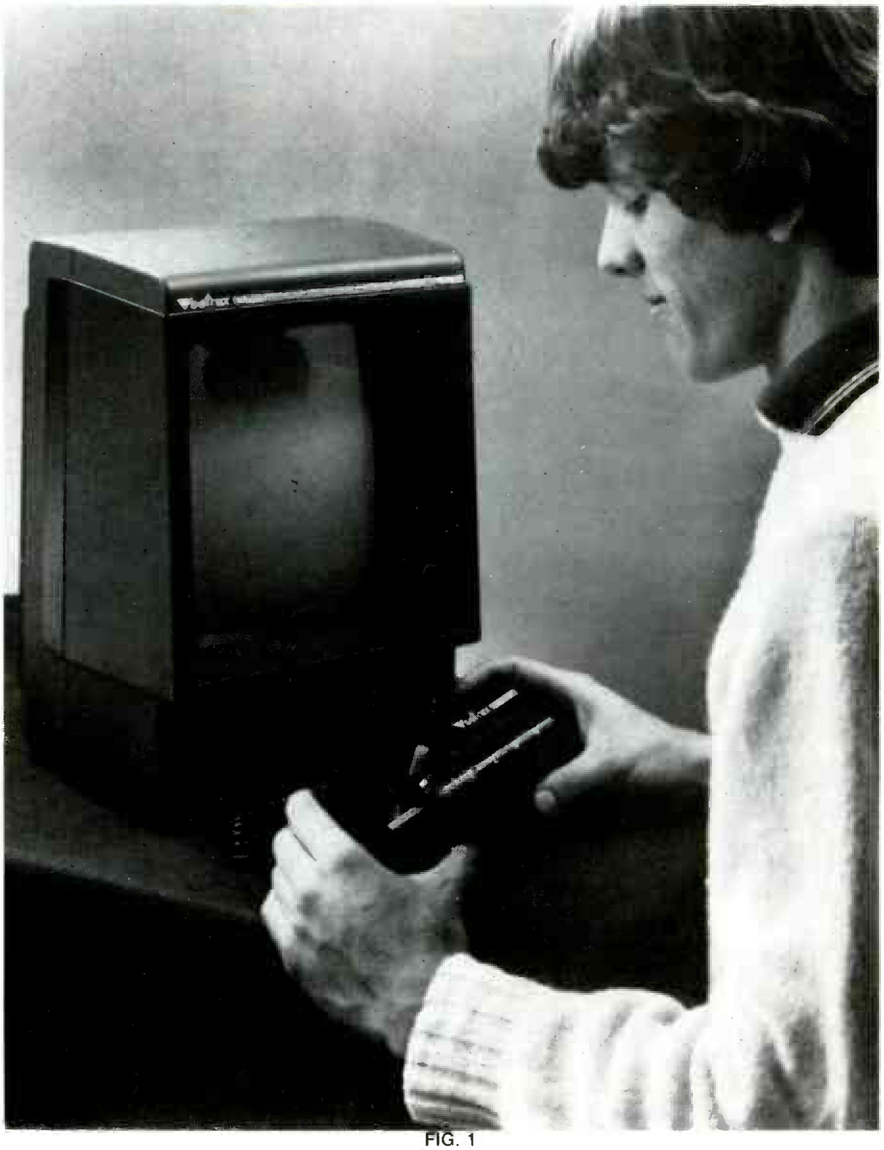

FIG. 1

### *Odyssey's K.C.'s Krazy Chase for Odyssey 2*

Ever since Odyssey's (I-40 and Straw Plains Pike, Knoxville, TN 37914) munchkin, named K.C., was held in chains by Atari's legal pursuers, he has been eager to reappear on the TV screens of *Odyssey-2* players. Now he has his chance, this time pursuing multi-segment monster, called a Dratapillar, that roams through a maze. (Is that Dratapillar perhaps a relative of Atari's dreaded

*continued on page 21*

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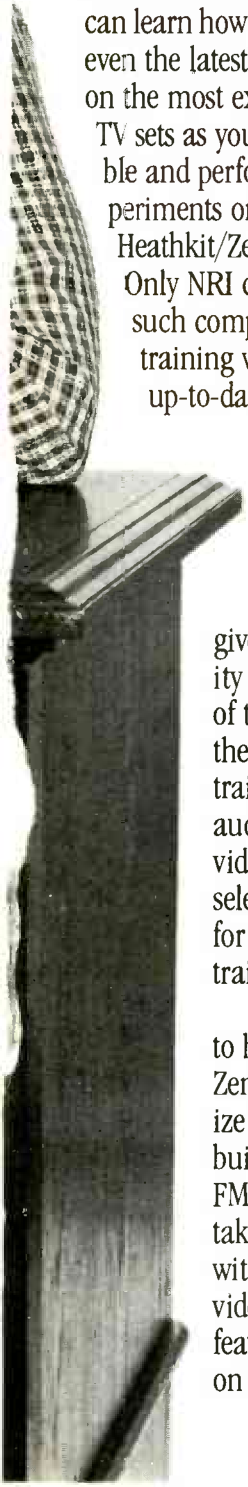

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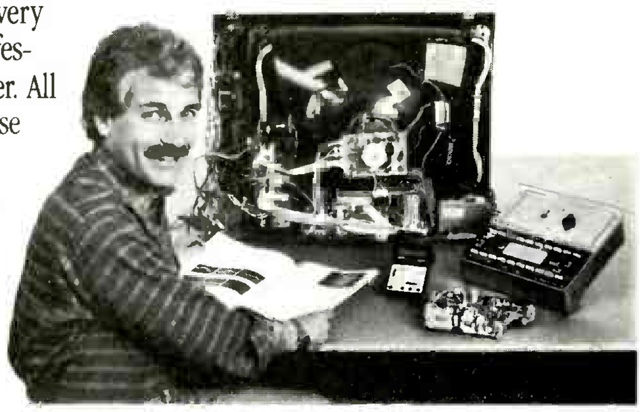

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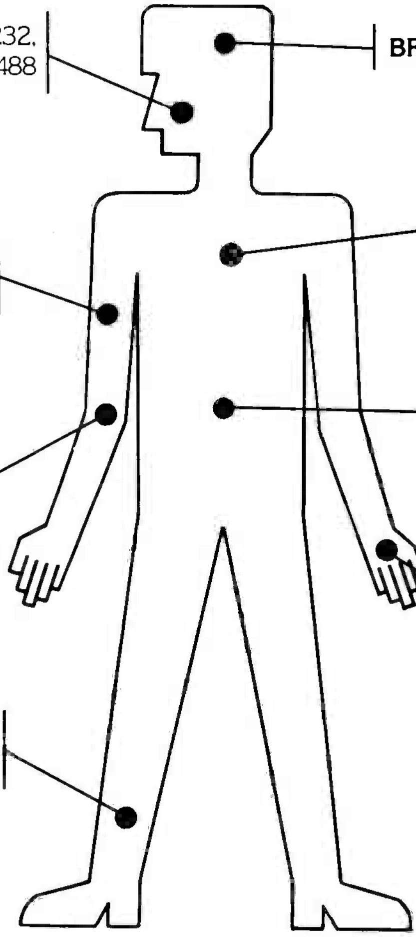

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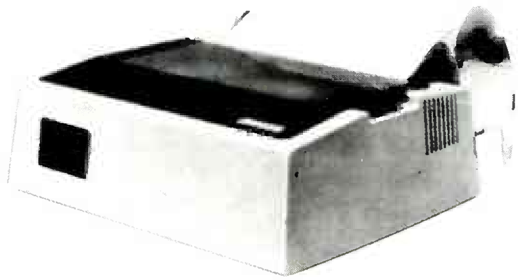

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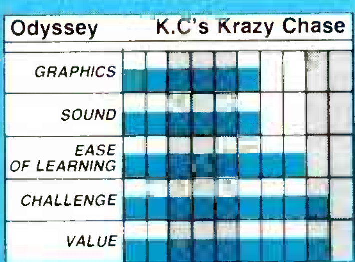
# VIDEOGAMES

*continued from page 14*

CIRCLE 101 ON FREE INFORMATION CARD




Centipede? No one is saying.)

*K.C.'s Krazy Chase* is one of the first Odyssey cartridges to be compatible with Odyssey's speech-synthesis module, *The Voice*, although that accessory is not required. The game is deceptively simple at first. You control K.C.'s movements through the maze, while the six-segment Dratapillar and two smaller characters (Drats) join forces to pursue K.C. Your goal at each level is to make K.C. gobble up the Dratapillar's segments without being eaten by the Dratapillar's head or touched by a Drat. Once you eat a segment, however, the Drats turn white and flee for a few seconds. Catching up to one causes it to stop and spin while you collect bonus points. The basic strategy then, is to have K.C. chase after the Dratapillar from behind. Of course, if you can cut off a few segments from the moving Dratapillar, they stop, giving K.C. plenty of time to chew them up.

*The Voice* can be distracting during game play. It seems to issue warnings like, "Run" and "Hurry" at random—K.C. can be miles away from the nearest danger, and the voice will say "Look Out." That's disappointing, but it redeems itself at the end of each level (when all Dratapillar segements are eaten) by letting out a contagious, high-pitched laugh (while K.C. hops up and down) and saying, "Incredible!" (while K.C.'s mouth moves). It will take quite a while for the novelty of the laugh to wear away.

I recently had out-of-town friends stay over a weekend. They didn't own a videogame, so their children, aged 7 and 9, were thrilled to have the luxury of having five different video-game systems and dozens of cartridges to keep them busy. The one cartridge they kept coming back to—and one that the non-gaming adults seemed to enjoy most—was *K.C.'s Krazy Chase*. That's a pretty good testimonial in my book.

## Mattel's Bomb Squad for Intellivision

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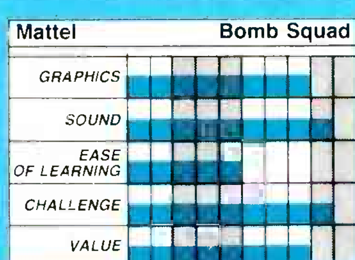


While the codebreaking games are not necessarily new, *Bomb Squad* from Mattel Electronics (5150 Rosecrans Ave., Hawthorne, CA 90250) is decidedly different and fresh. The game is designed for use with the *Intellivoice* speech-synthesis module. The speech from the module is used to prompt you through the steps of the game. Thus, although some is merely ornamental, much of the voice output is an integral part of the game play.

The scenario of the game puts you on a bomb-disposal team whose job it is to determine the correct code numbers (only one number at the easiest level) that will defuse a bomb set to destroy a large portion of the city within thirty minutes (game time, not real time). Each code number is hidden behind a grid of 20 squares. Each square of the grid in turn represents an electronic circuit that needs fixing before you can see whether or not the square contains part of the number. You need to fix as many circuits as you can within the time period to figure out the code number from the exposed squares.

When you choose a circuit to fix, the work really begins. The screen becomes a colorful circuit board, with several components highlighted. The demolitions expert, named Frank, calls out to you (via the *Intellivoice* module) to either cut out certain components (and substitute jumper wires) or replace them with spare ones located above the circuit. In the latter instance, however, you may have to try several components to determine whether you're to follow the shape or the color of the original. In any case, you have to follow the correct sequence that Frank calls out, or you're in big trouble.

While you and Frank are busy performing circuit surgery, Boris (the terrorist who planted the bomb) razzes you with phrases like, "It won't be easy," and a European-style police-car siren rises and falls in the background.

Breaking the code is cause for celebration: an on-screen fireworks display over the city's skyline and Frank hearty proclaims that "You're a hero!" But if you guess wrong, he says "Oh, no!"—and the skyline loses one-third of its buildings in an explosion while the waterfront ripples from the blast.

*Bomb Squad* is not a game to pick up for an easy or quick play. You'll need to understand the manual thoroughly before you get the hang of it. And be prepared for a lengthy sit-down. If adventure and strategy are your games, you'll enjoy *Bomb Squad*, but it's not something you will play over and over in one session. **R-E**

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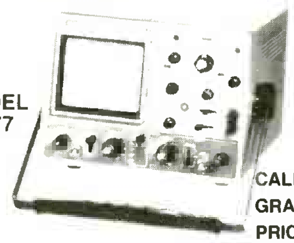

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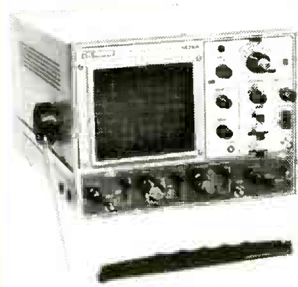

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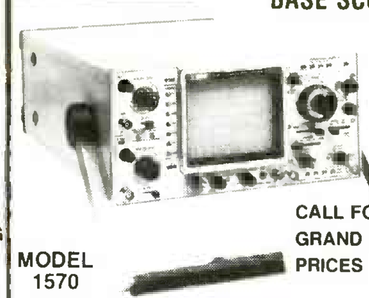

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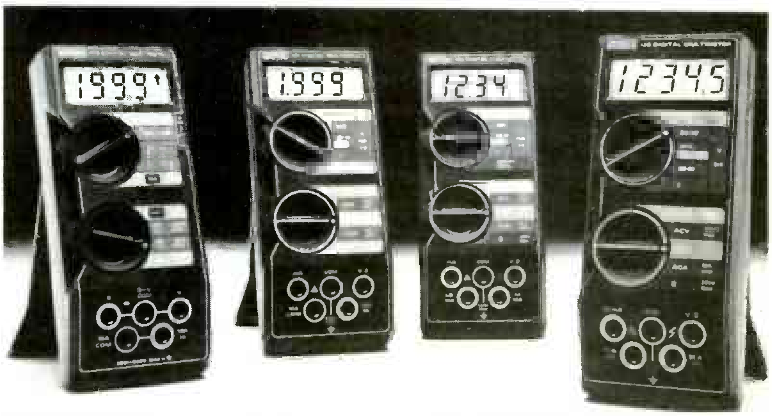

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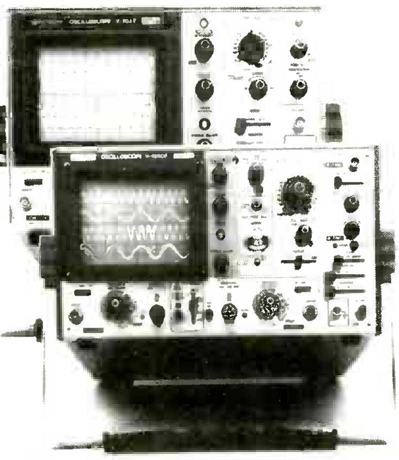

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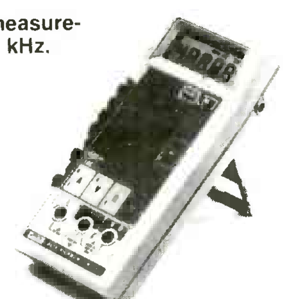

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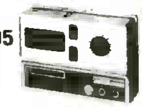

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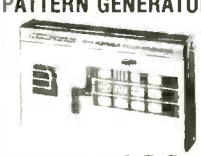

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# LETTERS

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## RADAR DETECTORS

The October 1982 issue of **Radio-Electronics** contains a letter on radar detectors by Mr. J. Frank Fields. Much of his letter is aimed at a letter of mine which had been published previously, but much of it is beside the point, because I had expressed no opinion in regard to the accuracy or reliability of radar speed measurements but had limited my discussion to the probable use to which radar detectors were put.

To support his views, Mr. Fields offers 20 years' experience as a physicist with the Department of Defense. To support mine I would offer over 50 years of driving experience. During that time, I have driven over a half million miles in 40 of the 50 States and in 10 of the 12 Provinces of Canada. Everywhere I have gone, I have observed that the vast majority of drivers exceed the speed limit when they think they can get away with it. Any impartial person can check that for himself by taking his car on an unpatrolled section of expressway and seeing what happens when he drives at exactly the speed limit—nearly everyone else will pass him. From that, I would conclude that is is the intent of most drivers to break the speed-limit laws.

At the same time, I have observed that when a police car is visible, all traffic slows down. From that I would conclude that it is the intent of most drivers to avoid getting caught for speeding. Whether they accomplish that by having one eye peeled for a police car, or by use of an electronic device is immaterial. The intent is the same.

Mr. Fields then gives some "other" uses for radar detectors, but it will be noted that in each case he starts with the assumption that the car is being driven within the speed limit. If my observation (that drivers who consistently drive within the limit even when they are unobserved by the police are insignificant portion of the total driving population) are correct, then it follows that Mr. Field's other uses for radar detectors are insignificant when compared to the primary most probable use, which is to avoid getting caught speeding.

RICHARD KOLASINSKI
*Richmond, MI*

## COMPONENT CHECKING

I enjoyed Karl Thurber's article on buying mail-order components (**Radio-Electronics,** September and November, 1982). I would really like to make several additions to his excellent article.

When checking diode or transistor junctions with a VOM, the readings are relative to the voltage and current impressed on the device. I have found the R × 1 current on various ohmmeters to be as much as 320 mA. Readers would be advised to measure their R × 1 scale with a milliammeter so they don't overcurrent the device under test. A way to do that is to measure the resistance of a good silicon or germanium diode with a milliammeter in series with it. Write the current reading (in the forward direction) on the VOM case for reference. Keep in mind that some ohmmeters may have reversed polarity on the test leads, and that some digital ohmmeters have such low voltage and current that a good junction will check open with either polarities.

Salvaging used components has great educational value. After testing thousands of resistors, capacitors, etc. the technician develops a good sense of how components change or fail. I use salvaged components to run "destructive" life tests. Do you know how hot a resistor gets at full load or how many volts you can put across a 400-volt capacitor before it blows? Lastly the sources of components mentioned in the article are also a good place to buy good industrial quality but old test equipment.
DELBERT S. SHAFER, CET
*Warren, OH*

## VOLTAGE FREEZER

Leonard Lee's voltage-freezer circuit (New Ideas, **Radio-Electronics,** November 1982) is a good solution to what is sometimes a vexing problem in circuit accessibility. I do have some comments on protecting the components in the circuit to ensure a long and healthy life, however.

First, if the circuit voltage being measured has a low impedance, the tantalum capactor could be damaged by a characteristic of solid tantalums—lack of electrolyte mobility. The current should be limited a series resistor to 333 mA. In addition, if the leads are even briefly reversed, the capacitor could be damaged. A better idea is to use a polypropylene on polycarbonate capacitor. An additional advantage to those capacitors is lower leakage, and no series resistor is required.

Second, a series resistor should be used between the capacitor and the non-inverting input of the op-amp. Since op-amps can be damaged in any number of ways (input signals outside the supply rails, excessive differential-mode voltage due to slew-rate limits, etc.) the resistor (about 10K is enough) can limit the input stage current to a safe value in case of a reversed or out-of-limit input voltage. That series resistor will not add any error because of the high op-amp input impedance.

Third, be sure that you *never* turn off the supply voltage while the storage cap is still charged. That will result in a high substrate current in the IC after which you can kiss it goodby! Always discharge the cap before shutting off the voltage freezer.
CHAS. HANSEN
*Tinton Falls, NJ*

## WHAT'S BETA?

I must compliment Manny Horowitz on his fine series written about analog circuits. It is an excellent review for me, and it also enlightens me about some subjects I have not studied.

There is an error however, in an equation as published (Equation 3-b in August 1982 issue). As written it is $\beta = \alpha/(\alpha-1)$. When trying to prove the formula (i.e. how is it derived?) by substituting $I_C/I_B$ for $\beta$ and $I_C/I_E$ for $\alpha$ and 1 replaced with $I_E/I_E$, it reduced to $I_E = I_C - I_B$. This is incorrect because $I_E = I_C + I_B$. At first, I thought my algebra incorrect (I still did not notice that the formula was wrong) and only when plugging in an assumed $\alpha$ ($\alpha = .99$ when $\beta = 100$) in the original equation and getting a negative $\beta$ for an answer did I realize that the denominator was reversed. The correction equation is $\beta = \alpha/(1 - \alpha)$.

There is also a statement that bothers me. It appears in the next-to-last paragraph on page 54: "Because the emitter current is equal to the base current multiplied by beta..." That is only an approximation. I learned that: $I_B = I_E/(\beta + 1)$ so $I_E = I_B(\beta + 1)$ and $I_C = I_B\beta$, neglecting leakage currents. I realize that it seems nit-picky on my part; however, having survived through 3rd Semester Electronics at Idaho State University (an excellent program and faculty by the way), I am conditioned: $I_C = I_B\beta$ and not $I_C \approx I_E$, although that approximation can be used in many instances. My point is that the word "approximately" should be used as a clarification and caution so that a beginner might not get misled and confused.
ANDREW HITT
*Boise, ID*

## NOT HIS WHOLE LIFE

Hurrah for Joseph Miller's letter suggesting that you ease off computer articles. New all-band receivers, amateur transceivers, scanners, radar detectors, and hi-fi receivers are hitting the market every day. Let's hear about them. Although I own a computer, it's not my whole life—I hope it doesn't become yours.
JOHN R. MYERS, K5CUY
*Kingsland, TX* **R-E**

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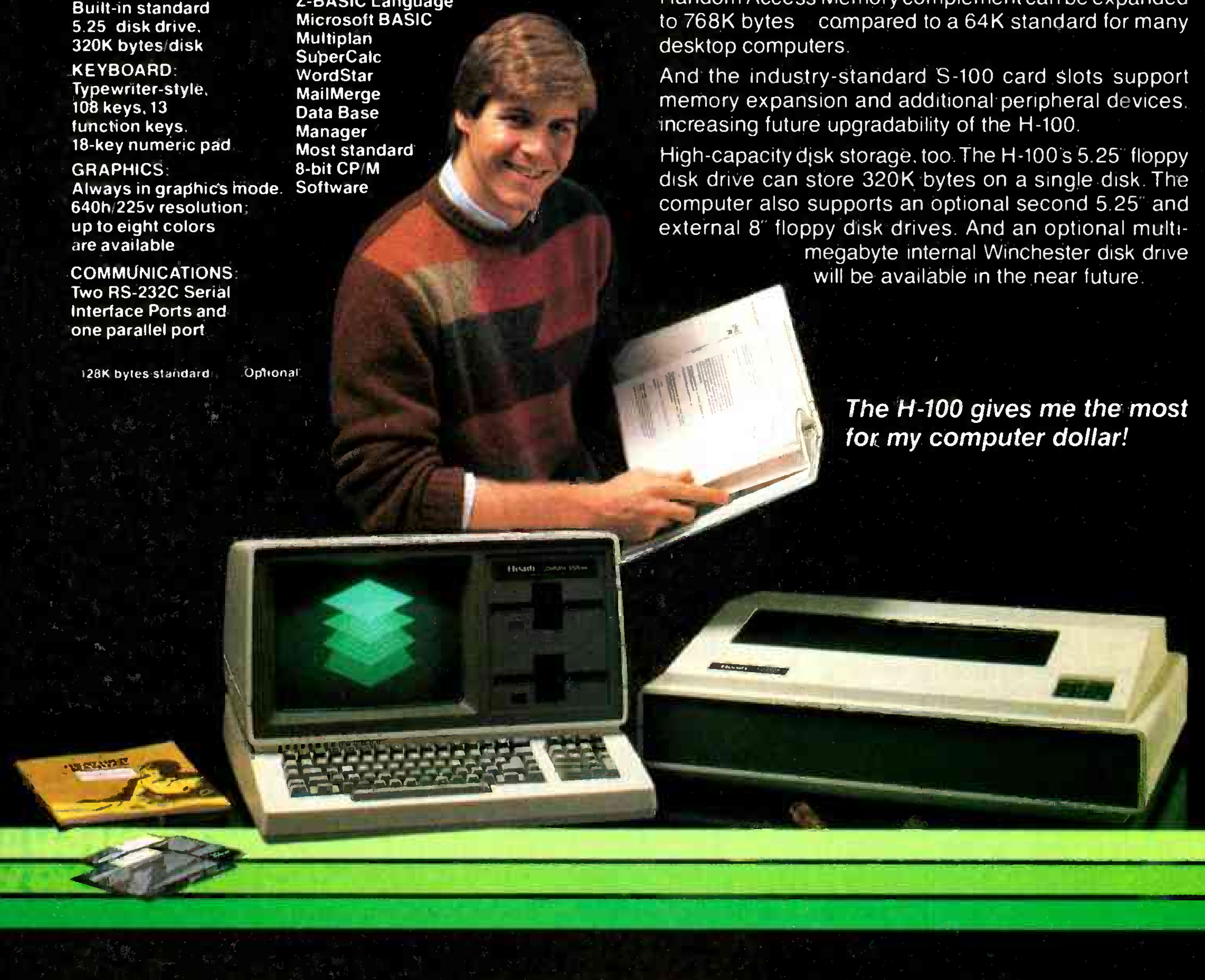

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| RANDOM ACCESS MEMORY: | | | |
| Minimum: | 128KB | 16KB | 128KB |
| Maximum: | 768KB | 576KB | 256KB |
| FLOPPY DISK STORAGE: | | | |
| Per Diskette: | 320KB | 320KB | 140KB |
| Maximum Internal: | 640KB | 640KB | 140KB |
| 8" Floppy Support: | Standard | — | — |
| EXPANSION SLOTS: | Five S-100 (four available) | Five (three available) | Eight |
| I/O PORTS: | | | |
| Parallel: | 1 | Optional | — |
| Serial: | 2 | Optional | 1 |
| VIDEO DISPLAY: | | | |
| Line/Columns | 25 x 80 | 25 x 80 | 24 x 80 |
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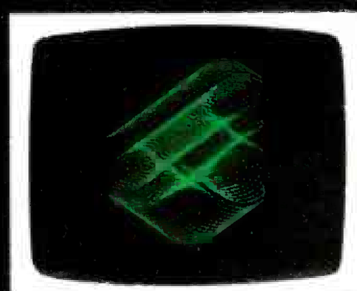

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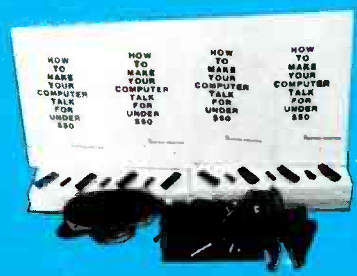
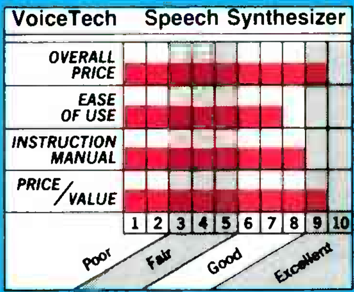
# EQUIPMENT REPORTS

## Voicetech Industries Speech Synthesizer Kit

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THOSE OF US WHO ARE INTO ELECTRONICS as well as computers enjoy the best of both worlds. Have you ever wondered how computerists who are not electronically oriented get along? You have to assume either that they cannot enjoy the full benefits of their computers or that they have fat wallets.

We, on the other hand, usually won't hesitate to pick up a soldering iron to build some add-on for our systems. We'll even take the covers off and go inside our machines to make a modification or repair now and then. What that means is that we can keep the expense of maintaining and expanding our computers relatively low.

Nonetheless, there is one computer application that, because of its cost, has been off limits even to builders. That application is speech synthesis. There are few computerists who would not at least like to experiment with adding speech capability to their systems. Many also have specific needs for computer speech; among the fields where it might be useful are early childhood education, working

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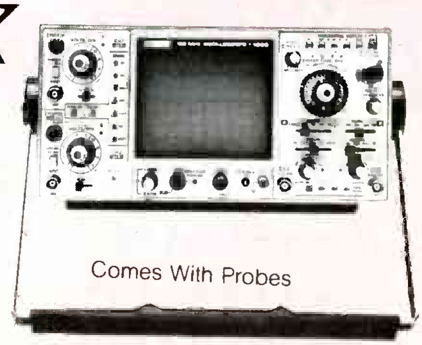

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with the handicapped, and process monitoring. The problem, however, was that the synthesizer IC alone could cost upwards of $70.00.

But speech synthesis no longer costs an arm and a leg. Voicetech Industries (PO Box 499, Fort Hamilton Station, Brooklyn, NY 11209) has come to the rescue with an inexpensive (the introductory price is $24.95) "starter kit" of parts for building your own synthesizer. The accompanying manual is very well written and provides all the information needed to enter that fascinating field.

The manual is called *How To Make Your Computer Talk For Under $50* and it tells you how to do just that. The first section contains background information on phonemes (the sounds that make up speech) and allophones (the acoustic signals for those sounds). That information allows you to use the synthesizer more effectively by teaching you how to create words out of their basic sounds.

The second section includes programs for Radio Shack and Apple computers. Those are complete, with thorough comments and some sample applications. Although the programs are rather rudimentary, they provide understandable algorithms that are easy to use.

The final section contains schematics for three synthesizers. Those synthesizers vary in complexity, but none is at all difficult to build. The kit you buy will depend upon which computer you are using, but each includes a 3.12-MHz crystal and a General Instruments SP0256 speech-synthesizer IC; all sell for the same price.

To complete your kit, you'll need to buy fewer than 20 additional components. Those are all readily available and include things like resistors, capacitors, a speaker, and an LM386 audio-amplifier IC. For those with depleted junkboxes, the parts are priced at Radio Shack for just under $25, including the card-edge connector and ribbon cable. That proves that the cost does indeed come to under $50.00.

### Construction and use

There's nothing critical in bulding the synthesizer. In fact, you can throw one together on a solderless breadboard in less time than it takes to read about it. Once that's done, just enter the program and you're all set to go.

You'll get speech the first time you run the program. A somewhat non-human, but quite intelligible voice says: "Welcome to Voicetech, my name is Chatterbox." After you replay that a few times for effect, you are ready to try some more ambitious tasks.

The process of programming words is not at all difficult. Allophones are selected from the chart provided (which also has examples) and typed on the keyboard. Thanks to the program's error-

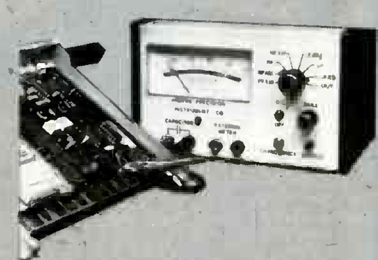
trapping and easy-editing features, you can have your computer saying your name in a couple of minutes. From there on, the sky is the limit—mix and match the available 64 allophones as you wish.

You need not be concerned about the quality of the Voicetech synthesizer or the intelligibility of its speech. With the the two-inch speaker we got from Radio Shack, speech was quite intelligible, but when a better speaker was used, the synthesizer put out speech that was at least as good as that of any microcomputer synthesizer this reviewer has ever heard. The speech quality is higher than some off-the-shelf models that cost a good bit more. In addition, it is relatively easy to modify the audio-filter components to produce a sound that best matches your speaker, preferences, and needs.

Adding speech to enhance your programs is an easy matter. The speech is held in simple one-dimensional arrays. When words are needed, one or more of the appropriate arrays are fed through a short "talk" subroutine.

Of course, neither this nor any other speech synthesizer is capable of producing speech comparable to that from a TV or recorder—the speech has a definite "machine-made" quality to it and people seem to vary in their adaptablity to it. Some hear it clearly and distinctly right from the first, while others seem to require a bit of time before they get used to it. In any case, the Voicetech speech-synthesizer kit and manual provide the least expensive way to get good quality speech from your computer. **R-E**

## *Anders Model CM-100 Capacitance Instrument*



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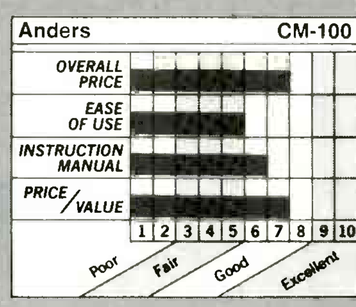



ALTHOUGH THE CAPACITANCE METER IS not usually mentioned in discussions of test instruments, it can be a very valuable addition to your test bench. One paricularly useful meter is the model *CM-100 Capacitance Instrument* from Anders Precision Instrument Co., Inc. (4 Bridge St. Plaza, PO Box 75, Willimantic, CT 06226). It not only can measure capacitance values in or out of circuit, but it can also measure capacitance current-leakage—the usual cause of capacitor failure.

The *CM-100* measures capacitance values from 1 pF to 25,000 $\mu$F in seven ranges: pF $\times$ 10, nF $\times$ 0.1, nF, nF $\times$ 10, $\mu$F $\times$ 0.1, $\mu$F, and $\mu$F $\times$ 5. For most capacitors, the measurement procedure is straightforward. You plug one end of the supplied test leads into the CAPACITOR jacks and clip the other end onto the capacitor (you must make sure that polarized capacitors are oriented correctly). If you do not know the approximate value of the capacitor you are measuring, start at the highest range ($\mu$F $\times$ 5) and work your way down. To make the actual measurement, hold in the CAPACITANCE button. Within eight seconds you will be able to read the value on the front panel's mirrored, 3½-inch, analog meter. That meter is marked from 0 to 100 in increments of two. The range switch provides you with the proper multiplier.

For capacitors larger than 5000 $\mu$F, the measurement procedure is different—an external 0-to-10-volt meter is required. That meter is attatched to the EXTERNAL METER jacks and the CAPACITANCE button is held in as before, but now the external meter is read. The voltage reading is converted into units of capacitance by using the External Range Calibration Curve that is found in the instruction manual. Be cautious when hooking your meter up to the *CM-100* to make capacitance measuremnts. When the positive voltmeter-lead was attatched to the red EXTERNAL METER jack on our test model, the needle deflected backwards.

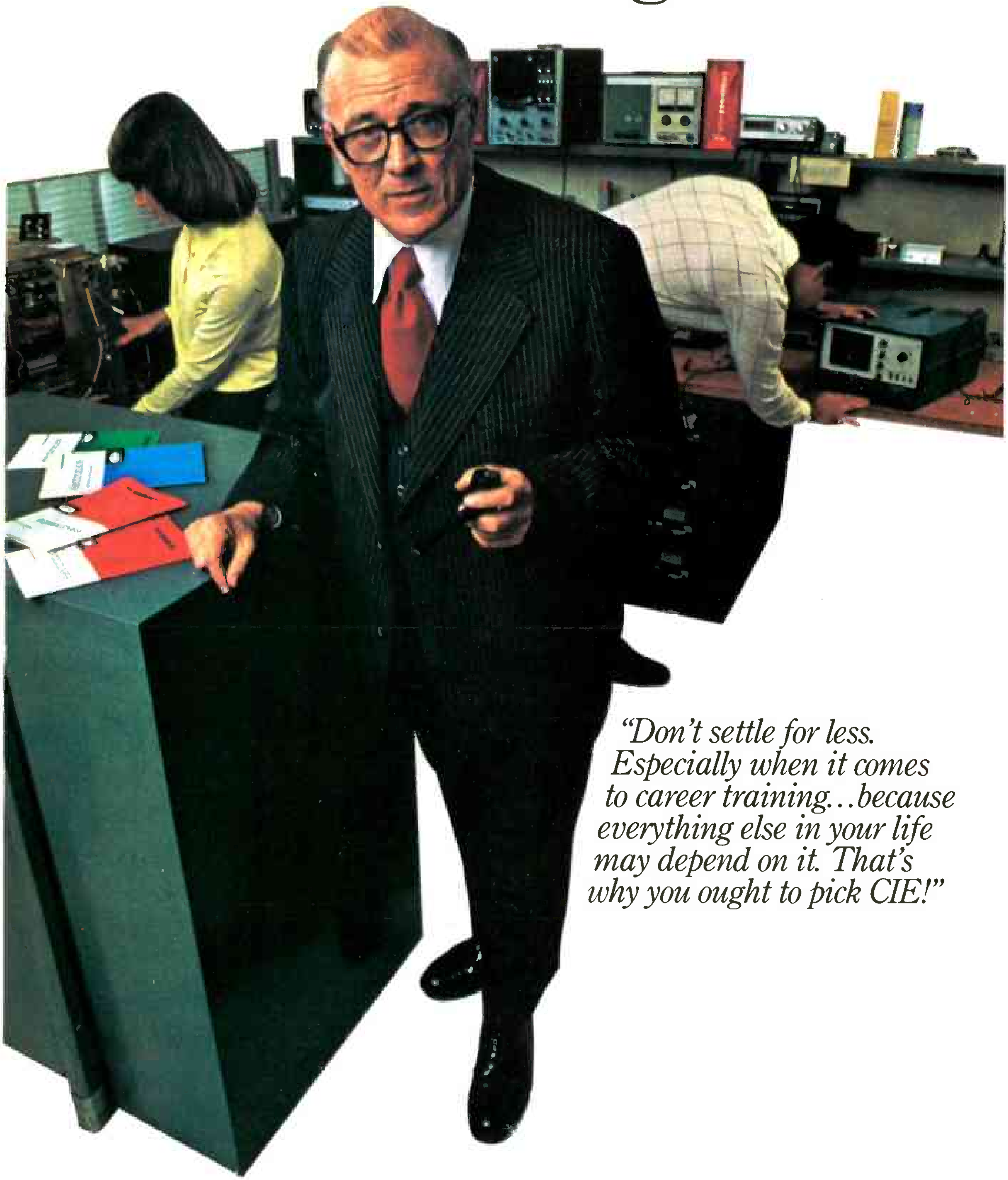
The NULL control is used to null out the capacitance of the test leads and the *CM-100* itself. It can null up to 10% of the measurement on any scale. Normally, the NULL controll is turned fully countercclockwise, but when using the lowest range (pF $\times$ 10), you must adjust the control so that the meter reads "2" without the capacitor connected.

When measuring capacitances greater than about 10 $\mu$F, the meter's needle will fluctuate between $\pm$ 5%. The instruction manual points out that a 10,000-$\mu$F capacitor can be wired across the meter terminals to reduce the fluctuation. Although the time it takes to make a measurement is increased when the capacitor is attached, the meter is easier to read with it in place.

The instruction manual also includes a schematic diagram, a parts list, a parts-placement diagram for the *CM-100*, and test and calibration instructions. A simple weak-battery test is also described in de-

*continued on page 38*

# "If you're going to learn electronics, you might as well learn it right!"



*"Don't settle for less. Especially when it comes to career training...because everything else in your life may depend on it. That's why you ought to pick CIE!"*

## EQUIPMENT REPORTS

*continued from page 32*

tail in the fifteen-page manual.

Measuring capacitance current-leakage also requires an external 0-to-10-volt meter. That meter and the capacitor are hooked up as before. (Except now, the positive voltmeter lead *is* hooked up to the red jack.) To make the measurement, the OUTPUT button is held in and the voltmeter is watched to determine the time it takes for the voltage to decrease to one-half of its original value. The leakage can then be determined by using the equation $i = C\,\Delta V/\Delta t$. However, exact measurements of leakage are usually not necessary, and leaky capacitors can be easily spotted—especially when using an analog meter.

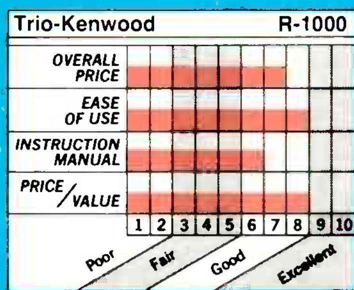
The *CM-100* is primarily a bench-top instrument in an attractive 7¼ × 7½ × 4½ inch aluminum and plastic walnut-grained case. It is powered by two 9-volt batteries, so, although it won't fit in your shirt pocket, it is portable. Remember though, you will need the chart in the instruction manual to measure capacitances greater than 5000 $\mu$F.

Besides measuring component values, the unit can be used to measure the capacitance between circuit-board traces (that "hidden" problem can often lead to poor circuit performance) or to find the distance to a short (or open) in a coaxial cable. The device is also useful for checking large quanities of components—it will not only find those that are mismarked or have changed value, but also ones that suffer from current leakage—try doing that with a digital meter!

The *CM-100* is available from the manufacturer for $89.95, plus $3.50 shipping and handling. **R-E**

### *Kenwood R-1000 Shortwave Receiver*

CIRCLE 105 ON FREE INFORMATION CARD




NOT TOO MANY YEARS AGO, SHORTWAVE listening required a lot of patience. Most often, that was because of the receiver itself. Though many were superheterodyne types, their dials were often crowded because of their poor selectivity and it was nearly impossible to find a specific frequency without a great deal of patience and/or luck. Also, those radios—especially the less expensive ones—tended to drift. So, if someone was listening to one frequency and left the rig for a while, he could come back and find it several kilohertz away.

The situation has changed in the last 10 years. Now shortwave receivers use phase-locked-loop tuning, sport digital displays, have excellent sensitivity and good selectivity, and have many of the features that were found only on super-expensive top-of-the-line receivers only a few years ago.

Kenwood's *R-1000* communications receiver is an example of a modern receiver. It is a general-coverage receiver, covering 200 kHz to 30 MHz, and has three reception modes: AM (both wide and narrow), USB, and LSB/CW.

The heart of this unit includes a highly stable VFO and a phase-locked-loop frequency synthesizer for rock-stable reception. Frequency stability is 2 kHz for the first hour of use, but it settles down to 300 Hz maximum for every 30 minutes thereafter.

As with other modern, general coverage receivers, the *R-1000* is relatively compact and lightweight (12¾ × 4½ × 8⅝ inches and 12.1 pounds) and has some respectable specifications. In actual use, we found that the performance of the receiver seemed to match its specifications.

Its claimed sensitivity, 10 dB or more S+N/N, is 20 $\mu$V on the AM-NARROW setting in the 200-kHz to 2-MHz range and is 0.7 $\mu$V when set in the SSB mode. In that frequency range, the radio requires a high-impedance antenna (in the vicinity of 1 kilohm). In the 2- to 30-MHz range, with a 50-ohm antenna, the sensitivity figures are 2 $\mu$V on AM-NARROW and 0.5 $\mu$V on SSB.

As mentioned before, the *R-1000* has both AM-wide and AM-narrow modes. In the AM-wide mode, (which has a 12-kHz, −6-dB bandwidth) local reception can be enhanced with better tone quality. The AM-narrow mode is used when unwanted signals are present near the frequency of the desired signal. In that mode, the receiver's bandwidth is narrowed, and interference is reduced. The −6-dB bandwidth is cut in half to 6 kHz. In use, I found that that setting does help improve AM reception, especially in high-static conditions on the medium-wave frequencies. (Kenwood suggests adding a jumper wire to further narrow the bandwidth of the AM-NARROW position to the same figure as the SSB position. That indeed is an improvement.)

The image- and IF-rejection figures are also excellent for a general-coverage receiver. The image ratio is claimed to be more than 60 dB, while the IF rejection is better than 70 dB. Those figures are better than those of my ham transceiver! I believe that the *R-1000* could be used as a separate receiver for amateur-radio operation on split frequencies. In fact, an accessory socket in the rear allows you to automatically mute the receiver when the transmitter is keyed.

The −60-dB selectivity figure is 5 kHz and the −6-dB figure is 2.7 kHz. Those figures indicates just how sophisticated general-coverage receivers have become.

The *R-1000* will operate with a variety of antennas, from simple random-length wire antennas to beam antennas. There are three antenna feedpoints, one for the standard SO-239 connector for coaxial cable and the others for simple wire-antenna inputs. All of the antennas are meant to be used in an unbalanced condition, the grounding coming from the radio itself, through a ground-wire input terminal. Interestingly, if a listener wants to listen to frequencies from 200 kHz to 2 MHz, he has to use a separate antenna. The coaxial and short-wave antenna inputs can't be used in that range. However, that's a minor inconvenience.

The receiver is so easy to use that after only a few minutes of studying the owner's manual, I was listening not only to foreign shortwave broadcasts, but also to radio amateurs on their frequencies. The manual is complete and gives operating hints, but it is apparently aimed at the "appliance operator" because there is no explanation of theory and although a schematic is included, there is very little troubleshooting help.

A large, green, fluorescent digital frequency display made finding frequencies very easy. Also, setting the receiver's frequency is quite simple. All that is required is a twist of the band switch to set the main frequency in megahertz. Then the larger, easy-turning main tuning knob is twisted to find a particular frequency within its 1-MHz range. The lighted tuning dial is of the analog variety and serves well as a backup for the digital display. You'll find very little backlash in this knob.

Finding the correct mode to use for any type of reception was also easy because the mode switches are well marked and are just to the left of the band switch. A set of pushbutton switches changes the various modes.

The signal-strength meter is a conventional D'Arsonval movement and seems a bit on the generous side. It also points up one area which could stand some improvement. When listening to Morse code transmission, the AGC ac-

*continued on page 103*

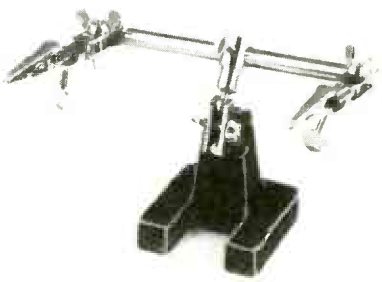
# NEW PRODUCTS

For more details use the free information card inside the back cover

**ASSEMBLY AID,** model *HPCB-15*, is a unique holding stand for aiding all types of electronics and mechanical assembly work. It features two strong alligator clips for reliable holding action, plus quick and easy clamping and release.

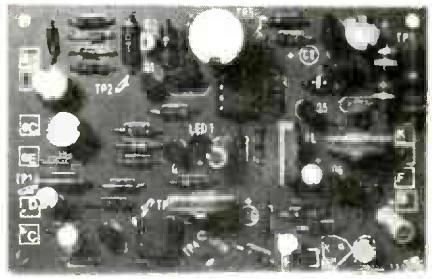
Both clips are mounted in ball joints, and the connecting bar is mounted in a third ball joint, enabling complete articulation and flexibility to suit any task. Finally, all ball joints may be locked in any position, and the entire assembly is mounted in a heavy cast-metal base to provide stability during use. The all-steel construction assures durability.

The model *HPCB* is designed for stuffing PC boards, electronics projects, mechanical work, and model making. It is priced at $7.95.—**OK Machine and Tool Corporation**, 3455 Conner Street, Bronx, NY 10475.



CIRCLE 111 ON FREE INFORMATION CARD

**CONVERSION KIT,** model *DVM-1*, is designed for receiver-to-monitor conversion featuring both audio and video interfaces using special-purpose opto-isolators. The model *DVM-1* will permit the user to operate in either a monitor or receiver mode of operation by selecting a switch position. It can be installed in either black-and-white or color sets, and permits the user to obtain high-resolution displays of up to 80 characters-per-line. It is a direct-video modification which, in the monitor mode, bypasses the tuner and IF sections of a conventional television set and thus provides the user with a high-quality display. Ghosting, color-shifting, and RF radiation and interference problems are eliminated with the direct-video method. The model *DVM-1* will work with all popular TV receivers presently on the market.



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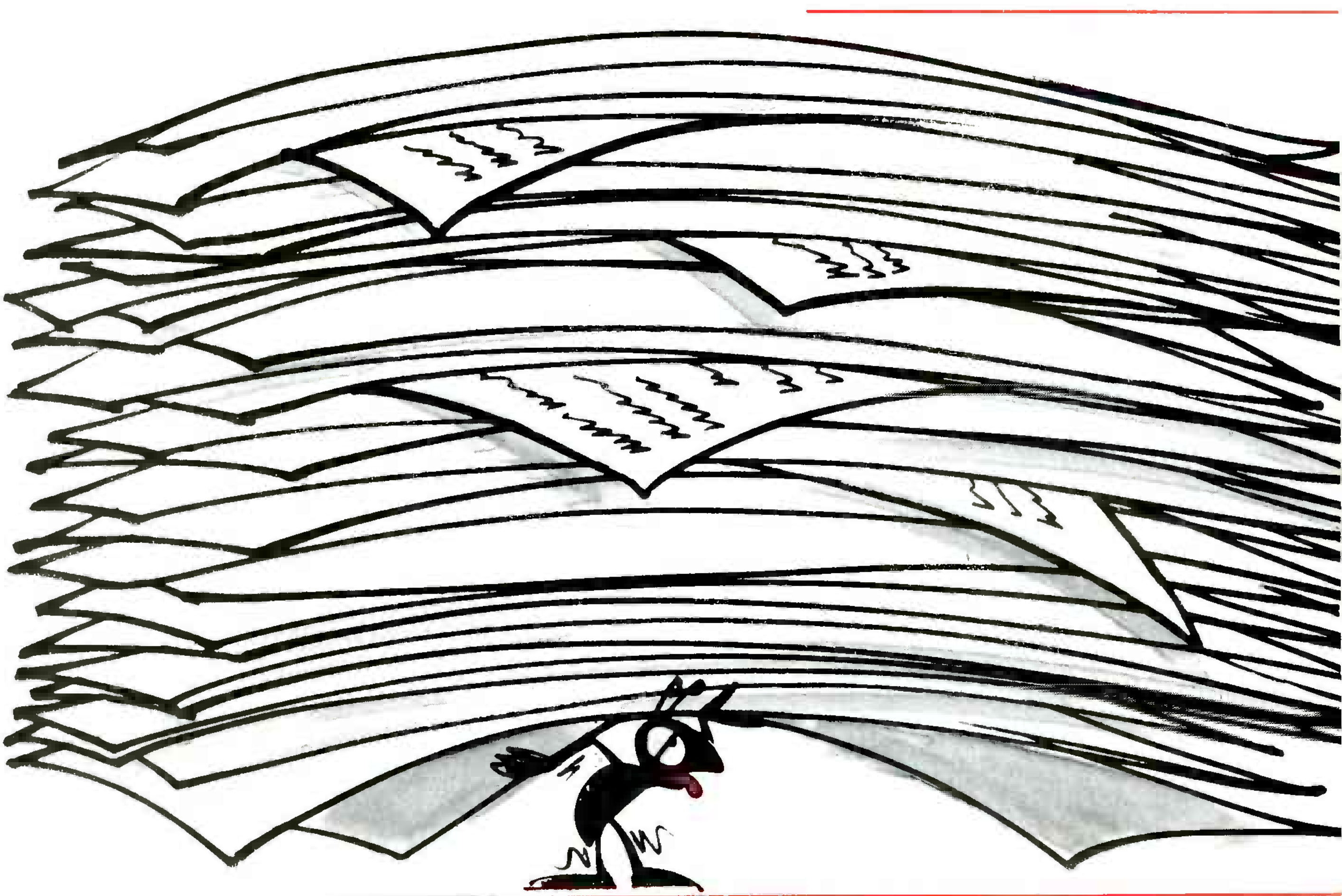
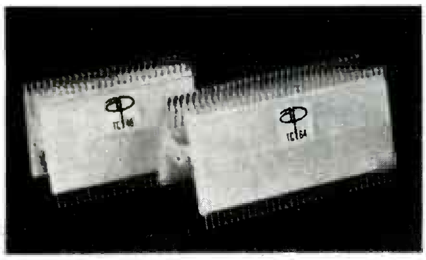


The model *DVM-1* conversion dit is priced at $64.95.—**V.A.M.P. Incorporated,** 6753 Selma Avenue, Los Angeles, CA 90028.

**TEST CLIPS,** model *TC-48* and model *TC-64,* are designed for troubleshooting very large scale integration (VLSI) IC's. They are manufactured with nail-head pins that keep probe hooks from slipping off ends, or with long, headless, test lead pins for connection to AP jumper cable assemblies. They are constructed of thermoplastic molded around contact pins, and feature a long-lasting steel pin and hinge design.



CIRCLE 113 ON FREE INFORMATION CARD

The model *TC-48* fits IC's with .5 to .6-inch row-to-row spacing and is priced at $25.00. The model *TC-64* fits IC's with .9-inch spacing and costs $32.00.—**AP Products Incorporated,** 9450 Pineneedle Drive, PO Box 603, Mentor, OH 44060.

**DMM,** model *DM25,* is a 3½-digit digital multimeter with a basic DC accuracy of ±0.2% of full scale. It will measure DC volts from 0.1 volt to 1000-volts; DC current from 0.1 mA to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200 mA; AC volts from 1 volt to 600 volts, and resistance from 1 ohm to 2 megohms.

Features include overload protection on all ranges, fuse-protected current and resistance ranges (to protect against *excessive* overload), automatic zeroing and polarity, and over-range and low-battery indication. An automatic limiter circuit will allow up to 140-volts AC to be applied on all ohms ranges without blowing the fuse.

The model *DM25* measures 5.4 × 3.4 × 1.4 inches, weighs 10.5 ounces, and has an 0.4-inch display. It is powered by a standard 9-volt battery (included). Also included are safety-type test leads, carrying case, and instructions. Both the battery and the fuse are located in an easy-access compartment; there are no screws to remove.

The model *DM25* is priced at $69.25.—**Universal Enterprises, Inc.,** 14270 N.W. Science Park Drive, Portland, OR 97229.

**POWER SUPPLY,** model *PEC SMPS 65W,* is designed for computers and computer peripherals and can have 3 to 4 outputs, under-voltage protection, a maximum ripple/noise factor of 2% peak-to peak, user-selectable input voltage, and 80% efficiency typical at maximum power at nominal line voltage. Choice of packaging can include PC board, open frame, or enclosed unit.

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The model *PEC SMPS 65-W* is priced at $99.00.—**Power Electronics Corp.,** 96 Milton Road, PO Box 2208, Rochester, NH 03867. **R-E**

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# INSIDE A

# 757-767 COCKPIT

*Microcomputers can fly the Boeing 757/767 airliners from takeoff to landing. Here, we will look at the major subsystems of the Flight Management System and the controls and displays that interface the pilots to the system.*

MARC STERN

**Part 2** WHO WOULD HAVE BELIEVED TEN YEARS AGO THAT IT would one day be possible for an airline flight crew to say in effect, "Look Ma No Hands!!??"

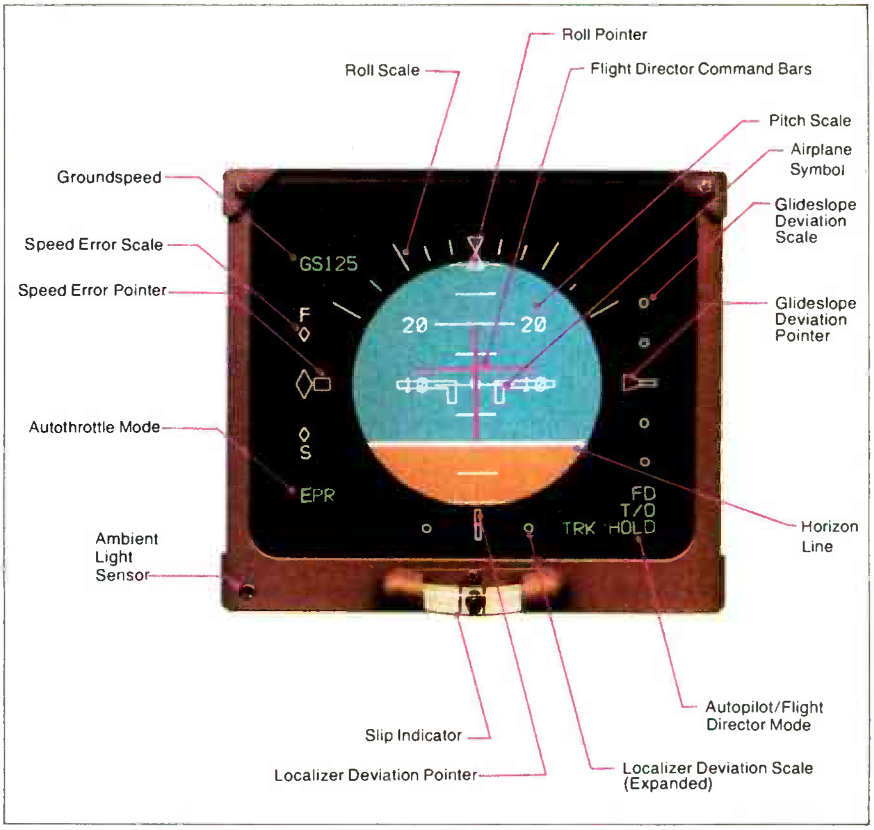
At that time, just to think that a computer could fly an airliner was the realm of science fiction. But, today it's true with the introduction of the sophisticated Boeing 757/767. Why was it done? The reasons are quite obvious. The skies today are more crowded than ever and the cost of fuel is exorbitant. Computers are needed to assist the captain and flight crew in planning not only the safest, but also the most economical route.

Using state-of-the-art microcomputers, the flight crew can fly this airliner from takeoff to landing without using the controls for other than minor corrections. The real "pilot" is the microcomputer-based Flight Management System (FMS), the result of more than 10 years of research.

What can this system do? It can determine correct control surface and engine-thrust settings for any given condition. Further, because of the interactive nature of the system, the flight crew can change the flight configuration, if necessary, with a few button pushes, and the system will then respond by flying the new parameters.

As you can see, with this system the flight crew is freed of many of the arduous tasks it had to perform by hand. This fact was indicated by Henry McGlynn, manager of propulsion control systems engineering for General Electric's Aerospace Control Systems Department in Binghampton, N.Y. His department developed the 757/767 Thrust Management Computer (TMC), one part of the FMS.

The system, as a whole, "takes a load off the pilots' shoulders. Before (the development of the TMC), the pilots carried tables and charts and the work was manually done and complex," he noted. Now with a few button pushes, the same job is done. This is just one example of how the pilots are freed from routine tasks. It enables them to devote more of their time to managing the aircraft.




**THE ADI (ATTITUDE DIRECTION INDICATOR). Flight Director Command Bars, generated by the Flight Control Computer, provide the pilot with steering guidance.**

## Flight management system

The FMS is actually more than just one microcomputer. In reality, it is made up of four major microcomputer-driven subsystems and the Flight Management Computer, the overall commander. The four major subsystems consist of the Flight Control System, the Inertial Reference System, the Emergency Indication and Crew Alerting System, and the Flight Symbol Generation System. (An overall block diagram of the system was presented last month.) The subsystems communicate with one another via a serial communications bus, operating at 12.5 and 100 kHz, which meets ARINC Standard 429.

Using bit-slice technology, the data stream is 32 bits wide. Instructions to and from components of the system are transmitted in 19-bit words, with the rest of the bit package reserved for data and machine address. This type of architecture is confirmed by the fact that the manufacturers of the major subsystems use bit-slice technology, applying 16-bit microprocessors to the task. When two 16-bit microprocessors are used in parallel, they can address a 32-bit data stream. However, the actual structure of the system, since the command microprocessors are 16-bit devices, is 16 bits. Only the communications are handled with a 32-bit path. Each major subsystem also communicates with members of its immediate grouping via the same bus.

According to a Boeing spokesman, system architecture is based on a consensus concept. If all subsystems involved in a task agree, then the task is performed. Further, because of the loose nature of the system, if one component fails, the other subsystems can continue operating. Called fail-soft, this allows safe airliner operation in the event of a major failure.

What all this means is that those systems interact and provide total flight management. It differs markedly from common practice on noncomputerized airliners. Let's look at the key differences between current airliners and the 757/767.

In other aircraft, the captain and first officer must generate their own information using charts, tables, and calculators. This requires a great deal of mental work and detracts from airplane management. In the 757/767, the information is available to the flight crew at the push of a button. It appears on one of the flight deck's five CRT displays.

For instance, if the captain wants to change a parameter in the flight plan he has entered into the FMS, then entering the data via a keyboard and punching the EXECUTE button displays these new parameters on the Control/Display Unit (CDU). That unit is the key interface between the Flight Management Computer (FMC) and the flight crew. (See Fig. 1.)

Essentially, the CDU is a system terminal. It consists of a green-on-black display and an alphanumeric keyboard,

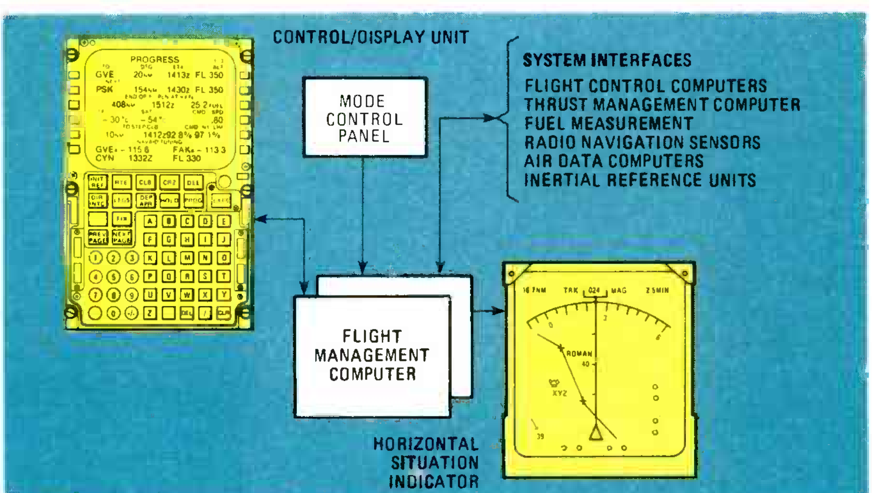
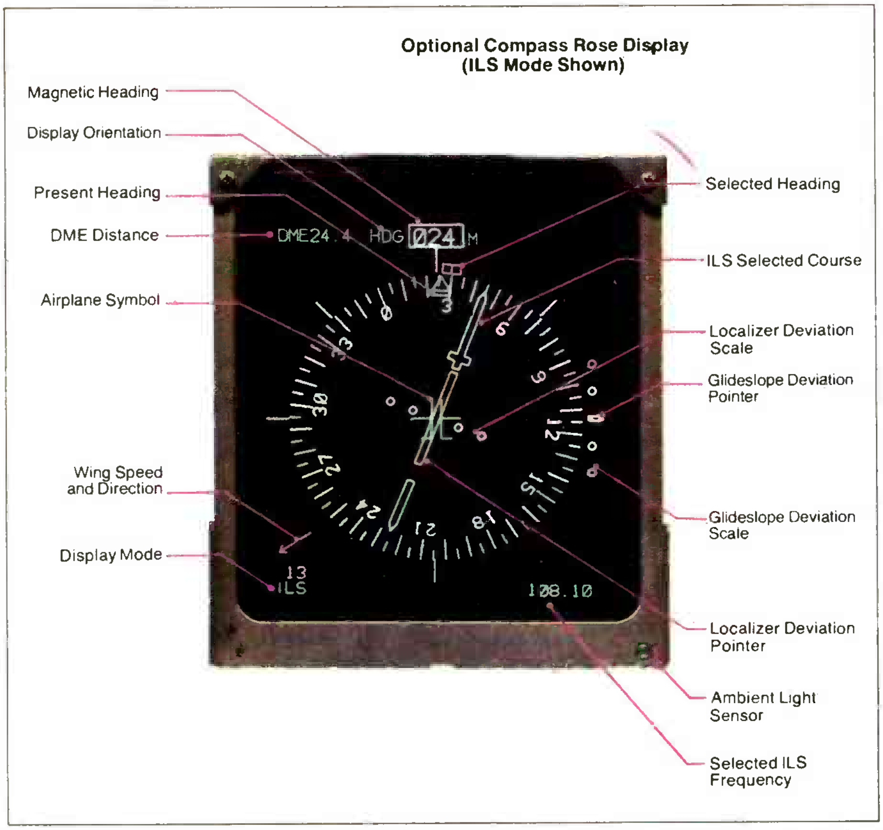



**FIG. 1—THE FLIGHT MANAGEMENT COMPUTER lets the crew concentrate on overall airplane management. It executes all phases of the flight in the most economical way.**




**THE HSI (HORIZONTAL SITUATION INDICATOR). Here it is shown in the Instrument Landing System mode with the optional compass display.**

which also includes 14 special function keys. Instead of using a traditional typewriter-type of keyboard, Boeing opted for one which is alphabet-oriented. (See Fig. 2.)

The special function keys allow one-key access to important information. For instance, if the captain would like to check on the progress of the flight, all he has to do is punch the RTE key on the CDU console located below and to the right of the command seat. This key gives instant access to either of two flight plans entered in the FMC. Using the active flight plan, a press of the key displays the current leg of the flight plan and then reads out its continuation.

The CLB or climb key enables the flight crew to display the current or any planned climb mode. Further, this key also allows the crew to take a look at other climb modes and allows their evaluation. The same is true of the pre-programmed CRZ key, which displays current or any planned cruise mode.

With a touch of the PROG key, the flight crew can monitor current dynamic flight information. This key allows an information readout only. It is presented in page or screen format.

Not only does the CDU provide this information, but as the airliner approaches an airport, it allows the crew to look at arrival procedures with a press of the DEP ARR button. These procedures can be integrated into the overall flight plan. And, as you can see, it also helps to facilitate flight management as the plane readies for landing because the crew no longer has to pore over lists of landing procedures as the airliners approaches the airport. In fact, FMS will handle the landing if the crew opts for that function.

If, however, the airliner is stacked up and put into a holding pattern anywhere during a flight, a push of the HOLD button allows the crew to choose a holding pattern, whether halfway to destination or waiting for landing.

But, even before a landing can take place, there's still the takeoff to deal with and the INIT/REF (initialization/reference) button on the CDU allows the flight crew to initialize both the FMC and the Inertial Reference System. This button also allows the flight crew to access various categories of reference data. It also begins the crew's part of the information process. At that time, the crew enters all the parameters the FMS will use during the flight.

Once the FMC is initialized and the airliner is in the air, the DIR/INTC button enables the crew to use FMC guidance from a current position to any designated geographic point or to intercept a selected course.

Meanwhile, the LEGS button gives detailed information on every leg of a flight plan. Further, this function allows detailed data entry of each leg.

If, during this time the captain or first officer would like information concerning the range and bearing to a particular entered position, one of them can press the FIX key. This function brings up a display of the information and further will cause radials from the fix to be displayed on the Horizontal Situation Indicator (HSI), another of the system's CRT's and the visual roadmap for the flight crew.

While all of this information is neces-

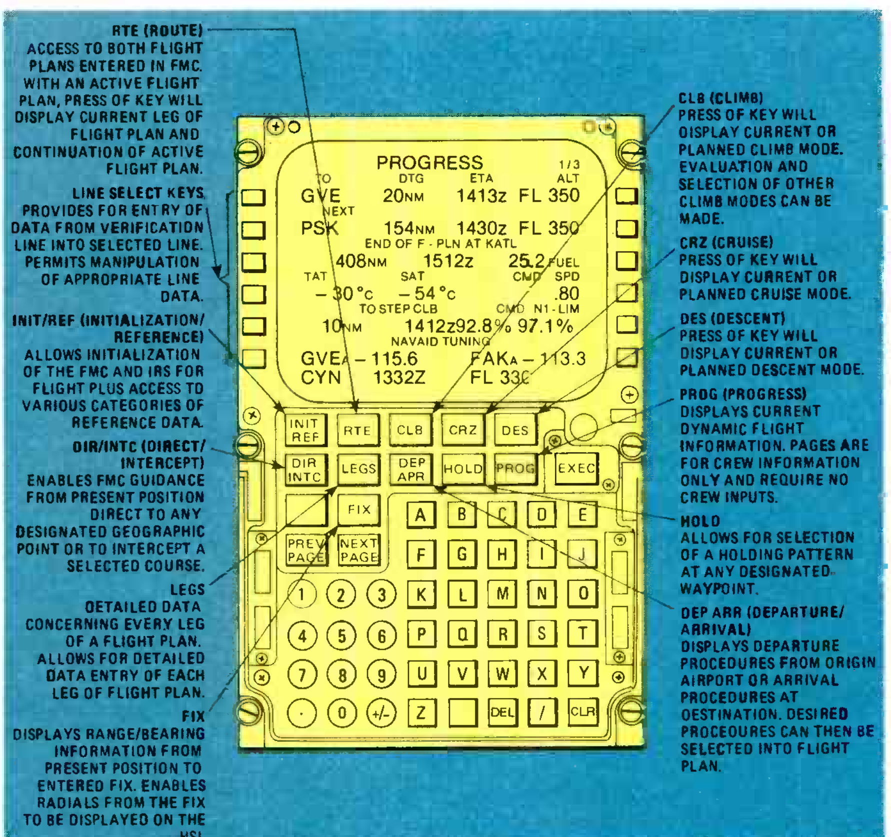



FIG. 2—THE CONTROL DISPLAY UNIT (CDU) gives the pilot complete control of the Flight Management Computer System.

sary for the captain and flight crew, it really wouldn't be much use if they weren't able to manipulate it. That function is handled by six line-select keys on the CDU. In the non-aircraft microcomputer world, information entry and retrieval functions are all pretty much standard fare. Most systems depend on some sort of keyboard for input and most use some sort of command address language. Programmers may use BASIC, COBOL, FORTRAN, or many other languages, while those people using word processing use English. However, the FMC language is unique, but one with which the captain and first officer are quite familiar —Air Traffic Control terminology.

This type of interface puts the FMS and flight crew on familiar terms and it eases the transition to a computerized airliner.

Lying below this human interface mechanism is the FMC itself. It is the master link in the FMS. This microcomputer is able to receive inputs from all the subsystems and is then able to compute its decision. It also commands the subsystems to perform their tasks.

Developed by the Sperry Flight Systems Division of Sperry Rand, headquartered in Phoenix, Ariz., the FMC is driven by a 16-bit processor.

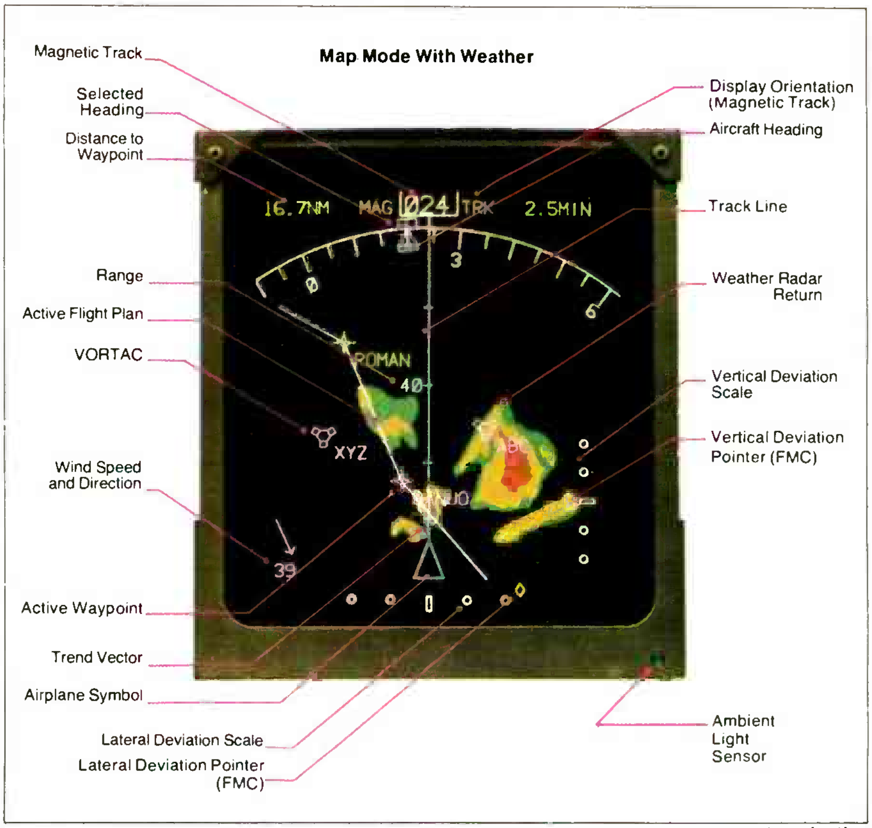
The FMC houses preprogrammed navigation and flight planning information. The program is updated every 28 days and is contained on a 4 megabyte disk. Other information resides in PROM (*P*rogrammed *R*ead-*O*nly *M*emory). This system also has up to 64K of RAM (*R*andom *A*ccess *M*emory), which is a necessity because of the interaction between the FMC and the pilots.

The system receives inputs from other subsystems and determines how best to fly a course. This function is, in turn, determined by a set of cost index parameters that are biased toward time and fuel factors, according to Larry Bowe, head of the engineering department at Sperry Flight Systems.

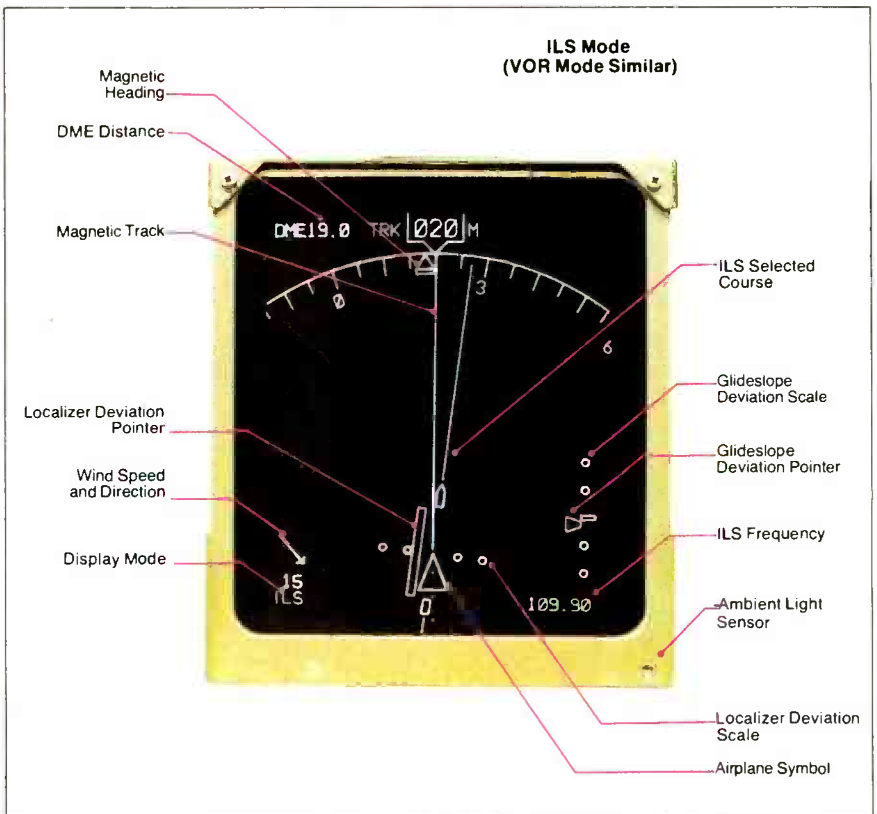
The FMC interfaces directly with the flight control system and the autopilot and it receives positional inputs from both. It then generates a map display on the Horizontal Situation Indicator (HSI) CRT. It also receives inputs from the VHF Omnidirectional Range (VOR) finder and from the Distance Measuring Equipment (DME), which are also used in its computations. When all of the information is digested and weighed by the FMC, it generates the flight readout, which is displayed on the CDU.

As one would expect in a system as critical as this one, there's redundancy for safety. Rather than relying on one FMC for both the captain's and first officer's CDU's, Boeing and Sperry designed the system so each unit is driven by a separate microcomputer. In this way, should one of these units fail, the other can be used to fly the aircraft.

Reliability is also a feature of this unit.




**IN ITS MAP MODE, the Horizontal Situation Indicator shows the desired flight path and navigation features.**




**THE HORIZONTAL SITUATION INDICATOR shows the airliner's relation to the selected ILS course.**

Bowe estimated the mean time between failures is 6,000 hours and since an air liner operates about 3,000 hours per year, the average time between failures will be on the order of two years.

As important as the CDU is for interfacing the Flight Management System and the flight crew, there's another key interface at the top of the pilots' glareshield, the Mode Control Panel. (See Fig. 3.) This system not only interfaces with the Flight Management Computer, but also the TMC and the Flight Control Computer (FCC) and the Inertial Reference System. The Inertial Reference System is shown in Fig. 4.

It is with this panel that the flight crew inputs such parameters as air speed, rate of climb and ultimate altitude. This panel provides a central area for all autopilot control selections and modes. Those functions include the autopilot, autothrottle and flight director. It is from this panel that the flight crew also has access to a backup landing option in the event of a major system failure.

The Mode Control Panel also initiates automatic tracking of the Flight Management Computer's flight plan in either the lateral or vertical planes.

### Thrust management computer

Another panel, beneath the Mode Control Panel—the Thrust Mode Select Panel—also interfaces with TMC.

Mounted in two line replaceable units, the TMC is responsible for determining and setting correct engine parameters after the flight crew makes its determinations of such variables as speed, altitude, heading, climb rate and whether the airliner is in a takeoff or cruise mode. These figures are entered through the Mode Control Panel. The TMC also looks at other variables and reports to the FMC and Engine Indication and Crew Alerting System (EICAS), which displays engine information on a color CRT.

Further, the TMC also acknowledges the crew's engine operational choices entered via the Thrust Mode Control Panel. This unit gives the pilot the ability to derate the engines from the TMC settings for better fuel economy. It further allows him to override the system for emergency power.

Proper thrust control is of primary importance to the air lines, explains McGlynn. If an airliner's engines run too hot it wears them out much more quickly than if the settings were cooler. Also, in this condition the engines use more fuel.

So, the primary function of this system is to limit engine thrust according to the aircraft's flight condition, height and temperature. This system also functions to bleed off engine power for such functions as cabin air conditioning and deicing.

TMC also aids in an important display function. Since it is involved with vertical navigation and flight level changes, its inputs, along with those from those of the Mode Control Panel, help drive the Attitude Direction Indicator (ADI). This instrument tells the flight crew whether the airliner is in level flight, climbing, descending or banking. This indicator is familiar to many fliers as the floating ball airplane whose wings have to be kept level with the artificial horizon.

Driven by a 16-bit General Electric MCP-701A 16-bit fixed point processor, the TMC is an accumulator-based system designed specifically for avionics control products. When it was first designed, this system relied on medium-scale integration and bit-sliced system architecture to achieve the same goal the one-board system now handles. However, the 701A allows GE to keep the system unit to one motherboard.

The microcoded instruction set emulates the one that is found in one of the nation's most sophisticated fighters, the F-18. Programmed in machine language, much of the memory is Read-Only Memory (ROM)-based. However, there is a small scratchpad area of Random Access Memory for storage of current flight information.

Via its transmitters and receivers, this system interfaces with the Air Data Computer, which computes air speed, wind speed and delivers these inputs to the system; the Thrust Mode Select Panel; the Flight Management Computer, and the throttles. Performance management functions are performed in concert with the FMC and the autopilot/flight director system.

The Mode Control Panel, also driven by a microprocessor, also interfaces with another of the major microcomputer subsystems of the FMS, the Flight Control Computer (FCC).

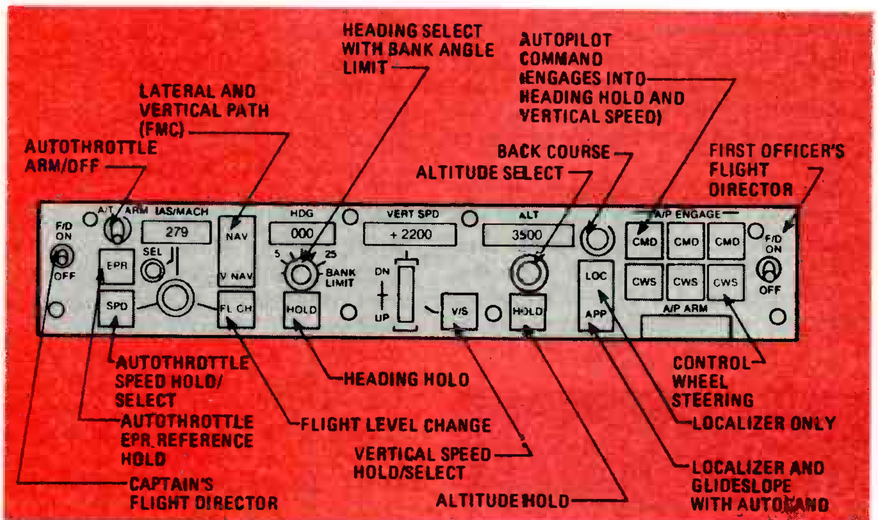



FIG. 3—THE MODE CONTROL PANEL is the centralized location for all autopilot-control selections and modes.

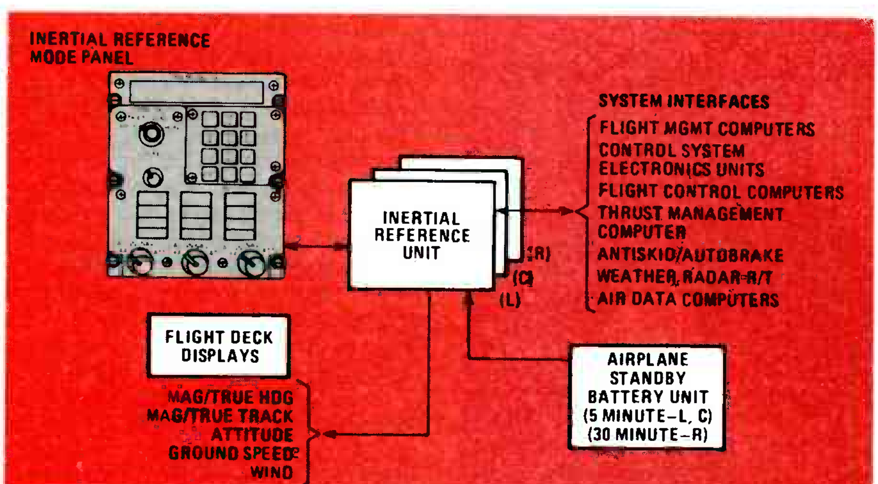



FIG. 4—THE INERTIAL REFERENCE SYSTEM uses Ring Laser Gyros. It can align its reference axes to true north by analyzing the spin vector generated by the earth's rotation.

### Flight control computer

Its primary functions are controlling vertical speed, providing takeoff assistance and integrated autopilot and autothrottle speed control, autolanding and autorollout control, and heading and altitude control.

In reality, the Flight Control Computer acts on the airliner's control surfaces. After receiving the inputs from the Flight Management Computer, inertial reference units, Air Data Computers, radio altimeters, instrument landing receivers, air-ground logic unit and the airspeed indicators, it sets those surfaces—elevators, ailerons and rudder—for each flight condition. (See Fig. 5.) If, for instance, the Flight Management System is programmed to climb at a certain point, the FCC will respond with settings for the climb.

Responsible for developing the FCC was Rockwell International's Collins Air Transport Division in Cedar Rapids, Iowa. This division also developed the circuitry for the highly advanced Electronic Flight Instrument System (EFIS), EICAS, the ADI and HSI displays. Those systems provide the key visual and warning indications for the entire Flight Management System.

Access to the various EFIS controls is obtained through the EFIS control panel. As with other system control panels on this aircraft, there are separate panels for the pilot and first officer.

The upper section of the panel controls the ADI and allows the pilot to enter his decision height prior to making an approach. This number is automatically displayed on the ADI during the approach and automatically shifts to a DH display when this height is reached. The lower section controls the HSI and allows the pilot to select a display mode.

If MAP or PLAN are chosen, then the display will be scaled according to the maximum range chosen by the RANGE knob. The MAP mode displays the map oriented along the current track of the airliner, while PLAN displays a north-up orientation. Buttons on either panel control access to supplementary navigation information. This information is then displayed on the color CRT's in front of the flight crew.

Those cólor displays are very sophisticated instruments themselves. Using 16-bit 8085 microprocessors, the CRT's are capable of high-level graphics. For instance, the ADI combines both CRT and electromechanical functions to present the flight crew with a picture of the airliner's attitude. The traditional ball-type of ADI indicator is combined with a surrounding CRT for quick information updates.

Further, the CRT displays the groundspeed, autothrottle mode, autopilot-flight director mode, glideslope deviation and localizer deviation scale. It is quite an advance over traditional ball-only mechanisms and centralizes these functions on one screen, instead of in several places on the instrument panel. As one can easily see, this eases the work of the flight crew.

## Other displays

A color CRT, the HSI presents the crew with a look at the horizontal position of the aircraft in relation to the flight plan. Further, it displays a map of navigation features and aircraft track. This map also shows where the airliner will be turning and the desired flight path. Also, it indicates where the aircraft is in relation to a desired position.

This type of display allows rapid and accurate flight path correction and maneuvering by the pilots, if needed.

Further, it gives the flight crew other needed information such as wind speed and direction, lateral and vertical deviation from the selected flight profile and distance to a waypoint. This information is selectable as desired by the captain or first officer.

Since the HSI is programmable, the captain and first officer can adjust the composition of the display to suit their specific needs. Color weather radar displays may be selected and presented at the same scale and orientation as the map, as well as navigation aid information and airport and ground reference symbols. There's even the option of displaying speed, altitude, and time of arrival for each flight path waypoint.

All of these functions are possible thanks to the programmability of the system. For instance, if the captain or first officer chooses the VOR or Instrument Landing System (ILS) mode on the EFIS panel, then the HSI shows the relationship of the airliner to a selected VOR or ILS course. This information is displayed in a similar format to current electromechanical devices. This last feature, alone, should help insure that even a newcomer to the system will feel comfortable with it. Again, weather radar displays can be overlaid on this display.

An optional compass display, which combines many of the features of the other displays, can also be chosen, if the airline operating the aircraft chooses to have it.

A similar type of Collins-developed system is used for the EICAS function of the FMS.

Set dead center in the instrument panel, EICAS monitors display not only engine parameters, but also give the crew warnings in the event of a problem with the aircraft. Urgent messages are displayed in red on the color CRT's, while less urgent messages are displayed in yellow. Aural warnings are also provided.

Access to this system is through the EICAS control panel, located directly below the pair of CRT's. An uncluttered panel, the pilot or first officer can have access to a full readout with the push of the ENGINE button. In normal operation, EICAS only displays primary engine readouts. When either flight officer pushes the STATUS select button, the lower EICAS display will show data relating to the status of the airplane including such information as hydraulic fluid levels and control surface positions. On the ground, these monitors will display maintenance information to technician. The flight crew has no control over this information.

Interestingly, this system was developed with an eye toward keeping costs down. If an HSI CRT should fail, it can be replaced with one of the EICAS monitors. Further, the entire EICAS system, which consists of two color CRT monitors, two EICAS computers, supplementary caution and warning annunciator and a standby liquid crystal engine indication display, consists of only six line-replaceable units. These are units which can be easily replaced by maintenance technicians right on the flight line. That contrasts with more than 40 in other standard airliners.

Even with all this computerization, you can again see the level of safety backup. If EICAS system should fail completely, then the LCD provides the flight crew with the information it needs to continue flying the aircraft. **R-E**

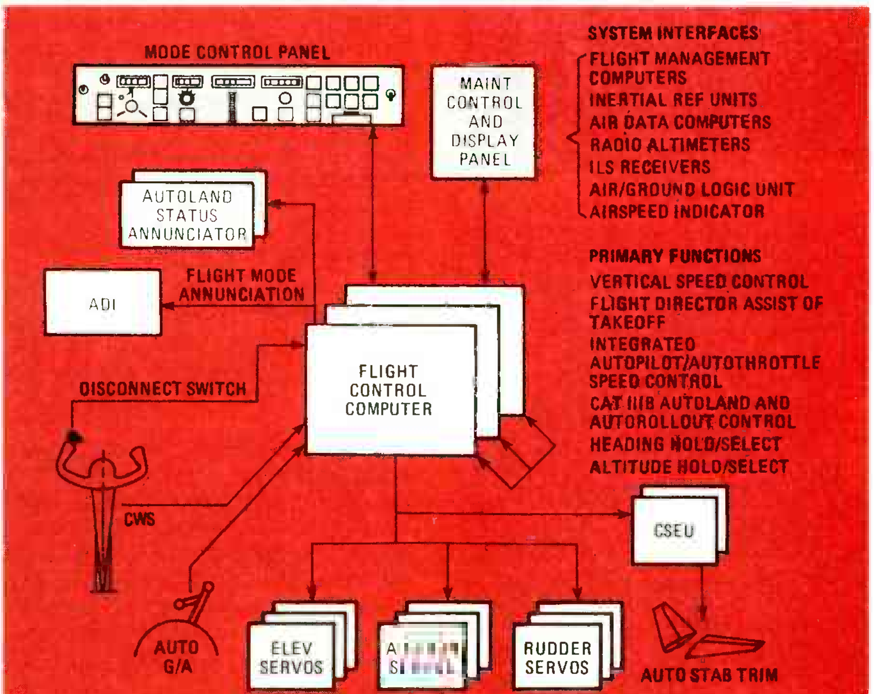
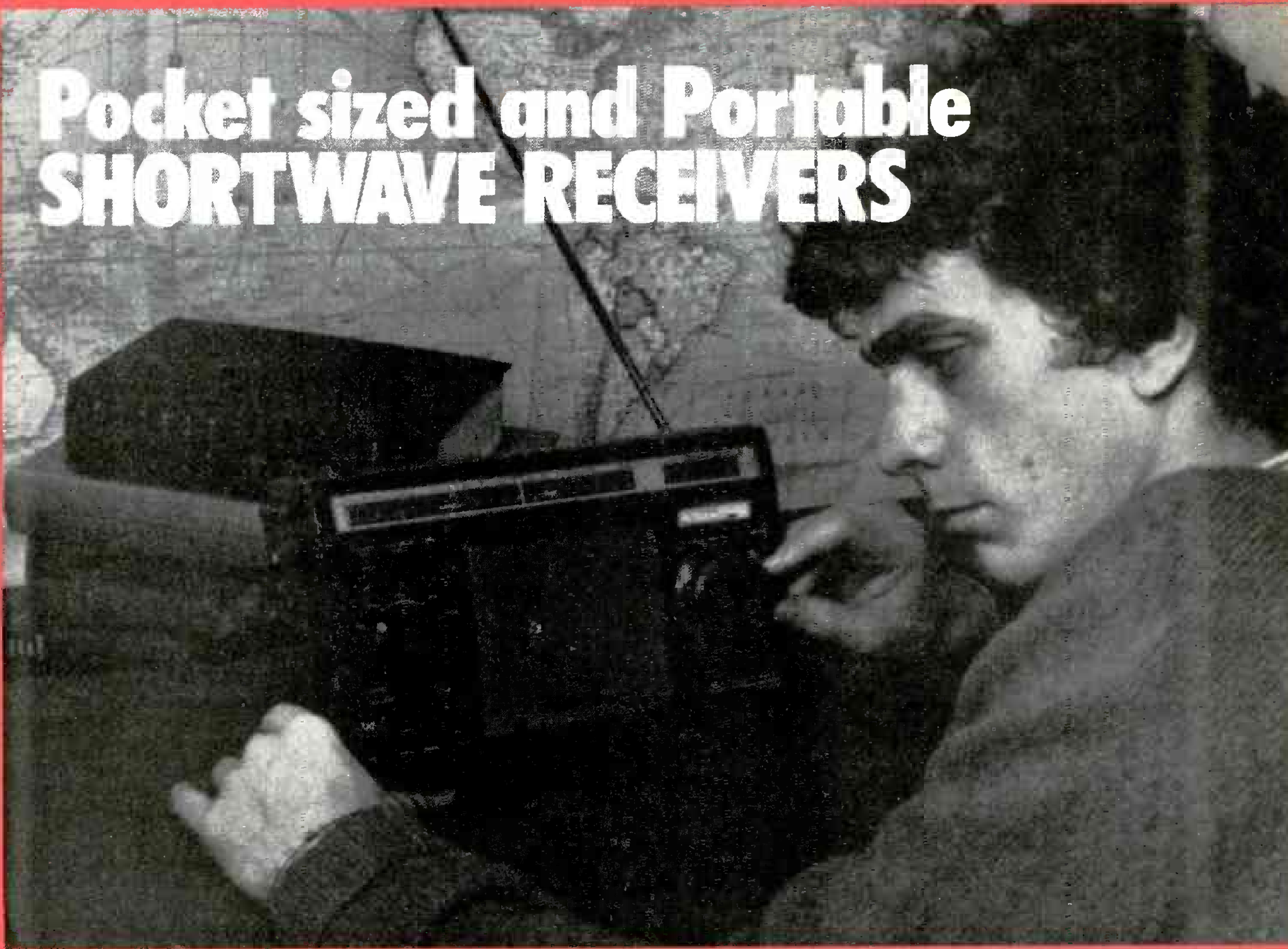



FIG. 5—THE FCC (FLIGHT CONTROL COMPUTER) receives inputs from many systems, including the Flight Management System, The Thrust Management Computer and the Inertial Reference system.



# Pocket sized and Portable SHORTWAVE RECEIVERS

*The newest generation of portable shortwave receivers offers features and performance previously found only on top-of-the-line table models. Here's a look at what's available, and what these small powerhouses can do.*

**DANNY GOODMAN**

IT WASN'T MANY YEARS AGO THAT shortwave listening was a hobby enjoyed only by technically capable individuals who had tabletops full of complicated receiving equipment. But that has changed dramatically over the past year or two as advanced semiconductor technology has found many applications in portable communications receivers, making them as easy to use as your TV set.

Today, affordable portable shortwave radios offer features previously available only on professional-quality equipment costing many thousands of dollars more. And some of the newest portables use integrated circuits and miniature components, allowing the sensitive electronics to be housed in cases that are small enough to fit in your pocket.

### The shortwave spectrum

By international agreement, users of the high-frequency (shortwave) spectrum (3.0-30.0 MHz) confine broadcasts intended for general listeners to several segments of the spectrum, called bands. Each band is identified by both its frequency and its wavelength (in meters) as shown in Table 1. Thus, the shortwave broadcast band that begins at 9.5 MHz is also called the 31-meter band, while the band of frequencies that begin at 17.8 MHz is called the 16-meter band (see Table 1). You'll note, of course, that as the frequency increases, the wavelength decreases.

The thing that makes shortwave listening so fascinating, however, is that under certain conditions a transmitted signal can be heard halfway around the world. That's because signals with frequencies below 30 MHz are reflected by the ionosphere. That phenomenon makes long-distance shortwave listening possible.

Because the ionosphere is strongly affected by the sun, the nature of that reflection—and hence, how far away the signal can be received—depends mainly upon the time of day and time of year. What that means is that not all frequencies are useful for broadcasting at all times. What's more, various factors can make conditions unstable even on a day-to-day basis. Radiation from the sun (more accurately, from sunspots) changes daily (and, on a larger scale, over an approximately 11-year cycle), adding uncertainty as to how well a signal will be received in a particular area. Signals may be strong on one frequency today, suffer from periodic fading tomorrow, and occasionally be almost inaudible. The last occurs especially during sudden ionospheric disturbances.

Broadcasters study radio-wave propagation carefully to help plan the times and frequencies for their broadcasts.

Equipped with predictions from propagation scientists, station planners may choose several frequencies in more than one band to make sure that a target area is adequately served during the season, no matter what the daily propagation variances may be. Then, even if they have correctly predicted the proper bands, they must hope that other broadcasters choose frequencies in those bands so that neither one interferes with the other. That is a far cry from the fixed-frequency allocations of our own AM and FM broadcast bands, which are strictly regulated by the Federal Communications Commission.

### Tuning in

To help SWL's keep track of broadcaster's schedules, the *World Radio TV Handbook* (WRTH) is like an annual *TV Guide* updated three times a year by a subscription newsletter. The WRTH is the most comprehensive listing of radio and television stations from practically every country in the world. Included with each listing is the mailing address for each of the stations, many of whom have detailed schedules available on request.

Once you know the time and frequency of a program you'd like to hear, you'll need to tune your receiver precisely to that frequency. However, on many multiband radios with shortwave capability, the shortwave spectrum may be divided into only two or three sections. The tuning rates—how big a chunk of the spectrum is covered with a single revolution of the tuning dial—of those receivers are inadequate for the number of stations you can tune in one revolution of the dial.

Consider, for example, that the entire AM broadcast band (0.550-1.600 MHz) is slightly more than one megahertz wide, and takes up the entire width of the tuning dial. That makes for comfortable tuning, given the local station spacing of 30 kHz or more. But a tuning range marked SW1 on a portable radio may use the same tuning dial space to cram nine megahertz; 3-12 MHz is a common range and it includes four complete shortwave broadcast bands, where crowded nighttime conditions will often find stations within 5 kHz of each other. Just tuning from station to station requires surgeon-steady hands for turning the dial just a small fraction of a degree. And trying to find 11.750 MHz accurately with a tuning dial on which the pointer covers a third of the band is practically impossible.

Another drawback to those types of receivers is that they are not necessarily optimized for shortwave reception and are, therefore, not particularly sensitive to stations other than the powerhouses. Nor are their circuits selective enough to eliminate interference from strong stations on frequencies close to that of the desired station. Many of them also are unable to tune above 16 MHz, cutting listeners off from two daytime shortwave bands, 16 and 13 meters.

Today, however, You can buy portable shortwave radios that overcome most of those deficiencies, making shortwave listening more enjoyable for the casual listener. Less time is spent twiddling with the radio, and more time is spent listening to the program.

Today's receivers fall roughly into

**TABLE 2—PORTABLE SHORTWAVE RECEIVERS**

| Type | Brand/Model No. | Price | LW | AM | FM | SW Coverage (MHz) |
|---|---|---|---|---|---|---|
| Pocket-sized | Panasonic *RF-085* | $ 89.95 | N | Y | Y | 2.3 – 18 |
| | Sony *ICR-4800* | 89.95 | N | Y | N | 5.95 – 6.2 |
| | | | N | N | N | 9.45 – 9.85 |
| | | | N | N | N | 11.70 – 12.00 |
| | | | N | N | N | 15.10 – 15.50 |
| | | | N | N | N | 17.60 – 18.00 |
| | Sony *ICF-7600A* | 159.95 | N | Y | Y | 5.95 – 6.20 |
| | | | N | N | N | 7.10 – 7.30 |
| | | | N | N | N | 9.50 – 9.80 |
| | | | N | N | N | 11.70 – 12.00 |
| | | | N | N | N | 15.10 – 15.45 |
| | | | N | N | N | 17.70 – 17.90 |
| | | | N | N | N | 21.45 – 21.75 |
| Digital readout | General Electric *7-2990* | 235.00 | N | Y | Y | 2.3 – 31 |
| | Magnavox *AL999* | 299.95 | Y | Y | Y | 1.6 – 26.2 |
| | Panasonic *RF-2600* | 239.95 | N | Y | Y | 3.9 – 28 |
| | *RF-2900* | 299.95 | N | Y | Y | 3.2 – 30 |
| | *RF-3100* | 319.95 | N | Y | Y | 1.6 – 30 |
| | Sony *ICF-6500W* | 199.95 | N | Y | Y | 3.9 – 28 |
| | *ICF-6800W* | 699.95 | N | Y | Y | 1.6 – 30 |
| | *CRF-1* | 1,795.00 | Y | Y | N | 1.6 – 30 |
| | *CRF-330K* | 2,495.00 | Y | Y | Y | 1.6 – 30 |
| Microprocessor-controlled | Magnavox *D2924* | 179.95 | Y | Y | Y | 5.95 – 15.45 |
| | Panasonic *RF-799* | 249.95 | Y | Y | Y | 2.3 – 26.135 |
| | *RF-6300* | 749.95 | Y | Y | Y | 1.6 – 30 |
| | *RF-9000* | 3,800.00 | Y | Y | Y | 1.6 – 30 |
| | Sony *ICF-2001* | 349.95 | Y | Y | Y | 1.6 – 30 |

**TABLE 1—BROADCASTING BANDS**

| Meter Band | Megahertz |
|---|---|
| 120 | 2.30 — 2.50 |
| 90 | 3.20 — 3.40 |
| 60 | 4.75 — 5.06 |
| 49 | 5.95 — 6.20 |
| 41 | 7.10 — 7.30 |
| 31 | 9.50 — 9.78* |
| 25 | 11.70 — 11.98* |
| 19 | 15.10 — 15.45* |
| 16 | 17.70 — 17.90* |
| 13 | 21.45 — 21.75* |
| 11 | 25.60 — 26.10** |

*This band will be expanded in the late 1980's or early 1990's.
**This band will be decreased in the late 1980's or early 1990's.

The Magnavox model *AL999*.

G-E model *7-2990* six-band portable.

| Size (inches) | Wght. | BFO | Wide/Narrow Filters | Dual Conversion | Tuned RF Amplifier |
|---|---|---|---|---|---|
| 4 7/16 × 6 15/16 × 1 1/4 | 17 oz | N | N | N | N |
| 2 15/16 × 5 1/4 × 7/8 | 8 oz | N | N | N | Y |
| 4 5/8 × 7 1/8 × 1 1/4 | 22 oz | N | N | Y | Y |
| 14 5/8 × 10 3/4 × 6 | 8 lbs | Y | Y | Y | Y |
| 13 × 9 × 4 1/4 | 8 lbs | Y | Y | Y | Y |
| 9 3/8 × 13 1/2 × 4 9/16 | 7lbs, 4oz | Y | Y | Y | Y |
| 9 11/16 × 15 × 4 3/4 | 8lbs, 10oz | Y | Y | Y | Y |
| 4 3/4 × 14 9/16 × 9 1/2 | 7lbs, 1oz | Y | Y | Y | Y |
| 6 1/2 × 11 3/8 × 4 | 4lbs, 1oz | Y | N | Y | N |
| 7 1/4 × 17 7/8 × 9 | 13 lbs | Y | Y | Y | Y |
| 10 1/4 × 4 × 13 1/8 | 14lbs, 9oz | Y | Y | Y | Y |
| 13 1/2 × 17 3/4 × 8 1/8 | 33lbs, 15oz | Y | N | Y | Y |
| 9 1/4 × 6 × 2 1/4 | 5 lbs | N | N | N | |
| 6 9/16 × 10 15/16 × 2 5/16 | 3lbs, 7oz | N | N | S | Y |
| 11 7/16 × 17 1/8 × 5 3/16 | 11lbs, 7oz | N | N | Y* | Y |
| 20 9/16 × 14 5/32 × 8 1/32 | 50lbs, 11oz | Y | Y | Y* | Y |
| 6 3/16 × 12 13/16 × 2 3/16 | 4lbs | Y | N | Y | Y |

*For most shortwave bands, single conversion for others.

three categories: sensitive pocket portables with analog (slide-rule) tuning; those with simple digital frequency readouts, and those with microprocessor-controlled phase-locked-loop (PLL) tuners. Table 2 lists some of the units currently available.

### Shirtpocket shortwave

Among the small shortwave portables, Sony's *ICF-7600A* is a good example of an easy-to-use receiver even though it features an analog, rather than digital, tuning-system.

The receiver covers the local AM and FM bands, plus seven shortwave bands from 49 to 13 meters in a most useful way: Each shortwave-broadcast band has its own tuning range. That spreads out the stations within a given band so that tuning is not so critical. Moreover, you are better able to tune to a specific frequency with the help of dial markings spaced every 50 kHz.

The receiver covers the 49- through 11-meter bands. That coverage, plus a bit of tuning above and below those ranges, includes most of the English-language stations you'll want to hear. Some broadcasts, however, like Radio Peking's clear frequency of 15.52 MHz (one of several frequencies) and a growing number of stations above 12.0 MHz, are outside the internationally agreed bands, and the tuning range of the unit.

Miniaturization plays a big role in the circuit design of that small receiver. Each shortwave band has its own crystal oscillator for tuning stability. It uses dual-conversion (two intermediate frequencies) superheterodyne circuitry on shortwave for good sensitivity and to help reduce unwanted images from interfering with the station you want to hear—a common problem in small portables. It also features a tuned RF amplifer to help insure that the best possible signal-to-noise ratio is obtained. There is even a ceramic filter to help limit interference from stations on adjacent frequencies, thus improving selectivity. While the performance of a radio its size—even with all its "big radio" features—won't measure up to table-model standards, that receiver holds its own rather well against many of the receivers listed in Table 2.

The *7600A's* little brother, the Sony *ICR-4800* is one of the smallest portable shortwave receivers available, measuring 5 1/4 × 2 15/16 × 7/8 inches. It features Am broadcast and five shortwave bands: 49, 31, 25, 19, and 16 meters, the ones most popular with broadcasters. The tuning range of some bands is a little wider than that offered by the *ICF-7600A*, making it possible to pick up more of those broadcasters who are slightly "out of band."

What neither of those receivers can tune, however, is the standard time signal station, WWV, a service of the National Bureau of Standards in Ft. Collins, CO. Usually audible on 5, 10, 15, and 20 MHz, a voice announces the time (with atomic clock accuracy) on the minute, plus severe ocean-storm warnings and radio-propagation forecasts at appointed times during the hour. The paperback-book-sized *RF-085* from Panasonic does allow you to receive WWV as it provides continuous tuning from 2.3 to 18 MHz (120 to 16 meters) over three bands. But, although it is remarkably sensitive for its small size, a beginning SWL may find the cramped and inexact shortwave band tuning a bit frustrating at times.

With those small radios—all of them wonderful travel companions—you'll have adequate signal quality under most conditions with the built-in telescoping antennas. Reception can often be improved by placing the radio as close to a window as possible, or by adding an external antenna, as discussed later.

### Digital readout

Another recent advance in portable-receiver technology is the addition of digital frequency-readouts to assist in tuning. The units offering that feature are anything but pocket sized, yet once you've experienced the convenience of such a readout, you won't want to return to the analog style unless you need to travel very light. With the digital display, there is no guessing whether you have the correct frequency. If you know that Swiss Radio International begins transmitting in English on 9.725 MHz at 0145 Greenwich Mean Time (8:45 pm EST), then

Panasonic's model *RF-085* five-band receiver.


The Sony nine-band *ICF-7600A*.

simply dial up 9.725 on the readout a few minutes before, and you'll be ready for the start of their broadcast. Digital-readout receivers are available with vacuum fluorescent displays (which consume a lot of battery power but can usually be turned off when not needed for tuning), or liquid crystal displays (LCD's). The latter require a backlight for viewing under low-light conditions.

General Electric's *7-2990* is a new receiver in this category. The GE receiver offers AM, FM, and four bands of shortwave tuning giving you continuous coverage from 2.3 to 31 MHz. That means you can hear all shortwave broadcast bands as well as amateur radio and commercial bands. Frequency can be read on either an analog- (slide-rule type) or vacuum-fluorescent digital-display. In that receiver, as in others in its class, the digital readout is provided by adding a frequency counter (with some modifications) to a standard analog shortwave receiver. An SW CALIBRATOR control on the front panel helps you align the receiver and the counter by tuning to a frequency standard like WWV.

The unit features dual conversion as well as a tuned RF amplifier. Another control you'll notice on that type of receiver is a WIDE/NARROW bandwidth switch. The intent of a narrow bandwidth is to reduce the amount of interfering signals on either side of the desired signal from reaching the speaker or headphones. Ideally, a narrow setting should keep out extraneous signals. But in practice, portable-receiver bandwidth filters are generally not as effective as those used in more expensive table radios. The wide setting may be fine for local AM stations with their healthy frequency spacing between stations, but is impractical for tightly spaced shortwave stations. Among today's portables, the *Sony CRF-1* has the most effective narrow bandwidth, according to specifications, but its price is out of reach for many.

The Panasonic *RF-3100* is one of a new generation of portable receivers. Adapting a technique used in expensive table-model communications receivers, the unit features PLL frequency synthesis—a sign of a very stable tuning section. Even solid-state receivers can be unstable and drift off their original frequency, particularly during the first 10 minutes of operation. They may also suffer from mechanical instability—just lightly tapping the receiver case with a finger will make the unit change frequency. But a PLL synthesized tuner "locks" onto the desired frequency. Nowhere is that more appreciated than when tuning single sideband (SSB) amateur radio or commercial stations. Successfully tuning those stations requires that the receiver's beat frequency oscillator (BFO) be engaged and tuned to the signal's natural voice pitch. The slightest drifting will raise or lower the voice's pitch beyond intelligibility.

To tune, say, 15.260 MHz on the *RF-3100*, you first turn the rotary BAND switch to the 15-MHz band, and then tune the large tuning knob until the last three digits on the display read 260. The tuning range is divided into 29 one-megahertz bands, plus AM and FM. Sometimes, as when you're just tuning through the spectrum to see what you can pick up, that one-MHz stepping can be just a little inconvenient because, if you want to tune continuously, you must whirl the tuning knob back to the beginning of the band every time you increment from one range to the next.

The *RF-3100*, like many other portables its size, comes with a soft shoulder strap for the SWL on the go; it can be removed if the receiver stays mostly at home.

### Computerized shortwave

The third type of portable receivers we will discuss takes the concept of PLL tuning a step farther. In those, microprocessors control the PLL circuit. The tuning knob, as we've known it, doesn't even exist. Instead, pushbutton keyboards let us "punch in" the frequency we want to hear. If we want to casually tune up or down the band looking for stations, we just push an appropriately marked button and the synthesizer will step up or down in frequency under microprocessor control until the button is released. The microprocessor can also store favorite frequencies in memories; those can be instantly recalled by just pressing a button.

The first affordable pushbutton shortwave was Sony's *ICF-2001*. More recently, Panasonic and Magnavox have added "smart" portables to their shortwave lines.

The Magnavox *D2924*, though offering only limited shortwave band coverage (49 through 19 meters), has a number of features useful for the shortwave neophyte and veteran as well. The radio has essentially four broad bands: longwave, AM, shortwave, and FM, each selected by pushbutton. In the shortwave mode, each press of the SW SELECTOR button puts the receiver at the lowest frequency in one of the five international broadcast bands. An indicator on the LCD display shows which band you're tuned to. From the bottom of each band, you can either tune up or down in steps with the corresponding manual tuning buttons, or have the receiver search the band for a strong signal. Pressing SEARCH silences the receiver's audio as the radio's frequency display shows where it's tuning. If a strong signal is detected, scanning stops on that frequency, and the audio is restored. If the station is not what you want to hear, press SEARCH again, and the tuner will quietly continue up the band. When it reaches the top band edge, it re-starts the search from the bottom. If no signals are found, the receiver searches twice more, just in case a station had briefly faded out when the tuner first raced by. If no signals are heard after three passes, the receiver then goes back to the lower band edge, awaiting further instructions.

Just because no strong stations were found in the SEARCH mode, doesn't necessarily mean there aren't weaker stations on the band that could be tuned manually. But for inexperienced listeners, using the SEARCH mode is one way to hear a variety of signals without a lot of extraneous signals to distract you along the way.

If, on the other hand, you know what frequency you want to tune, simply press KEYBOARD (which tells the microprocessor that you're about to enter a frequency on the keyboard) and key in the frequency. With the *D2924*, you can also store up to six frequencies from any band in the radio's memories using a simple two-button sequence. When you're tuned to one of the stored frequencies, the memory number appears on the LCD display along with the frequency. With receiver memories, you can switch instantly back and forth among broadcasters transmitting on different bands at the same time. Of if you have a set sequence of programs

*continued on page 102*

### SOURCE LIST

**General Electric Company**
Audio Electronics Products
Syracuse, New York 13221

**Magnavox**
N.A.P Consumer Electronics Corp.
I-40 & Straw Plains Pike
Knoxville, Tennessee 37914

**World Radio TV Handbook**
c/o Watson Guptill
1515 Broadway
New York, New York 10036

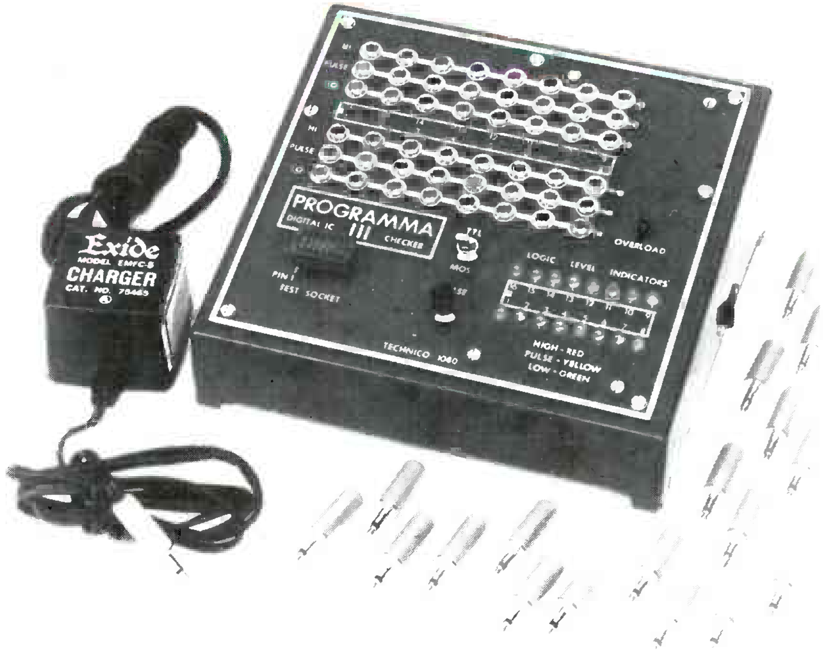
**Gilfer Shortwave**
Box 239
Park Ridge, New Jersey 07656

**MFJ Enterprises, Inc.**
921 Louisville Road
Starkville, Mississippi 39759

**Sony Corporation of America**
Sony Drive
Park Ridge, NJ 07656

**Panasonic**
One Panasonic Way
Secaucus, New Jersey 07094

# Digital IC Tester




*An IC tester can be a valuable addition to your test bench. Once you use one, chances are you'll wonder how you ever did without it.*

GARY McCLELLAN

## Part 3

WHEN WE LEFT OFF last time, we were almost finished wig the panel board. Here, we'll finish that up and complete assembly. Then we'll make sure that everything operates properly.

Now for the cable to the display board; that's shown in Fig. 14. Each lead from the 16-wire cable goes to one of the bus wires you just installed. Be sure you get the kind of cable with a 16 pin DIP plug attached; you'll need that (P101) to mate with the display board. If you can get multicolored ("rainbow") cable, that's better; it will help you trace your wiring.

Measure ten inches of cable from the header end, and cut off the excess. Then separate the wires at the cut end for three inches. Prepare the ends of the wires for soldering. Note that as the wires are connected, pin 1 of the header corresponds to the pin-1 jacks, pin 2 to the pin-2 jacks, etc. To keep things neat, connect the wires for pins 1–8 to the wire near the HI jacks and the wires for pins 9–16 to the wire near the LO jacks: that will allow the cable to run between the two rows of jacks. You'll probably have to use an ohmmeter to identify the wires in the cable because there are so many; jot down the color associated with each pin number on a piece of paper. When you are finished you should have a nice neat assembly like the one shown in Fig. 15.

There are six wire jumpers to be installed next. They aren't obvious because they just go through the board, from one side to the other, connecting the front wiring to the rear. The jumper positions are marked by asterisks (*) in Fig. 14, and are to the left of the jacks. Start at the top of the board, at the HI jack on pin 9. Run a piece of bare wire through the hole, and bend it over on both sides of the board. Solder it and clip off any excess. Move down to the PULSE jack, and repeat the process. Keep moving down until there are jumpers in all six holes.

Now for the switch and power wiring. Cut 11 pieces of hookup wire six inches long, and prepare one end of each. Still using Fig. 14 as a reference, solder wires to all the terminals of the two switches, and to the three pads above the OVERLOAD LED. Then carefully solder wires to the leads of that LED. Work quickly and with low heat so you don't damage the device.

Bundle up the wires into a cable, and measure four inches. Cut the wires off at that point. Prepare the ends, and solder them to a 12-pin socket (SO102) to mate

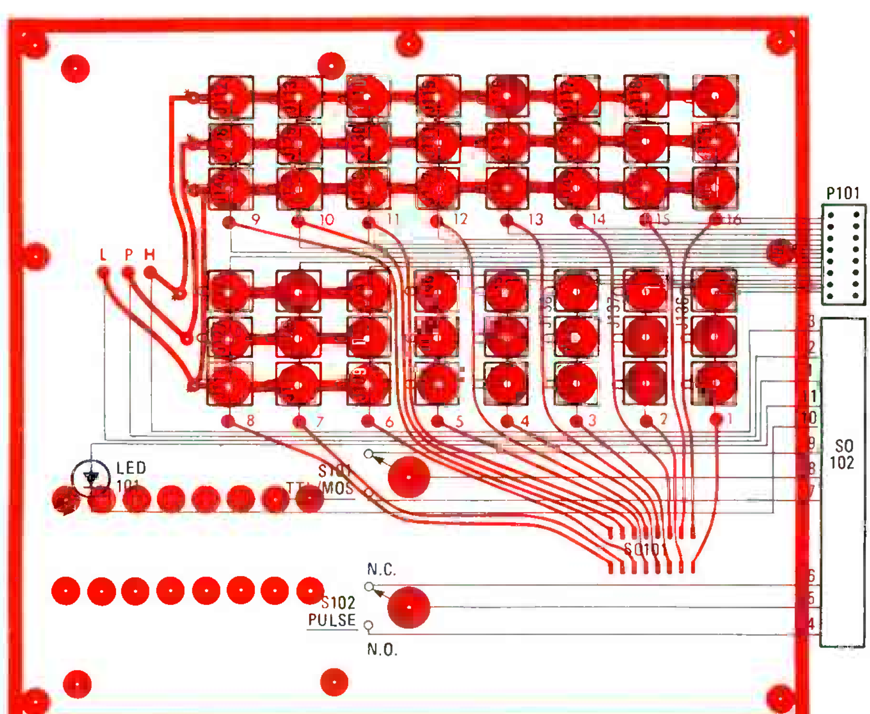



FIG. 14—EACH TRIO OF JACKS is connected to the appropriate pin of the test socket SO101. Separate 11-wire cable goes to SO102, which mates with P102.

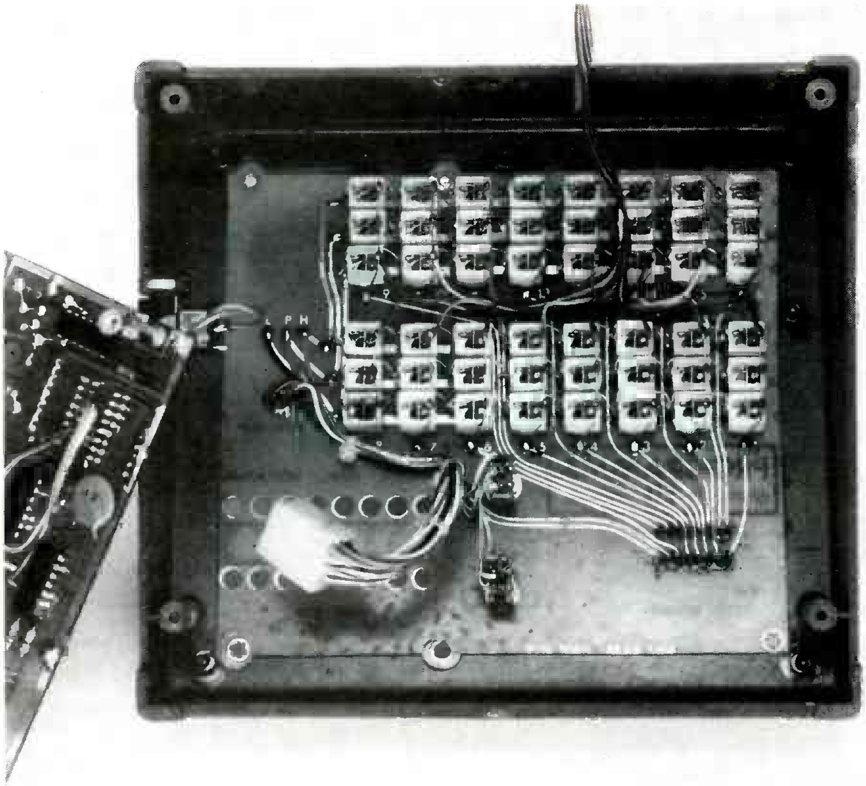


FIG. 15—**FOIL SIDE OF COMPLETED PANEL BOARD** shows connections to jacks and board, and illustrates routing of wires and cables.

with P102 from the display board. Note that the pushbutton-switch connections may not be what you expect—on the switch I used. the common terminal was at the edge of the body, and not at the center as on the other switch! Save yourself some embarassment by checking the pinouts marked on the switch body before you wire the connector. Once all the wires are connected, lace them into a professional looking cable. That completes the assembly of the panel board.

### Finishing up

At this point, the cabinet should be prepared for installation of the panel board. You'll have to make a large cutout in the top for that board. Start by placing strips of masking tape along the edges of the box. Then, using the panel board as a template, mark its outside dimensions on the tape with a pencil. Then, measure *in* ⅜-inch on each side to allow material for screw mounting of the board; the board will overlap the cutout slightly. (The overlap also allows for a sloppy cut, which will be hidden by the panel board.)

Drill holes at the corners of the cutout, and then use a keyhole saw. After the cutout has been made, drop the panel board in place to check for fit. It may be necessary to file slots for the spacers, but otherwise the fit should be good. Center the board and mark the positions for the seven 0.125-inch (⅛ inch) mounting holes. Remove the board, and drill the holes. Finish up by drilling holes for J201 and S201, the power jack and switch. The best place is on the right side of the box, near the bottom. That way, they won't interfere with the boards.

Now for the final assembly, which will go quickly. Clean up the box, removing any tape or shavings. Mount the panel board in place with 4-40 × ½ hardware. Then install the display board; it should just drop into place. If it doesn't, check for a bent LED. Secure it with 4-40 × ¼ hardware. Now refer to Fig. 16 for the connections between the two boards. Mate SO1 and P101 first, then P102 and SO102. Install J201 and S201 on the box next. Connect the power leads from the display board to them. That completes assembly of the IC tester.

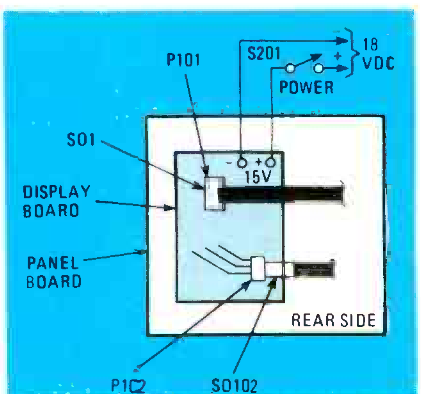



FIG. 16—**CONNECTIONS BETWEEN display board and panel board, and display board and power-supply jack.**

### Power sources

The Programma III is designed to operate from any 12–18-volt-DC power source. If you like, you can build the power supply shown in Fig. 17. You can use any 12.6-volt filament transformer with a capacity of 600 mA or greater.

The last thing you'll need for the IC tester is a number of shorting plugs for the jacks on the device—they select the inputs to each IC pin. Get about 20 miniature phone plugs. Remove the housing from each, and solder the two terminals together. Then, replace the housings. That's all there is to it. Later on, you may want to get more plugs and wire them up for special uses; that will be discussed in the applications section.

### Checkout

Now it's time to see if everything works. Apply power and watch the LED's. They should all come on green,

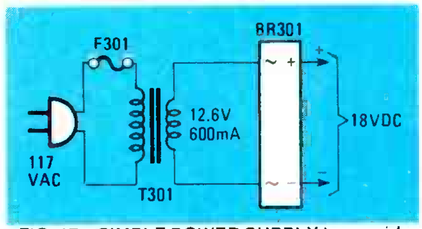



FIG. 17—**SIMPLE POWER SUPPLY to provide 18-volts DC for Programma III.**

**PARTS LIST—POWER SUPPLY**

F301—¼-amp fast-blow fuse (and holder)
BR301—50 PIV, 1-amp bridge rectifier
T301—12.6-volt filament transformer, 600 mA or greater
P301—2-conductor polarized connector to mate with J201 (phone plug OK)

which indicates that the circuitry is OK. If they don't, unplug P101. That will tell you if there is a short in the display or panel board.

If everything has checked out so far, you can proceed. Insert a plug into the HI jack for pin 1. Immediately the pin-1 lamp should glow red, indicating a logic-high state. Do the same for the other pins, and if the wrong LED turns red, check the P101 wiring. Then insert a plug into the PULSE jack for pin 1. The pin-1 LED should turn red. If it doesn't, check the PULSE switch wiring. Press the PULSE switch; the LED should change back to green. Press it quickly and repeatedly; the LED should appear yellow. Try the other jacks in the same manner. That completes the checkout.

### Applications

The best way to get acquainted with the Programma III is to check some familiar IC's. Once you've seen it in action, you can go on to more sophisticated applications, like determining the types of "unknown" IC's. You should have at least one good IC data book available for TTL devices, and another for CMOS. That way, you'll know how to connect your IC's. Since both the National and Texas Instruments data books are widely distributed, you should have little trouble getting a copy.

A good way to get started is with the CD4017. It's widely available, and, in addition, causes the tester to produce a spectacular display. The 4017 is a CMOS Johnson counter with ten decoded outputs; it is useful in applications like light sequencers, so you can probably use it elsewhere after testing.

After turning the tester on, since you'll be checking out a CMOS device, set the TTL/MOS switch to MOS. **Do not insert the IC yet!** Next, refer to your manual for the 4017 pinout. In this case, you can use Fig. 18-a.

First, identify the power-supply pins. In the case of the CD4017, $V_{SS}$ is ground, and $V_{DD}$ is positive. Turning to the tester, insert a plug at the LO jack for pin 8. That grounds the pin. (From now on, we'll use a kind of shorthand to indicate plug positions; LO at pin 8 becomes 8-LO.) Then, insert a plug at 16-HI. That supplies power to the IC socket.

The next step is to identify the inputs of the IC. Sometimes you'll have to read the databook carefully to determine what they are for. In the case of the 4017, pin 14 is the clock input, which we will want to pulse. Therefore, insert a plug at 14-PULSE. What about other inputs? The 4017 has both RESET, and CLOCK ENABLE pins. The data sheet indicates that a logic-high on the RESET pin resets the counter. So, insert a plug at 15-LO to make the counter run. As for the CLOCK ENABLE pin, the data sheet shows that it must be at a logic-low for the counter to run. So, insert another plug at 13-LO.

If you don't know the functions of the inputs, you can easily change the plugs around until the device works. Don't confuse the inputs with the outputs, though. You could do some damage.

You can now insert the IC, making sure that pin 1 is positioned properly. (It's clearly indicated on the panel board.) When the ZIF socket is open, no connections are made to the IC pins; it's only when you close it that $V_{CC}$, input signals, etc., are applied.

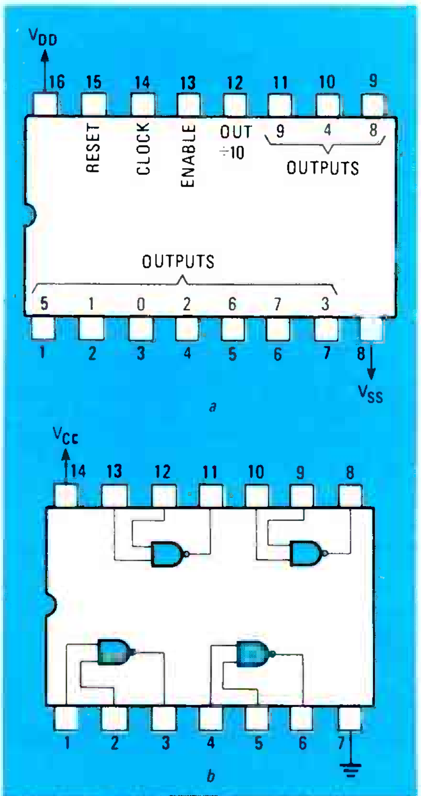


**FIG. 18—PINOUT OF 4017 counter is shown in *a*; that of 7400 in *b*.**

Press the PULSE button slowly, and note that different LED's turn red each time. Only one of the outputs will be high at a time, and the LED that corresponds to it will be illuminated. Pressing the button will step the counter, and each output will go high in sequence.

Reset the counter by removing the plug from 15-LO, and inserting it in 15-HI. Then return the plug to 15-LO. The pin-3 LED should be glowing red, indicating that the counter has been reset to zero. Press the PULSE button, and note whether the next LED lights just after the switch is pressed, or as it is released. The 4017 will increment (count up) when you release the switch. That shows that the counter is positive-edge triggered, as the data sheet indicates, because the output of the IC tester's pulse generator is positive-going when the PULSE switch is released. You have just discovered an important fact: knowing whether a device is positive- or negative-edge triggered is vital when working with counters, flip-flops, and shift registers. Spend some time experimenting with the 4017: change the RESET, CLOCK ENABLE, and CLOCK plugs. You'll quickly learn a great deal about the IC, and have some fun at the same time!

If you "borrowed" your 4017 from another device, and it didn't operate as described above, it's bad! What you've done is to confirm that the IC operates as described in the databook.

That sort of check came in handy for me a while back, when I used a 4017 as a programmable counter. An output was connected to reset, changing the division ratio. The idea was fine for large divisors, but wouldn't work for the small ones. The Programma III pinpointed the problem quickly—a "fine print" error in the data sheet.

By now you should have a good idea of how to use your IC checker. For practice, here's another example. Suppose you have a suspect 7400 TTL IC. Here's a brief reprise of the test procedure:

Step 1: Power up the unit. Since the 7400 is a TTL device, the TTL/MOS switch is set to TTL. Do not plug in the IC yet.

Step 2: Look up the IC in your databook. (For your convenience, the pinout is indicated in Fig. 18-b.) Study the illustration.

Step 3: Locate the power and ground pins of the IC. On the 7400, $V_{CC}$ is pin 14 and ground is pin 7. Since the 7400 is a 14-pin device, there will be nothing in the pin-8 and pin-9 positions of the test socket. Always line up IC packages so that pin 1 goes into the pin-1 position of the socket. The pin numbers on that side of the IC will be correct, but you'll have to make adjustments on the other side—pin 16 of the socket is now *pin 14* of the IC, so put a plug in 16-HI. Ground is still pin 7, so put a plug at 7-LO.

Step 4: Detemine the inputs of the IC, and connect them accordingly. Since the 7400 is a quad (four-section) NAND gate, check each section separately. Since pins 1 and 2 are inputs, you could start with them. Make pin 1 high, and put the pulse on pin 2 for starters.

Step 5: Insert the IC, and pulse it. Pin 3 should change state if the IC is good. Change pin 1 to ground, and note that the output doesn't (shouldn't) change state. Transpose the inputs to pins 1 and pin 2 and repeat the tests. Check the other gates in the same manner. If they work, fine! Don't bother to continue testing if you detect a fault, unless you need to use only a part of the IC.

That, in a nutshell, is the technique for testing IC's. With a little practice, it becomes routine and, after a while, you can introduce some shortcuts. For example, once the power and ground pins of the test socket are connected, the IC may be inserted. Just don't get careless when you insert the plugs—most IC's object strong-

*continued on page 100*

## OOOOOOPS!

In going from Part 1 to Part 2 to Part 3 of this article, several connector designations were confused. The following will, we hope, correct that confusion.

| Description | Part no. | Connects with |
|---|---|---|
| 12-pin Molex plug | P102 | SO102 |
| 12-pin Molex socket | SO102 | P102 |
| 16-pin IC socket | SO1 | P101 |
| 16-pin DIP header | P101 | SO1 |
| 16-pin ZIF socket | SO101 | panel board |
| Power jack | J201 | P301 |
| Power plug | P301 | J201 |
| Power switch | S201 | pads on display board |

# REPAIR ANTIQUE RADIOS

*Repairing an old radio and restoring its original performance and looks can be a source of pride. Let's take a look at the basics of this rewarding and challenging hobby.*

RICHARD D. FITCH

WHILE MOST COLLECTIBLE RADIOS ARE NOT OLD ENOUGH TO BE classified with antique furniture, many of them can be called antiques in their own right. You may be young enough to think that a radio from the thirties or forties is old. And, if you are a newcomer to the hobby of collecting radios, it is good to start with radios from that era because there are plenty to choose from. Often, you can even get such a radio for free. But, can it be restored?

As with any type of restoration, the task begins with what you have to work with in the first place. There are many old radios that are not worth restoring. (Of course, any radio that you identify with in some special way *is* worth restoring.) Also, some old radios are considered to be more of a classic than others (such as the cathedral-cabinet table model) and are more in demand. If you find one of these "classics" cheap, take it—no matter what the condition. Later, you may find another, and make one complete, working set.

When restoring an old radio, it is important to keep it as original as possible. That applies to everything from the chassis and parts to the knobs and the finish on the wood cabinet. That does not apply if you want only a working conversation piece and not a truly-restored radio. Any good cabinet can be fitted with a working radio chassis with a little alteration. Remember that proper ventilation and insulation must be observed. Although you might not have the rich, deep tone of the original, any modern radio in a cabinet from the thirties in daily use in your home will attract much attention.

## Where to find old restorable radios

Radios that can be restored are all around—but not in your local TV and appliance store. Try the classified ad columns, flea markets, and garage and yard sales. There are also many ads in magazines dedicated to this hobby. One example is *The Horn Speaker* (9820 Silver Meadow Dr., Dallas, Texas 75217). Some of your friends and relatives may have an old radio lying around for the asking. Of course you have to know what to look for when trying to find a radio to restore. We'll go into that next.

First, the radio should be old (whatever is old to you) and should have most if not all of its parts. The cabinet will be the first thing you will see. Can the cabinet be refinished to some semblance of its original condition? (Only knowing your own limits and abilities in wood-working and refinishing can answer that.) Are the knobs there? If not, you can most likely get some that fit and look original.

The big question is: Does it play? Ask the seller if he can play the old radio for you, or at least turn it on. If the old radio hasn't been played for years and the line cord and plug are corroded, you will have to rely on just what you can see. That will include the speaker assembly, the chassis, and the cabinet.

## The speaker assembly

The speaker assembly is a monstrous arrangement in old radios. Along with the cone and the voice coil, there is a field coil and impedence-matching transformer all mounted on a massive frame (see Fig. 1). That array, called an electro-dynamic speaker should be intact, even if it needs a little work. While it may be possible to replace the dynamic speaker with a PM (*P*ermanant *M*agnet) type, it will take much from the originality. The most visible problem might be the speaker cone. Finding a fifty-year-old radio with a speaker cone that is not warped or torn will be rare. If the cone isn't torn badly, it can usually be repaired with a little speaker cement, available in any parts shop. A warped speaker cone is not as obvious as a torn cone, but it is just as easy to repair.

Any radio that has not been used for many years is likely to have at least one of those speaker-cone problems. Checking for a warped speaker cone is a fairly simple procedure. With the set off and unplugged, of course, remove the speaker and examine the cone. (The wires are usually long enough to turn the speaker around without having to cut them.) A warped cone can cause an off-center voice coil. To determine if the voice coil is off center, apply a slight pressure around the center of the cone as shown in Fig. 2. If a scratching noise is heard, the voice coil is off center. That test must be done very carefully or you may put your finger through the cone. If you hear the scratching noise, all is not lost, for there are a few things that can be done to re-center the voice coil. Some old sets have small set-screws in the center of the cone that need simply be adjusted to re-center the voice coil. Also, the outer edge of the cone may be reglued to the frame to solve the problem.

Even if your speaker cone is completely tattered there is still hope. There are still a few places around that re-cone speakers. The cost of re-coning the old speaker will not be much more than buying a PM speaker and you will avoid the electrical and physical conversion problem. Also, keeping the set original will always be an asset when showing or discussing your restored set to knowledgable people.

If you are unable to pass a signal through the speaker because of unrelated problems with things such as tubes, line cords, etc., make a continuity test of the speaker components. With the set off and unplugged, check the voice coil, field coil, and both sides of the output transformer. Any inexpensive ohmmeter can be used, as the exact resistance is not important at this time. If you should fail to find continuity at any one of those points, the problem may be less than an inch away. The soldered connection where the coil or transformer is joined to the lead wire is the most likely culprit. You might have to carefully remove a little paper from the transformer to get to the connection. Even if there is no obvious break at the connection it still may have built up corrosion or a resin block. All those connections should be resoldered to make a good contact so they will cause no future problems.

### The chassis

You can get a wealth of information from the chassis just by looking at it. Naturally, the first question to ask is whether or not all the parts are there. It will be easy to see if there are any tubes missing. Finding tubes for those that are missing will be one of the easier chores. Many old sets had the tube number stamped on the socket or on the chassis near the socket. It might be your good fortune to find a legible diagram with all pertinent information (such as the model number, IF frequency, tube locations, and filament diagram where applicable) fixed to the inside of the cabinet. Missing chassis parts other than tubes can create big problems. If an exact or a similar schematic isn't available, finding out what was in that hole with the wires hanging out will challenge even an expert. Large, tapped, wire-wound resistors, capacitors, IF transformers, and coils are some of the parts that may have been ripped from a chassis over the years. Unless you have full schematic information or for some reason want the set very badly, pass it up if it has parts missing other than tubes and knobs.

Some old radios seem to withstand age better than others. Where a radio was stored is especially responsible for its condition, as is the quality of material used in its manufacture. One chassis may be completely corroded and have a cabinet warped beyond repair, while another of the same vintage—maybe even of the same make—will appear like-new. A corroded chassis can entail a lot more work than a warped cabinet and can make the project not worth your while. What's so serious about a corroded chassis? There are two big problems—the tube sockets and potentiometers. If the tubes are corroded in the sockets, removing them without any further damage to the tube or socket will take much patience—and a lot of solvent. And, you will still have a rusted socket when you are finished. To answer any question about the extent of the corrosion, you will have to remove the chassis from the cabinet for a look underneath. Often the underside of the chassis will be spared the corrosion and rust that was evident on top.

### Cabinet restoration

How well the cabinet can be restored is limited mostly by your own ability. If you enjoy woodworking and do it well, almost any cabinet can be restored. Even a cabinet with the plies separated can be re-glued. It is important that you take care to preserve any decals or designs (like that shown in Fig. 3) on the front of the cabinet. Before removing the finish, try restoring it with polish. However, if the finish must be removed, light-sand over those areas. Sometimes, furniture polish will restore an old finish and cover up minor scratches. If there are any deep scratches or dents, wood filler can be used. However, since the wood filler will rarely match the original cabinet, it will have to be tinted after the final finish is started so that it won't show through.

Before attempting any work on the cabinet, be sure to remove everything from inside. Also, all removable name plates, decorative speaker bolts, and even the grill cloth should be removed. Getting sanding dust and paint products on the chassis parts will not do anything to improve your old radio. If any parts of the cabinet are beyond restoration, they may be able to be replaced by a patient woodworker. That will apply most often to the bottom of a cabinet that absorbed moisture because it was stored in a damp place. Just be sure to replace any vent holes that were in the original cabinet, because an old radio with its big tubes and wirewound resistors radiates considerable heat.

### Troubleshooting old radios

Troubleshooting old radios is not much different than troublehooting new radios. (And it is just as important to be familiar with all safety procedures.) Many old radios have the grid cap conviently sticking out the top of the tube envelope.

FIG. 1.—MAKE SURE WHEN BUYING an old radio that all chassis parts are included. Without a schematic it may be impossible to identify a missing part.

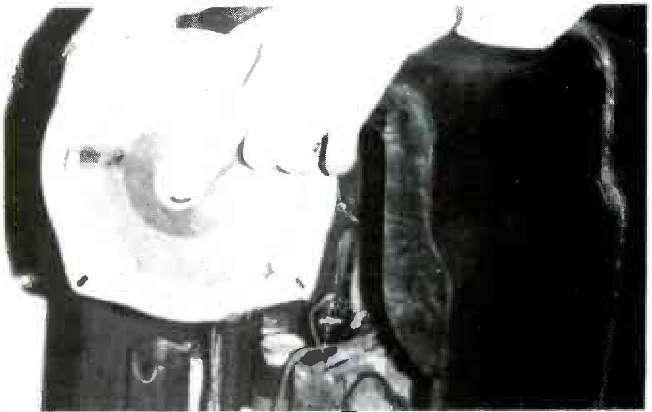


FIG. 2.—THERE IS A SIMPLE TEST to determine whether or not the speaker's voice coil is off center.

FIG. 3.—WHEN RESTORING A CABINET, take great care to preserve any decals or designs.

FIG. 4.—A TUBE TESTER can save you a lot of time and aggravation, especially if you buy a large numbers of used tubes.

That permits a signal injection or circuit-disturbance test without even removing the chassis from the cabinet. Most of the rest of the parts are similar to those in newer radios, but are much larger, of course.

When you select an old radio to restore, don't be surprised if it lights up but doesn't play. Even if there is just some slight hum from the speaker don't give up hope. There are a few factors to consider on early models that should be checked. If there is no built-in aerial, there should be a terminal on the back of the chassis for connection to an external one. (The radio might play weakly or not at all if it was designed to use an outside aerial.) Any piece of wire can be attached to the terminal screw for test purposes.

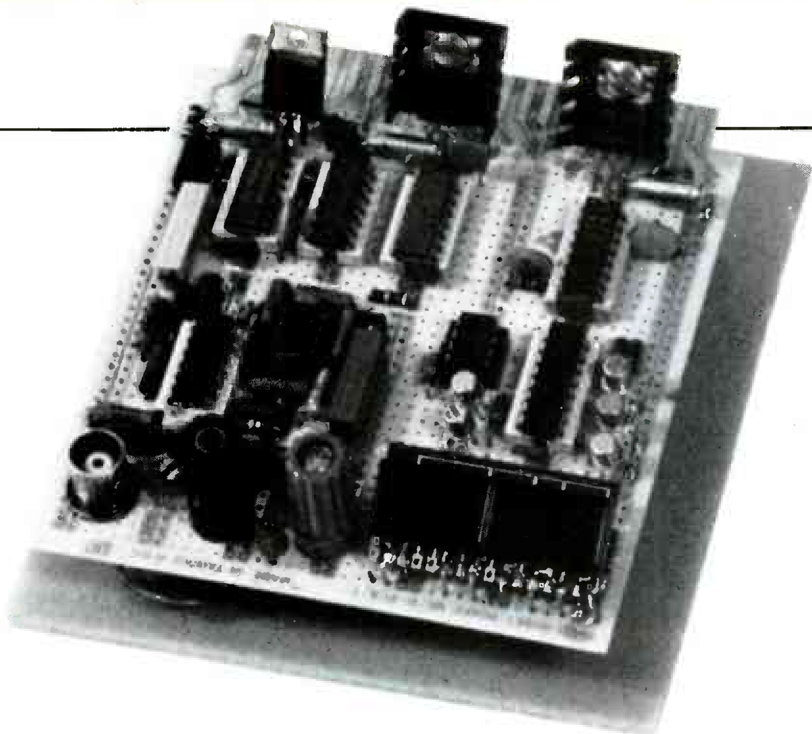
Keeping the equipment original is not as difficult as it sounds. The band switches, potentiometers, coils, and even IF transformers can be dismantled and repaired. As with speakers, the most likely problem with an intermediate-frequency transformer that will not pass a signal is a poor connection. Remove the transformer's shield and carefully resolder all of the connections. (A turn can even be taken from the winding if more of the hair-like wire is needed to make a good connection to the trimmer terminal.) If you have to remove the trimmer screw to clean it, you will want to reset it as closely as possible to its original position. You can do that by counting the turns as you screw it down as far as it will go. Then remove the screw and clean it and the trimmer if needed. Replace the screw and turn it as far in as it will go, then back it off the number of turns needed. You will probably have to align the entire set after the IF transformer work.

There isn't much that can be done to repair a bad tube. A partial solution is a good collection of used tubes. Also, there are still some mail-order houses offering old tubes. Even some long-established repair shops have some tubes for early sets. One source for tubes and information that comes to mind is Puett Electronics (P.O. Box 28572, Dallas, TX 75228). A tube tester with an older roll-chart, like the one shown in Fig. 4, is a priceless piece of equipment for the old-radio buff.

Even if restoring your nostalgic radio ends up costing you more than the radio did when it was new, the pleasure of restoring it and the pride of accomplishment can far outweigh the cost. And, if that's not enough, you can expect many offers to buy your restored radio. **R-E**

BUILD THIS

# Two Compact DVM's



*Equip your bench power-supply with its own digital voltmeter. LSI circuits make the project simple and inexpensive.*

**CLEMENT S. PEPPER**

THE POWER SUPPLY I USE ON MY BENCH has five outputs, two of which are variable over a range of ±25 volts. I found having to connect a voltmeter to either of those two merely to set a voltage or to make a status check to be a bother, and was thinking of adding an analog panel meter with selector switching, when I stopped to ask myself why I wanted to do a dumb thing like that. High performance linear and digital IC's now available make a built-in *digital* voltmeter practical at about the same cost as a high quality panel meter. All the semiconductors and the 4-digit display, for example, can be purchased for less than twenty-five dollars.

The circuit I designed performed so well that I modified it and made a general-purpose DVM for use on the bench. It is quite compact, so it can be close to the work at hand while taking up little space.

At the heart of both versions is the LM331 precision voltage-to-frequency converter. That device, along with the MM740925 (a 4-digit counter with multiplexed 7-segment output drivers) and the NSB3881 4-digit common-cathode multiplexed LED display, contributes to the high performance and compact construction of the DVM's. All three IC's are made by the National Semiconductor Corporation.

### LM331 V-to-F converter

The LM331 is a monolithic circuit designed for voltage-to-frequency or frequency-to-voltage conversion. Figure 1 shows the LM331 in simplified block-diagram form, along with the external resistors and capacitors needed for stand-alone V–F operation. The principal parts of the device are a switched current-source, an input comparator, and a one-shot timer.

The switched current-source establishes a positive reference voltage, $V_X$, as one input to the comparator, and a positive input-voltage, $V_{IN}$, as the second. If $V_{IN}$ exceeds $V_X$, the comparator will trigger the one-shot. The one-shot then turns on the output transistor and the switched current-source for a time, t, equal to $1.1R_tC_t$. During that time, current i provides a fixed charge Q, equal to $i_{Xt}$, to capacitor $C_L$. That will normally raise $V_X$ to a higher level than $V_{IN}$. At the end of the timing period, current i will turn off, and the timer will reset itself. Since there is then no current flowing from pin 1, capacitor $C_L$ is gradually discharged by resistance $R_L$ until $V_X$ falls to the level of $V_{IN}$. Then the cycle will repeat.

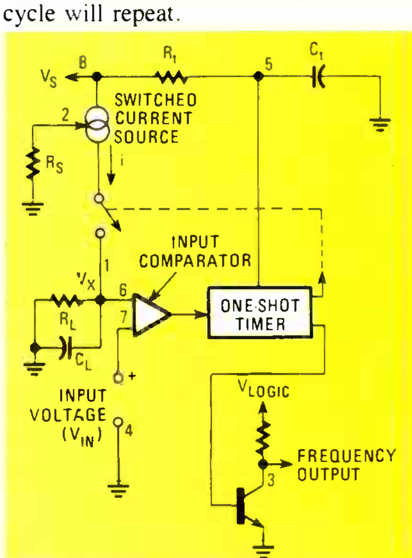



**FIG. 1—SIMPLIFIED BLOCK DIAGRAM of voltage-to-frequency converter showing LM331 with external components**

The output device is an open-collector transistor, a real convenience in translating between the 15-volt supply for the converter and the 5-volt one for the display. The output is a train of negative-going pulses that is input directly to the counter's clock input for counting and count display. The output frequency is given by the equation:

$$F_{OUT} = V_{IN}/2.09 \times R_S/R_{IN} \times 1/R_tC_t$$

The current flowing into $C_L$ is $i_{AVE} = i \times (1.1R_tC_t) \times F_{OUT}$, and the current flowing from $C_L$ is exactly $V_X/R_L$, which, in turn, is very nearly equal to $V_{IN}/R_L$. If $V_{IN}$ is doubled, $F_{OUT}$ will also double to maintain that balance. The converter can provide an output that is proportional to its input voltage over a broad range of frequencies. The voltage-to-frequency linearity in a circuit having values very nearly the same as those in the two versions of the DVM described here, is specified by National as ± 0.14% worst-case over the range of 10 Hz to 11 kHz.

### MM74C925 4-digit counter

The MM74C925, shown in Fig. 2, is a CMOS device containing a 4-digit decade counter, an internal latch, NPN output sourcing drivers for a 7-segment display, and internal multiplexing circuitry with four multiplexing outputs. It has its own free-running oscillator; no external clock is required for digit strobing. The counters advance on the negative edge of the incoming clock signal. A high on the RESET input will reset the counter to zero. A high on the LATCH ENABLE input allows data to flow through the counters without being latched; a low latches the number in the counters. The display can be driven

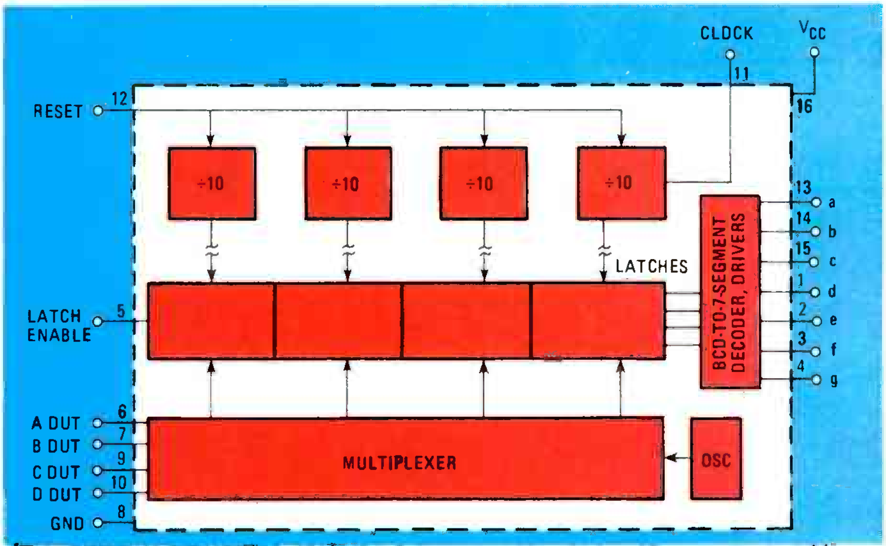



FIG. 2—INTERNAL STRUCTURE of 74C925 4-digit counter with multiplexed 7-segment output drivers.


| PIN | FUNCTION | PIN | FUNCTION |
|---|---|---|---|
| 1 | NC | 9 | NC |
| 2 | ANODE e | 10 | COMMON CATHODE DIGIT 3 |
| 3 | COMMON CATHODE DIGIT 1 | 11 | ANODE b |
| 4 | NC | 12 | ANODE a |
| 5 | NC | 13 | ANODE f |
| 6 | COMMON CATHODE DIGIT 2 | 14 | COMMON CATHODE DIGIT 4 |
| 7 | ANODE d | 15 | ANODE DP |
| 8 | ANODE g | 16 | ANODE c |

FIG. 3—NATIONAL SEMICONDUCTOR NSB3881 4-digit LED display.

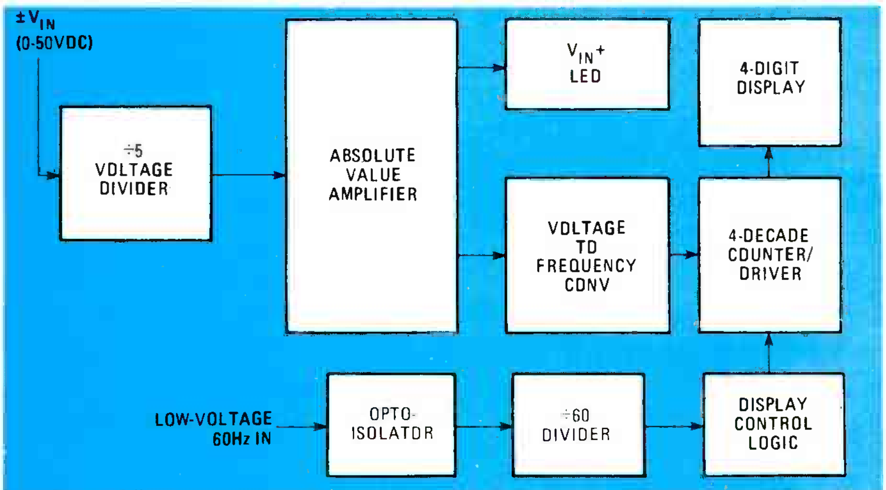



FIG. 4—BLOCK DIAGRAM of general-purpose DVM. Low-voltage 60-Hz current is used to clock display control-logic.

## PARTS LIST—GENERAL PURPOSE DVM

**All resistors 1%, ¼ watt unless otherwise specified**
R1—1 megohm
R2—20,000 ohms, multi-turn trimmer potentiometer
R3—250,000 ohms
R4—200,000 ohms
R5, R6, R8, R12—10,000 ohms
R7, R11—5000 ohms
R9—1000 ohms, multi-turn trimmer potentiometer
R10—4750 ohms
R13, R15—100,000 ohms
R14—47 ohms, 5%
R16—5620 ohms
R17—10,000 ohms, 5%
R18—10,000 ohms, multi-turn trimmer potentiometer
R19—6800 ohms
R20, R23, R36—1000 ohms, 5%
R21—220 ohms, 5%
R22—see Table 1
R24-R26, R35—3300 ohms, 5%
R27-R34—82 ohms, 5%

**Capacitors**
C1, C3, C5, C7-C10—0.1µF, ceramic disc
C2—1000 pF, ceramic disc
C4—1µF, Mylar or tantalum
C6, C11-C13—0.01µF, ceramic disc

**Semiconductors**
IC1—TL084C quad biFET op-amp
IC2—LM311N (or -H) voltage comparator
IC3—LM331N precision voltage-to-frequency converter
IC4—74121 monostable multivibrator
IC5—7492 divide-by-12 ripple counter
IC6—7490 divide-by-10 ripple counter
IC7—74123 dual monostable multivibrator
IC8—74C925 CMOS 4-digit counter w/multiplexed digit and segment drivers
IC9—MCT2E opto-coupler
DISP1—NSB3881 4-digit, 7-segment LED display
LED1—jumbo red LED
Q1—2N2907
Q2-Q5—2N2222
D1, D2—1N914
**Miscellaneous:** regulated power supply, perforated construction board, IC sockets, hardware, etc.

without external segment-current-limiting resistors, but they should be used to minimize power dissipation and chip heating.

### NSB3881 4-digit LED display

The NSB3881 is one of a family of multidigit LED-displays mounted on a small PC card, which greatly simplifies assembly and wiring. The individual digits are prematched for brightness and are mounted so as to be end stackable. Figure 3 shows the display and its pin assignments.

### DVM features

A block diagram of the DVM is shown in Fig. 4. The input range is ±50 volts, and the input is connected to an absolute-value amplifier through a voltage divider having a ratio of 1:5. That ratio can be changed—it just happened to meet my needs. The one strict requirement is that the maximum voltage to be measured result in a $V_{IN}$ to the voltage-to-frequency converter of no more than ten volts. That will keep the maximum signal within the linear operating range of the operational amplifier.

The output of the absolute-value amplifier is always postive, regardless of the polarity of the input voltage. That's necessary because of the input requirements of the LM331. An output is also taken from pin 7 of the amplifier (IC1-b) to light an LED and provide a visible indication of the polarity of the input. When the LED is lit, the voltage is positive; when it's dark, it's negative.

The 60-Hz line current serves as the clock source for the display. Division by 60 provides a one-second timebase. (The

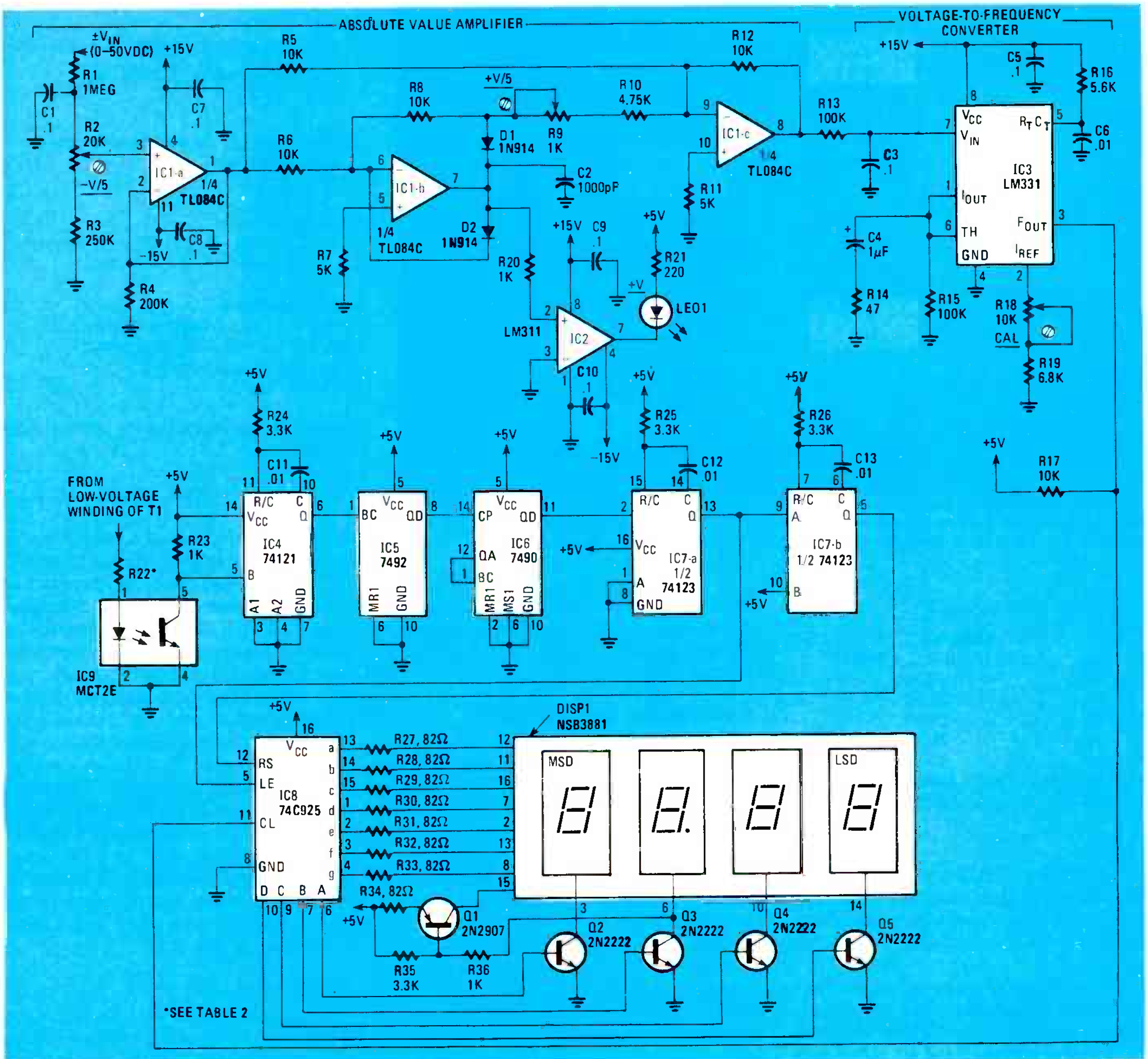



**FIG. 5—CIRCUITRY IN UPPER PART of schematic of general-purpose DVM contains absolute-value amplifier and V–F converter. Lower section is for timing and display.**

equation for $F_{OUT}$ assumes a one-second timebase.) However, any clock frequency can be used, provided that $F_{OUT}$ stays the same. The easiest component to change to compensate for a different timebase is $R_S$.

A schematic of the general-purpose voltmeter circuit is shown in Fig. 5. The TL084C quad bi-FET op-amp is used primarily because its very low bias currents allow the use of high-value resistors for the input divider.

Figure 6 helps to explain how the absolute-value amplifier section works. When $V_{IN}$ goes negative, the output of the first amplifier goes positive by the amount of one diode-voltage-drop (about 0.7 volt), shutting off the upper diode and bypassing the amplifier by virtue of the lower diode connected to the input. The second amplifier inverts $V_{IN}$ to provide a positive output equal in amplitude to the negative input. When $V_{IN}$ is positive, both amplifiers invert, but the output of the first is $-2V_{IN}$ which, when summed with $V_{IN}$ at the input to the second, results in an actual input equal to $-V_{IN}$, and thus an output of $V_{IN}$.

Referring once more to Fig. 5, the second amplifier, IC1-b, is connected to the non-inverting input of a LM311 comparator. Whenever $V_{IN}$ is positive, that input is negative and the LED lights. The three trimmer potentiometers should be preset to approximately midpoint for R2 and R9 and to about 6000 ohms for R18. The National data book suggests that C4 be a Mylar capacitor, but I used a tantalum with no apparent problems. If you are looking for accuracy on the order of one percent or so, and good long-time stability, you should use cermet trimmers and metal-film resistors throughout the amplifier and converter circuits.

As shown in Fig. 7, an opto-coupler is used to extract a clock signal from the low-voltage winding of the transformer used by the power supply that will be monitored. Table 1 will help you select a

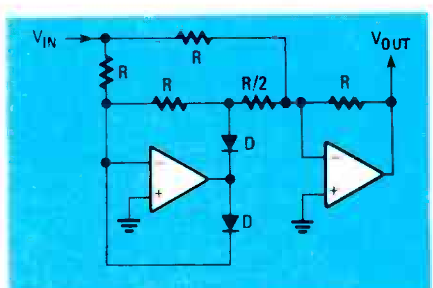



**FIG. 6—ABSOLUTE-VALUE amplifier uses two diodes to "decide" whether input voltage is positive or negative.**

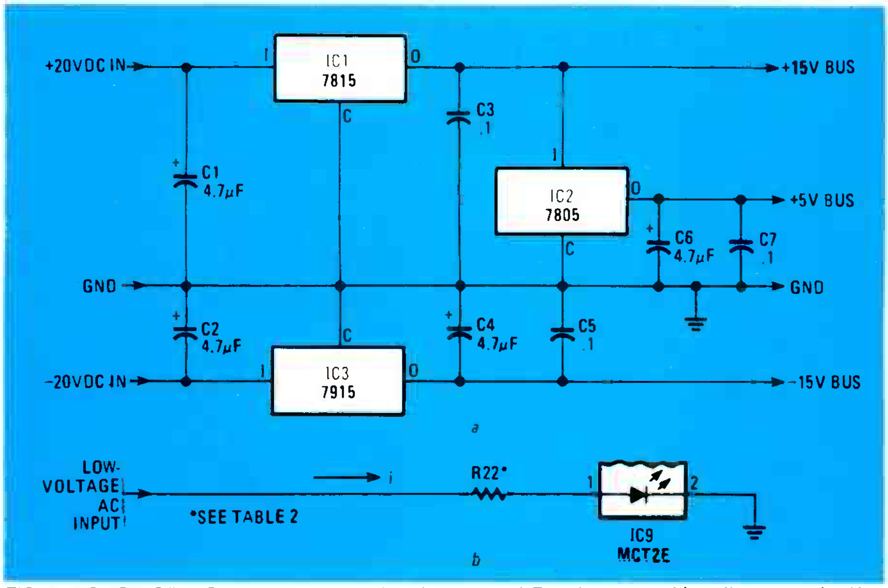



FIG. 7—POWER IS TAKEN from power supply being metered. Regulators provide voltages required by meter circuits. Two positive regulators require heatsinks. Resistor R22 and opto-coupler IC9 also appear in Fig. 5 and serve same functions as R20 and IC14 in Fig. 11.

## PARTS LIST— REGULATOR SECTION

**All resistors 1%, ¼ watt unless otherwise specified**
R22—see Table 1

**Capacitors**
C1, C2, C4, C6—4.7µF, 25 volts, tantalum
C3, C5, C7—0.1µF, ceramic disc

**Semiconductors**
IC1—7815 15-volt positive regulator
IC2—7805 5-volt positive regulator
IC3—7915 15-volt negative regulator
IC9—MCT2E

**Miscellaneous:** heatsinks for positive regulators

**TABLE 1**

| $V_{rms}$ | R22 (R20) ($I_{rms}$ = 20mA) |
|---|---|
| 7 | 270Ω |
| 10 | 390Ω |
| 13 | 560Ω |
| 16 | 680Ω |
| 19 | 820Ω |
| 22 | 1000Ω |
| 25 | 1200Ω |

suitable value of R22 for your transformer. Power for the meter circuit itself can also be obtained from within the power supply; ± 18-20 volts DC will do the job nicely.

The 60-Hz divider is quite conventional. When you build the circuit, keep in mind the fact that the 7490 and 7492 power pins are 5 and 10, rather than the more common 14 and 7 for $V_{CC}$ and ground, respectively. The leading edge of the output of the 7490 triggers IC7-a, a 74123 dual monostable-multivbrator. The output pulse, which has a duration of about ten microseconds, latches data from the 74C925 counter (IC8) for display updating. Its trailing edge triggers IC7-b to reset the counter.

The 74C925 is capable of driving the display directly—that is, without current-limiting resitors—but then you must heatsink the counter, and you may have a power-supply problem as well. The 82-ohm current-limiting resistors provide more-than-adequate brightness for good readability on a well-lighted bench. The 2N2907 transistor is used to turn on the second-digit decimal point. The counter does not feature leading-zero blanking, and I didn't think it worth the effort to include it. If you do wish to blank the leading zero, add logic to detect when segments "a–f" are at a logic-high, and segment "g" and pins 7, 9, and 10 of IC 8 are low. The logic should inhibit the drive to the base of Q2 whenever those conditions are met, and the first digit will remain dark.

### Construction and calibration

Construction can be quite compact if reasonable care is taken to prevent shorts and solder bridges. There are two things you should do to avoid oscillations: Connect 0.1-µF ceramic capacitors fairly close to the amplifier's "+" and "–" DC-power pins, and take care to separate the input and output circuits of the amplifiers.

I usually combine construction and testing. That is, I construct a block of circuitry, such as the analog portion of the meter, and then stop to check it out before proceeding. I assembled the amplifier and comparator circuits, followed by the voltage-to-frequency converter, the time-base, and the display.

It's a good idea to assemble the amplifier circuit, then stop to test and adjust it, before connecting it to the LM331. The reason is that the voltage-to-frequency converter will respond to positive voltages only, but should there be a defect in the amplifier wiring you could input a negative voltage. (That's because the initial step in the test-and-adjustment procedure is to connect a negative voltage to the input.) With a calibrated meter connected to pin 8 of the TLO84CN, apply a known negative voltage to the input of the meter you built. You should read a positive voltage equal to one-fifth the input. Adjust R2 to obtain that value.

Next, replace the negative voltage with a positive one of a similar amplitude and adjust R9 for the correct reading—again one-fifth the value of the input voltage. There is a somewhat larger error for a positive input than for a negative one, so you may want to make the adjustment using an input voltage of a value you will be measuring frequently (I used 15 volts).

The third—and final—adjustment has to be made after assembly is complete. Simply adjust R18 so your display shows the same input-voltage as does the meter you're using for calibration. Again, you may wish to perform that step with a voltage you use often. At 1½ volts my completed meter displayed a positive voltage that exceeded its negative counterpart by about 30 millivolts. That error approached zero at my calibration value; then the positive error increased slightly more than the negative as I continued upward. Overall, with an input span of 20 volts, the positive and negative values tracked my calibration meter within about two percent of full scale.

### A dual-input DVM

The longish rectangle to the left of the banana plug in Fig. 8 is the 4-digit display of a version of the DVM that monitors my power supply's variable outputs (the jacks between the two knobs). That version features two inputs—one for a positive voltage, the other for a negative one. Because the range of the supply is about 27 volts, I designed the meter circuit to span 30 volts. I constructed the circuit in three sections, as can be seen in Fig. 9, so I could tuck it all into the cramped space available inside the supply.

A function diagram of that meter is shown in Fig. 10. An inverting amplifier is required for the negative input; a non-inverting one for the positive, so that each provides a positive source for the voltage-to-frequency converter. Connection to the converter is made through a solid-state analog switch controlled by measurement logic derived from the one-second timing logic. The control logic for the display differs somewhat from that of the general purpose DVM, but the remainder of the circuitry is the same.

A schematic of the dual-voltage meter is shown in Fig. 11. A general-purpose

## PARTS LIST—DUAL-INPUT DVM

**All resistors 1%, ¼ watt unless otherwise specified**
R1, R3—20,000 ohms
R2, R4–R6—10,000 ohms
R7, R19—10,000 ohms, multi-turn trimmer potentiometer
R8—8200 ohms, 5%
R9, R10—5600 ohms, 5%
R11, R17—100,000 ohms
R12—47 ohms, 5%
R13—4700 ohms, 5%
R14, R16—10,000 ohms, 5%
R15—5600 ohms
R18—220 ohms, 5%
R20—see Table 1
R21, R34—1000 ohms, 5%
R22–R24, R33—3300 ohms, 5%
R25–R32—180 ohms, 5%

**Capacitors**
C1, C5, C10–C12—0.01µF, ceramic disc
C2, C4, C6–C9—0.1µF, ceramic disc
C3—1µF, Mylar or tantalum

**Semiconductors**
IC1, IC2—741 op-amp
IC3—4016 CMOS quad bilateral switch
IC4—7407 hex buffer, open collector
IC5—LM331N precision voltage-to-frequency converter
IC6—74121 monostable multivibrator
IC7—7492 divide-by-12 ripple counter
IC8—7490 divide-by-10 ripple counter
IC9—7474 dual D flip-flop
IC10—7408 quad 2-input NAND gate
IC11—7432 quad 2-input OR gate
IC12—74123 dual monostable multivibrator
IC13—74C925 CMOS 4-digit counter with multiplexed digit and segment drivers
IC14—MCT2E opto-coupler
DISP1—NSB3881 4-digit, 7-segment LED display
Q1, Q3–Q6—2N2222
Q2—2N2907

**Miscellaneous:** regulated power supply, perforated construction board, IC sockets, hardware, etc.

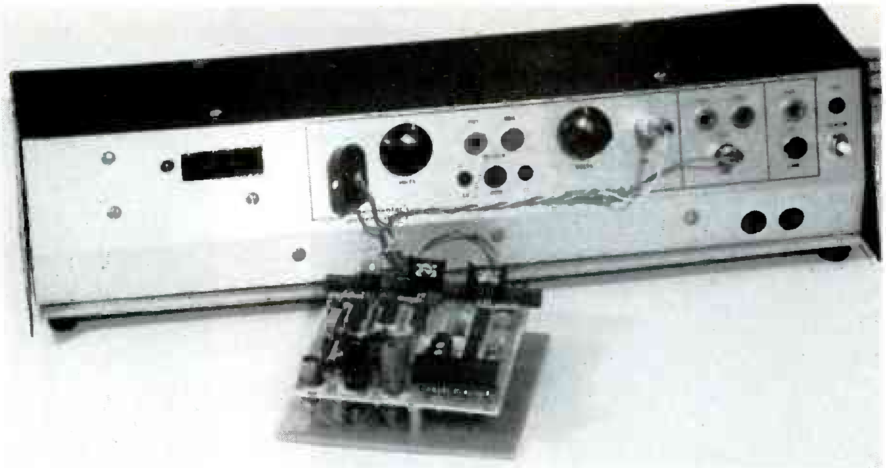


FIG. 8—DISPLAY OF DUAL-INPUT DVM can be seen at left of power supply. General purpose DVM is in foreground.

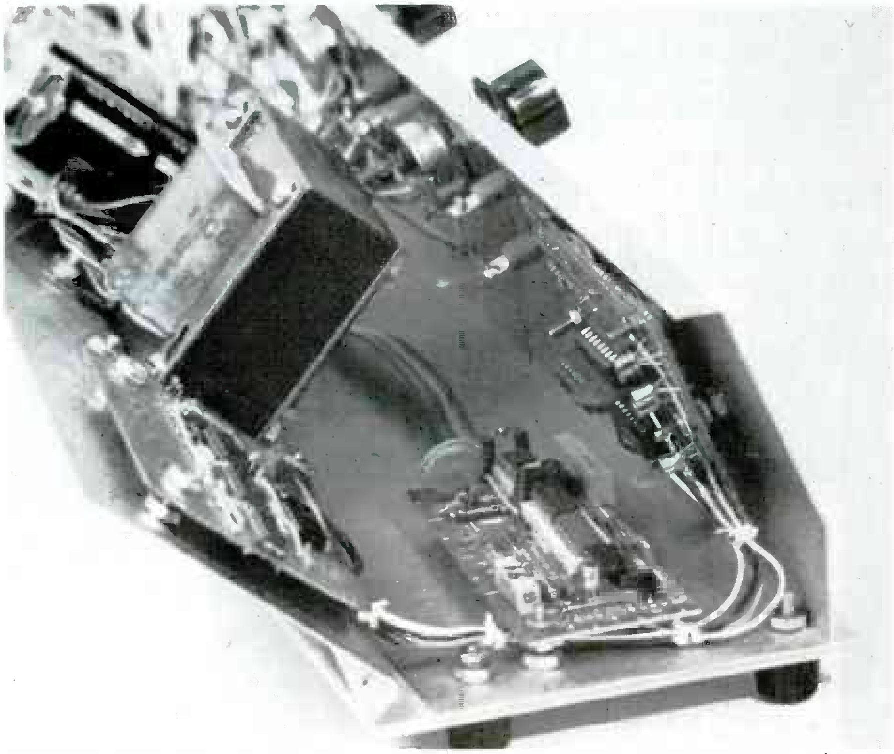


FIG. 9—DUAL-INPUT DVM was built in three sections to fit in tight cabinet. Timing logic is on left-hand board; amplifiers, switching, and V-F converter on center one, and display and display logic on front-panel mounted board at right.

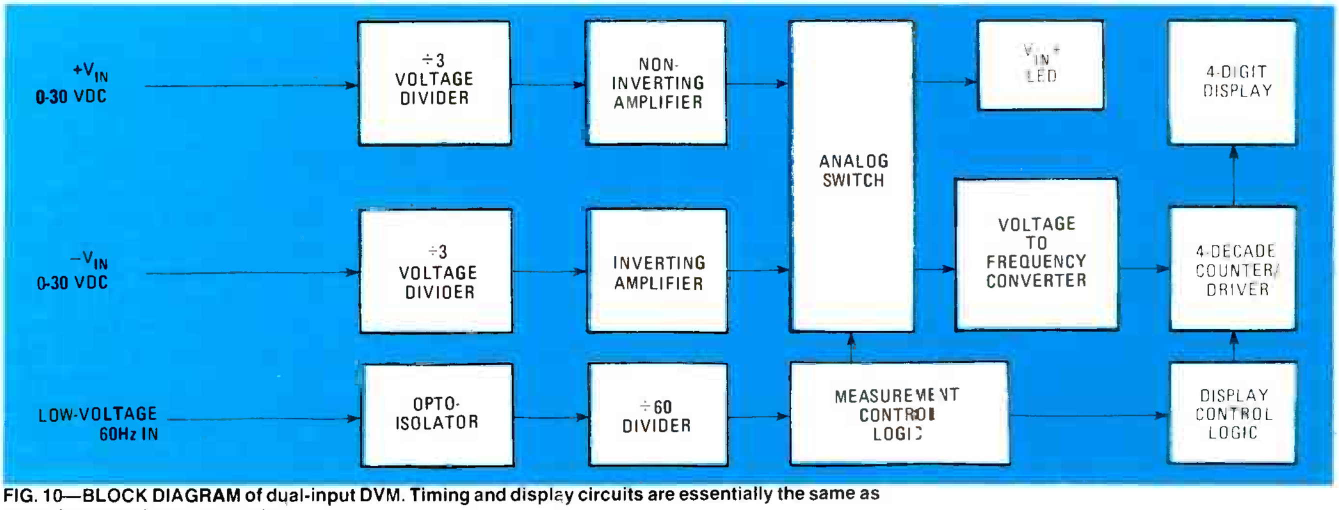



FIG. 10—BLOCK DIAGRAM of dual-input DVM. Timing and display circuits are essentially the same as those in general-purpose meter.

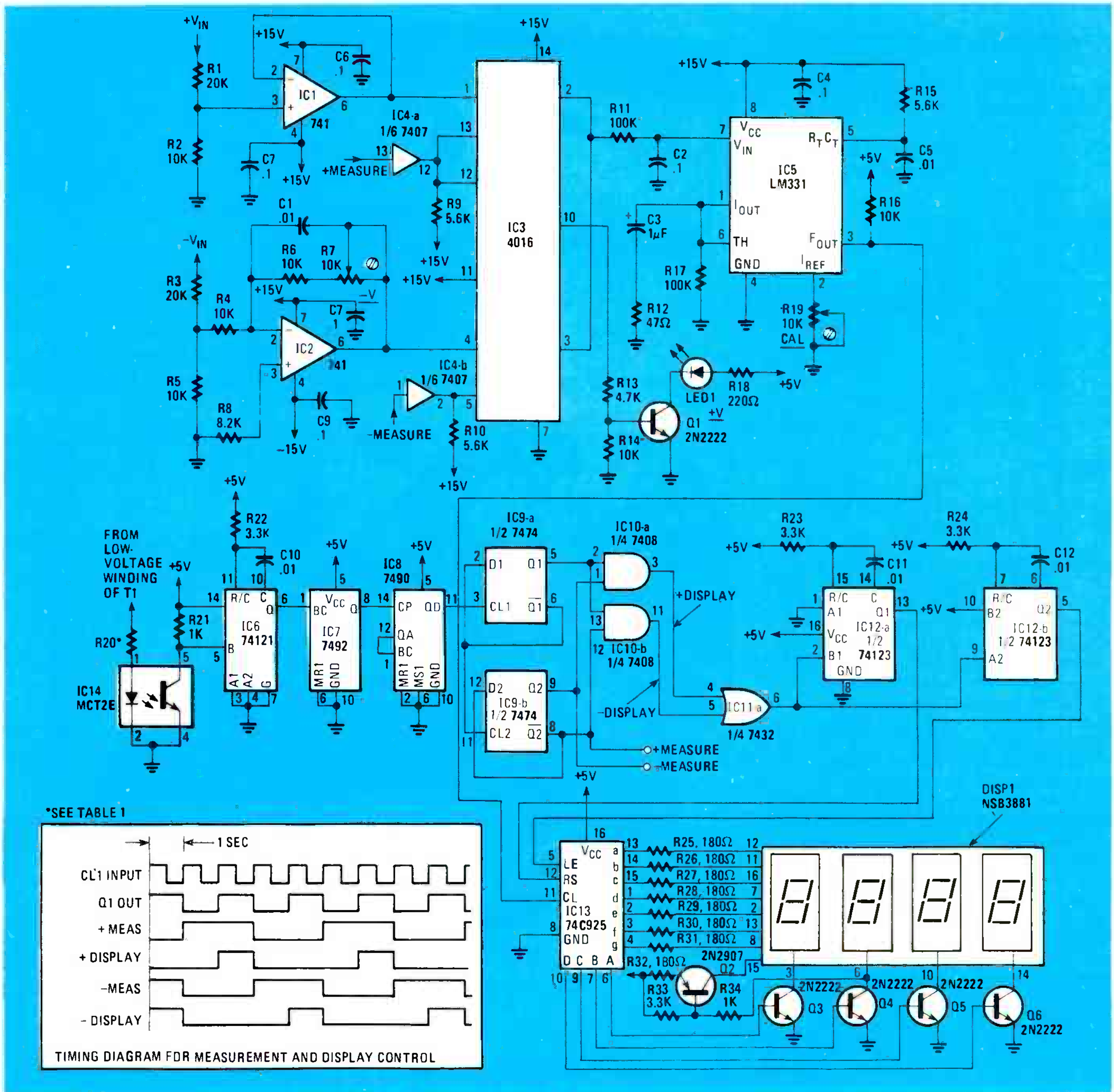


**FIG. 11—UPPER SECTION of schematic of dual-input DVM shows input amplifiers, switching, polarity indicator, and V-F converter. Lower section shows timing and display circuits.**

DVM requires a high input-resistance not necessary here, so I used less resistance in the divider, permitting use of the popular, low-cost 741 op-amp instead of the TL084C.

The TTL IC's used in the timer logic operate from 5 volts. A section of a 7407 open-collector buffer, IC4-a, provides translation to 15 volts for control of the 4016 quad CMOS switch. The switch is controlled by the + MEASURE and − MEASURE outputs of IC9-b, a 7474 flip-flop. The section of the 4016 used to drive the front-panel POLARITY LED is also controlled by the MEASURE output of the 7474.

A timing diagram is included in Fig. 11 as an aid in following the logic timing. A complication arises in this DVM in that the voltage presented the voltage-to-frequency converter can change by as much as ten volts in going from one source to the other. There is a time constant in the V–F circuitry that will cause a large error unless it is dealt with. My way around that was to allow the LM331 two seconds of measure time, then take only the last half of that time for display.

While at first glance it may appear that the display logic is providing the counter with a simultaneous LATCH and RESET. That, however, really isn't so. The 7432 (IC11-a) triggers IC12-a with the leading edge of its output to reset only the counter (and not the latch) while the display continues to show the currently-latched count. One second later, the trailing edge triggers IC12-b to latch the new count for display.

## Construction

I tailored the construction of this meter to fit the location. The board at the rear (seen at the left in Fig. 9) contains the timing logic. The one in the middle holds the two 741's, the measure switching, and the V–F converter. The display logic and the display snuggle up to the front panel so the display can poke through.

The display is supported on the circuit board only by its wiring—short lengths of No. 22 bus wire (quarter-watt resistor leads). Each short piece of wire has a 90°

*continued on page 99*

ALL ABOUT

# VLF Active Antennas

*An active receiving antenna can dramatically improve your receiver's performance, especially at very low frequencies. Here we will discuss some practical circuits for both wideband and narrowband operation.*

R.W. BURHANS

**Part 2** IN THE FIRST ARTICLE of this series, we presented some of the fundamentals of active receiving antennas. That type of antenna has several advantages over wire antennas, especially at very-low and low frequencies (VLF and LF). First, active antennas have a short physical length. The active antenna systems that we will discuss here are used with a one-meter long whip. That helps reduce the sensitivity to local noise from sources such as power lines. Because of the active antenna's high input-impedance and low output-impedance, it is more efficient than a simple wire antenna in converting a received signal at the antenna to a corresponding voltage level at the receiver's antenna terminals.

In general, the properties that we want our active receiving antenna to have are: high input-impedance, low input-capacitance, low output-impedance, and minimum distortion/high linearity.

Another objective is to keep the circuit as simple as possible. A single-stage JFET amplifier has the best combination of properties for active antenna preamplifier applications—and it allows the circuit to be kept relatively simple. (This is not to suggest that there might not be better, more complex circuits, using several semiconductors or IC's.)

### Wide-band amplifier circuit

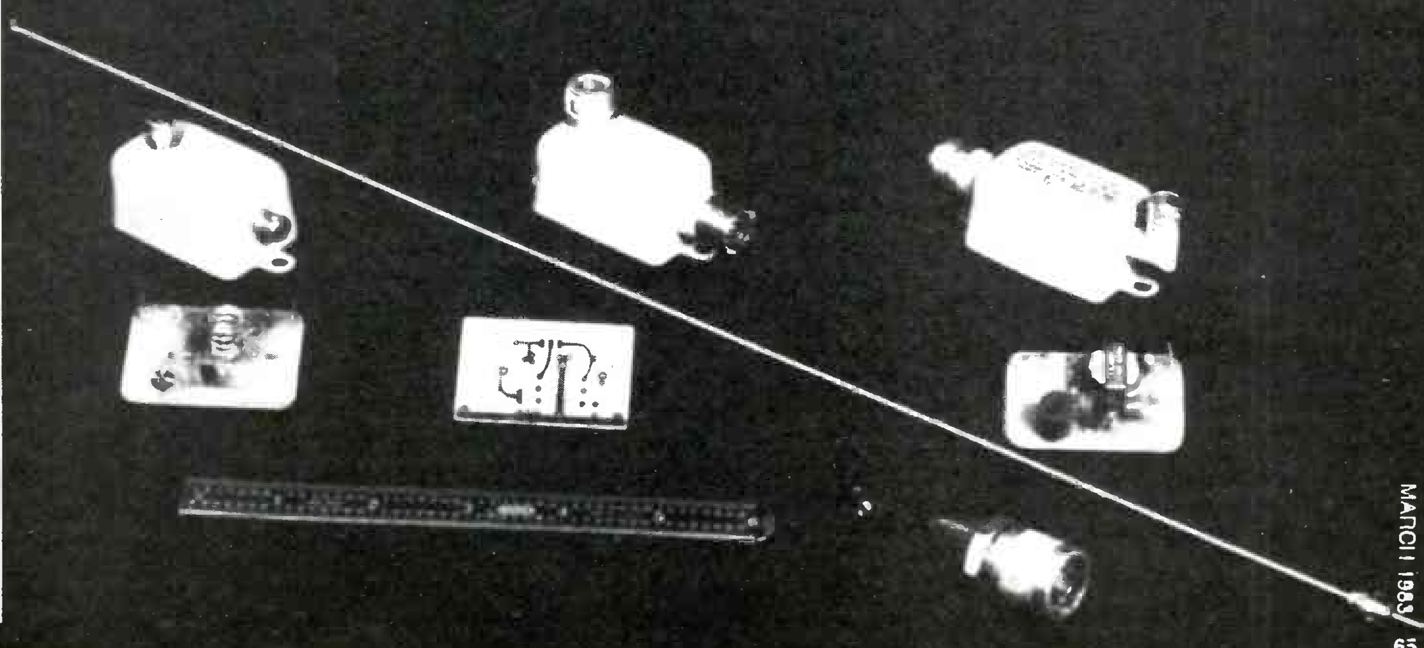
The JFET that we have chosen to use is the Siliconix J-310 (or U-310 in metal can). That JFET is often used as a grounded-gate transmission-line amplifier for TV and FM reception (at a 75-ohm input/output level). The J-310 will usually handle short-duration static surges up to 100 volts or so without damage, so a single low-capacitance neon bulb can provide input static-charge protection. That is of value since semiconductor diodes usually have a much higher junction-capacitance when used as protection devices and, if used, would increase the input capacitance of the preamplifier.

In our application as an active VLF-HF preamplifier, the J-310 is used in a common-source common-drain configuration with inductive feedback (that improves the linearity and lowers the output impedance). Figure 1 shows our wideband circuit for the range of 10 kHz to 30 MHz. Note that the feedback from drain to source is large because of the low resistance of the transformer and its 1:1 turns ratio. (We will discuss how to wind that transformer in Part 3 of this series; that part will contain actual construction details.) For the circuit to operate properly, the transformer's output should be opposite in phase to its input (with respect to ground).

The amplifier circuit is intended to be used with a 1-meter vertical whip. The antenna and its mount capacitances serve as part of an input filter. The input capacitance of the JFET is quite low (about 7 pF). The 2.2-µH inductor at the gate of the JFET serves as a lowpass filter or trap, resonating with the junction and circuit (including antenna) capacitances at a frequency near 30 MHz. That input filter aids in reducing FM-VHF interference over a range of 50 to 500 MHz where the 1-meter whip acts like a resonant antenna.

### Receiver coupler

The receiver coupler both provides power to the preamplifier and extracts the signal from the coaxial transmission line (from the preamp). A wideband receiver



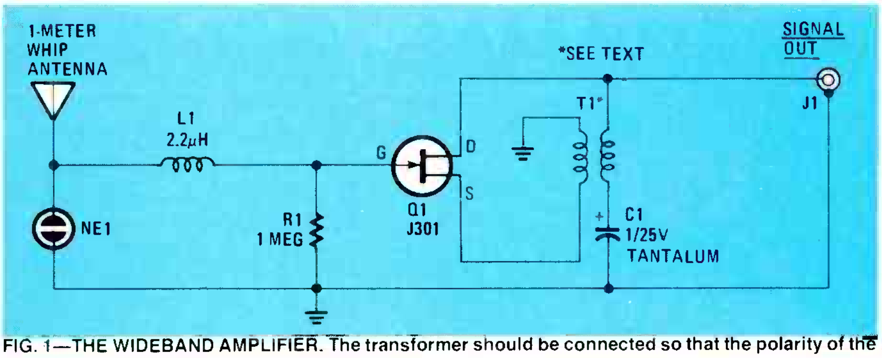


FIG. 1—THE WIDEBAND AMPLIFIER. The transformer should be connected so that the polarity of the output is opposite in phase to that of its input.

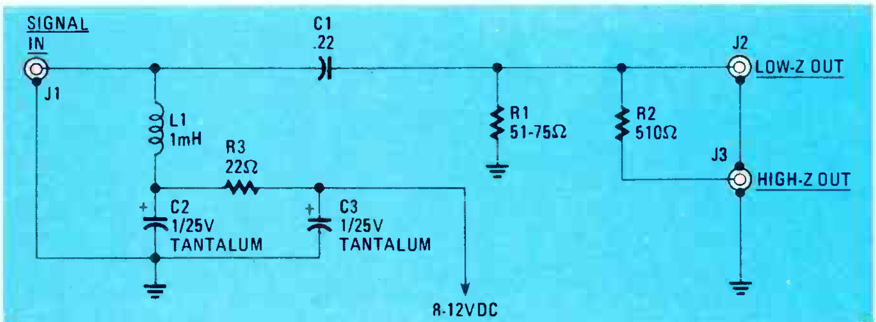


FIG. 2—THE RECEIVER COUPLER both provides power to, and extracts signals from, the amplifier, as well as acting as a highpass filter

coupler is shown in Fig. 2. Capacitor C1 and inductor L1 form a highpass L-section filter (with about a 10-kHz 3-dB rolloff). Resistor R1 is used to ensure that the preamplifier output sees a low-impedance load no matter what sort of receiver is connected. Resistor R2 is used for matching to a receiver with a higher input impedance. That resistor would cause a signal loss of 6 dB if the input impedance to the receiver were 500 ohms.

The coupler circuit provides DC power to the preamp through the coaxial cable. Power sources less than about +8 volts will reduce the dynamic range and linearity of the amplifier. The power dissipation of the JFET using a +8-volt supply will be about 200 mW. The rating of the J310 at 25°C is about 360 mW maximum. In practice, we have not burned one up even when operated with a +12 volt supply for an extended length of time.

The active antenna preamp is like a Class-A amplifier (where the output has low distortion, but the power furnished by the DC power supply is much greater than the power dissipated in the load). However, some distortion does ultimately appear in the output at high input-signal levels. That is due to the fact that a JFET biased in that way cannot be made perfectly linear over a wide dynamic swing of the output voltage. Other modes of operating the JFET with different biasing have been tried, but they have not resulted in any significantly better performance. So, in a sense, the circuits of Figs. 1 and 2 are of the "simpler is better" type.

## Intermodulation distortion

A wideband active antenna covering from 10 kHz to 30 MHz has poor performance with regard to IMD (*In*ter*M*odulation *D*istortion) because little input filtering is provided. Interference will be noted especially if the observer is close to strong AM broadcast-band transmitters. The standard method for evaluating the intermodulation response of a receiver is to measure the 2nd and 3rd order intercepts.

Figure 3 shows a plot of the output power of the two fundamental signals ($f_1$, $f_2$) versus the output power of the second order and third order distortion products. (We discussed intermodulation distortion products in the first part of this series, which appeared in the February issue of **Radio-Electronics**). Those are shown as a function of the power of a two-tone input signal.

One thing we should mention first is that when the input signals are too large, the amplifier output will not follow the input linearly. That is called *gain compression* and can be seen in Fig. 3.

If the linear portions of the curves are extended, they will eventually cross each other. That is shown in Fig. 3, where the curves are extended by dotted lines and cross at an output level that cannot be reached by the amplifier. The point where they cross is called the *amplifier intercept*. The input and output coordinates where they cross give you the input and the output intercepts.

In general, the higher the intercept point is on the graph, the better the amplifier's capability. Those measurements are best made with a sensitive spectrum analyzer, but an approximate idea can be obtained by using a receiver and recording the S-meter readings with appropriate signal-generator sources. The relatively low number of only +10 dBm for the 3rd order intercept indicates that the active antenna should be used

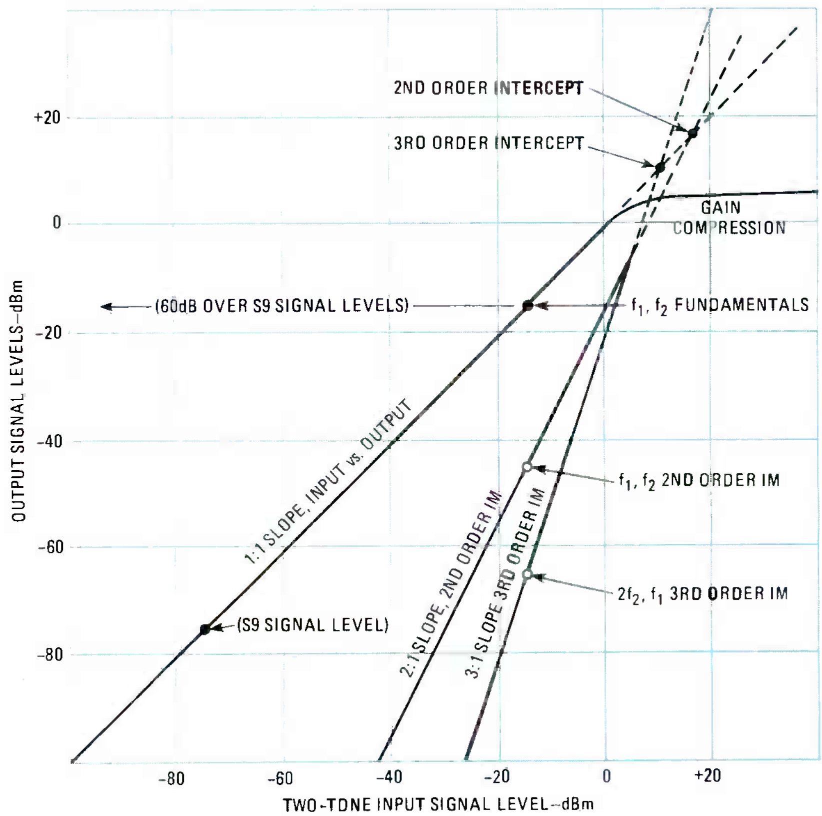


FIG. 3—THE HIGHER THE INTERCEPT POINTS, the better the amplifier's intermodulation rejection.

over a wide frequency range only where the local interference level is not severe. The antenna, of course, might be used in a high-signal area but the observer has to exercise some caution in making sure that the IM signals are not obscuring some desired signals on the same frequency.

For the wideband case of 10 kHz to 30 MHz, those intermodulation-distortion measurements suggest that only a short antenna of perhaps 1 meter or even less will provide the least amount of spurious responses—increasing the antenna length will only tend to increase the distortion level. Longer antennas should be used only when the active preamplifier is provided with some form of input and/or output filtering to reduce the out-of-band interference effects. With added input filtering, an active antenna with a 1-meter whip can provide less IMD because the input filter reduces the likely interfering signals before they have a chance to operate on the preamp input circuitry.

Although the wideband active antenna should not be used with anything longer than a 1-meter whip in areas of high adjacent-channel interference, longer antennas—perhaps up to 10 meters—can be tried in a "quiet" location for operating in the VLF-LF range. However, when using long antennas in the HF region there is an additional interference problem because the antenna is resonant at more than one frequency. One rule to follow here is to keep the length of the antenna less than 1/10 wavelength at the highest frequency used for a wideband system. Although that is short at the highest frequency, an antenna of that length used with the wideband preamp will perform almost as well as a 48-inch top-loaded vertical connected to a 50-ohm system (as in mobile CB radios at the 27-MHz region). A primary reason for using an active-antenna system is to provide good performance over a wide range with small physical size. Thus, if the antenna is to be used only for the CB range, it would be simpler to use an ordinary CB antenna and avoid all of the wideband problems.

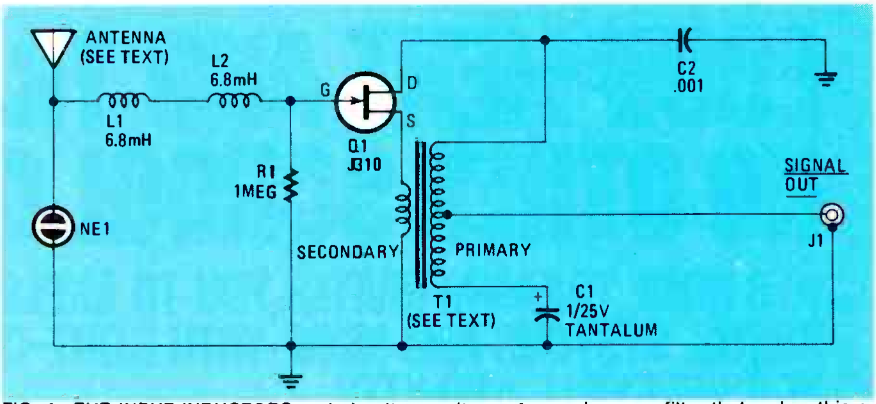



FIG. 4—THE INPUT INDUCTORS and circuit capacitance form a lowpass filter that makes this an amplifier for restricted use in the VLF-LF range.

## Amplifier circuit—VLF and LF

At frequencies below about 500 kHz, the amplifier circuit is modified to provide input filtering and higher voltage-gain. Figure 4 shows the modified circuit. Two input inductors and the circuit capacitances form a lowpass filter with a cutoff frequency near 450 kHz (see Fig. 5-a). The choice of those inductors is somewhat critical because the preamp's operation depends partly on the resonant frequency of the coils, the distributed capacitance, and the capacitance of the windings to the shield housing. To reduce mutual coupling, the coils are connected in series with their windings opposing each other. Therefore, they still can be mounted close together on a small circuit board with no interstage shield. That arrangement provides at least another 30 dB of attenuation for broadcast-band signals directly at the input to the preamplifier where the problem of intermodulation starts. A single inductor can be used, but it will not provide quite as sharp a cutoff for interference from the AM broadcast band.

The output transformer is an ultra-miniature audio-output transformer with a 200-ohm center-tapped primary and an 8-ohm center-tapped secondary. (We will talk more about that transformer when the series continues.) The output transformer has good response to at least 400 kHz, even though it was originally intended for audio-frequency use. The smaller amount of feedback applied from drain-to-source results in higher voltage gain of about +6 dB at the expense of slightly less power gain, or a higher output impedance when compared to the 1:1 wideband toroid. However, we use the iron core transformer because of its low cost as well as the lowpass output filtering provided.

When used with a 1-meter whip, the VLF-LF version of the active antenna—with an input lowpass filter with about a 450 KHz rolloff—provides higher intercept points with respect to broadcast-band interference (although it is about the same for interference from other frequencies). If you are located in a region free from high-power broadcast-band transmitters, then you can use the preamplifier of Fig. 4 with longer antennas. However, a point is reached with any active system where merely increasing the antenna size does not improve the overall signal-to-noise ratio because the atmospheric noise level increases at the same rate as the signal.

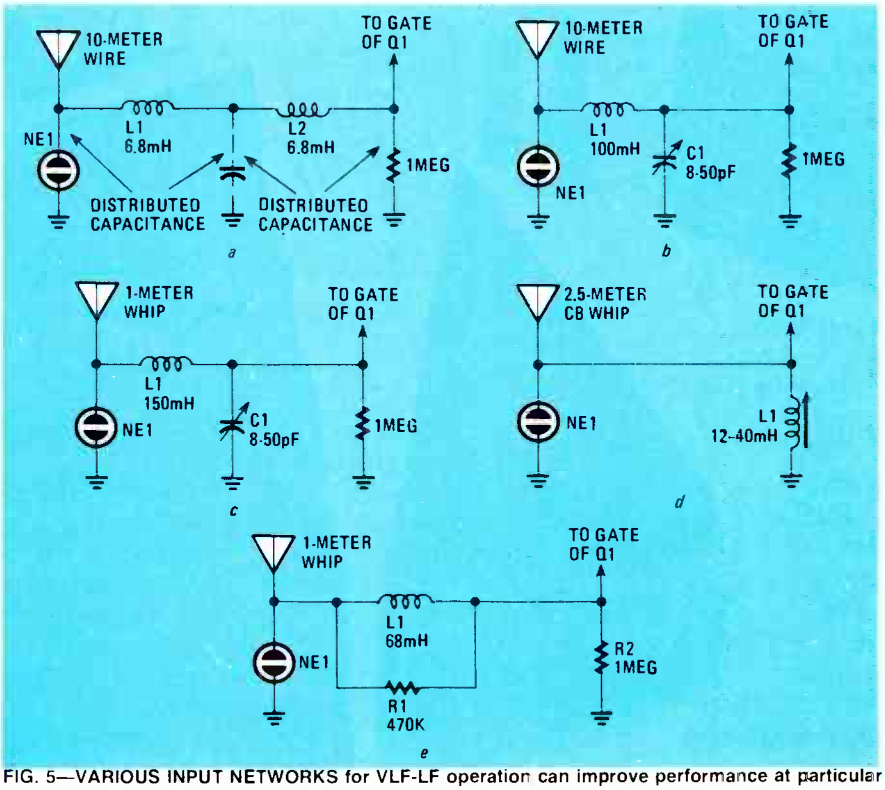



FIG. 5—VARIOUS INPUT NETWORKS for VLF-LF operation can improve performance at particular frequencies or increase the antenna's selectivity.

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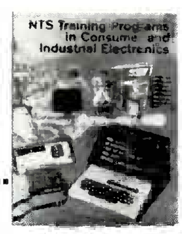


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## Resonant input circuit

Figure 5 illustrates various high-impedance input networks for restricted use in the VLF-LF region (such as Loran-C only, or WWVB, or for the 160 kHz–190 kHz experimenters' license-free band). A series inductor with a small input tuning capacitor can be used to further reduce interference and increase the antenna performance. A miniature trimmer-capacitor with a tuning range of 8 to 50 pf placed from the gate to ground, directly across the 1 megohm input resistor (see Figs. 5-b and 5-c) provides a means of tuning the series inductor for a peak at the desired frequency range. The result is a sharp, high-frequency cutoff with a more gradual low-frequency rolloff. The inductor was chosen to be self-resonant (remember, real inductors also have capacitance) at a somewhat higher frequency than the top of the desired tuning range. That technique will work for some pot-core or slug-wound inductors but will usually not work well with large toroids, as they have too much distributed capacitance at VLF. It is also possible to shunt a slug-tuned inductor from the gate to ground (as in Fig. 5-c) but the preamp will then require a larger housing. For that parallel-tuned case, the 1-megohm resistor can be removed because the inductor provides the ground return for the gate. The antenna is then connected directly to the gate terminal with the inductor chosen to resonate with the antenna, input-circuit, and antenna-mount capacitances. The minimum of external tuning capacitance provides the highest Q (most selective) antenna in this application. For DX hunting in the low-frequency experimenters' band (at 180 kHz), a narrowband antenna with a Q of more than 50 can be achieved with a parallel-tuned circuit.

One problem with using a tuned circuit is that it restricts the remote applications of the active antenna. That is because the antenna must be located conveniently so that it can be retuned. However, for covering some fixed frequency (such as the experimenters' band) the antenna system can be aligned on the bench and then mounted for unattended operation. When tuning those systems, it is advisable to temporarily mount the preamplifier assembly in a fairly clear area (preferably where it will be permanently located) to avoid nearby capacitive coupling, which might detune a very selective system.

One technique for broadbanding a tuned circuit is to place a resistor in parallel with the inductor (See Fig. 5-d). Resistor values in the range of 50K to 500K ohms can help broaden Loran-C systems where a wide bandwidth is necessary.

## Traps

Series-connected transmission-line traps tuned to local broadcast-band stations and placed just ahead of the receiver coupler can improve the IMD somewhat and reduce overload or gain-compression problems (see Fig. 6). The tuning capacitors must be isolated from ground and the inductor must be chosen so as to have a reactance greater than 50 ohms at the desired notch frequency. Dual traps are possible. For example, Fig. 6 shows a trap for 970 kHz and another for 1340 kHz connected in series. The combination of input lowpass filters at the antenna and traps at the preamp output can usually provide sufficient attenuation for cases of severe interference in the VLF-LF band from stations in the broadcast band.

A summary of some measurements made with different antennas at 60 kHz for WWVB reception is shown in Table 1. It should be noted that a 2-meter vertical whip is about equivalent in sensitivity to the much larger flat-top antenna. However, the flat top is much more susceptible to noise and interference, even when it is operated with a lowpass filter at the preamp input. The effective-height estimate may not be the same over the entire frequency range. For example, the flat top appears to have an effective height of about 2 meters at 200 kHz but less than 0.9 meters at 60 kHz. That is because of

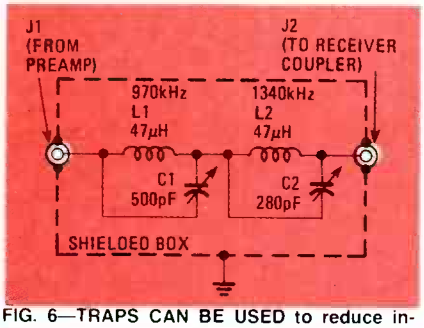



FIG. 6—TRAPS CAN BE USED to reduce interference from broadcast band stations—in this case from stations at 970 and 1340 kHz.

K—the shielding effect and conductivity of the local ground terrain, which includes all the trees, power lines, and building structures. However, we are still able to operate the antenna even down to the 10.2 kHz Omega frequency with reasonable success and it is used routinely to check GBR on 16 kHz for VLF propagation conditions. (GBR is a high-power military VLF station from Great Britain.) In practice, it is always wise to check for IM effects at the specific frequency range that you plan to use the antenna. Sometimes they are severe but only at relatively narrow frequency ranges usually not in the VLF range.

For general wideband surveillance, the 1-meter whip with an effective height of about 30 cm is the best antenna of all, because it has fewer IM interference effects and less local noise from the power lines.

A general conclusion from all of the experiments is that the local environment and the ground-conductivity effects of nearby structures are the most important factors in determining antenna sensitivity. Small changes in antenna location can produce remarkable differences in the antenna's performance.

Another observation is that the best location for a short whip is invariably up high in the clear. (That can especially be seen in aircraft applications where a very short vertical whip is used with remarkably good performance.)

Low-frequency experimental radio station operators have reported good results in mobile operation with reception of 160 to 190 kHz signals using 2.5-meter CB whips and parallel-tuned input networks. We have conducted similar experiments with Omega and Loran-C receivers in mobile vehicles where the only problems were those of shielding from buildings or when driving under bridges or near power lines. An additional problem in mobile operations is harmonic radiation from the vehicle's AC alternators.

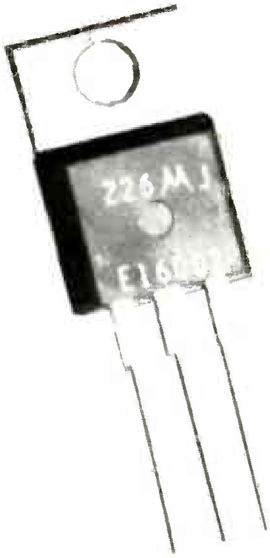
When we continue this series, we will discuss construction details and include printed-circuit board layouts for the active antenna preamplifier and receiver coupler. We will also discuss how to bench test the preamp, and how to mount the system. **R-E**

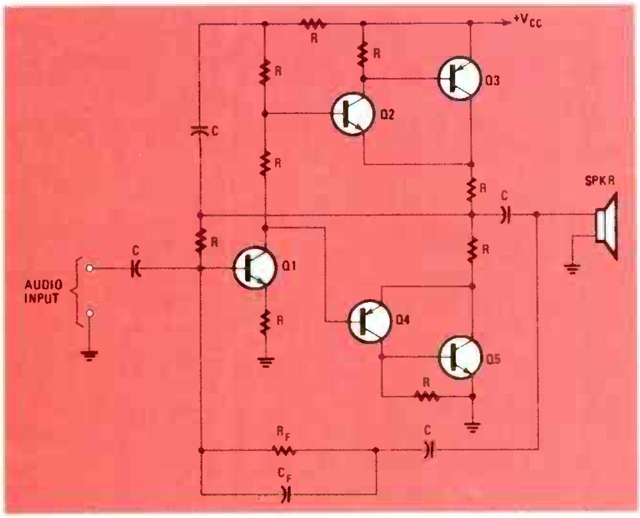
**TABLE 1**

| Parameter | | Whip 1 | Whip 2 | Flat Top |
|---|---|---|---|---|
| Physical Height | ($h_m$) | 1m | 2m | 10m |
| Antenna Capacitance | ($C_a$) | 10pF | 20pF | 118pF |
| Fixed Capacitance | ($C_m + C_g$) | 15pF | 15pF | 15pF |
| Voltage Gain at Preamp | ($A_v$) | 1 (0dB) | 1 (0dB) | 2 (+6dB) |
| Estimated Ground Coupling Effect | (K) | 0.7 | 0.7 | 0.05 |
| Effective Height | ($h_e$) | 0.28m | 0.80m | 0.88m |
| WWVB Reading on YAESU FRG-7700 | | S6 | S9 | S9+ |
| Estimated E-field for WWVB (from NBS chart) | ($E_i$) | 150 μV-per-m | 150 μV-per-m | 150 μV-per-m |
| Output S+N for 60kHz WWVB at Preamp | ($E_o = E_i \times h_e$) | 42 μV | 120 μV | 132 μV |
| Estimated (S+N)/N during 60 Hz "quiet hours" | | +10dB | +20dB | +20dB |
| Overall Noise Rating | | good | fair | poor |
| IM Distortion Rating | | fair | poor | very poor |

# How to Design Analog Circuits

## Audio Power Amplifiers






MANNIE HOROWITZ

*Here's a look at some practical audio power-amplifier circuits. Circuits using both bipolar and FET devices will be covered.*

ALTHOUGH IN THE PAST MANY PIECES OF audio equipment used transformers to couple the driver stage to the power transistors, and those transistors to the loudspeaker, output transformers are currently used only in equipment providing very low output power. You are likely to find an output transformer in a portable radio, but in little else. As for sophisticated equipment, economy may dictate that a driver transformer be used, but output transformers are usually avoided because they may severely limit the fidelity of the signal delivered to the loudspeaker. Instead, most modern audio equipment uses one of a variety of types of transformerless circuits to drive the power-amplifier stages.

Transformerless amplifiers have in the past mainly used bipolar power-transistors. The present trend, however, is to use power VFET's and MOSFET's. One reason for that is the absence of problems such as thermal runaway and second breakdown inherent in bipolar transistors. Another important reason is that FET characteristics are more linear than those of their bipolar counterparts. Consequently, when amplifiers using FET's as output devices are compared with those using bipolar transistors, the distortion is lower in the FET circuits. As a result, you need less feedback to reduce distortion to near ideal levels with FET amplifiers than you would in bipolar amplifiers. And, because less feedback is required in FET amplifiers, instability problems due to feedback are less.

### Driver transformer circuits

A circuit using a driver transformer is shown in Fig. 1. The input signal is fed to the base of Q1 and amplified. The amplified output appears across the primary winding (winding 1) of the driver transformer, T1. The signal from that winding is induced into the two secondary windings and applied from there to output transistors Q2 and Q3. Note that in Fig. 1 there is a dot shown at one end of each secondary. Those dots indicate which ends of the various windings are in phase. While a signal is applied to the base of output transistor Q3 from the end of winding 3 with the dot, a signal of the opposite phase is applied from winding 2 to the base of Q2 from the terminal without the dot—in other words, the same signal is applied out of phase to the two output transistors. If the transistors were biased so that they did not conduct when idling, each transistor would conduct only when a signal was present—in this case only during alternate halves of the cycle. The outputs from Q2 and Q3 will then combine across the loudspeaker load to reproduce the original signal.

Transistors are not biased for zero idling current. There is always some current flowing so that the output devices operate in Class-AB. Bias current for Q2 flows through R3 and through winding 2 of the transformer to the base. Although some of the current from R3 is diverted through R4, there is sufficient current left for the base of Q2 to keep it turned on while idling. A similar arrangment involving R5 and R6 keeps Q3 turned on.

Resistors R7 and R8 in the emitter circuits of Q2 and Q3 respectively are not used exclusively in circuits with driver transformers. They are frequently found in completely transformerless circuits. Those emitter resistors increase the voltage gain of the driver stage while significantly reducing the voltage gain of the output devices. To minimize that loss of gain, the values of the resistors are kept small, and the circuit is designed so that between 0.5 and 1 volt is across each of

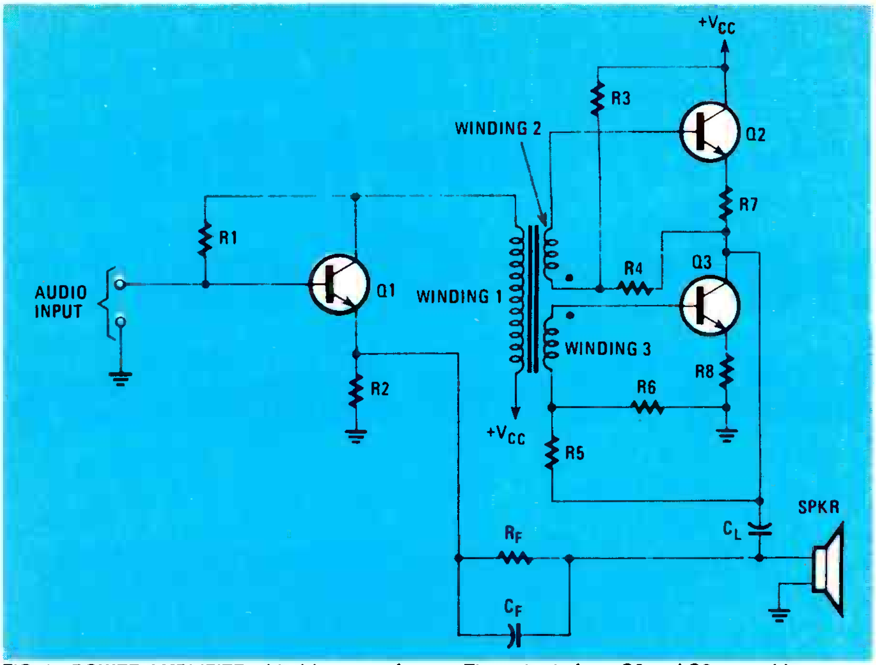



**FIG. 1—POWER AMPLIFIER with driver transformer. The outputs from Q2 and Q3 recombine across the speaker to reproduce the input signal**

the resistors when the transistors idle.

As is true with just about every other transistor circuit using a resistor in series with the emitter, resistors R7 and R8 help to stabilize both AC gain and DC bias. Those resistors also serve as output-transistor protection devices. That protection is important because an output transistor may break down if a short develops across the loudspeaker. But the protection that those resistors provide is somewhat limited; more complex feedback circuits do a better job.

In Class-AB push-pull amplifiers, during different portions of the cycle either one transistor or the other conducts more heavily. During one half cycle, Q2 may conduct heavily and Q3 may not conduct at all, while in the other half the situation may be reversed. In each cycle, however, both transistors must change from a conducting to a non-conducting state and vice versa. Resistors R7 and R8 help to make that transistion smooth, keeping crossover distortion to a minimum. To really improve the smoothness of the transistions, diodes can be substituted for the emitter resistors.

Driver transistor Q1 supplies the bulk of the voltage gain for the circuit while providing sufficient power to drive output transistors Q2 and Q3 through the transformer. The turns ratio of the transformer is selected for minimum distortion across the output load, and is found by trial and error. Typically, however, the turns ratio is usually about 1.7:1. If transformers are not readily available for substitution into the circuit, you will have to live with what you do have but add a feedback circuit to reduce distortion to reasonable levels.

Let's now see how feedback can be used to reduce distortion. The signal is fed back from the output to Q1 through $R_F$ and $C_F$. If the phase is proper, the voltage gain of the circuit is reduced when those components are connected as shown. (Should gain increase or should the circuit oscillate, improper phasing is usually at fault. To correct that situation, just reverse the connections to the primary of the driver transformer.) The network adds what is referred to as negative feedback. When the gain is reduced so is the distortion. If gain is reduced too much, however, the circuit may oscillate. You can determine the amount of usable feedback by trial and error—by varying both $R_F$ and $C_F$.

A circuit may become marginally unstable even when negative feedback is added. That is because feedback may be negative within a specific frequency range (the range in which the quantity of feedback is being measured) but become positive outside of that range. A squarewave generator and an oscilloscope can be used to check the stability of an amplifier with feedback. Start by feeding a 10-kHz squarewave to the input of the amplifier. Note the waveform across the amplifier's output—it should be reasonably square. The three displays that you are most likely to see are shown in Fig. 2. In Fig. 2-a, the ringing on the top and bottom of the squarewave tends to rise with time while in Fig. 2-b it decreases. In Fig. 2-c, there is no ringing, but the leading edge of the squarewave is rounded.

When the output is as shown in Fig. 2-a, the circuit has a tendency to oscillate. That is indicated by the rising amplitude of the ringing signal. Even though the signal in Fig. 2-b also shows ringing, it is more stable because the ringing decreases with time and tends to disappear. To go from the state shown in Fig. 2-a to the one shown in Fig. 2-b usually involves simply increasing the value of $C_F$. If, however, $C_F$ is made too large, ringing may be eliminated but the leading edge of the squarewave will become rounded as shown in Fig. 2-c. If that happens, there may be a loss of high frequency response. The best compromise to adjust $C_F$ so that the waveform is somewhere between those shown in Figs. 2-b and 2-c.

Do not disregard the information presented here concerning the proper design of transformer-coupled circuits with feedback. You may think that it does not apply when no transformer is used, but that is not true. The information presented here applies to all types of power amplifiers. As for feedback, the details and characteristics will be covered in a later article in this series.

## Amplifiers using a complementary circuit

For best results from a push-pull circuit, the two halves of the output circuit must be identical. That is not the case in the circuit shown in Fig. 1. There, the output from Q2 is is taken from its emitter while the output from the Q3 is taken from its collector. Consider, on the other hand, the circuit shown in Fig. 3. In that transformerless circuit, transistors Q2 and Q3 (NPN) and transistors Q4 and Q5 (PNP) form two darlington pairs.

The loudspeaker load is fed by one Darlington pair during the first half of the cycle, and the other one during the second so that the output signal is perfectly

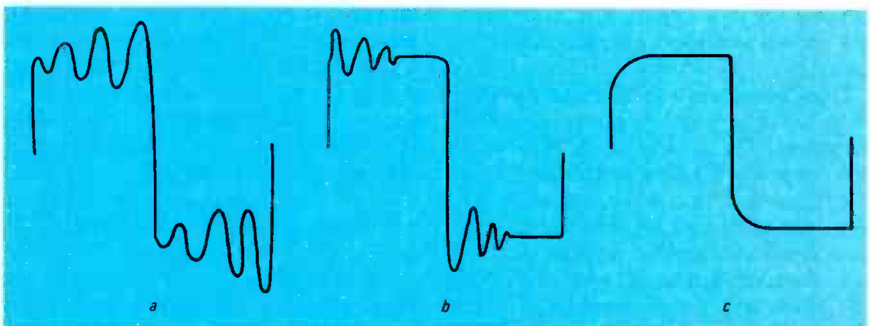



**FIG. 2—IF A SQUAREWAVE is applied to the input of an amplifier, the waveforms shown here may be observed at the output. The waveforms in *a* and *b* indicate oscillation (ringing); the one in *c* indicates loss of high-frequency response. All of those conditions can be changed by changing the value of $C_F$**

balanced. The input signal is applied to the voltage amplifier, Q1. Its amplified output is applied, in phase, to both ... ary ... the Q4. That phase relationship ... This for Q2 to conduct on positive ... out- cycle and Q4 on negative ... ts are same phase relation ... to re- ... in the puts from Q3 ... in the recombined ... of idling ... voltage de- produce ... ge, when ... Q4, pro- ... base-emitter ... emitter cur- ... base currents ... rrents of Q3 ... Q3 is replaced ... , or a series ... , to stabilize ... mperature var-

... voltage developed across ... is one of the load resistors in ... collector circuit of Q1.) The others, wired in series with R3, are R4 and R5. When collector current flows through Q1, the voltage required to forward bias Q2 and Q4 is developed across R3. Transistor Q1 is biased through resistor R1, which is connected to the junction of R8 and R9. When idling, the voltage at that junction is ideally ½ of $+V_{CC}$. Resistor R1 is connected to that point to help stabilize the bias of Q1 against temperature variations.

In order to minimize distortion, a considerable amount of negative feedback must be used around the circuit. If a lot of feedback is applied, however, the gain will drop to low levels. To compensate for that, the forward gain of Q1 must be made very high. Capacitor $C_B$ helps the circuit meet that gain requirement. Signal is fed back through $C_B$ from the output to the junction of R4 and R5. That is known as a "bootstrapping" circuit. That bootstrap circuit makes R4 appear to be much larger than it actually is. And, as R4 is part of the collector load-resistance, the forward gain of Q1 is very high because it is approximately equal to the ratio of the resistance in its collector to the resistance in its emitter.

Capacitor $C_B$ also serves a more important purpose. When the signal is large, the emitter of Q2 is at $+V_{CC}$ volts. When that happens, no current can now flow through its base-emitter junction because the emitter is more positive than the base and Q2 does not conduct. Peaks in the signals are consequently cut-off causing distortion. Let's see how including $C_B$ in the circuit corrects that situation. That capacitor is charged to about ¼ of $+V_{CC}$ when the circuit is idling. When a peak is present in the signal, not only is the emitter of Q2 at $+V_{CC}$, but since the bottom of $C_B$ is effectively at the same potential as the emitter, that terminal of the capacitor is also at $+V_{CC}$. Because the capacitor is charged to about $+V_{CC}/4$, the top terminal of $C_B$ is at $+V_{CC}+V_{CC}/4$. That voltage is applied to R4 to make the base of Q2 positive with respect to its emitter, turning Q2 on. Being turned on, peak positive pulses can now pass through Q2, and the balance of the circuit, to the loudspeaker.

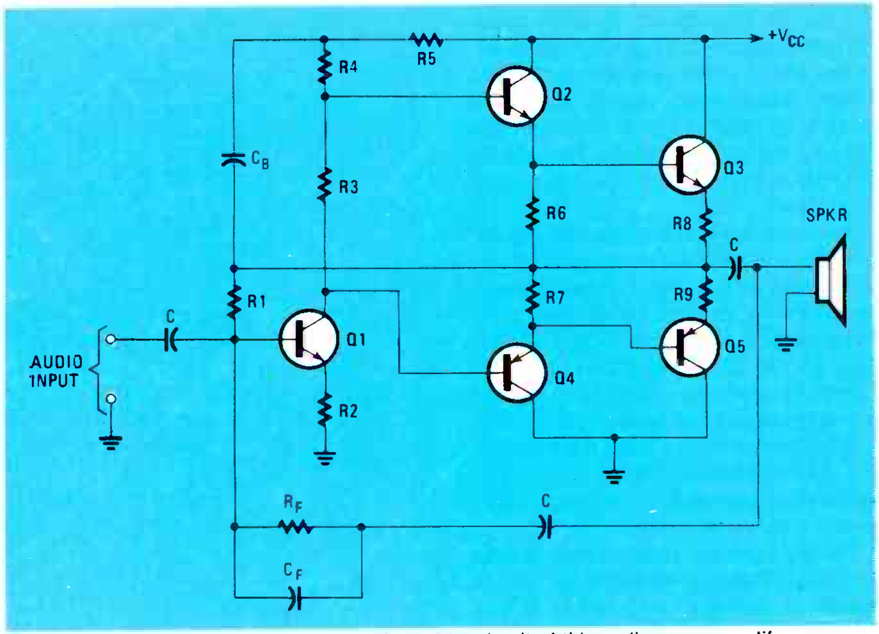



FIG. 3—DARLINGTON PAIRS are used in the output circuit of this audio power-amplifier.

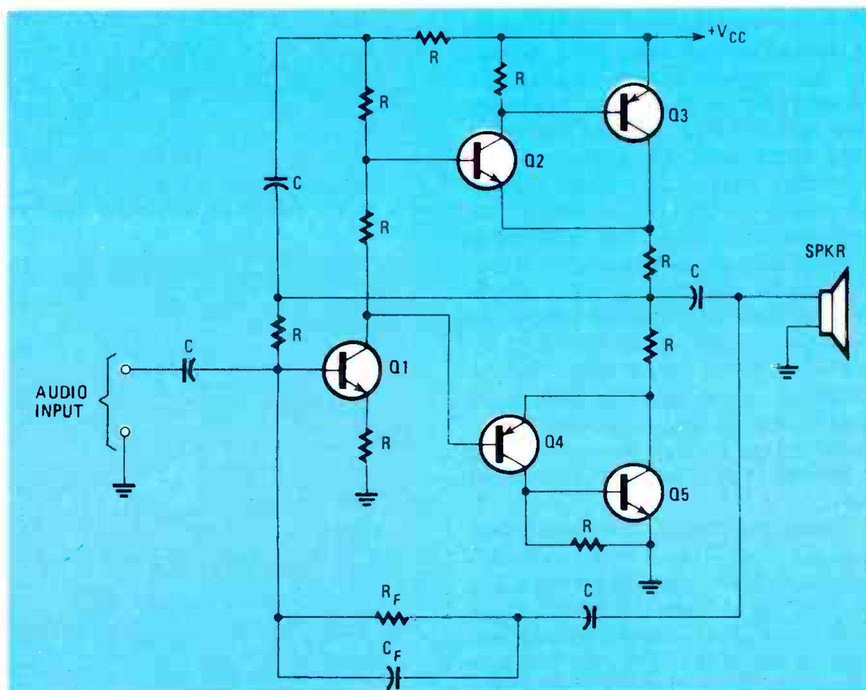



FIG. 4—COMPLEMENTARY PAIRS are used in the output circuit of this amplifier. The signals from them combine across the speaker to reproduce the input signal.

When the circuit is idling, $C_B$ does not affect the performance of the amplifier. Resistors R4 and R5 are chosen so that base current in Q2 and Q4 is proper for the desired idling current to flow through the output transistors. The values of R4 and R5 are usually identical. As before, $R_F$ and $C_F$ form the negative feedback circuit. The method used to find the values for those components are identical to the one previously discussed.

Complementary circuits can be used in place of the Darlington pairs in the power-output circuit. The complementary pair was described in the article on coupled circuits. A circuit using complementary pairs is shown in Fig. 4. Here, Q1 performs the same function as it did in the circuit shown in Fig. 3. Transistors Q2 and Q3 form one complementary pair; transistors Q4 and Q5 form a second.

One of the big drawbacks of the two transformerless circuits dicussed thus far is the presence of a capacitor between the output circuit and the loudspeaker. That capacitor must have a high value if it is to pass the low frequencies. Since the capacitor gets charged through the output transistors, and since the initial charge current is very large, more current may flow through Q3 and/or Q5 at that moment than can be handled safely. Because of that, one or both of those transistors may break down.

A second drawback using that capacitor is that it is almost always an electrolytic because of the high values required. An electrolytic capacitor is not linear, and consequently just the presence of that capacitor can add to distortion somewhat.

The circuit shown in Fig. 5 can be used to overcome some of those drawbacks by simply eliminating the need for a capacitor. Arrangements similar to the one shown there are used in some very high-quality amplifiers.

The big problem in amplifiers that do not use a capacitor between the output transistors and the loudspeaker is that there is no way of keeping DC from flowing through the speaker. The circuit in Fig. 5 eliminates that problem. If the output devices are connected to equal positive and negative voltage supplies, the voltage at the junction of the output devices is zero. That assumes that equal idling current flows through the two complementary pairs of transistors. Current can usually be adjusted to satisfy that requirement. However that relationship will hold only at one temperature; it will not when the temperature rises or falls in the preceding DC-coupled stages. To overcome that, differential amplifiers are used to drive the output stages—if the current changes in one of the devices, an equal current change will occur in the second device, keeping the overall circuit in balance. Let's see how that circuit works.

Transistors Q1 and Q2 form one differential amplifier. They drive a second differential amplifier consisting of Q3 and Q4. The output from Q3 is applied directly to the Q6/Q7 complementary pair while the signal from Q4 must first pass through Q5 before being applied to the Q8/Q9 complementary pair. Transistor Q5 is required because it shifts the phase of the signal from Q4 so that the signal fed to Q6 is in phase with that at the input of Q8. Resistors in the base and emitter circuits of Q5 are adjusted so that the current from Q5 is equal to the current from Q3. No bootstrap capacitor is required in that circuit as the proper current levels are always present at Q6 and Q8, through Q3 and Q5 respectively.

Potentiometer R1 is adjusted so that there is 0 volt at the junction of Q7 and Q8, and across the loudspeaker. Transistor Q10 is in a constant current source circuit, required for proper operation of the differential amplifier.

The circuit shown in Fig. 6 is similar to the one in Fig. 5. The op-amp, as discussed in a previous article, is actually a combination of differential amplifiers.

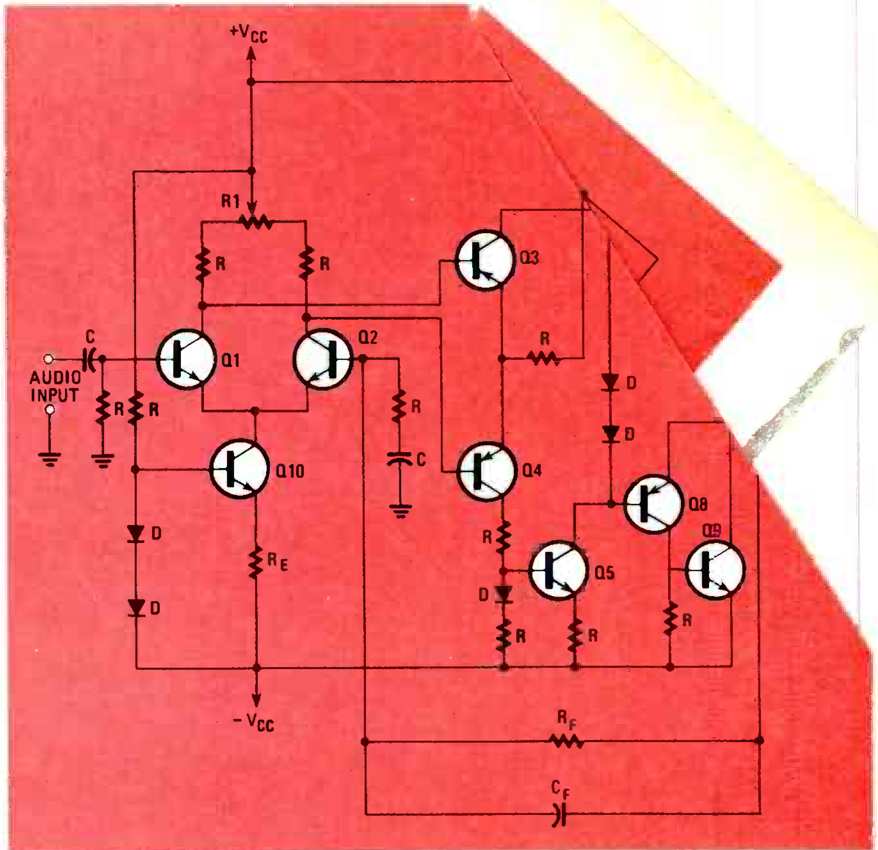



FIG. 5—THE HEART OF THIS high-quality circuit is a pair of differential amplifiers.

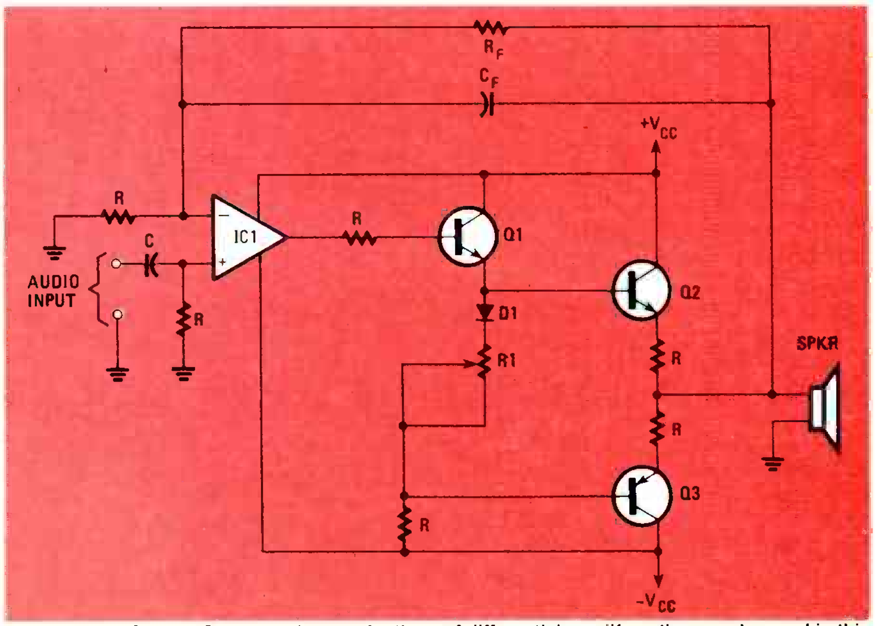



FIG. 6—SINCE OP-AMPS are simply combinations of differential amplifiers, they can be used in this variation of the circuit shown in Fig. 5.

As such, its DC-output level is extremely stable despite temperature changes. Because that stable voltage is coupled to the output devices, a loudspeaker can be connected directly to those output transistors without an intervening capacitor.

Note two items peculiar to this circuit. Instead of using Darlington or complementary pairs in the output, a single output transistor is used in each leg of the push-pull circuit. Second, the voltage developed across D1 and R1 is used to establish the bias for Q2 and Q3. The desirable idling current for the output transistors is set by adjusting R1 because that potentiometer varies the voltage applied to the base circuits. Diode D1 helps keep that voltage, and hence the idling current, constant despite variations in temperature.

Next month we'll continue our discussion of power amplifiers. R-E

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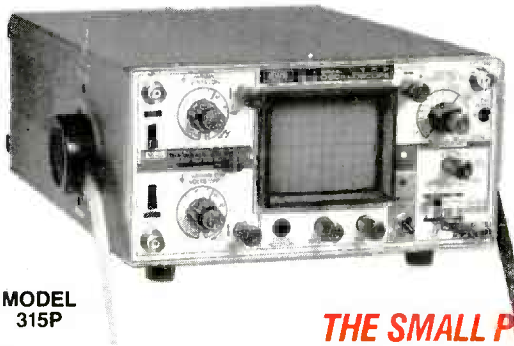

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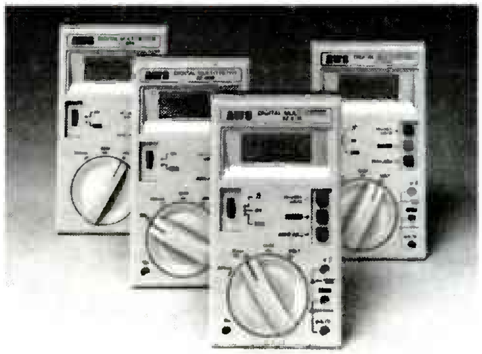

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# NEW IDEAS

## Use a clock radio as an appliance controller

DO YOU THINK THAT YOUR CLOCK RADIO should do more than just turn on its tiny internal radio (if its radio still works!)? Well, I have a solution. With this easy modification, you can use the clock to turn on any device of your choice automatically. If you are a heavy sleeper who doesn't usually wake up when the alarm rings, you can use this modification to "customize" your alarm to turn on lights, sirens, or anything else that may help you wake up more easily. As an added feature, a three-conductor cable allows you to remotely control one or two sets of devices.

I should point out right away that you do not have to cannibalize a clock radio that you are satisified with. Many surplus outlets (many of which advertise in the back pages of **Radio-Electronics**) offer the clock "guts" from clock radios. However, if you have a clock radio without a working radio, then this sure beats throwing it out!

The circuit for the modification, shown in Fig. 1, is fairly simple. We'll start with S1 and S2 which are the remote-control switches that are mounted at the end of a three-conductor cable. When one of those switches is closed, it will set its half of the flip-flop made up of IC1-a and IC1-b. That causes the output of IC2-b to go high, which, in turn, enables either IC1-c or IC1-d. That causes one of the relays to turn on, which drives one of the triacs that power the output sockets. (However, if you close both remote switches at the same time, though, the flip-flop becomes unstable.)

Switch S3 is part of the clock. On most clocks, it is a normally-open switch that closes when the alarm "rings." If the switch on your clock is a normally-closed type, don't worry—all you need to do is tie it to +5 volts and tie the 1K resistor to ground.

The resistor–capacitor network rejects all pulses (glitches) from the switch that are not long enough to charge the capacitor. When a long-enough pulse is sensed, IC4-a is clocked and Q is set. That enables IC1-c and IC1-d through IC2-b, which turns on the last device used, according to the S–R flip-flop. To turn off the alarm, either open S3, or close either S1 or S2. That causes IC3 to reset the alarm flip-flop. When S4 is pressed, the last device that was used turns on for as long as it is held down.

An eight-volt transformer is used to develop 12-volts peak across the 4700-µF capacitor. I used two panel lamps to illuminate the clock's face, but they are, of course, optional.

If you don't want to use the remote switches to shut off the alarm and instead want to use only S3 for that purpose, then you can eliminate IC3 and IC4 and connect S3 directly to IC2-b. If you need to control only one device instead of two, and also don't want S1 and S2 to shut off the alarm, then you can eliminate all of the IC's and connect the switches directly to the relays or the triacs.—*Donald H. Delorie, Jr.*

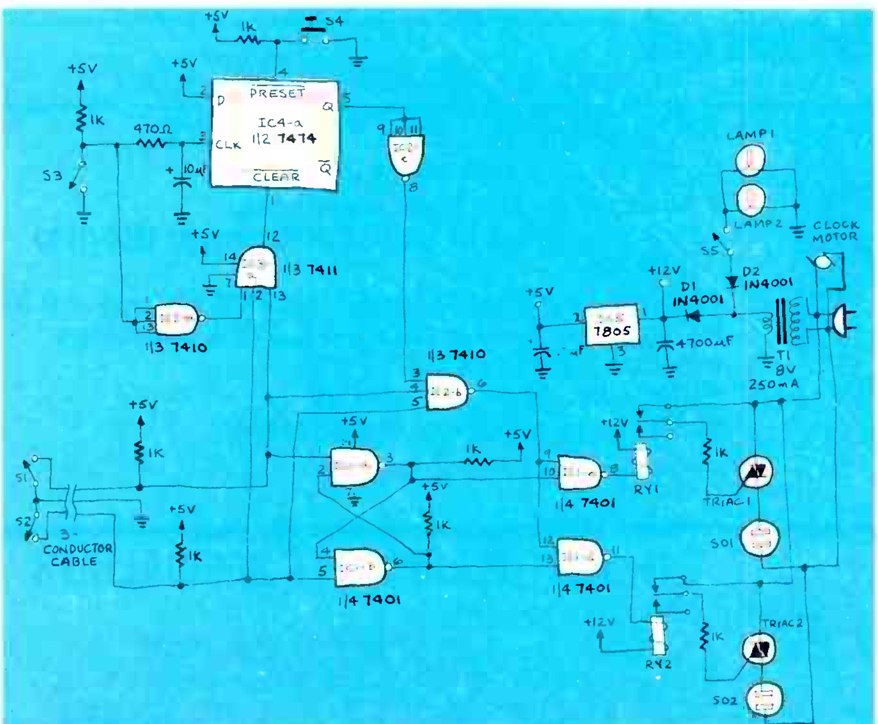

FIG. 1

### NEW IDEAS

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# HOBBY CORNER

## Light-puzzle solution and more

**EARL "DOC" SAVAGE, K4SDS,** HOBBY EDITOR

THE FIRST ORDER OF BUSINESS TODAY IS to consider the responses to John Cirillo's light-switch problem that was presented in the November issue. The question, as you may recall, was how a single light bulb could be controlled independently by three single-pole double-throw switches. The word "independently" means that the light could be turned on and off from each switch regardless of the position of the other two switches.

It does seem that John's puzzle really got to you! Each day for several weeks, the mail included many letters about those switches. I read every one, checked it out, and put it into one of several stacks. The great majority of you got the switching correct, but I would like to share some ideas from some of the other stacks (of incorrect answers) before getting to the answer directly.

A small group of you did send circuits with three SPDT switches in which one or more positions of two switches made the third inoperative. In two circuits, certain combinations of positions placed a direct short across the AC line!

One reader, David Potts of Ohio couldn't work out an SPDT solution but he said that there is an easy solution if the three apartments are on three seperate floors of a building. His solution is shown in Fig. 1. It seems that he once rigged such a system in a lighthouse. Good for you, David.

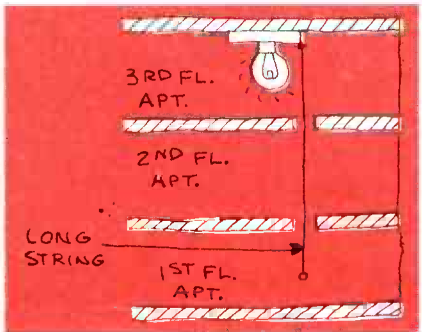

FIG. 1

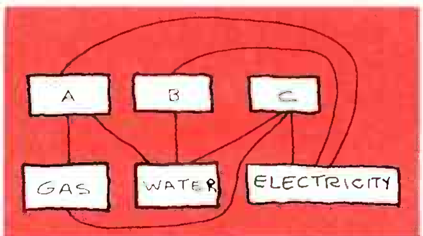

FIG. 2

A few of my friends out there chided me for not knowing the answer. Then, they proceeded to give me the answer—an answer which did **not** meet the conditions of John's problem. In other words, their answers did not use SPDT switches exculsively.

Actually, that question reminds me of a puzzle on which I whiled away many pleasant hours in junior high school. In case you have never run across it, look at the sketch in Fig. 2. The question here is how to serve three houses (A, B, C) with gas, water, and electrical utilities from their respective distribution points (G, W, E) without any branching lines. Each house must have direct, independent service and the kicker is that no line can cross another. (Come now, I have run all but one line—surely you can figure out how to run the last one!)

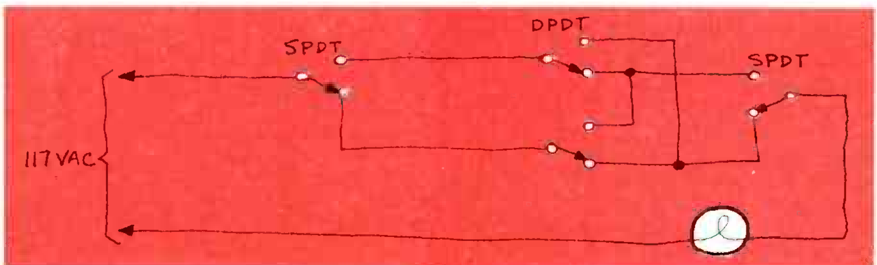

FIG. 3

> **AN INVITATION**
>
> To better meet your needs, "Hobby Corner" will undergo a change in direction. It will be changed to a question-and-answer form in the near future. You are invited to send us questions about general electronics and its applications. We'll do what we can to come up with an answer or, at least, suggest where you might find one.
>
> If you need a basic circuit for some purpose, or want to know how or why one works, let us know. We'll print those of greatest interest here in "Hobby Corner." Please keep in mind that we cannot become a circuit-design service for esoteric applications; circuits must be as general and as simple as possible. Please address your correspondence to:
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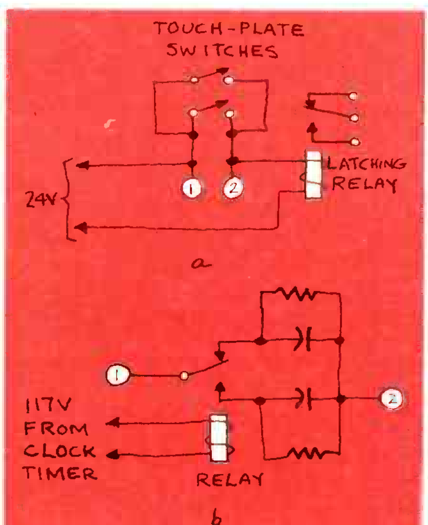


FIG. 4

As you may have gathered, no one came up with independent control of a light with three SPDT switches. A number of you took the time to offer a proof that there could be no solution to the problem as stated. The closest thing to a solution, as most of you pointed out, requires one DPDT and two SPDT switches. Such a circuit is shown in Fig. 3. Check it all you like—each switch can turn the light on or off regardless of the positions of the other two.

I must agree with those of you who thought that John somehow missed seeing in one of the apartments a DPDT or "four-way" switch. For those of you who have not seen this circuit before, be advised that you can put as many DPDT switches as you wish between the SPDT switches on the ends. Thus, you can have independent control of a light that can

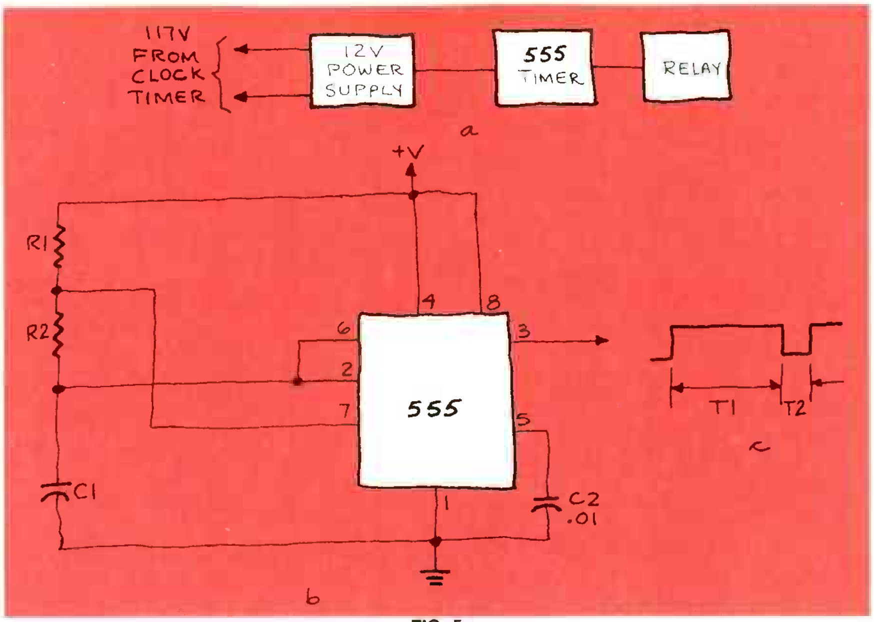



FIG. 5

come from any number of locations.

John should be sleeping soundly now that he knows no one else can solve his problem either. Thanks to all of you who responded to John's question.

### Touch plate timer

Robert Allen of Washington has a low-voltage "touch plate" wiring system in his home. That is one in which momentary switches operate 24-volt latching relays which control lights, outlets, and so on. You should note that any number of parallel switches can control any one relay. That is a very effective system for several reasons but it does have a disadvantage.

With the setup as shown in Fig. 4-a, what kind of timers can you use to turn lights on and off at preselected hours? Robert's best solution to date is to use a 120-volt relay between the timer and the touch-plate circuit as shown in Fig. 4-b. It does the job but not with complete dependability. In the absence of frequent contact cleaning, it gets out of synchronization and turns the lights on when they should be off and vice versa.

Well, Robert, why not use the familiar 555 IC timer to produce the controlling pulses? As shown in Fig. 5-a, a clock timer would control a 12-volt power supply for an astable 555 timer set to pulse the latching relay at the desired hours. That relay itself is a SPST latching-type that closes with the short pulses from the 555.

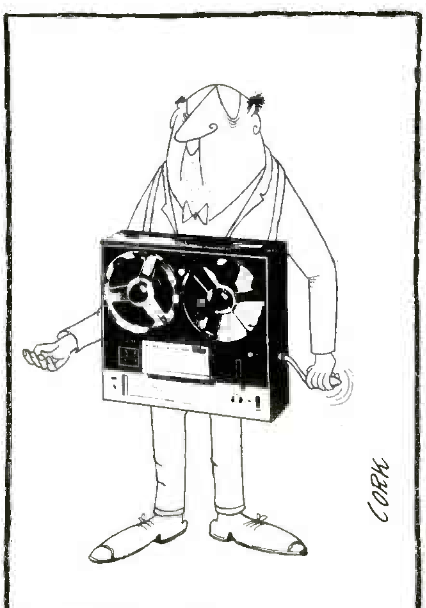
The 555 circuit and its output waveform are shown in Fig. 5-b. The values of R1, R2, and C are determined by the desired times. The relay contacts will close when it sees the leading edge of the pulse (low-to-high transition). Time $t_1$, the length of the pulse, can be determined by the formula: $t_1 = 0.693 \times (R1 + R2) \times C$. Time $t_2$, the length of time between pulses, can be determined by the formula: $t_2 = 0.693 \times R2 \times C$.

The length of time that your light will be on is the sum of $t_1$ and $t_2$ and is equal to $0.693 \times (R1 + 2R2) \times C$.

Set the clock timer to apply 12V to the 555. When power is first applied to the 555, the lights turn on. The next low-to-high transition (after time $t_2$) turns the lights off. Set the clock timer so that it goes off and removes power from the circuit before the 555 produces a third pulse (the third pulse would turn the lights back on).

Depending upon the intervals desired, you may need to cascade a couple of 555 IC's or insert a counter IC between the 555 and the relay.

That is an effective but fairly cumbersome approach to the problem. Next month I'll show you how to do the job in a much simpler way with a digital clock. Stick around. **R-E**



# THE DRAWING BOARD

## Adding a digit select to a BCD encoder

**ROBERT GROSSBLATT**

IF YOU BREADBOARDED THE BCD ENCODER we designed last month you found (we hope) that it was a trouble free, reliable circuit. However, its use was somewhat limited because the encoded data wouldn't latch and only one digit at a time could be placed on the bus. This month we're going to add additional logic to the circuit so that we can display and latch up to 10 digits at a time. We'll stick to the set of design criteria we listed last month and we'll use the same sort of step-by-step approach to add the new sections to our design. The choice of components will still be weighted in favor of those that are easily available and reliable, and that put the smallest possible dent in your wallet.

### The digit select

We want the digit select to sequentially address one thing after another. You could use some sort of shift-register approach for that, but the clocking can be a problem and the package count can get pretty heavy. There's a neater way to solve the problem that also happens to work out better in the long run. Not only can we solve the addressing problem with only two IC's, but expanding the circuit to handle ten digits will only call for one additional IC.

Instead of the shift-register approach, we'll create an input data bus and design circuitry that will enable one digit at a time. We take the "any key pressed" output of our BCD encoder and use that to clock a 4017 one-of-ten decoder. That means that each time we close one of the keyboard switches, we put a corresponding nybble (4 bits) on the data bus and the 4017 puts a high on one of its output pins. A new digit entry will result in a new nybble on the bus and a new high from the 4017. That continues for up to ten entries (sequentially). Figure 1 shows how you would connect the 4017 to handle four digits with the encoder circuit we started last month. Although the circuit will handle ten digits we'll limit our illustration to four. (The principle is the same and it makes the circuit easier to understand.)

Capacitor C8 serves the same purpose that C1 did in last month's circuit. It gives us a reset to zero at power-up and makes sure that everything starts out at the beginning. With the 4017 set up as shown in Fig. 1, it will reset after four low-to-high transitions of the "any key pressed" output. If you want to handle more than four digits all you have to do is connect the RESET pin, (pin 15), to the numbered output that is one past the number of digits you want to deal with. If you want to go all the way and encode ten digits, ground pin 15 through a 1K resistor.

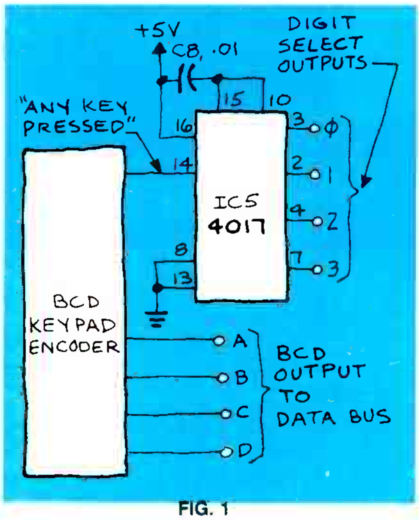



FIG. 1

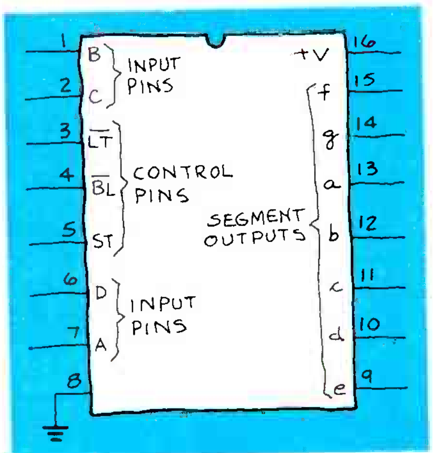



FIG. 2

Figure 2 shows the pinouts for a 4511—the decoder we will use to drive our display. The LAMP TEST and BLANKING control pins (pins 3 and 4) are active low and should be kept high for normal operation. The STORE input controls the internal latch and is active high. If it's held low, the 4511 will decode whatever BCD data is presented to its inputs. If it's made high it will latch and display the last nybble on the bus at the moment it went high. Any invalid BCD code will blank the display.

The obvious step in creating our data bus is to connect the A, B, C, and D inputs of the 4511's together and tie them to the appropriate BCD outputs of the encoder. Our four digit-select outputs would be connected to the STORE pins of the respective 4511's and we would be in business. Unfortunately that would fail miserably and a moment's reflection will show you why. The outputs of the encoder are constantly scanning from zero to nine at the clock rate, so the 4511's that weren't selected would display constant eights—and not even real eights at that. The selected digit would display the keyed number but would go to eights as soon as the digit selector shifted to the next digit.

What we need is a way of delivering a brief pulse to the STORE pin to open the latch just long enough to enter the nybble at the selected 4511. Now, pulse generators are a dime a dozen, and perfectly workable ones can be built with 555's and other IC's. In real down-and-dirty situations, you can get by with just a capacitor and a resistor, but the discharge time of the capacitor creates a very sloppy slope at the trailing edge of the waveform. The easiest way to get the job done and still be true to our design criteria is to use a half monostable.

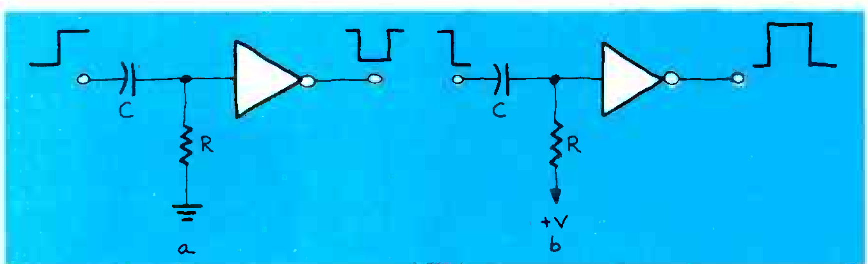



FIG. 3

Fig. 3 shows the basic configuration of half monostables. In actual fact they

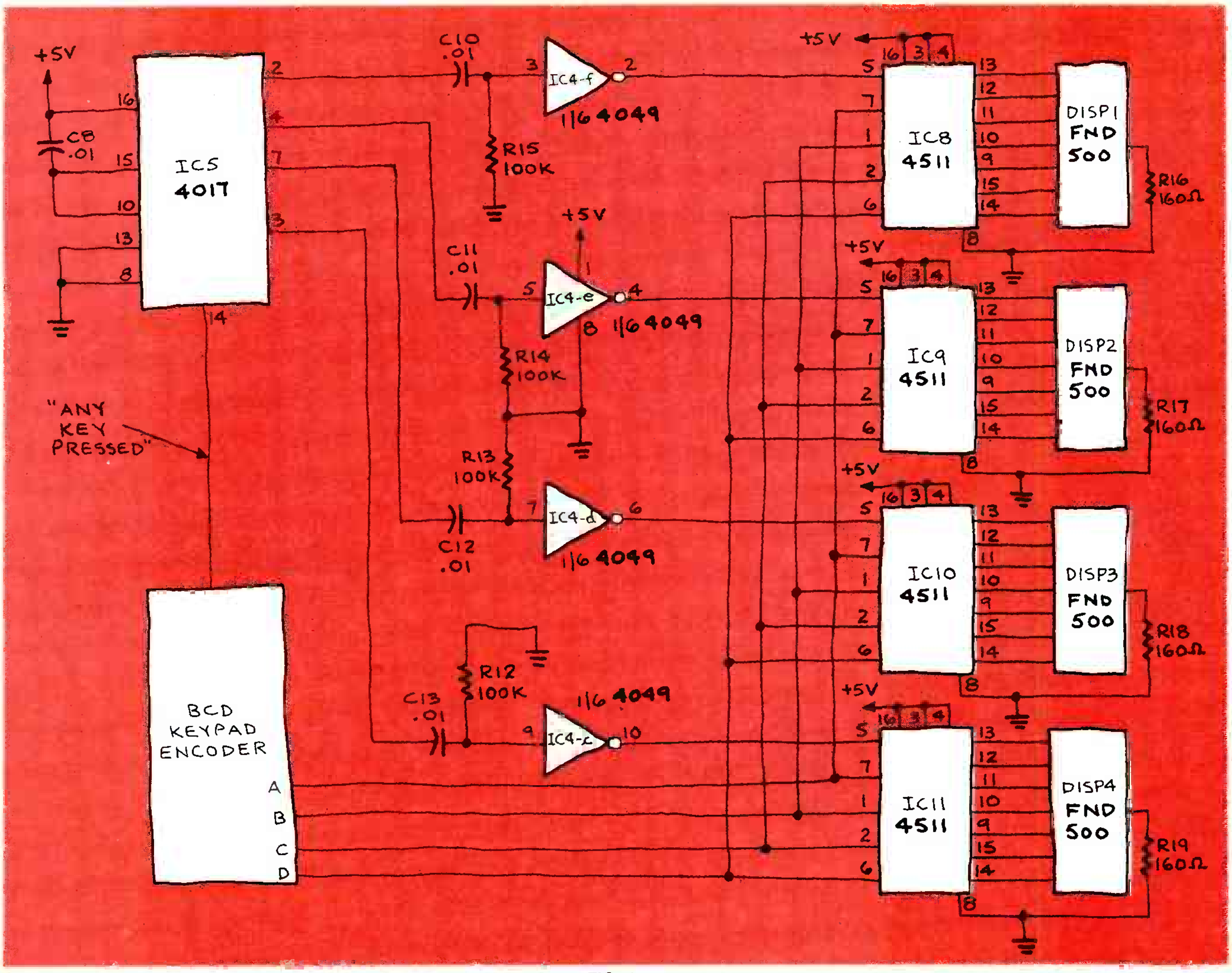



FIG. 4

should really be called edge detectors because they respond to either the leading or trailing edge of a logic level transition. With resistor R connected to V+, the gate input is held high. When the input goes low it forces the gate to change state for a period of time determined by the values of the resistor and the capacitor. The duration of the output pulse depends on the R–C value and the slope of the waveform depends on the transition time of the gate. A 4049 is a good choice here because it has enough internal gain all by itself to clean up the sloppy edge of the input waveform. The inherent hysteresis of a Schmitt trigger also makes it a good candidate for a half monostable. If you build those circuits with non-inverting gates, the same analysis applies but, of course, the output pulses will be in the opposite direction. The "big if" with these half monostables is that the input pulse has to be longer than the desired output pulse.

That is really self evident—a moment's thought will tell you that you have to give the capacitor enough time to charge up. If that condition isn't met the circuit won't blow up, but the output pulse will be the same width as the input pulse. In our case that's not a problem because the outputs of the 4017 latch high when they're decoded. All we have to do is make sure the output pulse-width of the half monostable is less than the fastest speed we can enter data from the keyboard. One millisecond should be fast enough for anybody—even for the world's fastest supermarket cashier.

In Fig. 4 we've completed the digit selector and display and connected it to the encoder we built last month. When we turn the power on, the 4017 is reset to zero and pin 3 goes high. Since the negative-to-positive transition is what triggers the half monostable, the first digit we enter will be on the negative-to-positive transition of output No. 1 (pin 2) of the 4017. That's why the schematic shows the zero output (pin 3) of the 4017 connected to the last digit.

In any event, as soon as power is applied, the circuit prepares itself to enter the first digit. When we close one of the keyboard switches, a BCD nybble is held on the data bus and the 4017 goes high on output No. 1. That triggers the half monostable and opens the 4511's latch just long enough to enter the nybble and then closes it again. The result is that the selected number appears in the display and stays there. When a second keyboard switch is closed, the 4017 enables the latch in the second 4511 and the number appears in the second display. That whole procedure continues until the fourth digit is entered and the 4017 resets. From that point on, the entered digits will write over the previously entered ones. The 4511 is designed to be used with common-cathode displays; we used Fairchild FND-500's. Only one current-limiting resistor was used for each numeral because I don't mind the slight differences in brightness that shows up when different numbers are displayed. If you want the numbers to be all of equal intensity, connect the cathodes of the display directly to ground and get yourself a huge supply of low-value resistors because you've got to put one on the line between each 4511 output and LED anode. Keep in mind that the 4511 can only supply about 25 milliamps per segment, so choose the resistor value accordingly. You can play with this circuit for a while but it will soon be painfully obvious that it leaves a bit to be desired.

Since we don't have any access to the nybble in the internal latch of the 4511 and decoding the segment outputs is, to put it mildly, a strange way to go about

*continued on page 99*

# SERVICE CLINIC

## Troubleshooting thermal problems

**JACK DARR**, SERVICE EDITOR

A LOT OF THE PROBLEMS WE RUN INTO are temperature-related. Transistors are inherently temperature-sensitive. And, if you think things are bad now, you should have seen some of the early sets that used germaniums! Their normal leakage is much greater than silicon transistors, and the hotter they get, the worse the leakage gets. Leakage increases almost linearly with temperature, until it "stops the works." In a curve tracer, the "fingers" of the curve start out fairly straight, and then curl as the temperature is raised, until the pattern looks like the one shown in Fig. 1. That's why you find such huge heat-sinks in early models.

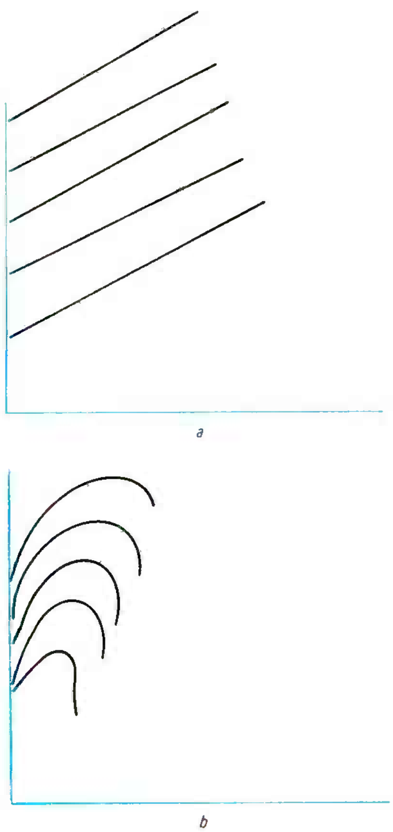



FIG. 1

Silicon transistors also can have that type of problem, especially if they aren't derated enough. (See Service Clinic in the October 1982 **Radio-Electronics** for more on that.) Even IC's will do it. In one case (a small import black-and-white TV set) the sound would distort badly after it was on for about an hour. After much experimenting, and hard thinking, we found that the the IC that handled the sound was the cause. Cooling the IC down brought the sound back. Adding a heat-sink cured the problem.

The key symptom in thermal problems is what we'll call the "time-constant"—the length of time the set runs before the problem appears. If that length of time is always about the same, the cause is very likely to be thermal. There's a sub-symptom here that can help. Short time constants (for anywhere up to 5-10 minutes) point to a problem that's apt to be in a power-handling circuit—some part that normally carried a good deal of current.

Some potential problem sources are resistors that overheat and change value, transistors that develop more and more leakage as they warm up, and (watch this one!) small, low-voltage electrolytic capacitors that have some leakage to begin and which gets worse as the set runs and they warm up. (I have a built-in suspicion of all low-voltage electrolytics anyhow, especially in the cheaper sets.)

If the time constant is quite long—anywhere from a full hour up to several hours—the trouble is apt to be in some part or circuit that normally does not develop enough power to get hot "by itself." The heat that causes the trouble is either conducted through the chassis or PC board to the part, or radiated from a nearby part that gets quite hot.

In the first case (power-handling parts) wait till the problem occurs and then carefully feel various parts to see which one is too hot. (Carefully! Some of them can get really hot.) Faulty voltage regulators are a common cause of those problems.

If the problem seems to be thermal, there are two things you do to find the cause: either heat or cool the suspected circuit or component to see if you can make the problem show up or go away. Cooling is the easier way. Just spray coolant on suspected parts to see what happens. The best type of spray coolant is the one with a long thin nozzle that lets you hit only one part at a time. Metal nozzles are thinner but plastic is safer!

Application of heat is a bit more difficult, but not impossible. A heat-gun like the Wahl *Thermal Spot* is ideal. It has a nozzle so that you get the heat right where you want it. If you don't have one, sneak out your wife's hair-drier, and rig up a plastic nozzle to give a smaller stream of hot air.

I've run across a bunch of sets with real oddball problems over the years. One of my pet oddballs is a tube from a set that would work perfectly for a minute then go out. It was the AGC tube. When I tried it in a tube-tester, it would come up to normal for exactly 60 seconds, then drop to zero! It would do this over and over. I've still got the tube on my bench!

One my favorite solid-state oddballs was a transistor, used as the 3rd video IF. When I tried it in a curve tracer, I would see a perfect pattern at room temperature. If I held the tip of a soldering iron near the case for a few seconds, pow—it would drop to zero. Let the transistor come back to room temperature and up it would come up normal again. If I sprayed coolant on it, out it would go. When it warmed up, it would come back! The thing would work perfectly over a range of temperature that couldn't be more than about 5 or 6 degrees! You can imagine what it did in the set. On a cold morning it wouldn't work till the room heated up!

All thermal problems aren't transistors either. Bad solder joints can either open up or close with temperature. Here again, the spray coolant and heat gun can save you an awful lot of time in pinning down the cause of the problem. The oddball in this department was a solder joint with a nice sharp spike of solder sticking up out of it. When the set heated up enough, this spike would penetrate the plastic insulation of a wire too close to it. (That one took a while to find, too.)

Hot IC's can cause some problems such as the sound problem mentioned previously. In another set, the color would drop out. The 3.58-MHz oscillator was a simple op-amp type IC. When it got hot, it went out. That was pinned down by spraying coolant on it. Replacing the IC turned out to show the same symptoms! The fix was attaching a good sized, very thin aluminum heat-sink to the case of the IC. That kept the temperature down to the point where it still worked. The heat sinks can usually be cemented to the top of the case, or if there's room, held by a clamp to the chassis.

At first, they told us that solid-state sets ran cool. That is true—they run cooler than tube-type sets, but from much field

experience we've found that they get as many thermal problems, or even more. So, when you run into a set that shows symptoms of thermal problems, get out the spray coolant and the heat-gun and go after it. Use the methods outlined. They work, and can save you a lot of time and perspiration! **R-E**

# SERVICE QUESTIONS

### WIDTH TOO WIDE

***I have a problem with a CTC-68 RCA chassis. There is too much width, especially on the left side. The width control works, but not enough.—H.S., New York, NY***

I suggested that he check the two 1.5μF capacitors from the horizontal yoke to ground. He wrote back and said that their values were right on the nose. However, experimenting, he found that using larger capacitors cleared up the problem. He settled for 5.7μF, and says that everything's fine.

### RAIN MAKES SNOW

***I have a satellite-TV receiving system that normally gives good reception. However, when it rains, it looks like I'm in a fringe area without a booster! I didn't think that rain was supposed to have any effect. All the components are good quality, or so I thought.—J.H. Pine Ridge, KY***

Rain shouldn't usually have any effect. Try this: Sprinkle each component, especially the coax fittings, one at a time while watching the picture to see whether and when snow shows up. You could have a bad socket or plug, etc.

(Feedback: When I "rained" on the LNA, there came the snow! The coax fitting wasn't waterproof. The unit was still under warranty, so I exchanged it. Thanks!)

### SMART SUBBING

I had a GE YA-E that kept blowing its horizontal amplifier, Q702. I found that two capacitors were shorted and leaking electrolyte, respectively. One, the .0075-μF, 1600-volt capacitor was replaced. The other, a .01-μF, 2400-volt device, was hard to find. The best that my local supply house could come up with was a .01-μF disc rated at 3 KV. I didn't like to replace a tubular electrolytic with a disc, but I gambled on a Sprague "Safety Capacitor" type PP16S11S. That came up just right. The heat sink and Q702 stopped running hot, and everything's working fine. I must admit that I learned that trick from a "Service Clinic" back in 1979.

*Thanks to Eric Urscher of Huntington, WV. Good work, Eric!* **R-E**

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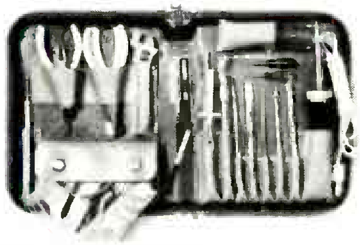

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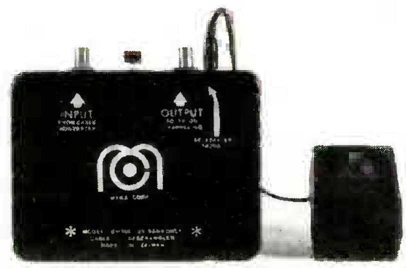

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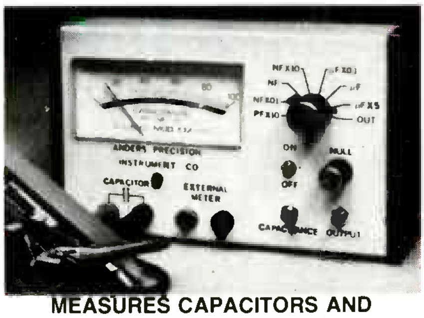

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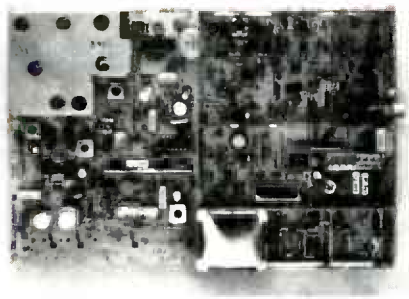

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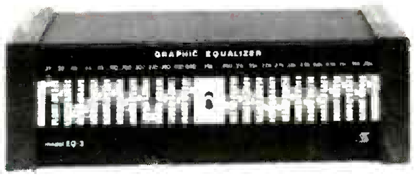

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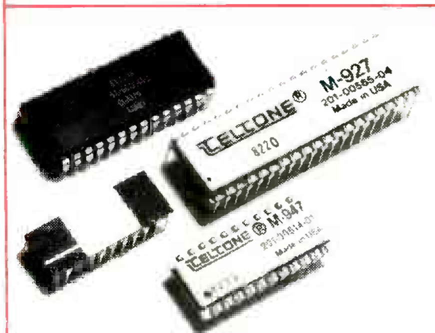

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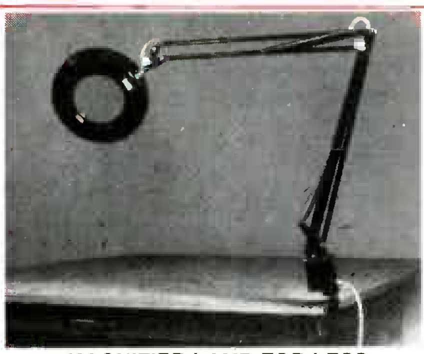

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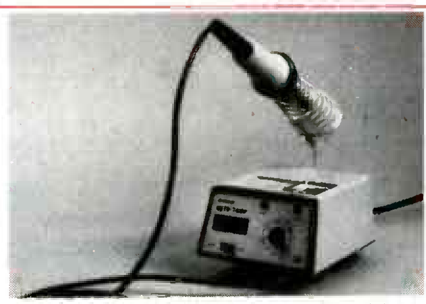

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# STATE OF SOLID STATE

## Compressors, expanders, and compandors

**ROBERT F. SCOTT,** SEMICONDUCTOR EDITOR

SINCE THE EARLY DAYS OF HIGH-FIDELITY audio, engineers have worked to improve the realism and signal-to-noise ratio of both recorded and broadcast music. Recording engineers, however, often limit or compress the dynamic range, and broadcasters limit or compress the signal amplitude, of that music. That is done to prevent overloading a tape or over-cutting a record, and to prevent over-modulation. However, those same efforts cause the full dynamic range of the original music to be lost to you—if your playback system does not include a *dynamic volume expander*.

### The Signetics NE570 compandor

You can build a professional-quality expander, compressor, or compandor (a combination compressor and expander circuit) for your hi-fi system by using circuits designed around the Signetics NE570 IC compandor. The pin-out of the IC is shown in Fig. 1. As a compressor, the device provides a 2:1 compression ratio—for example, a 100-dB dynamic range of +20 dB to −80 dB is compressed into a 50-dB (+10 to −40 dB) range as shown in Fig. 2. As an expander, it has a 1:2 expansion ratio, taking the +10 to −40 dB compressed signal and restoring its original full dynamic range.

A compandor can be used for noise reduction. In that application, the signal is compressed before noise can be introduced, and expanded afterwards. Figure 2 shows how that method of companding (compressing and then expanding) can improve the signal-to-noise ratio by about 45 dB.

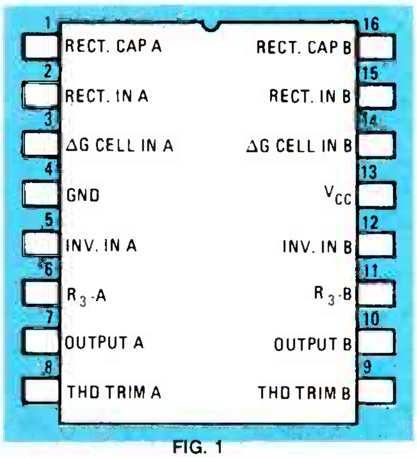


FIG. 1

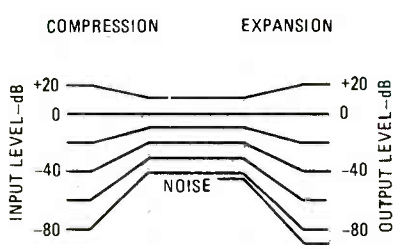


FIG. 2

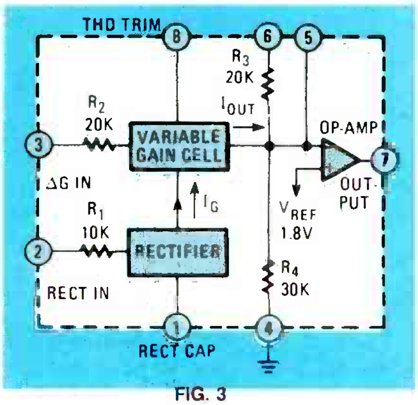


FIG. 3

A block diagram of one half of the NE570 is shown in Fig. 3. Each half of the IC consists of a full-wave rectifier, a variable-gain cell (ΔG), an op-amp, and a biasing system. The full-wave rectifier and an external capacitor (tied to the RECT CAP terminal) detect the average value of the input signal. The rectifier output current ($I_G$) controls the gain of the variable-gain cell. Therefore, the gain of that section of the circuit is proportional to the average value of the input-signal voltage. The ΔG output current, $I_{OUT}$, is fed to the inverting input of an on-chip op-amp that is biased at $V_{REF}$. That reference voltage is 1.8 volts and is provided by a very stable internal low-noise source. (That internal precision voltage-source also biases the THD TRIM circuit used for temperature compensation.)

The speed with which the circuit gain can follow changes in the amplitude of the input signal depends on the value of the external capacitor (the one attached to the RECT CAP terminal). A small capacitor will provide fast attack and fast decay times, but may not provide enough low-frequency filtering. In that case, residual low-frequency signal components will appear on $I_G$ and will modulate the signal passing through the variable-gain stage. That results in third-harmonic distortion, so there must be a compromise between fast response and distortion.

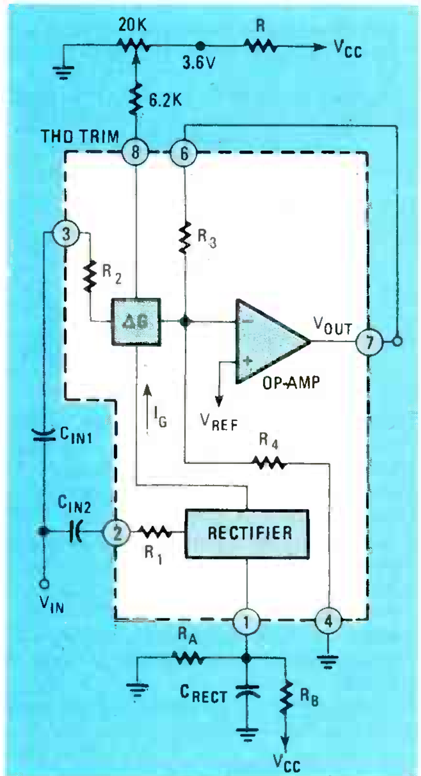


FIG. 4

The expander's output is determined by the DC gain provided by the op-amp. The output is related to the internal reference voltage and also to biasing resistors $R_3$ and $R_4$ as expressed by the equation: $V_{DC\ OUT} = (1 + R3/R4)\ V_{REF}$. When $V_{CC}$ (the supply voltage) is higher than 6 volts, $R_4$ should be shunted with an external resistor to bias the output up to ½ $V_{CC}$.

Resistor $R_3$ is brought out from the op-amp summing node and is used when you want expander or compressor gain to be set solely by on-chip components. You can adjust that gain to your needs by placing external resistors in series with $R_3$. You can also connect an external resistor across $R_4$ to change the bias to any value desired.

## The basic expander

Figure 4 shows the circuit of a basic expander. Input signal $V_{IN}$ is applied to the rectifier and ΔG stage inputs in parallel. The expander can handle a signal input up to 3 volts peak. Rectifier input current can be as high as 300 μA, while the input to the ΔG stage should be limited to 140 μA. If the compandor will see input signals greater than +2.8-volts peak, use suitable resistors in series with $R_1$ and $R_2$ to limit currents to the specified values.

Voltage offsets in the ΔG stage can cause distortion; primarily even harmonics. The THD TRIM pin permits a compensating external voltage to be applied to neutralize the effect of the offset voltages. A voltage divider composed of a 20K pot and series resistor R is connected between $V_{CC}$ and ground as shown in Fig. 4. A 6.2K resistor is connected to the THD TRIM pin. The value of resistor R is selected to develop 3.6 volts at the high end of the pot.

In Fig. 4 coupling capacitors are shown in series with both the rectifier and ΔG stage inputs. However, $R_1$ and $R_2$ can be tied together and connected to the signal input through a single coupling capacitor. In that case, though, tracking at low input-signal levels will be degraded.

The comparator transfer-tracking tends to be a linear 2:1 ratio down to a very low input-signal level. Then, tracking may deviate in either direction from the normal 2:1. Either resistor $R_A$ or $R_B$ (but not both) may be needed to adjust transfer linearity. To correct low-level tracking error, select a suitable value for $R_A$ ranging from around 1 megohm to 100K or for $R_B$ between 250K and 5 megohms.

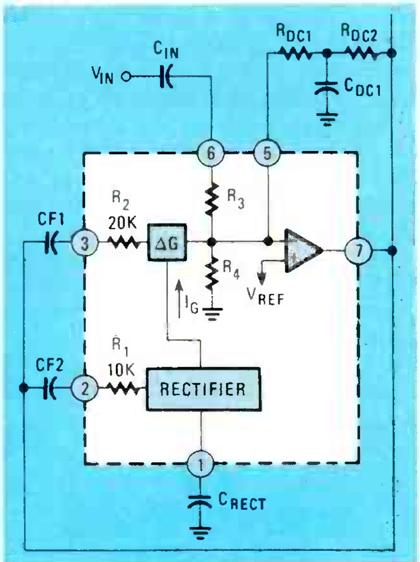

FIG. 5

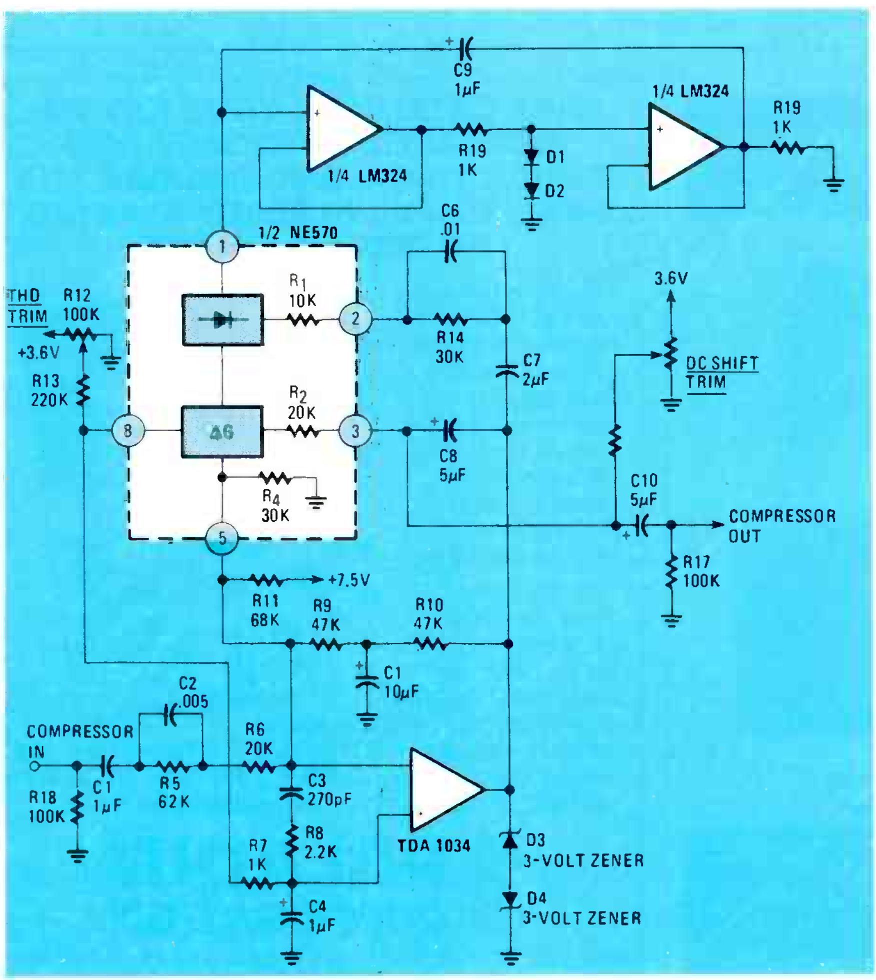

FIG. 6

## The basic compressor

Figure 5 shows that the dynamic compressor is essentially an expander inserted in the feedback loop of an op-amp. The inputs of the $\Delta G$ stage and the rectifier are tied to the op-amp output. The variable-gain stage is set to provide AC feedback only; DC feedback is provided by an external low-pass network composed of $R_{DC1}$, $R_{DC2}$, and $C_{DC1}$. The sum of the values of the two feedback resistors determines the bias at the op-amp's output. The output voltage $V_{DC\ OUT}$ can be written:

$$V_{DC\ OUT} = 1 + \frac{R_{DC1} + R_{DC2}}{R_4} V_{REF}$$

$$= \left(1 + \frac{R_{DC\ TOT}}{30K}\right) 1.8V$$

When internal bias resistors $R_3$ and $R_4$ are used alone, the expander output will be:

$$V_{DC\ OUT} = 1 + \frac{R3}{R4} V_{REF}$$

$$= \left(1 + \frac{20K}{30K}\right) 1.8V = 3.0V$$

You can shunt a suitable resistor across $R_4$ to raise the output bias to the desired level; and you can connect a resistor in series with R3 to increase op-amp output gain.

For the widest possible dynamic range, the compressor's output-level should be as high as possible. Therefore, the input to the rectifier should be as high as possible without exceeding the $+300\ \mu A$ peak-current limit. If the average input-signal level is low, a higher output can be obtained by using a shunt resistor to reduce the effective value of $R_3$ or by using an external series resistor to increase the effective value of $R_2$. Note well that a reduction in the effective value of $R_3$ reduces the circuit's input impedance.

## A high-fidelity compressor

Figure 6 shows a circuit for a hi-fi dynamic compressor that would make an ideal accessory for your tape-recording setup. It features high gain and wide bandwidth. Its external rectifier-capacitor (C9) is not grounded. Instead, it is connected to the output of an op-amp network (IC1-a and IC1-b) to shorten the compressor attack-time at low signal-levels. (The attack time of the basic circuits in Figs. 4 and 5 is relatively long.) That external op-amp is used to to provide improved high-frequency gain.

Diode D3 and D4 clamp the compressor output to a 7-volt peak-to-peak swing. That is necessary at times when the compressor is operating near maximum gain—as with a small signal input—and is suddenly hit with a high-level signal. Normally, the output would swing from $V_{CC}$ to ground and would overload the circuit the compressor was feeding—a tape recorder for example. The attack time and the time it takes for the compressor to recover from an overload depend on the value of C9. A value of about 1 $\mu F$ is a good compromise.

## Breathing

Even some of the best broadcast-quality compressors have been said to have a problem with *breathing*. That term refers to slow cyclic variations in background level that can be heard as the compressor changes gain. Breathing is minimized in this circuit by high-frequency pre-emphasis networks C2-R5 and C8-R14. Naturally, the expander should have a de-emphasis network to complement the compressor's pre-emphasis network. We'll take a look at the expander circuit, before we go on to other things, next month.

This material was abstracted from the Signetics *Compandor Product Guide* from the Analog Division, **Signetics Corp.**, PO Box 409, Sunnyvale, CA 94086. **R-E**

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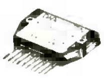

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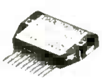

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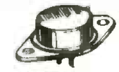

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| TRANSISTORS | |
|---|---|
| 2SA329 | 32 |
| A473 | 56 |
| A463 | 3.57 |
| A489 | 1.54 |
| A490 | 81 |
| A495 | 16 |
| A496 | 45 |
| A509 | 36 |
| A545 | 41 |
| A606 | 1.99 |
| A607 | 1.28 |
| A626 | 3.66 |
| A627 | 2.03 |
| A634 | 64 |
| A661 | 36 |
| A682 | 50 |
| A684 | 32 |
| A699A | 64 |
| A705 | 58 |
| A706 | 1.26 |
| A719 | 20 |
| A722 | 20 |
| A738 | 43 |
| A740 | 2.35 |
| A745A | 6.64 |
| A747 | 7.02 |
| A747A | 7.50 |
| A748 | 92 |
| A750 | 14 |
| A762 | 4.15 |
| A771 | 2.08 |

| | |
|---|---|
| A808 | 3.18 |
| A840 | 1.44 |
| A908 | 10.47 |
| A909 | 10.51 |
| 2SB22 | 25 |
| B75 | 28 |
| B173 | 32 |
| B202 | 1.04 |
| B220 | 1.00 |
| B257 | 32 |
| B303 | 32 |
| B324 | 36 |
| B367 | 1.85 |
| B407 | 1.22 |
| B426 | 1.22 |
| B449 | 1.72 |
| B474 | 1.12 |
| B507 | 60 |
| B509 | 2.15 |
| B511 | 64 |
| B528 | 66 |
| B529 | 66 |
| B536 | 90 |
| B537 | 90 |
| B541 | 2.77 |
| B555 | 3.09 |
| B556 | 5.35 |
| B557 | 2.93 |
| B561 | 18 |
| B595 | 1.24 |
| B617A | 1.36 |
| B656A | 3.84 |

| | |
|---|---|
| B697 | 3.23 |
| 2SC352A | 2.73 |
| C371 | 32 |
| C372 | 16 |
| C380A | 14 |
| C381 | 28 |
| C382 | 40 |
| C383 | 46 |
| C387A | 34 |
| C388A | 52 |
| C394 | 18 |
| C458 | 14 |
| C486 | 1.99 |
| C495 | 52 |
| C496 | 45 |
| C497 | 1.56 |
| C509 | 32 |
| C517 | 4.40 |
| C537 | 16 |
| C563 | 63 |
| C627 | 1.28 |
| C642A | 3.86 |
| C696 | 1.36 |
| C706 | 1.51 |
| C710 | 16 |
| C732 | 14 |
| C733 | 14 |
| C735 | 28 |
| C756A | 1.40 |
| C781 | 1.99 |
| C784 | 28 |
| C785 | 28 |

| | |
|---|---|
| C789 | 1.20 |
| C799 | 1.50 |
| C829 | 14 |
| C830H | 2.71 |
| C838 | 36 |
| C839 | 20 |
| C840 | 1.62 |
| C867A | 2.80 |
| C895 | 5.09 |
| C900 | 20 |
| C941 | 25 |
| C945 | 11 |
| C959 | 1.17 |
| C960 | 1.10 |
| C1012 | 1.36 |
| C1025 | 90 |
| C1034 | 5.60 |
| C1047 | 48 |
| C1050 | 1.71 |
| C1061 | 56 |
| C1096 | 40 |
| C1114 | 3.45 |
| C1115 | 4.06 |
| C1116A | 4.13 |
| C1124 | 99 |
| C1127 | 1.90 |
| C1161 | 1.95 |
| C1166 | 50 |
| C1169 | 5.69 |
| C1178B | 1.99 |
| C1173 | 52 |
| C1209 | 28 |

| | |
|---|---|
| C1212A | 58 |
| C1213 | 18 |
| C1215 | 28 |
| C1226A | 40 |
| C1239 | 1.50 |
| C1279 | 40 |
| C1306 | 97 |
| C1307 | 1.72 |
| C1308K | 1.99 |
| C1316 | 3.40 |
| C1318 | 18 |
| C1330 | 53 |
| C1345 | 16 |
| C1346 | 43 |
| C1364 | 25 |
| C1383 | 27 |
| C1384 | 29 |
| C1403A | 3.21 |
| C1413A | 4.97 |
| C1419 | 56 |
| C1448 | 1.20 |
| C1567A | 56 |
| C1664A | 2.00 |
| C1675 | 14 |
| C1678 | 1.05 |
| C1728 | 81 |
| C1760 | 82 |
| C1815 | 11 |
| C1816 | 26 |
| C1885 | 36 |
| C3904 | 36 |
| C1951 | 1.44 |

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|---|---|
| C1959 | 30 |
| C1973 | 61 |
| C2028 | 58 |
| C2029 | 1.53 |
| C2074 | 97 |
| C2166 | 97 |
| 2SD24Y | 80 |
| D72 | 65 |
| D92 | 1.66 |
| D93 | 1.72 |
| D157 | 2.51 |
| D180 | 1.89 |
| D187 | 2.03 |
| D201 | 2.49 |
| D226A | 1.43 |
| D234 | 82 |
| D235 | 82 |
| D287A | 2.97 |
| D313 | 45 |
| D315 | 1.02 |
| D350 | 3.99 |
| D353 | 2.82 |
| D357 | 61 |
| D358 | 66 |
| D381 | 76 |
| D386A | 79 |
| D424 | 3.03 |
| D425 | 3.03 |
| D426 | 2.89 |
| D438 | 34 |
| D467 | 16 |
| D468 | 16 |

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|---|---|
| D470A | 2.51 |
| D471 | 25 |
| D525 | 90 |
| D526 | 81 |
| D555 | 4.51 |
| D586A | 1.10 |
| D588A | 1.71 |
| D600 | 45 |
| D613 | 80 |
| D733K | 2.50 |
| D823 | 94 |
| **FET** | |
| 2SK19 | 45 |
| 2SK30A | 34 |
| 2SK45 | 76 |
| **IC** | |
| AN214Q | 1.50 |
| AN239 | 5.43 |
| AN247 | 2.99 |
| AN274 | 2.25 |
| AN313 | 2.79 |
| AN315 | 2.00 |
| AN362 | 1.41 |
| AN374 | 99 |
| AN612 | 1.35 |
| AN7145 | 2.46 |
| AN7150 | 2.33 |
| BA511A | 1.44 |
| BA521 | 1.23 |
| BA532 | 1.62 |
| BA1310 | 1.56 |
| HA1137W | 1.12 |

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|---|---|
| HA1138 | 1.36 |
| HA1151 | 1.62 |
| HA1156W | 1.26 |
| HA1196 | 1.36 |
| HA1197 | 1.28 |
| HA1199 | 1.43 |
| HA1201 | 76 |
| HA1202 | 94 |
| HA1306W | 2.08 |
| HA1319 | 2.75 |
| HA1329 | 1.62 |
| HA1339A | 1.84 |
| HA1342A | 1.84 |
| HA1361 | 2.08 |
| HA1366W | 1.99 |
| HA1366WR | 1.89 |
| HA1377 | 2.93 |
| HA1398 | 4.22 |
| LA1365 | 1.26 |
| LA3350 | 1.10 |
| LA4032P | 1.66 |
| LA4400 | 1.80 |
| LA4430 | 1.36 |
| M51513L | 1.69 |
| M51515BL | 3.05 |
| MB3705 | 1.54 |
| MB3712 | 1.51 |
| MB3730 | 3.18 |
| MB3756 | 1.99 |
| MB8719 | 4.78 |
| PLL01A | 3.66 |
| PLL02A | 6.34 |

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|---|---|
| STK0029 | 3.68 |
| STK0050 | 5.87 |
| STK0080 | 10.60 |
| STK013 | 7.70 |
| STK015 | 3.20 |
| STK032 | 7.65 |
| STK040 | 7.42 |
| STK043 | 8.80 |
| STK078 | 7.75 |
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| STK433 | 4.00 |
| STK435 | 4.10 |
| STK437 | 6.50 |
| STK439 | 6.80 |
| STK463 | 9.65 |
| STK502 | 7.50 |
| STK503 | 7.50 |
| TA7055P | 1.99 |
| TA7060P | 70 |
| TA7061AP | 90 |
| TA7063 | 56 |
| TA7074P | 2.05 |
| TA7075P | 2.05 |
| TA7076P | 3.39 |
| TA7120P | 58 |
| TA7130P | 97 |
| TA7201P | 2.03 |
| TA7203P | 2.30 |
| TA7204P | 1.35 |
| TA7205AP | 1.20 |
| TA7214P | 3.41 |

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|---|---|
| TA7222AP | 1.87 |
| TA7227PK | 4.04 |
| TA7310P | 1.02 |
| TC4081P | 58 |
| TC5080P | 5.42 |
| TC5081P | 2.19 |
| TC5082P | 2.19 |
| UHIC001 | 4.07 |
| UHIC003 | 4.07 |
| UHIC004 | 4.07 |
| UHIC005 | 4.07 |
| UPC41C | 2.19 |
| UPC157A | 2.19 |
| UPC554C | 2.15 |
| UPC555H | 45 |
| UPC571C | 2.44 |
| UPC575C2 | 1.10 |
| UPC576H | 3.18 |
| UPC577H | 72 |
| UPC592H | 52 |
| UPC1001H | 2.89 |
| UPC1008C | 2.44 |
| UPC1016C | 2.44 |
| UPC1020H | 2.89 |
| UPC1025H | 4.06 |
| UPC1026C | 88 |
| UPC1032H | 72 |
| UPC1154H | 2.43 |
| UPC1155H | 1.69 |
| UPC1156H | 1.69 |
| UPC1181H | 1.28 |
| UPC1182H | 1.28 |

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|---|---|
| UPC1185H | 3.11 |
| UPC1186H | 1.56 |
| UPC2002 | 1.43 |
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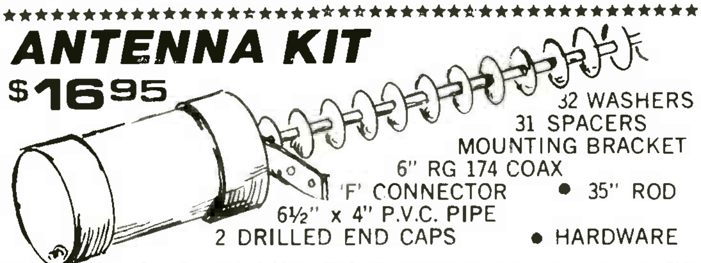


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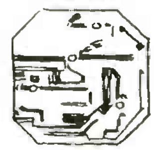

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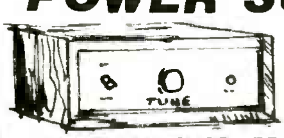


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# COMPUTER CORNER

## Choosing a printer

LES SPINDLE*

OF ALL THE PERIPHERALS THAT YOU WILL select as you assemble a complete computer system, a printer may at first seem to be the least necessary. You can still manipulate data and perform almost all the functions you want to by accessing data from the CRT screen. But sooner or later—especially in a business environment—you will want printed records of your computer transactions.

You may want to print invoices, statements, or mailing labels. You may want to send out form letters—or simply handle regular correspondence more conveniently. Or, you may simply need to share the computer's output with a number of people who need to have access to the information. How do you go about selecting the printer that is best for your needs?

Printer prices can range from about $200 up to $4000 or more. You'll be surprised to learn that an adequate printer will, in many cases, actually cost more than the computer itself. As in all computer-product purchases, you will need to analyze your specific requirements to find the printer that will provide the most cost-effective solution for you.

Printers used with microcomputers fall into two categories: dot-matrix and impact. Dot-matrix printers press small "hammers" against the paper through a ribbon, making patterns of dots that form the characters. Impact printers, which produce solid "letter-quality" type, usually fall into two major categories: ball-type (similar to the IBM *Selectric*) and daisy-wheel.

### Dot-matrix printers

Dot-matrix printers are fine for routine office paperwork, file reports, or informal documents. They are not generally considered good enough for generating professional-looking correspondence, however, or for documents that need to be photocopied. If your office generates a lot of correspondence, you may well want an impact printer (see below). Many users, though, are drawn to dot-matrix printers because they offer very fast speed at a reasonable cost. Many print 132 columns (characters-per-line) at 120–180 characters-per-second, although some recent models offer even higher speeds. A typical dot-matrix printer might cost $500–1000.

*Managing Editor, *Interface Age* magazine

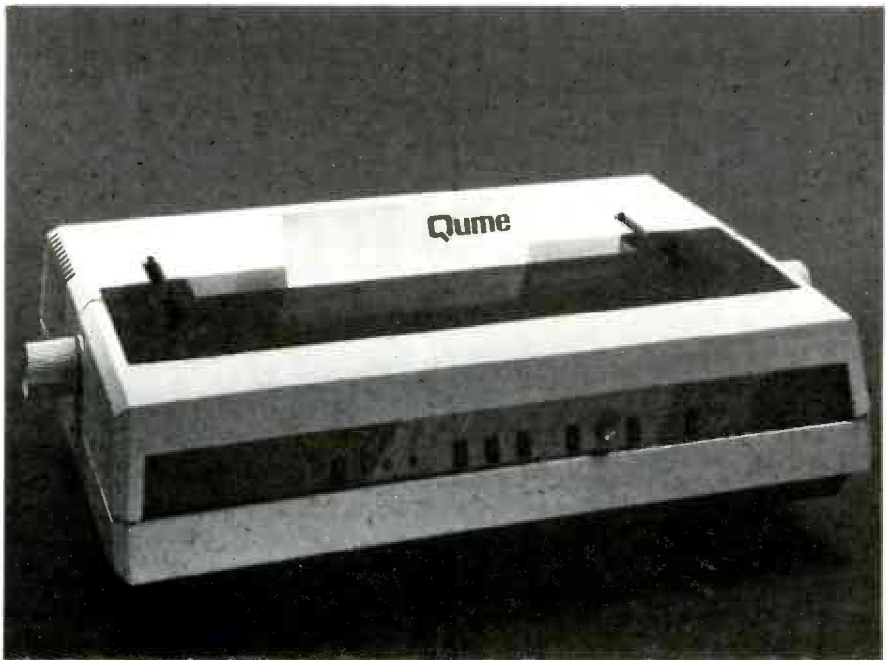


FIG. 1

What features should you look for in a dot-matrix printer? The first criterion, of course, is print quality. Although dot-matrix-formed characters, almost without exception, are inferior to those produced by impact printers, some dot-matrix printers produce better-quality output than others.

One very important factor to consider is whether the characters have *descenders*. Descenders are the portions of lower-case letters like "j," "g," and "y" that are printed "below the line." If there are no descenders, some characters will look "scrunched-up," and it may be difficult to tell the difference between, say, a "g" and an "s."

You will also want to check the unit's method of feeding paper. Some units accept single sheets, like letterhead, readily, while others can't. Many printers can use only continuous-form paper with sprocket holes.

### Impact printers

Impact printers vary widely in type and quality. It is important to understand all of the variables involved in order to make the appropriate choice.

Daisy-wheel printers use a print element shaped like a daisy. Each "petal" contains one character. The daisy-shaped wheel is rotated by a shaft, and, when the the appropriate character is in position, its "petal" is struck by a hammer and an impression is made, through the ribbon, on the paper.

Most daisy-wheel printers operate at only 40–60 characters-per-second—considerably slower than most dot-matrix units. They are also somewhat noisy—as are all other impact printers—but in many cases specially-designed enclosures will solve that problem. (That is not to say that dot-matrix printers are silent—sometimes the lower-volume noise they produce can be more irritating than that made by impact printers.) You may want to consider the cost of a noise-reduction enclosure when you are doing your comparison shopping. Daisy-wheel printers range in price from about $900 (for a 10-characters-per-second device) to over $4000.

Several manufacturers offer a thimble-shaped print element instead of a daisy wheel; both systems work on the same principles. Ranging in price from $2000 to $4000, thimble printers, such as the one shown in Fig. 1, are praised by many

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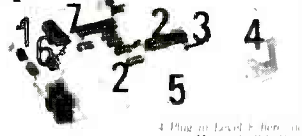

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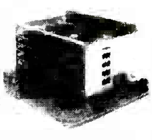

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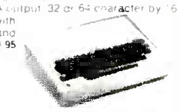

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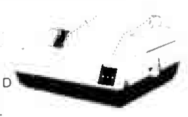

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users as offering superior speed and more reliable performance than other correspondence-quality printers.

Another type of printer has a ball-type print element, like that used by the IBM *Selectric*. They are slower than most other impact printers (about 15 characters-per-second), but normally range from $1500 to $2000 in price. For do-it-yourselvers who want to invest their time in some weekend labor, rather than spending a large amount of cash, a computer interface for the IBM *Selectric* is available from Escon Products (Pleasant Hill, CA). That kit enables you to modify your existing typewriter so that it will print output from your computer. It will work with most computers. Prices range from $500 to $800—plus labor cost, if you can't do the work yourself.

Among the pluses for the impact printers are the fact that they produce solid characters (as opposed to dot patterns) and, because the print elements can be removed and replaced with others, they allow you to use a variety of type styles.

### Interfacing

One important point to keep in mind when you purchase your printer is the interface between it and your computer. The appropriate cables and software are required to achieve effective communication between the two. There are two types of interfaces: *parallel* and *serial*. Parallel interfaces generally allow greater speed, but require that the printer be very close to the computer. Serial interfaces need simpler cables, and allow the printer to be separated from the computer by 50 feet or more.

Parallel interfaces are commonly used with dot-matrix printers. Bear in mind that not all parallel interfaces are the same and, as you shop for a printer, be sure to inquire whether a specific unit will work with your (specific) computer. That can avoid an enormous amount of frustration, and wasted time and effort, on your part.

Serial interfaces are more standardized than parallel ones, and allow a variety of printers to be used with a variety of computers. The common RS-232C serial-communications standard is used not only for printers, but also for telephone and Teletype communications.

If your computer is equipped for communications capability, it almost certainly has a serial interface. In some cases, additional software may be required to take advantage of all the capabilities of your printer. Make sure that it's available for your computer.

As is the case for all computer purchases, an important criterion is after-sale support and service. Consult with other users to be certain that you are making your purchase from a reputable manufacturer or vendor.

More than any other computer peripheral, a printer will require maintenance after a certain period of usage, due to its mechanical complexity. You'll want to be sure that you will be able to get prompt and reliable service and repair when it is necessary—and know that it won't cost an arm and a leg. If lost time is going to hurt you, see whether a service contract is available.

There are many decisions to make in finding the printer with the features and cost-effectiveness that are best for your applications. Sample a number of different offerings before narrowing your choices down, and try to talk to others who are using the printers you are considering. The time you spend in making your choice will be well worth it in the end. **R-E**




*"Cloudy again! That makes it twenty-six straight days!"*

# COMMUNICATIONS CORNER

## Computerized communications

**HERB FRIEDMAN,** COMMUNICATIONS EDITOR

NO MATTER HOW MUCH OR HOW FAST I read, it becomes more and more difficult to keep up with computerized communications. Just as I am learning about the latest developments, others come into use that open up new horizons for day-to-day communications. The adventures of one young fellow I know illustrates just how deeply we (meaning the government) have come to depend on computerized communications.

This fellow and some friends went down to Virginia for some scuba diving at Virginia Beach. As you might expect to happen to a car full of laughing teenagers, they were pulled over by a police cruiser. No hassling or anything, just a "routine check." My young friend reached into his wallet for his driver's license and registration and they weren't there. Somehow, he left them back in New York.

Instantly, he has visions of making big rocks into small ones. The cop asks a few questions, such as name, address, insurer, owner of car, previous traffic violations and so forth. He goes to his cruiser, and in a few minutes is back with my friend's life story: name, address, car identification, violations, etc. Everything was transmitted down the New York Motor Vehical Bureau computer to the Virginia police cruiser. Since everything that my friend said checked out, he was waved off with a warning to keep his license and registration with him in the future.

Now just consider for a moment that it wasn't some well-intentioned teenager out for a weekend of exploring the sea, but rather someone who had robbed a bank, or beat up on some old lady. Today, a call on the radio will bring forth in a matter of minutes the life history of both the driver and the car in question. That's a lot better than having to rely on luck.

A lot of folks will think this is nothing more than another example of how Big Brother is watching. I don't want to get involved in that discussion. All I'm trying to illustrate is one way in which the computer has dramatically altered one aspect of police radio communications.

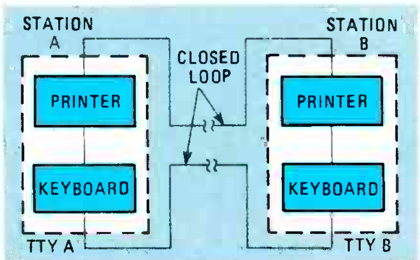


FIG. 1

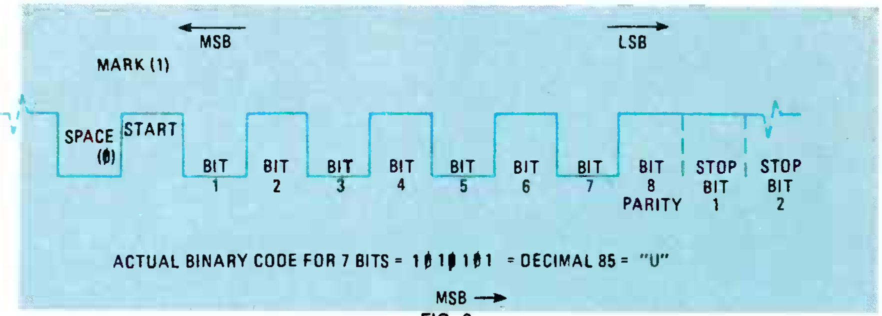


FIG. 2

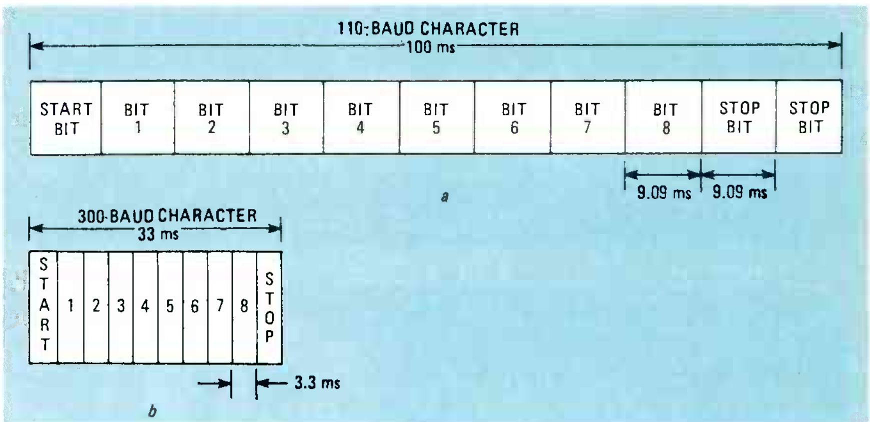


FIG. 3

### The magic of ASCII

As a general rule, computerized communications-data and control-signals are transmitted using ASCII code (ASCII is an acronym derived from the American Standard for Communications Information Interchange). It provides for 128 characters that represent the alphabet, numerals, punctuation, special symbols, and 32 control codes. Control codes provide, among other things, the printer's carriage return and linefeed, signals that turn peripherals on and off, and can cause characters not to be printed.

The ASCII code accommodates the original teletypewriter design, which was entirely mechanical, and was in fact originally intended for use as computer input/output using a terminal such as the *model 33* teletypewriter, a mechanical work-horse still being used for computer I/O—though it's fast being phased out because it is *slow*.

Early teletype circuits used the serial communications loop shown in Fig. 1. The keyboard at each end of the loop is in series with its associated printer, which is also in series with the equipment at the other end. What was typed on a keyboard appeared at its associated printer as well as at the receiving end. Each time a key was pressed, a mechanically-produced series of pulses (a pulse train) was transmitted through the loop. The pulse train consisted of a *start* pulse to let the printers know a *character* was to follow, then the pulses that represented the character itself, and finally a pulse(s) to let the printer know the character was complete, cause the character to print, and force a reset of the printer so that it was available for the next character.

In the normal series-TTY connection, current flows through the communications loop during the standby condition and is called the *mark*, representing a "1" or a "high." The pulses are caused by interrupting the current flow; they are called the *spaces*, representing a "0" or a "low."

The ASCII code presently used (it is

almost universal for communications, with the exception of the IBM EBCDIC code, which is less and less frequently used) provides for a total of 10 or 11 bits of information. Those bits include a start bit, seven bits which represent the character, one bit for *parity* (which is a check that can be used to test the reliability of the transmission), and one or two stop bits. A complete 11-bit character representing the letter "U" (decimal code 85) is shown in Fig. 2. For common mechanical teletypewriters, the information is transmitted at 110 bps (bits-per-second), which incidentally works out to a 110-baud rate. Two stop bits are used because 110 baud is intended for mechanical TTY devices that aren't all that precise: the two stop bits insure that the mechanical printer does indeed reset for the next character. Note that the stop bit(s) is a mark, so essentially a mark at least two bits in length signals a reset. The stop bits ensure a minimum mark two-bits in length. The total transmission length for a character at 110 baud is 100 milliseconds, so each bit is 9.09 milliseconds. Maximum data rate is 10 characters-per-second, while is about 100 real-words per minute.

At 300 baud and higher, (the rate used by electronic-controlled TTY's and printers) only one stop bit is necessary because we are dealing with electronic precision; we don't have to allow for mechanical tolerances. A typical 300-baud ASCII character is shown in Fig. 3. Note the total transmission length is 33 ms, with each bit requiring 3.3 ms. This works out to a maximum data rate of 30 characters-per-second, or 300 real-words per minute. A comparison between 110 and 300 baud ASCII characters is shown in Fig. 3.

For computers and computer-associated communications equipment, the ASCII code is handled by what is called an RS-232 interface, a device that translates the ASCII characters to a particular voltage standard. We will cover the RS-232 interface in more detail in a future column. **R-E**

## DRAWING BOARD

*continued from page 84*

things, it's clear our circuit is far from being complete. What we need is an output bus as well as the input bus used by the keyboard encoder. Another shortcoming is that we don't have any easy way to clear an entry other than entering zeros. We can enter numbers from a keyboard and have them show up in a display and even though we can expand to ten digits, more circuitry is needed before the encoder can be put to any practical use.

Next month we'll add all the bells and whistles to our encoder. We'll add a Tri-state data bus, an audio indication of keyboard entry, and the ability to clear the display from the keyboard. **R-E**

## TWO COMPACT DVM's

*continued from page 64*

bend at the final 1/16-inch of one end. With the display supported in a small bench vise, I dropped each wire into the appropriate hole in the display board, where it hung suspended while I soldered it into place. I only installed wires where they were required. When all the wires were in, I straightened them sufficiently to work them into the holes in the construction board. I soldered just one wire at first, to simplify adjusting the height of the display over the board, and then did the rest.

### Testing and calibration

You should assemble the two 741 circuits, and then calibrate them before continuing. Connect a known DC-voltage to the $+V_{IN}$ input and measure the output of IC1 at pin 6. It should be exactly one-third of the input. Trim either R1 or R2 if it is not. Then, connect a negative voltage to the other input and adjust R7 so you read one-third that value at IC2's ouput.

You should set R19 to about 3500 ohms before wiring it into the circuit; if you do that the display will show very nearly the correct voltage when you first turn the system on. After that, it's a simple matter to trim R19 for the final calibration. **R-E**

## IC TESTER

*continued from page 55*

ly to having their outputs tied to ground or 5 volts. Also, if a multi-section IC is being checked out, only the section(s) you will be using in the circuit it's intended for need be tested.

Of course, if inserting an IC causes the OVERLOAD LED to light brilliantly, the device may be shorted. Check a good part to be sure before discarding the questionable one. Checking counters or long shift registers can be tedious, so the pulse source may be replaced by the Programma 1 pulse generator (see the October 1980 issue of **Radio-Electronics**). Make up a cable with a miniature phone plug on one end to go between the pulse generator and the IC tester. Instead of using the tester's internal pulse-generator, insert that plug into the LO input for the IC's CLOCK pin, and use the Programmma I to clock the IC rapidly. You can then watch the outputs of the last stages change state on the LED's. That's great for devices like the 4020 binary divider.

### Adding external circuits

So far, we have concentrated on checking fairly simple IC's. But others—like one-shots and timers, which require additional circuitry to function—can also be checked. The trick is to obtain additional phone plugs, and connect the external circuitry to them. Then plug in that network whenever an IC requiring it is being tested.

For example, suppose you want to check a one-shot. Most one-shots require an external resistor–capacitor network to set the length of the output pulse. A five-second pulse is a good place to start; you can determine the values needed from the IC's data sheet. Solder the parts to the center terminals of two phone plugs (and possibly the outside terminal in the case of the resistor), and insert the plugs into the jacks corresponding to the appropriate IC pins. Trigger the one-shot using the internal pulse-generator; the outputs should immediately change state, and stay the way for about five seconds. If they don't, the part is bad.

There's one type of IC that can cause problems, and that's the device with open-collector outputs. Examples include the 7401 NAND gate. The outputs of those devices won't go high unless an external pull-up resistor is used. The solution is to solder a 1000-ohm resistor across the terminals of a phone plug, and insert it in the HI jack corresponding to the output pin of the section of the IC you're testing (Note that the open-collector outputs are indicated on the data sheet for the part).

You're sure to find other uses for your IC tester; try it as a logic analyzer. **R-E**

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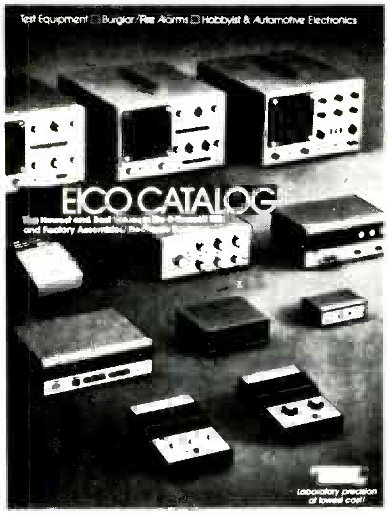


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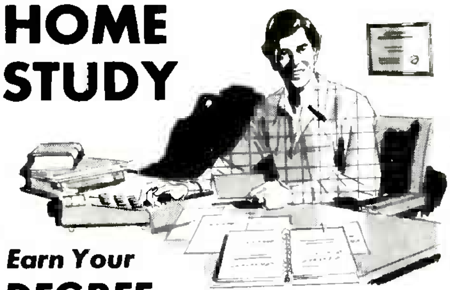

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## SHORTWAVE RECEIVERS

*continued from page 52*

you like to listen to, you can line up all the pre-sets and go from one to the next as the evening progresses.

### Antennas

All portables are equipped with telescoping whip antennas for shortwave (also used for FM if the radio has that band). While the whips are adequate for strong stations like the BBC, Radio Moscow, Radio Nederland, Radio Australia, and many others, you will be able to hear more stations and overcome more adverse propagation conditions with the help of an external antenna when you're at home. And all portables, including the shirtpocket radios, have provisions for attaching an external antenna.

Basically, an antenna's function is to intercept as much extremely low power radio energy (signals) as possible. Therefore, antennas that are high, long, and located as far away from trees or buildings will be most effective.

Outdoor wire antennas meet those requirements and are easy to install. Wire length for a receiving antenna is not critical, but the longer it is the better. Several commercially made antennas have tuned "traps" to help peak the wire's performance on the shortwave frequencies. Even if apartment, condominium, or aesthetic rules won't allow an outdoor antenna, you have the option of running wires in the attic, along exterior-wall baseboards, etc.

There is another type of indoor antenna that doesn't need any long lengths of wire, and can be almost as effective as an outdoor aerial: the active antenna. That type of antenna consists of either a telescoping whip or dipole antenna fed to the receiver through a tunable amplifier. The amplifier boosts the signal intercepted by the shortened antenna. The *MFJ-1020* active antenna (from MFJ Enterprises) with its short 21-inch whip far outperforms a receiver's built-in whip. Stations barely audible on the built-in antenna can be heard comfortably with the help of that active antenna. As with many active antenna amplifier sections, there are connectors to use the amplifier with external wire antennas for superb performance if you later add an outdoor wire.

A recent addition to MFJ's line is the *MFJ-1024* outdoor active antenna. A 4½ foot telescoping whip and its small RF amplifier can be mounted inconspicuously outdoors, and connected to the control unit located next to the receiver via 50 feet of coaxial cable (which is supplied).

Gilfer Shortwave, a mail-order shortwave specialist, offers two active antennas made by Datong, one each for indoors and outdoors. Both are dipoles (i.e., two short antenna elements emanating from a central preamplifier box) and can be mounted horizontally, which often reduces atmospheric and local electrical noise in the receiver, while also being less conspicuous.

Unlike local radio stations, which are limited in their range, international shortwave programs can join you on your travels, literally anywhere in the world. Often the sound of a familiar commentator or program will help you feel more "at home" even if you're far from home. And the latest generation of portable shortwave receivers let you take it all with you. **R-E**

*"He should have known better than to tangle with a solid-state computer."*

## EQUIPMENT REPORTS

*continued from page 39*

tion remains in a slow setting, which is good for listening to sideband transmission, but which doesn't promote top CW reception. It needs a switchable fast/slow AGC action. However, that really would be noticed more by the CW fanatic, rather than the casual listener.

The *R-1000* is one of the few rigs on the market with as much as 60 dB of signal attenuation. It is switchable in 20-dB steps. In the 60-dB position, the built-in attenuator virtually eliminates front-end overload.

While there is no provision for 12 VDC mobile operation, the *R-1000* still comes equipped with a noise blanker to take care of pulse-type noise. It does eliminate ignition noise from nearby cars, which can be a problem if you live near a major road.

No modern receiver would be complete without a few other bells and whistles and this one is no exception. It features an easily-settable digital clock which is accurate to about 15 seconds per month. There is also a timer which can serve as a wake-up alarm or can serve to fire up the radio for taping various broadcasts while you are away from home.

The *R-1000* also features more than enough audio output potential with a minimum of 1.5 watts available at 10 percent distortion. The built-in speaker provides excellent fidelity; however, there is also a jack for an external 8-ohm speaker. The internal speaker is muted when an external one is used. A headphone jack is also included.

Power consumption is a nominal 20 watts, making this a cool-running unit.

The *R-1000* is a superheterodyne receiver with a few image problems. It uses a standard frequency-down-conversion to achieve the final 455 kHz intermediate frequency. The down conversion begins with a first IF of 48.055 which is heterodyned with other frequencies to produce the 200 kHz to 30 MHz range of this receiver.

Overall, I was quite pleased with the simplicity of operation and the straightforward but sophisticated design of the *R-1000*. About the only drawbacks are the necessity for the extra medium-wave antenna input and the slow AGC action. A good feature is its ability to operate on a variety of voltages from 100 to 240 VAC. Thus it should be able to be used almost anywhere in the world you care to take it.

The Kenwood *R-1000* would be a worthy addition to anyone's radio shack, whether that person is a shortwave listener or an amateur radio buff. It is available from Trio-Kenwood Communications, Inc. at 1111 West Walnut St., Compton, CA 90220 and its price is $499. **R-E**

# NEW BOOKS

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**THE MASTER HANDBOOK OF ACOUSTICS, by F. Alton Everest. TAB Books, Inc., Blue Ridge Summit, PA 17214. 352 pp. including appendix, references, and index; 5 × 8½ inches; softcover; $12.95.**

Acoustics, the science of sound, has two natures: physical and psychophysical. Sound as a disturbance in the air is physical; sound as perceived by the ear is psychophysical. The old conundrum, "If a tree falls in the forest with no ear to hear it, is sound produced?", distinguishes between sound as a stimulus and sound as a sensation.

This book deals with both the physical and psychophysical aspects of sound because the two are interrelated so inextricably. Whether the end product is a recording, a radio or television program, or a live performance, the human ear-brain mechanism is involved intimately. In the electronics medium, room acoustics is involved twice: once in the pickup and recording in the studio, and again in reproduction in the home or classroom. Human ears listen and evaluate at both ends of the process.

All the basis of sound are covered: frequency, wavelength, simple sinusoid and complex waves, harmonics, phases, octaves, the sound spectrum, and white and pink noise. There is much detail on hearing—including discussions on ear sensitivity, ear anatomy, audibility, loudness versus frequency, loudness versus intensity, and loudness versus bandwidth. Hearing impulses, binaural localization, pitch versus frequency, timbre versus spectrum, the nonlinearity of the ear, Haas sense, the ear as a measuring instrument, hearing-loss with age, occupational and recreational deafness—all are outlined clearly

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**COMPUTERS AND THE RADIO AMATEUR, by Phil Anderson. Prentice-Hall, Inc., Englewood Cliffs, NJ 07632. 208 pp, including index; 7 × 9½ inches; hardcover; $18.95.**

This book is designed for radio amateurs who have had little or no exposure to computers. It explains in detail how they work, how to program them, and how to attach them to other equipment.

Chapters one and two explore present and future uses for computers in amateur radio, and the history and background of the computer. Chapter three explores how computers work. An analogy is made to how people solve mathematical problems, the point being that once a procedure for solving a problem is programmed, the computer will then follow, step by step, as laid out. The building blocks of the computer are examined and the reader is shown how they work together to follow a program that has been stored in memory.

Chapters four and five deal with programming procedures, first the fundamentals of BASIC, then assembly-language programming. The 6502 microprocessor is used as an example, and several straightforward programs are presented. Further chapters deal with logic circuits, interfacing amateur equipment, the computer as an electronic keyer, the computer as a random-code generator, the computer as a code reader, the computer as a contest secretary, and the computer as a programmable calculator.

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**PRACTICAL BASIC PROGRAMS: IBM PERSONAL COMPUTER EDITION, edited by Lon Poole; Osborne/McGraw-Hill, 630 Bancroft Way, Berkeley, CA 94710; 170 pages; 8⅜ × 10⅞ inches; softcover; $15.99.**

Considering all the small computers people have bought in recent years, one would think that it is easy to find practical computer programs, particularly since fewer users consider their computers as just a diversion. However, practical programs are *not* readily available, and most packages on the market today are specialized and expensive. In this book users will find 40 useful programs that cost less than 50¢ each; they are fully documented and each program has been tested and debugged, and is ready to run.

The programs run from income averaging to musical transposition, and include present value of a tax deduction, checkbook reconciliation, home budgeting, transportation algorithm, data-forecasting divergence, temperature conversion, and numeric base conversion. Each program is presented with a description, sample run, practical problems, and BASIC source listings. Using the documentation, anyone can run a program and easily make modifications to it.

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**SHORTWAVE FREQUENCY DIRECTORY, 1.6 - 30 MHz, Worldwide Edition, edited by Robert B. Grove; Grove Enterprises, Inc., Brasstown, NC 28902; 218pp., 8½ × 11 inches, spiral bound; $12.95 plus $1.50 UPS or $1.00 bookrate USPS.**

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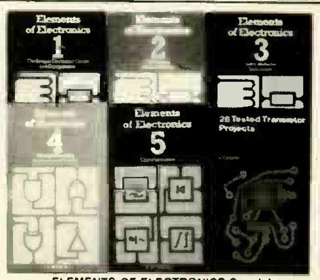


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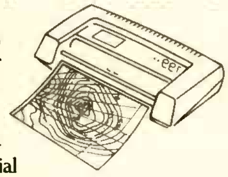

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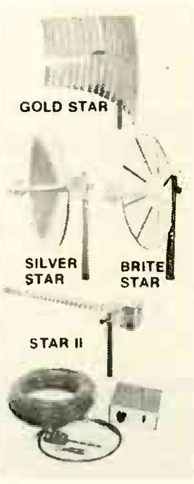


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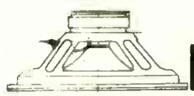

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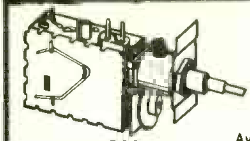

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|---|---|---|---|---|---|---|
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| 200 | .06 | .17 | .50 | 1.30 | 5.25 | 9.00 |
| 400 | .09 | .25 | .65 | 1.50 | 6.50 | 12.00 |
| 600 | .11 | .30 | .80 | 2.00 | 8.50 | 15.00 |
| 800 | .13 | .35 | 1.00 | 2.50 | 10.50 | 18.00 |
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GRAY, 28 gauge
26 conductor ... .60/ft 40 conductor ... .90/ft
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2N404A PNP GE TO 5 ........ 3/$1.00
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MRF-8004 CM RF TRANSISTOR NPN ........ $ .75
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2N4908 PNP Si TO 3 ........ $1.00
TIP 2955 PNP Si ........ $ .90
2N2222 NPN Si TO-18 ........ 10/$1.00
2N2907 PNP Si TO-18 ........ 10/$1.00
2N3055 NPN Si TO-3 ........ $ .60
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2N6109 PNP Si TO 220 ........ $ .55
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TIP 32B PNP Si TO 220 ........ $ .55
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TIP 121 PNP Si U84 ........ $ .80
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|---|---|---|---|---|---|
| 7400 | .17 | 7472 | .30 | 74162 | .60 |
| 7401 | .17 | 7473 | .35 | 74163 | .60 |
| 7402 | .17 | 7474 | .32 | 74164 | .60 |
| 7403 | .17 | 7475 | .40 | 74165 | .60 |
| 7404 | .24 | 7476 | .35 | 74166 | .70 |
| 7405 | .24 | 7480 | .45 | 74170 | 1.60 |
| 7406 | .28 | 7483 | .50 | 74173 | .75 |
| 7407 | .28 | 7485 | .56 | 74174 | .65 |
| 7408 | .24 | 7486 | .35 | 74175 | .60 |
| 7409 | .18 | 7489 | 1.60 | 74176 | .75 |
| 7410 | .17 | 7490 | .35 | 74180 | 1.90 |
| 7411 | .22 | 7491 | .45 | 74182 | .45 |
| 7412 | .30 | 7492 | .45 | 74190 | .70 |
| 7413 | .35 | 7493 | .35 | 74191 | .75 |
| 7414 | .45 | 7494 | .60 | 74193 | .79 |
| 7416 | .25 | 7495 | .55 | 74194 | .85 |
| 7417 | .25 | 7496 | .60 | 74195 | .45 |
| 7420 | .17 | 74107 | .30 | 74196 | .75 |
| 7425 | .25 | 74116 | 1.50 | 74221 | 1.00 |
| 7426 | .25 | 74121 | .29 | 74273 | .85 |
| 7427 | .25 | 74122 | .39 | 74279 | .60 |
| 7430 | .17 | 74123 | .42 | 74298 | .65 |
| 7432 | .27 | 74126 | .45 | 74365 | .65 |
| 7437 | .27 | 74145 | .60 | 74367 | .65 |
| 7438 | .27 | 74148 | 1.10 | 74390 | .90 |
| 7440 | .17 | 74150 | 1.10 | 75324 | 1.75 |
| 7441 | .75 | 74151 | .50 | 75325 | 1.50 |
| 7442 | .45 | 74153 | .40 | 75492 | 1.05 |
| 7445 | .65 | 75154 | 1.10 | 9601 | .75 |
| 7446 | .65 | 74156 | .50 | 9602 | .75 |
| 7447 | .65 | 74157 | .50 | DS0056H | 1.50 |
| 7448 | .65 | 74160 | .85 | | |
| 7450 | .17 | 74161 | .65 | | |

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|---|---|---|---|
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| 200 | .80 | 1.30 | 2.20 |
| 400 | 1.00 | 1.65 | 3.30 |
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D.P. 400 ohm coil 1.25

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| 74LS01 | .20 | 74LS109 | .36 | 74LS221 | .75 |
| 74LS02 | .23 | 74LS112 | .38 | 74LS240 | .90 |
| 74LS03 | .23 | 74LS113 | .45 | 74LS241 | .90 |
| 74LS04 | .23 | 74LS114 | .56 | 74LS242 | 1.20 |
| 74LS05 | .23 | 74LS123 | .80 | 74LS243 | 1.20 |
| 74LS08 | .23 | 74LS124 | 1.25 | 74LS244 | .80 |
| 74LS09 | .25 | 74LS125 | .45 | 74LS245 | 1.50 |
| 74LS10 | .23 | 74LS126 | .45 | 74LS247 | .75 |
| 74LS11 | .25 | 74LS132 | .56 | 74LS248 | 1.10 |
| 74LS12 | .25 | 74LS136 | .46 | 74LS251 | .68 |
| 74LS13 | .45 | 74LS137 | .96 | 74LS253 | .68 |
| 74LS14 | .40 | 74LS138 | .50 | 74LS257 | .68 |
| 74LS15 | .35 | 74LS139 | .62 | 74LS258 | .68 |
| 74LS20 | .23 | 74LS151 | .38 | 74LS259 | 1.40 |
| 74LS21 | .26 | 74LS153 | .40 | 74LS266 | .60 |
| 74LS22 | .25 | 74LS155 | .60 | 74LS273 | 1.15 |
| 74LS26 | .35 | 74LS156 | .80 | 74LS279 | .48 |
| 74LS27 | .23 | 74LS157 | .45 | 74LS280 | 1.80 |
| 74LS28 | .45 | 74LS158 | .48 | 74LS283 | .86 |
| 74LS30 | .22 | 74LS160 | .70 | 74LS290 | .76 |
| 74LS32 | .27 | 74LS161 | .70 | 74LS293 | .95 |
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| LM301/748 | .30 | LM382 | .80 | 1458 | .50 |
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| LM308 | .85 | LM386 | .85 | LM2901 | .95 |
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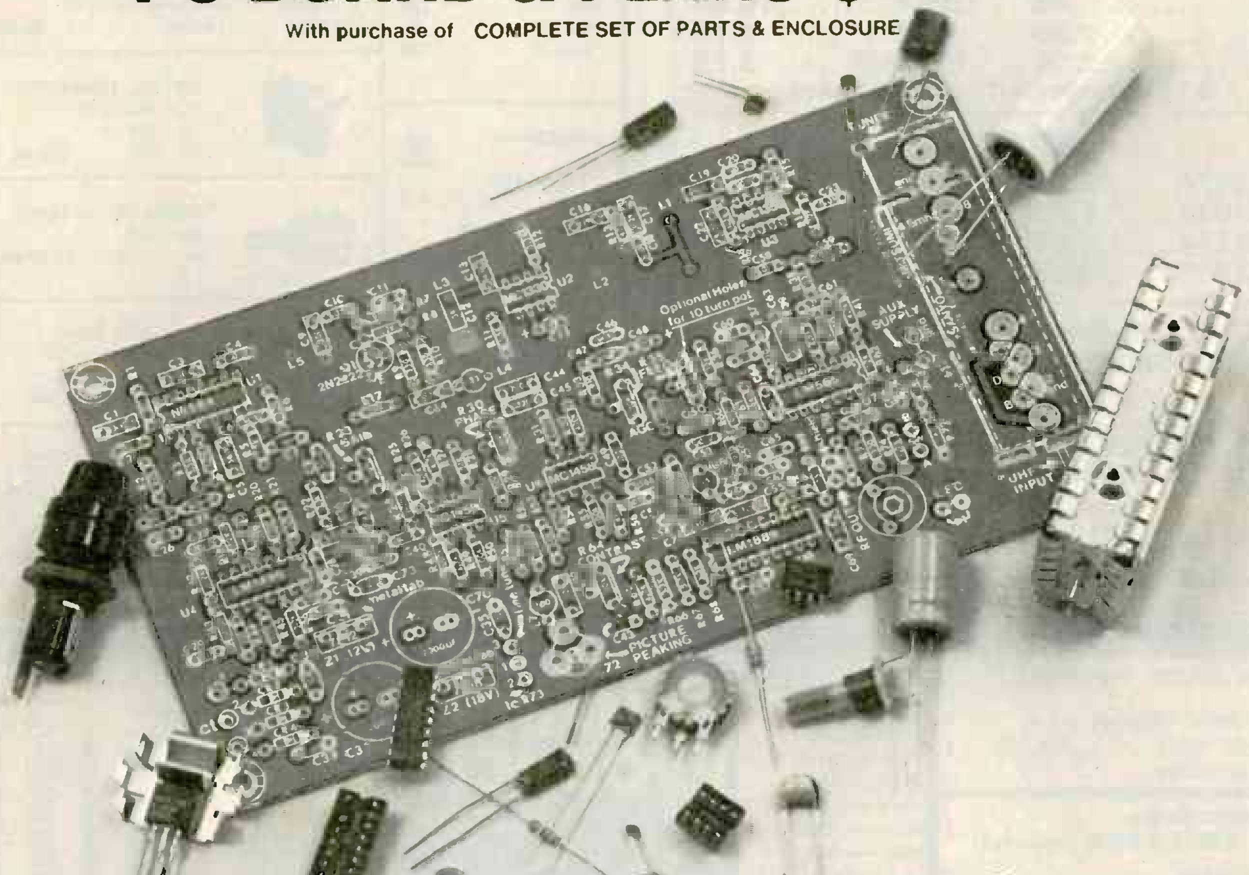


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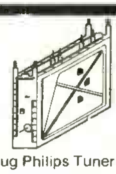

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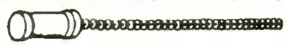

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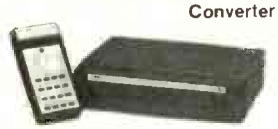

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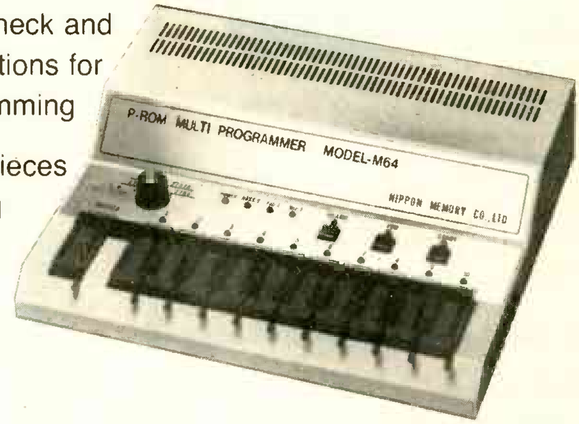


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NEW

### High Quality 16K RAM Card Kit
(no cable required)
Same feature as the one we've been selling but without the mess of Dip-wire for Apple® & Pineapple™. **$59.95** per kit

### 5¼" Flexible Disc Sale
Why buy other brands when you can buy WABASH discs for much less and backed by 1-year factory warranty.
All discs come with Hub Rings

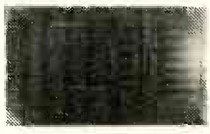
| | | | |
|---|---|---|---|
| M13A411X | 5¼" SSDD Soft Sector | $2.25 | 10-99 |
| M43A411X | 5¼" SSDD 10 Hard Sector | $2.25 | |
| M53A411X | 5¼" SSDD 16 Hard Sector | $2.25 | |
| M14A411X | 5¼" DSDD Soft Sector | $3.65 | |
| F111111X | 8" SSSD IBM compatible | $2.45 | |
| F131211X | 8" SSDD 26 sectors 128 bytes | $3.05 | |

### At last! Here's the computer case everyone has been looking for!
Ideal for your homebrew
*AP-II 6502 MPU based computer.
Made with high impact plastic.
Color and shape are compatible with the standard Apple II computers.
Introductory Offer
**$150.00** ea.
Keyboard not included see our Ad in this page.

**MODEL: AP-II**

*AP-II model is compatible with Apple II but not manufactured by Apple Computers, Inc. ®Apple or Apple II is a registered trade mark of Apple Computers, Inc.

### 6502 MPU Based Computer Motherboard! You ask for it, you got it!
- ★ 48K on board memory (4116)
- ★ 12K on board EPROM memory (2716 or 2732)
- ★ 8 expansion slots for peripheral cards
- ★ Composite-video output
- ★ size: 14¼" × 8½"

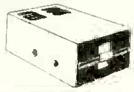


**$99.95** ea.

### 16K RAM Card Kit For Your Apple® & Pineapple™ Computer

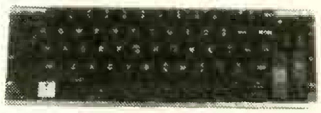
Kit includes:
• High Quality P.C. Board • 8 ea. 4116 (200ns) • All the IC's & parts • 16-pin Dip wire • Easy to assemble. You can do it in less than 30 minutes! **$49.95** per kit

### 5¼" Disc Drive 100% Apple® & Pineapple™ Compatible



We did it once, response was great!
Now we are doing it again, don't miss it!
**$295.00** ea. w/o controller
**$385.00** ea w/controller

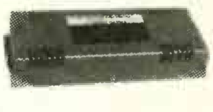
### Replacement Keyboard For Your Apple® II Computer
Got a bad Keyboard? Here's the alternative!
- ★ Full ASCII code
- ★ N-key rollover function
- ★ TTL level output
- ★ On-Off indicator
- ★ Low power consumption
- ★ With upper/lower case function



**$99.95** ea.

### Switching Power Supply For Apple®, AP-II, and Pineapple Computer
Compact size switching power supply.

| Specification: | 4006A | 4007A |
|---|---|---|
| +5V at | 3A | 5A |
| -5V at | 2A | 3A |
| +12V at | .5A | 1A |
| -12V at | .5A | 1A |



4006A ..... **$99.00** ea. 4007A ..... **$145.00** ea.
Size: Width 3½", Depth 9¾", Height 2¼"
Size and mounting holes will be same as the one used in Apple II.

* Apple is a registered trademark of APPLE COMPUTERS, INC.

SHIPPING AND HANDLING CHARGES

| | Under $50.00 Purchase | Over $50.00 Purchase |
|---|---|---|
| Inside California | 10% | 5% |
| Outside Calif (Incl Mexico & Canada) | 15% | 10% |
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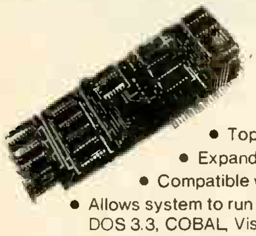
CIRCLE 41 ON FREE INFORMATION CARD

CIRCLE 41 ON FREE INFORMATION CARD

# ADVANCED COMPUTER PRODUCTS

SEND $2.00 for 1983 CATALOG

## 16K Apple™ Ramcard



LIST 195
ACP
**$59.95**

- Full 1 year warranty
- Top quality — gold fingers
- Expand Apple II 48K to 64K
- Compatible with Z-80 Softcard™
- Allows system to run with CP/M™, PASCAL, DOS 3.3, COBAL, Visicalc, etc.
- Supplied with extra 16K RAM & has (2) LED's

## 32K STATIC RAM

2 or 4 MHz Expandable Uses 2114L's

| | |
|---|---|
| 16K 4 MHz Kit | $159.95 |
| 16K 4 MHz A&T | 217.95 |
| 32K 4 MHz Kit | $129.95 ~~289.95~~ |
| • 32K 4 MHz A&T | • 339.00 |
| BARE BOARD | 39.95 |
| Bare Bd w/all parts less mem. | 99.95 |

## BARE BOARDS

| | |
|---|---|
| S-100 Sound Board | $34.95 |
| 8080A CPU | 34.95 |
| 32K Static RAM (2114) | 34.95 |
| 8K EPROM (2708) | 24.95 |
| 2708/2716 EPROM | 34.95 |
| ACP Proto Board | 22.95 |
| Vector 8800 Proto | 22.20 |
| Vector 8803 11 slot MB | 29.95 |
| ACP Extender with connector | 18.95 |
| 13 Slot Mother Board (WMC) | 32.95 |
| 9 Slot Mother Board (WMC) | 29.95 |
| 8 Slot Mother Bd (Expandable) | 34.95 |
| Floppy PCB (8" SHUGART) | 39.95 |
| S100 (AY5-8910) Sound Board | 34.95 |
| Apple Sound Board | 24.95 |

## 64K CMOS RAM

S100 (200nS)
Uses 2716's or 6116's **$299.00**
Assembled & Tested **$399.00**

## MOSTEK 4K RAMS

**29¢ ea.**
200,000 pieces in stock — priced to move. Same as MK4027 except 1mS refresh. MK4015 4Kx1 RAM

## STEPPER MOTOR

Operates by applying 12VDC in one direction and then reversing polarity (or square wave). Uses 12VDC. Clock Wise Rotation, Rated 3 RPM at 4 P.P.S. with a 5 degree stepping angle.

ACP PRICE **$4.95 ea.** 10 for $39.95

## UV "EPROM" ERASER

Model UVs-11E **$79.95**
Holds 4 EPROM's at a time.
Model S-52T $325.00

## 4K STATIC RAM SELL-OFF

**10/$9.90**
Same as TMS4044 but designed specifically for Z-80 based systems. This is a full-spec 4Kx1 RAM, 450nS. Order P/N Zilog 6104-4 while supply lasts.

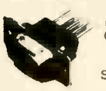
## 16K Memory Expansion Kits for Apple/TRS-80

8 pcs 4116 16K 200/250nS
Specify computer **$12.95**
CALL FOR VOLUME PRICING

## Zilog Z8 CPU with TINY BASIC

Debug prog. **$49.95**
Plus 6132 companion quasi-static RAM 29.95

## "D" SUB CONNECTORS



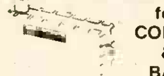
Unreal price DB37 male, DB25 female. Gold PC mount with mounting holes. Mfg. AMP. Specify 25 or 37 pins.

DB37 **$2.50** DB25 **$1.95**

## Stepper Motor

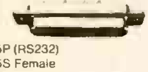
NEW
USED IN DATA PRODUCTS PRINTER
**$19.95 ea.**

## Astec RF Modulator



for COLOR & B/W
P/N 1082 Channel 3 or 4 $6.95

## CONNECTORS



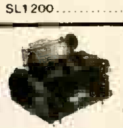
| | |
|---|---|
| DB25P (RS232) | $3.25 |
| DB25S Female | 3.75 |
| Hood | 1.25 |
| Set with Hood, Sale | 7.50 |
| 22/44 S/T, KIM | 2.95 |
| 43/86 S/T, MOT | 6.50 |
| 50/100 S-100 Connector W/W | 4.95 |
| 50/100 S-100 Connector S/T | 3.95 |

## 1200 BAUD MODEM IC

Features:
- 1200 Baud
- 40 Pin
- 5Volts Only

SL1200 ............... **$129.00**

## PARALLEL ALPHA NUMERIC PRINTER



19 Column Printer prints 16 numerical columns plus 3 columns which have math, alpha and other notations. Each wheel has 12 positions with position 12 blank. Position 11 on numerical columns have decimal point or #. Utilizes 2.75" wide adding machine tape and a dual color ink ribbon. Input data parallel with four bit BCD comparator circuit (schematic provided). Print rate 3 lines per second. Operating voltage 22-28VDC with typical cycle time of 340mS. Size 6½"W x 3⅛"H x 5⅜"Dp. New. **$9.95 ea. 3/$27**

## MICROPROCESSORS

| | | | | | |
|---|---|---|---|---|---|
| Z8001 | $39.00 | 8008-1 | $14.95 | 6802P | 14.95 |
| Z8002 | 69.00 | 2901 | 9.90 | 8035 | 14.95 |
| Z80 | 9.95 | 2901A | 14.95 | 8039 | 12.95 |
| Z80A | 11.95 | 9900JL | 49.95 | 8073N | 34.95 |
| F-8 (3850) | 16.95 | 6502 | 9.95 | 8755 | 49.95 |
| 2650 | 16.95 | 6502A | 16.95 | 8748 | 49.95 |
| 1802 | 9.75 | IM6100 | 29.95 | 6809 | 30.00 |
| 8080A | 4.75 | 6800 | 11.75 | 8086 | 49.95 |
| 8085 | 14.95 | 6800B | 19.95 | 68000 | 129.95 |

## RAMS

CALL FOR QTY PRICING

| | | | | | |
|---|---|---|---|---|---|
| 6116/2016 | $7.95 | 2147 | $5.99 | 5290 | $1.99 |
| 8264-64K | 5.95 | 411 | 5.99 | 5298 | 1.49 |
| 4116-2 | 1.99 | 414 | 4.69 | 6508 | 4.50 |
| 4116-2 | 8/12.95 | 1101 | .99 | 6518 | 6.79 |
| 2101 | 3.99 | 1103 | .99 | 6561 | 3.79 |
| 2102 | .79 | 4027 | 4.69 | 6604 | 3.99 |
| 21L02-3 | 1.49 | 4044 | 3.99 | 6605 | 7.99 |
| 21L02-4 | 1.29 | 4050 | 4.69 | 9130 | 8.99 |
| 2111 | 3.49 | 4060 | 4.69 | 9140 | 8.99 |
| 2112 | 3.49 | 4096 | 3.99 | 93415 | 6.99 |
| 2114 | 1.99 | 4115 | 1.49 | 93425 | 6.99 |
| 2114L-2 | 3.25 | 4200 | 7.95 | | |
| 2114L-4 | 2.29 | 4402 | 1.99 | | |
| 2125 | 6.99 | 5280 | 4.60 | | |

64K only $5.95

## SUPPORT

| | | | | | |
|---|---|---|---|---|---|
| 8155 | $9.95 | 8259 | $8.95 | 68047 | $22.95 |
| 8156 | 9.95 | 8275 | 19.95 | 68488 | 19.95 |
| 8202 | 29.95 | 8279 | 9.50 | 46505 | 22.95 |
| 8205 | 2.69 | 6810 | 4.75 | 6520 | 6.95 |
| 8212 | 2.75 | 6820 | 6.50 | 6522 | 9.95 |
| 8214 | 4.95 | 6821 | 6.50 | 6530-X | 24.95 |
| 8216 | 2.75 | 6828 | 10.50 | 6532 | 17.95 |
| 8224 | 2.95 | 6834 | 16.95 | 6551 | 19.95 |
| 8226 | 2.95 | 6845 | 22.95 | Z80-PIO | 6.50 |
| 8228 | 3.95 | 6847 | 27.95 | Z80A-PIO | 9.50 |
| 8243 | 9.50 | 6850 | 5.25 | Z80-CTC | 6.50 |
| 8250 | 14.95 | 6852 | 5.25 | Z80A-CTC | 9.50 |
| 8251 | 6.50 | 6860 | 10.95 | Z80-DMA | 19.95 |
| 8253 | 11.95 | 6862 | 10.95 | Z80A-DMA | 27.95 |
| 8255 | 4.50 | 6875 | 5.95 | Z80-SIO | 24.95 |
| 8257 | 9.50 | 6880 | 2.49 | Z80A-SIO | 29.95 |

## MOS PROMS

| | | | |
|---|---|---|---|
| 2764 (8Kx8) TS | $69.95 | 2708 (450nS) | $5.75 |
| 2732 (4Kx8) TS | 12.95 | 2708 (650nS) | 5.25 |
| 2716/2516, 5V (2Kx8) ~S | 7.95 | 1702A | 5.75 |
| TMS2716, 5V, 12V | 17.95 | MM5203AQ | 14.50 |
| 2758, 5V, (450nS) | 3.50 | MM5204Q | 9.95 |

## HI-TECH

| | | | |
|---|---|---|---|
| 2513-001 (5V) Upper | $9.50 | DAC08 | $9.95 |
| 2513-005 (5V) Lower | 10.95 | DAC100 | 9.95 |
| 2513-ADM3 (5V) Lower | 14.95 | 8038 Function Generator | 4.50 |
| MCM6710 ASCII Shifted | 12.95 | MC4024 VCO | 2.95 |
| MCM66740 Math Symbol | 13.95 | LM566 VCO | 1.95 |
| MCM66750 Alpha Control | 13.45 | XR2206 Function Generator | 5.25 |
| 1771-01 8" & Minifloppy | 24.95 | TR1602B (5V, 12V) | 3.95 |
| 1781 Dual Floppy | 29.95 | AY51013 (5V 12V) | 4.95 |
| 1791-01 Dual Floppy | 36.95 | AY51014A/1612 (5-14V) | 6.95 |
| 1791-02 Dual Floppy | 44.95 | AY51015A/1863 (5V) | 6.95 |
| 1793 DD DS Floppy | 44.95 | IM6402 | 7.95 |
| 1797 DD, DS Floppy | 54.95 | IM6403 | 8.95 |
| 1691 Data Separator | 18.95 | 2350 USRT | 9.95 |
| 2143 Clock Generator | 18.95 | 1671B Astros | 24.95 |
| 8700 8 bit Binary | 13.50 | MC14411 | 11.95 |
| 8701 10 bit Binary | 22.00 | 4702 | 14.95 |
| 8703 8 bit TS | 13.50 | WD1941 | 9.95 |
| 9400 Volt to Freq Conv | 7.25 | COM5016 | 16.95 |
| 8750 3½ Digit BCD | 13.95 | INS8250 | 15.95 |
| 1408L6 6 bit | 3.95 | AY5-2376 | 13.75 |
| 1408L8 8 bit | 5.95 | AY5-3600 | 13.75 |
| DAC01 D to A | 5.95 | MM5740AAC | 8.95 |

## SOCKETS

### LOW PROFILE SOCKETS (TIN)

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

### 3L WIREWRAP SOCKETS (GOLD)

| | 1-24 | 25-49 | 50-100 |
|---|---|---|---|
| 8 pin WW | .55 | .54 | .49 |
| 10 pin WW (Tin) | .65 | .63 | .58 |
| 14 pin WW | .75 | .73 | .67 |
| 16 pin WW | .80 | .77 | .70 |
| 18 pin WW | .95 | .90 | .81 |
| 20 pin WW | 1.15 | 1.08 | .99 |
| 22 pin WW | 1.45 | 1.35 | 1.23 |
| 24 pin WW | 1.35 | 1.26 | 1.14 |
| 28 pin WW | 1.60 | 1.53 | 1.38 |
| 40 pin WW | 2.20 | 2.09 | 1.89 |

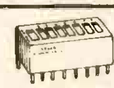
## LINEAR

| | | | |
|---|---|---|---|
| 78H05K | $5.95 | LM1414N | $1.90 |
| 78M06 | 1.49 | LM1458CN/N | .49 |
| 78M G. | 1.49 | MC1488N | .99 |
| LM108AH | 2.95 | MC1489N | .99 |
| LM300H | .99 | LM1496N | .89 |
| LM301CN | .35 | LM1556N | 1.50 |
| LM304H | 1.98 | LM1820N | .95 |
| LM305H | 1.89 | LM1850N | .95 |
| LM306H | 3.25 | LM1889N | 3.10 |
| LM307CN | .29 | LM2111N | 1.75 |
| LM308CN | .98 | LM2900N | .99 |
| LM309K | 1.49 | LM2901N | 2.50 |
| LM310CN | 1.25 | LM2917N | 2.95 |
| LM311D/CN | .89 | CA3013T | 2.19 |
| LM312H | 1.75 | CA3018T | 1.99 |
| LM317T | 1.70 | CA3021T | 3.49 |
| LM318CN | 1.49 | CA3023T | 2.99 |
| LM319N/H | 1.25 | CA3035T | 2.75 |
| LM320K-XX* | 1.35 | CA3039T | 1.29 |
| LM320T-XX* | 1.39 | CA3046N | 1.29 |
| LM320H-XX* | 1.25 | LM3053N | 1.49 |
| LM323K | 4.95 | CA3059N | 3.19 |
| LM324N | .95 | CA3060N | 3.19 |
| LM337K | 5.95 | CA3062N | 4.95 |
| LM338K | 6.95 | LM3065N | 1.49 |
| LM339N | .95 | CA3080T | 1.29 |
| LM340K-XX* | 1.75 | CA3081N | 1.69 |
| LM340T-XX* | 1.25 | CA3082N | 1.69 |
| LM340H-XX* | 1.25 | CA3083N | 1.55 |
| LM344H | 1.95 | CA3086N | .80 |
| LM348N | 1.20 | CA3089N | 2.99 |
| LM350K | 5.60 | CA3096N | 3.49 |
| LM358CN | .98 | CA3097N | 1.99 |
| LM360N | 1.49 | CA3130T | 1.30 |
| LM372N | 1.95 | CA3140T | 1.19 |
| LM376N | 3.75 | CA3146N | 2.49 |
| LM377N | 2.75 | CA3160T | 1.19 |
| LM380CN/N | 1.25 | CA3190N | 1.95 |
| LM381N | 1.79 | CA3410N | .59 |
| LM383T | 1.95 | MC3423N | 1.49 |
| LM386N | 1.25 | MC3460N | 3.95 |
| LM387N | 1.40 | SG3524N | 3.95 |
| LM390N | 1.95 | CA3600N | 3.39 |
| NE531V/T | 3.75 | LM3900N | .59 |
| NE555V | .39 | LM3905N | 1.19 |
| NE556N | .98 | LM3909N | .98 |
| NE561T | 19.95 | LM3914N | 3.75 |
| NE565N/H | 1.25 | LM3915N | 3.95 |
| NE566H/V | 1.75 | LM3916N | 3.75 |
| NE567V/H | 1.50 | RC4131N | 2.95 |
| NE592N | 2.75 | RC4136N | 1.10 |
| LM702H | 1.99 | RC4151N | 3.70 |
| LM709N/H | .29 | RC4194TK | 4.95 |
| LM710N/H | .75 | RC4195TK | 5.40 |
| LM711N/H | .39 | ULN2001 | 1.25 |
| LM715N | 1.95 | ULN2003 | 1.50 |
| LM723N/H | .65 | SN75450N | .59 |
| LM733N/H | .98 | SN75451N | .35 |
| LM739N | 1.15 | SN75452N | .49 |
| LM741CN/H | .33 | SN75453N | .49 |
| LM741CN-14 | .19 | SN75454N | .49 |
| LM747N/H | .75 | SN75491N | .89 |
| LM748N/H | .39 | SN75492N | .89 |
| LM760CN | 2.95 | SN75493N | .89 |
| LM1310N | 1.90 | SN75494N | .89 |
| MC1330 | 1.95 | TL494CN | 4.20 |
| MC1350 | 1.95 | TL496CP | 1.65 |
| MC1358 | 1.75 | | |

## 74S00

| | | | | | |
|---|---|---|---|---|---|
| 74S00 | $.39 | 74S124 | 3.69 | 74S244 | $2.99 |
| 74S02 | .43 | 74S133 | .54 | 74S251 | 1.35 |
| 74S03 | .45 | 74S134 | .66 | 74S253 | 1.35 |
| 74S04 | .52 | 74S135 | 1.15 | 74S257 | 1.29 |
| 74S05 | .52 | 74S136 | 1.69 | 74S258 | 1.29 |
| 74S08 | .49 | 74S138 | 1.29 | 74S260 | .75 |
| 74S09 | .49 | 74S139 | 1.29 | 74S280 | 2.79 |
| 74S10 | .42 | 74S140 | .73 | 74S287 | 2.99 |
| 74S11 | .42 | 74S151 | 1.29 | 74S288 | 2.55 |
| 74S15 | .42 | 74S153 | 1.29 | 74S373 | 3.10 |
| 74S20 | .42 | 74S157 | 1.29 | 74S374 | 3.10 |
| 74S22 | .42 | 74S158 | 1.29 | 74S387 | 2.75 |
| 74S30 | .42 | 74S160 | 2.79 | 74S471 | 7.95 |
| 74S32 | .49 | 74S174 | 1.49 | 74S472 | 7.95 |
| 74S38 | 1.19 | 74S175 | 1.49 | 74S473 | 7.95 |
| 74S40 | .49 | 74S188 | 2.69 | 74S474 | 9.95 |
| 74S51 | .42 | 74S194 | 1.89 | 74S475 | 9.95 |
| 74S64 | .46 | 74S195 | 1.89 | 74S570 | 5.75 |
| 74S65 | .46 | 74S196 | 1.89 | 74S571 | 5.75 |
| 74S74 | .69 | 74S240 | 2.75 | 74S572 | 8.95 |
| 74S86 | .72 | 74S241 | 2.75 | 74S573 | 8.95 |
| 74S112 | .72 | 74S242 | 2.99 | 74S940 | 2.90 |
| 74S113 | .72 | 74S243 | 2.99 | 74S941 | 2.90 |
| 74S114 | .72 | | | | |

## DIP SWITCHES



| | | | |
|---|---|---|---|
| 2 Position | $ .99 | 7 Position | $1.39 |
| 4 Position | 1.19 | 8 Position | 1.49 |
| 5 Position | 1.29 | 9 Position | 1.65 |
| 6 Position | 1.35 | 10 Position | 1.69 |

## MUFFIN® FAN

The dependable, low cost, largest selling fan for commercial cooling applications.
- 105cfm free air delivery
- 4.68" sq x 1.50" deep Weight - 17 oz.

SPECIAL PURCHASE
NEW! **$9.50 ea.**

## 7400

| | | | | | |
|---|---|---|---|---|---|
| 7400 | $.19 | 7475 | $.38 | 74161 | $.88 |
| 7401 | .22 | 7476 | .34 | 74162 | .89 |
| 7402 | .22 | 7479 | 4.60 | 74163 | .87 |
| 7403 | .22 | 7480 | .49 | 74164 | .87 |
| 7404 | .22 | 7482 | .95 | 74165 | .87 |
| 7405 | .23 | 7483 | .55 | 74166 | 1.20 |
| 7406 | .35 | 7485 | .65 | 74167 | 1.95 |
| 7407 | .35 | 7486 | .35 | 74170 | 1.69 |
| 7408 | .26 | 7489 | 1.75 | 74172 | 4.75 |
| 7409 | .23 | 7490 | .39 | 74173 | .79 |
| 7410 | .22 | 7491 | .57 | 74174 | .89 |
| 7411 | .29 | 7492 | .45 | 74175 | .85 |
| 7412 | .29 | 7493 | .45 | 74176 | .75 |
| 7413 | .39 | 7494 | .69 | 74177 | .75 |
| 7414 | .59 | 7495 | .65 | 74179 | 1.34 |
| 7416 | .29 | 7496 | .69 | 74180 | .75 |
| 7417 | .29 | 7497 | 2.90 | 74181 | 1.75 |
| 7420 | .22 | 74100 | 2.90 | 74182 | .75 |
| 7421 | .35 | 74107 | .32 | 74184 | 2.25 |
| 7422 | .29 | 74109 | .37 | 74185 | 2.25 |
| 7423 | .29 | 74116 | 1.95 | 74186 | 9.95 |
| 7425 | .29 | 74121 | .29 | 74188 | 3.90 |
| 7426 | .29 | 74122 | .39 | 74190 | 1.15 |
| 7427 | .25 | 74123 | .59 | 74191 | 1.15 |
| 7429 | .45 | 74125 | .39 | 74192 | .85 |
| 7430 | .23 | 74126 | .44 | 74193 | .85 |
| 7432 | .29 | 74128 | .59 | 74194 | .85 |
| 7437 | .25 | 74132 | .69 | 74195 | .68 |
| 7438 | .29 | 74136 | .75 | 74196 | .85 |
| 7439 | .29 | 74139 | .95 | 74197 | .85 |
| 7440 | .19 | 74141 | .79 | 74198 | 1.39 |
| 7441 | .79 | 74142 | 2.95 | 74199 | 1.39 |
| 7442 | .57 | 74143 | 2.95 | 74221 | 1.19 |
| 7443 | .95 | 74144 | 2.95 | 74251 | .95 |
| 7444 | .95 | 74145 | .62 | 74273 | 1.05 |
| 7445 | .79 | 74147 | 1.95 | 74276 | 1.89 |
| 7446 | .79 | 74148 | 1.20 | 74279 | .75 |
| 7447 | .65 | 74150 | 1.09 | 74283 | 1.40 |
| 7448 | .79 | 74151 | .67 | 74284 | 3.90 |
| 7450 | .19 | 74152 | .67 | 74285 | 3.90 |
| 7451 | .19 | 74153 | .67 | 74290 | 1.25 |
| 7453 | .19 | 74154 | 1.19 | 74298 | .95 |
| 7454 | .19 | 74155 | .78 | 74365 | .68 |
| 7459 | .25 | 74156 | .78 | 74366 | .68 |
| 7460 | .23 | 74157 | .69 | 74367 | .68 |
| 7470 | .29 | 74158 | 1.65 | 74368 | .68 |
| 7472 | .29 | 74159 | 2.49 | 74390 | 1.45 |
| 7473 | .34 | 74160 | .88 | 74393 | 1.90 |
| 7474 | .34 | | | 74490 | 1.90 |

## 74LS00

| | | | | | |
|---|---|---|---|---|---|
| 74LS00 | $.26 | 74LS113 | $.43 | 74LS245 | $2.20 |
| 74LS01 | .28 | 74LS114 | .43 | 74LS247 | 1.10 |
| 74LS02 | .28 | 74LS122 | .55 | 74LS248 | 1.10 |
| 74LS03 | .28 | 74LS123 | 1.19 | 74LS249 | 1.19 |
| 74LS04 | .35 | 74LS124 | 1.35 | 74LS251 | 1.40 |
| 74LS05 | .28 | 74LS125 | .89 | 74LS253 | 1.40 |
| 74LS08 | .28 | 74LS126 | .52 | 74LS257 | .85 |
| 74LS09 | .35 | 74LS132 | .79 | 74LS258 | .98 |
| 74LS10 | .28 | 74LS136 | .49 | 74LS259 | 2.95 |
| 74LS11 | .39 | 74LS138 | .85 | 74LS260 | .65 |
| 74LS12 | .33 | 74LS139 | .85 | 74LS261 | 2.49 |
| 74LS13 | .47 | 74LS145 | 1.25 | 74LS266 | .59 |
| 74LS14 | .95 | 74LS148 | 1.49 | 74LS273 | 1.75 |
| 74LS15 | .33 | 74LS151 | .79 | 74LS275 | 4.40 |
| 74LS20 | .26 | 74LS153 | .79 | 74LS279 | .59 |
| 74LS21 | .33 | 74LS154 | 1.70 | 74LS283 | .99 |
| 74LS22 | .33 | 74LS155 | 1.19 | 74LS290 | .99 |
| 74LS26 | .33 | 74LS156 | .99 | 74LS293 | .99 |
| 74LS27 | .33 | 74LS157 | .85 | 74LS295 | 1.10 |
| 74LS28 | .33 | 74LS158 | .75 | 74LS298 | 1.19 |
| 74LS30 | .26 | 74LS160 | 1.05 | 74LS324 | 1.75 |
| 74LS32 | .33 | 74LS161 | 1.15 | 74LS347 | 1.95 |
| 74LS33 | .55 | 74LS162 | 1.05 | 74LS348 | 1.95 |
| 74LS37 | .45 | 74LS163 | 1.05 | 74LS352 | 1.19 |
| 74LS38 | .39 | 74LS164 | 1.19 | 74LS353 | 1.19 |
| 74LS40 | .26 | 74LS165 | .89 | 74LS363 | 1.49 |
| 74LS42 | .79 | 74LS166 | 2.48 | 74LS365 | .69 |
| 74LS47 | .79 | 74LS168 | 1.15 | 74LS366 | .69 |
| 74LS48 | .95 | 74LS169 | 1.15 | 74LS367 | .69 |
| 74LS51 | .26 | 74LS170 | 1.99 | 74LS368 | .69 |
| 74LS54 | .29 | 74LS173 | .89 | 74LS373 | 1.89 |
| 74LS55 | .29 | 74LS174 | .89 | 74LS374 | 1.89 |
| 74LS73 | .45 | 74LS175 | .89 | 74LS375 | .69 |
| 74LS74 | .42 | 74LS181 | 2.20 | 74LS377 | 1.95 |
| 74LS75 | .59 | 74LS190 | 1.15 | 74LS385 | 1.95 |
| 74LS76 | .45 | 74LS191 | 1.15 | 74LS386 | .65 |
| 74LS78 | .45 | 74LS192 | .98 | 74LS390 | 1.95 |
| 74LS83A | .79 | 74LS193 | .98 | 74LS393 | 1.95 |
| 74LS85 | 1.19 | 74LS194 | 1.15 | 74LS395 | 1.70 |
| 74LS86 | .45 | 74LS195 | .95 | 74LS399 | 2.35 |
| 74LS90 | .57 | 74LS196 | .89 | 74LS424 | 2.95 |
| 74LS92 | .75 | 74LS197 | .89 | 74LS668 | 1.75 |
| 74LS93 | .75 | 74LS221 | 1.15 | 74LS670 | 2.29 |
| 74LS95 | .88 | 74LS240 | 1.69 | 81LS95 | 1.69 |
| 74LS96 | .98 | 74LS242 | 1.69 | 81LS96 | 1.69 |
| 74LS107 | .45 | 74LS243 | 1.69 | 81LS97 | 1.69 |
| 74LS109 | .45 | 74LS244 | 1.49 | 81LS98 | 1.69 |
| 74LS112 | .43 | | | | |

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| 4002 | .35 | 4041 | 1.25 | 4094 | 2.95 |
| 4006 | 1.05 | 4042 | .95 | 4098 | 2.29 |
| 4007 | .25 | 4043 | .85 | 4099 | 2.25 |
| 4008 | 1.39 | 4044 | .85 | 14408 | 12.95 |
| 4009 | .45 | 4046 | 1.75 | 14409 | 12.95 |
| 4010 | .45 | 4047 | 1.25 | 14410 | 12.95 |
| 4011 | .35 | 4048 | .99 | 14412 | 12.95 |
| 4012 | .25 | 4049 | .45 | 14415 | 8.95 |
| 4013 | .45 | 4050 | .69 | 14419 | 4.95 |
| 4014 | 1.39 | 4051 | 1.10 | 4501 | .39 |
| 4015 | 1.15 | 4052 | 1.10 | 4502 | 1.65 |
| 4016 | .59 | 4053 | 1.10 | 4503 | .69 |
| 4017 | 1.19 | 4055 | 3.95 | 4505 | 8.95 |
| 4018 | .89 | 4056 | 2.95 | 4506 | .75 |
| 4019 | .45 | 4059 | 9.25 | 4507 | .95 |
| 4020 | 1.10 | 4060 | 1.39 | 4508 | 3.75 |
| 4021 | 1.19 | 4066 | .75 | 4510 | 1.19 |
| 4022 | 1.15 | 4069 | .35 | 4511 | 1.19 |
| 4023 | .29 | 4070 | .49 | 4512 | 1.39 |
| 4024 | .75 | 4071 | .35 | 4515 | 2.75 |
| 4025 | .25 | 4072 | .35 | 4516 | 1.45 |
| 4027 | .65 | 4073 | .35 | 4518 | 1.39 |
| 4028 | .85 | 4075 | .35 | 4520 | 1.25 |
| 4029 | 1.29 | 4076 | 1.29 | 4555 | 4.95 |
| 4030 | .45 | 4077 | .35 | 4556 | .99 |
| 4031 | 3.25 | 4078 | .35 | 4566 | 2.25 |
| 4032 | 2.15 | 4081 | .35 | 80C95 | 1.50 |
| 4034 | 3.25 | 4082 | .35 | 80C97 | 1.25 |
| 4035 | .95 | 4085 | 1.95 | | |

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| LM733CN | 3/1.99 | 6522 | 6.95 | 74LS93 | 3/1.00 | 1103 RAM | 3/1.50 |
| MC1414 | 3/1.99 | 6602 CPU | 5.95 | 2114 | 8/14.50 | 8700 A/D | 2/16.95 |

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Black phenolic conforming to MIL M-14, type CFG. Rated at 20 amps for any voltage to 250. Includes neoprene washer, hex nut, and lock washer.

## National Semiconductor

### MA1026 Time-Temp. Clock Module

Giant .7 Inch 4-Digit LED Display
- °F and or C° and virtually any number of sensors
- 50/60Hz line frequency operation
- 12 or 24 Hour Display

Instruction included with all orders

Typical Applications Include Clock Radio Timers, Alarm Clock, Desk Clock, TV and Stereo Timer, Instrument Panel Clock, Digital Thermometer and much more.

| Part No. | Description | Price |
|---|---|---|
| MA1026W | MA1026 clock module only | $18.95 |
| MA1026P | Digi Key switch panel kit (P.C. Board, 12 switches, two LM334Z temp. sensors, two KOA32 potentiometers, instructions) | 11.95 |
| MA1026T | 110 VAC transformer for MA1026M | 3.95 |
| MA1026B | Alarm buzzer for MA1026M | 3.36 |
| MA1026K | MA1026M, P, T, B | 34.95 |

For additional sensor units, you will need:

| | | |
|---|---|---|
| LM334Z | Temperature Sensor | 1.51 |
| K4A32 | 300 ohm Potentiometer | .32 |
| 502PB | Normally open SPST Switch | .24 |

### "Programmable" Clock Modules

0.7" or 0.84" Red 4-Digit LED Display

User Programmable For
- 12 or 24 hour display
- 50/60 Hz line frequency
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- Display, hours and minutes, minute and seconds, alarm time, and sleep time
- Battery back up in case of power failure
- Typical applications include clock radio timer, alarm clock, desk clock, instrument panel clock, and many more.

MA1020 — 0.84 INCH HIGH DIGITS

| Cat. No. | Description | Price |
|---|---|---|
| MA1020M | MA1020 Clock Module only | $15.96 |
| MA1020P | Digi Key switching panel (includes P.C. board, switches, hardware and instructions) | 7.95 |
| MA1020T | 110 VAC Transformer for MA1020M | 3.95 |
| MA1020B | Buzzer for MA1020M alarm output | 3.36 |
| MA1020K | MA1020M, P, B and T | 29.95 |

MA1023 — 0.7 INCH HIGH DIGITS

| Cat. No. | Description | Price |
|---|---|---|
| MA1023M | MA1023 Clock Module only | $8.95 |
| MA1023P | Digi Key switching panel (includes P.C. board, switches, hardware and instructions) | 6.95 |
| MA1023T | 110 VAC Transformer for MA1023M | 3.95 |
| MA1023B | Buzzer for MA1023 alarm output | 3.36 |
| MA1023K | MA1023M, P, B and T | 21.30 |

### .5" 4-Digit LCD Clock

National Semiconductor MA1032 Clock Module
- One year use on a 90mA hour battery (typ.)
- Buffered alarm and sleep outputs
- AC or DC alarm output
- Hold function
- Seconds display
- Backlighted display
- 12 or 24 hour time display

| Cat. No. | Description | Price |
|---|---|---|
| MA1032M | MA1032 Clock Module only | $17.95 |
| MA1032C | Switches for MA1032 | 2.85 |
| MA1032K | MA1032M, C, and AA battery holder | 21.20 |

### DIGI-CLOCK Kit

12 VDC — Ideal for Car, Van or Boat!

Part No. 5001K — ONLY $17.95

### LED's — Red, Green, Amber, Orange

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## PCB Transformers

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Specifications:

5% Carbon Film Resistor Values in Ohms

When ordering individual resistors place a "Q" after the ohms value for ¼W and an "H" for ½W resistors.

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RS125 — 5 each of 73 values in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc. to 1M ohm of the ¼W 5% resistor for a total of 365 pieces — $9.90

RS225 — 5 each of 72 values in the series 1.1, 1.3, 1.6, 2.0, 2.4, etc. to 910K ohm of the ¼W 5% resistor for a total of 360 pieces — $9.90

½ WATT 5% CARBON FILM RESISTOR ASSORTMENT

RS150 — 5 each of 73 values in the series 1.0, 1.2, 1.5, 1.8, 2.2, etc. to 1M ohm of the ½W 5% resistor for a total of 365 pieces — $9.90

RS250 — 5 each of 72 values in the series 1.1, 1.3, 1.6, 2.0, 2.4, etc. to 910K ohm of the ½W 5% resistor for a total of 360 pieces — $9.90

Remember a "Q" after the resistance value indicates a ¼ watt, an "H" indicates a ½ watt (i.e. 10KQ or 10KH). Prices are for single values.

¼ Watt — 5 for 25¢; 200 for $3.40, 1000 for $13.00
½ Watt — 5 for 25¢; 200 for $3.40, 1000 for $16.00

In order to receive the pricing above, the resistor part number must be followed by a "-ND" (i.e., 10KQ-ND) and ordered in multiples of 1,000 only.

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### TERMINATION JUMPERS

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P = PCB CONNECTOR TERMINATION
X = CARD EDGE CONNECTOR TERMINATION

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### DIP Jumper Cable Assemblies

Standard Assembly Styles

Number After Dash Is Cable Length In Inches

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## 9 DIGITS 600 MHz $129.95 WIRED

PRICES

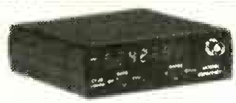
| | |
|---|---|
| CT-90 wired, 1 year warranty | $129.95 |
| CT-90 Kit, 90 day parts warranty | 109.95 |
| AC-1 AC adapter | 3.95 |
| BP-1 Nicad pack +AC Adapter/Charger | 12.95 |
| OV-1, Micro-power Oven time base | 49.95 |
| External time base input | 14.95 |

The CT-90 is the most versatile, feature packed counter available for less than $300.00! Advanced design features include; three selectable gate times, nine digits, gate indicator and a unique display hold function which holds the displayed count after the input signal is removed! Also, a 10mHz TCXO time base is used which enables easy zero beat calibration checks against WWV. Optionally, an internal nicad battery pack, external time base input and Micro-power high stability crystal oven time base are available. The CT-90, performance you can count on!

SPECIFICATIONS:

| | |
|---|---|
| Range: | 20 Hz to 600 MHz |
| Sensitivity: | Less than 10 MV to 150 MHz<br>Less than 50 MV to 500 MHz |
| Resolution: | 0.1 Hz (10 MHz range)<br>1.0 Hz (60 MHz range)<br>10.0 Hz (600 MHz range) |
| Display: | 9 digits 0.4" LED |
| Time base: | Standard-10.000 mHz, 1.0 ppm 20-40°C.<br>Optional Micro-power oven-0.1 ppm 20-40°C |
| Power: | 8-15 VAC @ 250 ma |

## 7 DIGITS 525 MHz $99.95 WIRED



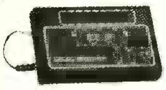
SPECIFICATIONS:

| | |
|---|---|
| Range: | 20 Hz to 525 MHz |
| Sensitivity: | Less than 50 MV to 150 MHz<br>Less than 150 MV to 500 MHz |
| Resolution: | 1.0 Hz (5 MHz range)<br>10.0 Hz (50 MHz range)<br>100.0 Hz (500 MHz range) |
| Display: | 7 digits 0.4" LED |
| Time base: | 1.0 ppm TCXO 20-40°C |
| Power: | 12 VAC @ 250 ma |

The CT-70 breaks the price barrier on lab quality frequency counters. Deluxe features such as; three frequency ranges - each with pre-amplification, dual selectable gate times, and gate activity indication make measurements a snap. The wide frequency range enables you to accurately measure signals from audio thru UHF with 1.0 ppm accuracy - that's .0001%! The CT-70 is the answer to all your measurement needs, in the field, lab or ham shack.

PRICES:

| | |
|---|---|
| CT-70 wired, 1 year warranty | $99.95 |
| CT-70 Kit, 90 day parts warranty | 84.95 |
| AC-1 AC adapter | 3.95 |
| BP-1 Nicad pack + AC adapter/charger | 12.95 |



## 7 DIGITS 500 MHz $79.95 WIRED

PRICES:

| | |
|---|---|
| MINI-100 wired, 1 year warranty | $79.95 |
| AC-Z Ac adapter for MINI-100 | 3.95 |
| BP-Z Nicad pack and AC adapter/charger | 12.95 |

Here's a handy, general purpose counter that provides most counter functions at an unbelievable price. The MINI-100 doesn't have the full frequency range or input impedance qualities found in higher price units, but for basic RF signal measurements, it can't be beat! Accurate measurements can be made from 1 MHz all the way up to 500 MHz with excellent sensitivity throughout the range, and the two gate times let you select the resolution desired. Add the nicad pack option and the MINI-100 makes an ideal addition to your tool box for "in-the-field" frequency checks and repairs.

SPECIFICATIONS:

| | |
|---|---|
| Range: | 1 MHz to 500 MHz |
| Sensitivity: | Less than 25 MV |
| Resolution: | 100 Hz (slow gate)<br>1.0 KHz (fast gate) |
| Display: | 7 digits, 0.4" LED |
| Time base: | 2.0 ppm 20-40°C |
| Power: | 5 VDC @ 200 ma |

## 8 DIGITS 600 MHz $159.95 WIRED

NEW READ RECEIVER FREQUENCY

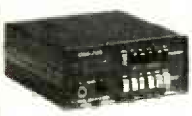
SPECIFICATIONS:

| | |
|---|---|
| Range: | 20 Hz to 600 MHz |
| Sensitivity: | Less than 25 mv to 150 MHz<br>Less than 150 mv to 600 MHz |
| Resolution: | 1.0 Hz (60 MHz range)<br>10.0 Hz (600 MHz range) |
| Display: | 8 digits 0.4" LED |
| Time base: | 2.0 ppm 20-40°C |
| Power: | 110 VAC or 12 VDC |

The CT-50 is a versatile lab bench counter that will measure up to 600 MHz with 8 digit precision. And, one of its best features is the Receive Frequency Adapter, which turns the CT-50 into a digital readout for any receiver. The adapter is easily programmed for any receiver and a simple connection to the receiver's VFO is all that is required for use. Adding the receiver adapter in no way limits the operation of the CT-50, the adapter can be conveniently switched on or off. The CT-50, a counter that can work double-duty!

PRICES:

| | |
|---|---|
| CT-50 wired, 1 year warranty | $159.95 |
| CT-50 Kit, 90 day parts warranty | 119.95 |
| RA-1, receiver adapter kit | 14.95 |
| RA-1 wired and pre-programmed (send copy of receiver schematic) | 29.95 |



## DIGITAL MULTIMETER $99.95 WIRED

PRICES:

| | |
|---|---|
| DM-700 wired, 1 year warranty | $99.95 |
| DM-700 Kit, 90 day parts warranty | 79.95 |
| AC-1, AC adaptor | 3.95 |
| BP-3, Nicad pack +AC adapter/charger | 19.95 |
| MP-1, Probe kit | 2.95 |

The DM-700 offers professional quality performance at a hobbyist price. Features include; 26 different ranges and 5 functions, all arranged in a convenient, easy to use format. Measurements are displayed on a large 3½ digit, ½ inch LED readout with automatic decimal placement, automatic polarity, overrange indication and overload protection up to 1250 volts on all ranges, making it virtually goof-proof! The DM-700 looks great, a handsome, jet black, rugged ABS case with convenient retractable tilt bail makes it an ideal addition to any shop.

SPECIFICATIONS:

| | |
|---|---|
| DC/AC volts: | 100uV to 1 KV, 5 ranges |
| DC/AC current: | 0.1uA to 2.0 Amps, 5 ranges |
| Resistance: | 0.1 ohms to 20 Megohms, 6 ranges |
| Input impedance: | 10 Megohms, DC/AC volts |
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# MICROPROCESSOR COMPONENTS

## MICROPROCESSOR CHIPS

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| CDP1802 | 40 | CPU | $9.95 |
| 2650 | 40 | MPU | 14.95 |
| IDM2901ADC | 40 | CPU—4-bit slice (Com. Temp. Gr.) | 19.95 |
| MC6502 | 40 | MPU w/Clock (65K bytes mem.) | 9.95 |
| MC6802CP | 40 | MPU w/Clock and RAM | 7.95 |
| INS8035N-6 | 40 | MPU—8-bit (6MHz) | 5.95 |
| INS8039N-6 | 40 | CPU-Sgl. chip 8-bit (128 bits Ram) | 5.95 |
| INS8040N-6 | 40 | CPU (256 bytes RAM) | 5.95 |
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| MC68661PB | 28 | Enhanced Prog. Comm. Int. | 8.95 |

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| INS8154 | 40 | 128 Byte RAM 16-Bit I/O | 13.95 |
| INS82C06 | 20 | Octal D Flip Flop Tri-State (74C374) | 2.49 |
| DP8212 | 24 | 8-bit Input/Output (74S412) | 2.25 |
| DP8214 | 24 | Priority Interrupt Control | 3.95 |
| DP8216 | 16 | Bi-Directional Bus Driver | 2.25 |
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| DP8308 | 20 | 8-bit Bi-Directional Receiver | 2.49 |
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## MICROPROCESSOR MANUALS & DATA BOOKS

| | | |
|---|---|---|
| M-Z80 | User Manual | 7.50 |
| M-CDP1802 | User Manual | 7.50 |
| M-2650 | User Manual | 5.00 |
| 1D400 | 1982 Intel Data Book (1405 pg.) | 14.95 |
| 30001 | 1981 Nat. CMOS Book (628 pg.) | 6.95 |
| 30002 | 1980 Nat. Interface Book (640 pg.) | 6.95 |
| 30003 | 1982 Nat. Linear Book (1952 pg.) | 11.95 |
| 30005 | 1981 Nat. TTL Book (624 pg.) | 9.95 |
| 30008 | 1980 Nat. Memory Data Book (464 pg.) | 6.95 |
| 30011 | 1980 Nat. Linear Applications (736 pg.) | 15.95 |
| 30013 | 1983 Zilog Data Book (641 pg.) | 7.95 |
| 205610 | 1981 Intel Peripheral Design (828 pg.) | 9.95 |

## DYNAMIC RAMS

| Part No. | **Pins | Function | Price |
|---|---|---|---|
| 1103 | 18 | 1024x1 (300ns) | .99 |
| **4027** | **16** | **4096x1 (250ns)** | **2.49** |
| 4116N-2 | 16 | 16,384x1 (150ns) | 1.89/8-$14.95 |
| 4116N-3 | 16 | 16,384x1 (200ns) | 1.69/8-12.95 |
| 4116N-4 | 16 | 16,384x1 (250ns) | 1.49/8-10.95 |
| 4164N-150 | 16 | 65,536x1 (150ns) | 7.95/8-59.95 |
| 4164N-200 | 16 | 65,536x1 (200ns) | 7.49/8-54.95 |
| MM5261 | 18 | 1024x1 (300ns) | .49/8-1.95 |
| **MM5262** | **18** | **2048x1 (365ns)** | **.49/8-1.95** |
| MM5270 | 18 | 4096x1 (200ns) MK4096 | 4.95 |
| MM5280 | 22 | 4096x1 (200ns) 2107 | 3.95 |
| MM5290-2 | 16 | 16,384x1 (150ns) | 1.89/8-14.95 |
| MM5290-3 | 16 | 16,384x1 (200ns) | 1.69/8-12.95 |
| MM5290-4 | 16 | 16,384x1 (250ns) | 1.49/8-10.95 |
| MM5298-3 | 16 | 8192x1 (200ns) | 1.69 |

## STATIC RAMS

| | | | |
|---|---|---|---|
| 1101 | 16 | 256x1 (650ns) | 1.49 |
| 2101 | 22 | 256x4 (450ns) 8101 | 2.49 |
| 2102 | 16 | 1024x1 (350ns) | .89 |
| 21L02 | 16 | 1024x1 (450ns) L.P. | 1.49 |
| 2111 | 18 | 256x4 (450ns) 8111 | 2.95 |
| 2112 | 16 | 256x4 (450ns) MOS | 2.95 |
| 2114 | 18 | 1024x4 (450ns) | 1.95/8-13.95 |
| 2114L | 18 | 1024x4 (450ns) L.P. | 2.25/8-15.95 |
| 2114-2 | 18 | 1024x4 (200ns) | 2.25/8-15.95 |
| 2114L-2 | 18 | 1024x4 (200ns) L.P. | 2.49/8-17.95 |
| 2141-3 | 18 | 4096x1 (150ns) | 3.95 |
| 2147 | 18 | 4096x1 (70ns) | 4.95 |
| 2148 | 18 | 1024x4 (70ns) | 6.95 |
| TMS4044 | 18 | 4096x1 (450ns) | 3.95 |
| TMS4045 | 18 | 1024x4 (450ns) | 3.95 |
| 5101 | 22 | 256x4 (450ns) CMOS | 4.95 |
| MM5257 | 18 | 4096x1 (450ns) 4044 | 4.95 |
| HM6116P-3 | 24 | 2048x8 (150ns) CMOS | 7.95 |
| HM6116-4 | 24 | 2048x8 (200ns) CMOS | 6.95 |
| HM6116LP-4 | 24 | 2048x8 (200ns) L.P. CMOS | 7.95 |
| 7489 | 16 | 16x4 (50ns) 3101 | 2.25 |
| 74C920 | 22 | 256x4 (250ns) CMOS (6551) | 3.95 |
| 74C921 | 18 | 256x4 (250ns) CMOS | 3.95 |
| 74C929 | 16 | 1024x1 (250ns) CMOS (6501) | 3.95 |
| 74C930 | 18 | 1024x1 (250ns) CMOS (6518) | 3.95 |
| 74S189 | 16 | 16x4 (35ns) 93405 | 1.95 |
| 74S200 | 16 | 256x1 (80ns) 93410 | 3.95 |
| 74S206 | 16 | 256x1 (60ns) 93411 | 3.95 |
| 74S289 | 16 | 16x4 (35ns) 3101 | 2.25 |
| 82S10 | 16 | 1024x1 (50ns) O.C. (93415) | 3.95 |
| 82S25 | 16 | 16x4 (50ns) O.C. (74S289) | 2.25 |

## EPROMS

| | | | |
|---|---|---|---|
| 1702A | 24 | 256x8 (1us) | 4.95 |
| 2708 | 24 | 1024x8 (450ns) | 3.95 |
| 2708-5 | 24 | 1024x8 (550ns) SM00246 | 2.95 |
| TMS2516 | 24 | 2048x8 (450ns) 2716 | 6.95 |
| TMS2532 | 24 | 4096x8 (450ns) NMC2532 | 9.95 |
| TMS2564 | 28 | 8192x8 (450ns) | 19.95 |
| TMS2716 | 24 | 2048x8 (450ns) 3 voltage | 7.95 |
| 2716 | 24 | 2048x8 (450ns) | 4.95 |
| 2716-1 | 24 | 2048x8 (350ns) | 6.95 |
| 2732 | 24 | 4096x8 (450ns) | 9.95 |
| 27580 | 24 | 1024x8 (450ns) single +5V | 2.95 |
| MM2764 | 28 | 8192x8 (450ns) | 16.95 |
| MM2764-3 | 28 | 8192x8 (300ns) | 19.95 |

## PROMS

| | | | |
|---|---|---|---|
| 74S188 | 16 | 32x8 PROM O.C. (6330-1) | 1.49 |
| 74S287 | 16 | 256x4 PROM T.S. (6301-1) | 1.95 |
| 74S288 | 16 | 32x8 PROM T.S. (6331-1) | 1.95 |
| 74S387 | 16 | 256x4 PROM O.C. (6300-1) | 1.95 |
| 74S471 | 20 | 256x8 PROM T.S. (6309-1) | 5.95 |
| 74S472 | 20 | 512x8 PROM T.S. (6349-1) | 4.95 |
| 74S473 | 20 | 512x8 PROM O.C. (6348) | 4.95 |
| 74S474 | 24 | 512x8 PROM T.S. (TBP28S86) | 4.95 |
| 74S475 | 24 | 512x8 PROM O.C. (6340) | 4.95 |
| 74S478 | 24 | 1024x8 PROM T.S. (TBP28S86) | 8.95 |
| 74S570 | 16 | 512x4 PROM O.C. (6305) | 2.95 |
| 74S571 | 16 | 512x4 PROM T.S. (6306) | 2.95 |
| 74S572 | 18 | 1024x4 PROM O.C. (6352) | 4.95 |
| 74S573 | 18 | 1024x4 PROM T.S. (82S137) | 4.95 |
| 82S23 | 16 | 32x8 PROM O.C. (27S18) | 2.95 |
| 82S115 | 24 | 512x8 PROM T.S. (27S15) | 9.95 |
| 82S123 | 16 | 32x8 PROM T.S. (27S19) | 2.95 |
| 82S126 | 16 | 256x4 PROM O.C. (27S20) | 3.95 |
| 82S129 | 16 | 256x4 PROM T.S. (27S21) | 3.95 |
| 82S130 | 16 | 512x4 PROM O.C. (27S12) | 5.95 |
| 82S185 | 18 | 2048x4 PROM T.S. (TBP24S81) | 9.95 |
| DM87S180N | 24 | 1024x8 PROM O.C. (82S180) | 9.95 |
| DM87S181N | 24 | 1024x8 PROM T.S. (82S181) | 9.95 |
| DM87S184N | 18 | 2048x4 PROM O.C. (82S184) | 9.95 |
| DM87S185N | 18 | 2048x4 PROM T.S. (82S185) | 9.95 |
| DM87S190N | 24 | 2048x8 PROM O.C. (82S190) | 19.95 |
| DM87S191N | 24 | 2048x8 PROM T.S. (82S191) | 19.95 |

## DATA ACQUISITION

| | | | |
|---|---|---|---|
| DC10 | | Mostek DC/DC Convert. +5V to -9V | 2.95 |
| MC3470P | 18 | Floppy Disk Read AMP System | 4.95 |
| MC1408L7 | 16 | 7-bit D/A Converter (DAC0807LCN) | 2.49 |
| MC1408L8 | 16 | 8-bit D/A Converter (DAC0808LCN) | 2.95 |
| ADC0804 | 20 | 8-bit A/D Converter (1 LSB) | 3.49 |
| DAC0806 | 16 | 8-bit D/A Converter (0.78% Lin.) | 1.95 |
| ADC0809 | 28 | 8-bit A/D Converter (8-Ch. Multi.) | 4.49 |
| **AY-5-1013A** | **40** | **30K Baud Uart (TR1602)** | **4.95** |

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- Burglar alarms • IR data link
- Remote slide projector control
- Consumer remote data links
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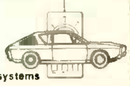

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# INTERSIL

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| Part No. | **Pins | Function | | Price |
|---|---|---|---|---|
| 7045IPI | 28 | CMOS Precision Timer | | 14.95 |
| 7045EV/Kit* | 28 | Stopwatch Chip, XTL | | 19.95 |
| 7106CPL | 40 | 3½ Digit A/D (LCD Drive) | | 9.95 |
| 7106EV/Kit* | 40 | IC, Circuit Board, Display | | 34.95 |
| 7107CPL | 40 | 3½ Digit A/D (LED Drive) | | 11.95 |
| 7107EV/Kit* | 40 | IC, Circuit Board, Display | | 29.95 |
| 7116CPL | 40 | 3½ Digit A/D LCD Dis. HLD. | | 16.95 |
| 7117CPL | 40 | 3½ Digit A/D LED Dis. HLD. | | 15.95 |
| 7201IUS | | Low Battery Volt Indicator | | 2.25 |
| 7205IPG | 24 | CMOS LED Stopwatch/Timer | | 12.95 |
| 7205EV/Kit* | 24 | Stopwatch Chip, XTL | | 14.95 |
| 7206CJPE | 16 | Tone Generator | | 4.95 |
| 7206CEV/Kit* | 16 | Tone Generator Chip, XTL | | 7.95 |
| 7207AIPD | 14 | Oscillator Controller | | 5.95 |
| 7207AEV/Kit* | 14 | Freq. Counter Chip, XTL | | 7.95 |
| 7208IPI | 28 | Seven Decade Counter | | 15.95 |
| 7209IPA | 8 | Clock Generator | | 3.95 |
| 7215IPG | 24 | 4 Func. CMOS Stopwatch CKT | | 13.95 |
| 7215EV/Kit* | 24 | 4 Func. Stopwatch Chip, XTL | | 14.95 |
| 7216AIJI | 28 | 8 Digit Univ. Counter C.A. | | 29.95 |
| 7216CIJI | 28 | 8 Digit Freq. Counter C.A. | | 24.95 |
| 7216DIPI | 28 | 8 Digit Freq. Counter C.C. | | 19.95 |
| 7217IJI | 28 | 4 Digit LED Up/Down Counter C.A. | | 10.95 |
| 7217AIPI | 28 | 4 Digit LED Up/Down Counter C.C. | | 11.95 |
| 7224IPL | 40 | LCD 4½ Digit Up Counter DRI | | 10.95 |
| 7226AIJL | 40 | 8 Digit Univ. Counter | | 29.95 |
| 7226AEV/Kit* | 40 | 5 Function Counter Chip, XTL | | 74.95 |
| 7240IJE | 16 | CMOS Bin Prog. Timer/Counter | | 4.95 |
| 7242IJA | 8 | CMOS Divide-by-256 RC Timer | | 2.25 |
| 7250IJE | 16 | CMOS BCD Prog. Timer/Counter | | 6.00 |
| 7260IJE | 16 | CMOS BCD Prog. Timer/Counter | | 5.25 |
| 7555IPA | 8 | CMOS 555 Timer | | 1.45 |
| 7556IPD | 14 | CMOS 556 Timer | | 2.20 |
| 7611BCPA | 8 | CMOS Op Amp Comparator | 5MV | 2.25 |
| 7612BCPA | 8 | CMOS Op Amp Ext. Cmvr. | 5MV | 2.95 |
| 7621BCPA | 8 | CMOS Dual Op Amp Comp. | 5MV | 3.95 |
| 7631CCPE | 16 | CMOS Tri Op Amp Comp. | 10MV | 5.35 |
| 7641CCPD | 14 | CMOS Quad Op Amp Comp. | 10MV | 7.50 |
| 7642CCPD | 14 | CMOS Quad Op Amp Comp. | 10MV | 7.50 |
| 7660CPA | 8 | Voltage Converter | | 2.95 |
| 8038CCPD | 14 | Waveform Generator | | 3.95 |
| 8048CCPE | 16 | Monolithic Logarithmic Amp | | 16.95 |
| 8069CCQ | | 50ppm Band—GAP Volt Ref. Diode | | 2.50 |
| 8211CPA | 8 | Volt Ref/Indicator | | 2.95 |
| 8212CPA | 24 | Volt Ref/Indicator | | 2.95 |

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## 74C—C/MOS

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|---|---|---|---|---|---|---|---|---|
| 74C00 | 14 | .35 | 74C95 | 14 | 1.39 | 74C221 | 16 | 1.95 |
| 74C02 | 14 | .35 | 74C107 | 14 | .89 | 74C240 | 20 | 1.95 |
| 74C04 | 14 | .29 | 74C151 | 16 | 2.49 | 74C244 | 20 | 1.95 |
| 74C08 | 14 | .35 | 74C154 | 24 | 3.49 | 74C373 | 20 | 2.49 |
| 74C10 | 14 | .35 | 74C157 | 16 | 2.25 | 74C374 | 20 | 2.49 |
| 74C14 | 14 | .59 | 74C160 | 16 | 1.19 | 74C901 | 14 | .59 |
| 74C20 | 14 | .35 | 74C161 | 16 | 1.19 | 74C903 | 14 | .59 |
| 74C30 | 14 | .35 | 74C162 | 16 | 1.19 | 74C906 | 14 | .59 |
| 74C32 | 14 | .39 | 74C163 | 16 | 1.19 | 74C911 | 28 | 8.95 |
| 74C42 | 16 | 1.39 | 74C164 | 14 | 1.49 | 74C912 | 28 | 8.95 |
| 74C48 | 16 | 1.95 | 74C173 | 16 | .79 | 74C915 | 18 | 1.19 |
| 74C73 | 14 | .79 | 74C174 | 16 | 1.19 | 74C917 | 28 | 8.95 |
| 74C74 | 14 | .69 | 74C175 | 16 | 1.19 | 74C922 | 18 | 4.49 |
| 74C85 | 16 | 1.95 | 74C192 | 16 | 1.49 | 74C923 | 20 | 4.95 |
| 74C86 | 14 | .39 | 74C193 | 16 | 1.69 | 74C925 | 16 | 5.95 |
| 74C89 | 16 | 5.95 | 74C195 | 16 | 1.39 | 74C926 | 18 | 5.95 |
| 74C90 | 14 | 1.19 | | | | 80C95 | 16 | .39 |
| 74C93 | 14 | 1.19 | | | | 80C97 | 16 | .39 |

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## LINEAR

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| TL071CP | 8 | .79 | LM340K-15 | | 1.35 | NE570N | 16 | 3.95 |
| TL072CP | 8 | 1.39 | LM340T-5 | | .79 | LM703CN | 8 | 1.19 |
| TL074CN | 14 | 1.95 | LM340T-12 | | .79 | LM709N | 14 | .49 |
| TL081CP | 8 | .59 | LM340T-15 | | .79 | LM710N | 14 | .69 |
| TL082CP | 8 | 1.19 | LM348N | 14 | .99 | LM711N | 14 | .79 |
| TL084CN | 14 | 1.95 | LM350K | | 4.95 | LM723N | 14 | .55 |
| LM301CN | 8 | .35 | LF355N | 8 | 1.10 | LM733N | 14 | 1.00 |
| LM302H | | 1.95 | LF356N | 8 | 1.10 | LM739N | 14 | 1.95 |
| LM304H | | 1.95 | LM370N | 14 | 4.49 | LM741CN | 8 | .35 |
| LM305H | | .99 | LM373N | 14 | 3.95 | LM747N | 14 | .69 |
| LM307CN | 8 | .45 | LM377N | 14 | 1.95 | LM748N | 8 | .59 |
| LM308CN | 8 | .69 | LM380N | 14 | .89 | LM1310N | 14 | 1.49 |
| LM309K | | 1.25 | LM381N | 14 | 1.79 | LM1458CN | 8 | .59 |
| LM310CN | 8 | 1.75 | LM382N | 14 | 1.39 | LM1488N | 14 | .69 |
| LM311CN | 8 | .69 | LM384N | 14 | 1.79 | LM1489N | 14 | .69 |
| LM312H | | 2.49 | LM386N-3 | 8 | .89 | LM1496N | 14 | 1.95 |
| LM317T | | 1.19 | TL494CN | 16 | 2.95 | LM1800N | 16 | 1.49 |
| LM317K | | 3.95 | TL496CP | 8 | 1.19 | LM1889N | 18 | 1.95 |
| LM318CN | 8 | 1.95 | NE510A | 14 | 4.95 | LM1896N | 14 | 2.95 |
| LM319N | 14 | 1.95 | NE529A | 14 | 2.95 | LM2002T | | 1.49 |
| LM320K-5 | | 1.35 | NE531V | 8 | 2.95 | LM3189N | 16 | 1.59 |
| LM320K-12 | | 1.35 | NE536H | | 8.95 | LM3900N | 14 | .59 |
| LM320K-15 | | 1.35 | NE540H | | 4.95 | LM3905CN | 8 | 1.19 |
| LM320T-5 | | .89 | NE544N | 14 | 2.95 | LM3909N | 8 | .99 |
| LM320T-12 | | .89 | NE550A | 14 | 1.95 | LM3914N | 18 | 3.49 |
| LM320T-15 | | .89 | NE555V | 8 | .35 | LM3915N | 18 | 3.49 |
| LM323K | | 5.95 | LM556N | 14 | .69 | LM3916N | 18 | 3.49 |
| LM324N | 14 | .59 | NE564N | 16 | 2.95 | **RC4136N** | **14** | **1.25** |
| LM337T | | 1.95 | LM565N | 14 | 1.19 | RC4151NB | 8 | 1.95 |
| LM338K | | 6.95 | LM566CN | 8 | 1.49 | ICL8038B | 14 | 3.95 |
| LM339N | 14 | .69 | LM567V | 8 | .89 | LM13080N | 8 | 1.19 |
| LM340K-5 | | 1.35 | | | | LM13600N | 16 | 1.19 |
| LM340K-12 | | 1.35 | | | | MORE AVAILABLE | | |

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# CONNECTORS

## DB25 — D Subminiature (meets RS232)

| Part No. | Description | Price |
|---|---|---|
| DE9P | 9 Pin Plug | $1.79 |
| DE9S | 9 Pin Socket | 1.95 |
| DA15P | 15 Pin Plug | 1.95 |
| DA15S | 15 Pin Socket | 2.95 |
| **DB25P** | **25 Pin Plug (Meets RS232)** | **2.49** |
| **DB25S** | **25 Pin Socket (Meets RS232)** | **3.25** |
| DB25P-831 | 25 Pin Right Angle Plug | 4.95 |
| DB25S-831 | 25 Pin Right Angle Socket | 5.25 |
| DC37P | 37 Pin Plug | 4.95 |
| DC37S | 37 Pin Socket | 5.95 |
| DD50P | 50 Pin Plug | 5.95 |
| DD50S | 50 Pin Socket | 6.95 |

### Accessories

| | | |
|---|---|---|
| DE-9H | Hood for DE-9 Series Connectors | $1.19 |
| DA-15H | Hood for DA-15 Series Connectors | 1.29 |
| DB25H | Hood for DB25 Series Connectors | 1.25 |
| DC37H | Hood for DC37 Series Connectors | 1.39 |
| DD50H | Hood for DD50 Series Connectors | 1.49 |
| D20418-2 | 2 screws for mtg. connectors to a panel | .79 |

## Solder Eyelet/Wire Wrap Edge Card

| Part No. | Cnts. | Sp. | Description | Price |
|---|---|---|---|---|
| 15/30SE | 15/30 | .156 | Solder Eyelet | $1.79 |
| 18/36SE | 18/36 | .156 | Solder Eyelet | 1.95 |
| 22/44SE | 22/44 | .156 | Solder Eyelet | 2.49 |
| 22/44PC | 22/44 | .156 | PC type (no mtg. ears) | .99 |
| 50/100SE | 50/100 | .125 | Solder Eyelet | 9.95 |
| 22/44WW | 22/44 | .156 | Wire Wrap - Level 3 | 4.95 |
| 67031-5 | 22/44 | .156 | WW (Pins .0625x.03x.75) | 3.95 |
| R-681-1 | 50/100 | .125 | Wire Wrap - Level 3 | 7.95 |
| R-681-2 | 50/100 | .125 | Wire Wrap - Level 1 | 6.95 |

## RF Coaxial Connectors

| Part No. | Description | Price |
|---|---|---|
| PL259 | UHF Plug | $ .89 |
| SO239 | UHF Panel Receptacle | .69 |
| PL258 | UHF Straight Adapter | .89 |
| UG175/U | UHF Reducing Adapter | .49 |
| UG88/U | BNC Plug | 1.49 |
| UG89/U | BNC Jack | 1.69 |
| UG306/U | BNC Angle Adapter | 2.49 |
| UG260/U | BNC Plug | 1.49 |
| UG1094/U | BNC Bulkhead Receptacle | .89 |

# IC SOCKETS

For Socket Required, See Column After The IC Part No.

## LOW PROFILE (TIN) SOCKETS

| | 1-9 | 10-99 | 100-999 |
|---|---|---|---|
| 8 pin LP | .16 | .14 | .13 |
| 14 pin LP | .17 | .15 | .14 |
| 16 pin LP | .19 | .17 | .16 |
| 18 pin LP | .26 | .24 | .23 |
| 20 pin LP | .30 | .27 | .25 |
| 22 pin LP | .31 | .28 | .26 |
| 24 pin LP | .33 | .30 | .28 |
| 28 pin LP | .40 | .37 | .35 |
| 36 pin LP | .46 | .42 | .39 |
| 40 pin LP | .49 | .46 | .43 |

— Soldertail Standard Tin & Gold Also Available —

## WIRE WRAP (GOLD) SOCKETS LEVEL #3

| | 1-9 | 10-99 | 100-999 |
|---|---|---|---|
| 8 pin WW | .49 | .45 | .42 |
| 10 pin WW | .65 | .62 | .59 |
| 14 pin WW | .65 | .62 | .59 |
| 16 pin WW | .69 | .65 | .61 |
| 18 pin WW | .89 | .85 | .79 |
| 20 pin WW | 1.09 | 1.05 | .99 |
| 22 pin WW | 1.25 | 1.19 | 1.15 |
| 24 pin WW | 1.29 | 1.23 | 1.18 |
| 28 pin WW | 1.59 | 1.50 | 1.45 |
| 36 pin WW | 1.85 | 1.75 | 1.69 |
| 40 pin WW | 1.99 | 1.89 | 1.79 |

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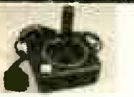
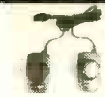
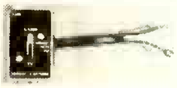
## ATARI



**JOYSTICKS**
JSA (2) . . . $6.95/pair



**PADDLES**
JSP (2) . . . $4.95/pair

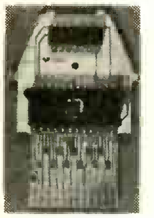


### TV GAME SWITCH

Switches TV to video game or computer operation. Used on Atari.

**TGS-1 . . . $2.95 ea.**

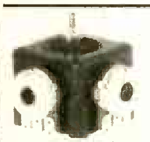
### VIDEO GAME CHIPS



Pull-outs from hand-held video games. AP2000 consists of one MM2716Q EPROM and one 74LS04. AP2002 consists of two MM2716 EPROMs and one 74LS04. These EPROMs are mounted on a circuit board with a 12-pin edge card connection. EPROMs can be reprogrammed for other applications.

AP2000 . . . . . . . . . . $2.49 ea. or 2 for $3.95
AP2002 . . . . . . . . . . $3.49 ea. or 2 for $6.49

### JOYSTICKS



JS-5K (Pictured)

| | | |
|---|---|---|
| JS-5K | 5K Linear Taper Pots | $5.25 |
| JS-100K | 100K Linear Taper Pots | $4.95 |
| JS-150K | 150K Linear Taper Pots | $4.75 |
| JVC-40 | 40K (2) Video Controller in Case | $4.95 |

JS KNOB Knob for JS5K,100K,150K . . . . . $.99 ea.
JVC KNOB Knob for JVC-40 . . . . . . . . . . . . $.99 ea.

### Jameco ELECTRONICS Digital Thermometer Kit

Dual sensors — switch controls for indoor/outdoor or dual monitoring — can be extended to 500 feet. Continuous LED .8" ht. display. Range: -40°F to 199°F, -40°C to 100°C. Accuracy ±1° nominal. Calibrate for Fahrenheit/Celsius. Simulated walnut case. AC wall adapter included. Size: 6⅞"L x 3¾"H x 1⅞"D.

**JE300 . . . . . $39.95**

### BOOKS

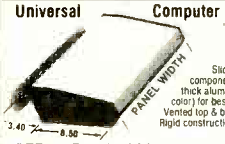
NATIONAL SEMICONDUCTOR — INTERSIL — INTEL

30001 National CMOS Data Book (1981) . . . . . $6.95
(640 pages) 74C, CD4000, and A/D Converters
30002 National Interface Data Book (1980) . . . . . $6.95
(704 pages) DP, DS8000, DS3600, DS5700, etc.
30003 National Linear Data Book (1982) . . . . . $11.95
(1376 pages) LM, LF, ADC, DAC, LH Series
30004 National Series 80 — Board Level Computer (1980) . . . . $4.95
(224 pages)
30005 National TTL Logic Data Book (1981) . . . . . $9.95
(624 pages) 7400,LS,L,H,S, and DM8000 Series

**30006 Above (3) 30001,3,5 as set . . $24.95**

30008 National Memory Data Book (1980) . . . . . $6.95
(464 pages) RAMs, ROMs, PROMs, EPROMs Series
30009 Intersil Data Book (1983) . . . . . $9.95
(1356 pages) Complete line.
30010 National Audio/Radio Handbook (1980) . . . . . $5.95
(240 pages) Pre-Amps, AM, FM & FM Stereo, Power Amps
30011 National Linear Application Handbook (1980) . . . . . $15.95
(736 pages) Application Notes, Linear Briefs, etc.
30012 National PAL Data Book (1982) . . . . . $5.95
(176 pages) Data Sheet, PAL Design
30013 Zilog Data Book (1983) . . . . . $7.95
(641 pages) Microprocessors and Support Chips
010400 Intel Component Data Book (1982) . . . . . $14.95
(1405 pg.) Full data sheets for Intel's products incl. mem. devices, microproc., periph. & ind./mil. products
205610 Intel Peripheral Design Handbook (1981) . . . . . $9.95
(828 pages) Full data sheets, application notes for Intel peripheral device components

### Universal Computer Keyboard Enclosures




"DTE" Blank Desk-Top Enclosures are designed for easy modification. High strength epoxy molded end pieces in mocha brown finish. Sliding rear/bottom panel for service/component access. Top/bott. panels .080" thick alum. alodine type 1200 finish (gold tint color) for best paint adhesion after modification. Vented top & bottom panels for cooling efficiency. Rigid construction provides unlimited applications. Assembly Instructions included.

DTE-8 Panel Width 7.5" . . . . . . . . . . $24.95
DTE-11 Panel Width 10.13" . . . . . . . . . . $27.95
DTE-14 Panel Width 13.5" . . . . . . . . . . $29.95
DTE-20 Panel Width 19.25" . . . . . . . . . . $34.95

### Mostek DC/DC Converter +5 VOLTS TO -9 VOLTS

Input: +5V. Output: -9V (regulated) @ 30mA. Printed circuit mounting. Specifications Incl.

DC10 . . . . . . . . . $2.95 ea. or 2/$4.95

### Battery Checker

Easy-to-use hand-held battery checker tests AA, AAA, C, D, and 216 batteries. A multi-colored meter shows if battery is good, weak or needs replacing. Size: 6¼"L x 2¼"W x 1-7/8"H.

**BC-1 . . . . . . . . . . . . $6.95 ea.**

## KEYBOARDS — POWER SUPPLIES

17⅛"L x 6"W x 1⅞"H

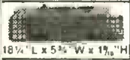
**DATANETICS 73-KEY KEYBOARD** *Apple Compatible*
Data Entry Keyboard uses MM5740 BEE/N encoder chip (Included). 73-Key Keyboard features 11-key numeric keypad, SPST switching, 24-pin edge card connection. Includes pin-out.
Part No. KB261 (Fits DTE-20 Enclosure) . . . . . . . . $49.95 each

16⅜"L x 5¼"W x 1⅞"H

**MICRO SWITCH 69-KEY KEYBOARD**
Data Entry Keyboard, Encoded Output: 8-bit Parallel EBC DIC. Switching: Hall Effect, 24-pin Edge Card Connection. Complete w/Pin Connection. Can easily be modified to ASCII code.
Part No. KB69SD12-2 (Fits Into DTE-20 Enclosure) . . . . . . . . $19.95 each

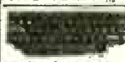
23"L x 5¼"W x 1 3/8"H

**MICRO SWITCH 85-KEY KEYBOARD**
Word Processing Keyboard, 26 Pin Edge Card Connection. Supply Voltage +5VDC. Main Keyboard is QWERTY. Additional Key Pads for Cursor and word processing functions.
Part No. 85SD18-1 . . . . . . . . $29.95 each



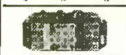
18¼"L x 5¾"W x 1⅞"H

**MICRO SWITCH 88-KEY KEYBOARD (PARALLEL**
Data Entry Keyboard used in a Diablo 1640 Terminal. Supply Voltage: +5V, -12V. Switching: Hall Effect — 10-pin Edge Card Connection. Schematic included. Uses 8048 Encoder Chip.
Part No. 88SD22 (Fits into DTE-20 Enclosure) . . . . . . . . $49.95 each



11½"L x 3¾"W x 1½"H

**HI-TEK 58-KEY KEYBOARD**
SPST switching, mechanical, monolithic housing, charcoal grey keycaps. Keyboard is not mounted on circuit board (each key is individually accessible). Used to replace touch-membrane found on Sinclair, Atari, and TRS-80 computers.
Part No. K-58 (Fits DTE-14 Enclosure) . . . . . . . . $19.95 each



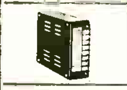
9⅜"L x 4⅞"W x 1⅞"H

**ALPS 29-KEY CALCULATOR KEYBOARD**
Features one 8-position decimal select switch, one 3-position switch, and two 2-position switches, mechanical SPST switching, 22-pin edge card connection. Pin-out included.
Part No. KB297040 (Fits DTE-11 Enclosure) . . . . . . . . $4.95 each

**POWER SUPPLY +5VDC @ 1 AMP REGULATED** *Transaction Tech*
Output +5VDC @ 1A (also +30VDC) reg. Input 115VAC 60Hz. 2-tone (black/beige) self-enclosed case. 6 ft., 3 cond. black power cord. 6⅛"W x 7"D x 2¼"H. Wt. 3 lbs. Data sheet incl.
Part No. PS51194 . . . . . . . . $19.95 each

**POWER SUPPLY +5VDC @ 3 AMP REGULATED** *Deltron*
Input: 115VAC, 47-440Hz. Output: 5VDC Adjustable @ 3 amp, 6VDC @ 2.5 amp. Adjustable current limit, Ripple & Noise: 1MV rms, 5MV p-p — 2 mounting surfaces. UL recognized. Size: 4"W x 4½"L x 2-7/16"H - wt. 2 lbs. Data sheet included.
Part No. QPS-1 . . . . . . . . $29.95 each

**POWER SUPPLY +5VDC @ 7.5 AMP, 12VDC @ 1.5 AMP SWITCHING**
Input: 115VAC, 50-60Hz @ 3 amp/230VAC, 50Hz @ 1.6 amp. Fan volt./power supply select switches (115/230VAC). Output: 5VDC @ 7.6 amp, 12VDC @ 1.6 amp. 8 ft. blk. pow. cord. 11½"W x 13¼"D x 3¾"H. Wt. 6 lbs.
Part No. PS94VD . . . . . . . . $49.95 each



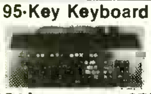
**POWER SUPPLY 4-Channel Switching Power Supply**
Microprocessor, mini-computer, terminal, medical equipment and process control applications. Input: 90-130VAC 47-440Hz. Output: +5VDC @ 5A, -5VDC @ 1A; +12VDC @ 1A, -12VDC @ 1A. Line req.: ±0.2%. Ripple: 30mV p-p. Load reg.: ±1%. Overcurrent protection. Adj: 5V main output ±10%. 6-3/8"L x 1-7/8"W x 4-15/16"H. Wt. 1½ lbs.
Part No. FCS-604A . . . . . . . . $69.95 each

**POWER SUPPLY Adjustable Switching 4-24VDC to 5 Amps**
Adj. 4-24VDC; 5VDC @ 5A, 6VDC @ 4.8A, 9VDC @ 4.1A, 12VDC @ 3.3A, 18VDC @ 1.9A, 24VDC @ .5A. Overvoltage Protection. Input: 115VAC 50/60Hz. Output variations within 20mV. 8.25"L x 4.25"W x 2.25"H. Wt. 3.25 lbs.
JE224 Kit . . . . . . . . $79.95 each
JE224A Assembled & Tested . . . . . . . . $99.95 each

### 84-Key Keyboard

CA153A . . . . . . . . . $69.95

### 95-Key Keyboard

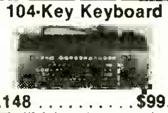


CA154A . . . . . . . . . $79.95

### CONTROL DATA

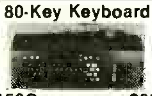
Data Entry Keyboards
RS232 Interface
FT2 Shielded Base
SPST Switching
Momentary Contact Keyswitches
30" Interface Cable
Attractive Case

### 104-Key Keyboard



CA148 . . . . . . . . . $99.95

### 80-Key Keyboard



CA150C . . . . . . . . . $89.95

Color; keycaps: black, blue, red - cover: black w/beige base. 21½"x9"x3½". 6 lbs.

**BUG BOX™** — 30 individual compartments • Stores 60 8-pin or 30 14- or 16-pin DIPs • Bug rugs not included • Clear plastic cover slides & locks • Cover marked w/numbers 1-30 • Compartment size: 1" x 3.75" x .5" deep • Box size: 4.9" x 3.3" x .6" • Weight: 1.75 oz.

**BUG BOX™**
Please specify color code: (B) Blue, (R) Red, (W) White (Y) Yellow

| Part No./Color Code | QTY | PRICE |
|---|---|---|
| BGX-001-( ) | 1 | $ 2.29 |
| BGX-010-( ) | 10 | 19.99 |
| ANTI-STATIC | | |
| BGX-001-( )AS | 1 | $ 3.29 |
| BGX-010-( )AS | 10 | 28.89 |

**BUG CAGE™** — 12 locations store Bug Boxes, Big Bug Boxes or Bug Trays • Modular and interlocking • Heavy duty injection molded plastic • Each cage has 6 slip-on locations • 2 cages per pkg. • Cage size: 5-1/8" x 5" x 3-7/8" • 4 colors available — please specify color code: (B) Blue, (R) Red, (W) White, (Y) Yellow

| Part No./Color Code | Price |
|---|---|
| BGC-001-( ) 2 Cages (6 loc. ea.) | $11.95/pkg. |

**BUG TRAY™** — Stores in Bug Cage • Molded plastic • Three styles: Open (1 compartment 3.05" x 4.6" x .6"); Vertical (5 compartments .5" x 4.6" x .6"); and Horizontal (8 compartments .4" x 3.95" x .6") • Ideal for tools, hardware, components, etc. • Tray size: 3.55" x 5.05" x .6" • Black color only

| PART NO. | DESCRIPTION | PRICE |
|---|---|---|
| BTH-001 | Horizontal Bug Tray | $1.95 |
| BTV-001 | Vertical Bug Tray | 1.95 |
| BTO-001 | Open Bug Tray | 1.95 |
| BTX-003 | 1 of each Bug Tray (3) | 4.98 |

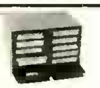
**BUG RUG™** — Static discharge protection for CMOS and MOSFET devices • Pre-cut to dimensions of BUG BOX (1" x .35")

| Part No. | Description | Price |
|---|---|---|
| BRG-030 | 30 foam rectangles for Bug Box | $1.98 |
| BBR-036 | 6 foam rec. for LSI Big Bug Box | 1.98 |

**CAGE KEEPER™** — Pins column of Bug Boxes in Bug Cage

| | | Price |
|---|---|---|
| CKP-005 | 5 Inch | $4.98/pkg. |
| CKP-010 | 10 Inch | 6.98/pkg. |

### BUG BOX™ STORAGE SYSTEMS



BUG CAGE™ (BGC-001-____) with Bug Boxes

**LSI BIG BUG BOX™** — Designed to store large IC's, Resistors, Capacitors and Diodes • Divided into three compartments measuring 1" x 4.15" x .5" deep • Three vertical and three horizontal dividers included • Bug Rugs not included • Box size: 4.9" x 3.3" x .6" • Weight: 1.75 oz.

**LSI BIG BUG BOX™**
Please specify color code: (B) Blue, (R) Red, (W) White, (Y) Yellow

| PART NO./COLOR CODE | QTY | PRICE |
|---|---|---|
| BLX-001-( ) | 1 | $ 3.29 |
| BLX-010-( ) | 10 | 28.79 |
| ANTI-STATIC | | |
| BLX-001-( )AS | 1 | $ 4.29 |
| BLX-010-( )AS | 10 | 37.89 |

**BACK PACK™** — Self-adhesive labels for the back of ICs • Shows exact internal logic in relation to IC pins • 532 labels in each package (including several blank labels) • Each package for 8, 14, 16, 24, 28 and 40-pin ICs • Combo package includes 1,068 labels for TTL and CMOS ICs • Microprocessor package contains 744 labels

| Part No. | Description | Price |
|---|---|---|
| BPT-012 | TTL | $7.95 |
| BPC-012 | CMOS | 8.95 |
| BPM-012 | Combo | 14.95 |
| BPU-012 | Microprocessor | 9.95 |

**BUG TAGS™** — Self-adhesive, easy-to-read labels for marking Bug Box and LSI Big Bug Box • Most popular components

| PART NO. | DESCRIPTION | QTY. | PRICE |
|---|---|---|---|
| BTT-200 | TTL | 200 | $4.98 |
| BTC-200 | CMOS | 200 | 4.98 |
| BTK-200 | LS Schottky | 200 | 4.98 |
| BTS-200 | Special | 200 | 4.98 |
| BTM-800 | Mixer | 800 | 13.95 |

*MORE BUG TAGS AVAILABLE!*

### ★ ★ ★ BUG BOX SYSTEMS INTRODUCTORY SPECIAL ★ ★ ★

Your choice: regular or anti-static. Includes 2-Bug Cages (12 locations); 6-Bug Boxes; 3-LSI Big Bug Boxes; 1-horizontal Bug Tray; 1-open Bug Tray; 1-vertical Bug Tray; 1 package Bug Rug for regular Bug Boxes; 1 package Bug Rug for LSI Big Bug Boxes; 1 package Mixer Labels (800 each). Color: Bug Boxes and Cages - Blue, Bug Trays - Black.

SP-BUG Regular (Retail value $59.45) . . . . . . . . *Sale Price $49.95*
SP-BUG-AS Anti-Static (Retail value $67.45) . . . . . . . . *Sale Price $59.95*

$10.00 Minimum Order — U.S. Funds Only
California Residents Add 6½% Sales Tax
Shipping — Add 5% plus $1.50 Insurance
*Send S.A.S.E. for Monthly Sales Flyer!*

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## EXPAND YOUR MEMORY

### TRS-80 to 16K, 32K, or 48K

**Model 1 = From 4K to 16K Requires (1) One Kit
Model 3 = From 4K to 48K Requires (3) Three Kits
Color = From 4K to 16K Requires (1) One Kit

**Model 1 equipped with Expansion Board up to 48K Two Kits Required
— One Kit Required for each 16K of Expansion —

TRS-16K3 *200ns for Color & Model III . . . . . . . . $12.95
TRS-16K4 *250ns for Model I . . . . . . . . $10.95

### TRS-80 Color 32K or 64K Conversion Kit

Kit comes complete with 8 each 4164-2 (200ns) 64K dynamic RAMs and conversion documentation. Converts TRS-80 color computers with D and E circuit boards, and all new color computers to 32K. Minor modifications of 32K memory will allow the use of all 64K of the dynamic RAM.

**TRS-64K2 . . . . . . . . . . . . . . . . . $54.95**

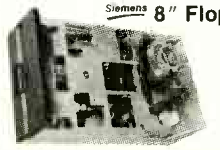
### 5¼" Mini-Floppy Disk Drive

Pertec Computer Corp.

FOR TRS-80 MODEL I (Industry Standard)
Features single or double density. Recording mode: FM single, MFM double density. Power: +12VDC (±0.6V) 1.6A max., +5VDC (±0.25V) 0.8A max. Unit as pic. at left (does not incl. case, power supply, cables). 30-pg. data book incl. Wt. 3½ lbs. Size: 5¾"W x 8"D x 3¼"H.

Part No. *Limited Quantity!* Price
FD200 . . . . . . . . . . . . . . $179.95
Single-sided, 40 tracks, 250K bytes capacity
FD250 . . . . . . . . . . . . . . $199.95
Double-sided, 35 tracks, 438K bytes capacity

### Siemens 8" Floppy Disk Drive



- Shugart 801R compatible
- Single-Sided
- 77 Tracks
- 400/800K Bytes Capacity
- Industry Standard

The FDD100-8 8" Floppy Disk Drive (Industry Standard) features single or double density. Recording mode: FM single, MFM double density. Transfer rate: 250K bits/sec. single density; 500K bits/sec. double density. The FDD100-8 is designed to work with the single-sided soft sectored IBM Diskette 1, or eq. disk cartridge. Hard-sectored option available. Power: 115/230VAC @ 50-60Hz, +24VDC @ 1.7 amps max., +5VDC @ 1.2 amps max. Unit as pictured above (does not include case, power supply, or cables). Size: 8.55"W x 14"L x 4.5"H. Weighs 12 lbs. Incl. 96-pg. manual.

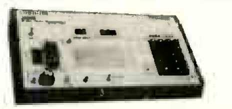
| Part No. | | Price |
|---|---|---|
| FDD100-8 | Buy 1 for | $269.95 each |
| FDD100-8 | Buy 2 for | $259.95 each |
| *FDD100-8* | *Buy 10 for* | *$249.95 each* |

2708,2716,2732 & 2764 EPROM Programmer

### JE664 EPROM PROGRAMMER

**8K TO 64K EPROMS — 24 AND 28 PIN PACKAGES**
Self-Contained — Requires No Additional Systems for Operation

NEW!



• Programs, validates, and checks for properly erased EPROMs • Emulates PROMs or EPROMs • RS232C Computer Interface for editing/program loading • Loads data into RAM by keyboard • Changes data in RAM by keyboard • Loads RAM from an EPROM • Compares EPROMs for content differences • Copies EPROMs • Power Input: 115VAC, 60Hz, ◄ 10W power consumption • Enclosure: Color-coordinated, light tan panels w/molded mocha brown end pieces • Size: 15-5/8"L x 8¾"D x 3½"H • Wt.: 5¾ lbs.

**JE664-A EPROM Programmer . . . . . . . . $995.00**
Assembled & Tested ( Includes JM16A Module)

**JE665 — RS232C INTERFACE OPTION** — The JE665 RS232C Interface Option implements computer access to the JE664's RAM. Sample software written in BASIC provided for TRS-80® Model I, Level II Computer. Baud rate: 9600 Word Lgth: 8 bits - odd parity Stop bits 2 Option may be adapted to other computers.

**JE664-ARS EPROM Prog. w/JE665 Option . . . . . . . . $1195.00**
Assembled and Tested (Includes JM16A Module)

**EPROM JUMPER MODULES** — The JE664's JUMPER MODULE (Personality Module) is a plug-in Module that pre-sets JE664 for proper programming pulses to the EPROM & configures EPROM socket connections for that particular EPROM.

| Part No. | EPROM | EPROM MANUFACTURER | PRICE |
|---|---|---|---|
| JM08A | 2708 | AMD, Motorola, National, Intel, TI | $14.95 |
| JM16A | 2716, TMS2516 | Intel, Motorola, National, NEC, TI | $14.95 |
| JM16B | TMS2716 | Motorola, TI (+5,-12,+12) | $14.95 |
| JM32A | TMS2532 | Motorola, TI | $14.95 |
| JM32B | 2732 | AMD, Fujitsu, NEC, Hitachi, Intel | $14.95 |
| JM64A | MCM68764, MCM68L764 | Motorola | $14.95 |
| JM64B | 2764 | Intel | $14.95 |
| JM64C | TMS2564 | TI | $14.95 |

### UV-EPROM Eraser

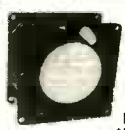
8 Chips — 51 Minutes

1 Chip — 37 Minutes

Erases 2708, 2716, 2732, 2764, 2516, 2532, 2564. Erases up to 8 chips within 51 minutes (1 chip in 37 minutes). Maintains constant exposure distance of one inch. Special conductive foam liner eliminates static build-up. Built-in safety lock to prevent UV exposure. Compact — only 9.00" x 3.70" x 2.60". Complete with holding tray for 8 chips.

UVS-11EL Replacement Bulb . . . . . $16.95
**DE-4 UV-EPROM Eraser . . . . $79.95**

### Sprite-style Fan

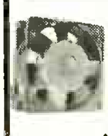


- 36cfm free air delivery
- 3.125" sq. x 1.665" depth
- 10 yrs. cont. duty at 20°C
- 115V 50/60Hz

Metal Frame

PWS2107U Cleaned & tested (used) . . . . $ 9.95 ea.
*PWS2107F New . . . . . . . . $14.95 ea.

### Muffin-style Fan



- 105cfm free air delivery
- 4.68" sq. x 1.50" depth
- 10 yrs. cont. duty at 20°C
- Impedance protected, ambients to 70°C
- 115V 50/60Hz 14W Wt. 17 oz.

Metal Frame

MU2A1-U Cleaned & tested (used) . . . . . . . $9.95 ea.
*MU2A-1N New . . . . . . . . . . . $14.95 ea.

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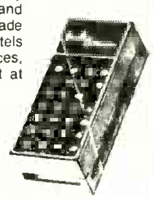
**Portable Smoke Detector And Intrusion Alarm**

The Traveller's Companion is an extremely sensitive portable smoke detector and burglar/intrusion alarm system. It's made to protect you wherever you are: in hotels or motels, mobile homes, R.V.'s, offices, apartments, dormitory room and at at home. Features:



- Extra loud 85db alarm horn
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- Fully portable — hangs on door
- Handsome carrying case for travel
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- Operates from one 9V alkaline battery (not included)
- Size — only 5½" x 2¼" x 1½"

We are a factory authorized dealer and are offering this incredible advanced design system at this low introductory price.

C4831 $24.95

### MICRO-MINIATURE SPEAKER

Only 5/16" dia. mounted on a 1" square PC board.

C4832 $1.95 ea.

### SOLID CARBIDE PC DRILL BIT

#65 .035
Standard size for PC boards.

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10 for $12.00

### KESTER PC TYPE SOLDER

6 foot coil of ultra thin diameter low melting temperature 60/40 rosin core.

C4456 $1.00

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## Tiger TECH ELECTRONIC COMPONENTS

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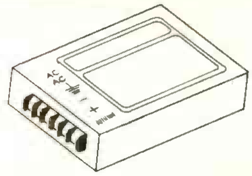

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5VDC Computer power supply. 120 VAC 50-400 HZ input. External sense

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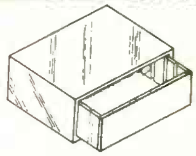

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Beautiful solid anodized aluminum case with insert that holds up to six 1"x4" cards. Two lense colors!
US$8.39 1-1/2"h x 4-1/2" x 3-1/2"d

CIRCLE 72 ON FREE INFORMATION CARD

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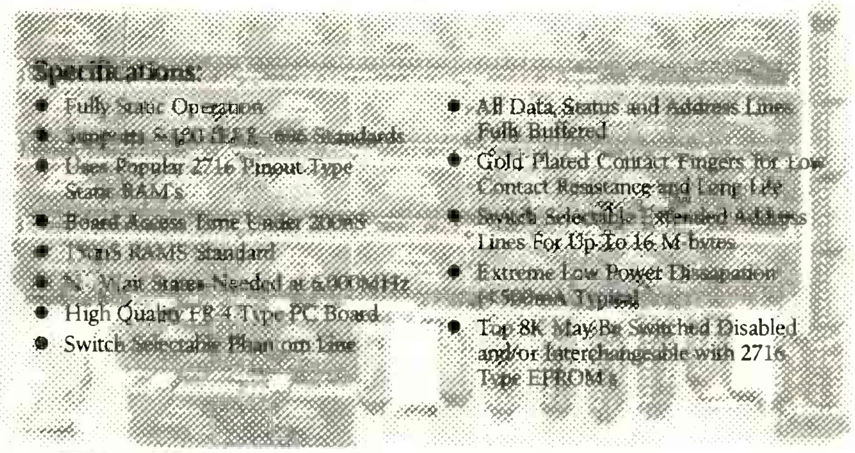
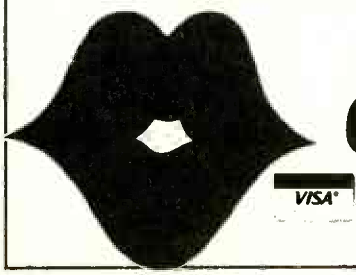



COEX 64K S-100 CMOS STATIC RAM BOARD

only $299.00

Assembled & Tested



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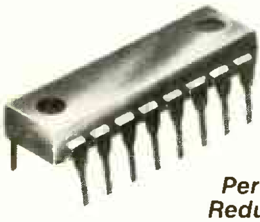


**6.99**

*Perfect for Noise Reduction Systems*

NE572. Dual channel—can be used either for dynamic range compression or expansion. Independent attack and recovery control. 6 to 22VDC single supply. 16-pin DIP with data.
276-1781 .......... 6.99

### 43-Range Multitester

**38% Off**

**24.88** Reg. 39.95

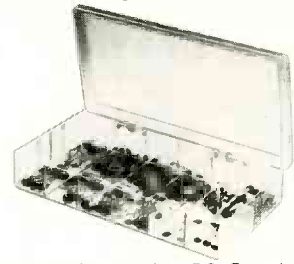
*50,000 Ohms Per Volt*

Measures AC and DC volts, DC milliamps, resistance and dB. Range-Doubler switch. Requires one "AA", one 9V battery. With leads. 22-204 .......... Sale 24.88

### 150 Disc Capacitors

**Cut 31%**

Reg. 9.95



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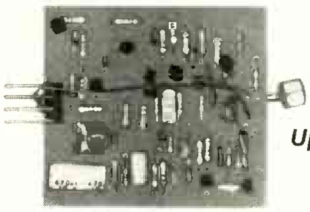
**$30.25 Individual Parts Value.** 50WVDC. Contains 15 .005μF, ten each of 100, 220 and 470pF; .001, .002, .01, .02, .05, .1μF. 29 other assorted values. With chart. 272-601 .......... Sale 6.88

### Sound Switch Module



**1.99**

*Up to 25-Ft. Range*

Just whistle—once for on, again for off! Remote-control a relay, motor, radio or TV. 6-9VDC. With data. 277-1011 .......... 1.99

### Waveform Generator

**5.95**

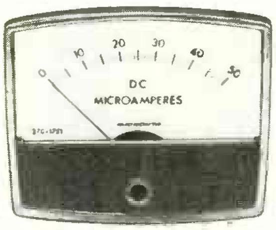
ICL8038. Produces precise sine, square, triangle, sawtooth and pulse waves with minimum external parts. Simultaneous high-level sine, square and triangle outputs. Range: .001 Hz to 300 kHz+. Single/split supply. 14-pin DIP. 276-2334 .......... 5.95

### Mini 12VDC Buzzer

**1.69**

Small enough to hide, loud enough to call attention. 1 1/16" mounting centers. With leads.
273-055 .......... 1.69

### Precision Panel Meters




**8.95 Each** *Monitor Your Critical DC Circuits*

Jeweled movements. Accuracy: ±5% full scale. 2 3/4 x 2 1/4 x 1 1/4". Require 1 7/8" round mounting holes.

0-50 μA DC. 270-1751 .......... 8.95
0-1 mA DC. 270-1752 .......... 8.95
0-15VDC. 270-1754 .......... 8.95

### Submini Toggle Switches

Low As **1.99**

- *10 Amps at 125VAC*
- *1/4" Mounting Holes*

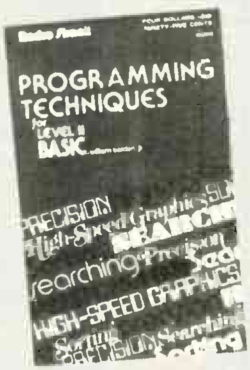
| Description | Cat. No. | Each |
|---|---|---|
| SPST | 275-324 | 1.99 |
| SPDT | 275-326 | 2.19 |
| SPDT Center Off | 275-325 | 2.39 |
| DPDT | 275-1546 | 2.69 |
| DPDT Center Off | 275-1545 | 2.89 |

### CdS Photocell

**1.29**

3 megohms in darkness to 100 ohms in bright light. 200 mW at 170V, max. 276-116 .......... 1.29

### Books to Program Your TRS-80®




**54% Off**

Both For Only

**5.88**


A B

**Save $7.02**

A **Programming Techniques for Level II BASIC. Reg. $4.95.** A "cookbook" of program applications for the TRS-80 line. Describes Level II commands, data search, string manipulation, high-speed graphics and much more. Everything you need to write BASIC computer programs. 224 pages. Softbound. 62-2062

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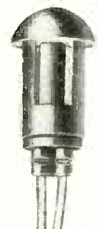
### SPST Toggle

**2.99**

Red LED lights when "on". 5A. For 12VDC use only. 7/16" mounting hole.
275-680 .......... 2.99

### 12V Snap-In Lamps



**1.89**

*Panel Mounting*

Assemblies have one amber, one blue lens. Mounting tabs for 1/2" dia. hole. 4" leads. With bulbs.
272-335 .......... Pkg. of 2/1.89

### Electret Mike Element

**1.19**

Omnidirectional. PC board mounting. 2 to 10VDC, 1 mA max. 20 to 15,000 kHz.
270-090 .......... 1.19

### Metal Project Enclosure

**28% Off**

Reg. 10.95

**7.88**

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270-270 .......... Sale 7.88

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# TMM2016 2KX8 STATIC 200 NS $4.15

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## STATIC RAMS

| | | |
|---|---|---|
| 2101 | 256 x 4 (450ns) | 1.95 |
| 5101 | 256 x 4 (450ns) (cmos) | 3.95 |
| 2102-1 | 1024 x 1 (450ns) | .89 |
| 2102L-4 | 1024 x 1 (450ns) (LP) | 1.29 |
| 2102L-2 | 1024 x 1 (250ns) (LP) | 1.69 |
| 2111 | 256 x 4 (450ns) | 2.99 |
| 2112 | 256 x 4 (450ns) | 2.99 |
| 2114 | 1024 x 4 (450ns) | 8/14.95 |
| 2114L-4 | 1024 x 4 (450ns) (LP) | 8/15.25 |
| 2114L-3 | 1024 x 4 (300ns) (LP) | 8/15.45 |
| 2114L-2 | 1024 x 4 (200ns) (LP) | 8/15.95 |
| 2147 | 4096 x 1 (55ns) | 4.95 |
| TMS4044-4 | 4096 x 1 (450ns) | 3.49 |
| TMS4044-3 | 4096 x 1 (300ns) | 3.99 |
| TMS4044-2 | 4096 x 1 (200ns) | 4.49 |
| MK4118 | 1024 x 8 (250ns) | 9.95 |
| TMM2016-200 | 2048 x 8 (200ns) | 4.15 |
| TMM2016-150 | 2048 x 8 (150ns) | 4.95 |
| TMM2016-100 | 2048 x 8 (100ns) | 6.15 |
| HM6116-4 | 2048 x 8 (200ns) (cmos) | 4.95 |
| HM6116-3 | 2048 x 8 (150ns) (cmos) | 5.95 |
| HM6116-2 | 2048 x 8 (120ns) (cmos) | 8.95 |
| HM6116LP-4 | 2048 x 8 (200ns) (cmos)(LP) | 6.95 |
| HM6116LP-3 | 2048 x 8 (150ns) (cmos)(LP) | 8.95 |
| HM6116LP-2 | 2048 x 8 (120ns) (cmos)(LP) | 10.95 |
| Z-6132 | 4096 x 8 (300ns) (Qstat) | 34.95 |

LP = Low Power    Qstat = Quasi-Static

## DYNAMIC RAMS

| | | |
|---|---|---|
| TMS4027 | 4096 x 1 (250ns) | 1.99 |
| UPD411 | 4096 x 1 (300ns) | 3.00 |
| MM5280 | 4096 x 1 (300ns) | 3.00 |
| MK4108 | 8192 x 1 (200ns) | 1.95 |
| MM5298 | 8192 x 1 (250ns) | 1.85 |
| 4116-300 | 16384 x 1 (300ns) | 8/11.75 |
| 4116-250 | 16384 x 1 (250ns) | 8/11.95 |
| 4116-200 | 16384 x 1 (200ns) | 8/13.95 |
| 4116-150 | 16384 x 1 (150ns) | 8/15.95 |
| 4116-120 | 16384 x 1 (120ns) | 8/29.95 |
| 2118 | 16384 x 1 (150ns) (5v) | 4.95 |
| 4164-200 | 65536 x 1 (200ns) (5v) | 6.25 |
| 4164-150 | 65536 x 1 (150ns) (5v) | 7.25 |

5V = single 5 volt supply

## EPROMS

| | | |
|---|---|---|
| 1702 | 256 x 8 (1us) | 4.50 |
| 2708 | 1024 x 8 (450ns) | 3.95 |
| 2758 | 1024 x 8 (450ns)(5v) | 5.95 |
| 2716 | 2048 x 8 (450ns)(5v) | 3.95 |
| 2716-1 | 2048 x 8 (350ns)(5v) | 6.25 |
| TMS2516 | 2048 x 8 (450ns)(5v) | 5.50 |
| TMS2716 | 2048 x 8 (450ns) | 7.95 |
| TMS2532 | 4096 x 8 (450ns)(5v) | 7.95 |
| 2732 | 4096 x 8 (450ns)(5v) | 4.95 |
| 2732-250 | 4096 x 8 (250ns)(5v) | 12.95 |
| 2732-200 | 4096 x 8 (200ns)(5v) | 16.95 |
| 2764 | 8192 x 8 (450ns)(5v) | 16.95 |
| 2764-250 | 8192 x 8 (250ns)(5v) | 18.95 |
| 2764-200 | 8192 x 8 (200ns)(5v) | 24.95 |
| TMS2564 | 8192 x 8 (450ns)(5v) | 24.95 |
| MC68764 | 8192 x 8 (450ns)(5v)(24 pin) | 39.95 |

5v = Single 5 Volt Supply

## EPROM ERASERS

| | Timer | Capacity Chip | Intensity (uW/Cm²) | |
|---|---|---|---|---|
| PE-14 | | 6 | 5,200 | 83.00 |
| PE-14T | X | 6 | 5,200 | 119.00 |
| PE-24T | X | 9 | 6,700 | 175.00 |
| PL-265T | X | 20 | 6,700 | 255.00 |
| PR-125T | X | 16 | 15,000 | 349.00 |
| PR-320 | X | 32 | 15,000 | 595.00 |

## DISC CONTROLLERS

| | |
|---|---|
| 1771 | 16.95 |
| 1791 | 29.95 |
| 1793 | 38.95 |
| 1795 | 54.95 |
| 1797 | 54.95 |
| 6843 | 34.95 |
| 8272 | 39.95 |
| UPD765 | 39.95 |
| 1691 | 18.95 |
| 2143 | 18.95 |

## INTERFACE

| | |
|---|---|
| 8T26 | 1.69 |
| 8T28 | 2.49 |
| 8T95 | .99 |
| 8T96 | .99 |
| 8T97 | .99 |
| 8T98 | .99 |
| DM8131 | 2.95 |
| DP8304 | 2.29 |
| DS8835 | 1.99 |
| DS8836 | .99 |

## MISC.

| | |
|---|---|
| 3242 | 7.95 |
| 3341 | 4.95 |
| MC3470 | 4.95 |
| MC3480 | 9.00 |
| 11C90 | 13.95 |
| 95H90 | 7.95 |
| 2513-001 UP | 9.95 |
| 2513-002 LOW | 9.95 |

## SOUND CHIPS

| | |
|---|---|
| 76477 | 3.95 |
| 76489 | 8.95 |
| AY3-8910 | 12.95 |
| MC3340 | 1.49 |

## CRT CONTROLLERS

| | |
|---|---|
| 6845 | 14.95 |
| 68B45 | 35.95 |
| HD46505SP | 15.95 |
| 6847 | 12.25 |
| MC1372 | 6.95 |
| 68047 | 24.95 |
| 8275 | 29.95 |
| 7220 | 99.95 |
| CRT5027 | 39.95 |
| CRT5037 | 49.95 |
| TMS9918A | 39.95 |
| DP8350 | 49.95 |

## BIT-RATE GENERATORS

| | |
|---|---|
| MC14411 | 11.95 |
| BR1941 | 11.95 |
| 4702 | 12.95 |
| COM5016 | 16.95 |
| COM8116 | 10.95 |
| MM5307 | 10.95 |

## UARTS

| | |
|---|---|
| AY3-1014 | 6.95 |
| AY5-1013 | 3.95 |
| AY3-1015 | 6.95 |
| PT1472 | 9.95 |
| TR1602 | 3.95 |
| 2350 | 9.95 |
| 2651 | 8.95 |
| TMS6011 | 5.95 |
| IM6402 | 7.95 |
| IM6403 | 8.95 |
| INS8250 | 14.95 |

## KEYBOARD CHIPS

| | |
|---|---|
| AY5-2376 | 11.95 |
| AY5-3600 | 11.95 |

## CLOCK CIRCUITS

| | |
|---|---|
| MM5314 | 4.95 |
| MM5369 | 3.95 |
| MM5375 | 4.95 |
| MM58167 | 8.95 |
| MM58174 | 11.95 |
| MSM5832 | 6.95 |

## Z-80

**2.5 Mhz**

| | |
|---|---|
| Z80-CPU | 3.95 |
| Z80-CTC | 5.95 |
| Z80-DART | 15.25 |
| Z80-DMA | 17.50 |
| Z80-PIO | 5.75 |
| Z80-SIO/0 | 18.50 |
| Z80-SIO/1 | 18.50 |
| Z80-SIO/2 | 18.50 |
| Z80-SIO/9 | 16.95 |

**4.0 Mhz**

| | |
|---|---|
| Z80A-CPU | 6.00 |
| Z80A-CTC | 8.65 |
| Z80A-DART | 18.75 |
| Z80A-DMA | 27.50 |
| Z80A-PIO | 6.00 |
| Z80A-SIO/0 | 22.50 |
| Z80A-SIO/1 | 22.50 |
| Z80A-SIO/2 | 22.50 |
| Z80A-SIO/9 | 19.95 |

**6.0 Mhz**

| | |
|---|---|
| Z80B-CPU | 17.95 |
| Z80B-CTC | 15.50 |
| Z80B-PIO | 15.50 |

## ZILOG

| | |
|---|---|
| Z6132 | 34.95 |
| Z8671 | 39.95 |

## CRYSTALS

| | |
|---|---|
| 32.768 khz | 1.95 |
| 1.0 mhz | 4.95 |
| 1.8432 | 4.95 |
| 2.0 | 3.95 |
| 2.097152 | 3.95 |
| 2.4576 | 3.95 |
| 3.2768 | 3.95 |
| 3.579535 | 3.95 |
| 4.0 | 3.95 |
| 5.0 | 3.95 |
| 5.0688 | 3.95 |
| 5.185 | 3.95 |
| 5.7143 | 3.95 |
| 6.0 | 3.95 |
| 6.144 | 3.95 |
| 6.5536 | 3.95 |
| 8.0 | 3.95 |
| 10.738635 | 3.95 |
| 14.31818 | 3.95 |
| 15.0 | 3.95 |
| 16.0 | 3.95 |
| 17.430 | 3.95 |
| 18.0 | 3.95 |
| 18.432 | 3.95 |
| 20.0 | 3.95 |
| 22.1184 | 3.95 |
| 32.0 | 3.95 |

## DATA ACQUISITION

| | |
|---|---|
| ADC0800 | 15.55 |
| ADC0804 | 3.49 |
| ADC0809 | 4.49 |
| ADC0817 | 9.95 |
| DAC0800 | 4.95 |
| DAC0806 | 1.95 |
| DAC0808 | 2.95 |
| DAC1020 | 8.25 |
| DAC1022 | 5.95 |
| MC1408L6 | 1.95 |
| MC1408L8 | 2.95 |

## 8000

| | |
|---|---|
| 8035 | 5.95 |
| 8039 | 6.95 |
| INS-8060 | 17.95 |
| INS-8073 | 24.95 |
| 8080 | 3.95 |
| 8085 | 5.95 |
| 8085A-2 | 11.95 |
| 8086 | 29.95 |
| 8087 | CALL |
| 8088 | 39.95 |
| 8089 | 89.95 |
| 8155 | 7.95 |
| 8156 | 8.95 |
| 8185 | 29.95 |
| 8185-2 | 39.95 |
| 8741 | 39.95 |
| 8748 | 29.95 |
| 8755 | 32.00 |

## 8200

| | |
|---|---|
| 8202 | 29.95 |
| 8203 | 39.95 |
| 8205 | 3.50 |
| 8212 | 1.80 |
| 8214 | 3.85 |
| 8216 | 1.75 |
| 8224 | 2.25 |
| 8226 | 1.80 |
| 8228 | 3.49 |
| 8237 | 19.95 |
| 8238 | 4.49 |
| 8243 | 4.45 |
| 8250 | 10.95 |
| 8251 | 4.49 |
| 8253 | 6.95 |
| 8253-5 | 7.95 |
| 8255 | 4.49 |
| 8255-5 | 5.25 |
| 8257 | 7.95 |
| 8257-5 | 8.95 |
| 8259 | 6.90 |
| 8259-5 | 7.50 |
| 8271 | 39.95 |
| 8272 | 39.95 |
| 8275 | 29.95 |
| 8279 | 8.95 |
| 8279-5 | 10.00 |
| 8282 | 6.50 |
| 8283 | 6.50 |
| 8284 | 5.50 |
| 8286 | 6.50 |
| 8287 | 6.50 |
| 8288 | 25.00 |
| 8289 | 49.95 |

## FUNCTION GENERATORS

| | |
|---|---|
| MC4024 | 3.95 |
| LM566 | 1.49 |
| XR2206 | 3.75 |
| 8038 | 3.95 |

## INTERSIL

| | |
|---|---|
| ICL7103 | 9.50 |
| ICL7106 | 9.95 |
| ICL7107 | 12.95 |
| ICL7660 | 2.95 |
| ICL8038 | 3.95 |
| ICM7207A | 5.59 |
| ICM7208 | 15.95 |

## 6800

| | |
|---|---|
| 68000 | 59.95 |
| 6800 | 4.95 |
| 6802 | 7.95 |
| 6808 | 13.90 |
| 6809E | 19.95 |
| 6809 | 12.95 |
| 6810 | 2.95 |
| 6820 | 4.95 |
| 6821 | 3.25 |
| 6828 | 14.95 |
| 6840 | 12.95 |
| 6843 | 34.95 |
| 6844 | 25.95 |
| 6845 | 14.95 |
| 6847 | 12.25 |
| 6850 | 3.45 |
| 6852 | 5.75 |
| 6860 | 9.95 |
| 6862 | 11.95 |
| 6875 | 6.95 |
| 6880 | 2.25 |
| 6883 | 24.95 |
| 68047 | 24.95 |
| 68488 | 19.95 |

6800 = 1MHZ

| | |
|---|---|
| 68B00 | 10.95 |
| 68B02 | 22.25 |
| 68B09E | 29.95 |
| 68B09 | 29.95 |
| 68B10 | 7.95 |
| 68B21 | 12.95 |
| 68B45 | 35.95 |
| 68B50 | 12.95 |

68B00 = 2 MHZ

## 6500

**1 MHZ**

| | |
|---|---|
| 6502 | 5.95 |
| 6504 | 6.95 |
| 6505 | 8.95 |
| 6507 | 9.95 |
| 6520 | 4.35 |
| 6522 | 8.75 |
| 6532 | 11.25 |
| 6545 | 22.50 |
| 6551 | 11.85 |

**2 MHZ**

| | |
|---|---|
| 6502A | 9.95 |
| 6522A | 11.70 |
| 6532A | 12.40 |
| 6545A | 23.50 |
| 6551A | 12.95 |

**3 MHZ**

| | |
|---|---|
| 6502B | 14.95 |

## EXAR

| | |
|---|---|
| XR 2206 | 3.75 |
| XR 2207 | 3.85 |
| XR 2208 | 3.90 |
| XR 2211 | 5.25 |
| XR 2240 | 3.25 |

## 9000 SERIES

| | |
|---|---|
| 9316 | 1.00 |
| 9334 | 2.50 |
| 9368 | 3.95 |
| 9401 | 9.95 |
| 9601 | .75 |
| 9602 | 1.50 |
| 96S02 | 1.95 |

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| 74LS02 | .25 | 74LS91 | .89 | 74LS173 | .69 | 74LS352 | 1.29 |
| 74LS03 | .25 | 74LS92 | .55 | 74LS174 | .55 | 74LS353 | 1.29 |
| 74LS04 | .24 | 74LS93 | .55 | 74LS175 | .55 | 74LS363 | 1.35 |
| 74LS05 | .25 | 74LS95 | .75 | 74LS181 | 2.15 | 74LS364 | 1.95 |
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| 74LS10 | .25 | 74LS109 | .39 | 74LS191 | .89 | 74LS367 | .45 |
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| 74LS12 | .35 | 74LS113 | .39 | 74LS193 | .79 | 74LS373 | .99 |
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| 74LS14 | .59 | 74LS122 | .45 | 74LS195 | .69 | 74LS377 | 1.39 |
| 74LS15 | .35 | 74LS123 | .79 | 74LS196 | .79 | 74LS378 | 1.18 |
| 74LS20 | .25 | 74LS124 | 2.90 | 74LS197 | .79 | 74LS379 | 1.35 |
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| 74LS51 | .25 | 74LS156 | .69 | 74LS260 | .59 | 74LS683 | 3.20 |
| 74LS54 | .29 | 74LS157 | .65 | 74LS266 | .55 | 74LS684 | 3.20 |
| 74LS55 | .29 | 74LS158 | .59 | 74LS273 | 1.49 | 74LS685 | 3.20 |
| 74LS63 | 1.25 | 74LS160 | .69 | 74LS275 | 3.35 | 74LS688 | 2.40 |
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| 74LS76 | .39 | 74LS164 | .69 | 74LS290 | .89 | 81LS96 | 1.49 |
| 74LS78 | .49 | 74LS165 | .95 | 74LS293 | .89 | 81LS97 | 1.49 |
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| 74LS85 | .69 | 74LS168 | 1.75 | 74LS298 | .89 | 25LS2521 | 2.80 |
| | | | | 74LS299 | 1.75 | 25LS2569 | 4.25 |

## IC SOCKETS

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| 14 pin ST | .15 | .12 |
| 16 pin ST | .17 | .13 |
| 18 pin ST | .20 | .18 |
| 20 pin ST | .29 | .27 |
| 22 pin ST | .30 | .27 |
| 24 pin ST | .30 | .27 |
| 28 pin ST | .40 | .32 |
| 40 pin ST | .49 | .39 |
| 64 pin ST | 4.25 | call |
| ST = SOLDERTAIL | | |
| 8 pin WW | .59 | .49 |
| 14 pin WW | .69 | .52 |
| 16 pin WW | .69 | .58 |
| 18 pin WW | .99 | .90 |
| 20 pin WW | 1.09 | .98 |
| 22 pin WW | 1.39 | 1.28 |
| 24 pin WW | 1.49 | 1.35 |
| 28 pin WW | 1.69 | 1.49 |
| 40 pin WW | 1.99 | 1.80 |
| WW = WIREWRAP | | |
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| S-100 ST | 3.95 |
| S-100 WW | 4.95 |

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| 5 POSITION | .90 |
| 6 POSITION | .90 |
| 7 POSITION | .95 |
| 8 POSITION | .95 |

## 7400

| | | | |
|---|---|---|---|
| 7400 | .19 | 74132 | .45 |
| 7401 | .19 | 74136 | .50 |
| 7402 | .19 | 74141 | .65 |
| 7403 | .19 | 74142 | 2.95 |
| 7404 | .19 | 74143 | 2.95 |
| 7405 | .25 | 74145 | .60 |
| 7406 | .29 | 74147 | 1.75 |
| 7407 | .29 | 74148 | 1.20 |
| 7408 | .24 | 74150 | 1.35 |
| 7409 | .19 | 74151 | .55 |
| 7410 | .19 | 74152 | .65 |
| 7411 | .25 | 74153 | .55 |
| 7412 | .30 | 74154 | 1.25 |
| 7413 | .35 | 74155 | .75 |
| 7414 | .49 | 74156 | .65 |
| 7416 | .25 | 74157 | .55 |
| 7417 | .25 | 74159 | 1.65 |
| 7420 | .19 | 74160 | .85 |
| 7421 | .35 | 74161 | .69 |
| 7422 | .35 | 74162 | .85 |
| 7423 | .29 | 74163 | .69 |
| 7425 | .29 | 74164 | .85 |
| 7426 | .29 | 74165 | .85 |
| 7427 | .29 | 74166 | 1.00 |
| 7428 | .45 | 74167 | 2.95 |
| 7430 | .19 | 74170 | 1.65 |
| 7432 | .29 | 74172 | 5.95 |
| 7433 | .45 | 74173 | .75 |
| 7437 | .29 | 74174 | .89 |
| 7438 | .29 | 74175 | .89 |
| 7440 | .19 | 74176 | .89 |
| 7442 | .49 | 74177 | .75 |
| 7443 | .65 | 74178 | 1.15 |
| 7444 | .69 | 74179 | 1.75 |
| 7445 | .69 | 74180 | .75 |
| 7446 | .69 | 74181 | 2.25 |
| 7447 | .69 | 74182 | .75 |
| 7448 | .69 | 74184 | 2.00 |
| 7450 | .19 | 74185 | 2.00 |
| 7451 | .23 | 74186 | 18.50 |
| 7453 | .23 | 74190 | 1.15 |
| 7454 | .23 | 74191 | 1.15 |
| 7460 | .23 | 74192 | .79 |
| 7470 | .35 | 74193 | .79 |
| 7472 | .29 | 74194 | .85 |
| 7473 | .34 | 74195 | .85 |
| 7474 | .33 | 74196 | .79 |
| 7475 | .45 | 74197 | .75 |
| 7476 | .35 | 74198 | 1.35 |
| 7480 | .59 | 74199 | 1.35 |
| 7481 | 1.10 | 74221 | 1.35 |
| 7482 | .95 | 74246 | 1.35 |
| 7483 | .50 | 74247 | 1.25 |
| 7485 | .59 | 74248 | 1.85 |
| 7486 | .35 | 74249 | 1.95 |
| 7489 | 2.15 | 74251 | .75 |
| 7490 | .35 | 74259 | 2.25 |
| 7491 | .40 | 74265 | 1.35 |
| 7492 | .50 | 74273 | 1.95 |
| 7493 | .35 | 74276 | 1.25 |
| 7494 | .65 | 74279 | .75 |
| 7495 | .55 | 74283 | 2.00 |
| 7496 | .70 | 74284 | 3.75 |
| 7497 | 2.75 | 74285 | 3.75 |
| 74100 | 1.75 | 74290 | .95 |
| 74107 | .30 | 74293 | .75 |
| 74109 | .45 | 74298 | .85 |
| 74110 | .45 | 74351 | 2.25 |
| 74111 | .55 | 74365 | .65 |
| 74116 | 1.55 | 74366 | .65 |
| 74120 | 1.20 | 74367 | .65 |
| 74121 | .29 | 74368 | .65 |
| 74122 | .45 | 74376 | 2.20 |
| 74123 | .49 | 74390 | 1.75 |
| 74125 | .45 | 74393 | 1.35 |
| 74126 | .45 | 74425 | 3.15 |
| 74128 | .55 | 74426 | .85 |
| | | 74490 | 2.55 |

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| | | | |
|---|---|---|---|
| 4000 | .29 | 4527 | 1.95 |
| 4001 | .25 | 4528 | 1.19 |
| 4002 | .25 | 4531 | .95 |
| 4006 | .89 | 4532 | 1.95 |
| 4007 | .29 | 4538 | 1.95 |
| 4008 | .95 | 4539 | 1.95 |
| 4009 | .39 | 4541 | 2.64 |
| 4010 | .45 | 4543 | 1.19 |
| 4011 | .25 | 4553 | 5.79 |
| 4012 | .25 | 4555 | .95 |
| 4013 | .38 | 4556 | .95 |
| 4014 | .79 | 4581 | 1.95 |
| 4015 | .39 | 4582 | 1.95 |
| 4016 | .39 | 4584 | .75 |
| 4017 | .69 | 4585 | .75 |
| 4018 | .79 | 4702 | 12.95 |
| 4019 | .39 | 74C00 | .35 |
| 4020 | .75 | 74C02 | .35 |
| 4021 | .79 | 74C04 | .35 |
| 4022 | .79 | 74C08 | .35 |
| 4023 | .29 | 74C10 | .35 |
| 4024 | .65 | 74C14 | .59 |
| 4025 | .29 | 74C20 | .35 |
| 4026 | 1.65 | 74C30 | .35 |
| 4027 | .45 | 74C32 | .39 |
| 4028 | .69 | 74C42 | 1.29 |
| 4029 | .79 | 74C48 | 1.99 |
| 4030 | .39 | 74C73 | .65 |
| 4034 | 1.95 | 74C74 | .65 |
| 4035 | .85 | 74C76 | .80 |
| 4040 | .75 | 74C83 | 1.95 |
| 4041 | .75 | 74C85 | 1.95 |
| 4042 | .69 | 74C86 | .39 |
| 4043 | .85 | 74C89 | 4.50 |
| 4044 | .79 | 74C90 | 1.19 |
| 4046 | .85 | 74C93 | 1.75 |
| 4047 | .95 | 74C95 | .99 |
| 4049 | .35 | 74C107 | .89 |
| 4050 | .35 | 74C150 | 5.75 |
| 4051 | .79 | 74C151 | 2.25 |
| 4053 | .79 | 74C154 | 3.25 |
| 4060 | .89 | 74C157 | 1.75 |
| 4066 | .39 | 74C160 | 1.19 |
| 4068 | .39 | 74C161 | 1.19 |
| 4069 | .29 | 74C162 | 1.19 |
| 4070 | .35 | 74C163 | 1.19 |
| 4071 | .29 | 74C164 | 1.39 |
| 4072 | .29 | 74C165 | 2.00 |
| 4073 | .29 | 74C173 | .79 |
| 4075 | .29 | 74C174 | 1.19 |
| 4076 | .79 | 74C175 | 1.19 |
| 4078 | .29 | 74C192 | 1.49 |
| 4081 | .29 | 74C193 | 1.49 |
| 4082 | .29 | 74C195 | 1.39 |
| 4085 | .95 | 74C200 | 5.75 |
| 4086 | .95 | 74C221 | 1.75 |
| 4093 | .49 | 74C373 | 2.45 |
| 4098 | 2.49 | 74C374 | 2.45 |
| 4099 | 1.95 | 74C901 | .39 |
| 14409 | 12.95 | 74C902 | .85 |
| 14410 | 12.95 | 74C903 | .85 |
| 14411 | 11.95 | 74C905 | 10.95 |
| 14412 | 12.95 | 74C906 | .95 |
| 14419 | 7.95 | 74C907 | 1.00 |
| 14433 | 4.18 | 74C908 | 2.00 |
| 4502 | .95 | 74C909 | 2.75 |
| 4503 | .65 | 74C911 | 8.95 |
| 4508 | 1.95 | 74C912 | 8.95 |
| 4510 | .85 | 74C914 | 1.95 |
| 4511 | .85 | 74C915 | 1.19 |
| 4512 | .85 | 74C918 | 2.75 |
| 4514 | 1.25 | 74C920 | 17.95 |
| 4515 | 1.79 | 74C921 | 15.95 |
| 4516 | 1.55 | 74C922 | 4.49 |
| 4518 | .89 | 74C923 | 4.95 |
| 4519 | .39 | 74C925 | 5.95 |
| 4520 | .79 | 74C926 | 7.95 |
| 4522 | 1.25 | 74C928 | 7.95 |
| 4526 | 1.25 | 74C929 | 19.95 |

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|---|---|---|---|
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| 74S02 | .35 | 74S168 | 3.95 |
| 74S03 | .35 | 74S169 | 3.95 |
| 74S04 | .35 | 74S174 | .95 |
| 74S05 | .35 | 74S175 | .95 |
| 74S08 | .35 | 74S181 | 3.95 |
| 74S09 | .40 | 74S182 | 2.95 |
| 74S10 | .35 | 74S188 | 1.95 |
| 74S11 | .35 | 74S189 | 6.95 |
| 74S15 | .35 | 74S194 | 1.49 |
| 74S20 | .35 | 74S195 | 1.49 |
| 74S22 | .35 | 74S196 | 1.49 |
| 74S30 | .35 | 74S197 | 1.49 |
| 74S32 | .40 | 74S201 | 6.95 |
| 74S37 | .88 | 74S225 | 7.95 |
| 74S38 | .85 | 74S240 | 2.20 |
| 74S40 | .35 | 74S241 | 2.20 |
| 74S51 | .35 | 74S244 | 2.20 |
| 74S64 | .40 | 74S251 | .95 |
| 74S65 | .40 | 74S253 | .95 |
| 74S74 | .50 | 74S257 | .95 |
| 74S85 | 1.99 | 74S258 | .95 |
| 74S86 | .50 | 74S260 | .79 |
| 74S112 | .50 | 74S274 | 19.95 |
| 74S113 | .50 | 74S275 | 19.95 |
| 74S114 | .55 | 74S280 | 1.95 |
| 74S124 | 2.75 | 74S287 | 1.90 |
| 74S132 | 1.24 | 74S288 | 1.90 |
| 74S133 | .45 | 74S289 | 6.89 |
| 74S134 | .50 | 74S301 | 6.95 |
| 74S135 | .89 | 74S373 | 2.45 |
| 74S138 | .85 | 74S374 | 2.45 |
| 74S139 | .85 | 74S381 | 7.95 |
| 74S140 | .55 | 74S387 | 1.95 |
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