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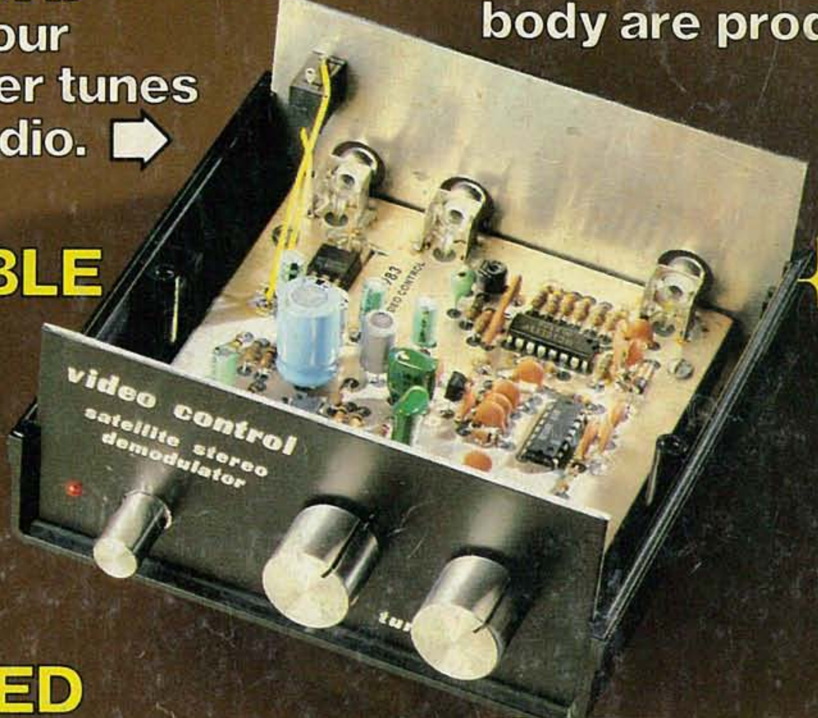

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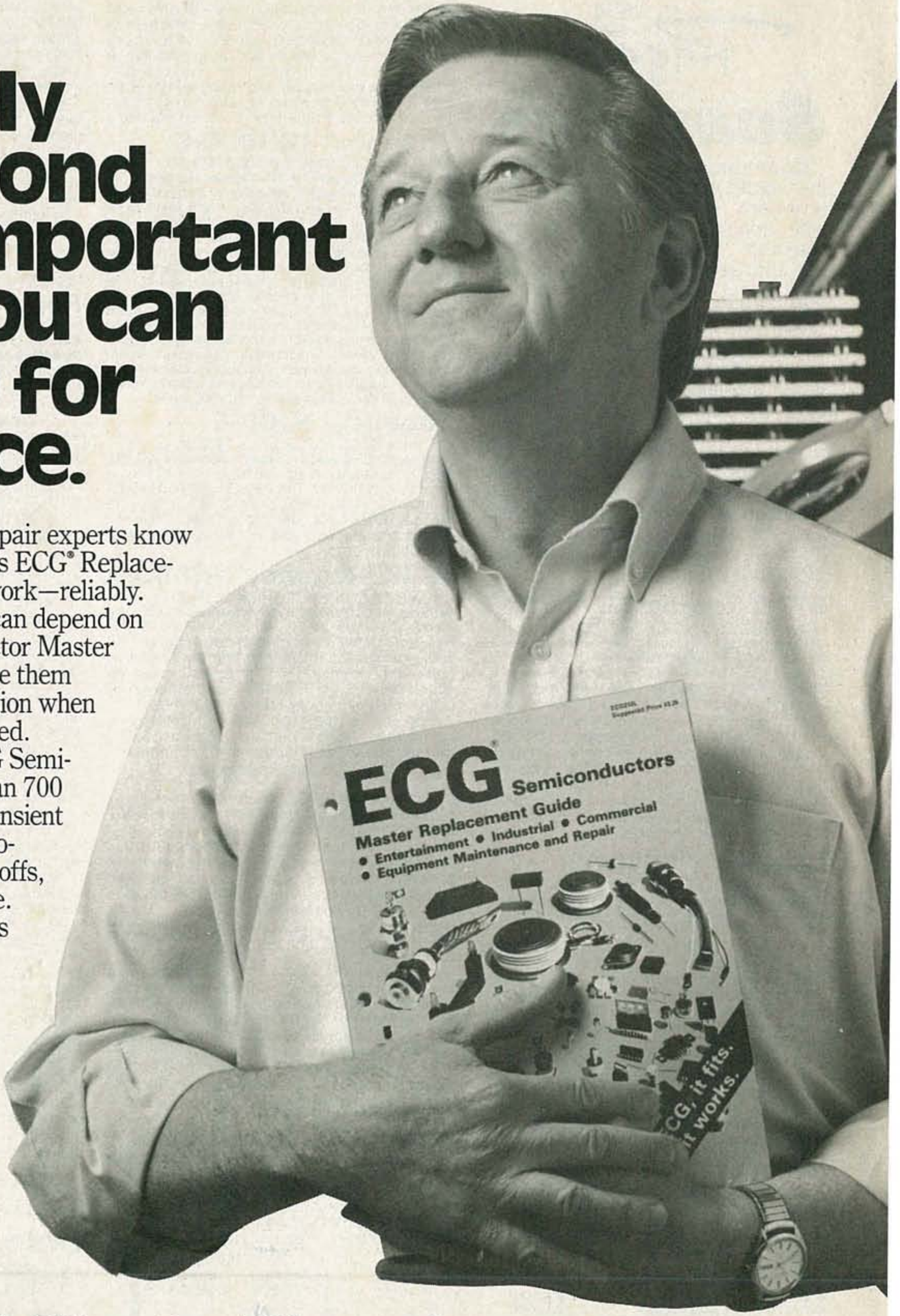

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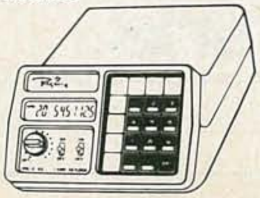

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OCTOBER 84

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Vol. 55 No. 10

COVER 1

Even though much of the programming transmitted from satellites contains stereo audio, if you don't have a stereo demodulator, you won't hear it in stereo. Unfortunately the price of add-on stereo demodulators—often hundreds of dollars—can certainly rob you of the pleasure you'd otherwise gain from stereo reception.

The stereo demodulator that we'll show you how to build costs less than $80. You can use it to listen to the stereo audio that is transmitted along with video signals. And you can use it to listen to the many audio-only programs. Either way, you don't have to wait for terrestrial TV to start stereo programming. If you have a TVRO, you can listen in stereo NOW. The story begins on page 51.

NEXT MONTH

ON SALE OCTOBER 23

COLOR-DISPLAY TECHNOLOGY
New technology will make it possible to offer color displays in many applications.

INTERFACING THE ZX81
Part 4 (which did not run this month due to space restrictions) shows how you can control a speech synthesizer with the ZX81 or Timex Sinclair 1000.

SHORTWAVE BROADCASTING CONFERENCE
A look at the Geneva Shortwave Broadcasting Conference (WARC-HFBC) and what it means to you.

AND LOTS MORE!

Cover photo by Robert Lewis

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EDITORIAL

ART KLEIMAN

Satellite TV Reception—Present and Future

This is the second time this year we're presenting a special section on Satellite TV. In July, we presented the basics. This month, you will find a comprehensive buyers quide. Why are we putting forth so much effort to present Satellite TV to our readers?

It has been almost 5 years since we first presented our *Backyard Satellite TV Receiver* series by Bob Cooper. Back then, the Satellite-TV industry was in the embryo stage. Few manufactured systems existed. The majority of home satellite systems were assembled and erected by electronics enthusiasts like yourself. Information was rare and difficult to come by. Equipment and parts were hard to find—and quite expensive when you did find them. Dish antennas were large; most people were very lucky if they could get away with using a 6-foot dish. Performance from component to component varied drastically. Aligning the various components, such as a satellite-TV receiver, was genuinely a nightmare come true.

Today, the Satellite-TV industry is in its infancy. Manufactured equipment, albeit still expensive (although much cheaper by yesterday's standards), is plentiful. For $1000-$1500, you can own your own Satellite-TV system, including antenna, receiver, LNA, and feedhorn. For the additional cost of installation, you can own this system without the headache of setting it up. And you can be confident that the reception will be fairly decent. That's a big step forward in five years!

The Satellite-TV industry will grow into adulthood rapidly. Within the next year or two, you will see tremendous reductions in price and an increase in performance. Several factors will be responsible for those changes: First, semiconductor manufacturers are realizing the market potential of this industry. As a result, right now they are spending large sums on R&D to produce custom IC's. They have already successfully produced a complete monolithic LNA. And they are hard at work applying this same technology to receiver design. When production lines are geared up to produce those IC's, prices will drop drastically. The IC's will obsolete the necessity for equipment alignment. Also, performance variations from component to component will be non-existent. The elimination of alignment procedures and performance variations, coupled with the newer, more powerful, satellites that have been recently launched, will result in smaller antennas. Where 6-foot dishes were once required, 4-foot dishes will provide acceptable pictures.

While this effort to produce custom IC's is going on, Japan is gearing up to produce large quantities of equipment. Within the next year or two, we will see a flood—no, a tidal wave—of imported satellite receivers and LNA's reach the market. This will exert a tremendous downward pressure on equipment prices. Within the next year or two, the price of a complete Satellite-TV system, including receiver, LNA, feedhorn, and 4-foot dish, will be in the $300–$400 range. With this in mind, why would a consumer consider the purchase of a DBS system? Especially when the projected cost for a DBS system is in the same price range and channel selection will be limited.

The Satellite TV industry is growing up. And in the years to come, you can bet that **Radio-Electronics** will be there covering the developments and presenting them to you, our readers.

Art Kleiman

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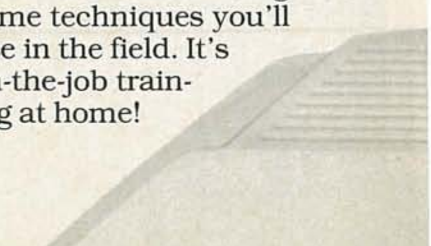


WHAT'S NEWS

"Out-of-this-world" technicians honored

Mission Specialists George D. Nelson and James D. van Hoften have been honored by the International Society of Certified Electronics Technicians (ISCET) with the title of Honorary Certified Electronics Technician. They are cited for outstanding technical achievements in space during the period of April 8-12, 1984, when the *Solar Max* satellite was serviced and returned to operation.

The association of professionally certified technicians honored the two astronauts for exemplifying the highest ideal of the electronics service industry by:

1. Preparing for the maintenance of high-technology electronic equipment through study, training, and retraining.
2. Personal dedication to restoring faulty equipment to a standard of performance and reliability that matches or exceeds the original.
3. Performing technically precise electronics service in the hostile environment of space.
4. Using state-of-the-art technology testing and service equipment to perform quality service.
5. Demonstrating that adequate preparation for service is essential in successful repairs.

The ISCET Board of Governors, at a special meeting, recognized the achievement of those two astronauts, working outside the space shuttle *Challenger* where the 5,000-pound *Solar Max* was berthed. Nelson and van Hoften used power tools designed for weighless conditions to change and repair electronics instruments. This restored the satellite to operational health for the first time in three years and added years to its useful lifetime.

In congratulating the two astronauts, ISCET Chairman, John Krier CET, of Wichita, KS, cited the extremely difficult and delicate work required to repair the electronics box for the Coronagraph-Polarimeter, an instrument that was not designed to be repaired in space.

Nelson, a Ph.D. in Astronomy, and van Hoften, a Ph.D. in Hydraulic Engineering, both trained for product servicing in space in special water tanks at the Lyndon B. Johnson Space Center in Houston, TX, and the George Marshall Space Flight Center in Huntsville, AL.

New solid-state switch turns on in 1 microsecond

A new high-power switch, developed for radar transmitters, is 50 to 100 times as fast as comparable devices. Developed by Westinghouse Electric Corp's semiconductor division, the T62R is a two-terminal, four-layer reverse blocking thyristor. Its switching transition is so rapid that the device conducts a pulse current of up to 2500 amperes within one microsecond of turn-on.

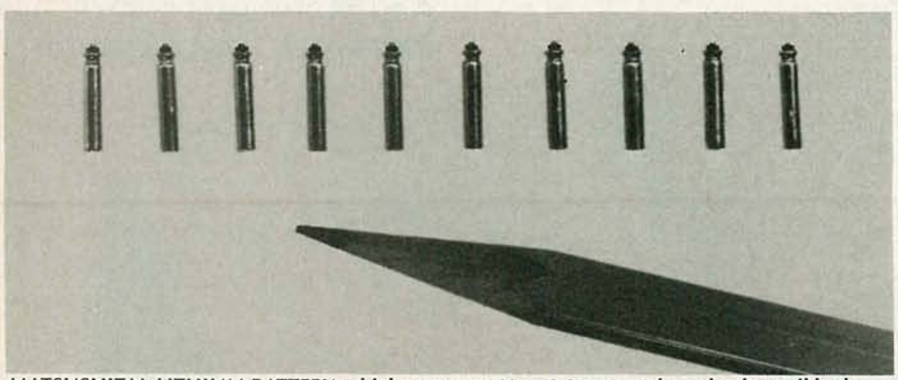
The rapid transition is attained by using a high, fast-rising triggering voltage. That voltage produces a displacement current over the entire junction, activating all areas of the cathode emitter simultaneously. The required trigger impulse can be produced by capacitive discharge through a step-up transformer. **R-E**

NEW LITHIUM BATTERY

Matsushita Electric Co., of Osaka, Japan, has started mass production of the world's smallest pin-type lithium battery, 11 mm long and 2.2 mm wide (0.43 × .087 inch). The new 3-volt battery will have its first use in ultra-small fishing floats with light-emitting diodes (LED's) for night fishing. The unit price in Japan is 200 yen (a little less than one U.S. dollar).

The cathode material is polycarbon monofluoride and the anode, lithium. To mass-produce the battery, Matsushita has to decrease dimension tolerances to one-tenth that of previous models. The 3-volt output is twice that of silver-oxide or mercury batteries.

Expected uses are in wrist watches, calculators, microphones, and hearing aids.



MATSUSHITA's LITHIUM BATTERY, which measures 11 × 2.2 mm, makes a lead pencil look large.

VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **RCA's Audio-Video System.** RCA,which discontinued sale of audio products a decade ago, is coming back to sound, adding high-end audio to its high-end video in a unique system called *Dimensia*, which RCA describes as "intelligent audio-video." The heart of *Dimensia* is a new 26-inch color monitor-receiver, rack-mounted with other audio and video components, which can include a VCR, AM-FM tuner, record turntable, audio cassette-recorder, and a CD player.

The various components are designed to be connected one to the other—in series—with special connection cables. The complete system is integrated so that everything can be operated by means of one 52-button handheld infrared remote-control unit. For example, without leaving his easy chair, the user can command the audio cassette recorder to tape bands two and four from the compact-disc player, while the VCR is showing a movie. The programming is done with the aid of on-screen prompts on the TV monitor, which then confirms the commands to avoid mistakes.

The on-screen prompts include such key words as TIME, PLAY, RECORD, STOP, FAST, REPEAT, PAUSE, BAND, PAGE, AUDIO A and AUDIO B, SEEK, SLOW, MEMORY, CLEAR, SCAN, STATUS, ANTENNA, MUTE, VOLUME, TRACK, and PREVIOUS CHANNEL. Components may be purchased all at once or a few at a time and carry the RCA brand name but are made to RCA's specifications by Hitachi, which also manufactures RCA's VCR's.

• **Sanyo Enters 8mm.** A third company announced its entry into the American market with a VCR designed around the new 8mm video format. While the first two—Eastman Kodak and Polaroid—are photography firms making their debuts in home video with combination camera-recorders, or camcorders, the third is an old-line home-video firm.

The company is Sanyo, and its VCR is a deck without built-in camera, weighing just 2.4 pounds, which makes it the lightest VCR announced so far. Sanyo is expected to start selling the new deck here at a suggested list price of about $1,500 in the fourth quarter of this year. The companion to the new deck is a unique video camera that looks like a 35mm still camera and accepts standard 35mm lenses.

Sanyo, which was the first company to produce both Beta and VHS-format VCR's, now is the first to offer all three VCR formats. The company's subsidiary, Tokyo Sanyo, makes VHS recorders that are sold in the United States under Sanyo's Fisher brand name. Sanyo also is expected to be the first brand to offer camcorders in two different formats—the *Betamovie* under the Sanyo brand, and the VHS *VideoMovie* under the Fisher name.

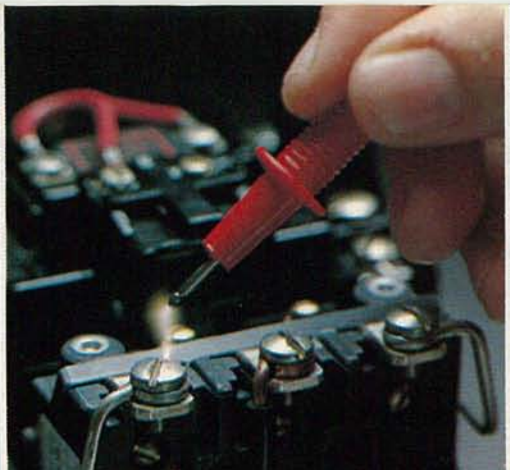
Meanwhile, it was announced in Japan that Pioneer would enter the 8mm video field with a model of its own manufacture, which would be sold on the Japanese market, but for which the company has no export plans. It will be the first VCR to be made by Pioneer, which offers a Sony-produced Beta Hi-Fi recorder under its own name on the Japanese market.

Sony, meanwhile, announced it would manufacture 8mm videotape cassettes in Japan, but has detailed no plans on 8mm VCR hardware.

• **CBS Discontinues Videodiscs.** Three months after RCA announced it was discontinuing production of CED videodisc players (**Radio-Electronics**, July 1984), CBS said it was ending production of discs for the system. CBS had been the only source other than RCA for pressing of the capacitive discs and originally had planned to continue disc output, but noted that its volume declined sharply after RCA's announcement. RCA said it planned to continue producing the discs for at least three years and longer if the demand warrants. RCA and the movie studios continue to announce new releases in the CED format.

After the closeout of CED players here, the only videodisc players on sale in the United States will be in the Laservision format, under the brand names of Pioneer, Magnavox, and Sylvania. The VHD format, developed by JVC, is on sale in Japan by most video manufacturers there, but it has not been introduced in any other countries. **R-E**

Drop-proof



Overload-proof

Contamination-proof

Oops proof.

Now there's a new breed of Beckman Industrial Corporation hand-held DMMs tough enough to withstand accidental drops, input overloads and destructive environments.

The new HD100 and HD110 DMMs are drop-proof, packed with overload protection and sealed against contamination. You won't find a more rugged meter than our HDs.

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All DC voltage inputs are protected up to 1500 Vdc or 1000 Vrms. Current ranges are protected to 2A/600V with resistance ranges protected to 600 Vdc. Transient protection extends up to 6KV for 10 microseconds.

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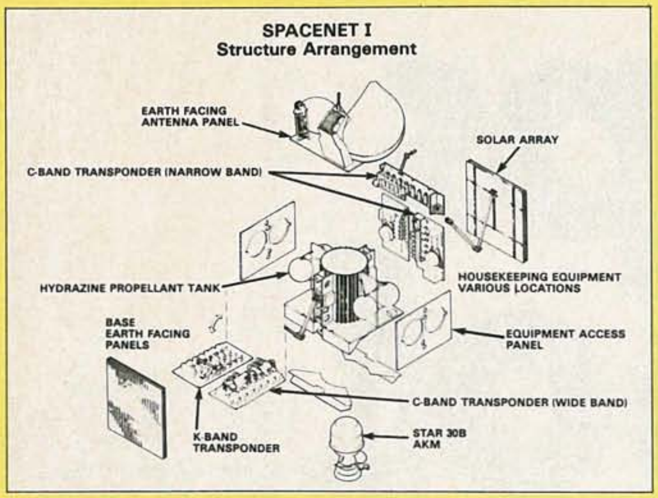
SATELLITE/TELETEXT NEWS

GARY ARLEN
CONTRIBUTING EDITOR



• **Spacenet I in place.** Spacenet I, GTE's first communications satellite, is now in orbit at 120° west longitude. The new satellite covers all 50 states and has dual mode C- and Ku-band capability. The bird, launched in late May aboard an Ariane rocket, is the first of three GTE satellites. Video programmers using the satellite include Bonneville Telecommunications and American Christian Television System, along with several voice and data services.

• **Satellite viewing rights.** Two legislative proposals now making their way through Capitol Hill will make it easier for satellite earth-station users to pick up whatever satellite programming they want. The "Satellite TV Viewing Rights Act of 1984," as the bills are called, would force pay TV and cable networks to deal with private dish owners.

Although Washington insiders concede that the proposed laws won't make it through Congress in this busy election year, they hope that the current examination will lay a foundation for passage of similar bills next year. The Senate version, introduced by Sen. Barry Goldwater and others, affirms the legality of TVRO reception of non-scrambled signals, allowing users to watch anything they can pick up. However, it bars the manufacture and sale of unauthorized decoders that make it possible for users to receive encrypted signals; that last point was considered a necessary compromise to satisfy program producers. The House version of the bill wants to establish a formula of rates and terms for receiving scrambled signals—forcing pay-TV networks to deal with TVRO users.

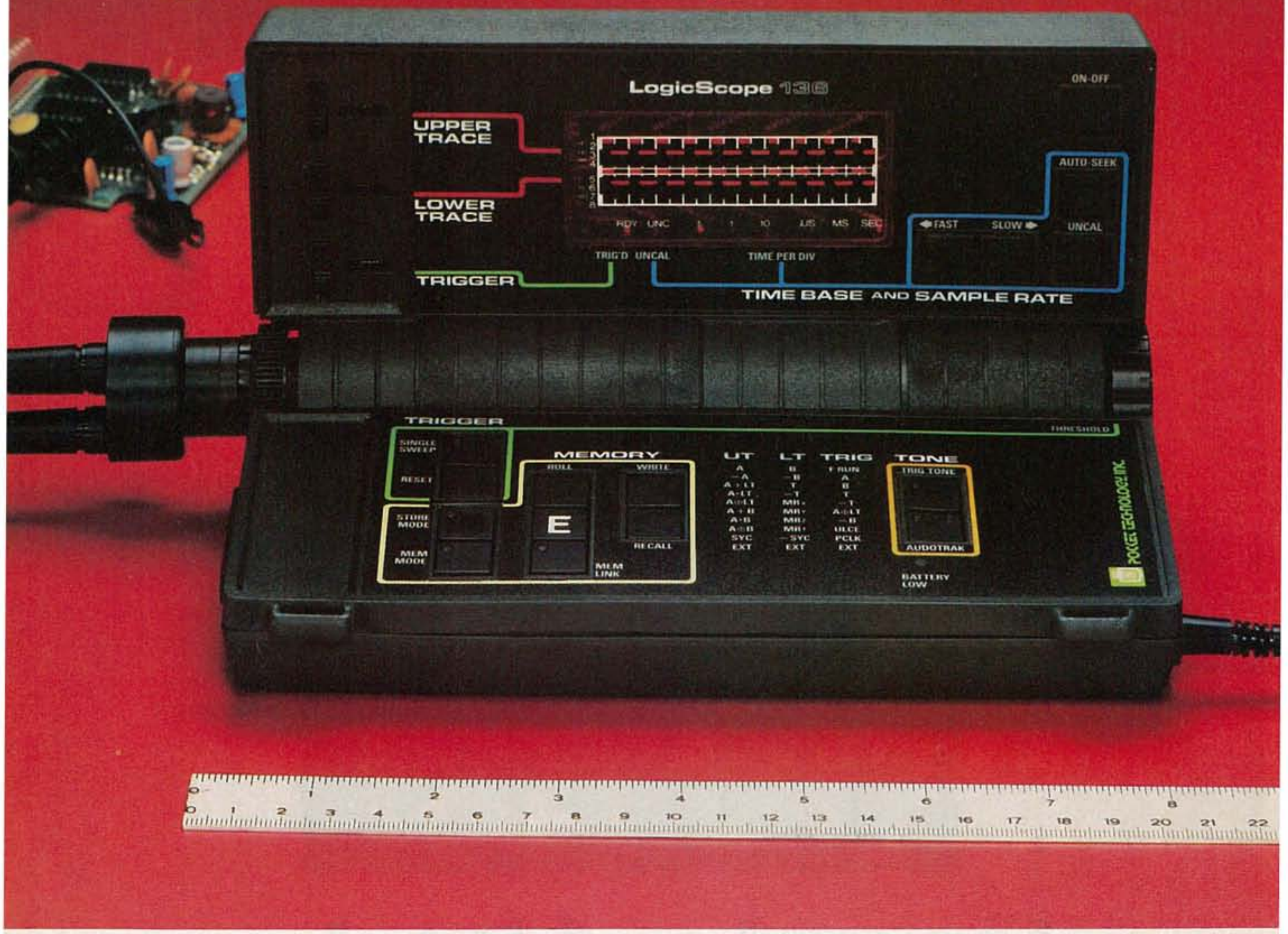
The bills are strongly endorsed by SPACE and other private satellite groups. Supporters are encouraging TVRO owners to write to their Congressmen and Senators to support the plans, now known as HR. 5176 in the House of Representatives and S. 2437 in the Senate.

• **Teletext news bits. The final draft** of the North American Basic Teletext Specification, a 70-page technical document spelling out precise details for making teletext reception and transmission equipment, has been published. The U.S. Electronic Industries Association (2001 Eye St. NW, Washington, DC 20006) and the Canadian Videotex Consultative Committee have agreed on the engineering details spelled out in the document (EIA Interim Standard #14).

• **Motorola Semiconductor** Products has developed a Raster Memory System (RMS) a two-IC microprocessor set that can support the widely used NAPLPS videotex format; it sells for only about $20. RMS has 640 × 500 resolution and can handle vertical or horizontal scrolling, displaying up to 32 colors simultaneously. It uses VLSI processing, which can convert a graphics program stored in memory to the video stream, producing high-resolution displays. The two-IC RMS set consists of the MC68486 raster memory interface and the MC68487 raster memory controller; it is highly programmable, and is designed to operate with three of Motorola's microprocessors.

• **Mullard,** the British-based IC-making subsidiary of Philips, will offer an NTSC version of its "computer controlled teletext" IC set. The company says the IC's, which support World System Teletext, could be built into TV sets by mid-1985, adding barely $50 to retail prices of TV receivers. The IC's are modifications of Philips' Euro CCT IC's (SAA5240) and offer higher-resolution characters and an eight-page storage capacity, plus a new video-input processor. **R-E**

Meet Our New LogicScope 136. . . . A True Dual Trace 10 MHz Digital Storage Scope. Only $495.



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■ The pocket-sized LogicScope 136 is made possible by a patented breakthrough in display technology. The conventional cathode ray tube has been replaced by a unique array of 400 LED's that permits simultaneous display of two digital waveforms.

■ The 136 can be used for viewing single shot events, or repetitive waveforms. It can be operated in real time mode, or in memory mode which permits acquisition and storage of up to 24 128-bit waveforms. These can be recalled, logically compared (AND, OR, EXCLUSIVE OR) to other stored/input waveforms, or output to an external device via an RS 232 port.

■ Its very low cost, convenience and ease-of-use make the LogicScope the ideal instrument, for designing, troubleshooting or repairing digital systems.

Consider its Engineering & Field Service Applications:

■ On microprocessor-based systems, check the timing relationship of various parameters relative to the system clock and other key events. Its storage capability allows visual and logical comparison of non-repetitive waveforms to known reference signals. Output in the start-up of the digital device can be compared to reference signals to determine the operating state of the device. Questionable waveforms can be stored for analysis.

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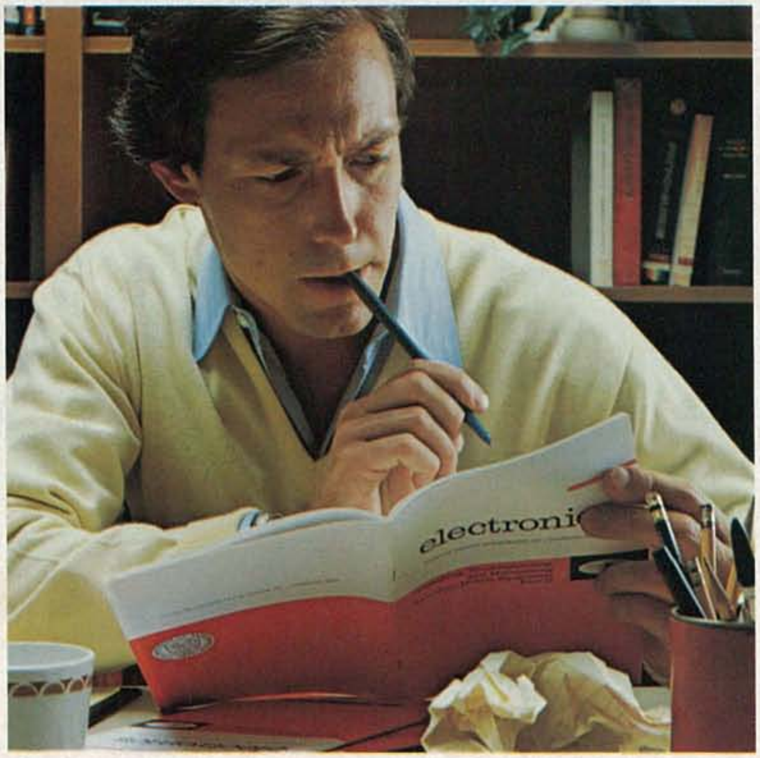
Learning electronics is no picnic.



At any level it takes work and a few sacrifices. But with CIE, it's worth it.

Whoever said, "The best things in life are free," was writing a song, not living a life. Life is not just a bowl of cherries, and we all know it.

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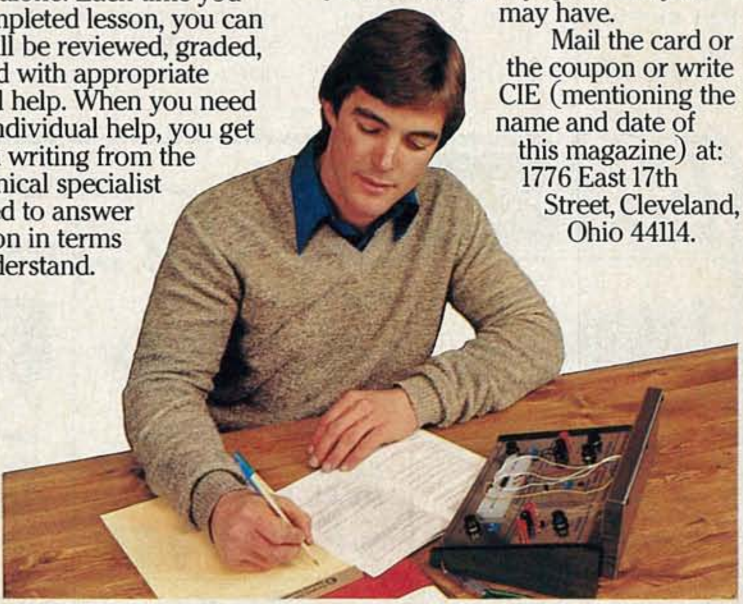
Mail the card or the coupon or write CIE (mentioning the name and date of this magazine) at: 1776 East 17th Street, Cleveland, Ohio 44114.



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CABLE-TV DESCRAMBLING

A few comments about the Cable-TV Descrambling article published in your February 1984 issue. First, in order to obtain the correction signal shown in Fig. 8-e, the 680-ohm resistor, R10, should be connected to pin 12 instead of pin 5 of IC2. The foil pattern must be modified.

Secondly, one of the multivibrators of IC2 delays the correction signal. Changing R18 to a 100-kilohm trimmer potentiometer allows one to adjust the proper delay.

Finally, for those who have difficulty finding the inductors T1, T2, and L2, the following seems to work fine: Replace T1, T2, and L2 with 0.1-μH fixed inductors: Replace C1, C3, and C18 with 100, pF trimmer capacitors.

SENCER YERALAN
Columbia, MO

IRKSOME PRACTICES

I find two things done by most of the electronics, computer, and mechanic/science magazines most irksome. The first is demonstrated on page 86 of the May 1984 issue of **Radio-Electronics,** and relates to the use of the letters *TRS-80*. By that, I assume you mean any of the several models of *TRS-80* available. Yet the program doesn't work on my *Color Computer,* a *TRS-80,* and it most assuredly won't work on any of the *TRS-80's* that fit into the business category like the Tandy *2000,* the *Model 16B,* or the *12,* which, unless I am blind, don't even have a cassette port. If you doubt me just look at the Radio Shack computer-products catalog Number RSC-11: It's the "1984 *TRS-80* Catalog". In short, then, please specify which *TRS-80* you mean!

The other infuriating item,

Build your own IBM PC compatible and save hundreds of dollars.

Heath proudly announces the NEW HS-151 Desktop and HS-161 Portable computers.

One of the world's largest software libraries has IBM's name on it. Now you can run that software on Heath's new IBM PC compatible computers, available in easy-to-build kits.

Can you build one of these computers? 85% of our first-time customers ask the same question. And the answer is 100% yes. You can.

In fact, you *should* build one. You'll save a lot of money while learning about computers in general and the Heath PC's in particular.

Build confidence...and your new computer...one step at a time. Two main circuit boards come to you pre-assembled and factory-tested. So that you can build the three other boards, we include a test soldering board plus helpful soldering instructions to make sure you get it right.

Our instruction manuals are easy to understand, thorough and packed with cogent illustrations. And once it's built, the computer guides you through a full range of included disk-based diagnostics.

Expert advice is only a phone call away, should you need it. You'll reach a trained consultant whose specialty is talking sense, not jargon.

We'll do whatever's necessary to make our pledge come true: "We Won't Let You Fail." Our entire business depends on that simple promise.

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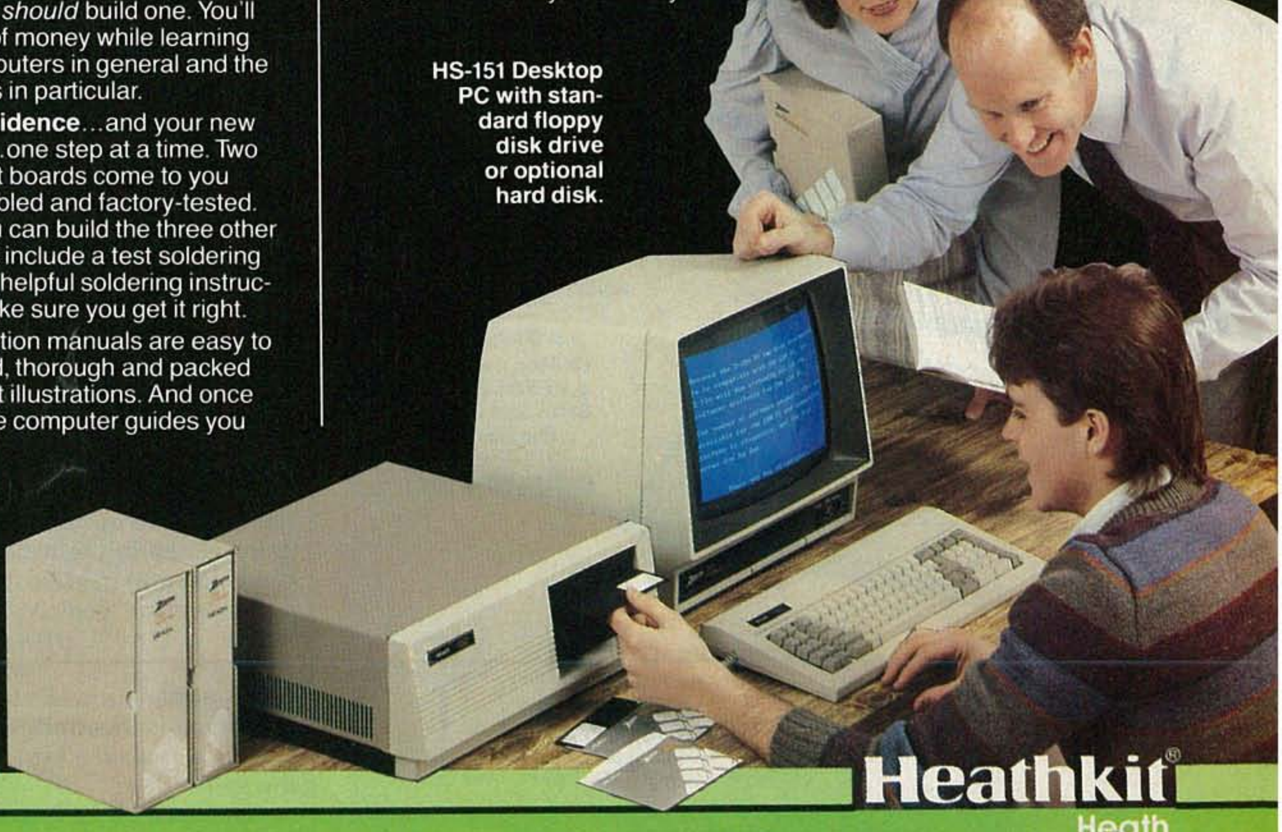
*MS is a registered trademark of Microsoft Corporation.

For computing on the go... the HS-161 Portable.

The HS-161 has the same features as the HS-151. Amber Monitor included. Convenient keyboard folds up, two disk drives fold down.



HS-151 Desktop PC with standard floppy disk drive or optional hard disk.

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A subsidiary of Zenith Radio Corporation which one individual can never change, is the baloney handed out by manufacturers. Do you truly believe that when you buy a car with certain things "standard"—like the radio or air conditioner—you do not pay extra for those "standard" features as the manufacturer would have you believe? The "extra" is just incorporated into the sticker price. That same kind of hype is used in many ways by many companies. Not the least of which is Apple's claim that the *MacIntosh* is a 32-bit machine when even Motorola, the IC's manufacturer, says it is a 16-bit device. If, as you indicate in your insert, you use 32-bit only as long as we remember that you are "referring to the microprocessor's internal architecture", and not make such a designation each time you refer to the *MacIntosh* as being a "32-bit" machine then, by the same designation you must always refer to the *TRS-80* Color Computer as a 16-bit machine, because it uses a 6809 microprocessor, as does the business/industry-oriented *GIMIX* system, and several other systems. The 6809 is 8/16, just as the 68000 is 16/32. You get what you pay for! Please don't continue Apple's hype; you do a disservice to those who make truthful claims, such as Radio Shack, who has at least one machine that uses the 68000.

HENRY C. GERNHARDT, Jr.
Huntington, WV

INVERTING OP AMPS

I have been reading **Radio-Electronics** for the past three years and like it very much. Since I am studying electronics in preparation for my career, I have been reading your back-to-school series of articles with great interest. The article in the May 1984 issue, which covered inverting op-amps (which was covered at school two weeks ago), was confusing in a way and I'd like to take some time to clarify the point.

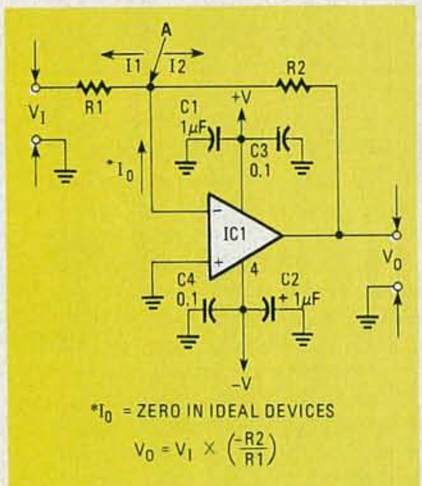

FIG. 1

The article became confusing with so many negative values being used. I thought that it should be emphasized that the gains stated in the example 5-b is not a negative gain (loss of signal), but a positive gain ($V_{OUT} > V_{IN}$) with a 180° phase shift ($+V_{IN} = -V_{OUT}$). I have found it much easier to note the fact that the signal is inverted, rather than writing a negative sign in front of the gain value.

Also, in Fig. 1, C2 is connected in a reverse polarity. It should be

continued on page 28

NEW!

uniden® Bearcat® Products

Communications Electronics,™ the world's largest distributor of radio scanners, is pleased to announce that *Bearcat* brand scanner radios have been acquired by Uniden Corporation of America. Because of this acquisition, Communications Electronics will now carry the complete line of Uniden *Bearcat* scanners, CB radios and Uniden *Bandit*™ radar detectors. To celebrate this acquisition, we have special pricing on the Uniden line of electronic products.

Bearcat®† 300-E

List price $549.95/**CE price $339.00**
7-Band, 50 Channel • Service Search • No-crystal scanner • AM Aircraft and Public Service bands. • Priority Channel • AC/DC
Bands: 32-50, 118-136 AM, 144-174, 421-512 MHz.
The *Bearcat* 300 is the most advanced automatic scanning radio that has ever been offered to the public. The *Bearcat* 300 uses a bright green fluorescent digital display, so it's ideal for mobile applications. The *Bearcat* 300 now has these added features: Service Search, Display Intensity Control, Hold Search and Resume Search keys, Separate Band keys to permit lock-in/lock-out of any band for more efficient service search.

Bearcat® 20/20-E

List price $449.95/**CE price $269.00**
7-Band, 40 Channel • Crystalless • Searches AM Aircraft and Public Service bands • AC/DC Priority Channel • Direct Channel Access • Delay
Frequency range 32-50, 118-136 AM, 144-174, 420-512 MHz.
Find an easy chair. Turn on your *Bearcat* 20/20 and you're in an airplane cockpit. Listening to all the air-to-ground conversations. Maybe you'll pick up an exciting search and rescue mission on the Coast Guard channel. In a flash, you're back on the ground listening as news crews report a fast breaking story. Or hearing police and fire calls in your own neighborhood, in plenty of time so you can take precautions. You can even hear ham radio transmission, business phone calls and government intelligence agencies. Without leaving your easy chair. Because you've got a *Bearcat* 20/20 right beside it.

The *Bearcat* 20/20 monitors 40 frequencies from 7 bands, including aircraft. A two-position switch, located on the front panel, allows monitoring of 20 channels at a time.

Bearcat® 210XL-E

List price $349.95/**CE price $209.00**
6-Band, 18 Channel • Crystalless • AC/DC
Frequency range 32-50, 144-174, 421-512 MHz.
The *Bearcat* 210XL scanning radio is the second generation scanner that replaces the popular *Bearcat* 210 and 211. It has almost twice the scanning capacity of the *Bearcat* 210 with 18 channels plus dual scanning speeds and a bright green fluorescent display. Automatic search finds new frequencies. Features scan delay, single antenna, patented track tuning and more.

Bearcat® 260-E

List price $399.95/**CE price $249.00**
8-Band, 16 Channel • Priority • AC/DC
Frequency range 30-50, 138-174, 406-512 MHz.
Keep up with police and fire calls, ham radio operators and other transmission while you're on the road with a *Bearcat* 260 scanner. Designed with police and fire department cooperation, its unique, practical shape and special two-position mounting bracket makes hump mounted or under dash installation possible in any vehicle. The *Bearcat* 260 is so ruggedly built for mobile use that it meets military standard 810c, curve y for vibration rating. Incorporated in its rugged, all metal case is a specially positioned speaker delivering 3 watts of crisp, clear audio.

NEW! Bearcat® 201-E

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9-Band, 16 Channel • Crystalless • AC only Priority • Scan Delay • One Key Weather
Frequency range 30-50, 118-136 AM, 146-174, 420-512 MHz.
The *Bearcat* 201 performs any scanning function you could possibly want. With push button ease, you can program up to 16 channels for automatic monitoring. Push another button and search for new frequencies. There are no crystals to limit what you want to hear.

NEW! Bearcat® 180-E

List price $249.95/**CE price $149.00**
8-Band, 16 Channel • Priority • AC only
Frequency range: 30-50, 138-174, 406-512 MHz.
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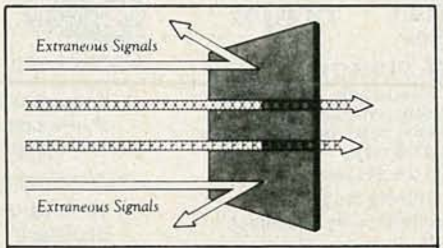

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LETTERS

continued from page 24

connected with the positive lead to ground.
CURT SWANSON
Maple Grove, MN

You're right about C2. However, you shouldn't assume that a negative gain necessarily indicates a signal loss. An amplifier that has an output smaller than its input has a gain (be it negative or positive) between 0 and 1. A negative gain indicates a 180° phase shift.—Editor

RADAR AND THE SPEED LIMIT

Regarding letters that concern radar and the 55-mile-per-hour speed limit—I have enjoyed reading the stimulating comments from others about those contemporary issues that are directly related to products in the consumer-electronics market.

However, might I suggest that 1984 would be an appropriate year for **Radio-Electronics** to feature articles on attempts by municipalities to ban home-satellite antennas, radar-detectors, and mobile scanners.

Many readers may also be interested in the subject of privacy and security in their telephone communications, home banking, and cable-TV viewing. Please continue offering your readers enlightening articles and challenging construction projects.
THOMAS R. CICCATERI
Santa Rosa, CA

GOOD FORMAT

I want to sincerely thank you for not selling out your excellent format. I am a totally self-taught electronic designer and I work on state-of-the-art electronics and software for industrial instrumentation. I taught myself using texts, hands-on-experiments, and magazines like yours. Thank you for keeping electronics articles that I can sink my teeth into, along with keeping up on computers and software.
MICHAEL CHRISTOPHER
Dayton, OH **R-E**

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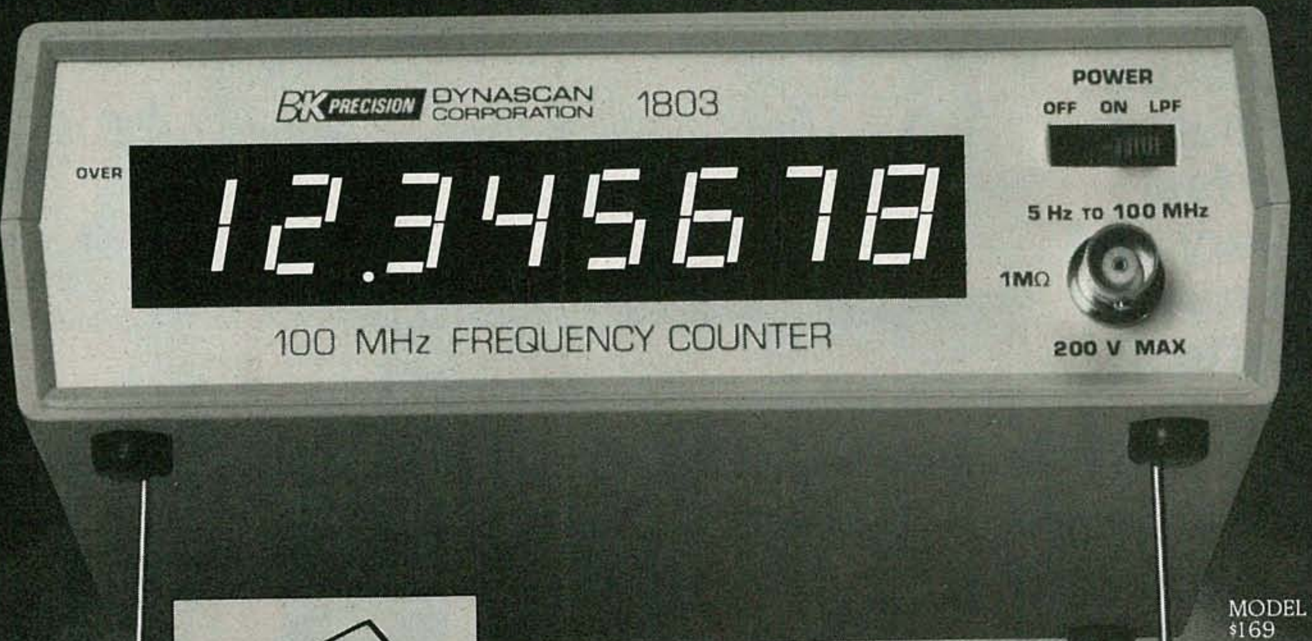

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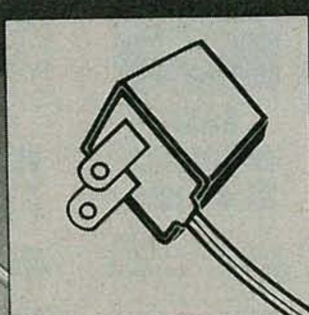

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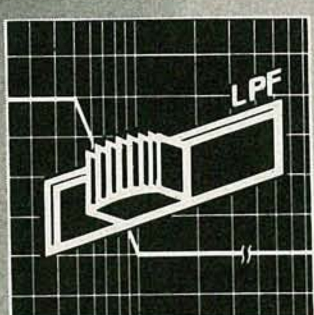

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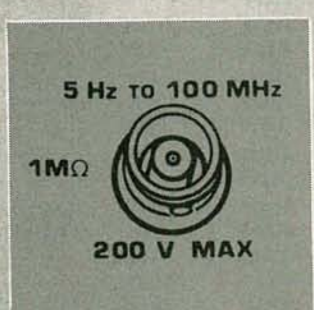

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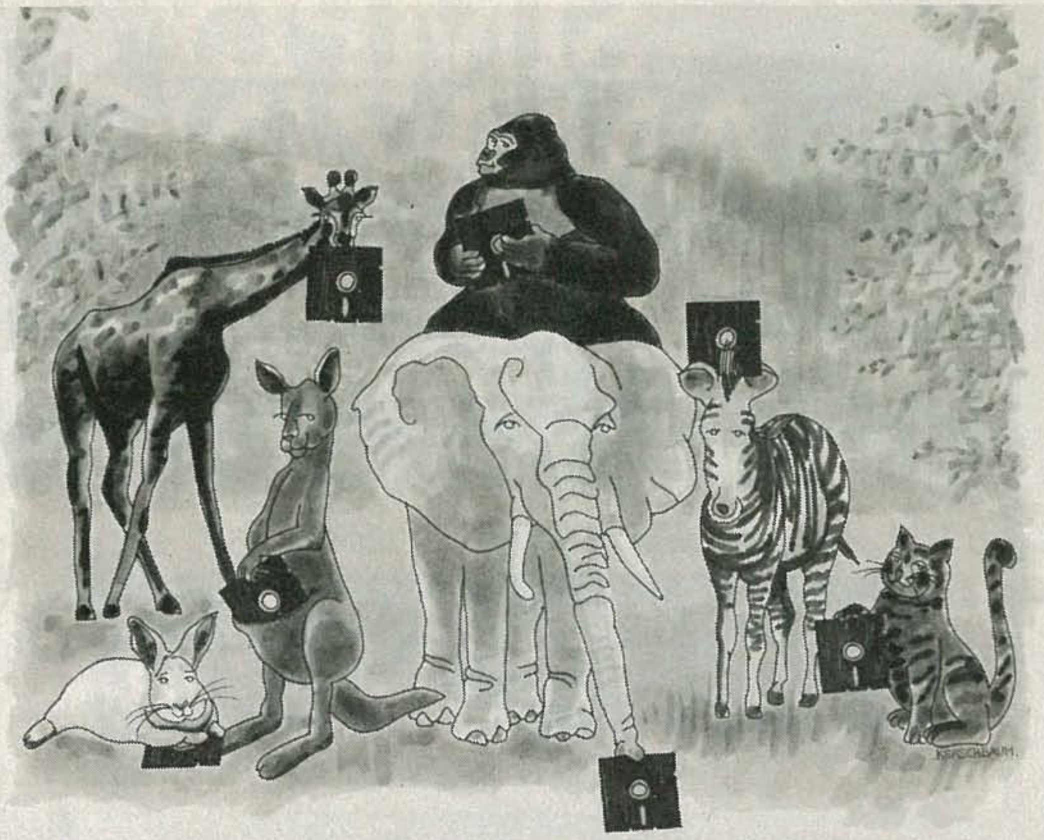

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5¼" SSSD 10 Hard Sector w/Hub Ring	——	——	M41A-P	1.19	——	——	——	——
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CIRCLE 35 ON FREE INFORMATION CARD

NEW IDEAS

Add-on scope multiplexer

HAVING A DUAL-TRACE SCOPE IS A LUXury that many of us, unfortunately, must do without. However, with the simple circuit we'll describe, you can add dual-trace capability to your single-trace scope at a cost of less than $5. Unfortunately, the device has one major "drawback," it only monitors logic levels (TTL and CMOS); but at that price, who cares!

How it works

Figure 1 shows the multiplexing circuit that lets you view two traces simultaneously. The operation of the unit revolves around three IC's: a 4093 quad NAND Schmitt-trigger, 4066 quad analog-switch, and a 7555 timer (that is used to gate IC2-b and IC2-c on or off.)

The device can be powered from a supply ranging of from 4.5 to 15 volts, and draws less than 2 mA. With a supply of 5 volts, the unit may be used to monitor TTL or CMOS logic-levels. At higher supply voltages (15 volts), it may be used to check only CMOS logic signals.

To make the operation of the unit a little easier to understand, we'll first look at the two input circuits separately and then see how the switching action of the circuit is handled.

When a high is fed to PROBE 1 IN, it is inverted by IC1-a and once again by IC1-b, so that the input to IC2-a is high. That high causes the "switch contacts" in IC2-a to close. With the "contacts" closed, a high-level output is presented to the input of IC2-b.

Meanwhile, let's suppose that a high is fed to PROBE 2 IN. That signal is then inverted by IC1-d and routed to IC2-d, causing its "contacts" to open and the unit to output a logic-level high. The output of IC2-d is then fed to IC2-c.

Unless a gating pulse is presented to both IC2-c and IC2-d,
continued on page 112

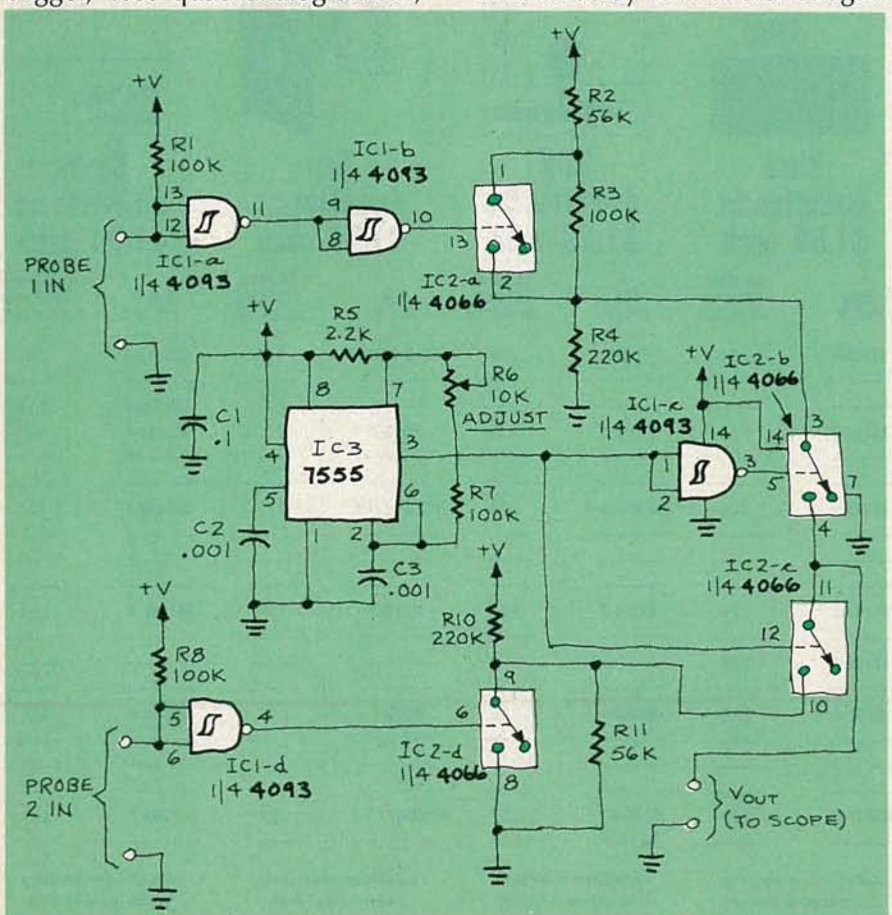

FIG.1

NEW IDEAS

This column is devoted to new ideas, circuits, device applications, construction techniques, helpful hints, etc.

All published entries, upon publication, will earn $25. In addition, for U.S. residents only, Panavise will donate their *model 333*—The Rapid Assembly Circuit Board Holder, having a retail price of $39.95. It features an eight-position rotating adjustment, indexing at 45-degree increments, and six positive lock positions in the vertical plane, giving you a full ten-inch height adjustment for comfortable working.

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The *HM605*

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continued on page 40

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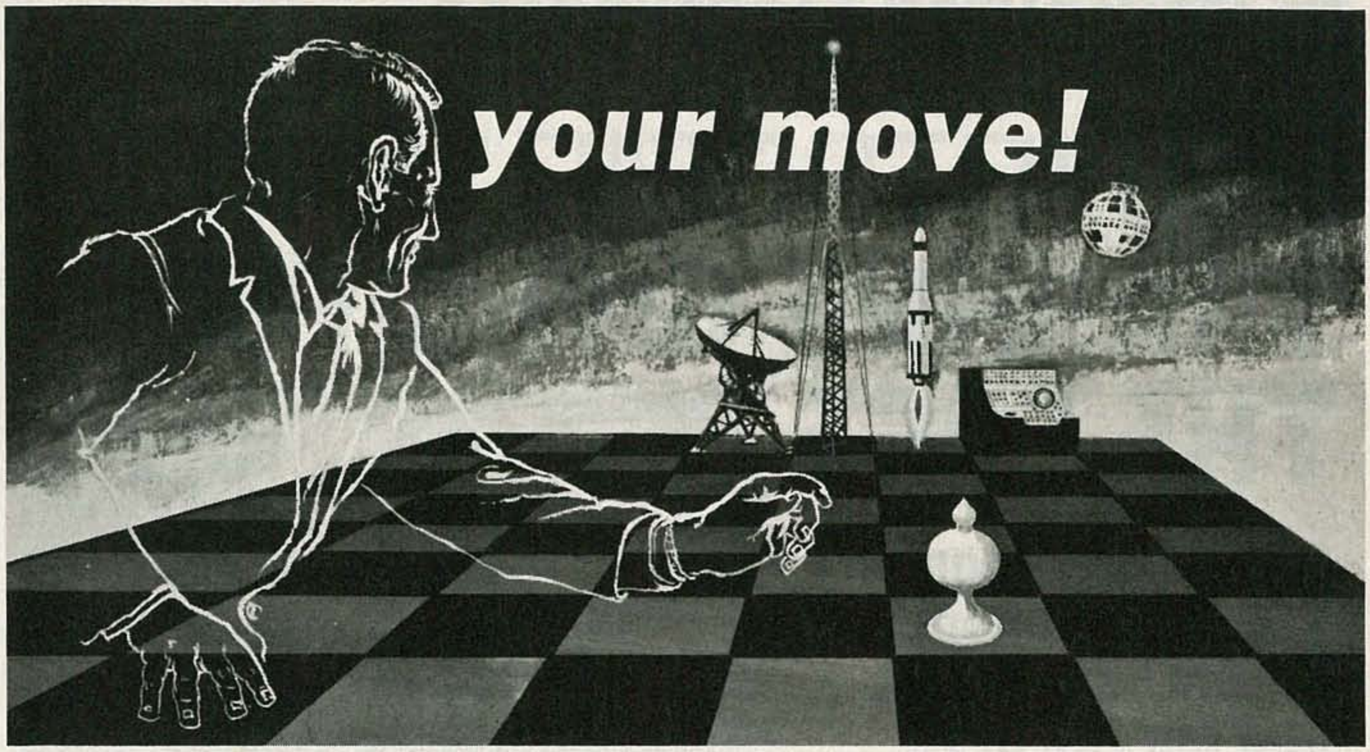

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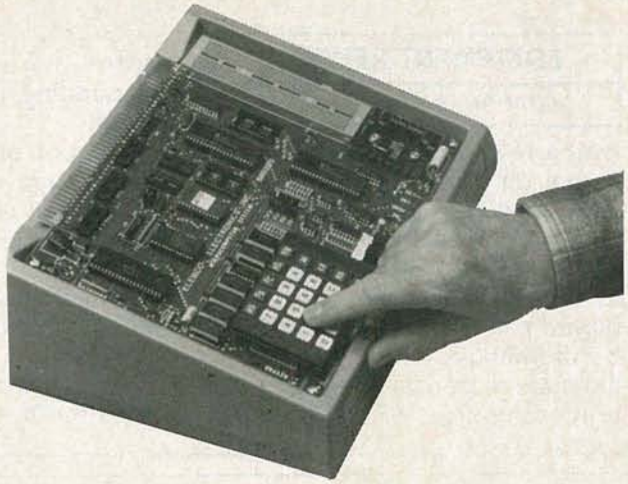

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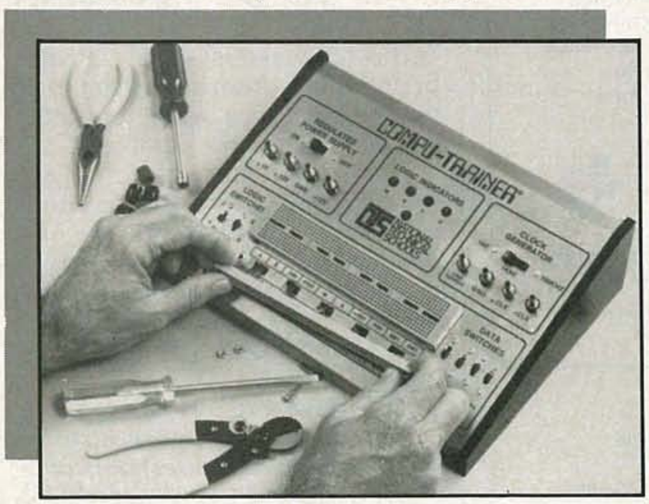

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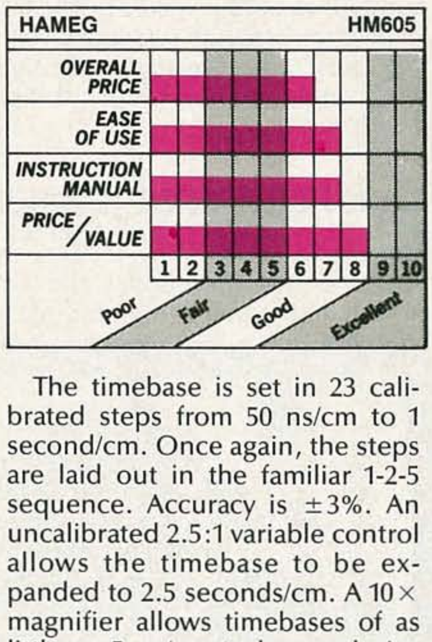
EQUIPMENT REPORTS

continued from page 34

with a 14-kilovolt acceleration potential for sharp, bright displays. The graticule is 8 × 10 divisions, with each division measuring 9.7 millimeters. For those who need to take photographs of the displayed patterns, the graticule can be illuminated. Two levels of illumination are provided (in addition, of course, to no illumination), with the level chosen depending on the film and camera used.

The unit boasts a variety of operating modes. Those are channel 1, channel 2, channels 1 and 2 alternated or chopped (the chopping frequency is approximately 1 MHz), sum or difference (channel-2 ± channel-1), and X-Y mode.

Turning to the vertical (Y) amplifier, as previously mentioned, it boasts a DC to 60-MHz bandwidth (−3dB). The risetime is 5.8 nanoseconds (ns), with a maximum overshoot of 1%. The amount of vertical deflection is set in 12 calibrated steps from 5 mV/cm to 20 V/cm. The steps are set up in the customary 1-2-5 sequence and accuracy is claimed to be ±3%. An uncalibrated 2.5:1 variable control allows signals up to 50 volts to be displayed. In addition, a calibrated 5:1 magnifier is provided. The sensitivity of the magnifier is 1mV/cm, allowing extremely low-level signals to be displayed. The bandwidth of the scope when the 5:1 magnifier is used is DC to 20 MHz (–3dB). Finally, two LED's are used to indicate vertical overscanning, and a built-in delay-line feature allows viewing of the trigger leading edge.



The timebase is set in 23 calibrated steps from 50 ns/cm to 1 second/cm. Once again, the steps are laid out in the familiar 1-2-5 sequence. Accuracy is ±3%. An uncalibrated 2.5:1 variable control allows the timebase to be expanded to 2.5 seconds/cm. A 10× magnifier allows timebases of as little as 5 ns/cm to be used. Accuracy with the 10× magnifier is ±5%.

The triggering system can accommodate trigger signals up to at least 80 MHz with thresholds of 5 mm internal and 50 mV external. A variety of triggering modes are available. Among those are peak, where the sweep is triggered automatically from the peak voltage of the test signal; external; line, where the trigger signal is derived from the AC line, and single-sweep. A variable hold-off control to adjust the time between sweeps is also provided. Triggering can be selected on any point on the

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positive or negative edge of the test signal.

The *HM605* also features a rather handy sweep-delay facility. That facility allows the sweep to be started at selected delayed times after the trigger signal has been applied. That delay can be set from 1 μs to a maximum of 1 second. The usefulness of the feature is that it allows horizontal (X) expansion of at least 1000 times.

A rather interesting feature is the unit's built-in electronic component tester. That tester displays a test pattern that will instantly tell the user if the component is in working condition. Among the components that can be tested are resistors, capacitors, inductors, diodes, and transistors. In addition, a limited number of tests can be made on IC's. When working with resistors, capacitors, and inductors, the approximate value of the component can also be found from the pattern. With experience, precise values can be found. Precise values can also be found by comparison with a component of known value. All components can be tested either in or out of circuit. The unit uses a test voltage of 8.5-volts rms.

For probe compensation (two 1×/10× probes are included with the unit) and general system checks, the unit includes a built-in squarewave generator. That generator has a switchable 1-kHz/1-MHz, selectable .2- and 2-volt (peak-to-peak) output.

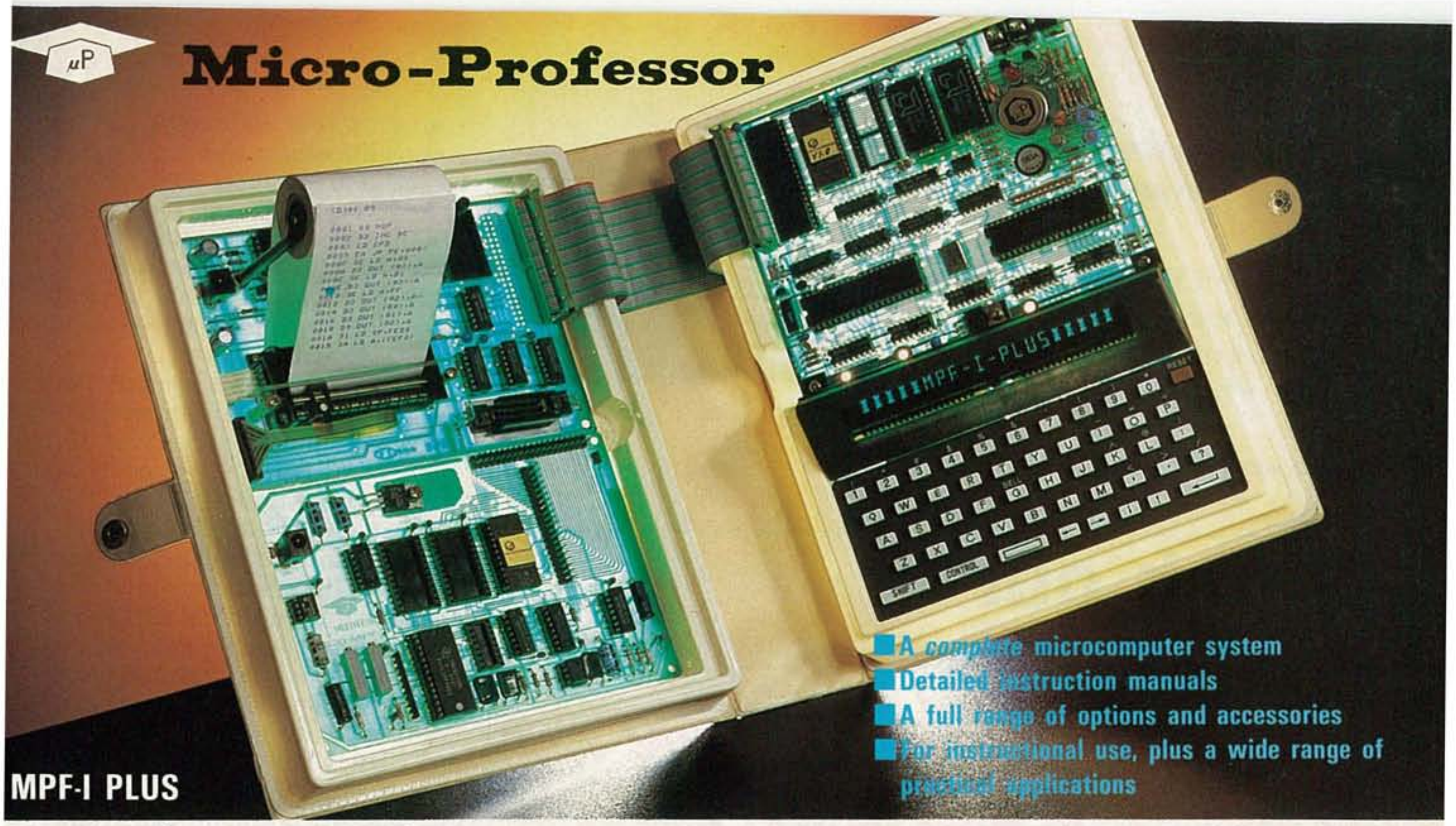
As you would expect, *HM605* is a ruggedly built scope. It is housed in a beige steel cabinet and is designed and tested to meet international safety standards (IEC 348).

It is intended to be used as a bench-top unit; as such, no provision for battery power has been made. It can run off any one of four selectable voltage sources. Those are 110, 125, 220, or 240 volts, all at 50–60 Hz. A carry handle, which doubles as a tilt stand, is provided.

Of course, an excellent scope deserves an excellent manual and the one provided with the *HM605* is just that. It is well written and well illustrated. About the only omissions are the theory of operation and a detailed parts list, but there is a block diagram of the unit and all parts, including their industry-standard designations, are clearly identified on the schematic diagrams.

The *HM605* is a well-thought-out, easy-to-use unit with an impressive array of features and specifications. It carries a suggested list price of $965. **R-E**

"I'd like to turn it off, father, but he's telling me to stay tuned, and he's *bigger than you!"*



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THE APPLE LINE OF COMPUTERS IS among the oldest and most popular on the market. One of its strongest selling points is the wide variety of software available for it. In fact, it is believed that there are more programs available for the Apple *II/IIe* than for any other machine.

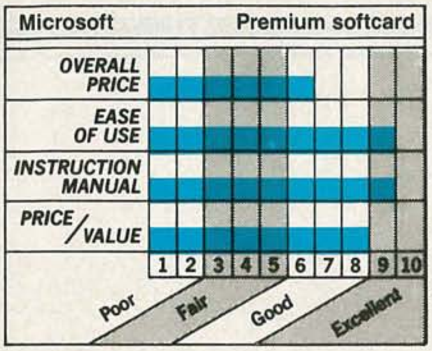
One group of programs it can not run, however, are those written to be run under the CP/M operating system. Use of that operating system requires that your computer use a Z80/8080 microprocessor; the Apple *II/IIe* uses the 6502. The disadvantage of not being able to run CP/M programs is rather large, as among those are some of the best written and most useful pieces of business software.

But Apple owners are not out of luck. For years now there have been a variety of add-ons—cards that plug into one of the expansion slots inside the computer—designed to give the computer the capability of running CP/M. What those cards do is add a second microprocessor—a Z80—to the machine. When the card is activated, it is as if the Apple *II/IIe* were transformed into a Z80-based computer.

One of the first, and most popular of those cards, called the *SoftCard*, was developed by a Washington state firm called Microsoft (10700 Northup Way, Bellevue, WA 98004). Now, Microsoft has released the successor to that product. It is called the *Premium SoftCard IIe*, and is intended for use with Apple's *IIe* computer.

But that card does more than just add CP/M capability to that Apple machine—it also adds 64K of additional RAM, and upgrades the computer's 40-column display to an 80-column one. Both of those capabilities are important. Extra memory is always useful, especially if you are working with large databases or spreadsheets. Note, however, that the additional 64K can only be accessed by the computer when it is in its "6502 mode."

As for the larger display, 80 columns are absolutely essential if you intend to do any serious word processing, and come in handy for just about any other application you can name.



Installation

Before we go any farther, we want to make it perfectly clear that this card will only work with the *IIe*, not with the earlier *II* or *II+*, or many of the "clones" that are based on the earlier design. One reason for that is that it installs in a special "AUXILARY CONNECTOR" that's been added in the newer Apple machine.

If you own an Apple computer, and have ever installed a printer or modem interface, a disk controller, or any of the many other types of add-on cards available, you will have no problems installing the *Premium Softcard IIe*. The only requirements to do the job is a minimal amount of manual dexterity and some care. Since the IC's on the circuit board are, of course, sensitive to high voltages, any personal static electricity should be discharged before the unit is handled. The board also should be handled only by the edges of the board to prevent body oils from contaminating the etched traces or the edge connector. Finally, needless to say, the computer must be off before any work is done.

To install the board, the top cover of the computer must be removed to gain access to the accessory slots. That's done by simply pulling up gently on two tabs at the rear of the top cover until that cover comes off. Set the cover aside, locate the auxiliary connector-slot, and align the board's bottom edge-connector with it making sure that the component side faces the right side of the chassis (when looking into the computer from the rear). Press the board into the connector using a steady, but firm, pressure until the board seats. Re-install the top cover and the job is done.

Software and manuals

The package also includes the CP/M operating system, Microsoft Basic, and a wide variety of CP/M utility programs. Those utility programs, needed for disk formatting, file transfers, and other tasks, include just about all of those that you would expect, including PIP, STAT, COPY, and DDT.

Those of you who are familiar with computer documentation know that more often than not it is just plain awful. Fortunately, the manuals supplied here are excellent. Included are a system installation and operation manual, a copy of *The Osborne CP/M User's Guide*, and a Microsoft BASIC reference manual. The installation and operation manual is a well-done affair that tells you everything you need to know to install and use the *Premium Softcard IIe*. It also gives a brief rundown of the

continued on page 110

NEW PRODUCTS

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TECHNICIANS TOOL KIT, the model *JTK-86,* is a full-service kit in a compact zipper case. Its selection of tools includes some rarely found in a zipper case: a complete 13-piece ¼-inch drive socket set with ratchet, spinner handle and extensions; a vise-grip locking plier; a 9-blade fold-up hex-key set, and an 11-blade feeler gauge.

The model *JTK-86* is available in a vinyl, leather, or Cordura nylon case with three outside pockets for meters, test leads, or service manuals. Two pockets measure 5½ × 9 × 2¼, and the third measures 10½ × 9 × 2¼.

The model *JTK-86* is priced at $249.00.—**Jensen Tools, Inc.,** 7815 S. 46th Street, Phoenix, AZ 85040.

PRINTER, model *LQ/2* is designed for use with a number of personal computers; it will fit into computer rooms or areas easily because of its small size.

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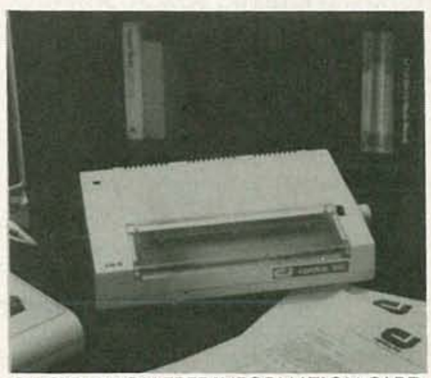

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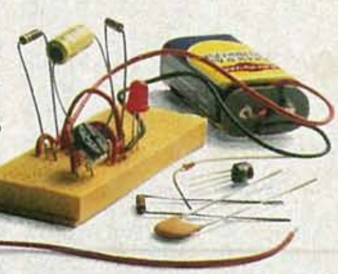

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All this along with a record output jack, external antenna terminal and a rugged and attractive carrying case make the R-11 portable receiver the perfect travel companion!

More information on the Kenwood receivers is available from authorized dealers of Trio-Kenwood Communications 1111 West Walnut Street, Compton, CA 90220.

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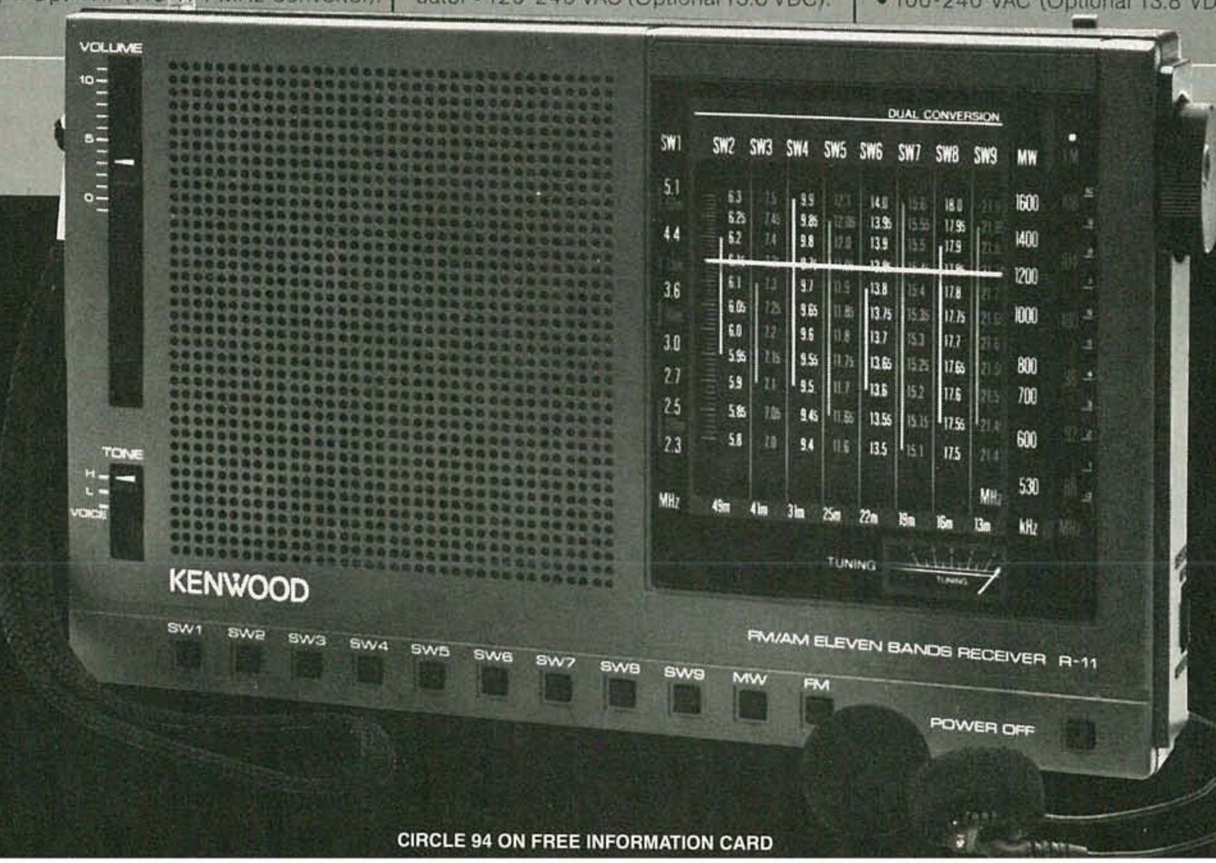

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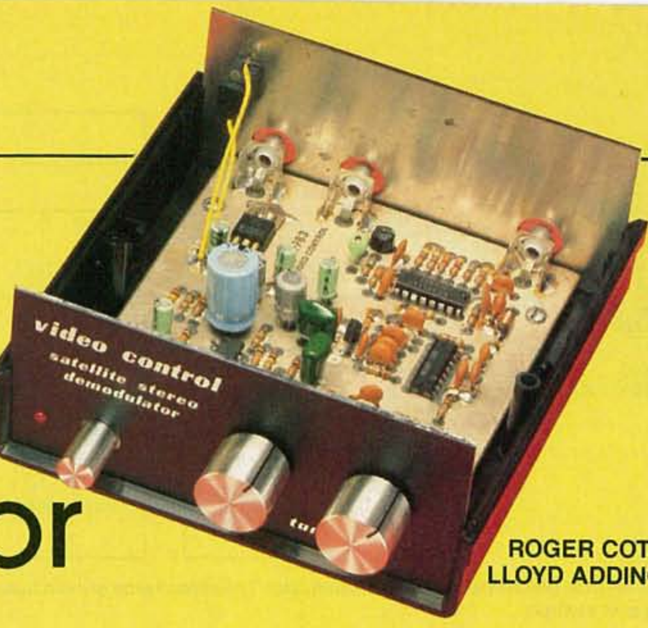

Satellite Stereo Demodulator

ROGER COTA and LLOYD ADDINGTON

A stereo demodulator is a must for any TVRO-system owner who wants full enjoyment of his system. You can't receive stereo satellite broadcasts on your TVRO? Build this and hear what you've been missing!

ANYONE WITH A TELEVISION RECEIVE only (TVRO) home satellite system can now receive TV and audio broadcasts in stereo! If you integrate a satellite stereo demodulator into your present monaural system, you'll be able to enjoy stereo movies at home—without the hassle, expense, and crowds of a movie theater. And it wont cost any more than just a few trips out to the movies!

Much of the programming beamed to us from satellites is in stereo. That includes movies, music videos, and audio-only programming on *The Disney Channel*, *Bravo*, *The Movie Channel*, *The Nashville Network*, *MTV*, and more. In fact, stereo broadcasting is quickly becoming the norm.

Many of the more-recent satellite receivers have stereo capability built in. But if you want to add stereo capability to a monaural receiver that you already own, you can end up spending anywhere from $300 to $1100 for a commercially available demodulator.

But there is a less expensive alternative—you can build a stereo processor for less than $80. And not only is the device we'll describe inexpensive, it's also easy to build and easy to operate. And it allows you to hear those movies, music videos, etc, the way that they were meant to be heard—in stereo.

We shouldn't forget to emphasize that this add-on will also let you listen—in stereo—to the many audio-only broadcast services that are present on a number of transponders on various satellites. Table 1 lists some of sources of video transmissions with stereo audio, while Table 2 lists audio-only stereo services.

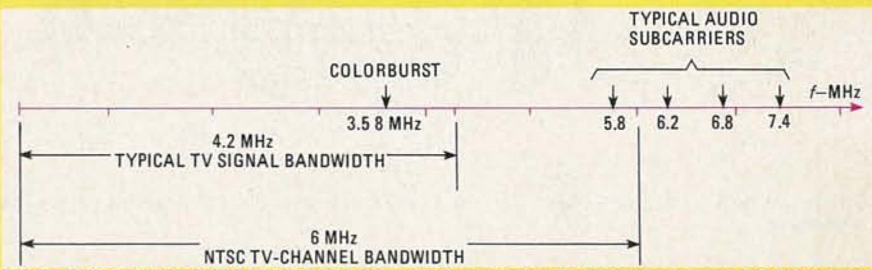

FIG. 1—THE TYPICAL SUBCARRIER FREQUENCIES used for audio transmissions are 5.8, 6.2, 6.8, and 7.4 MHz.

The satellite stereo demodulator offers both discrete and matrix capabilities, tunable left and right channels, and an input that can receive either the raw video signal or the audio subcarrier signal from a mono satellite receiver.

The stereo demodulator

The effective bandwidth of a satellite transponder is about 10 MHz. Since standard NTSC signals have a bandwidth of 6 MHz, there is ample room for audio subcarriers from 6 to 10 MHz of the transponders spectrum. Any subcarrier located above about 5.8 MHz can be used to carry additional audio programming. As shown in Fig. 1, 5.8, 6.2, 6.8, and 7.4 MHz are the most frequently used subcarrier frequencies. But in order to effectively obtain the desired stereo effect, the frequency-modulated audio subcarriers must be separated from the video. And that's why we need a stereo demodulator.

Figure 2 shows a block diagram of the satellite stereo demodulator. An incoming video or audio signal enters the first amplifier stages where it is filtered, amplified, and limited. The result, as shown in Fig. 3, is a hard-limited, noise-free FM signal with the video portions removed. The subcarrier signals proceed to two phase-locked loop sections.

One phase-locked loop IC is used for each stereo channel. Each is configured to cover the range from 5 to 8 MHz. A varactor diode is used to determine each center frequency. (A varactor is a voltage-variable capacitor formed from a diode in which the inherent capacitance is emphasized, instead of minimized as in a "normal" semiconductor diode.) The bias voltages for the varactor diodes are independently controlled by the front panel TUNE A and TUNE B controls. Increasing the voltage increases the frequency of the phase-locked loop.

The audio that is output by each PLL IC's is then lowpass filtered by de-emphasis circuits, applied to gain stages, and then sent to the matrix circuit, which is controlled by the front-panel-mounted DISCRETE/MATRIX selector.

Most of the stereo-audio subcarriers are

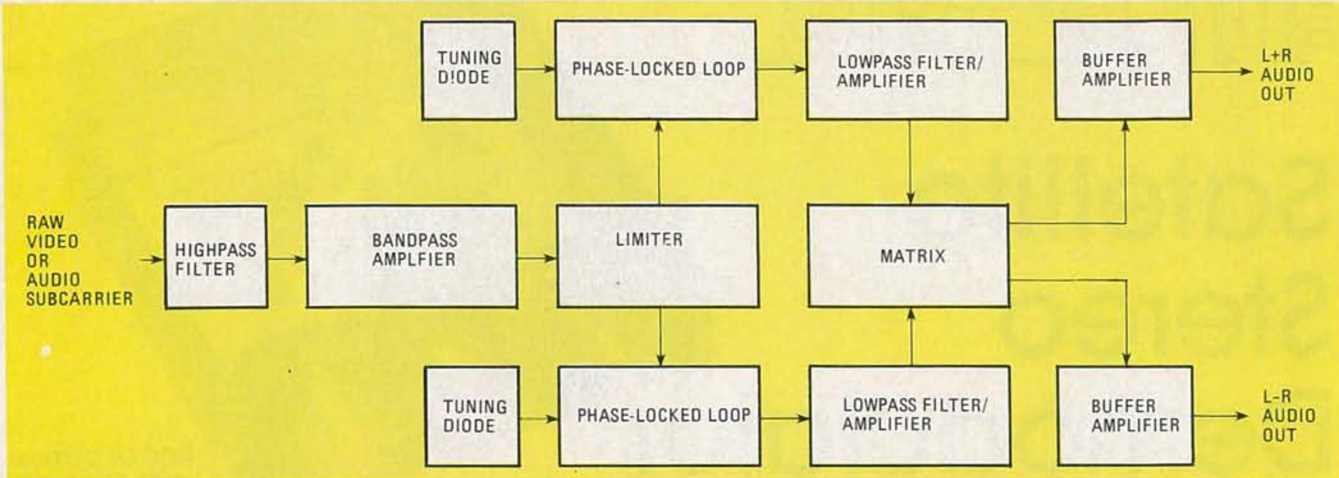

FIG. 2—BLOCK DIAGRAM OF stereo demodulator. The capacitance of each tuning diode is varied by front-panel controls.

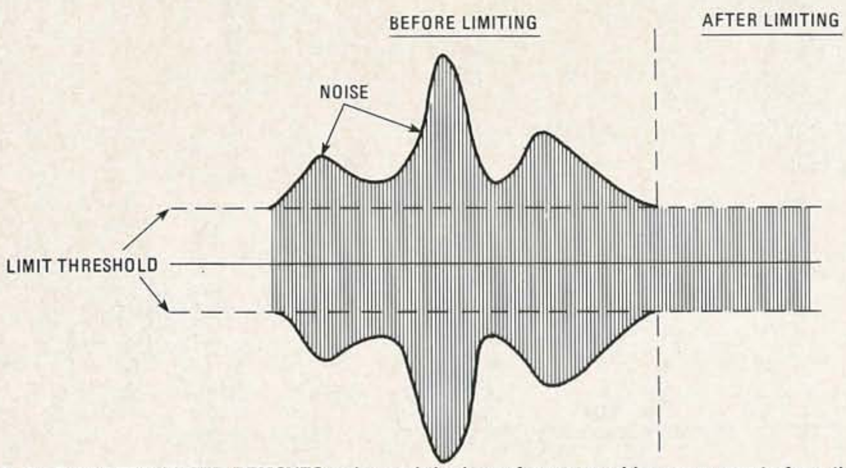

FIG. 3—THE INPUT FILTER REMOVES noise and the lower-frequency video components from the input signal.

TABLE 1—STEREO VIDEO-PROGRAMMING

Satellite	Transponder	Service	Subcarrier A (MHz)	Subcarrier B (MHz)	Mode
SATCOM F3	4	Spotlight	5.8	6.2	Discrete
SATCOM F3	5	The Movie Channel	5.8	6.8	Matrix
SATCOM F3	11	MTV	5.8	6.62	Matrix
SATCOM F3	16	HTN Plus	6.8		Multiplex
SATCOM F4	6	Bravo	-5.8		Multiplex
SATCOM F4	8	Entertainment Channel	5.94	6.12	Discrete
WESTAR F5	10	Disney Channel	5.8	6.8	Discrete
WESTAR F5	12	Disney Channel	5.8	6.8	Discrete
WESTAR F5	17	Nashville Network	5.58	5.76	Discrete

TABLE 2—STEREO-AUDIO PROGRAMMING

Satellite	Transponder	Service	Subcarrier A (MHz)	Subcarrier B (MHz)	Mode
SATCOM F3	3	Moody Broadcasting	5.2	7.92	Discrete
SATCOM F3	3	Country Coast to Coast	5.58	5.76	Discrete
SATCOM F3	3	Star Station	5.94	6.12	Discrete
SATCOM F3	3	WFMT-FM	6.3	6.48	Discrete
SATCOM F3	3	Bonneville Broadcasting	7.38	7.56	Discrete
SATCOM F3	3	Stardust	8.05	8.14	Discrete
SATCOM F3	3	Music in Air	5.4	5.94	Discrete
SATCOM F3	3	Music in Air	5.58	5.76	Discrete
SATCOM F3	8	Cable Jazz Network	5.94	6.12	Discrete
SATCOM F4	7	Family Radio (East)	5.58	5.76	Discrete
SATCOM F4	7	Family Radio (West)	5.94	6.12	Discrete
ANIK D1	18	CIRK	6.17		Multiplex

transmitted either in *discrete* or *matrix* modes. In the discrete mode, one subcarrier contains only the left-channel information and another subcarrier contains only the right-channel information. In the matrix mode, each subcarrier contains a combination of the left- and right-channel information: One subcarrier contains the sum of the two signals (left + right or L+R) and the other subcarrier contains the difference of the two signals (left − right or L−R). The matrix circuit adds and subtracts those signals at the appropriate levels to separate out the two stereo channels. Those left- and right-channel signals are then amplified and presented at their respective output jacks.

A closer look at the circuit

Now that we've gone over the basics of what the circuit does, let's look at it in more detail. Refer to the demodulator schematic in Fig. 4.

The input to the demodulator—either the raw-video output or the subcarrier output from the satellite receiver—is fed to the VIDEO IN jack, J1. From there, the input signal passes through a highpass filter made up of C35 and R40. That leaves the audio subcarriers unattenuated but rolls off any video components that might be in the signal. The signal then enters IC2, a 10116 ECL triple line receiver. That device contains three amplifier stages that are used to amplify, filter, and limit the signal.

After passing through the first amplifier stage of the IC, the signal is filtered through L1 and C1. That series L-C circuit is tuned to 6.5 MHz, the center of the subcarrier spectrum. Resistor R38 presents a 75-ohm load for the tuned circuit (to give the appropriate Q factor).

The input to IC2 is biased up through a bias pin (pin 11) and R43. The signal then enters the next stage of the op-amp, exits at pin 15, and passes through a tuned circuit made up of C13 and L2. That circuit is also tuned to the center of the subcarrier-frequency band (6.5 MHz). At that point, the signal has been amplified and limited by IC2 to 1-volt peak-to-peak. All the

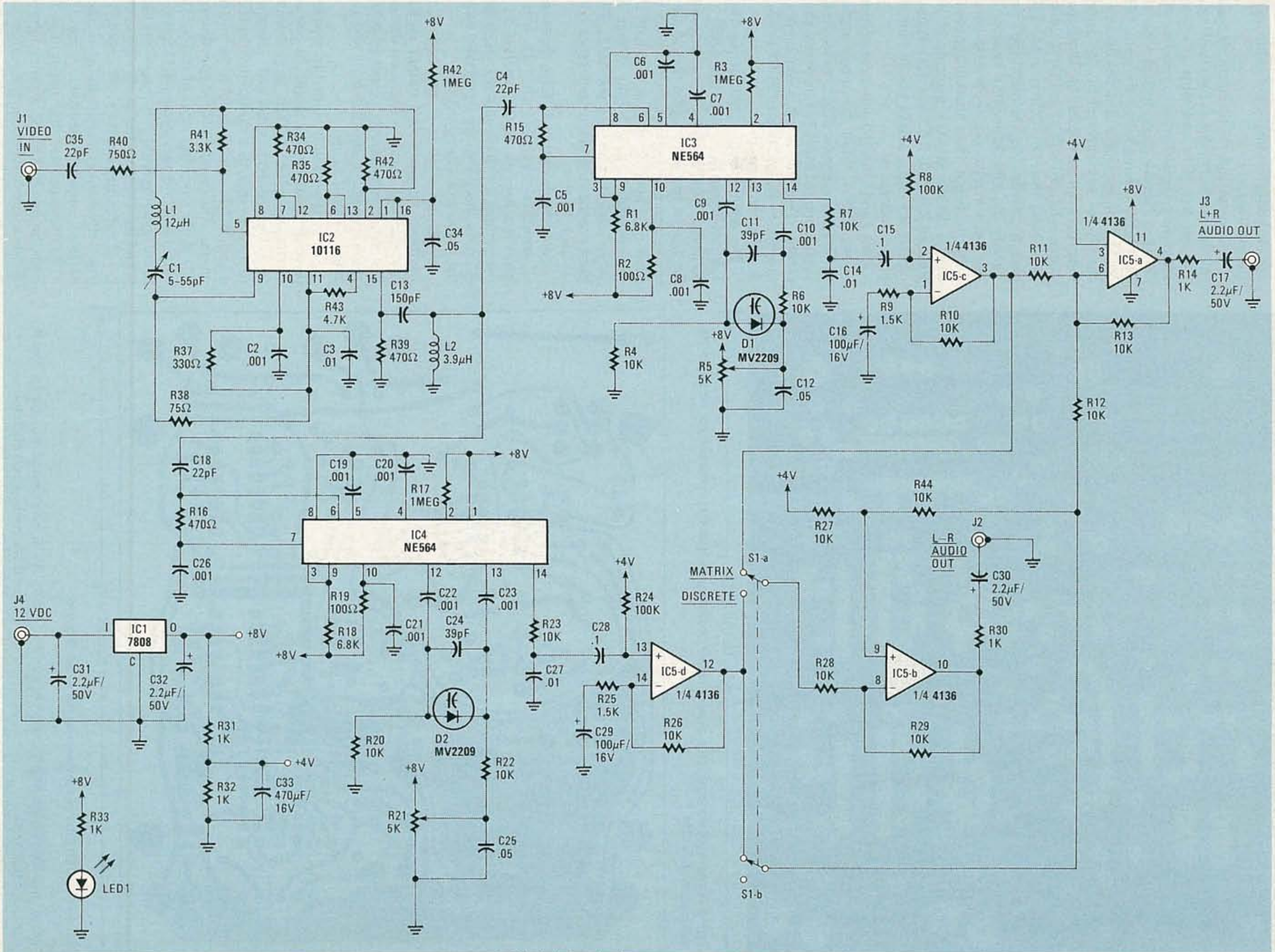

FIG. 4—SATELLITE STEREO DEMODULATOR SCHEMATIC. The frequency of each PLL is determined by the capacitance of a varactor diode (which is controlled by R5 and R21).

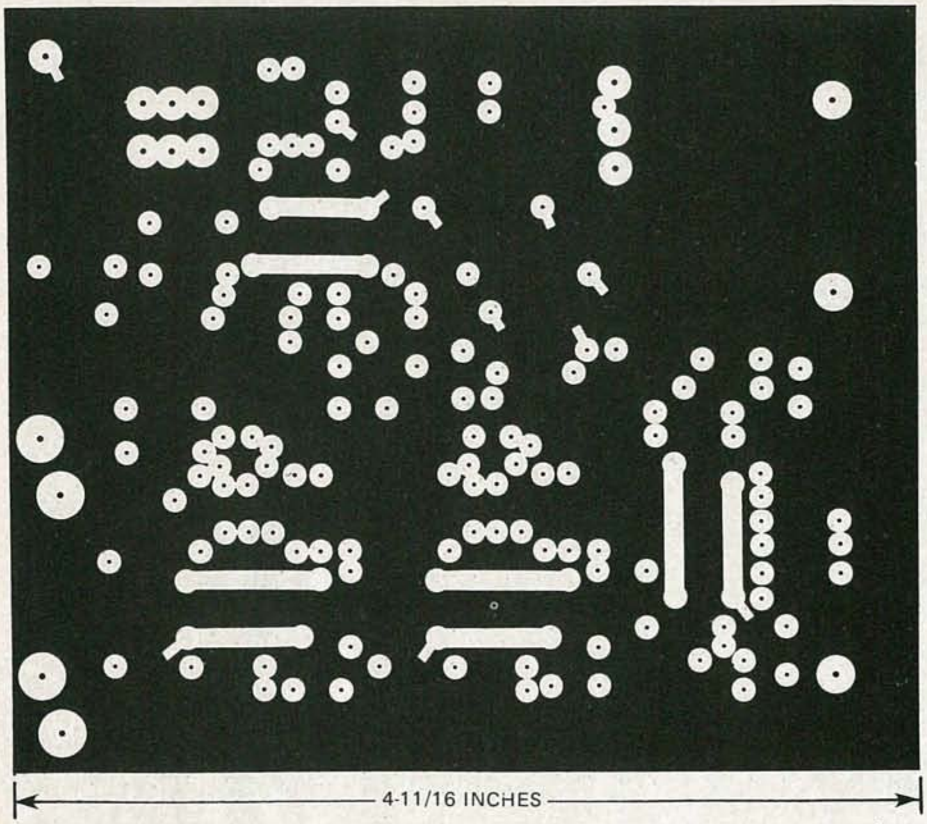

FIG. 5—COMPONENT SIDE of the demodulator's circuit board. Note that some components must be soldered on this side.

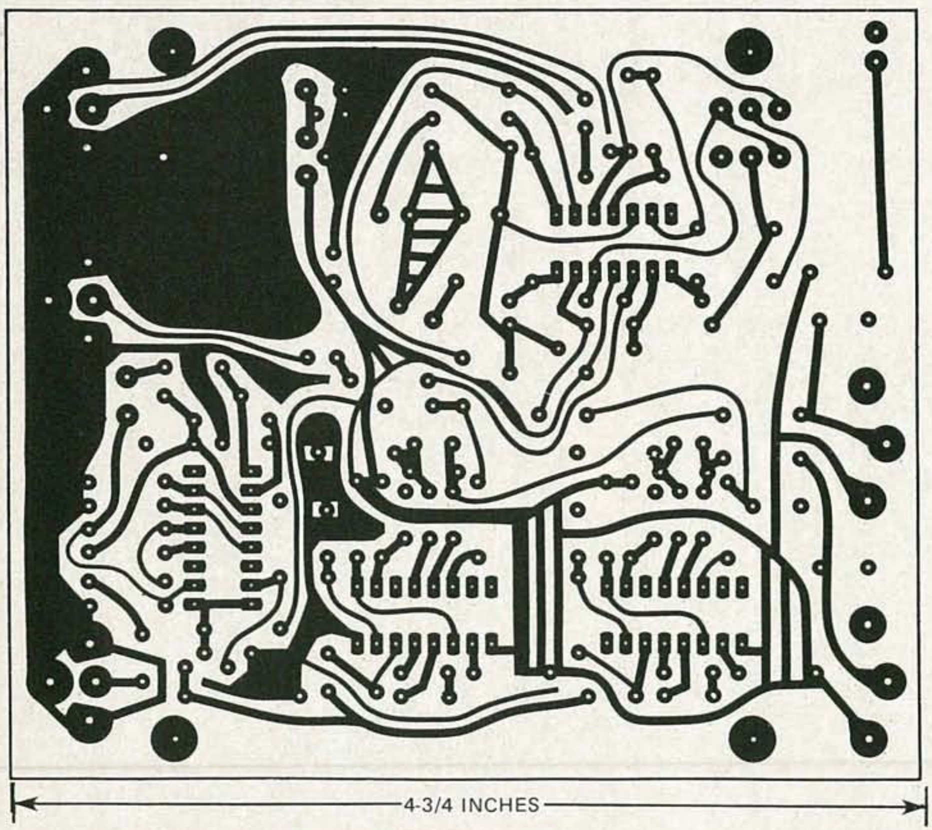

FIG. 6—SOLDER SIDE of the demodulator's circuit board.

noise and amplitude-modulated components are removed.

From the tuned circuit, the signal passes to the demodulator PLL IC's (IC3 and IC4). As we mentioned previously, one IC is used for each stereo channel.

Note: Because the PLL circuits are essentially the same, we will discuss only one set of components. We will, however, list the corresponding set of components in parenthesis.

The signal from the tuned circuit passes through another highpass filter made up of C4 and R15 (C18 and R16) to roll off interfering signals prior to entering IC3 (IC4), a NE564 phase-locked loop IC. That IC then demodulates the signal. The VCO (*V*oltage-*C*ontrolled *O*scillator) in the NE564 is controlled by the capacitance between pins 12 and 13. That capacitance is formed by C11 and D1 (C24 and D2). Note that D1 (D2) is a MV2209 varactor diode. As we mentioned previously, the capacitance of a varactor diode varies in relation to the reverse-biased voltage across it. Here, that voltage comes from a divider network made up of R4, R6, and R5 (R20, R22, and R21). Potentiometer R5 (R21) allows you to tune the proper subcarrier.

Pins 1 and 10 are the power connections on the NE564. While the voltage applied to pin 1 can be greater than 12 volts, the the voltage applied to pin 10 cannot rise above 6 volts. Thus, the 8-volt power supply is dropped by R2 and filtered by C8 to give a 5-volt input to pin 10.

The demodulated output at pin 14 is lowpass filtered (or de-emphasized) via R7 and C14 (R23 and C27). At that point, we have a low-level signal that requires amplification by op-amp IC5-c (IC5-d). That op-amp is biased at one-half the power-supply voltage by the voltage divider made up of R31 and R32. That biases up the amplifier output stages to the +4-volt level.

After the de-emphasis filter, the signal is amplified by IC5-c (IC5-d), which gives it a gain of approximately 6.6, as determined by R10 and R9 (R26 and R25). At that point, the signal goes to S1, the MATRIX/DISCRETE switch.

With the switch in the DISCRETE position, the amplified output signals from the two phase-locked loop demodulators are run through the output buffer amplifiers IC5-a and IC5-b, to the two audio outputs, J2 and J3.

When the switch is in the MATRIX position, however, the amplified outputs of the two phase-locked loop demodulators are added together and subtracted from each other, then run through the IC5-a and IC5-b, which perform the matrix mixing. The output of IC5-c goes through R11 to the inverting input of IC5-a. The output of IC5-d goes through R12 and also to the inverting input of IC5-a, where they are added together. The summation of the L + R subcarrier and the L − R subcarrier (the left-channel information) is then buffered, amplified, and fed to output J3.

At the same time, the output of IC5-c goes through R28 to the inverting input of IC5-b where a subtraction is performed, giving an output of the L + R subcarrier

continued on page 114

ALL ABOUT

Rechargeable Batteries

We continue our look at batteries with a description of rechargeable types and how to use them.

ROBERT GROSSBLATT

Part 2 THIS MONTH, WE CONclude our two-part look at batteries and battery technology by turning our attention to rechargeable (lead-acid and nickel-cadmium) cells, and how to choose the type you need.

Lead-acid batteries

The modern lead-acid cell is a far cry from its predecessors. Its open-circuit voltage is about 2 volts, which means that it has the second-highest energy capacity of the commercially available batteries, both disposable and rechargeable. Only a lithium-thionyl chloride cell, with an open-circuit voltage of 3.7 volts, has a higher energy-density—and it's not rechargeable! The drawbacks to lead-acid batteries—leakage, highly corrosive acid electrolyte, evaporation, and a host of other problems—have been eliminated in the designs of more modern cells. Lead-acid batteries come in a variety of sizes, voltages, and energy capacities and have characteristics that make them the ideal energy source for applications requiring the use of rechargeable batteries.

So, you may well ask, if they're so wonderful why aren't they more available? The answer to that is...Well, I haven't the vaguest idea and would appreciate finding out why. Possibly the answer has something to do with the ready availability of nickel-cadmium batteries, the other major type of rechargeable battery. Before we start comparing the two technologies, let's take the time to find out how each is used. Once that's done, we'll list the advantages and disadvantages of both types and you'll be able to make your own decisions.

Lead-acid batteries are easy to use. Anyone who owns a car knows that those batteries can operate successfully under the most adverse conditions and are extremely forgiving when it comes to things like accidental deep discharge and constantly repeated partial discharge.

Figure 6 is a cutaway view of a typical lead-acid cell. Although there are variations from manufacturer to manufacturer, most of the batteries use the basic construction shown. The electrolyte is an acid that is permanently sealed in the body of the cell. It's worth nothing at this point that that technique (permanently sealing in the electrolyte) is starting to be found in car batteries as well. Some companies that make lead-acid batteries "immobilize" the electrolyte by gelling it. This means that the cell can be used in any position without any risk of the electrolyte leaking out. Even though the construction of the cell usually involves several heavy-duty seals and double-walled insulation, the acid is extremely corrosive and anything that helps maintain the integrity of the battery is a good idea.

Rechargeable lead-acid batteries are available in voltages ranging from 2 to 24 volts and they can be used in any configuration you want. Unlike some other batteries, you can either parallel them to increase the current or put them in series to increase the voltage. Since the energy density in lead-acid cells is very high, you can get really impressive amounts of power by packing together a number of

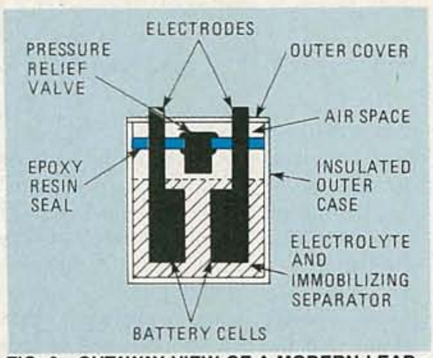

FIG. 6—CUTAWAY VIEW OF A MODERN LEAD-ACID CELL. Some batteries use a gelled electrolyte.

TABLE 4—LEAD-ACID BATTERY CHARGING PARAMETERS

Type of charge	Charging voltage (volts DC per cell)	Charging current (percent of cell capacity)	Charging time
RAPID	2.55 - 2.65	100%	1 - 3 hours
QUICK	2.50 - 2.55	20% - 50%	12 - 20 hours
STANDARD	2.45 - 2.50	10% - 40%	10 - 18 hours
TRICKLE	2.28 - 2.32	10% - 20%	Continuous

cells. And how much power the battery can deliver has nothing to do with how the battery was used previously.

A battery that is normally charged after only a small part of its stored energy has been used can still deliver its total power whenever the situation calls for it. That is a common scenario in applications where rechargeable batteries are used as emergency backups in case the primary power fails. Batteries that are constantly charged can similarly always be counted on to deliver their full power if the circumstances require it. In other words, lead-acid batteries have no "memory" of their previous use.

The charging circuits for these batteries can be as simple or sophisticated as you like. They are capable of being charged at extremely high rates if the proper safeguards are taken. How you charge them depends on how you plan to use them. Table 4 gives you the recommended charging rates and other information you'll need to be able to safely recharge the batteries. It's important to stay within the guidelines shown—overcharging can have catastrophic results.

Even though the chemistry of the cells is designed to be reversible (which is what makes the cells rechargeable), overcharging them carries the same sort of dangers as trying to charge the throw away batteries we discussed last month. During the charging cycle of *any* battery, gas is produced. A major functions of the electrolyte is to act as a "depolarizer"—a rather fancy way of saying that it's designed to absorb the gas produced during a charge. However, and this is a really big however, the electrolyte can only absorb gas at a certain rate. If the gas is produced faster that it can be absorbed, then **BOOM!**. Good-bye battery and anything else that happens to be around *and that can include you, too!* Make sure you don't exceed the recommendations for the charging rates and times given in Table 4. A lot of batteries were blown up to compile those figures.

Nickel-cadmium batteries

Nickel-cadmium (NiCd) batteries are the most popular rechargeable batteries on the market today. They are packaged in all the standard sizes and the cell's open-circuit voltage is 1.25 volts (which makes them a close match for most of the applications where throw-away batteries are used.) Prices depend on where you buy them but, in general, it's safe to say that they're more expensive than alkaline and lead-acid batteries, but cheaper than lithium and silver-oxide batteries. The voltage-discharge curve is nice and flat, meaning that the battery will have a constant voltage for most of its discharge cycle. Unlike lead-acid cells, nickel-cadmium cells are not designed to be used in a parallel configuration. The normal method of use is to decide what your current requirements are and then get cells of the needed ampere-hour capacity and connect a number of them in series to build up the voltage you need for your system.

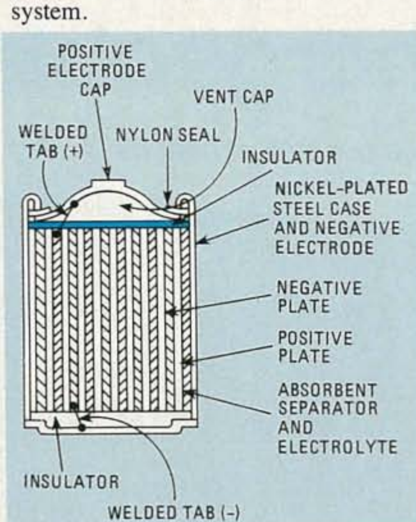

FIG. 7—A NICKEL-CADMIUM CELL consists of nickel and cadmium strips wound together and separated by absorbent nylon.

Figure 7 is a cutaway view of a typical cylindrical NiCd cell. The nickel anode and cadmium cathode are made in strips that are wound together into a coil with an absorbent nylon separator between them. The separator is used to absorb the alkaline electrolyte. It is also permeable to oxygen (the gas produced during the charge cycle). The assembled battery is packed into the outer case, usually made of nickel-plated steel, the external positive and negative contacts are welded to the electrodes, and the cell is finally sealed. The seals keep the electrolyte from drying out and are designed to act as pressure-relief valves. If the internal buildup of gas gets excessive, the seal will open and vent the extra pressure. How well the battery functions afterward depends on how much electrolyte is lost. In any event, you can bet that the battery will be but a shadow of its former self.

The internal resistance of the average NiCd cell is very low—usually less than 100 milliohms—which means they can be used in circuits where high discharge-rates are required. Some NiCd cells, however, are specifically designed with a higher internal resistance that, although lowering the maximum discharge rate, increases the cells ability to retain a charge. Button cells and 9-volt "transistor battery" substitutes are usually manufactured like that. The internal resistance of the cell is a good guide to the charging rate: The higher the value, the lower the charging rate. The most common cause of NiCd cell failure is an improper charging rate.

A dead NiCd will be either an open or short-circuited cell. Open circuits are usually the result of electrolyte loss and this is directly caused by constant rapid discharging, constantly high charge-rates, or anything else that will make the cell blow its seal. Remember that by the time the cell parameters are exceeded enough to make the seal open, the high current rate that caused it in the first place will have made the battery heat up, and that will make the electrolyte evaporate at a greater rate. In any event, there's no way to replace the electrolyte, so if you measure the internal resistance of the battery with a multimeter and find it to be an open circuit, the battery is gone forever.

Short-circuited cells are another story. Sometimes the separator will get ruptured and metallic salts will form a small bridge that shunts the current around the rest of the plate. A high current pulse can burn out the short and the cell can then be charged, since the correct current path has been restored. Commercial "zap" circuits use this technique by charging a large capacitor and then discharging it through the cell. If you monitor the battery's voltage, you'll see the voltage start to increase as all the internal shorts are cleared out. If the separator has deteriorated in the cell, the battery is beyond salvage and should be replaced.

Reoharging batteries

So now that we know everything about lead-acid and nickel-cadmium cells, let's find out about how to charge them. The circuits needed can be as sophisticated—or as simple—as you like. Which circuit you want to use depends on which cells you use, now fast you want to charge them, and how you want to use them.

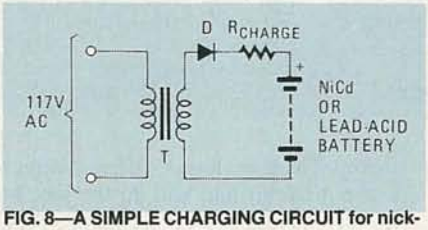

FIG. 8—A SIMPLE CHARGING CIRCUIT for nickel-cadmium or lead-acid batteries.

The simplest charging circuit you can have is illustrated in Fig. 8. Calculating the resistor value and which diode to use is simple. First, let's lay down some general guidelines. The transformer you use should have a voltage at its secondary at least twice the open circuit voltage of the battery you want to charge and the diode should have a PIV (*P*eak *I*nverse *V*oltage) rating at least twice that. The resistor has to be able to handle the charging current at the open-circuit voltage of the battery. To be on the safe side, let's use the voltage of the transformer's secondary. Now that we have those things out of the way, let's use Ohm's law to fill in the blanks.

$$V_{system} = V_{transformer} - (V_{battery} + V_{diode})$$

$$R_{charge} = V_{system}/I_{charge}$$

$$WATTAGE_R = V_{transformer} \times I_{charge}$$

The key here is deciding what you want the charging current (I_{CHARGE}) to be. The rate of current flow through a rechargeable battery is referred to in terms of the total capacity of the cell. The rate of charge or discharge for a particular battery is usually given in the C-rate. The C-rate is the current rate in amperes numerically equal to the rated minimum amp-hour capacity. If the recommended charging rate for a cell is listed as 0.1C, for example, that would tell you that the maximum current you can use to charge the battery is numerically equal to 1/10 the total amp-hour capacity of the cell. If the cell was rated at 500 milliamp-hours, 0.1C would translate into a charging current of 50 milliamps.

Table 5 shows the various rates of charge and how long it will take to fully charge a cell. It's important to remember that not all cells can be charged at the higher rates. Nickel-cadmium cells are too expensive to risk destroying by impatience. All the cells, however can withstand the standard 0.1C rate. But let's get back to our example.

If we're going to charge a 4.8 volt series of batteries that have a 1.2 amp-hour capacity at the standard 0.1C rate and are using a transformer with a 9 volt secondary:

$$V_{system} = V_{transformer} - V_{battery} = 9 - 4.8 = 4.2 \text{ Volts}$$

$$I_{charge} = 0.1C = (0.1)(1.2) = 120mA$$

$$R_{charge} = V_{system}/I_{charge} = 4.2/.12 = 35\Omega$$

$$WATTAGE_R = (V_{transformer})(I_{charge}) = 9 \times .12 = 1.08 \text{ WATTS}$$

Finding a resistor with a rating of 1.08 watts is going to be difficult, so let's make a general rule: we'll always bump the value up to the next available size. That means a 35-ohm, 2-watt resistor. The PIV rating of the diode has to be at least twice the transformer secondary or 18 volts and it has to be able to handle at least .12 amps. Any of the family of 1N4xxx diodes is a good choice for the circuit. In this particular case, the 1N4001 is fine. It should be noted that we did not take the voltage drop across the diode into account when we calculated the parameters of the circuit. Since the diode drop is going to be small compared to the other voltages, and our assumptions have built-in safety margins, it can reasonably be ignored. If you're building a charger for battery systems that have lower voltages and are looking for larger charging currents, the diode drop should be considered in calculating the overall system voltage. By the same token, if the charging current you need is really small, the diode's forward resistance will have to be taken into account and subtracted from the calculated value of the current limiting resistor. If the value of the calculated resistor is small enough you can do away with it altogether and let the diode serve as the current limiter.

A more efficient charger can be built using a full-wave rectifier. The math is exactly the same as in our example. Just get the values of the circuit parameters and plug them into the formulas. More elaborate chargers will monitor the state of charge of the battery and automatically switch over to trickle charging when the battery is fully charged. These circuits are used when the initial charge rate is going to be in the "quick" or "rapid" range. How the circuit is put together will depend on the batteries that are being charged and what the initial charging rate is going to be. The actual design of these circuits is involved because it's a good idea to have several levels of protection for the battery. That way if the primary switchover circuit fails, other parts of the circuit will save the day.

TABLE 5—NICKEL-CADMIUM BATTERY CHARGING PARAMETERS

Type of charge	Charging voltage (volts per cell)	Charging current (percent of cell capacity)	Charging time
RAPID	Depends on Cell	Depends on Cell	1 - 3 hours
QUICK	2.50 - 3.00	20%	3 - 5 hours
STANDARD	2.50 - 3.00	10%	14 hours
TRICKLE	2.50 - 3.00	5%	Continuous

The dangers here shouldn't be minimized. If you overcharge a cell at a high rate of charge, you can, of course, kiss the battery good-bye. But we've already seen that you're running the risk of explosive rupture of the cell from the accumulated gas and that can destroy a lot more than just the battery. I overcharged a 20-milliamp NiCd button cell—the smallest nickel-cadmium battery you can buy. When it exploded it blew a hole in the side of the charger's plastic case! Be warned and be careful to follow the manufacturer's recommendation.

There have been charging circuits published repeatedly in any number of magazines, data books, and so on. Look them up and decide which one you want to use in your particular application. I can offer you a few general rules and a couple of useful tips.

The overall system voltage in your charging circuit will decrease as the cell charges up and the current flowing in the circuit will, naturally enough, start to drop until it reaches a steady state. This is because a discharged cell will rapidly regain enough energy to be at its nominal voltage.

For this reason you shouldn't be alarmed if you measure the current flow in your circuit and find it a lot higher at the beginning of the charge cycle. It will soon drop to a point as close to your calculated value as your component values are close to their calculated values. If your charger is designed for the standard rate, you shouldn't have any problems.

If you use a full-wave rectifier and put the current-limiting resistor between the transformer and the rectifier, you will have a variable-current charger. Current flow will continue to decrease as the cell takes on more and more of a charge. That circuit arrangement is shown in Fig. 9. Figure 10 is a handy circuit that you can use to monitor the current flow. If it looks familiar, it's because you've already seen it in the June installment of the "Designer's Notebook" and you'll find a full description of it there.

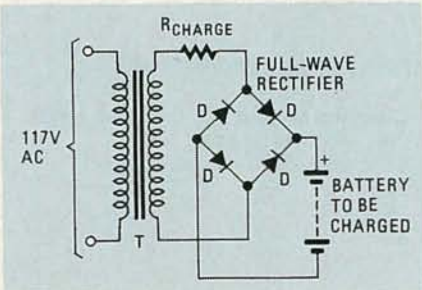

FIG. 9—AS THE BATTERY CHARGES, the current rate will decrease.

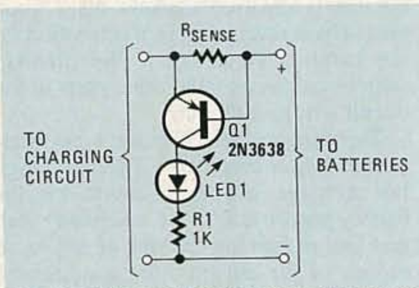

FIG. 10—YOU CAN MONITOR THE CHARGING CURRENT with this simple circuit.

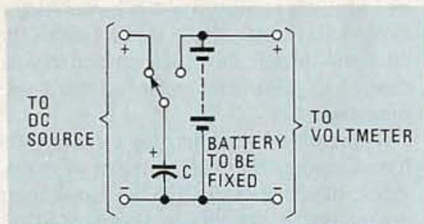

FIG. 11—YOU CAN CLEAR SMALL SHORT-CIRCUITS made up of metallic salts in NiCd batteries.

TABLE 6

Parameter	Lead-acid batteries	Nickel-cadmium batteries
Memory	None	Requires Reconditioning
Current Capacity	Generally in Amperes	Generally in Milliamps
Cost	Moderate	High
Weight	Generally over 1 pound	Generally under 1 pound
Configurations	Parallel or Series	Series Only
Availability	Hard to Find	Available Everywhere
Shelf Life	50% Loss in 8 Months	50% Loss in 3 Months

Basically the small voltage across R_{SENSE} turns on Q1 and the transistor turns on the LED. (Anything you want can be substituted for the LED. A relay, for example could put another resistor in series with the current-limiting resistor and cut the charging current down to a trickle charge.) The formula for calculating the value of R_{SENSE} is: $R_{SENSE} = 0.65/I_{CHARGE}$, where 0.65 volt is the voltage needed to turn on the transistor. If you're really a whiz at working out circuit parameters, you could get the value of R_{CHARGE} to equal R_{SENSE} and do the whole job with just one resistor. I can't work things out for you because the values for the components depend on the batteries you use, the charging rate, and many other factors. If you're careful though, you should be able to build yourself a charger that has several charging rates and can automatically switch over to over to trickle charge when a predetermined point is reached.

Rapid charging of cells should not be tried unless the cell is specifically designed to handle very high charging-currents and lots of safeguards are built into the charger. This kind of charging takes place under *very* controlled conditions. The usual method of operation for this kind of charger is to monitor the *temperature* of the cell and switch to a trickle charge, (or completely off), when the temperature of the cell reaches a certain level. Thermistors and other temperature-sensing components monitor the cell and control logic that switches the charger to a lower rate.

We've already discussed how battery "zapping" can be used to try and clear out small internal shorts and revive cells that are apparently dead. Figure 11 is the basic circuit that's used. When the switch is thrown to the left, the capacitor charges, and when the switch is thrown to the right, the capacitor discharges through the theoretically dead battery and, we hope, burns out the small bridges of metallic salts that are shunting the current in the cell.

If the cell can be saved, after you blast it a few times you should see the voltage starting to rise on the meter. Once that happens, give the cell a few more hits and then charge it normally. It won't be as good as a good cell, but then again, it won't be as bad as a bad cell. You'll notice that I haven't given you any value for the capacitor. Well, the voltage rating should be *at least* as much as the largest voltage in the system, (either the battery or the source), and the capacitance should be as big as you can get. This is one of those instances where bigger *is* better. The more capacitance you have, the larger the blasting current is going to be and the more chance you're going to have of resuscitating the battery.

Our last helpful hint has to do with one of the most common uses for rechargeable cells: memory retention and emergency backup. There are lots of different ways to design a circuit that will do the job, but the basic idea is shown in Fig. 12. When the DC voltage source is present, the batteries charge through R, the current-limiting resistor (because the diode is reverse biased). When the main power supply fails, the diode is forward biased and the NiCd batteries provide power to the load. The calculations for finding the value of R and the considerations for choosing the diode are exactly the same ones we discussed for our simple charger. There are other, more elaborate schemes for using rechargeable batteries like this, but they all use this approach. Diodes are used to steer the current where you want it and the biasing of the diodes is switched by the presence or absence of the main power supply.

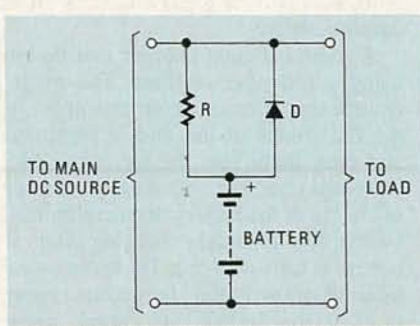

FIG. 12—ONE OF THE MOST POPULAR applications for rechargeable batteries is backing up power supplies.

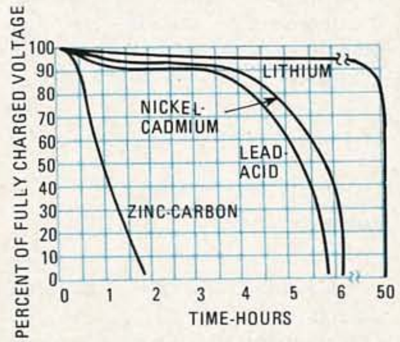

FIG. 13—VOLTAGE DISCHARGE CURVES for various types of batteries discharged at the 0.2C rate. Note the break in the hours scale.

We now come to the question of which battery type you should use. Well, the answer is, as we saw with disposable batteries last month, it depends. As a general rule, lead-acid batteries are used where the current draw is going to be heavy and NiCd's are used where it's not. Now I know that these are all relative terms but, like I said, it depends. For practical purposes, let's just say that if the current draw is going to be consistently in the multi-ampere range, go for lead-acid. If it's under an amp, look at NiCd cells. The relative merits of each system are summed up in Table 6 and the voltage-discharge curves for some of the various batteries are shown in Fig. 13. I've put in the curves for some of the lithium-based batteries as well as the zinc-carbon ones so you can make an overall comparison.

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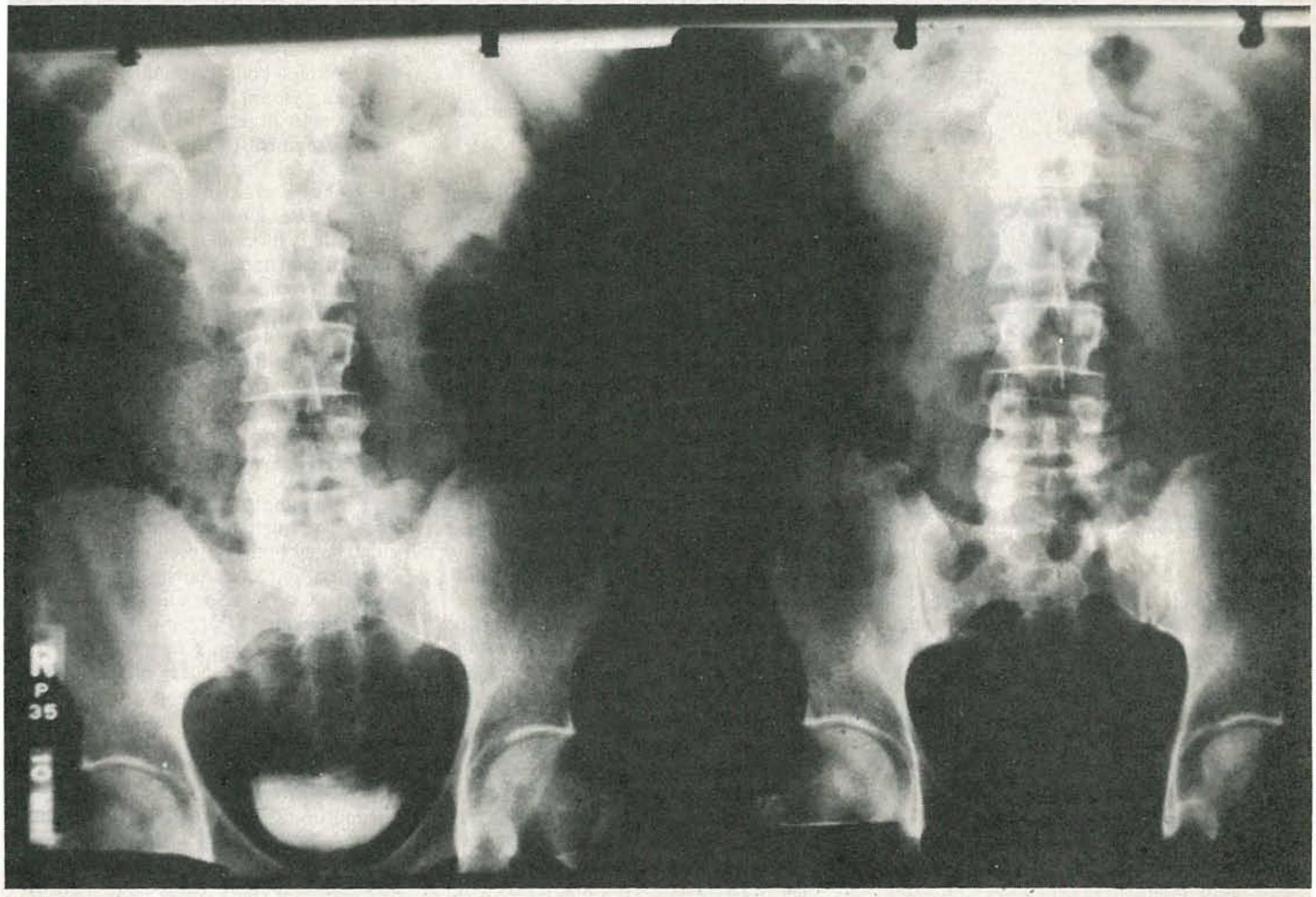
ALL ABOUT

Electronics In Medical Imaging



Various imaging techniques, such as X-rays and CAT scans, are commonly used in medicine. In this article, we'll take a look at those techniques and the role electronics plays in them.

Ray Fish, Ph.D., M.D.

MEDICAL IMAGING IS USED TO DISPLAY the structure and function of the body. It is used to obtain information about the status of a healing fracture, the presence of a tumor, the ability of the kidneys to remove substances from the blood, the presence of bleeding in the head, and the flow of blood through arteries and veins. Electronics has played an important role in medical imaging in the past, and that role is steadily increasing. In this article we will discuss medical imaging techniques such as conventional X-rays, fluoroscopy, linear tomography, computerized tomography, and ultrasound.

X-rays

X-rays are produced when a tungsten target is bombarded by an electron beam of sufficient energy. In 1895, Professor Roentgen discovered that X-rays were capable of penetrating living tissue and making images of it appear on fluorescent surfaces.

Photographic film itself is relatively insensitive to X-rays. In order to overcome that, the film is placed in a "cassette" that holds a fluorescent screen close to the X-ray film. When struck by X-rays, the fluorescent screen emits light that blackens the film. If an object prevents X-rays from reaching the film and fluorescent screen, the film remains transparent (light) in appearance at such points.

Figure 1 shows the arrangement used to take a conventional X-ray picture. Exposure parameters vary according to the size of the person. A standard chest X-ray will use an exposure time of about 1/40 second, an X-ray tube voltage of 120 kilovolts, and a current of 400 milliamperes. The exact exposure time is determined automatically in many systems by an X-ray sensitive detector behind the film and screen. Note that the X-ray beam is divergent; it is cone-shaped and increases in size as it travels from its source. Therefore distances between the film, the patient, and the source of radiation will affect the size of images seen. For that reason, standardized techniques must be used when taking pictures to avoid confusion.

Figure 2 shows a conventional chest X-ray. Air permits the greatest amount of radiation to reach the film cassette. The lungs contain much air, hence they are the darkest area on the X-ray. Decreasing

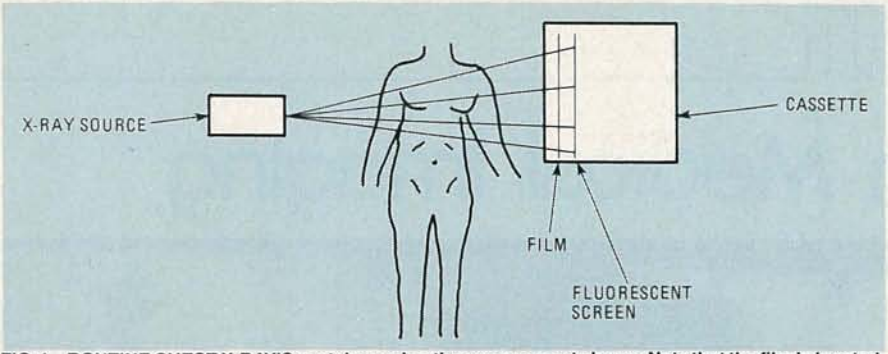


FIG. 1—ROUTINE CHEST X-RAY'S are taken using the arrangement shown. Note that the film is located in a cassette that also has a flourescent screen.

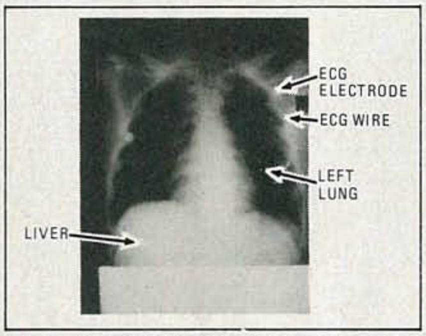


FIG. 2—A CHEST X-RAY. Since air allows the maximum amount of X-rays to reach the film, the lungs show up as a dark area.

amounts of radiation are able to penetrate soft tissues, bone, and metal. All material between the X-ray source and film contributes to the image regardless of the distance of the material from the film. For example, a rib on the front of the chest will be imaged about the same as a rib on the back of the chest.

Tomography

Figure 3 shows a method of obtaining images at a certain depth inside the body. That technique is called conventional tomography and has been in use for many years. In conventional (non-computerized) tomography, the X-ray source and film are moved simultaneously for several seconds as the picture is being taken. The geometry is arranged such that tissue densities at a certain distance from the film will remain in focus at all times during the X-ray exposure, while tissue densities in other planes will be smeared broadly across the film. That type of tomography is relatively inexpensive and is useful even though it does not produce as clear an image as computerized tomography. Computerized tomography (which will be discussed below) is more sensitive to small differences in tissue density and has a finer resolution (smaller objects and smaller details can be seen).

Figure 4 compares images obtained by conventional tomography (Fig. 4-a) and conventional X-rays (Fig. 4-b). Different levels in the body are displayed in separate images in conventional tomography, showing detail not visible in a standard X-ray.

It is possible to put substances inside the body that strongly block X-rays. One can inject liquids called contrast agents into arteries, veins, and various body cavities. If placed into an artery, an arteriogram is obtained. Contrast agents injected into a vein will allow an X-ray to be taken that will show the vein, as seen in Fig. 5. Blockage in branches of an artery or vein can thus be seen. Blockages can occur when materials are deposited on the inner wall of an artery. Those form a relatively solid mass called a plaque. That is especially important when the coronary arteries that supply blood to the heart muscle are involved. People often have chest pain from partial blockage of the coronary arteries. Similarly, partial blockage of the arteries supplying the legs may cause leg pain with walking. Partial blockage of the arteries supplying a kidney can cause high blood-pressure (hypertension). Blockage of arteries and veins can also occur because of blood clots, foreign bodies, or injury.

When a partial blockage of an artery is discovered, surgery can be performed to place a segment of vein in parallel with the blockage. That allows blood to bypass the blockage via the vein. Alternatively, in some cases a balloon can be placed in the partially blocked blood vessel and inflated. The material obstructing the vessel will be compressed into the walls of the vessel. Those techniques permit normal blood flow and cause relief of symptoms. In patients with certain types of coronary artery blockage, coronary bypass surgery is used to prolong life.

The kidneys normally remove many substances from the blood. Contrast agents can be injected into a vein in the arm, a simple procedure. The contrast agent will then travel through the circulatory system and eventually be concentrated and excreted by the kidneys. Kidney X-rays, also called intravenous pyelograms or IVP's can then be taken. The functioning and structure of the kidneys, ureters, and bladder can be studied using an IVP. While many kidney stones will not show on an X-ray, they can be seen in an IVP.

Flouroscopy

Fluoroscopy is imaging that occurs when X-rays strike a surface that emits light as a result of X-ray exposure. Image intensifiers used in fluoroscopy can increase the amount of light seen and de-

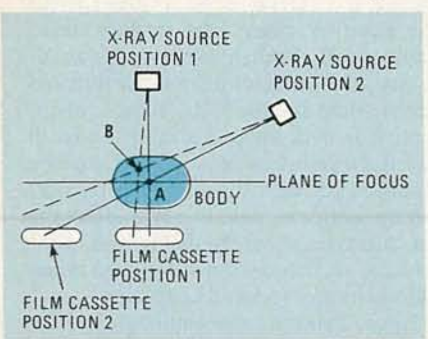


FIG. 3—CONVENTIONAL TOMOGRAPHY. In this technique, the X-ray source and the film cassette move in such a way as to keep all the structures in one plane in focus.

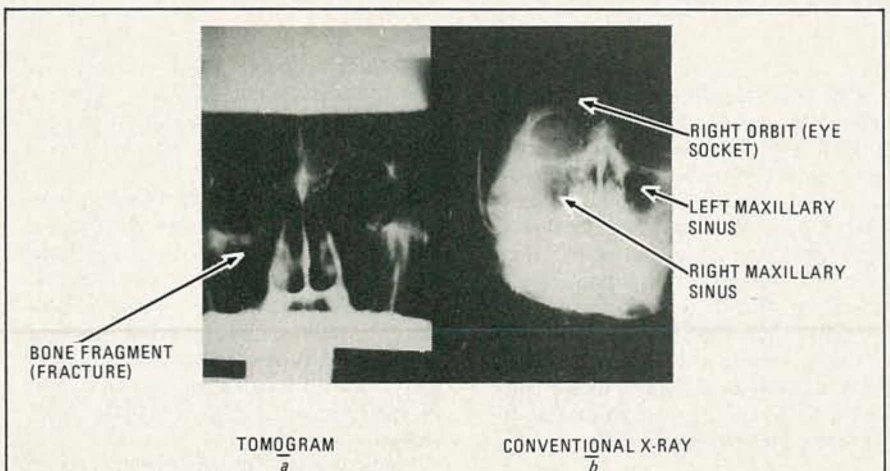


FIG. 4—A BONE FRAGMENT that shows up in the tomogram in *a*, does not show up in the conventional X-ray shown in *b*.

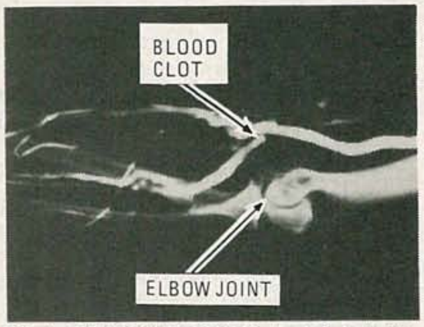


FIG. 5—IN THIS VENOGRAM, dye is injected to help pinpoint the location of a blocked vein.

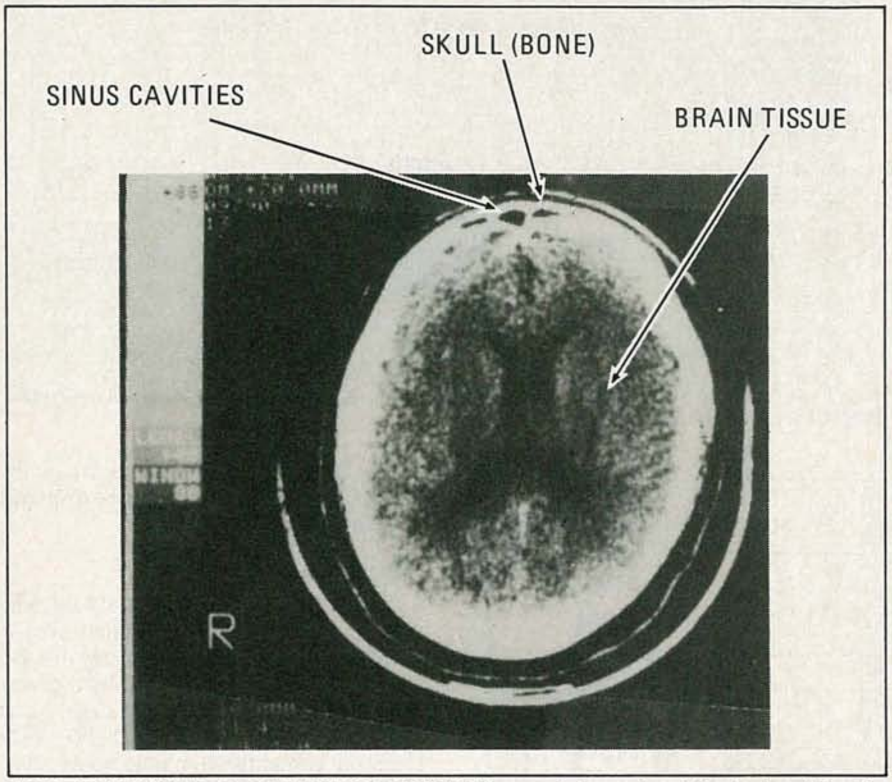


FIG. 6—A COMPUTERIZED AXIAL TOMOGRAPHY (CAT) scan of a human head. One horizontal level is shown here.

crease by a factor of 1000 the amount of radiation needed to give a useful image. Image-intensifier tubes have a fluorescent screen that emits light when struck by X-rays. That light causes electrons to be emitted from a light-sensitive surface that is just behind the fluorescent screen. Those electrons are attracted to a second fluorescent screen by a high voltage, producing a brighter image than the one on the first fluorescent screen. The second fluorescent screen may be looked at directly or may be viewed by a television camera.

Use of a television camera permits magnification, image enhancement, image recording, and other image processing to be done by standard video equipment. X-ray images can be stored in a digital memory. It is possible that in the future, most X-rays will be taken with fluoroscopic equipment and be stored on videodiscs or videotape, rather than on large, expensive pieces of film. Thousands of separate X-ray pictures could be recorded on one videodisc or videotape.

Digital subtraction angiography

Digital subtraction angiography is a technique that allows imaging of arteries without injecting contrast material directly into them. Without digital-subtraction techniques, it is necessary to inject a liquid contrast material directly into an artery that is to be imaged. X-rays are taken when the contrast material is in the artery.

If the artery being studied is deep in the body, a catheter must be placed near the artery and the contrast material injected. For example, the renal (kidney) arteries are often examined. That involves placing a catheter near the kidneys by threading it through an artery, such as the femoral artery in the leg. That procedure is uncomfortable, is difficult to perform, and has the risk of complications. Complications include infection or bleeding at the site the artery is punctured. Also, the catheter may knock a plaque off the wall of any artery it passes through (such as the aorta between the groin and the kidney). A plaque knocked loose by a catheter will travel through the blood stream and eventually cause occlusion of a branch of the artery. That causes a lack of blood in the area supplied by the artery. If that area is in the brain, for instance, the person will have a stroke. Such complications caused by the insertion of a catheter are fortunately infrequent (about 0.1% of cases), but the cost and discomfort of arteriography do affect every patient.

With digital subtraction angiography, the need for an arterial catheter is eliminated. With the subtraction technique, an X-ray image of the area containing the artery of interest is obtained and stored in a digital memory. A contrast agent is injected into a vein in the arm, a simple, relatively safe procedure. A small percentage of the contrast agent will travel to the artery of interest, but not enough to cause an image to form on a plain X-ray. A second X-ray image is taken and stored in digital memory. The first image is then subtracted, point by point, from the second image. Structures that were the same when the two pictures were taken cancel out.

The image remaining is that caused by the circulation of the small amount of dye through the artery during the second picture. An image similar to a standard arteriogram is thus obtained without the cost, discomfort, and dangers of arterial catheterization. If there is movement between the two pictures, the images will not line up properly. Taking multiple pictures before and after the injection and choosing those that give the best image is sometimes done. Digital subtraction angiography is of limited use in imaging the coronary arteries because the heart moves about significantly. As digital subtraction angiography equipment becomes more refined and less expensive, it is expected that it will gradually replace conventional arteriography equipment in many applications.

Computerized axial tomography

Computerized axial tomography (CAT) is a technique that can obtain images of slices of tissue a few millimeters thick. That technique is very sensitive to differences in X-ray absorption of tissues. Conventional X-rays and tomograms are incapable of detecting the differences in X-ray absorption of soft tissues and fluids (such as blood, brain tissue, and water). Computerized axial tomography can be used to detect those differences (see Fig. 6).

If surgery is needed to correct bleeding inside the head, the CAT scan will usually show that. Arteriography was necessary to detect bleeding in the head before the CAT scan was available. The arteriography dye was injected into the carotid arteries that supply blood to the head. Arteriography is difficult, expensive, and uncomfortable. The CAT scan is safer than arteriography, without discomfort, and easy to perform. On the other hand, one drawback to CAT scans is that they are still somewhat expensive.

The CAT scan is performed by having one or more sources of X-rays and multi-

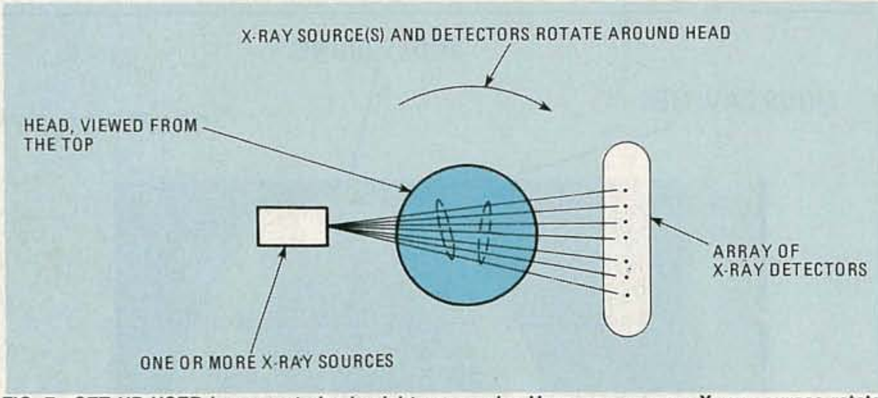


FIG. 7—SET UP USED in computerized axial tomography. Here, one or more X-ray sources rotate around the part of the body being scanned.

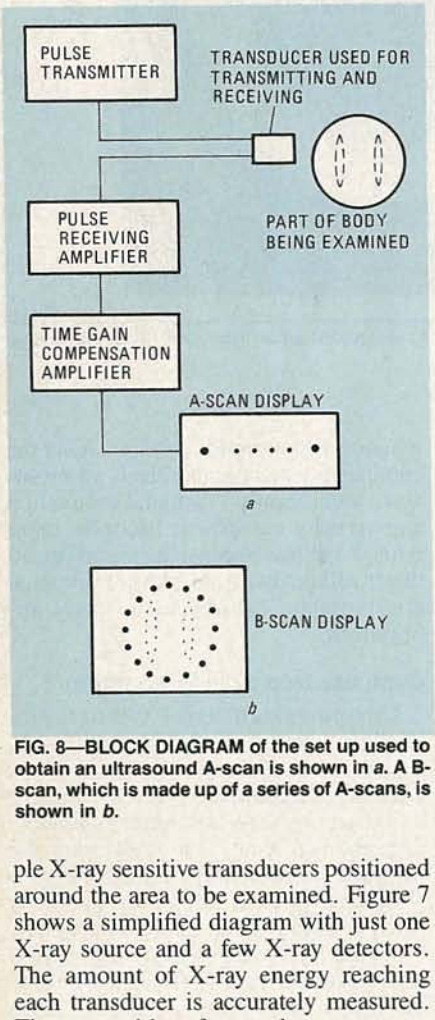


FIG. 8—BLOCK DIAGRAM of the set up used to obtain an ultrasound A-scan is shown in *a*. A B-scan, which is made up of a series of A-scans, is shown in *b*.

ple X-ray sensitive transducers positioned around the area to be examined. Figure 7 shows a simplified diagram with just one X-ray source and a few X-ray detectors. The amount of X-ray energy reaching each transducer is accurately measured. The assembly of transducers rotates around the area, taking measurements along many lines that pass through the plane being examined. Tens of thousands of measurements are made. The plane is divided into picture elements (pixels). A computer notes which lines crossed through which pixels and how much energy got through the tissue each line crossed. Having that information, the X-ray density (or the absorption) of each pixel can be calculated. In practice, the calculation of pixel density is too time-consuming, but computers can make approximate solutions and fit them to the data. Once that task is completed, an image made up of the pixels can be displayed by the computer.

Ultrasound

Ultrasound is sound that is at a frequency too high to hear. Ultrasound used in medicine usually has a frequency of 1 to 5 MHz. Ultrasound is emitted by a crystal transducer that is placed on the skin. A jelly-like material is placed between the transducer and the skin to increase transmission. A portion of the transmitted ultrasound is reflected back to the transducer when an interface between different tissues is met. Thus, after a short pulse of ultrasound is emitted, a series of echoes is received, as shown in Fig 8-a. That tracing is referred to as an A-scan. The strength of individual echoes depends on the differences in mechanical properties of the tissues at each interface. For example, when a pulse crosses the boundary between muscle and blood, about 0.1% of the energy is reflected. The remainder of the energy continues on to image deeper structures.

The attenuation of ultrasound increases with frequency. For most soft body tissues, the attenuation coefficient is about 1 dB/cm/MHz. A structure 5 cm deep in the body will attenuate a 3.5-MHz signal 35 dB. A 10-MHz signal will be attenuated 100 dB. To compensate for the decrease in signal strength with depth, a time (or distance) gain control (TGC) system is used to pre-process the signal from the transducer. Signals received further in time after the transmitted pulse are amplified more. A series of gain switches are present on some ultrasound machine panels so the technician can set the gain at various depths to obtain a picture that continues to show tissue interface reflections despite the attenuation of the signal that occurs due to depth and various intervening structures.

Higher frequencies give a finer picture resolution because it is not possible to resolve structures smaller than about a wavelength in size. The wavelength at 1.5 MHz is about 1 millimeter. Higher frequencies are desirable unless the signal must travel so deep into the body that it will be attenuated too much. Frequencies up to 15 MHz are used to examine the eye and other small body parts. Frequencies around 3 MHz are used for deep abdominal imaging.

The angle the tissue interface makes with the direction of the ultrasound beam may cause deflection of the beam in another direction. Successive echoes decrease in amplitude because the energy of the ultrasound is absorbed by the tissue as well as being reflected and refracted.

The mechanical properties of air and bone differ from those of soft body tissues so much that, for practical purposes, ultrasound does not penetrate air and bone. That inability to penetrate air and bone obviously limits the use of ultrasound greatly.

Despite significant absorption and refraction, useful images can be obtained using ultrasound. A two-dimensional picture, called the B-scan (see Fig. 8-b), is produced by displaying many A-scans simultaneously. Those are produced using a rapidly vibrating or rotating transducer that emits hundreds of pulses per second. That technique can be used to produce a real-time picture. Alternatively, a storage-type display can be used. In that technique, the transducer is moved manually by a technician and successive images are retained on the display, producing a picture. The quality of the picture that results from that technique can vary greatly because it depends on the skill of the technician.

B-scan ultrasound machines produce images that can be stored in a computer memory. Some commercially available machines have pictures with 16 gray levels. The images can be frozen, magnified, measured electronically, and photographed. A movable dot (cursor) can select an area to be examined for overall movement (such as a heartbeat) or for blood flow.

Some B-scan ultrasound machines have two movable dots (calipers) that can be positioned anywhere on the screen by a joystick. A digital readout of the distance between the two dots is displayed. That is useful for such things as measuring the head size (called the biparietal diameter) of fetuses. The biparietal diameter is related to the age of the fetus. Some ultrasound machines are made specifically for obstretics. With those ultrasound machines, the heartbeat of a fetus can be monitored, for instance along with other physical data.

The screen containing the B-scan image in some machines will display the patients' name and other data so the photograph will not need further labeling or get mixed up with other patient's records. The patient's name and information about exposure settings is displayed on CAT images in a similar manner. **R-E**

OCT. 1984

RECEIVING Satellite® TELEVISION

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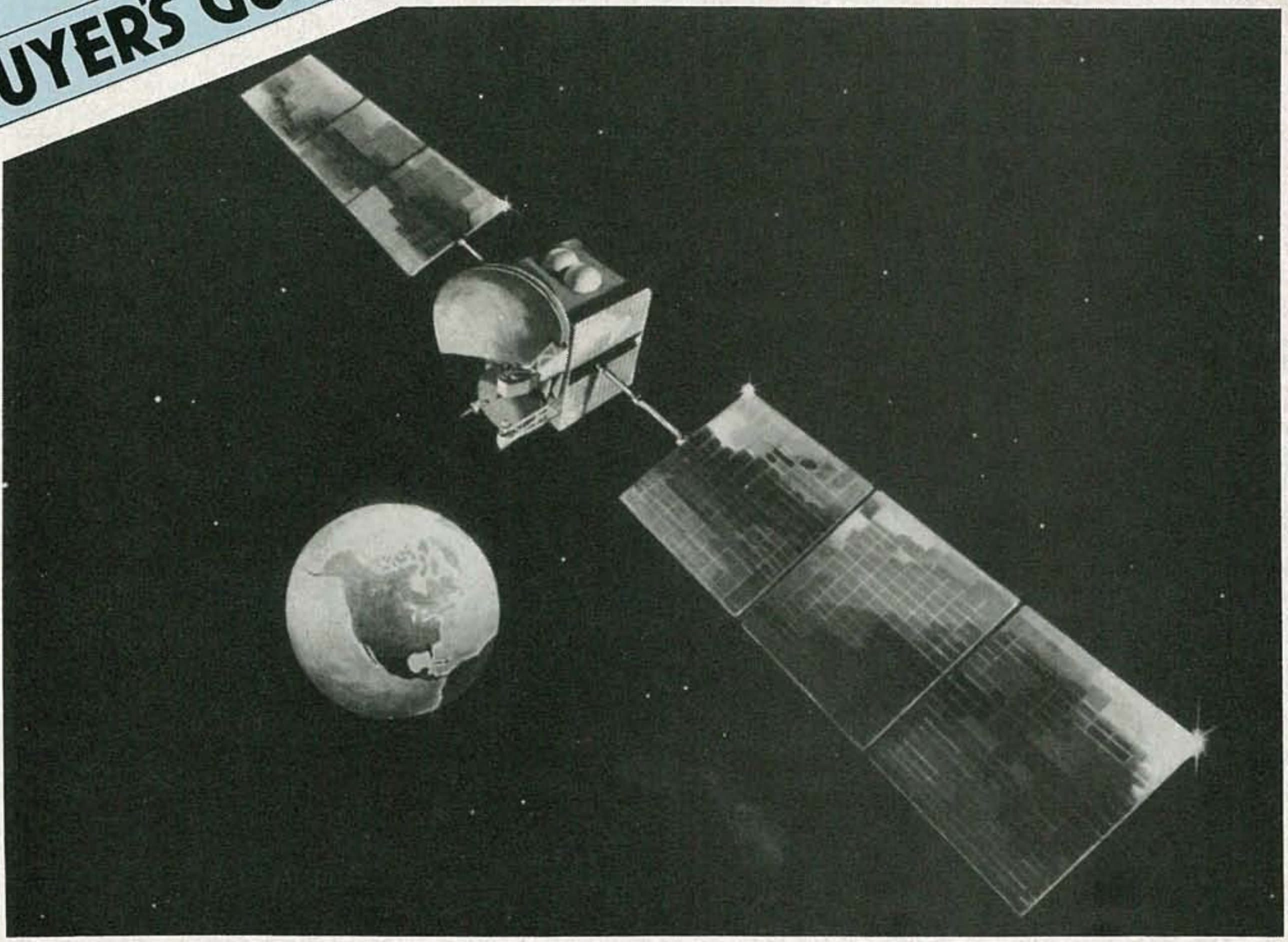
Satellite-TV Receivers

The Dish

Feedhorns, Waveguides, and LNA's

BUYER'S GUIDE



Satellite-TV Basics

By MARC STERN

Here's a quick review of some important satellite-TV basics.

THERE'S LITTLE DOUBT THAT ONE OF THE hottest areas of consumer electronics is satellite-TV reception. In this special section, we will be taking a look at the current state of the market, and what equipment is out there for the budding satellite-TV enthusiast. Before we do that, however, it might be a good idea to review some basic satellite-TV concepts and terms.

Satellite concepts

The satellites used for satellite TV are *geostationary*. That means that they are placed in an orbit 22,279 statute miles above the equator. The speed of a satellite placed into such an orbit matches the speed of the rotation of the earth and thus appears to stand still in relation to the spot beneath it.

The purpose of satellites used for TV is to receive signals from an *earth station*, a communications facility that is capable of both reception and transmission, and retransmit them back to earth. On earth, the signals can be received by other earth stations, or by *TVRO's* (*Tele*Vision *R*eceive *O*nly). Home setups are TVRO's.

Satellite-TV operates at microwave frequencies. There are two primary bands in use. The *C-band*, the one most often used by cable companies and others to distribute their programming, spans the frequencies from 3.5 to 6 GHz, while the *Ku-band* is located between 12 and 14 GHz.

The signal strength of a satellite-TV signal will of course vary with location. A chart of the signal strength at various points on the map can be made. That chart is called a *footprint*, and is shown in Fig. 1. Naturally enough, the area of maximum signal strength is located at the center of the footprint; that area is known as the *boresight point*.

As mentioned earlier, satellites orbit above the equator, in what is known as the equatorial plane. They are located in that plane between 79° and 143° west longitude (see Fig. 2). At the moment, there are 16 U.S. and Canadian satellites occupying slots in that orbit. Those slots are separated by about 4 degrees of arc, which is about 1838 miles. The reason for

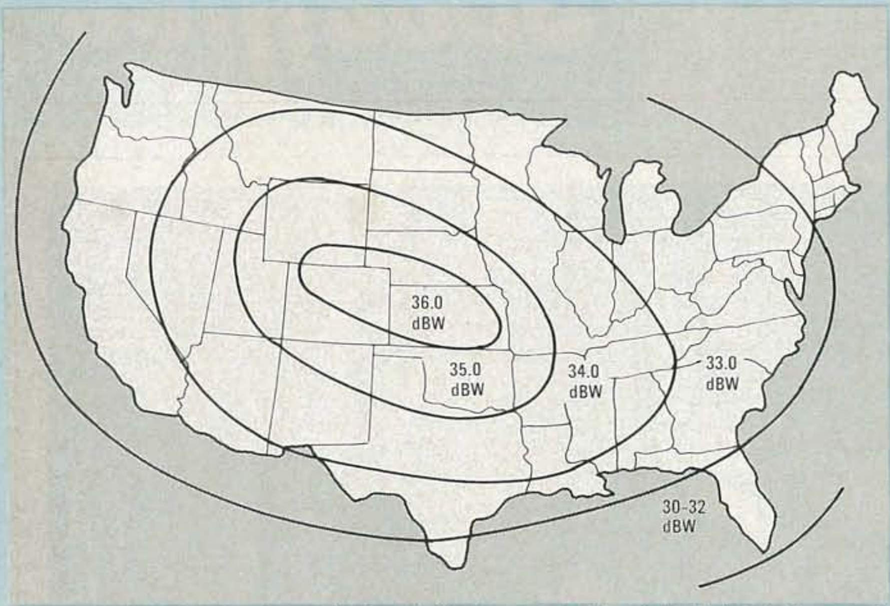


FIG. 1—A PLOT of the signal strength of a satellite transmission is called a footprint. The area of maximum strength is called the boresight point.

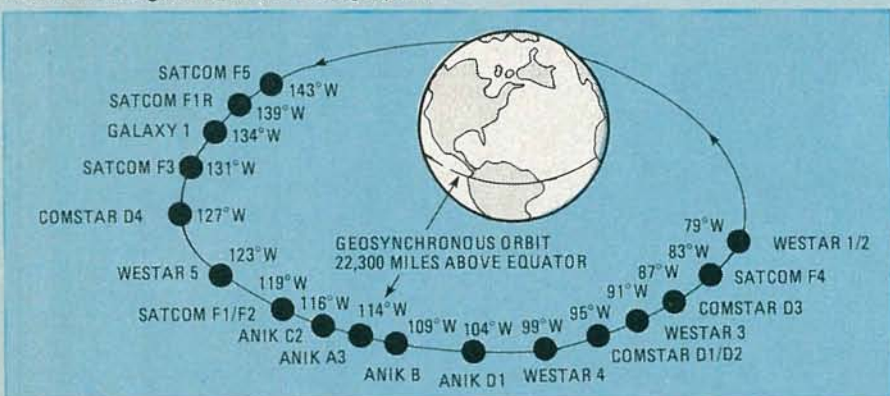


FIG. 2—ALL NORTH-AMERICAN SATELLITES orbit in the equatorial plane. They are located in that phase between 79° and 143° west longitude.

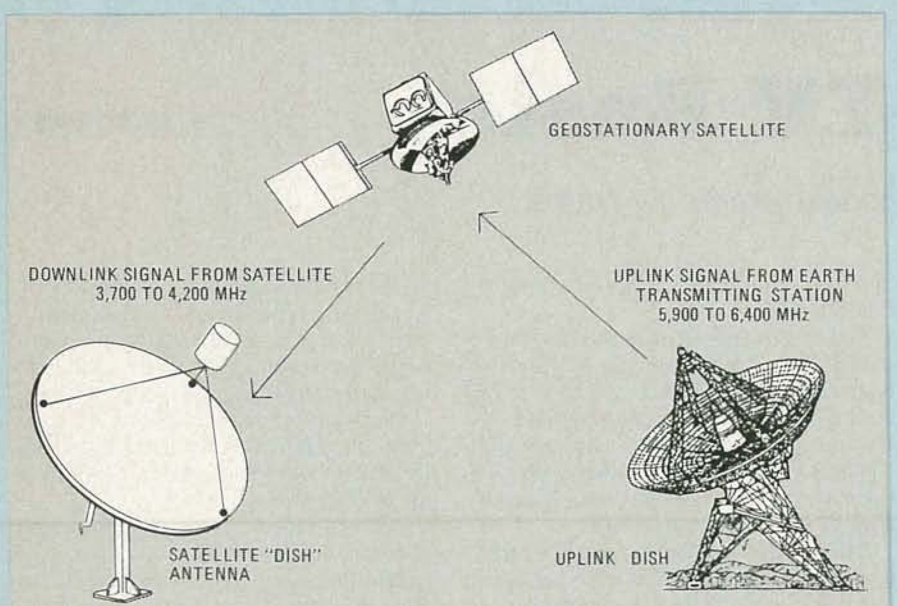


FIG. 3—C-BAND SIGNALS ARE UPLINKED at frequencies between 5.9 and 6.4 GHz, and downlinked at frequencies between 3.7 and 4.2 GHz.

that spacing is to keep the satellites far enough apart to allow each satellite to use the same set of frequencies without interference (more on that shortly). However, in order to accommodate more satellites, the FCC has laid down guidelines that will allow that spacing to be reduced to 2° over the next few years.

The current crop of satellites can be identified in several ways—designation, name, position, or any combination of those. Sometimes a letter or number follows the satellite's name. That indicates that the satellite is a member of a family of satellites or is a replacement for a satellite that is no longer in service. A satellite usually has a working life of about 7 to 10 years.

If you were to look at a satellite from the equator, it would appear tilted to you. That is known as the *tilt angle* of the satellite and it can be adjusted by on-board *thrusters* (rocket engines) that are controlled via sophisticated telemetry from the ground. Those thrusters are also used to compensate for any variations in the satellite's orbit.

Low-power transmitters

You might imagine that satellite transmitters would be high-powered affairs because of the great distances their signals must travel. That, however, is not the case. Instead, the average satellite *transponder*, the device that receives a signal from the ground and retransmits it back from space, has an output power of about 5 watts. Each transponder receives and sends a wide variety of video and audio information; among the types of communications handled are telephone, business data—and, of course, television and radio programming.

Power for the transponders and the satellite itself is obtained from on-board batteries. Those batteries are kept charged through solar cells mounted on wing-like panels that are deployed about the satellite. For maximum charging, the cells must be at a right angle with respect to the Sun. To maintain that orientation as the satellite travels in its orbit, the positioning of the panels is constantly being adjusted.

While low-powered transponders do draw less current than high-powered ones, conserving battery life isn't the only reason that low-powered transponders are used at C-band frequencies. On earth, that band is also used for the transmission of telephone communications. By keeping power-levels low, interference with those telephone communications is kept to a minimum. You will find higher power-output in Ku-band satellites; Canada's Anik D, for instance. That's because that particular band is not shared by any terrestrial services.

Uplink and downlink

When a signal is sent from the earth to a satellite it is being *uplinked*. And when the satellite sends it back, that signal is being *downlinked* to earth. Uplinking and downlinking take place at different frequencies, with C-band signals sent to the satellite at 5.9 to 6.4 GHz, and returning signals at 3.7–4.2 GHz (see Fig. 3).

The 500-MHz uplink and downlink bands are broken up into a number of channels. Each transponder on-board a satellite is assigned one of those channels and each C-band satellite can have as many as 24 transponders.

On first inspection, that would seem to be at odds with the bandwidth requirements of the transponders. That's because each transponder needs 36 MHz for video and audio, and 4 MHz for a guard band. That would seem to limit the maximum number of transponders to 12 (12×40 is 480 MHz). But, by alternating the polarization of transponders on adjacent satellites, and by maintaining adequate satellite spacing, as many as 24 transponders can be used.

Let's take a closer look at alternating polarity. You will find if you look at two adjacent satellites that one will have its odd channels vertically polarized and its even channels horizontally polarized, while the other will use the opposite scheme. Thus, signals from adjacent transponders will be 90° out-of-phase. That allows the signals from adjacent transponders to overlap somewhat without interference. Note that alternating polarity is used only if a satellite has 24 transponders. If it has 12, then all transponders are horizontally polarized. Most U.S. satellites have either 12 or 24 transponders, although some have as few as 6. Ku-band satellites, on the other hand, have as many as 32 transponders.

Signal loss

As we've stated, a satellite signal has a long way to travel. Its round trip is about 44,600 miles and during that long trip up and down a great deal of it is lost. On a one-way trip from the satellite to the earth, about 196 dB of signal is lost and the signal that arrives at a TVRO antenna has a strength of about 0.5×10^{-20}. That signal level is less than thermal noise present at the antenna.

Even the uplink signal is affected by loss. For the most part, you will find uplink signals run from 400 watts to a kilowatt. The uplink dish affords a gain of 50 dB, or a power ratio of 100,000. Thus, the 400-watt signal effectively becomes a 40-megawatt one. But, that signal too is greatly attenuated so that it is on the order of a few microwatts by the time it reaches the satellite.

Signal improvements

Because of the extremely long distances they must travel, satellite signals greatly benefit from the use of some type of signal processing.

In order to improve the signal-to-noise ratio of a satellite audio-signal, pre-emphasis is supplied to the audio waveform prior to uplinking. After the pre-emphasis is added, the signal is modulated onto a subcarrier in the 5 to 8 MHz frequency range. The compensation for that pre-emphasis—which emphasizes the high-frequency component of the signal—is supplied by the satellite receiver. That compensation is done before the signal is demodulated, and the task is handled by a de-emphasis network.

Video-signal processing, called *dithering*, also occurs before uplinking. In dithering, an *energy-dispersal waveform* (a triangular waveform with a frequency of 30 MHz) is added to the video signal. That process produces a more uniform dispersal of the video signal and compensates for energy concentration. Satellite receivers have a video clamping network to counter the effects of dithering.

A typical TVRO system

When you think of a home TVRO system, generally the first thing that comes to mind is the *dish*. That device acts as the reflector for the weak satellite signals and concentrates them at a focal point where the *feedhorn* is located. The feedhorn is actually the entrance to the *waveguide*.

The waveguide acts much like the coaxial or twin-lead antenna cable with which you are familiar. It serves as the carrier for the signal from the focal point to the metal antenna probe. That device, which is usually no more than an inch long, is the actual antenna.

From the antenna probe, the signal is fed to a *Low-Noise Amplifier* (LNA). That broadband device amplifies the very low-level signals so that they are usable by the rest of the system.

At that point, the frequency of the signal is still in the 3.7–4.2-GHz range. Such frequencies require special transmission lines, however. To allow standard coaxial-cable transmission lines to be used, the frequency of the signal must be reduced to a more usable range. That task is handled by the *downconverter*.

Thus, from the LNA the signal is passed to a downconverter, which acts much like the front-end or first stage of a superheterodyne receiver. In the downconverter, the incoming 3.7–4.2-GHz signal is beat against a local oscillator and a new intermediate frequency (IF) results, typically 70 MHz. Signals of that frequency can be handled by coaxial cable with much lower loss.

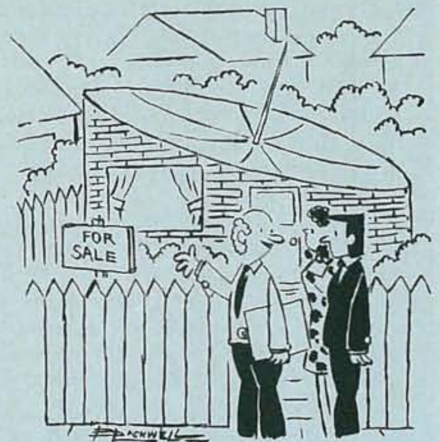
As you would guess from the preceding, you will find most downconverters are located right at the output of the LNA for minimum signal loss. Since both the LNA and downconverter are located outdoors, care must be taken to shield those devices from the elements.

After downconversion, the signal is passed via cable—typically 75-ohm RG59/U coaxial cable—to the receiver. At the receiver, the signal is again amplified and then demodulated into the original baseband audio and video. The baseband signals are then remodulated, either by a separate remodulator or one that is integrated into the receiver. (The reason demodulation and remodulation are necessary is because both video and audio are frequency modulated in a satellite system and can't be used by the television receiver. The video must be remodulated into an amplitude-modulated signal so it can be used by the television set, while the audio remains frequency-modulated.) The remodulator has an RF output, usually Channel 3 or 4, that is fed directly to the TV set.

A buyers guide

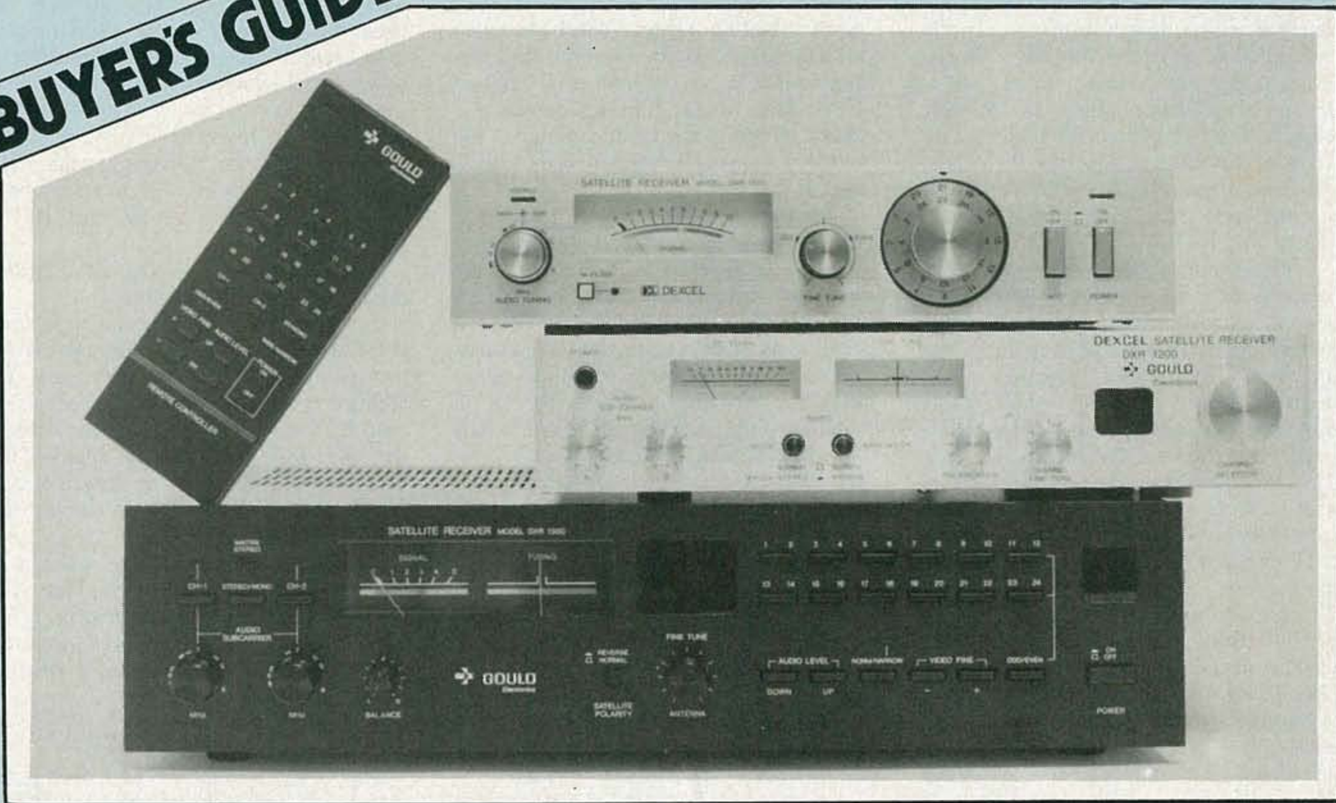
Now that we have covered some of the basic elements of a TVRO system, it's time to take a look at what is currently available in terms of satellite-receiving equipment for the home. We have tried to cover many of the major TVRO hardware suppliers, and have listed some key technical specifications to allow you to make comparisons between the various units.

A word on prices before we move on: The prices shown in the following articles are manufacturer's suggested retails. As with many other areas of consumer electronics, the actual price you may pay can vary wildly, depending on such things as demand, availability, and competition. If you are thinking about purchasing a TVRO, we suggest you do some careful comparison shopping beforehand. Now, let's move on to the guide! **R-E**



"Now if you're interested in satellite TV, this is just the house for you.!"

BUYER'S GUIDE



Satellite-TV Receivers

The satellite-TV receiver is the final link in a TVRO system. Learn more about those devices, including what's currently available, in this article.

MARC STERN

THE FINAL LINK IN A SATELLITE-TV SYStem is the satellite receiver. In some ways it is probably the most important link in the whole chain because it is the device that finally takes the signal that has been received at the antenna, amplified by the low-noise amplifier, and downconverted by the downconverter and turns it into a form that can be viewed on a home television set or monitor.

One of the few parts of the entire system that is located indoors, the best type of receiver to choose is one with 24-channel receive capability. The reason it is the best is that it gives you the ability to receive every transponder with which a satellite may be equipped. Granted, there are satellites with only 12 transponders aboard, but most of them have 24, so it makes more sense to buy a receiver with 24 channel-capability.

When you shop for a receiver, you will find there are two basic types from which to choose: the frequency-agile receiver, described above, and the dedicated or single-channel receiver that is tuned to one particular frequency. In general, you will find, the frequency-agile receiver is what you want because it gives you the ability to tune in every possible satellite channel available. The dedicated receiver, on the other hand, is fixed to one channel and is best suited for those installations where you only want to receive one channel or service. For instance, news organizations or those companies that need only to receive information from a single source would make use of a single-channel receiver.

Receiver operation

The first step in processing a satellite-TV signal is downconversion. Receiver set-ups handle that in one of two ways. Many use an external downconverter mounted at the dish. Others handle the downconversion process internally.

Looking first at the receivers that handle the downconversion internally, those are generally double-conversion units. The first downconversion is handled by a mixer/local-oscillator arrangement. That stage produces an IF of typically (it can, and does, vary according to the manufacturer) 1100 MHz. In addition, that stage also acts to increase the selectivity and gain of the receiver.

The 1100-MHz signal is then fed to a second mixer/local-oscillator stage. The output of that second stage is the second IF frequency of 70-MHz.

Note that only the first IF is tunable, despite the fact that two IF stages are used. That's because the output of the first stage remains the same (1100 MHz) regardless of which frequency is selected, allowing the use of a fixed second IF stage.

A word about bandwidth: the bandwidth of the uplinked and downlinked signals is 36 MHz and normally that would be the bandwidth of the IF stages. In many receivers, however, that bandwidth is limited to only 28–30 MHz. That is done to reject noise that normally lies at the upper and lower limits of the 36-MHz signal. Narrowing the bandwidth also increases the gain of the two IF stages. There is, of course, a tradeoff; by narrowing the bandwidth, picture quality is reduced slightly.

That system has one major drawback. It requires that the microwave downlinked signal be brought some considerable distance from the outdoor LNA to the indoor receiver. Unfortunately, because of the high-frequency of those signals, cable losses can be significant if standard coaxial cable is used. Instead, heliax, which is very expensive, must be used. Because of that, receivers that use an external downconverter are far more popular.

There are two types of external downconverters—dual and single. Systems that use external dual downconversion differ little from those that use internal dual downconversion. The major difference is that the two IF stages discussed previously are housed in a separate weatherproof cabinet and are located at the dish. The output of the downconverter is, once again, 70 MHz, and signals of that frequency can be brought into the house using standard coax (such as RG-59/U).

In single-downconversion systems, all of the downconversion is handled in a single stage, as the name would imply. Once again, the circuitry is housed in a weatherproof box located at the dish and the output of the downconverter is 70 MHz. The major drawback to that scheme is that it is susceptible to the generation of image signals. To guard against that, receivers that use single-stage downconverters may be equipped with an image-rejection mixer.

Tuning and more

Satellite-TV receivers differ from other receivers in a few aspects. For one thing, a standard superheterodyne AM or FM receiver is tuned by varying the local oscillator and the RF amplifier. In a satellite-TV receiver, the RF amplifier is the LNA, which is not tunable. Instead, all tuning is handled by the local oscillator in the first IF stage (which in the case of single-conversion units, is the only one). That IF stage is either at the dish or at the receiver, depending on the location of the downconverters as previously discussed. As tuning is done by varying a DC voltage to the oscillators, the type of oscillators used are VCO's (*V*oltage *C*ontrolled *O*scillators).

More significantly, however, a satellite-TV receiver must do at least some signal processing. The video signal, for instance, is frequency modulated, which means it is incompatible with the NTSC standard. To overcome that, the receiver must extract the original baseband video from the signal and then amplitude modulate so that it can be input to a standard TV-receiver. In addition, a video de-emphasis circuit is needed to counteract the signal processing performed on the uplink signal.

In addition to the primary frequency, each transponder may also relay a number of audio subcarriers. In order to receive those subcarriers, which are (usually) located at 5.6, 5.8, 6.2, and/or 6.8 MHz, a satellite receiver is equipped with a tunable audio demodulator. While the sound output is normally mono, stereo can be obtained if the unit is equipped with a pair of audio demodulators (one for each channel of sound). Some units are so equipped; in others, an add-on is required if stereo is desired.

Receiver features

Satellite receivers use several different tuning schemes. Many receivers feature continuous tuning with detent or click-stop tuning dials. Some use rotary dials, while others are of the slide-rule type. Still others offer digital readouts, which are, of course, much more convenient.

An important feature of any receiver is a tuning, or signal-strength meter. That meter indicates the strength of the signal being received. The tuning meter lets you know when the strength of the signal being received is at its maximum. As such, it is a valuable aid in tuning the receiver and in adjusting the position of the dish.

Many receivers use SAW (*S*urface *A*coustic *W*ave) filters. A SAW filter delivers almost ideal shaping for the IF bandpass waveform and delivers a nearly flat response over the passband region. That type of filter does have a high insertion loss, around 30 dB, but that can be overcome through the use of additional IF stages.

Another feature to look for in a satellite receiver is a vertical/horizontal polarization selection switch. That allows you to set the receiver to the particular polarization used by a satellite. Of course, its use is predicated on having the proper dual-polarization antenna feed at the dish.

Here is a quick listing of other features to look for in a satellite receiver:

A video-output terminal gives you easy access to the baseband video (and sometimes audio) signals. If you have other equipment (TV, VCR, etc.) that can accept that type of signal (i.e., has a video input), its use will provide better video resolution.

A channel-calibration control, which is usually located on the rear of the receiver, is used to assure that the tuning is correct.

Some satellite-TV programmers scramble their transmissions to prevent unauthorized viewing. While there are many scrambling schemes that may be used, one relatively simple one is simply to invert the video signal. Some receivers, however, are equipped with a video inverter that allows the viewer to defeat that (and only that!) type of scrambling.

For convenience, you might want a remote control. While frequency selection from your easy chair isn't a must, it is a nice feature.

A fine tuning control is handy for peaking the quality of the picture.

Some receivers offer a scanning feature that is used to rapidly scan through the 24 transponder channels in succession. In addition, some offer a dual-speed scanning feature that lingers at an active channel, giving the viewer time to decide if he wants to override the scan function and watch the programming at the current frequency.

Last but not least, tunable audio is a nice feature to have. That control lets you fine-tune the sound for best results.

Now that we have gone over some receiver basics, let's take a look at what is available in the marketplace.

Anderson Scientific

Supplied with an *SC24* block downconverter, the dual-conversion *ST1000* receiver is available for $300. It features a built-in RF modulator, 5.5- to 7.2-MHz

ANDERSON SCIENTIFIC *ST1000*

audio tuning, a signal-strength meter, audio and video outputs, wide range AGC, built-in AFC, and a rotary tuning-dial. The IF bandwidth is a narrow 28 MHz, and the *SC24* downconverter offers a gain of 20 dB.

Arunta

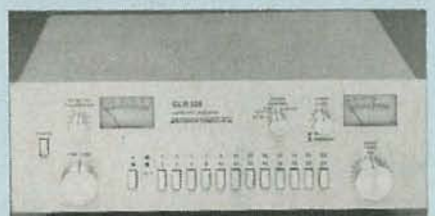
The *Challenger II* Receiver is available for $510. It features a tuning meter, 5–8-MHz audio tuning, a polarity switch, rotary tuning and readout, built-in RF modulator, remote downconverter (single conversion), a SAW filter, a 26-MHz IF bandwidth, and composite and baseband video outputs.

The single-conversion *InVader* sells for $815. It features a digital readout, LED-bar-graph signal-strength meter, automatic polarity-switching with skew adjustment, frequency-agile audio with auto deviation and center-tuning indicator, SAW filter, an IF bandwidth of 26 MHz, and composite- and baseband-video outputs.

The single-conversion $2195 *Interceptor* contains a complete stereo processor for monaural and multiplexed, matrix, and discrete stereo. It features selectable wide or narrow audio bandwidth and dynamic noise reduction. Other features of the unit include a SAW filter, video inverter, signal-strength meter, rotary tuning-selector, polarity control, and an IF bandwidth of 26 MHz.

Automation Techniques

The *GLR-500*, priced at $495, features full rotary tuning, tunable audio (5–8 MHz), polarity control, signal-strength meter, and a weatherproof downconverter. The *GLR-520*, priced at $650, features pushbutton transponder selection, audio-level control, fine-tuning control, signal-strength meter, remote control, and tunable audio. The *GLR-560*, priced at $750, features pushbutton transponder selection, dual audio channels for stereo with metered level controls, 30-MHz IF bandwidth, a fine-tuning control, and audio tuning-meters.



AUTOMATION TECHNIQUES *GLR-500*

The *GLS-808*, available for $1095, is a complete receiving system. It includes an LNA, downconverter, RF modulator, infrared remote-control, and cabling. The receiver features synthesized tuning, automatic polarity-switching, pushbutton channel-selection, LED readout, and signal-strength meter. Optional accessories include a relative-power meter for downconverter monitoring and additional remote control units. Remote control units are also available for Automation Techniques other receivers. Those feature 12-position (with detents) rotary transponder selection, polarity control, and fine tuning.

Avcom

Priced at $1595, the rack-mounted *COM-66(T)* works with the BDC-60 block downconverter. It features a tuning meter, rotary channel selection with scanning, audio and IF filtering control, a 30-MHz IF bandwidth, and polarity-, black-and-white-/color-, and normal-/inverted-video selectors. Also offered is a *COM-65(T)*, which is similar to the previous unit but offers only two-channel selection.

AVCOM model *COM-3*

The Avcom *COM-2A* and *COM-2B* are priced at $695 and $663 and feature rotary channel selection, tuning meter, and automatic polarity-reversal. The *COM-2A* features a remote-tuning unit. Both units are supplied with Avcom's *RDC-10* downconverter.

Priced at $1895, the Avcom *COM-3* and *COM3R* feature a signal-strength meter, rotary channel tuning, automatic polarity-switching, and dual video outputs. The *COM-3R* has remote tuner.

Blonder-Tongue

The $2281 model *6007* receiver features detent tuning, signal-strength meter, remote control, automatic polarity switching, and special circuitry to aid in the reception of low-level signals.

Boman Industries

Priced at $1199, the *SR-2000* receiver features pushbutton tuning, preset audio, time display, dynamic noise-reduction, video inversion, AFC, transponder search, and 6.8-MHz audio preset. Other features include automatic polarity-switching, east-west antenna-position tuning control (for use with Boman's antenna positioners and polar mounts), skew polarity tuning, dual-speed scanning, LED display, and tuning and signal-strength meters. Also available is a remote control that features channel selection, up and down search, standby, LED readout, 6.62- and 6.8-MHz audio presets, and audio override.

The *SR-2500*, priced at $1364, features satellite search (a programmable feature that allows you to control the dish positioning from the receiver; for use with Boman's dish positioner and polar mounts), left-right channel variable audio-tuning controls, auto polarity selector (for use with Boman's *Polarmatic*), skew tuning, polarity reverse button, scanning, discrete stereo selector, stereo-balance control, matrix-stereo selector button, LED display, 6.8-MHz audio preset, wide/narrow audio-bandwidth selection, left-right-channel audio meters, signal-strength meter, video-inverter, AFC, fine tuning, detent volume-control, LNA/DC power remains on when unit is switched off, IF-gain control, dynamic noise-reduction, and a parental-guidance switch (for locking out certain transponders).

The *SR-800*, priced at $599, features 24-channel detent tuning, stereo capability, fine tuning, signal-strength meter, AFC, and six preset audio channels.

Earth Terminals

Earth Terminals *Microwave Receiver*, priced at $1,425, features automatic AFC, remote control, automatic 5.5- to 6.8-MHz audio-subcarrier selection tuning, signal-strength and center-tuning meters, remote downconverter, continuous rotary tuning, and a 30-MHz IF bandwidth.

Gensat

The Model *CSR-1200* stereo receiver, priced at $700, is designed to work with the *BDC-1200* block downconverter. It features polarity control, dual-audio and integral-stereo decoders, full subcarrier tuning, tuning meter, remote control, and has a 24-MHz IF bandwidth.

Gillaspie

The model *9600* is priced at $495. It features an infrared remote-control, polarity control, pushbutton tuning, signal-strength meter, LED channel readout, built-in fine tuning, tunable 5-8 MHz audio, AFC, and scanning.

GILLASPIE model *9600*

Gould (Dexcel Division)

The Dexcel satellite receiver lineup consists of the *DXR-1100*, *DXR-1200*, and *DXR-1300*, which are priced at $1,225, $1,255, and $1,990, respectively. The *DXR-1100* includes among its features built-in matrix stereo decode, a standard remote control, AFC, fine-tuning control, and a signal-strength meter. The *DXR-1300* offers a built-in control for the Polarotor (a device that automatically switches antenna polarity), matrix and descrete stereo, selectable narrow and wide audio-bandwidths, digital channel-display, and signal-strength and channel-tuning meters. The *DXR-1300* offers pushbutton tuning, a digital channel-display, built-in Polarotor control, matrix or discrete stereo, infrared remote-control, selectable narrow/wide audio bandwidth, and a 35-watt audio amplifier.

GOULD *DXR-1300*

KLM

Seven models are available—the *Sky Eye IV*, priced at $635; the *Sky Eye V*, priced at $495; the *Sky Eye VI*, priced at $975; the *Sky Eye 7X*, priced at $710; the *Sky Eye VIII*, priced at $825; the *Sky Eye*

KLM *Sky Eye VI*

X, priced at $550, and the *Olympiad I*, priced at $385. The *Sky Eye IV* features a slide-rule tuning dial, 24-channel coverage, defeatable AFC, polarity switch, 5.5- to 7.5-MHz audio tuning, center-tune LED, and an LED signal-strength meter. The *Sky Eye V* features a polarity switch, signal-strength meter, 5.5- to 7.5-MHz audio tuning, slide-rule tuning dial, and a SAW filter. The *Sky Eye VI* features 5.5- to 7.5-MHz audio tuning, switchable narrow and wide audio band-width, AFC defeat, polarity switch, fine-tuning, two-speed scan tuning, signal-strength meter, and a remote control. The *Sky Eye 7X* features a polarity switch, polarity skew selector, AFC defeat, 5.5- to 7.5-MHz tuning, center-tune LED, and LED signal-strength meter. The *Sky Eye VIII* features 5.5- to 7.5-MHz audio sub-carrier tuning, polarity-skew control, polarity switch, scanning, seek, fine tune, LED channel indicator, synthesized tuning, and signal-strength meter. The *Sky Eye X* features AFC defeat, polarity switch, and 5.5- to 7.5-MHz audio tuning. The *Olympiad I* offers a polarity control-switch, 5.5- to 7.5-MHz audio tuning, and a 30-MHz IF bandwidth.

Lowrance

Lowrance offers two receivers, the *System 70*^{x} and the *System 70*^{s}, priced at $650 and $750. The *System 70*^{x} offers detent tuning, variable fine-tuning, AFC with defeat, variable audio-tuning, wide and narrow audio-bandwidth selection, signal-strength meter, video inverter, audio/video outputs, switchable polarity interface, and scan tuning. The *System 70*^{s} offers all of the above and adds dual variable audio-tuning (wide or narrow band-

LOWRANCE *System 70*

widths), independent subcarrier tuning, and both descrete and matrix stereo capability.

Luxor/Magnum

The $850 *9550* features dual scanning modes, video inversion, defeatable AFC, Dolby noise-reduction, 2 to 1 audio expander, outputs for composite video and audio, remote antenna control with addition of dish positioner, remote control, mono and stereo modes with dual audio-bandwidth selection, LED channel-readout, and pushbutton tuning. A remote control is available as an option. The $650 *9539 (Mark One)* features mono and stereo modes, polarity control, switchable audio IF, scanning, video inversion, video level-meter, pushbutton tuning, and LED channel-readout.

LSI Technologies

Priced at $550, the *model 131* features block downconversion, tuning meter, video inversion, polarization control, continuous rotary-tuning, 5.5- to 8-MHz tunable audio, video and audio outputs, and a SAW filter.

McCullough

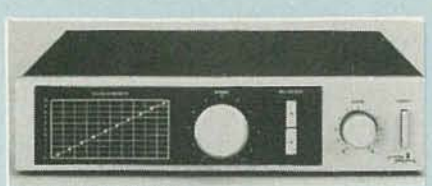
McCullough offers four models, the *ELC-24, ELX-24, USA-1,* and *USA-1M* which sell for $445, $495, $345, and $365. Those are tunable 24-channel satellite receivers with a remote single-conversion downconverter. Standard features include signal-strength meter, local, remote and scan tuning, wired remote control, polarity control, tunable audio, discrete and matrix stereo capability, and a baseband video/audio output.

National Microtech

National Microtech offers two models—The *Apollo Z-70*, priced at $700, and the *Apollo Elite*, priced at $1352. The *Apollo Z-70* offers continuous 24-channel rotary tuning with detents, automatic polarity switching, fine tuning, scanning, a 27-MHz IF bandwidth, remote downconverter, tunable audio, and a tuning meter. There is an optional remote control. National Microtech's other unit, the *Apollo Elite,* offers an infrared remote control, microprocessor-based direct/sequential tuning, LED channel display, automatic polarity-switching, fine tuning, scanning, tunable audio, tuning meter, volume control, television set on/off control, mute, channel lockout, remote-antenna control (for use with the company's *Navigator* antenna positioner with memory), and a 22-MHz IF bandwidth.

Radio Semiconductor

For those who need to feed signals to more than one set, Radio Semiconductor's *Locom* system, which consists, in part, of the *BR 220* block receiver ($260)/*BC 124* block converter ($95), offers an interesting alternative. In block conversion, rather than tuning the down-converter for a single transponder frequency, the entire C-band is downconverted at once and the receiver uses a broadband UHF tuner to select the frequency of interest. That could be a less expensive approach for multi-set set-ups. Among the *BR 220's* more noteworthy features are tunable audio and a 23-MHz bandwidth.



REGENCY *SR-1000*

Regency

Regency offers two models, the *SR 1000*, priced at $499, and the *SR 3000*, priced at $550. The *SR 1000* features polarity control, "X/Y graph" LED signal-strength meter for tuning, variable audio, built-in RF modulator, video/audio output, subcarrier output, inversion control, a weatherproofed remote downconverter, and continuous rotary tuning. The *SR 3000* features detent tuning with defeatable AFC, preset and variable audio-control, signal-strength and center-tuning controls and meters, polarization skew adjustment, dynamic-noise-reduction circuitry, format switch control, external-meter jack, video inversion control, video/audio outputs, a 25-MHz IF bandwidth, and a remote downconverter.

Sat-Tec

Three models are available from Sat-Tec—the *SR-3240*, priced at $539; the *R-5000SP*, priced at $279, and the *R-7000*, priced at $379. The *SR-3240* features rotary detent tuning, LED readout, automatic polarity switching; automatic antenna-selector, built-in scanner, and matrix stereo. The *R-5000SP* offers a polarity switch, AFC, 5.5-to 7.5-MHz audio tuning, signal-strength meter (tuning), rotary tuning, remote downconverter, and a video output. The *R-7000* features a signal-strength meter scanning, polarity control, polarity-skew compensation and stereo.

Wilson Microwave Systems

Two models, the *YM 400*, priced at $495, and the *YM 1000*, priced at $750, are offered. The *YM 400* features continuous rotary tuning, scanning, automatic switching between satellite- and terrestrial-TV, signal-strength meter, polarity control switch, 5.5- to 7.5-MHz audio tuning, and a SAW filter. The *YM 1000* features pushbutton tuning, remote control, 5.5- to 7.5-MHz audio tuning, LED channel-readout, signal-strength meter, and automatic switching between satellite- and terrestrial-TV.

Winegard

Winegard offers the model *SC-7035*, priced at $950, and the model *SC-7035S*, priced at $1,025. Both units feature continuous rotary tuning with LED display, fine tuning, remote antenna control, scanning, polarity switch, 5.5- to 8-MHz audio tuning, signal-strength meter, and a 27-MHz IF bandwidth. **R-E**

BUYER'S GUIDE

The Dish

MARC STERN

A guide to what to look for when shopping for a dish, and a guide to what's available.

THERE IS NO PART OF A TELEVISION RECEIVE-ONLY (TVRO) system that is more obvious than the antenna dish. The dish, of course, is not actually an antenna. Instead it serves a double function, gathering the very weak signals from a geostationery satellite, and focusing them on the antenna itself. In reality, the dish is little more than a signal-reflecting device.

The importance of such a device is quite obvious when you consider the low strength of a downlinked signal. The output power of a typical satellite-TV transponder is on the order of 5 watts. In addition, that signal must contend with traversing 22,000 miles and the losses that that entails. That loss, known as space or spreading loss, can be on the order of 196 dB, so the signal strength on earth can be as low as $.05 \times 10^{-21}$ watts. The result is that the signal can literally be buried in a hash of thermal noise when it reaches the antenna's reflector.

For those reasons, the gain of the TVRO antenna needs to be 35 to 45 dB or more just to pull the signal out of the thermal noise level. That's why relatively large reflectors are needed.

In general, most TVRO dishes are parabolic, although there are some on the market that are spherical. Regardless of the shape, most dishes are made form either aluminum, stainless steel, or fiberglass (or similar material) with a metalized surface. To reduce the effects of weathering, a metal dish is usually further treated with some heat-absorptive (not reflective) material; the thermal properties of the material are important because we want to keep heat away from the feedhorn. That treatment involves either applying rustproofing or coating the dish with fiberglass. It is important that that step be taken so that the antenna doesn't oxidize or pit, which can change the signal characteristics of the antenna. Pitting caused by oxidation can cause reflections and signal loss at the feedhorn.

Two considerations that you should keep in mind when shopping for a dish for your home TVRO system are the type of construction and wind-loading. In general, dishes can be one-piece or petalized, and either solid or wire mesh. You will find that a dish that is petalized—made up of many sections—is easier to ship than a one-piece unit, but more difficult to assemble. It is also easier to move a petalized dish, should the need arise.

In general, you will also find that a solid dish is more prone to problems in high winds than one that is made up of wire mesh. Solid dishes are also much heavier than mesh ones and can accumulate water or, in freezing weather, ice.

Spherical versus parabolic

Although the majority of dishes on the market are parabolic, spherical dishes do offer some advantages. For starters, the signal reflection characteristics of the dish can be excellent, with a sharper area of focus than that of a parabolic dish. A spherical dish doesn't have to be precisely pointed at a satellite, unlike a parabolic antenna. In fact, it can be as much as 20-degrees off a direct line and the picture will still be usable. That means you can use a spherical dish to focus on several satellites simultaneously. Of course, the focal point for each satellite will be different.

You will primarily find a spherical dish used in a fixed installation with a fixed support that is usually very substantial. That substantial support is of benefit in an area where wind-loading is a significant factor.

The primary disadvantage of the spherical dish, and the main reason it is not popular for use in home TVRO's, is its long focal length, which can reach 12 to 20 feet. (The focal length of an dish is the distance from its center to the focal point—the area where all of the signals are gathered at the feedhorn.)

Special considerations

When you are choosing a dish for your TVRO system, there are some special considerations of which you should be aware.

Dish gain, usually from 35 to 50 dB in a home TVRO system, is related to dish aperture. Unfortunately, dish manufacturers usually quote that specification at the high end of the C-band range, where gain is usually higher, rather than at the middle or low-end of the band. Still, that specification is useful as a guide. In general, you will find a six-foot dish has a gain of about 35 dB, with gain increasing about 1 dB for each extra foot in dish aperture until you reach 11 feet. Beyond 11 feet, you will find about 1/2-dB gain-per-foot. Gain also depends on the curvature, shape (spherical vs. parabolic), and condition of the dish.

Beamwidth tells you how well a particular antenna will accept the signals of one satellite, while rejecting those of others. Therefore, the narrower the beamwidth the more selective is the dish.

For a TVRO system to function properly, it must be properly matched throughout. That is why the *VSWR*, or *V*oltage *S*tanding *W*ave *R*atio, must be low, as close to 1 to 1 as possible. If the VSWR of a particular dish is poor, it means too much of the signal is not being focused on the feedhorn, which results in a poor transfer of signal from the antenna to the receiver. That, of course, means that there's a deterioration in the quality of the picture that you eventually see.

Mounting Considerations

There are several types of mounts that are suitable for a TVRO dish. Those are fixed mounts, Az/El mounts, and polar mounts. The fixed mount, as its name implies, is fixed in one direction at one satellite. That type of mount, if suitably reinforced, can withstand high winds the best. Of course, it also has the advantage of not requiring adjustments once it's installed. That advantage is also its chief disadvantage, as it restricts you to viewing only one satellite.

The most versatile mount is the Az/El (*AZ*imuth/*EL*evation) type of mount. That type of mount allows you to move the dish across the satellite arc, as well as up and down. The chief disadvantage of that type of mount is that a change in one parameter (either azmuth or elevation), will require a change in the other. Hence, that type of mount is very difficult to adjust.

The most popular mount for home TVRO's is the polar mount. It features the adjustability of the Az/El mount, but takes many of the headaches out of adjustment because you only adjust the angle of azmuth; the elevation is taken care of automatically. That type of mount can also be controlled from indoors.

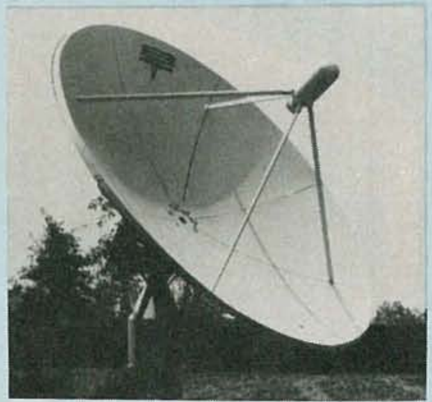
With all of that out of the way, let's take a look at what the dish manufacturers are offering.

Blonder-Tongue

Our first manufacturer, Blonder-Tongue, offers 5 dishes suitable for home TVRO's. Those are the $2050 model *6034* (9-foot), which is expandable to the $2440 model *6035*(10-foot); the $2318 model *6053* (12-foot); the $5107 model *6048* and the $5186 model *6050* (15-foot), and the $6500 model *6026* (16-foot).

Looking a little more closely at the dishes, the *6034/6035* is a solid dish of petalized construction. An interesting feature is that the 9-foot *6034* can be retrofitted with extender panels to turn it into the 10-foot *6035*. Gain is 39.5 dBi (9-foot)/40.1 dBi (10-foot), beamwidth is 1.9 (9-foot)/1.7 (10-foot) degrees, VSWR is 1.3:1, and winds to 100 mph can be withstood. The dish weighs 350 pounds (9-foot)/440 pounds (10-foot) and is available with either Az/El or polar mounts.

The model *6053* 12-foot dish offers a gain of 41.7 dBi and a beamwidth of 1.5 degrees. It is a solid dish of petalized construction, weighs 1100 pounds, and can withstand winds to 125 mph. The dish comes with a "T-bar" Az/El mount.



BLONDER-TONGUE *6034*

Blonder-Tongue's 15-foot models are available with either prime focus *(6048)* or Cassegrain *(6050)* feeds. Both models are solid (fiberglass) dishes of petalized construction, weigh 1200 pounds, feature Az/El mounts, and can withstand winds to 100 mph. The model *6048* offers a gain of 43 dBi, a beamwidth of 1.1 degrees, and a VSWR of 1.3:1. The model *6050* features a gain of 43.5 dBi, a beamwidth of 1.12 degrees, and a 1.3:1 VSWR.

Finally, the 16-foot *6026* features a gain of 44.1 dBi, a beamwidth of 0.86 degrees, and a 1.3:1 VSWR.

Boman Industries

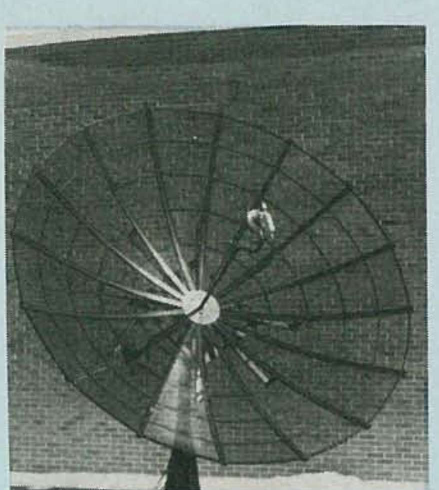
Boman Industries offers two dishes, the model *SA-3000* and the model *SA-2400*. Looking at the top-of-the-line *SA-3000*, that 10-foot one-piece construction, fiberglass dish is rated to withstand winds of up to 120 mph. It boasts a VSWR rating of 1.2:1 and a gain of 40.1 dB. It sells for $840.50. The smaller (8-foot) *SA-2400* is also of one-piece construction, but the material used is spun aluminum. It sells for $365.50.

Comtech Antenna Corporation

Comtech offers offers a wide variety of dishes. Their 10-foot model boasts a gain of 40 dBi, a beamwidth of 1.7 degrees, and weighs 650 pounds. It is made of fiberglass, features a manual Az/El mount, and sells for $1790. The 12.5-foot model has a gain of 42.9 dBi, a beamwidth of 1.4°, and a weight of 800 pounds. It is made of fiberglass, features either an Az/El or polar mount, and sells for $2060.

Conifer

Conifer offers a 12-foot, petalized wire-mesh dish. The model *AN-1200* features a

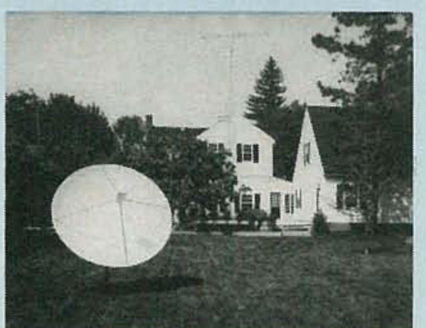


CONIFER *AN-1200*

gain of 42.3 dBi, a beamwidth of 1.5 degrees, and weighs 300 pounds. It uses a polar mount, is rated to withstand winds up to 100 mph, and sells for $1300.

Delta Satellite

Delta's *Starduster* is an 8-foot spun aluminum solid dish that boasts a gain of 38.5 dB, uses a polar mount, weighs 69



DELTA *Starduster*

pounds, and sells for $799. Other dishes in the line include the 10-foot fiberglass *Delta 1* ($1149) and the 13-foot *Delta II* ($1895)

General Instrument

Among the offerings from General Instrument are the *SA081S*, *SA102*, and the *SA122*. The 8-foot *SA081S* features a gain of 38.1 dB and a beamwidth of 2.2 degrees. It is made of aluminum, uses a polar mount, and sells for $1025. The 10-foot *SA102* features a gain of 40.3 dB and a beamwidth of 1.8–3.8 degrees. It is made from spun aluminum, uses a polar mount, and sells for $2235. The 12-foot *SA122* features a gain of 42.2 dB and a beamwidth of 1.5–3.2 degrees. It is made of spun aluminum, uses a polar mount, and sells for $2540.

Industries PPD

The *Sphinx* is a 12-foot petalized, polyurethane dish. It boasts a gain of 42 dBi and a beamwidth of 1.35 degrees. The dish weighs 380 pounds, uses a polar

INDUSTRIES PPD *Sphinx*

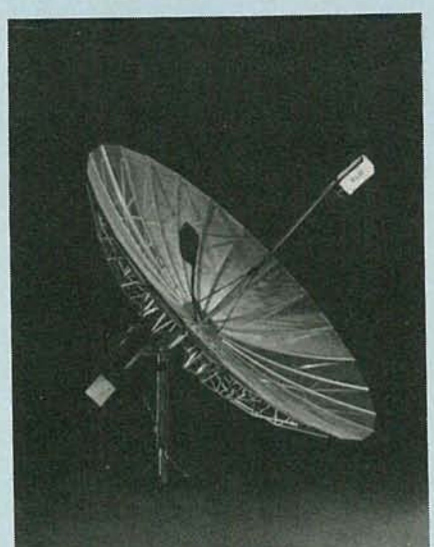
mount, and sells for $1235. A 10-foot version and Cassegrain feed are also available.

Janeil

The Janeil 9-foot dish is a petalized, aluminum mesh unit. It boasts a gain of 39.5 dB and a beamwidth of 1.89 degrees. Its polar mount features a full declination-tracking adjustment. The dish itself weighs 110 pounds; the mount weighs 130 pounds. The suggested retail price is $929.

Also from Janeil is their *Dark Star* dish. That 12-foot mesh dish sells for $1149.

KLM



KLM *X-11*

KLM offers 8-, 11-, and 16-foot models. The 8-foot *Mini-X* has a 37.3-dB gain. It is of of petalized wire-mesh construction, weighs 85 pounds, uses a polar mount, and can withstand winds to 100 mph. It sells for $850.

The 11-foot *X-11* has a gain of 40.5 dB. It is of petalized wire-mesh construction, weighs 125 pounds, uses a polar mount, and can withstand winds to 100 mph. The dish sells for $1420.

The 16-foot *X-16* has a gain of 43.5 dB. It is of petalized wire-mesh construction,

KLM *Mini-X*

weighs 290 pounds, uses a polar mount, and can withstand winds to 100 mph. It sells for $2995.

Luly Telecommunications

Luly offers a variety of popular-sized wire-mesh dishes. Their 6-foot model has a gain of 35 dB, a beamwidth of 2.8 degrees, and sells for $950. Their 8-foot model has a gain of 37.5 dB, a beamwidth of 2.2 degrees, and sells for $1050. Their 10-foot model has a gain of 39.5 dB, a beamwidth of 1.7 degrees, and sells for $1150. Their 12-foot model has a gain of 41.5 dB, a beamwidth of 1.4 degrees, and sells for $1250.

McCullough Satellite

McCULLOUGH SATELLITE *Wagon Wheel*

McCULLOUGH SATELLITE *8-Ball*

McCullough offers both spherical and parabolic dishes in kit form. Their aluminum-mesh *8-ball* spherical dish (featured in the August and September 1981 issues of **Radio-Electronics**) is available in 8- ($395), 10- ($445), 12- ($475) and 16-foot ($1200) versions. Their aluminum-mesh *Wagon-Wheel* parabolic dishes are available in 8- ($300) and 10-foot ($350) sizes. Also available from the company are 8- ($300) and 10-foot ($350) parabolic fiberglass dishes.

Miralite Corp.

The Miralite Corporation offers two dishes that are suitable for home TVRO applications. Their 12-foot model offers 42-dB gain, weighs 300 pounds, and can withstand winds to 125 mph. It sells for $2484. An 8-foot model, which sells for $1085, is also available.

Paradigm Manufacturing

Paradigm offers their *Paraclipse* dishes in three sizes. All models are of mesh construction and come with polar mounts. The 9-foot model has 39.3-dB gain and a beamwidth of 1.8 degrees. It sells for $995. The 12-foot model has a gain of 42.3 dB and a beamwidth of 1.28 degrees. It sells for $1295. Finally, the 16-foot model has a gain of 44.8 dB and a beamwidth of .9 degrees. That dish sells for $4995.

Pico Satellite

Pico offers single and dual-feed models. The *SAR-14SF* is a 14-foot dish with a 43.6-dB gain and a 1.27 degree beamwidth. It weighs 356 pounds, is of cast aluminum construction, can withstand winds to 120 mph, and costs $3350.

The *SAR-10SF* is a 10-foot dish with a gain of 40.8 dB and a beamwidth of 1.51 degrees. It is made of cast aluminum, weighs 205 pounds, and is rated to withstand winds to 125 mph. The dish sells for $2,050.

In dual-feed models, there is the *SAR-10DF*. That 10-foot dish has a 40.5-dB gain and a 1.55-degree beamwidth. It weighs 205 pounds, is made of cast aluminum, and can withstand winds to 125 mph. It sells for $2,250.

The 14-foot *SAR-14DF* dual-feed dish has a gain of 43.1 dB and a beamwidth of 1.3 degrees. It weighs 356 pounds, is made of cast aluminum, and can withstand winds to 125 mph. It sells for $3,350.

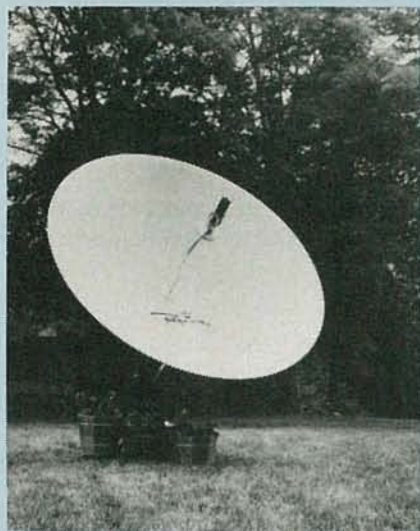
Quadralite

QUADRALITE 4-foot dish

Quadralite offers a rather interesting entry—a 4-foot dish intended for recreational-vehicle (RV) use. That relatively small dish has a gain of 34 dB and a beamwidth of 3.75 degrees. It is of plastic/fiberglass/metal construction and weighs 85 pounds, including polar mount. The dish sells for $335.

Regency Satellite Systems

From Regency comes the *SA 9000*. That 7½-foot dish is made from marine aluminum, is of one-piece construction, weighs 156 pounds, and offers 38.5-dB gain. It sells for $595.



REGENCY *SA9000*

Symtel

The *Vision 2000* from Symtel is available in two sizes. The 8-foot model has a gain of 38.5 dB, a beamwidth of 1.9 degrees, uses a polar mount, and weighs 94 pounds; the one-piece, solid-construction dish sells for $579.

The 10-foot *Vision 2000* has a gain of 40.5 dB, a beamwidth of 1.65 degrees, uses a polar mount, and weighs 167 pounds. That one-piece, solid-construction dish sells for $899.

USS/Maspro

USS/Maspro markets three antennas. At the low end of its line is the model *300-1*, which has a gain of 42.2 dB, a VSWR of 1.25:1, and a beamwidth of 1.35 degrees. That 12.6-foot dish is made of fiberglass, features two-piece solid construction, weighs 520 pounds, can withstand winds to 125 mph, and uses a polar mount. It sells for $1095.

The model *380-1* has a gain of 44.4 dB, a VSWR of 1.25:1, and a beamwidth of 1.05 degrees. That 16-foot dish is made of fiberglass, features three-piece solid construction, weights 1270 pounds, can withstand winds to 120 mph, and uses a polar mount. It sells for $1895.

At the top-of-the-line is USS/Maspro's commercial-grade model *500-1*. The model *500-1* has a gain of 44.4 dB, a VSWR of 1.25:1 and a beamwidth of 1.05 degrees. That 16-foot dish is made of fiberglass, features three-piece solid construction, weighs 1270 pounds, can withstand winds to 120 mph, and uses a polar mount. That dish sells for $4995.

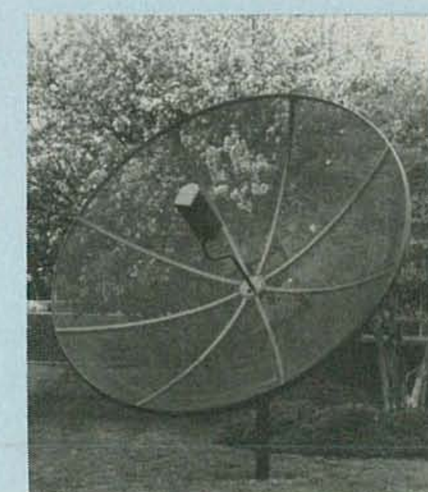
Wilson Microwave

The *MD-9* has a gain of 38.5 dB and a beamwidth of 1.8 degrees. The galvanized-steel, petalized construction, 8-foot, 8-inch dish weighs 250 pounds and can withstand winds to 100 mph. It sells for $499.

WILSON *MD-9*

Winegard

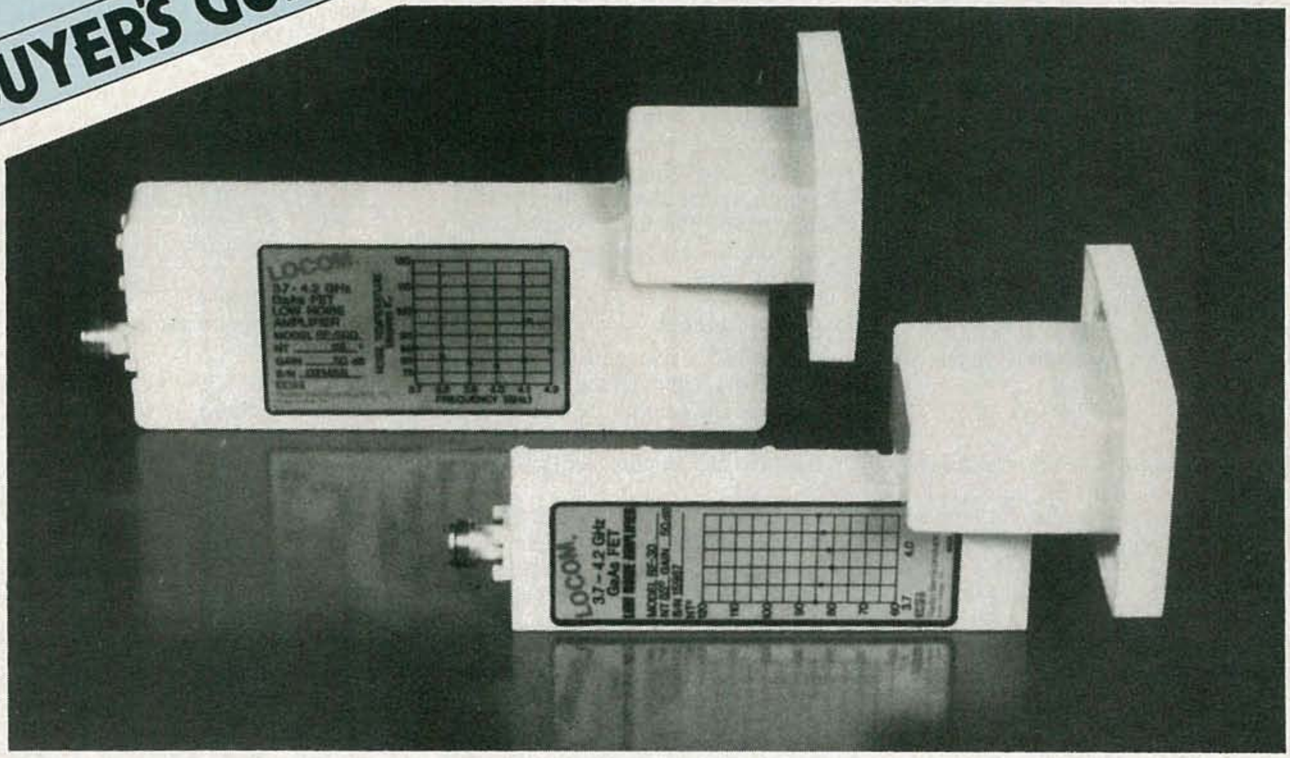
The model *SC-1018/SC-1019* (chrome/black satin finish) is a 10-foot perforated aluminum dish. It boasts a gain of 39.5 dB and a beamwidth of 1.6-degrees. It weighs 92 pounds, can withstand winds to 125 mph, and uses a polar mount It sells for $1077.



WINEGARD *SC1019*

Winegard also offers an 8-foot aluminum dish with a gain of 37.5 dB. It uses a polar mount and sells for $484. **R-E**

BUYER'S GUIDE



Feedhorns, Waveguides, and LNA's

MARC STERN

A TVRO system has many stages, each doing a specific job and having its own set of specifications. In this article, we'll look at those stages that get the signal from the dish and feed it to your receiver.

THE POPULARITY OF SATELLITE-RECEIVER systems has brought with it a great deal of confusion as to which one to purchase. That's because several manufacturers offer a number of microwave products with hard-to-understand specifications.

To the average consumer, specifications sheets contain nothing more than a lot of electronic mumbo-jumbo that only serves to further add to the problem. So to help make the task of deciding which system to purchase a little easier, we've simplified the specifications of some of the devices and listed only the most important.

Feedhorn

One of the most important parts of any home TVRO system—after the dish, of course—is the feedhorn. That device collects the weak signals that are reflected from the dish and focuses them on the antenna itself.

The most widely used feedhorn arrangement is known as a *prime-focus* arrangement, so named because of the placement of the feedhorn. Located at the spot (known as the focal point) where the reflected signals from the dish are concentrated, its function is to collect as much of the focused signal energy as possible. It is the type most likely to be found in a home TVRO system.

Another type of feed—called a Cassegrain system—uses a second reflector shaped as a hyperbola; hence, it is known as a hyperboloidal subreflector. The first reflector is the dish itself, with the secondary reflector located at the prime focal point. The sub-reflector refocuses the reflected satellite signal (from the dish) through an opening (aperture) in the center of the dish to a low-noise amplifier or LNA.

The primary advantage of the Cassegrain arrangement over the feedhorn type is the additional gain that it provides. The disadvantage of that system is that it's harder to adjust than the prime-focus arrangement and the second reflector is in the path of the incident signals. That means that some of the signal will be blocked out (aperture blockage).

There are ways, however, to overcome the drawbacks associated the Cassegrain system. One remedy is to use a larger dish to allow for apertureblockage losses.

However, that's not always convenient.

Waveguide

Unlike the conventional TV receiver where the incoming signal is picked up by an antenna and transferred to the signal-processing circuits in a TV set, microwave signals are reflected from the dish onto a waveguide, which then directs the signal to the antenna. A waveguide is used at microwave frequencies because of its lower loss when compared to coaxial cable. While it is possible to use other cable types, those cables are very expensive.

In many cases, when you look at the feedhorn you will see several metallic circles surrounding the central waveguide. Those rings are part of what is known as a *scalar feed*. The purpose of those rings is to help concentrate any satellite signals in the waveguide.

The antenna

The antenna (also sometimes called the antenna probe or simply the probe) is located in the feedhorn at the end farthest away from the prime focal point. (Note that you cannot buy the probe separately—it comes with the feedhorn.) From the antenna, the signal is fed to the LNA.

Because TVRO systems operate in the gigahertz region, the antenna is tiny—about one-inch overall. That broadband antenna is tuned to be resonant over the C-band frequency range.

Low-noise amplifiers

The signal from the antenna probe is, as stated before, directed to an LNA. That wideband, non-tunable amplifier has an amplification factor of about 100,000 (roughly 50 dB). It is usually encased in a weather-proof container—since it is located outdoors—and mounted just to the rear of the feedhorn (usually as a part of the feed system). It has an input-frequency range of 3.7–4.2 GHz.

Not only does the LNA amplify the satellite signal, but it also amplifies any noise that may be presented to its input. That includes any noise generated by the amplifier itself.

Also, even the noise generated by the radiated heat-energy from the earth can interfere with the satellite signals (which are inherently very weak). That's why an LNA's most important specification is given in Kelvins (or degrees Kelvins). The lower that *noise-temperature* rating, the lower the noise that is generated by the device. Popular LNA's generally have noise temperatures in the range of 80°K–120°K.

In putting together a TVRO system, another important rating to keep in mind is the signal-to-noise ratio (G/T) or figure of merit (expressed in Kelvins or decibels). That figure is a measure of how much electrical noise will be added to signals presented to the LNA input, however the figure of merit is independent of the gain of the amplifier. In other words, the noise level does not effect the gain of the LNA.

The gain is far more dependent on frequency range than the noise figure. For instance, an LNA with a noise figure of 1.5 dB can have gain variation of as much as 6 dB, as the frequency range changes over the C band. As noted in other articles in this section, manufacturers usually specify the maximum gain figure in their literature, rather than on the average. Therefore, you may find the actual gain at a particular frequency to be considerably lower.

LNA components

Most LNA's use gallium-arsenide (GaAs) FET's, although some use bipolar transistors. The features we need are excellent gain and the ability to take low-level signals and amplify them into usable levels.

The LNA is little more than a signal amplification device. It raises the amplitude of the signal by many orders of magnitude, but that's all it does. That means that the signal exiting the LNA is at the same frequency as that presented to its input.

While, it is possible to feed those signals directly to the satellite receiver through coaxial cable (as was once the case), to do so requires using fairly long runs of very expensive, hard-to-work-with cable—called helix. (The losses associated with "regular" coax at are too high for the cable to be used at microwave frequencies.)

A more practical arrangement is the one found in the most systems today: The downconverter is placed at the output of the LNA (mounted on the dish structure), and its output is fed to the receiver through common coaxial cable. The downconverter acts like the front end of a superheterodyne receiver: It takes the LNA's output and mixes it to produce an intermediate frequency of about 70 MHz.

Low-noise converter

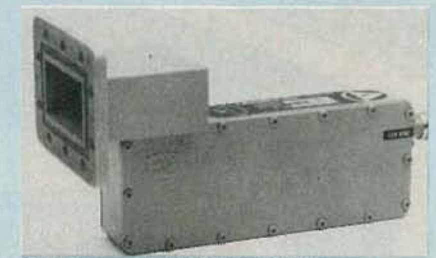
Sometimes the LNA and downconverter are combined into one device, called a low-noise converter (LNC). That eliminates the need to run a line between the LNA and downconverter. The two components may then be mounted in a single waterproof enclosure, which results in reduced installation time and lower manufacturing cost.

Low-noise block downconverter

There is another type TVRO system in which the antenna and LNA handle all transponder frequencies as a block; here the LNA acts as a low-noise block converter or LNB, combining the amplification and mixing functions.

Amplica

Amplica has several LNA models to choose from, ranging in price from about $300 to $800. Each of the models, the *ACD30530, ACD305329, ACD305331* and *ACD305332* has a gain of 50 dB. But each model's noise figure is different: The $329 ACD30530 has a noise temperature



AMPLICA model ADC 305-305 LNA.

of 120°K, the $399 ACD305329 has a noise temperature of 100°K, the $599 ACD305331 has a noise temperature of 90°K, while the $799 ACD305332 has one of only 85°K.

Avantek

A similar situation exists with Avantek's LNA's. While each model has a gain of 48 dB, the noise temperature vary from 120°K for the $375 *AWC-42120* to 100°K for the $525 *AWC42100*, to 90°K for the $689 *AWC-42085*, to 80°K for the $895 *AWC-42080*.

Boman Industries

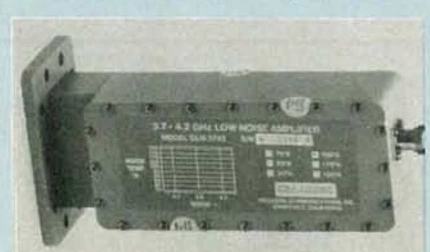
The *LNA-912* series of low-noise amplifiers from Bowman features a gain of 50 dB, while their *LNA-910* series features a gain of 53 dB. Six different models are available, ranging in price from $139 to $219. Their noise temperatures range from 120 °K to 80°K.

Boman also offers a variety of feedhorns including the $99.50 *RFH-75-t* ($114.50 with remote) and their *EFH-75-IIt* ($79.50). Both are scalar-feed types and use DC motors for antenna probe rotation. The *EFH-90* is priced at $99.50 and is another scalar feed with 180-degree rotation. (A solid-state version is available.)

The *EFH-90-PH* polarizer mounts in standard feedhorns and costs $129. It uses a ferrite design to keep moving parts to a minimum. It features 180-degree rotation.

Gillaspie Communications, Inc.

Two LNA's from Gillaspie are avail-



GILLASPIE model GLN-3742 LNA.

able, each with a gain of 50 dB. The *GLN-3742-100N/A* sells for $175 and has a noise temperature of 100°K. The *GLN-3742-120* sells for $150, and has a noise temperature of 120°K.

International Satellite Video

International Satellite Video offers their *Polatron III* polarizer, for $59.95. It's a solid-state polarizer: Polarity changes are accomplished magnetically (no moving parts are used).

M/A-COM Electronics Canada

This line of LNA's features a minimum gain of 50 dB. Priced from $160 to $300, the models in the *2016* LNA line are rated at 120°K, 100°K, and 85°K.

Microwave Applications Group

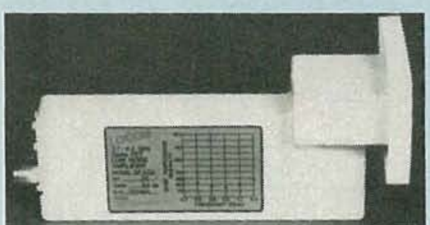
The ferrite polarization rotator, model *FPR-1 C/D*, available for $132 features

MICROWAVE APPLICATIONS GROUP FPR1 ferrite polarization rotator.

automatic polarization selection, using Faraday rotation. It has an insertion loss of 0.15 dB and a rotation of 120°.

Radio Semiconductor/Locom

The *RF-900-120*, which sells for $180 has a noise temperature of 120°K. The *RF-900-100*, which sells for $160 has a



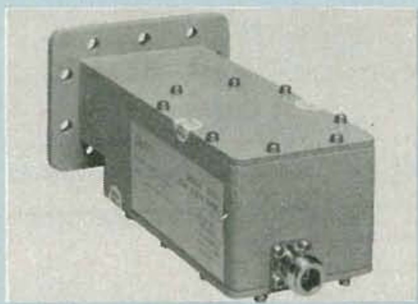
LOCOM models RF-900 (top) and RF-30.

noise temperature of 100°K. The *RF-900-85*, which sells for $280, is rated at 85°K. Each model has a gain of 52 dB.

R.L. Drake

Drake has three LNA models, the *2575*, *2574*, and the *2573*. They sell for $329, $429, and $599 respectively. The Drake LNA's use GaAs FET amplifiers and each has a gain of 53 dB. Their respective maximum noise temperatures are 120°K, 100°K, and 85°K.

The LNA's, as you might expect use weatherproof construction and are covered by a 9 month warranty.



R.L. DRAKE model 2575 LNA.

Syntronic

An integrated LNA and feedhorn is available from Syntronic for $495. It has no insertion loss between the LNA and feed, and electronic polarity selection (with no moving parts or adjustments). An adjustable choke is included to optimize the focal point. The noise temperature of the integrated LNA/feedhorn is 100°K. Its gain is 50 dB.

Winegard

Winegard's *SC-8101* sells for $384. It has a gain specified at 50 dB and a noise temperature of 100°K. **R-E**

MANUFACTURER LIST

Anderson Scientific, Inc.
2121 Rand Road
Rapid City, SD 57702

Antenna Technology Corp.
895 Central Florida Parkway
Orlando, FL 32809

Arunta Satellite Telecommunications
Box 15082
Phoenix, AZ 85060

Automation Techniques, Inc.
1550 North 105th East Ave.
Tulsa, OK 74116

Avantek, Inc.
481 Cottonwood Drive
Milpitas, CA 95035-7492

Avcom
500 Research Rd.
Richmond, VA 23236

Birdview Satellite Communications, Inc.
Box 963
Chanute, KS 66720

Blonder-Tongue
Brown Road
Old Bridge, NJ 08857

Boman Industries
9300 Hall Rd.
Downey, CA 90241

Burr Engineering
730 East Michigan Ave.
Battle Creek, MI 49017

Channel Master
Ellenville, NY 12428

Comtech Antenna Corp.
3100 Communications Rd.
Box 428
St. Cloud, FL 32769

Conifer Corp.
1400 North Roosevelt
Burlington, IA 52601

Delta Satellite Corp.
One Echo Plaza
Cedarburg, WI 53012

Earth Terminals
One Microwave Plaza
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General Instrument RF Systems
4229 South Fremont Ave.
Tucson, AZ 85714

Gensat/Microdesign Ltd.
1300 Bay St.
Toronto, Ont. M5R 3K8

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Gould/Dexcel Division
2580 Junction Ave.
San Jose, CA 95134

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Lake Saint Louis, MO 63367

Janeil Corp.
6860 Camby Ave. #113
Reseda, CA 91335

KLM Electronics Inc.
P.O. Box 816
Morgan Hill, CA 95037

Lindsay America
477 East Willow St.
Williamsport, PA 17701

Locator, Inc.
Box 3422
Kimberling City, MO 65686

Lowrance Electronics, Inc.
12000 East Skelly Dr.
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LSI Technologies
340A West Trinity Lane
Nashville, TN 37207

Luly Telecommunications Corp.
Box 2311
San Bernardino, CA 92406

Luxor (North America) Corp.
600-108th Ave. N.E.
Suite 539
Bellevue, WA 98009-0032

M/A-COM Prodelin, Inc.
Box 468
Newton, NC 28658

McCullough Satellite Equipment
Route 5, Box 97
Salem, AR 72576

Microdesign Ltd.
(Gensat) 951 Alness St.
Downsview, Ont. M3J 2J1

Micro-Link Systems, Inc.
6101 Webster St.
Dayton, OH 45414

Microwave Applications Group
3030 Industrial Parkway
Santa Maria, CA 93455

Miralite
4050 Chandler
Santa Ana, CA 92704

National Microtech, Inc.
Drawer E
Grenada, MS 38901

National Micro-Dynamics, Inc.
6153 Airways Blvd.
Chattanooga, TN 37421

Newton Electronics Inc.
340 East Middlefield Rd.
Mountain View, CA 94043

Odom Antennas, Inc.
1st State Bank Bldg. 202
PO Box 1017
Beebe, AR 72012

Paradigm Manufacturing, Inc.
3711 Meadowview Drive
Redding, CA 96002

Pico Satellite, Inc.
415 Gator Drive
Lantana, FL 33462

Quadralite, Inc.
114 West Corsicana
Athens, TX 75751

Quantum Associates
Box 18
Alpine, WY 83128

Radio Semiconductor, Inc. (Locom)
315 Brenner Pike
State College, PA 16801

Regency Satellite Systems
7707 Records St.
Indianapolis, IN 46226

R.L. Drake Co.
540 Richard St.
Miamisburg, Ohio 45342

Sat-Tec Sales, Inc.
2575 Baird Rd.
Penfield, NY 14526

Symtel, The Barnhart Corp.
6135 2nd St., NW
Albuquerque, NM 87107

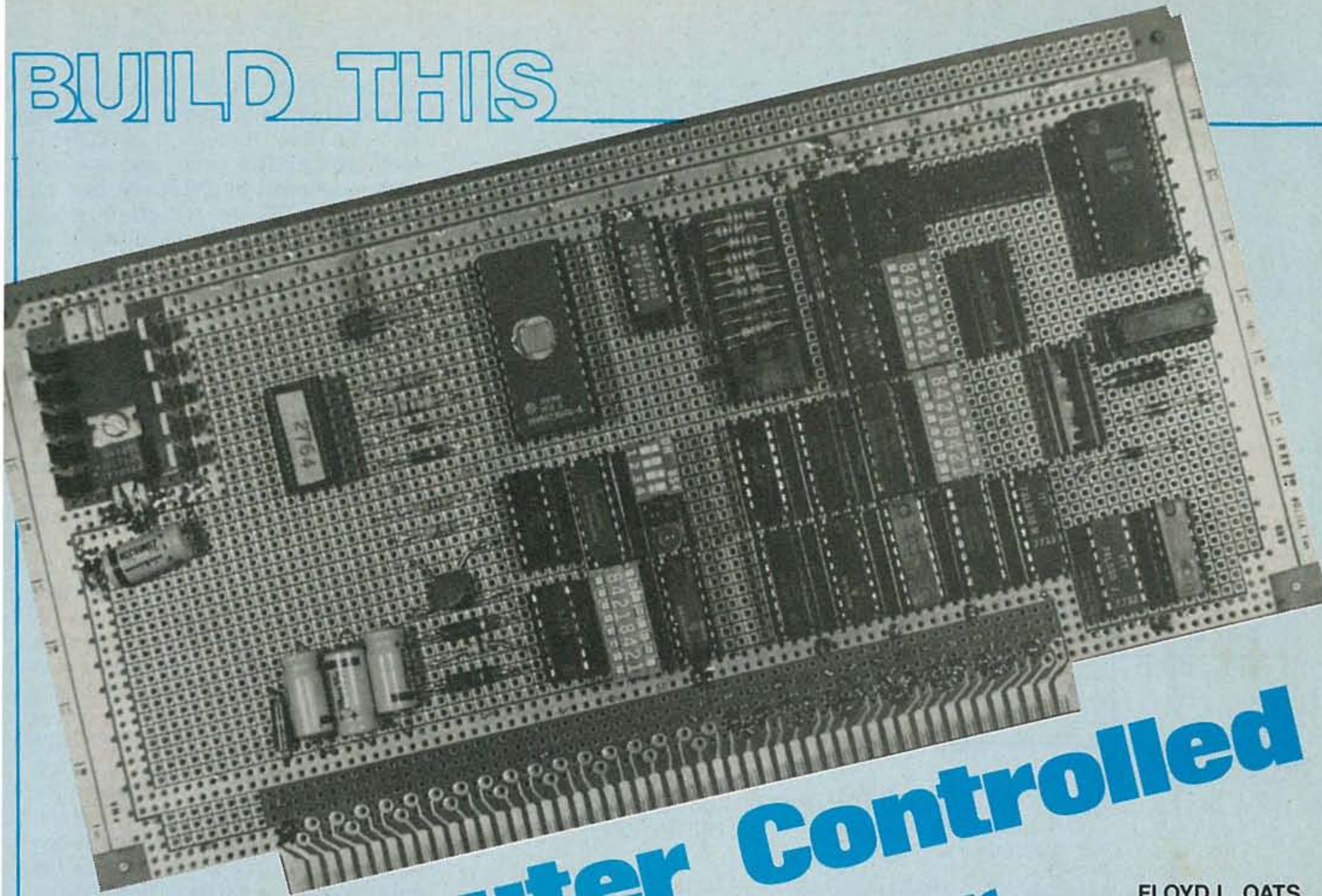
Syntronic Instruments, Inc.
100 Industrial Road
Addison, IL 60101

United Satellite Systems(USS/Maspro)
Highway One West
Thief River Falls, MN 56701

Vista Electronics
1101 West Elm St.
Cabot, AR 72023

Wilson Microwave Systems, Inc.
4286 South Polaris Ave.
Las Vegas, NV 89103

Winegard Satellite Systems
3000 Kirkwood St.
Burlington, IA 52601



Computer Controlled IC Tester

FLOYD L. OATS

This month we'll test the IC tester and then we'll look at some options that you can add.

Part 2 LAST MONTH, WE DEscribed the IC-tester circuit and the theory behind how it works. Now it's time to make sure that it *does* work. After we do that, we'll look at some options that you can add to your tester. For example, we'll build a low-budget logic analyzer—it works by expanding your oscilloscope display to 16 traces.

Testing the tester

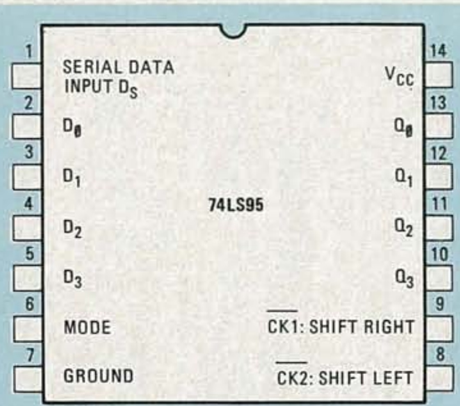
Most of the components and wiring are located in the data paths so the inherent self-diagnostic feature of the tester can be utilized as a debugging aid for the finished project. After the device is built and connected to the host computer, preliminary testing can begin.

For the purpose of discussion, we will assume that the device has been mapped into memory addresses CFØØH through CFFFH (as it is shown in the schematic). **Note:** An "H" indicates that a number is written in hexadecimal form.

Open all the isolation switches (S1–S16) and make sure that the test socket is empty and that there are no power-supply jumpers between SO3 and SO2. Read the sixteen response bits by performing memory reads on addresses CFØØH and CFØ1H. Both of those addresses should return FFH, indicating that the response is equal to sixteen "1" bits. Next, close all the isolation switches and write sixteen zeros in the stimulus latches by writing ØØ into address CFØØH. Read the response as before and look for sixteen zero bits. Now write all ones in the stimulus latches by writing FFH into memory address CFFFH and check for a response of all ones, as before. At this point, the tester is in a configuration where all stimulus information should be exactly duplicated on the response lines.

The next test will require a short program to send counting stimuli to the tester. After each stimulus is sent to the latches, the response is accepted and compared with the stimulus for equality. If single-bit failures are observed during the the test, the components and wiring associated with that particular bit should be checked carefully. If the bit patterns don't change or if they don't even resemble the correct patterns, the control circuitry might be at fault. Any discrepancies noted up to this point must be repaired before proceeding with further tests.

The final series of tests will verify the wiring of the isolation switches. Starting with all switches closed, open one switch and send a stimulus of all zeros. The response should be all zeros except for a single "1" bit, which should correspond to the open switch. Now close the switch just tested and open the next switch, then perform a similar stimulus/response test on this switch. Continue in this fashion until all sixteen switches have been tested. The final test is started with all switches open and is similar to the previous test in that one switch at a time is tested. This time the switches will be closed one at a time. Send test patterns of all zeros and



OPERATION	INPUTS MODE	$\overline{CK1}$	$\overline{CK2}$	D_S	D_n	OUTPUTS Q_0	Q_1	Q_2	Q_3
PARALLEL LOAD	H	X	↓	X	I	L	L	L	L
	H	X	↓	X	H	H	H	H	H
SHIFT RIGHT	L	↓	X	I	X	L	q0	q1	q2
	L	↓	X	H	X	H	q0	q1	q2
MODE CHANGE	↑	L	X	X	X	NO CHANGE			
	↑	H	X	X	X	UNDETERMINED			
	↓	X	L	X	X	NO CHANGE			
	↓	X	H	X	X	UNDETERMINED			

I: LOW VOLTAGE ONE SETUP TIME PRIOR TO HIGH-TO-LOW CLOCK TRANSITION
LOWER CASE LETTERS REPRESENT STATE OF REFERENCED OUTPUT ONE SETUP TIME PRIOR TO HIGH-TO-LOW CLOCK TRANSITION
↑: LOW-TO-HIGH TRANSITION
↓: HIGH-TO-LOW TRANSITION

FIG. 5—THE 74LS95. Before you test any IC, you have to prepare a function table. That's not only because you have to determine a valid and complete set of stimuli, but you also have to determine what kind of response you should expect.

look for a response of all ones except for the single closed switch.

Using the tester

In order to test an IC, the isolation switches and the power-supply jumpers must be configured for the specific circuit to be tested. The switches assigned to input pins of the test circuit must be closed and those assigned to output pins and power supply pins must be open. The actual test is done by comparing the set of test responses with a set of known good responses.

The best way to obtain a set of good responses is to issue stimuli to an IC (of the type you want to test) that you know to be good. You can save the responses for future comparison. Actually you should save both stimuli and responses since the patterns issued during the test must exactly match those used to create the initial patterns. A less attractive way of obtaining good response data is to issue patterns to a circuit thought to be good and then manually examine the response data to see if it is correct.

Let's consider the steps involved in testing the SN74LS95, a four-bit shift register with parallel-load capability. Figure 5 shows the pinout for that 14-pin IC along with a table that describes the circuit's functions. The MODE input (pin 6) determines the mode in which the circuit is operating (parallel load or shift), and also determines which of the two clocks is permitted to change the register contents. The function table reveals that there are edge transitions in the mode-change area that will cause indeterminate results. Those transitions should be avoided during the testing process because they represent invalid stimuli.

Fourteen-pin IC's should be mounted in the 16-pin socket such that pins 8 and 9 of the 16-pin socket are empty. (Consequently, pin 14 of the IC is connected to pin 16 of the test socket and to S16.) Figure 6 shows that and also indicates the required position of each isolation switch for that particular IC. The +5-volt power-supply jumper must be connected from SO3 pin 14 to SO2 pin 16. The ground jumper goes from SO3 pin 7 to SO2 pin 7. Set up the switches and power-supply jumpers, insert the IC into the test socket, and testing can begin.

The 74LS95 has multiple edge-sensitive inputs. As we mentioned previously, counting through the inputs does not generate suitable (complete and valid) stimuli for that IC. We shall use what amounts to a smaller and somewhat simpler set of test patterns as shown in Table 1.

Table 1 indicates that several patterns are issued to the 74LS95 before each response is read. For example, consider line 12 of the table. A stimulus of Ø228H is sent, bringing $\overline{CK2}$, MODE, and D_2 high. That is followed by ØØ68H on line 13, which brings $\overline{CK2}$ low. A response is then accepted; it and should equal 9Ø28H on line 14.

How does the host know when to accept a response? The software driver can take advantage of the fact that the isolation switches for the two power-supply pins are known to be open and that, consequently, those two pins are not sensitive to stimuli. Bits 7 and 16 can be used to imbed control-flag bits into the test data. Those can be used to tell the host whether to generate a stimulus, expect a response, call a subroutine, etc.

For example, when the ground line (bit 7) is made high, as on line 16, it indicates (to the author's test software) that a response is to be taken after the pattern is sent. When the +5-volt line is made high as on line 18, the software driver will call a subroutine to clear the 74LS95 before sending the test pattern on line 18. Notice that line 15 brings bits 16 and 7 of the test circuit low. The software driver writes that pattern and then proceeds to the next pattern on line 16. The pattern on line 16 has bit seven high (ground pin), causing the driver to accept a response (line 17) after sending the ØØ7ØH pattern. When both supply lines are high as on line thirty, it signifies "end of test." That use of power supply pins is one way, but not the only way, of simplify the passage of control parameters to the software.

Because the SN74LS95 does not have a separate CLEAR pin, the clear subroutine (Table 1, lines 1–4) must use the parallel-load capability of the circuit to load all zeros into the internal register. The response should be tested after the clear subroutine since a failure here will cause subsequent failures in the main body of the test. It is good general practice to flag the earliest possible failure in a series of tests, especially if the software is going to perform a complete and exhaustive failure analysis.

Options

If you build the tester on a prototyping board designed for your host system, you will almost certainly find that there is plenty of space left on the board for possible expansion. For example, an 18-pin socket may be added for the purpose of testing specific 18-pin circuits such as the popular 2114 RAM series. (The power supply pins would be permanently wired to the power-supply lines, while the other sixteen pins would be wired parallel to the sixteen test socket pins.) Pin correspondence between the test socket and the 18-pin socket can be assigned in any convenient order.

The addition of a PROM or EPROM

SN7495 PIN	14	13	12	11	10	9	8			7	6	5	4	3	2	1
FUNCTION	+5V	Q_0	Q_1	Q_2	Q_3	$\overline{CK1}$	$\overline{CK2}$	NC	NC	GD	MODE	D_3	D_2	D_1	D_0	D_S
SWITCH NUMBER	S16	S15	S14	S13	S12	S11	S10	S9	S8	S7	S6	S5	S4	S3	S2	S1
AND POSITION																

FIG. 6—SWITCH SETUP for testing the 7495 4-bit shift register.

programmer is practical because there are already sixteen latches on the board. If you add another SN74LS75, you'll have enough latches for the data and address lines of a 4K PROM. A square- or rectangular-wave generator may be added by selecting a bit and placing it under software control. Parameters describing the desired wave could be passed to software which would then compute the loop variables required to create the wave on the chosen bit line. Squarewave monitoring could be done by bringing the external wave into a bit line and letting the software sample the line. Those are just a few of the many ways to expand the IC tester.

Oscilloscope adapter

The logic analyzer is a very useful tool. But because it's also rather expensive, most hobbyists do not have access to one. However, we'll offer an alternative to the logic analyzer: an adapter for your oscilloscope that allows it to display 16 signals. Of course, its linearity and general quality of presentation won't match that of the logic analyzer. And it won't imitate the varied and complex functions of a logic analyzer. But it *can* be built from inexpensive, common logic-components. So for a very small expense, you can add a valuable tool for testing digital IC's to your testbench. Perhaps more important, the oscilloscope-adapter logic analyzer can be an excellent tutorial aid.

The author's display-adapter prototype was developed as an expansion of the digital IC tester that was presented last month, and it uses TTL IC's. However, the oscilloscope adapter can be built as a stand-alone unit, and the ideas can be applied to other logic families as well as TTL.

A look at the circuit

The oscilloscope adapter's circuit (its schematic is shown in Fig. 7) uses a counter/multiplexer/converter scheme to time-share sixteen digital signals onto a single oscilloscope channel.

The display counter, IC12 (a 74LS191 synchronous up/down counter), selects one of the sixteen channels for display. As it counts, each channel is selected in proper sequence—channel 1 is displayed on top, and channel 16 on the bottom.

A 74150 1-of-16 data selector/multiplexer, IC11 accepts the sixteen digital inputs from the tester. It selects one of them to pass to its output (pin 10). The selected input depends on the contents of the display counter.

The inverting buffer/drivers, IC13, along with its associated resistors, form a 5-bit 32-state digital-to-analog (D/A) converter. It combines the four display-counter bits and the single, selected channel bit into one of thirty-two discrete voltage steps—two voltage levels for each displayed channel. The output signal to the oscilloscope swings through more than four volts of the available 5-volt power-supply range.

TABLE 1

		SIGNAL TYPE	HEX VALUE	BIT VALUES 16..13	12..9	8..5	4..1	ACTION
	01	Stimulus	0220	0000	0010	0010	0000	- Bring $\overline{CK2}$ and MODE high
CLEAR	02	Stimulus	0020	0000	0000	0010	0000	- Drop $\overline{CK2}$ (load zeros)
	03	Stimulus	0040	0000	0000	0100	0000	- Drop MODE, then test
	04	Response	8000	1000	0000	0000	0000	- All pins low except V_{cc}
	05	Stimulus	8020	1000	0000	0010	0000	- Clear, then bring MODE high
	06	Stimulus	0222	0000	0010	0010	0010	- Bring $\overline{CK2}$, MODE, D_0 high
	07	Stimulus	0062	0000	0000	0110	0010	- Drop $\overline{CK2}$, then test
	08	Response	C022	1100	0000	0010	0010	- V_{cc}, Q_0, MODE, D_0 high
PARALLEL	09	Stimulus	0224	0000	0010	0010	0100	- Bring $\overline{CK2}$, MODE, D_1 high
LOAD	10	Stimulus	0064	0000	0000	0110	0100	- Drop $\overline{CK2}$, then test
TEST	11	Response	A024	1010	0000	0010	0100	- V_{cc}, Q_1, MODE, D_1 high
	12	Stimulus	0228	0000	0010	0010	1000	- Bring $\overline{CK2}$, MODE, D_2 high
	13	Stimulus	0068	0000	0000	0110	1000	- Drop $\overline{CK2}$, then test
	14	Response	9028	1001	0000	0010	1000	- V_{cc}, Q_2, MODE, D_2 high
	15	Stimulus	0230	0000	0010	0011	0000	- Bring $\overline{CK2}$, MODE, D_3 high
	16	Stimulus	0070	0000	0000	0111	0000	- Drop $\overline{CK2}$, then test
	17	Response	8830	1000	1000	0011	0000	- V_{cc}, Q_3, MODE, D_3 high
	18	Stimulus	8401	1000	0100	0000	0001	- Clear, then bring $\overline{CK1}$, D_S high
	19	Stimulus	0041	0000	0000	0100	0001	- Drop $\overline{CK1}$, then test
	20	Response	C001	1100	0000	0000	0001	- V_{cc}, Q_0, D_S high
	21	Stimulus	0400	0000	0100	0000	0000	- Bring $\overline{CK1}$ high D_S low
SHIFT	22	Stimulus	0040	0000	0000	0100	0000	- Drop $\overline{CK1}$, then test
TEST	23	Response	A000	1010	0000	0000	0000	- V_{cc}, Q_1 high
	24	Stimulus	0401	0000	0100	0000	0001	- Bring $\overline{CK1}$, D_S high
	25	Stimulus	0041	0000	0000	0100	0001	- Drop $\overline{CK1}$, then test
	26	Response	D001	1101	0000	0000	0001	- V_{cc}, Q_0, Q_2, D_S high
	27	Stimulus	0400	0000	0100	0000	0000	- CK_1 high and D_S low
	28	Stimulus	0040	0000	0000	0100	0000	- Drop $\overline{CK1}$, then test
	29	Response	A800	1010	1000	0000	0000	- V_{cc}, Q_1, Q_3 high
	30	Stimulus	8040	1000	0000	0100	0000	- END OF TEST

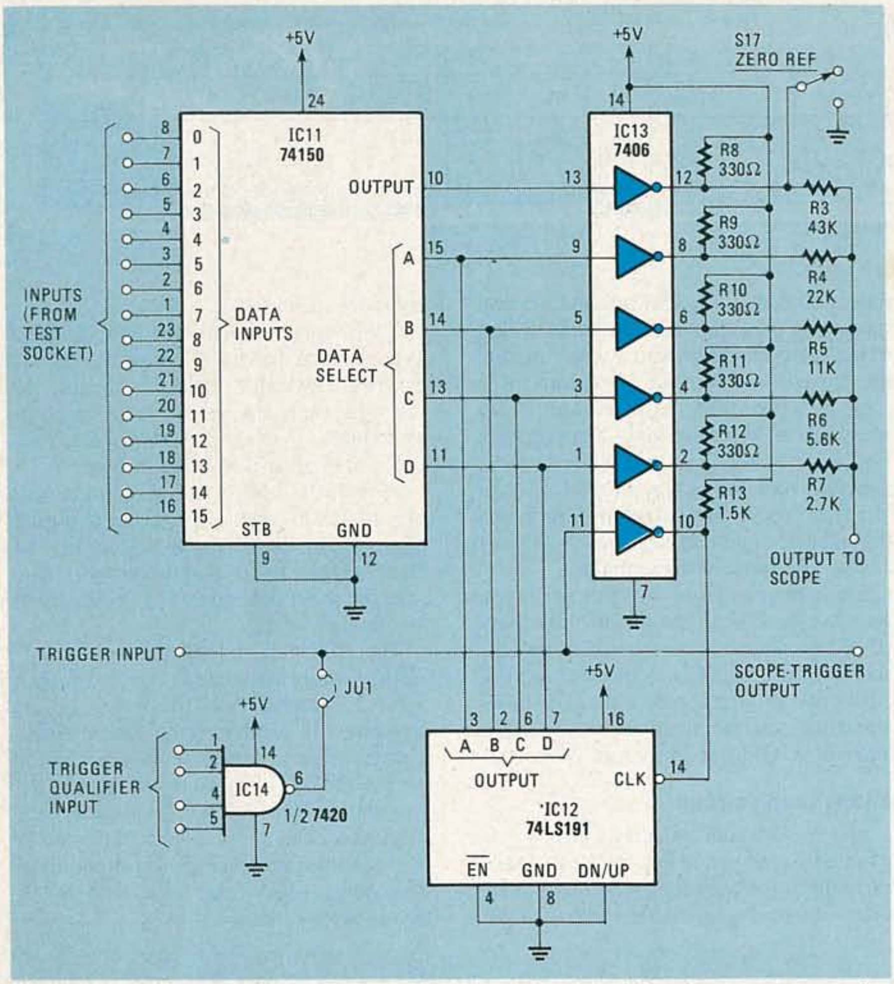


FIG. 7—OSCILLOSCOPE ADAPTER SCHEMATIC. IC12 selects which of IC11's inputs gets sent to the output buffer. The resistor network at the output of the buffer establishes 32 discrete voltage steps—two for each channel. IC14 is a trigger qualifier; it's optional, but suggested. Jumper JU1 is used to take the qualifier in and out of the circuit.

A trigger must be supplied by the logic system or device being observed. The trigger is needed both to act as a clock for the display counter and to initiate a horizontal oscilloscope sweep. The trigger signal is applied to pin 11 of IC13; sixteen of those trigger pulses are required to generate a complete 16-trace image on the scope. In complex digital systems, a single signal that can act as a suitable trigger is not always available—you may need an optional trigger qualifier so that you can create an acceptable trigger. A qualifier gate, such as what is shown for IC14, can be used. We recommend that you add such a qualifier gate along with a provision to enable it simply by the insertion of a jumper.

Switch S17 is an optional zero-reference switch. It is used to place a low logic-level on the least-significant input leg of the converter. When the switch is closed, the scope will display the 16 base lines. By momentarily closing the switch, you can quickly identify a steady-state channel as steady high or steady low. The switch is also useful in linearity tests.

Construction

You probably have enough room left on your original IC tester board to build the display adapter. Since the wiring or component layout is not critical, practically any construction technique may be used with good results.

There are many possible component substitutions that can be made in the TTL design. For example, the counter does not have to be a 74LS191: It can be another kind of synchronous counter like the 74LS163 or the 74LS193. Or it may be a standard (as opposed to low-power Schottky) TTL counter like the 74191. If substitutions are made, be sure to check the pinout of the new IC and document the changes where necessary. The use of ripple counters such as the 7493 is not recommended in this circuit—they tend to introduce excessive channel-switching transients. The 7406 may be substituted by other open-collector hex inverters including the 7416, and the 7405.

One final construction note: Assuming that you are building the circuit as an expansion of the IC tester, each display channel should be connected to its corresponding pin on the test socket. In other words, channel 1 should display the signal on pin 1 of test socket SO1 and so on. That makes using the analyzer easier.

Using the display adapter

For illustration purposes, let's set up the IC tester so that we can examine the waveshapes associated with the 74LS138 one-of-eight decoder. Table 2 lists the proper stimulus patterns. The trigger should be jumpered from the stimulus latch side of the isolation switch for pin 8 to pin 11 of IC13 in Fig. 7, and the scope should be set to trigger from the positive edge of an external signal. Isolation switches S1–S6 should be closed, and switches S7–S16 should be open.

Notice that the first two stimulus patterns will send a clock pulse to the display counter and trigger the oscilloscope, respectively. As shown in Fig. 8, the counter counts on the leading edge of the trigger pulse and the display begins on the trailing edge. That eliminates the channel-switching lines and lets us see a clean display.

Program your host computer to generate the looping stimulus patterns in Table 2 and run the test on a 74LS138. Connect the oscilloscope test leads to the adapter and, with the test running, we are ready to observe digital waveforms.

Set the vertical-sensitivity control to 1 volt/division and set the timebase to the fastest sweep. The exact sweep speed required for observation will depend on the speed at which the host system emits stimuli. Decrease the sweep speed and carefully observe the counting stimuli on channels one, two, and three, to determine when the proper speed is found. (It will probably be necessary to decalibrate the timebase to display the entire interval between triggers.) If the display shows four or eight traces with connecting steps, then the sweep is too slow but is close to the correct speed. If the display resembles multiple downward staircase waveforms, then the sweep is far too slow. Once the timebase is adjusted, the vertical sensitivity can be adjusted (and decalibrated) so that the sixteen channels cover the entire face of the scope, giving maximum channel separation. The display should resemble that shown in Fig. 9.

(continued on page 111)

TABLE 2

STIMULUS (HEX)	COMMENT
0020	Trigger low, count counter
00A0	Trigger high, trigger scope
00A1	
00A2	
00A3	Test patterns
00A4	
00A5	
00A6	
00A7	
	Loop back to first stimulus

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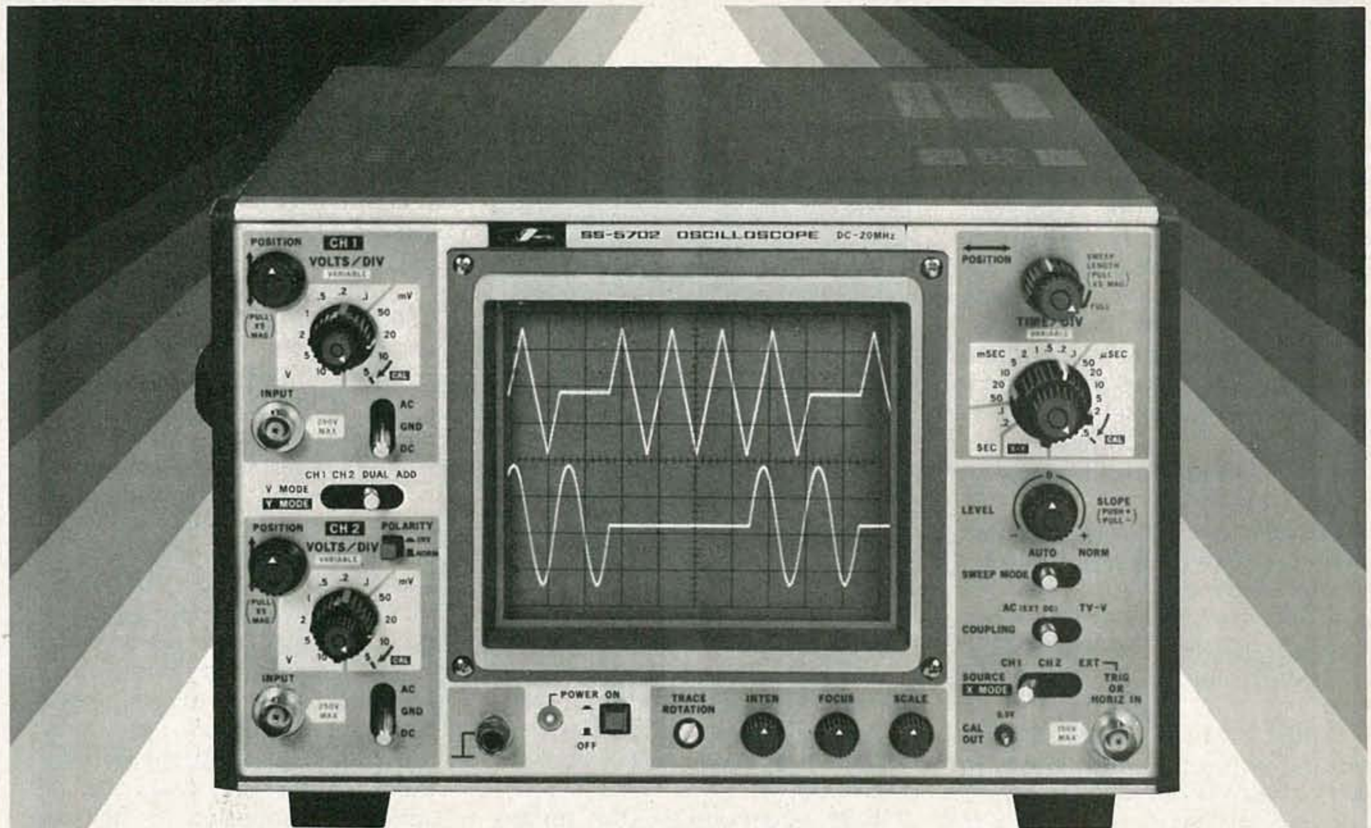

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HOBBY CORNER

Why discuss computers?

EARL "DOC" SAVAGE, K4SDS,
HOBBY EDITOR

WE RECEIVE MANY LETTERS FROM OUR readers and every one is appreciated. However, I find it particularly interesting that one sentiment appears about every twentieth letter. After the subject of concern has been covered, there is an added paragraph that states in one manner or another, "forget about computers." In fact, no other topic has been so enthusiastically rejected by so many of you.

I am at a loss to explain the phenomenon. I can't help but wonder where we would be today if we had said, "let's stick to tubes and forget transistors" or later, "stick to transistors and forget integrated circuits."

I must confess that I find computers extremely interesting. In fact, I have seven various makes and models, and each one has proved its worth in appropriate applications. Not only do their innards consist of fascinating electronics, but they are really terrific tools for doing wide variety of tasks. No one, however, intends "Hobby Corner" to become exclusively computer oriented.

What we are trying to say is that the subjects covered here should be balanced. The readers who ask how to get started in computers deserve the same consideration as those who ask how to get started in learning about transistors, or IC's, or electronics in general. So, even if you hate computers, read on—you might pick up an idea. Those of you who have asked how to get started in computer electronics may find the following reply helpful.

FIG. 1

Mike Stanridge (GA) needs help in designing and building a computer—specifically the video and CPU sections. Well, Mike, that is a tall order.

First, you need a good understanding of digital electronics principles and technology. Reading between the lines of your letter, I gather that your background in that area could stand a little beefing up. I can suggest nothing better than studying some of the books that have been mentioned in past issues of "Hobby Corner," and building and experimenting with the IC circuits that have appeared over the last several years.

I do know, however, that when a fellow wants to work in computer circuits, he doesn't want to wait six months or a year to do so. Therefore, here is a second suggestion for you (and the others reading along).

Get yourself a cheap computer. Perhaps a Radio Shack *MC-10* or a Commodore *VIC-20*. The Timex/Sinclair *1000* (shown in Fig. 1) has to be the cheapest one around—if you can find it. It uses the popular Z80 microprocessor.

I noticed a new Timex/Sinclair *1000* in a store the other day that was selling for less than $30. And recently, a friend shelled out $10 at a yard sale for a *1000* with a 16K expansion memory and a stack of program tapes. It had a small glitch in one section of the keyboard, but at that price, what the heck!

The Timex/Sinclair *1000* is not "a production" machine, but it is a computer of considerable power and, as such, can do amazing things. However, to do more than a minimal amount of useful work (word processing, for example), you would have to spend plenty on additional memory and other peripherals. Therefore, in that case you would be better off getting a larger machine.

I refer to computers such as those above as "learning machines." Electronics hobbyists can get in there to study and dig with no worry of blowing up an expensive machine. With a small investment, budding operators can learn to program and use a computer without losing their shirts if they decide not to continue.

Mike, I suggest that you get a learning machine, an appropriate data book or data sheets on the IC's inside, a schematic or technical manual (if one is available) and a logic probe. You will be surprised at how much you can learn. When you understand how the Timex/Sinclair (or other) machine works, you will be well on your way in preparation for designing your own.

Where can you find one of those little computers? My guess is that there are a great many of them gathering dust on closet shelves because their owners have graduated to larger machines. So ask around, visit local computer groups, advertise in the local paper and you're sure to find one. They're out there—all you have to do is some detective work.

Good luck to you, Mike, and to others who want to get started in the computer field.

April Fool!

No, it is not April and this is not an April Fool's joke. Instead, it is an early warning about next April. I had intended to wait until March to discuss this topic, but a letter from one reader (who shall remain nameless for obvious reasons) has prompted this discussion now.

Apparently, our friend obtained an old April issue of a magazine—not **Radio-Electronics**—that featured some ridiculous device. The gist of his letter was that he did not see how such-and-such device could possibly work, but he was interested and did want to build it. His request was for a detailed parts list, schematic, and so on.

Each year many periodicals celebrate the first of April by printing rather farcical articles. Even **Radio-Electronics** tries to provide its readers with a "laugh" in the April issue. Some years ago there was one that regularly went to great lengths, even to the point of presenting a seemingly realistic, detailed construction article. Needless to say, several readers were caught each year.

Of course, discoveries are made daily. And there are now devices that will do things believed impossible a short time ago. However, if you read about something that seems incredible—such as a 100-watt amplifier that's powered by the juice of a lemon, or a dead 6L6 tube mounted on the hood of a car to kill all radar in a five mile radius—check the date on the magazine. It just may be April! **R-E**

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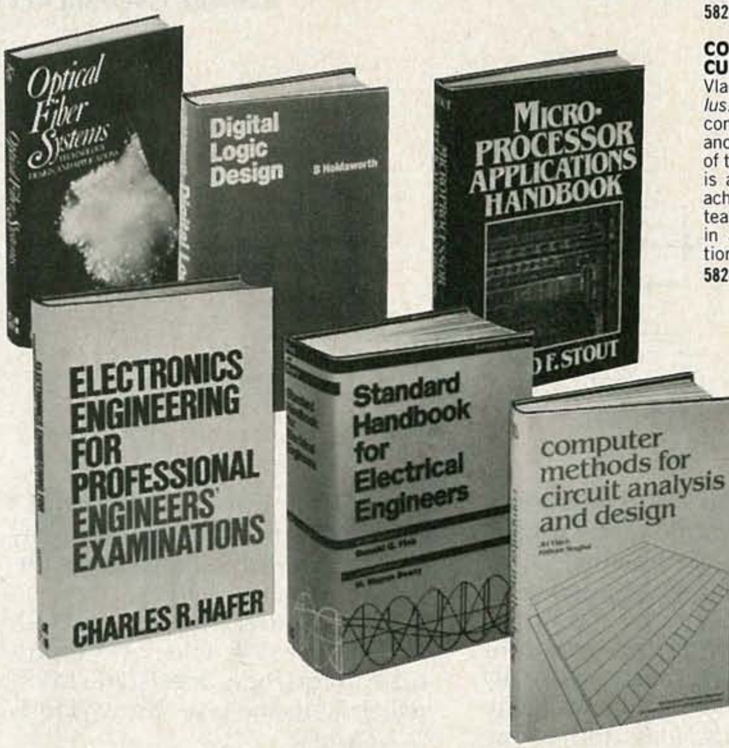

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DRAWING BOARD

ROBERT GROSSBLATT

Counting with the 4089

ANYBODY WHO HAS BEEN FOLLOWING this column on a regular basis knows that I'm a real freak when it comes to paperwork, data sheets, and generally anything that makes life on the bench a little easier. That's because it's always a good idea to collect as much information as possible before you start "getting your hands dirty."

However, there are limits to how much information you can absorb. Sooner or later you'll find it impossible to learn any more from paperwork alone. That means that you must actually work with a device in order to truly understand its operation. So, in line with that sage advice, let's get our hands dirty, and see what we must do with rate multipliers to make them perform some useful task.

Using rate multipliers

Once again, we'll be using the 4089 for our discussion because, in the first place, it's a CMOS IC—I believe in using CMOS whenever possible. Second, I just happen to have some of them lying around the house—always an important consideration when trying to cut costs!

The chart in last month's column should've given you a good idea of what the 4089 can do. Although the numbers may seem confusing at first, you'll find that actually powering up one of those IC's will make its use a lot clearer. As with most other special-purpose IC's, the majority of the control pins are held either high or low during normal operation. That greatly simplifies understanding how the IC works.

The majority of uses for the rate multiplier will revolve around some sort of arithmetic—usually multiplication or division. Other kinds of operations are possible as well (because more-complex arithmetic, such as square roots or exponential functions, can usually be reduced to repetitive basic arithmetic). But, let's start off by seeing what we have to do to multiply two numbers together.

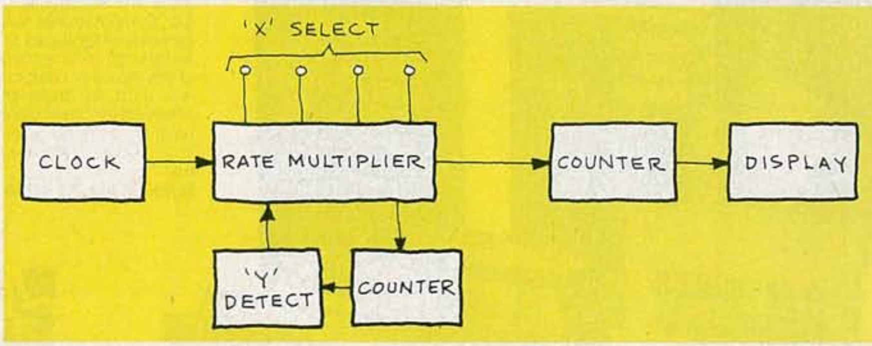


FIG. 1

Multiplication circuit

Figure 1 is a block diagram of the circuit we want to put together to multiply "X" times "Y." Although there are a number of boxes there, things aren't as complicated as they may seem to be. The basic operation of the circuit is simple and the clock can be any type of arrangement that you want to use, as long as it's noise-free and the waveforms look something like a squarewave.

A basic 555 oscillator or some other type of clocking arrangement works fine. You may be wondering about the frequency needed from the clock. Well, the answer to that question will surprise you: It doesn't matter what the frequency is! How's that for simplicity? But right now, let's clean off our hands and see why that apparently screwball statement is true.

First consider how the rate multiplier works: It takes the input-clock frequency, does some internal division and gives us two kinds of outputs.

Now recall that the "base-rate" is equal to one sixteenth the input clock, and that the "multiplied-rate" is the base rate multiplied by whatever number is presented at the binary inputs. If we were to write that statement as a formula, it would look something like what appears below:

Base rate = Input Clock/16
Multipled Rate = (X)(Input Clock/16)

Where "X" is one of the numbers we're multiplying.

That means that every time a pulse appears at the base-rate output, we'll get "X" number of pulses at the multiplied-rate output. To multiply "X" and "Y" all we need to do is count the base-rate pulses and stop after "Y" number of (multiplied-rate) pulses. Getting the right answer is really as simple as counting the total number of pulses at the multiplied-rate output, or expressed as a formula:

Base Rate = Input Clock / 16
Multiplied Rate = (X)(Base Rate)
= (X) (Input Clock/16)
X = (Multiplied Rate) / (Base Rate)

$$X = \frac{[(X)\ (\text{Input Clock} / 16)}{(\text{Input Clock} / 16)]}$$

X = X

As you can see, when we're doing multiplication with a rate multiplier, both the input clock and the internal base-number of the IC are completely unimportant—they cancel out. Getting the answer is only a matter of, as we said before, keeping track of the base-rate output pulses and counting up the multiplied-rate pulses.

The only part of Fig. 1 that could be at all tricky is the counter and other associated circuitry needed to detect when "Y" number of pulses have been generated at the base-rate output. There are two ways to do that. The method that you choose depends mostly on the type of counter you decide to use.

Since we want to count something "Y" times, we can either use an up counter starting at zero to detect "Y," or preload a down counter with "Y" to detect a zero. The choice again depends on the IC you want to use. Because up counters are a lot easier to come by, that's the way we'll go. Just remember that it's only a matter of personal choice.

One of the nicest things about CMOS counters is that there's a whole range of ripple counters that provide a one-IC solution to problems just like ours. They come in really handy when you want to count to some large number.

The 4020, 4040, and 4060 are all members of the ripple-counter family, but of those only the 4040 has outputs covering a continuous 12-stage count. That means that you can use it to detect any number from 0 to 4096.

Figure 2 shows the pinout of the 4040. It's used just the way you'd expect it to be; a clock is routed to pin 10, the reset pin is held low, and the IC will advance one count

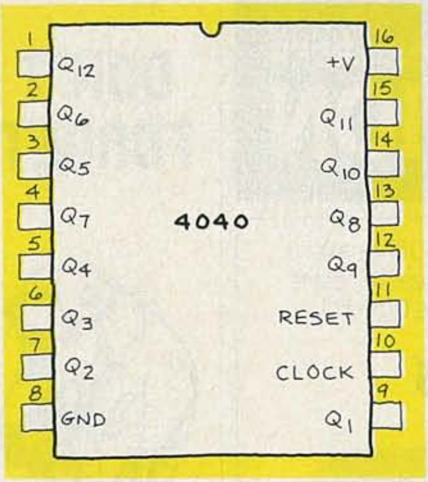


FIG. 2

on the negative-going edge of each incoming clock pulse.

Detecting "Y" involves a bit of gating. How you set things up, naturally, depends on the number that you're trying to detect. For instance, let's say that we want to multiply 14 by 67.

The only special thing about picking the numbers to be multiplied is to make sure that one of them is less than 16. That's because the 4089 has only four weighted inputs and the highest number that those inputs can represent is 15 (or 1111 in binary). However, the 4089 is easily cascaded for larger numbers. We'll examine that in more detail once we get through our example.

Figure 3 is a schematic of the circuit that we're designing; it shows everything except the counter and the display. We'll deal with them later.

The weighted inputs of the 4089 are set to load in a binary 14 (1110). We'll be using ⅓ of a 4073, 3-input AND gate to decode the Q1, Q2, and Q7 outputs of the 4040. Switch S1 is used to start the whole business going.

When S1 is pressed, IC3 resets and causes the output of the IC4-a to go low. That enables the rate multiplier, IC2, by bringing pin 11 low, causing it to start sending base-rate pulses to the clock input of IC3. For each base-rate pulse, 14 pulses are output at pin 6, the MULTIPLIED-RATE OUTPUT. You can see that the way we're doing our multiplication is to make IC2 count to 14 over and over until it's done it 67 times.

When that happens, 67 is decoded and the output of IC4-a goes high. That resets IC3 to zero

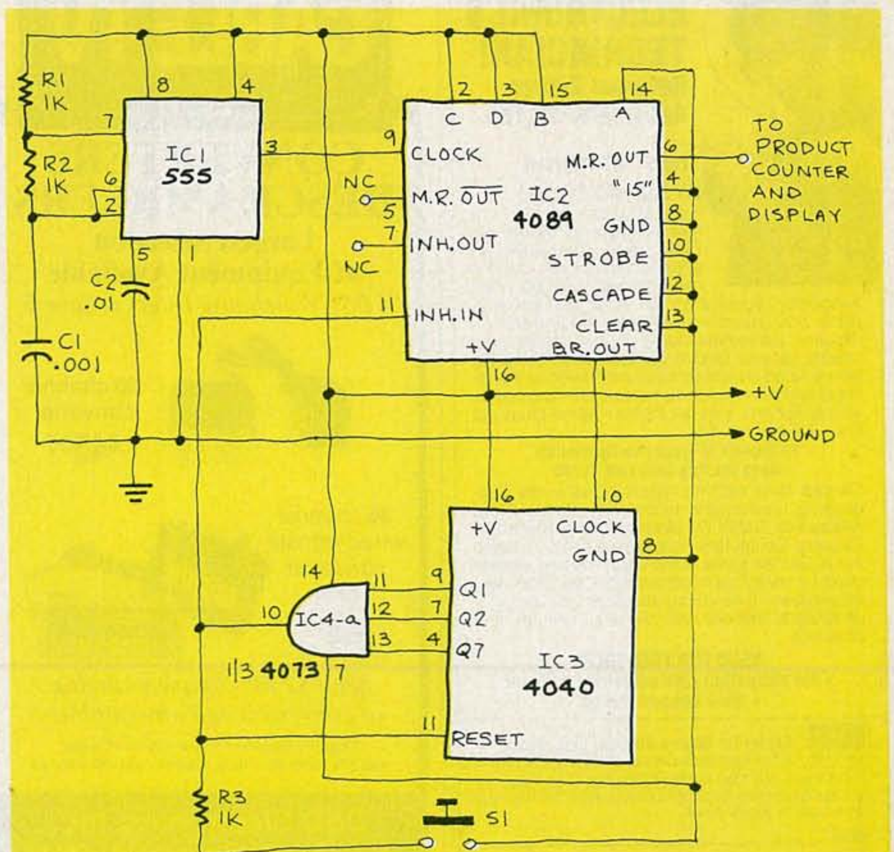


FIG. 3

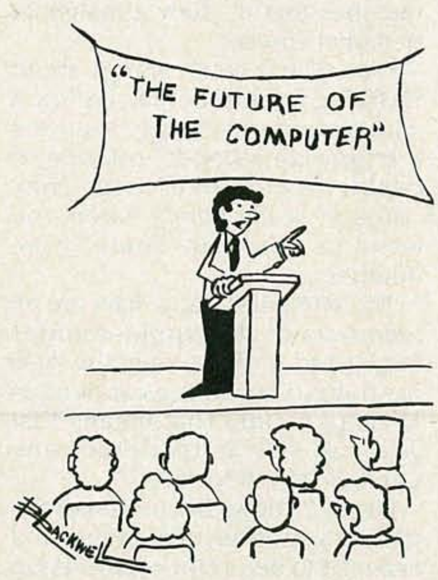
and brings the INHIBIT INPUT (pin 11) of IC2 high, preventing it from putting out any more pulses.

You could easily modify the circuit and use a gated oscillator so that the 4073 (IC4-a) would also stop the clock—there are many ways to accomplish that.

Since IC3 is reset to zero each time the circuit is used, any number that comes after 67 will never appear at the output. If you use a number other than 67, (which you probably will), you'll more than likely have to use a gate with more input legs. Not to worry though, because that can be taken care of by the two remaining gates in the 4073.

To add more inputs, just use a second gate as an input device and the third one to AND the first two together. It's not too difficult to figure out what gating you have to use and since that's not really what we're talking about, we won't go into it.

Next month we'll add a display to the circuit and see what kind of things must be done to cascade two or more rate multipliers together and allow us to multiply by virtually any number we want. We'll also see how to configure the circuit to do division. Believe it or not, that task is much easier than you think! And better yet, it gives us yet another opportunity to use—and become more familiar with—the 4089. **R-E**



"My computer tells me that there is no future in artificial intelligence."

DESIGNER'S NOTEBOOK

Inverting logic oscillators

ROBERT GROSSBLATT

ONE OF THE NICEST THINGS ABOUT digital circuits is that you can make an oscillator out of just about anything. Just look around your design and find a few spare parts (unused gates on the board), connect them together and you've got an oscillator. While working with analog components requires some thought, digital stuff is just lying there, begging for the chance to squirt out squarewaves. But that kind of convenience tends to make you sloppy.

Because most gate-type oscillators are essentially trouble free, you can easily get into the habit of thinking that they all are—but they're not! Everybody is familiar with (and has used) the oscillator arrangement shown in Fig. 1. (We've shown it with inverters, but any type of simple inverting logic will fill the bill.)

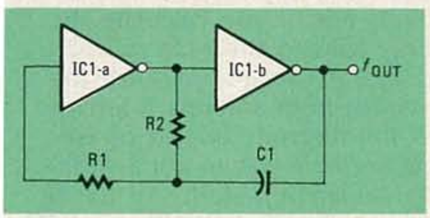


FIG. 1

Oscillator circuits

The circuit in Fig. 1 is simple to put together, forgiving of part values, and relatively stable for a given supply voltage. However, there is one problem associated with it—it won't always oscillate!

Like a good many of you, I've relied on that circuit whenever I needed a simple clock generator. More convenient ones, with fewer parts can be built with Schmitt triggers; however, not every circuit uses Schmitt triggers.

Imagine my surprise, after having figured out the component values for an oscillator I was building to get the clock frequency I wanted, and found that when I plugged the parts into the board, nothing happened. There I was, the victim of my own sloppiness.

The reason that the oscillator in Fig. 1 won't always work can be understood by taking the part values to the extremes—decreasing component values—and seeing what happens to the circuit. That kind of experimentation can come in handy when it comes to simplifying any circuit.

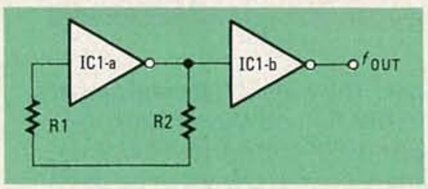


FIG. 2

If we keep on reducing the value of capacitor C1 and let it go to zero, we're going to wind up with the circuit shown in Fig. 2. There we see that IC1-b is no longer a part of the circuit, and it doesn't take much analysis to see that the circuit won't oscillate. What that tells us is that there are limits to the allowable value of the capacitor.

What those limits are will depend on several things; the supply voltage, load, component values, and a whole bunch of other stuff. In other words, what had been a really handy, no-thought type of circuit has turned into one that requires some consideration before we can use it.

The problem here is that the schematic in Fig. 1 is not an inherently astable circuit. That can been seen by looking at Fig. 2 and comparing it to Fig. 1. Remember, the capacitor forces the circuit to oscillate and if it's value is not large enough (or there is none at all), the circuit will just sit there and do absolutely nothing.

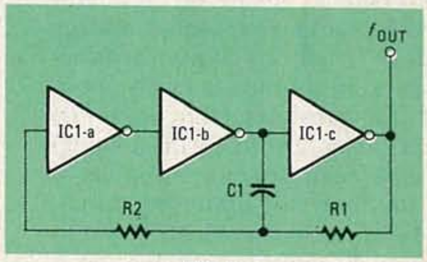


FIG. 3

What we need is a trouble-free oscillator that is inherently astable. Figure 3 is the type of circuit that we're looking for. As stated before, you can do a lot better and greatly simplify things by using Schmitt triggers. For all those other times, however, the circuit shown in Fig. 3 is just what the doctor ordered.

The circuit is sure-starting and trouble-free—it will oscillate over a much wider range than an oscillator made with just two inverters (like the one in Fig. 1). The formula for determining the output frequency is admittedly a bit complex, but several assumptions can greatly simplify things. Since it's not the kind of circuit that you would use if you need good stability or heavy-duty precision, the following approximations are more than adequate:

continued on page 134

COMMUNICATIONS CORNER

Antenna systems

HERB FRIEDMAN,
COMMUNICATIONS EDITOR

SOMEONE ONCE SAID SOMETHING TO the effect that the more things change, the more they remain the same. That thought came to mind recently while traveling through the "outback" of our country—the "Wild West."

Back in the East, most VHF communications antennas are omnidirectional, meaning they radiate RF (*R*adio *F*requency) energy equally in all directions; a directional VHF antenna is rarely seen. But out West it often becomes quite necessary to beam a signal up a canyon, down a mountain—or, anything but omnidirectional. That's because there's no sense in wasting RF energy by beaming it where it's not needed. It is, therefore, not uncommon to run across directional VHF antennas—usually two verticals sticking up from an arm that protrudes from a mast or tower.

Seeing those vertical beams reminded me that one of the standard questions on the FCC Radiotelephone License exam concerns two quarter-wavelength vertical broadcast-band antennas that are spaced one half-wavelength (180 degrees) apart, and are fed out-of-phase by 180 degrees. "What is the radiation pattern," the exam asks. You are supposed to know the answer: "Bi-directional, in-line with the two antennas."

For more than 35 years, the FCC has asked essentially the same question as it concerns antennas for the standard broadcast-band. However, the same technique is used for VHF communications antennas. The only difference is that it's easier to feed the smaller, low-power VHF antennas because ordinary coaxial cable can be used for the phasing networks. So that you can better understand the characteristics of phasing networks, let's look at a couple of examples.

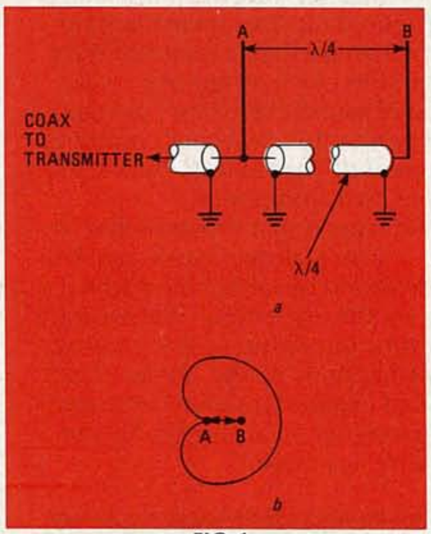


FIG. 1

Antenna Phasing Networks

Figure 1-a shows how two vertical antennas can be installed to provide a unidirectional radiating pattern or, more precisely, a cardioid pattern. A cardioid is a heart-shaped closed curve formed by the overlapping of two equal fixed circles. That pattern is shown in Fig. 1-b. A unidirectional antenna would have greater forward energy and even less energy at the sides; but with an inexpensive antenna system, the cardioid pattern is as unidirectional as we're going to get. For a highly unidirectional radiation pattern, we would use a multi-element yagi or stacked yagi's—a subject for detailed future discussion.

The two antennas in Fig. 1-a are physically spaced a quarter-wavelength apart, and the RF signal is fed to them 90-degrees out of phase with each other. To accomplish the phase difference, antenna A is fed directly from the transmission line, and a quarter-wavelength section of coax is placed between antennas A and B. The coax cable between the two antennas is an electrical quarter-wavelength, so it delays the energy to antenna B by 90 degrees. By the time the signal reaches antenna B, the wavefront from A has already arrived; the energy from A and B combine in the forward direction. But, if you calculate the energy toward the rear you will find that it cancels, because the wavefront from antenna B arrives at A 180-degrees out of phase. What a simple way to get a directional radiation pattern! All that is needed is just a couple of pieces of wire and some coaxial cable.

However, there is one major problem with that arrangement: The coaxial phasing section won't reach from antenna A to B. And because the coax effectively slows down RF flow within the cable, a half-wavelength of coax is less than a half-wavelength in free space. The reduced speed of the RF flow is called the "*velocity factor*" which, for coaxial cable, is nominally 66% of the calculated wavelength in free space. For example, if a wavelength in free space is 10 feet, an electrical wavelength of coax is 6.6 feet. Let's consider a second example: If a quarter wavelength in free space is three feet, a quarter-wavelength of coax is just short of two feet. Therefore, if the antennas are spaced a quarter-wavelength apart and fed a quarter-wavelength out of phase, the coax from antenna A to B is obviously not going to reach—it will reach only 66% of the required distance.

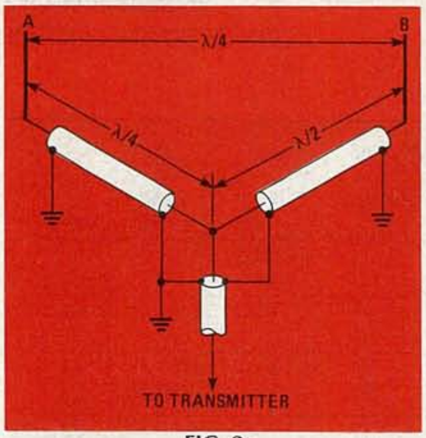


FIG. 2

The way we "stretch" the coax is by changing the method by which the two antennas are fed. One such solution is shown in Fig. 2. There, instead of the coax from the transmitter going directly to point A as in Fig. 1, it is connected through a quarter-wavelength section of coax. From the junction of the main transmission line and the quarter-wavelength coax, a half-wavelength section is connected to point B.

At first glance it might appear as if everything is out of joint, but take a moment to study the phase relationships more closely. Though we have delayed the signal to point A by 90 degrees, we have delayed the signal to point B by 180 degrees. The phase difference between the two is still the desired 90 degrees—the only problem now is that we have more coax than we need going to point B. And since the half-wavelength section is about 30% oversize, we can coil the excess and tape it to the mast or tower if necessary.

You can play with the antenna spacing and coax phasing-sections to handle almost any problem that comes up. For example, let's go back to that question of which the FCC is so fond. Imagine that a VHF station for a tow-truck service is to be located in the center of a long, thin island. An omnidirectional antenna is obviously going to radiate RF energy over the water, where it won't do anyone any good. What's needed is a bi-directional or a figure-8 radiation pattern—the same one that is on the FCC tests.

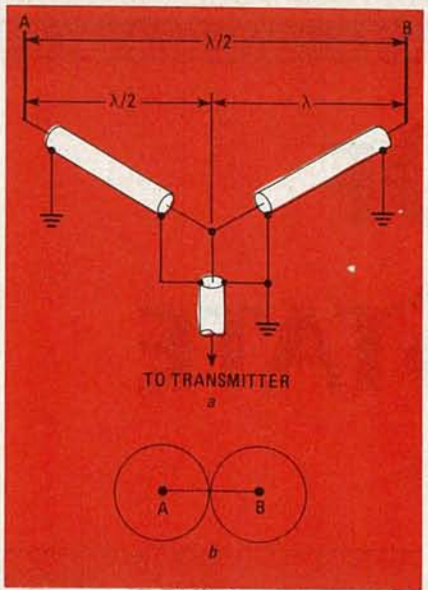


FIG. 3

Figure 3 shows the desired pattern and how it's attained. Here the antennas (in Fig. 3-a) are spaced a half-wavelength apart; the signal is fed to them 180 degrees out of phase with each other by using a half-wavelength coax section to antenna A and a full-wavelength coax section to antenna B. The difference between a half-wavelength and a full-wavelength is 180 degrees—the value needed for the bi-directional pattern, and exactly the answer needed for the FCC's question.

Determining how transmission-line phasing-sections work is not only fun, but also gives a good understanding of how to use ordinary coaxial cable to overcome unusual antenna-installation problems. Try working the examples shown using unusual feedline arrangements, such as bringing the feed into point B instead of point A, or experimenting to see how much length must be added to a coax cable to reach from one antenna to the next to achieve the desired phase difference. **R-E**

STATE OF SOLID STATE

Low-power amplifier IC's

ROBERT F. SCOTT,
CONTRIBUTING EDITOR

IF YOU'VE BEEN FRUSTRATED IN YOUR efforts to complete an electronics project or experiment by the lack of a small, low-power audio amplifier, I urge you to consider building one around either of two power-amplifier IC's recently introduced by the Sprague Electronic Company.

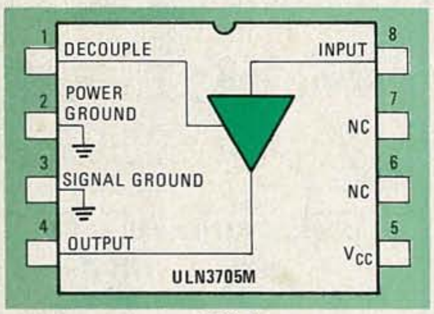


FIG. 1

First we'll look at the ULN-3705M—its pinout is shown in Fig. 1. That class-AB amplifier is housed in an 8-pin mini-DIP and has a voltage gain of 42 dB. Its operating temperature can vary between −20 and +85°C.

The typical power-output of the unit can range from 60 to 600 milliwatts, depending on supply voltage and speaker impedance. For example, operating from a 9-volt supply and driving a 16-ohm load, the unit's output power is 600 milliwatts. Audio power output levels for three different speaker impedances (8, 16, and 32 ohms) and supply voltages appear in Table 1.

The recommended supply voltage for the ULN-3705M can range from 4.5 to 9 volts with a 6- to 10-mA quiescent current-drain. However, the amplifier operates (at reduced volume) with supplies as low as 1.8 volts without a notable increase in harmonic distortion. Total harmonic distortion is specified at from 0.4–1.0% and 0.5–1.0% for 32- and 16-ohm loads, respectively.

TABLE 1—ULN-3705

Characteristic	Symbol	Test Conditions	Limits Min.	Typ.	Max.	Units
Supply Voltage Range	V_{CC}		1.8	6.0	9.0	V
Quiescent Supply Current	I_{CC}	V_{CC} = 4.5 V	—	6.0	—	mA
		V_{CC} = 6.0 V	—	7.0	15	mA
		V_{CC} = 9.0 V	—	10	20	mA
Voltage Gain	A_V		—	42	—	dB
Audio Power Output	P_{OUT}	R_L = 8Ω, V_{CC} = 4.5 V, THD = 10%	—	220	—	mW
		R_L = 8Ω, V_{CC} = 6.0 V, THD = 10%	250	430	—	mW
		R_L = 16Ω, V_{CC} = 4.5 V, THD = 10%	—	125	—	mW
		R_L = 16Ω, V_{CC} = 6.0 V, THD = 10%	150	240	—	mW
		R_L = 16Ω, V_{CC} = 9.0 V, THD = 10%	—	600	—	mW
		R_L = 32Ω, V_{CC} = 4.5 V, THD = 10%	—	60	—	mW
		R_L = 32Ω, V_{CC} = 6.0 V, THD = 10%	85	110	—	mW
		R_L = 32Ω, V_{CC} = 9.0 V, THD = 10%	—	310	—	mW
Distortion	THD	P_{OUT} = 50 mW, R_L = 32Ω	—	0.4	1.0	%
		P_{OUT} = 50 mW, R_L = 16Ω	—	0.5	—	%
Output Noise	V_{OUT}	Input Shorted, BW = 80kHz	—	225	—	μV
Input Resistance	R_{IN}	Pin 8	—	250 K	—	Ω
Power Supply Rejection	PSRR	C_D (Pin 1) = 500 μF, f = 120 Hz	—	34	—	dB

The ULN-3705M is recommended for use as a headphone driver in battery-powered portable radios and tape recorders. It is, therefore, ideally suited for use in audio signal-tracers and bench amplifiers, and is intended as a low-cost alternative to designs using discrete transistors.

Figure 2 shows a typical application for the ULN3705. The circuit's performance is influenced by the values of two external electrolytic capacitors (C3 and C4). One is used for output coupling and the other for feedback and ripple decoupling.

The output-coupling capacitor, C4, works with the speaker impedance to control the low-frequency cutoff. The −10-dB points are about 20, 30, and 60 Hz when driving an 8-ohm speaker through coupling capacitors of 500 μF, 250 μF, and 100 μF, respectively.

Capacitor C3 is used for feedback decoupling and power-supply ripple rejection. The 500-μF capacitor specified provides 34 dB of rejection at 120 Hz. The ampli-

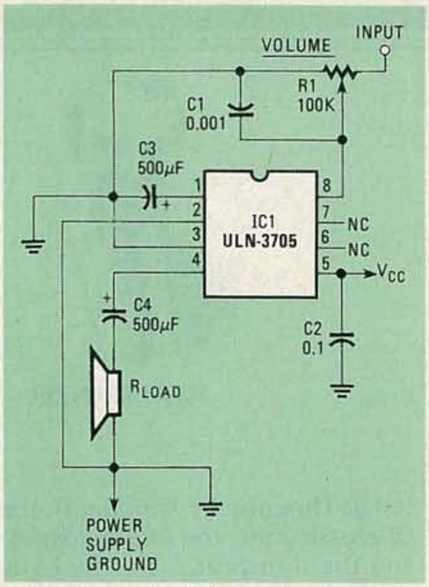


FIG. 2

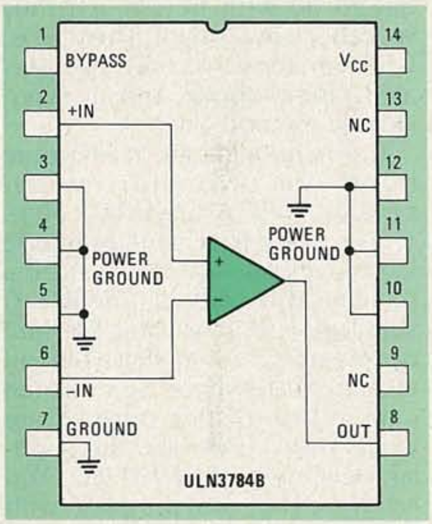


FIG. 3

fier input (pin 8) must be provided with a DC return path to ground for a current of approximately 1 µA. That current produces a voltage (IR) drop that, when multiplied by the circuit's closed-loop DC gain, appears as an error in the output offset-centering. The value of resistance between the input and ground is ideally 100 kilohms or less, although up to 200 kilohms may be used.

The other amplifier, the ULN-3784B, is housed in a 14-pin DIP and is designed for such applications as automotive, communications, and consumer electronics that require a high-quality audio output. The device's pinout is shown in Fig. 3.

The ULN-3784B is a pin-compatible improvement on several earlier designs and is a direct replacement for National Semiconductor's LM380N and LM384N, and Sprague's ULN-2280B and ULN-2281B IC's. However, it provides a wider margin of protection against supply-voltage transients. Table 2 shows the electrical characteristics of the IC.

The ULN-3784B operates from a single supply that can range from 9 volts up to about 28 volts. The unit has a 34-dB internally fixed gain. Operating from a 24-volt supply, its typical output power is 4-watts minimum when working into an 8-ohm load. With a 28-volt supply, its power output is 4.8 watts working into 16 ohms.

The ULN-3784B's typical quiescent current is 20 mA, and it has a bandwidth of 100 kHz and its

continued on page 112

TABLE 2—ULN-3784B

Characteristic	Symbol	Test Conditions	Limits Min.	Typ.	Max.	Units
Supply Voltage Range	V_{CC}		9.0	24	28	V
Quiescent Supply Current	I_{CC}	$V_{IN}=0$ V	—	20	—	mA
Quiescent Output Voltage	V_{OQ}	$V_{IN}=0$ V, See Note 1	—	12	—	V
Voltage Gain	A_V	$P_{OUT}=0$ W	31	34	37	dB
Total Harmonic Distortion	THD	$P_{OU}T=50$ mW, $R_L=8\Omega$, $V_{CC}=24V$	—	0.2	—	%
		$P_{OU}T=50$ mW, $R_L=16\Omega$, $V_{CC}=28V$	—	<0.2	—	%
		$P_{OU}T=4$ W, $R_L=8\Omega$, $V_{CC}=24V$	—	<0.3	5.0	%
Audio Output Power	P_{OUT}	$R_L=8\Omega$, $V_{CC}=24$ V, THD=5%	4.0	5.0	—	W
		$R_L=16\Omega$, $V_{CC}=28$ V, THD=5%	4.0	4.8	—	W
Input Impedance	Z_{IN}	Each Input	140 K	170 K	—	Ω
Power Supply Rejection	PSRR	$P_{OUT}=0$ W, $f=120$ Hz	—	30	—	dB
Equiv. Input Noise Voltage		$f=20$ Hz to 20kHz	—	60	—	μV_{RMS}
Bandwidth (−3 dB)	BW	$P_{OUT}=1$ W, See Note 2	—	100	—	kHz

NOTES: 1. The quiescent output voltage typically equals ½ the supply voltage.
2. Unity gain typically occurs between 10 MHz and 100 MHz.

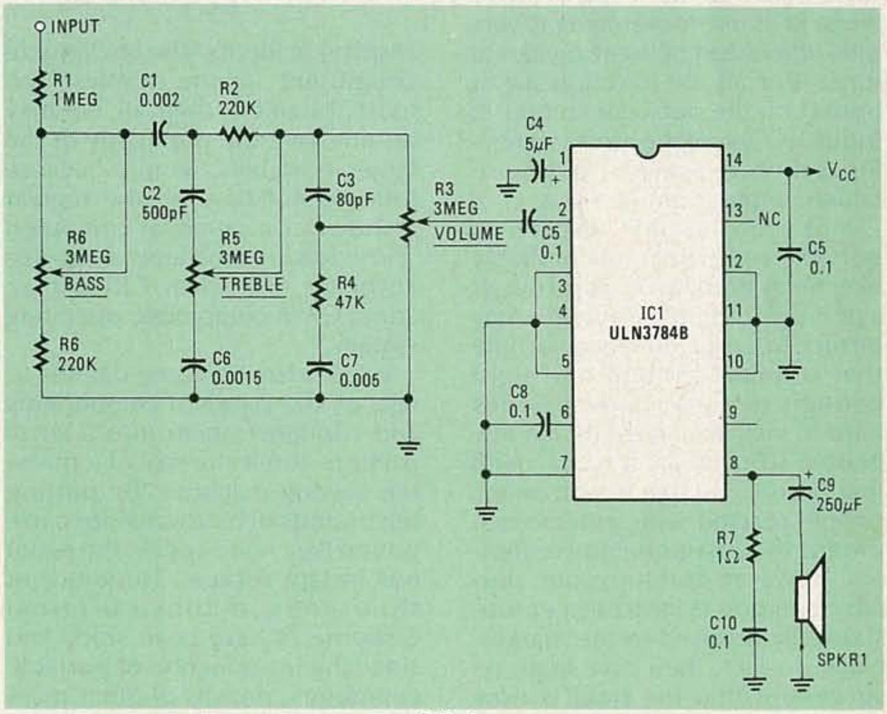


FIG. 4

COMPUTER CORNER

LOU FRENZEL

Portable computers

THERE IS ALWAYS A LOT GOING ON IN the hyperactive personal-computer field. However, four major trends seem to be dominating the market at the present. Those include the low-end home-computer price war and shake-out; the movement toward IBM *PC*-compatible systems; the integrated-software movement, and the portable-computer phenomena. None of those movements is very old—the oldest being two years at most. But all are having a major impact on the personal-computer industry. One of the most interesting of those movements is the portable-computer phenomena.

Most people's first reaction to portable computers was probably like mine: Who in the world needs a portable computer? While it may be nice to have a compact machine that is small enough and light enough to carry anywhere, it's hard to visualize more than a few people who might actually need that feature. For that reason, many people reacted with indifference toward the first portable computers. However, as it turns out, portable computers have been enthusiastically received in the marketplace. In fact, they have been so successful that the field is now crowded with competitors.

Industry guru Adam Osborne started the portable-computer business when he introduced his famous *Osborne I* early in 1981. During that same year, Radio Shack and some of the Japanese manufacturers originally introduced their pocket-size handheld calculator-like personal computers, which contained BASIC in ROM and had LCD (*L*iquid *C*rystal *D*isplay) readouts. The pocket-size computers are the smallest and most portable of them all. But they do not have the popularity of the larger portables, simply because they do not have all the regular features of a personal computer. Those features includes a full-size keyboard, disk drives, CRT display, and a CP/M-compatible operating system.

FIG. 1

What Adam Osborne did was to take all the standard components and condense them into a small package about the size of a portable sewing-machine. By putting ten pounds of hardware into a five pound bag, so to speak, the result was instant success. Hundreds of thousands of those original *Osborne I*'s have been sold. And since the introduction of portable computers, dozens of other manufacturers including Kaypro, Compaq, Columbia, Seequa, Dynalogic, and others have come along to take advantage of this totally new market niche. With such fierce competition, prices have dropped while features and functionality have been increased.

Classifying portables

There are four basic categories of portable computers available today. They are the *handhelds*, the *briefcase* units, the *intermediates*, and the *transportables*. The basic method of categorizing portables has to do with how much they weigh, how large they are, whether they are battery operated, type of display, and the mass-storage method used.

The *handhelds* are really more like large calculators in appearance than anything else. Those units have alphanumeric keyboards and usually feature a one-line LCD readout. The BASIC language is built-in, and they are battery-operated so that you can take them anywhere. Some of the units typical of this category are Radio Shack's *PC-4* and the popular Hewlett-Packard *HP-75C*. You can write your own programs with the built-in BASIC interpreter, and store them on standard audio-cassettes by using a cassette player/recorder and a cassette interface (usually optional). Many handhelds also feature plug-in ROM cartridges that allow you to perform special business, engineering, and statistical or scientific calculations. The handhelds are also the cheapest of the portables. You can get one for less than $100, although the more advanced units sell for prices ranging up to $500, depending on the accessories you choose.

The *briefcase* computers are the newest portables on the market. And like the handhelds, they are usually battery-operated so that they can be taken along and used anywhere. These units are larger however, since they contain more circuitry, and larger displays and keyboards. The keyboard is usually the same full-size you would find on a typewriter. The LCD readouts are used because of their low power consumption. However, the display on a briefcase portable, unlike the handhelds, can present multiple lines of data. For example, Radio Shack's Model *100* briefcase computer (see Fig. 1) can display eight 40-character lines. The Epson *HX-20* briefcase computer displays four 20-character lines. Both of those machines have a BASIC interpreter built-in. The Epson *HX-20* also contains a microcassette player/recorder built-in so that programs may be written, stored, and retrieved. And it also features a tiny built-in printer: Its output format is 24-character lines.

In addition to a BASIC interpreter, the Radio Shack Model *100* also contains built-in applications software. That software includes a text editor for elementary word-processing applications; a simple data-storage program for maintaining telephone numbers and address files; an appointment calendar, and a communications program that allows the unit to be used as a terminal. A built-in 300-baud direct-connect modem allows you to connect the Model *100* to the telephone lines and communicate with remote computers.

In addition to Radio Shack and Epson, other manufacturers include Casio, Nippon Electric, Sunrise Systems, MicroOffice, and Convergent Technologies. All of the machines from those manufacturers weigh about 4 to 5 pounds, are fully battery-operated, and will fit inside a standard-size briefcase.

Next we come to the *intermediate portables* that are somewhat larger and heavier but, of course, they contain more features. The typical intermediate weighs in the 8-to-16-pound range and many of them are still small enough to be put into a briefcase.

One of the most popular intermediate portables is the new *Gavilan*. That machine features an 8088 microprocessor and uses the popular Microsoft MS-DOS operating system. It has an eight-line 80-column LCD readout and contains 64K of RAM, and a single built-in 3.5-inch micro-floppy with a storage capacity of 360K bytes. There are all sorts of accessories for the unit, including a printer. Again, the unit is battery-powered for complete portability. This 9-pound unit does almost everything that you might expect from a larger machine.

The final category is the *transportables*. They were the first portable computers to go on the market, and are really nothing more than tightly repackaged versions of standard desk-top personal computers. The units feature CRT displays, full-size keyboards, and built-in floppy-disk storage. Some of the newer units, like the Kaypro *10*, even contain a hard-disk drive.

The reason for the term "transportable" is that the size and weight of the typical unit is such that it can barely be considered portable. Most of these machines weigh in the 20-to-30-pound range and are not all that easy to lug around. Also, most of them are not capable of operating from a battery supply—you have to use a standard AC power-line.

The transportables fall into one of two categories. First, there are the 8-bit machines, usually featuring a Z80 microprocessor and running the popular CP/M operating system. The original Osborne and the Kaypro models fall into this category. The other popular group of transportables are those that use the 8088 or 8086 16-bit microprocessors. Those latter machines are typically compatible with the popular IBM *PC*, and can run the MS-DOS operating system. Some of the machines typical of that category are the popular Osborne *Executive*, the *Hyperion*, the Compaq, Seequa *Chameleon*, and the Columbia Data Products *1600-VP*.

The portability issue

In looking at the whole portable-computer affair, it really seems that portability is not the major reason for the popularity of those machines. While most transportables weigh less than 30 pounds, and can be carried, they are not exactly what you would call convenient. And though the ability to put a personal computer under an airline seat is a nice idea, few users really need it. There are some true portables like the battery-operated calculator look-alikes and the briefcase computers, but their computing power is far less than that of desk-tops or transportables, thereby making them less useful.

The two things that have really made the portable computer popular are its small size and the software it can handle. The small size comes strictly by deliberately engineering a complete machine that is portable. Everything that you need, including a keyboard, disk-drives, display, and all of the other goodies, is packaged in a single container. That makes the unit unusually compact. The fact is, it is considerably smaller than more conventional desk-top computers. When you stop and consider the more traditional personal computers, you'll discover they are not only large, but also usually consist of several separate interconnected items. The resulting package takes up a lot of space on the desk—in fact, many of them occupy an entire desk. However, the portable compresses all of the same features down into an area that occupies no more space than a typewriter. About the only penalty that you pay is in the display's size. Most portables have 5-, 7-, or 9-inch screens, where the average desk-top computer uses a larger and certainly more readable 12-inch screen.

Overall, people like portables because they have a small "footprint." You can pick them up and move them from one desk to another without the hassel of disconnecting the cables, moving the individual pieces, and then having to reassemble the system at the new site. To move a portable computer, all you do is snap the keyboard back on the front, unplug it, and away you go.

Another feature introduced by Adam Osborne with the original *Osborne I* computer is bundled software. By bundled we mean that key software packages are included with the computer when it is purchased. Everybody knows that a computer is worthless without software, yet few computers actually include the software. Instead, you are forced to buy the operating system, languages, and application programs separately. However, most portables (the only exception being Compaq) offer several useful software packages with the machine. They include the operating system (either CP/M or MS-DOS), BASIC, and a selection of popular applications programs. Most portable computers include a word processor, a spreadsheet, a data-base management package, and sometimes, a communications program. Those are the packages that most people want and need anyway: Besides, it is always nice to have the software (ready to run) at the time the computer is purchased.

When you add up the total retail price, if you purchased the software individually, you would find that in most cases you are getting well over a thousand dollars worth of software with the purchase of the machine. That's an outstanding bargain, and one that most people have not overlooked. **R-E**

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JACK DARR

Chip components

THE RAPID ADVANCEMENT OF ELECtronic technology has provided us with many interesting and useful consumer products, such as portable VCR's, personal computers, and so on. It was mainly the development of transistors and later, the integrated circuit, that rocketed us into this new era of miniaturization and made possible the development of those and other products.

As a result of the miniaturazition process, a new family of components was born. That new family, known as *chip components* (or surface-mounted devices), are small units encapsulated in IC-type packages. Because of their small size, chip components demand that you be especially careful when soldering—you need just the right solder, soldering iron, etc. We'll get to that in a moment. For now, let's see how to identify the component values.

Identifying chip components

Because of their small size, some practical means of identifying chip components had to be developed. But don't worry—it's not hard to learn: The system used for both resistors and capacitors is similar to the method you're already using to identify small capacitors.

Instead of using colored dots or bands, chip resistors are identified by numbers printed on the top of the device, as shown in Fig. 1-a. For example, a 1000-ohm resistor would be marked "102." The first two numbers (10) are the first two digits of the value. The third number is the power-of-ten multiplier. (It tells you how many zeros to add, as seen in Fig. 1-a.)

Ceramic capacitors are marked with a similar system, except that two rows of numbers are used, as shown in Fig. 1-b. For instance, a .047-μF capacitor would be marked "47" in the top row and "3-u" in the bottom one. The top two numbers represent the first and second digit in the part value. The number in the second row is the power-of-ten multiplier. All values are marked in picofarads. (To convert that value to microfarads, the decimal point is then moved six places to the left.) That is practically the same as the system used now for small mica and ceramic types. The letter following the number represents the class or tolerance of the capacitor.

Identifying chip transistors is quite different from identifying capacitors and resistors. Chip transistors have two letters printed lengthwise across the top. The first letter shows the "2S" (EIA) number and the second gives the transistor's gain rating. A transistor with a gain rating of "C" will have higher gain than one rated "A" or "B," and so on. While you can replace a transistor with one with higher gain, the opposite is not true. Table 1 is a partial identification chart for chip transistors.

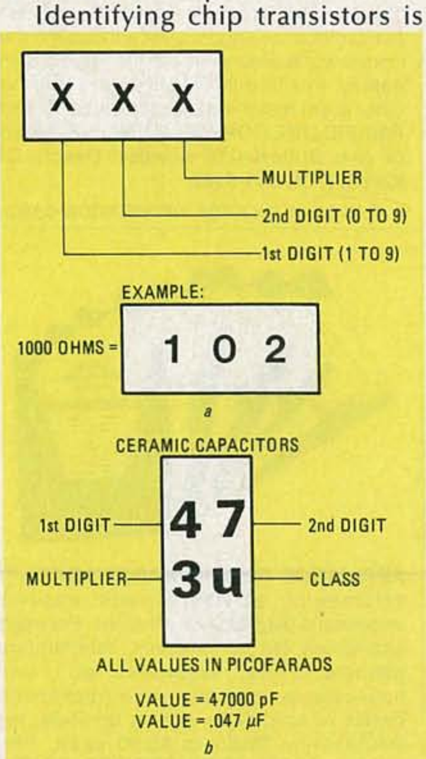

FIG. 1

TABLE 1

1st LETTER	2S NUMBER	2nd LETTER h_{FE} RANK (GAIN)
E	2SA1022	A to C
F	2SA1034	R to U
H	2SA1035	R to U
Ⓐ	2SB709	O to T
Ⓑ	2SB709A	O to T
Ⓒ	2SB710	P to S
D	2SB710A	P to S
A	2SB766	P to S
B	2SB766A	P to S
C	2SB767	P to S
V	2SC2295	A to C
U	2SC2404	B to E
S	2SC2405	R to U
T	2SC2406	R to U
R	2SC2480	T to S
Y	2SD601	O to T
Z	2SD601A	O to T
W	2SD602	P to S
X	2SD602A	P to S
Q	2SD813	P to R
P	2SD814	P to T
Ⓩ	2SD874	P to S
Ⓨ	2SD874A	P to S
Ⓧ	2SD875	P to S

Now let's see what precautions must be taken when using them.

Soldering chip components

Some manufacturers of chip components recommend a solder

continued on page 108

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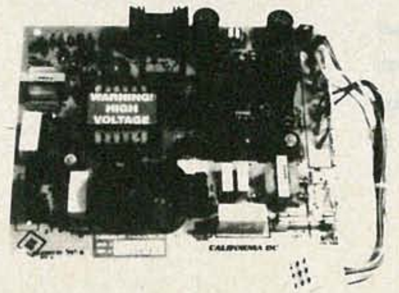

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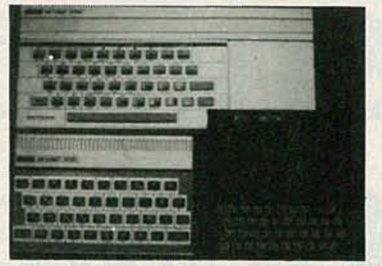

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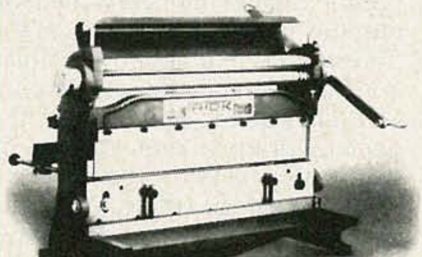

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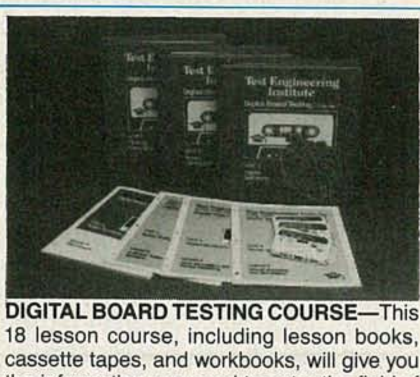

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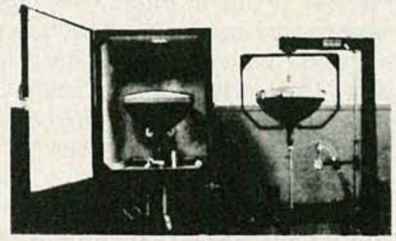

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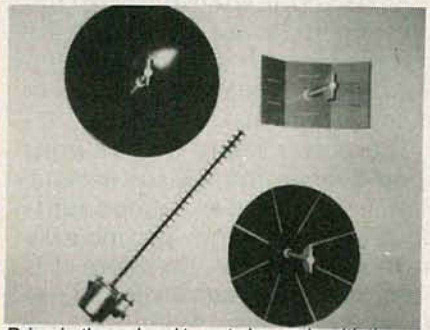

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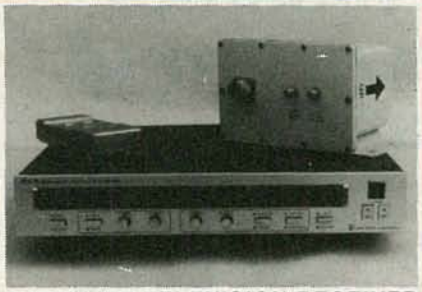

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containing 63% tin to 37% lead, with a pure rosin-flux core. Others recommend a solder with 2–3% silver added to reduce "silver migration" in components having fired-on silver-platinum conductors (like some small ceramic capacitors, for example).

Silver migration during soldering results in weak joints and poor adhesion. The addition of silver to the solder raises its cost a bit, and also raises the melting temperature. (No, silver solder isn't something new, it has been around for some time now.)

As far as soldering irons are concerned, there are many that are compatible with high-tech soldering, and are available in a variety of styles and prices.

The power rating for the irons should range from 10 to 50 watts. Remember that as components decrease in size, they also increase in heat sensitivity. Therefore it is recommended that you do not use an over-rated iron. Note: Because of the electrostatic sensitivity of chip components, isolated or grounded-tip soldering irons should be used. Needless to say, surface-mounted parts will have to be replaced by exact duplicates because nothing else will fit in their places.

When it comes to desoldering, any one of three desoldering methods may be used; wicking, heat plus a suction device, or a desoldering iron (which are made by several of the major manufacturers). Each one will give good results if properly used—so, it's just a matter of personal preference. I happen to like the desoldering iron.

When desoldering always use the smallest size iron you can; a 30-watt iron will do a good job on the average small part. Just be sure that the solder is completely melted when either soldering or desoldering. That is especially necessary when replacing parts. Make sure that the joint is bright and shiny, not "frosty or fuzzy-looking." If you do see something like that, you know that you have a cold solder joint.

One of the longest jobs we had turned out to be a bad solder joint at the bottom of the base winding of a driver transformer for a horizontal output stage. (I did tell you that it was an intermittent, didn't I?) As if that wasn't enough, we had three of the same model set with the same problem! Fix one and you've fixed all three.

I wrote to the service manager of the firm that manufactured the set about it and he wrote back saying: "Yes, we've run into that problem, but only in about 20% of the sets!" That one nearly went by me, until I finally realized that 20% of the sets meant one in every five sets had a problem!

After that, when ever one of those sets came in, we went right to that joint and resoldered it. In fact, we caught some that didn't even have that problem, but definitely did have a bad solder joint.

In any repair, it's also a good idea to clean the board after any resoldering. That gets off any remaining flux; that stuff is sticky and can catch dust, which will almost certainly result in trouble in the future. **R-E**

VOL. 1 No. 7 October 1984

COMPUTER DIGEST

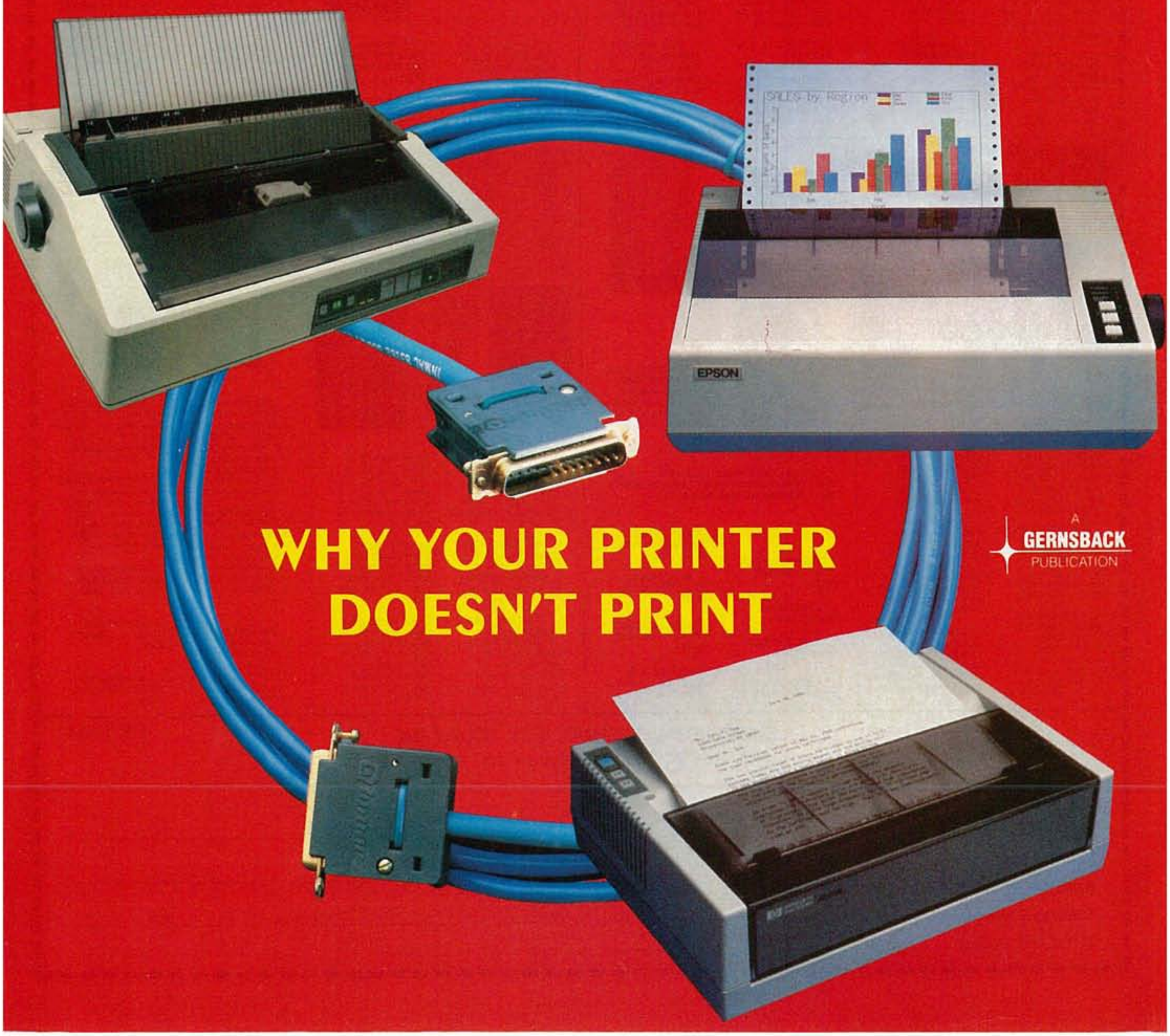
NEW KIND OF MAGAZINE FOR ELECTRONICS PROFESSIONALS

OP-AMP DESIGN...

You can use your computer to save yourself a lot of time and work in designing Operational Amplifiers.

COMMODORE CASSETTE INTERFACE...

How to build a simple circuit that lets you use ANY small audio tape recorder with your Commodore computer.



WHY YOUR PRINTER DOESN'T PRINT

A GERNSBACK PUBLICATION

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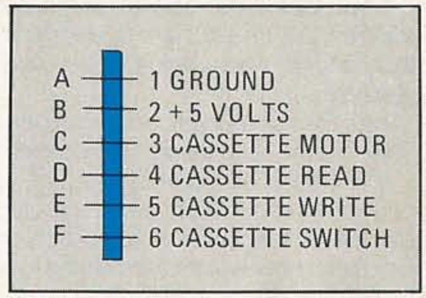

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ON THE COVER

Looking up at you from the middle of our cover, is an RS232 connector. And clockwise, starting at the other end of the cable, is the NEC printer, followed by the Epson and at the lower right, Hewlett Packard's entry. See page 7.

EDITORIAL

The future is here today!

This century has been a highly innovative one. If you stop to think that at the beginning of the 20th Century, man was still bound to Earth and hadn't learned to fly, that medical science was almost barbaric as compared to today, and that electronics was but a fantastic-fiction dream, you pause and wonder at our accomplishments.

If you look at our progress in this past 100 years and try to look ahead to the next 100, it's sufficient to boggle the mind. The very computer on which this editorial is now being written could not have existed those scant few years ago.

Let's try a small exercise—an experiment, if you will. We're going to "brainstorm" or "blue-sky" the coming of the future.

Our readers are, for the most part, intelligent, scientific types. Let's concentrate on the future of computer technology. Where will we be in another century, as far as computers are concerned? What will computers be doing, how will they be doing it, and what will *we* be doing with them? And please, nothing off-the-wall.

Give us those things with sound, scientific basis, following normal developmental processes. Send your ideas to **ComputerDigest**, 200 Park Avenue South, New York, NY 10003. Got any artistic skills? Send along sketches too.

This will make an interesting project for our readers; and, of course, when all the results are tabulated, we'll put an article together that should make some fantastic reading. All entries will become the property of Gernsback Publications, Inc., and no submissions can be returned.

So put your thinking caps on, and get to work. We'll be anxious to see what you come up with!

Byron G. Wels

Byron G. Wels
Editor

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LETTERS

Wants portables

I'd like to see an applications-oriented article on portable computers. I'm sure that a lot of other readers would be just as interested.—Sam Bennett, Fresno, CA.

Sounds like a great idea Sam. We'll get one of our experts busy on that one right away!

No games?

How come you don't report on new computer games the way some computer magazines do? —Fred Morrison, Madison, WI.

Fred, take a look at our front cover. It says "A New Kind of Magazine For Electronics Professionals." We want all the readers we can get, but no magazine can be all things to all people.

Settle an argument

A friend says that a good computer "hacker" can break into almost any computer system, regardless of the security. I am wondering if that statement is really true? —Gene Lyons, Atlanta, GA.

Gene, while nothing is ever 100%, the odds are against it, despite what the movies show! Cracking the most basic system would take more patience than most people have, and a system, where codes are periodically changed, would be all but foolproof.

More kudos!

I would like to see *ComputerDigest* continue to present concise summaries of current events in the computer field, and am relieved to have discovered a computer magazine which is not just a sales pitch! —P. D. Broadhurst, Channel Islands.

Thank you too, Mr. Broadhurst. More and more, our readers are beginning to learn what we're all about! It's very gratifying indeed.

More hardware

I'm so tired of software-only articles that I could write some myself, just from the ones I read! Yours is the last magazine that contains useable information on projects and hardware. And printing my comments is not expected. —Irving E. Shivar, Jr., Camden, SC.

Surprise, Mr. Shivar! Thanks for understanding (and appreciating) what we're trying to do. Keeping a wide variety of readers happy is our goal.

COMPUTER PRODUCTS

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

PORT EXPANDERS/SWITCHERS, *Data Director* models *Q23, Q24, Q25, Q13, Q14,* and model *Q15* are a series of "port traffic cops"—port expanders with A/B/C switch routing—that can switch one port to any of three devices, or one device to any of three ports.

CIRCLE 111 ON FREE INFORMATION CARD

Model *Q23,* model *Q24,* and model *Q25* are in stand-alone cabinets, while model *Q13,* model *Q14,* and model *Q15* are designed to fit inside Computer Accessories' model *P12* Power Director (line-conditioning power-control accessory) cabinet.

The three models in each series meet specific connector needs for a given port or system. For standard RS-232 serial ports, Data Director offers model *DB25* female (models *Q13/Q23*) or male (models *Q14/Q24*) connectors. For standard parallel (printer) ports, Data Director (models *Q15/Q25*) offers 36-pin Centronics-style connectors.

Models *Q23, Q24,* and *Q25* are priced at $199.00 each; models *Q13, Q14,* and *Q15* are priced at $189.00 each.—**CA Computer Accessories,** 7696 Formula Place, San Diego, CA 92121.

POWER OUTLET EXPANDER/FILTER, the *Power Director* model *P22,* model *P2,* and model *P12* are designed to filter radio-frequency noise, spikes, glitches, and surges that imperil sen-

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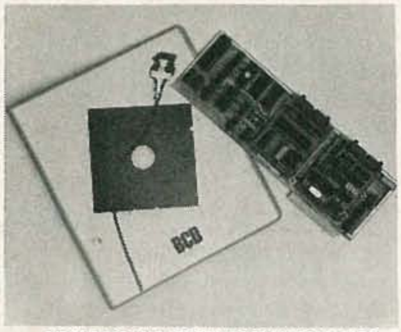
sitive electronics equipment.

These are desktop-design devices and individual and collective (master) outlet control are part of the design. Each outlet is monitored with a power pilot light (amber for the individual outlets, red for the master) a circuit breaker adds overload protection. While the pilot lights are located on the front panel, the actual outlets are out of sight on the back panel.

The stand-alone model *P22* (sized to stack with such items as disk drives and modems) offers four outlets and is available for $99.00. The monitor-base model *P2* (sized to fit under a CRT or video monitor) offers five outlets and is available for $129.00. The model *P12* (sized to fit atop the IBM PC system unit, for example) offers six outlets, plus a digital clock and stowaway storage areas for diskettes, quick-reference cards, or small manuals, is priced at $199.00.—**Computer Accessories Corporation,** 7696 Formula Place, San Diego, CA 92121.

VIDEO TAPE/DISC CONTROLLER, model *VIPc,* is a plug-in board that lets an IBM *PC* (or similar computer) control industrial-type videotape recorders with frame-accurate precision. It can also control videodisc players. The internal microprocessor, and up to 32K of RAM/ROM, translates simple user commands into complex videotape-recorder and/or videodisc player operations. The model *VIPc's* motherboard plugs into the computer and may host one or two "video modules" to control tape, disc, or one of each.



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The model *VIPc* with tape or disc video module is priced at $1195.00; with tape and disc video modules, it costs $1695.00.—**BCD Associates, Inc.,** 5809 S.W. 5th Street, Oklahoma City, OK 73128

UNINTERRUPTABLE POWER SUPPLY, model *1350,* provides 10 minutes of backup electric power for computers during a power failure. It weighs 32 pounds and fits in a compact, ½ cubic-foot space.

The model *1350* provides 120 volts at 350 volt-amps—sufficient power for a computer, disk-drive, printer, and monitor. The unit has a transfer time of 12 milliseconds, typical, and a single-phase 60-Hz supply (±0.5%). It also contains a patented clipper circuit to

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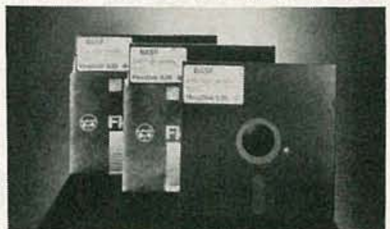
provide on-line surge protection from both normal and common-mode transients. RFI suppression is handled by Sprague filters.

The model *1350* has a suggested retail price of $750.00 and comes complete with a maintenance-free battery.—**Dymarc Industries,** 21 Governor's Ct., Baltimore, MD 21207.

HIGH-DENSITY DISKETTE, model *2HD,* features a new coating technology that allows the 5.25-inch diskette to store up to 1.6 megabytes, or 60% more than the conventional 5.25-inch 96 TPI floppy. The improved storage value helps to close the gap between the 5.25-inch rigid and the



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5.25-inch floppy. It is priced at $9.25 per disk.—**BASF Systems Corporation,** Crosby Drive, Bedford, MA 01730.

AMBER MONITOR, model *SA-1000,* has a 12-inch CRT and a non-glare, high contrast faceplate. Among its features are composite video-input signal, a resolution of 900 dots center and 800

CIRCLE 116 ON FREE INFORMATION CARD

dots corner. It also includes an RCA-type input connector, and 2000 character display format (5 × 7 dots, 80 characters × 25 lines).

The amber monitor model *SA-1000* is priced at $159.00.—**Sakata USA Corporation,** 651 Bonnie Lane, Elk Grove Village, IL 60007.

WHY YOUR PRINTER DOESN'T *PRINT...*

It's standards that make parallel printers work. It's the lack of standards that gives us trouble.

HERB FRIEDMAN

■*Standards* are what keeps the world working. They insure that an 8-32 screw from Outer Mongolia will fit an 8-32 nut manufactured in Lower Sandusky, Ohio: that your telephone will access any other telephone in North America, possibly the world: that the portable TV you purchased in New York—which was manufactured in Osaka—will not blow up when you plug it in to a power outlet in Yellowknife.

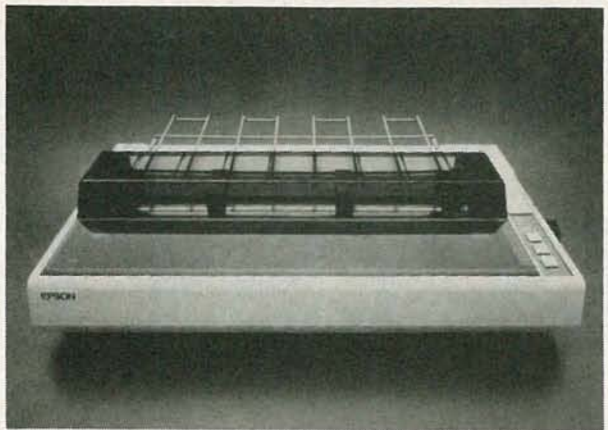
Unfortunately, manufacturers of many kinds of consumer equipment are prone to utilizing only part of a standard, prefering—for whatever the reason—to make their own proprietary modifications to the standard for what often appears to be be no rational reason. In actual fact, many times an actual standard or a *de facto* standard is modified to intentionally prevent a device from being used with any other equipment supposedly using the *standard*. Printers intended for use with personal computers are an excellent example of modified standards, which is often the reason you can't get your old and faithful printer to work with the new computer, or why your new computer won't work with someone else's printer. For example, we all know the IBM graphics printer is an Epson. Right? Only partially right. Use your old Epson and you'll print the standard ASCII characters, but not the IBM graphics.

And while we're talking about IBM, we all know the Epson printer, or a Smith Corona L-1000 daisy wheel, or any of a hundred printers have *standard* Centronics-type connections. So does the IBM. So how come you can't plug a Centronics type printer into an IBM-compatible personal computer? Because while the connections are standard, the connector isn't. IBM-compatible computers employ a a DB-25 connector for their parallel printer output, but the DB-25 is the standard for RS-232/O, it in no shape, form or manner is the equivalent of the truly standard Centronics-type Delta connector. To use a Centronics-type printer with an IBM-compatible computer the user must purchase a special, and somewhat expensive, adapter cable having a DB-25 on one end and a Centronics connector on the other end. But don't blame only IBM for not using a *standard*. How about Diablo and Xerox (same printer, different brand name)? Their daisy printers—considered the very finest by most users—have what is supposedly a standard RS-232 serial I/O. True enough, it's standard, only the connections aren't the ones used by most of the computer manufacturers. Take your printer home, plug it in, and it's an odds-on bet it won't work properly, if at all.

Get it working.

The best way to start interfacing a printer is to just get it working. If it can at least print the full ASCII alphanumeric character set and feed paper you're on your way. We'll start with parallel printer connections because they are the least troublesome. Parallel printer connections are called Centronics-type because they are the connections for the earliest printers—manufactured by Centronics—that were used with personal computers. To their credit, the Centronics connections were well thought out and have never required upgrading or a retrofit. The only time they give trouble is when a manufacturer goes out of their way to muck things up, as did Apple with non-sequential wiring of their parallel printer card; IBM and IBM-compatible computers with their use of a DB-25 connector for the parallel output; and Radio Shack with their card edge-connectors having non-sequential numbering and a forced automatic line feed after carriage return. Fortunately, the Centronics interfacing was so well thought out that most users can easily get around any problems created by the computer manufacturer. The Centronics printer connections are shown in Table 1. While there are many individual circuit connections because Centronics provided for every possible kind of parallel handshaking and fault indication, every connection isn't necessarily used by every printer. For example, a printer that uses the BUSY for handshaking (stopping and starting the computer's output) won't use the ACK, and vice versa.

THE NEW HP 2225 INKJET PRINTER from Hewlett Packard is fully portable, may be used with portable or desktop computers, operates below 50 dB.



EPSON'S RX-100 DOT MATRIX PRINTER operates at a speed of 100 characters per second on a 136-column carriage.

But be careful! Sometimes you can make a false assumption and get yourself into really-big trouble. The safest bet is that anything that can go wrong, will go wrong.

Unfortunately, some manufacturers modify the wiring of the signal pair returns—which are grounded—or put +5 volts on one of the normally-unused pins. If in doubt, the safest thing to do is wire only those connections which are absolutely required for parallel operation, the ones indicated with an asterisk (*), for no manufacturer will meddle with them (so far); they are safe to use because a computer or printer will automatically reject their use if not needed. The connections marked with a "pound" (#) symbol are normally unused and they are the ones manufacturers often employ to provide external voltages for external accessories—or they tie them together and connect them to +5 volts—which can prove a disaster. Do not use these wires unless you are absolutely certain you need them. Try running the printer without them. Be especially careful of terminal #18, which is often, but not always used to provide +5 volts from the printer or the computer for powering ancillary devices, such as a serial-to-parallel converter. Some manufacturers put the full rail voltage on the connection, others provide the 5 volts through a resistor. If in doubt, leave this connection open because 5 volts on #18 is not part of the standard wiring. Depending on the equipment, the wrong hook-up can cause a lot of damage. Same thing for terminals 33-36. They aren't used for standard connections. Some manufacturers use them for providing power to ancillary hardware or tie them to +5 volts. If in doubt, leave the connections open. Terminals 16 (GND) and 17 (CHASSIS) are "ground." Terminals 19 thru 30 are return lines for the signal and handskaking circuits, "return" being a fancy word for "common" or "ground" connection.

Depending on the particular printer and the computer being used, your equipment might work if all terminals 19 thru 30 aren't connected; then again, the equipment might not work. Your equipment will always work if the wires are individually brought through from one connector to the other, but if you're making up a multi-wire cable and are short on connecting wires, you can connect terminals 19 thru 30 to terminal 16; and if in doubt, also connect 17 to 16. Be extremely careful of terminal 35; do not use it unless you know what you're doing. While not used in the Centronics standard, one very popular computer uses it for a redundant ground while an equally popular printer uses it for +5 volts.

In your anxiety to get things going, you tend to look for shortcuts. This can result in dire consequences. While it may seem expedient to take advantage of "unused" terminals, they aren't always as available as they might seem.

The potential for a catastrophic failure is obvious, so don't use terminals 33 through 36 unless you have schematics for everything. Do not eliminate any standard connections thinking they aren't needed.

Some connections accommodate several different fault indicators which your computer might require for operation. For example, while the BUSY signal normally tells the computer the printer isn't ready for data because it's printing, some printers use the BUSY to also stop the computer when the ribbon runs out, the cover is open, the power is off, the paper has run out, etc. Other printers put the out of paper indicator, cover open, ribbon out, etc. on the FAULT line. The safest bet is to always use all the standard connections. Normally, Centronics-type connectors can be wired straight across, that is, the wire connected to terminal #1 on one side connects to terminal #1 on the opposite side.

To their credit, even when using different connectors (ie., card edge-connectors) Radio Shack has always arranged the circuits in the Centronics order so the wiring is always correct when connectors are squeezed on ribbon cable. Unfortunately, this isn't the case with other computers. The IBM-compatibles use a DB-25 for the parallel output, and the terminal numbers simply don't match. Also, you can mistake the IBM parallel printer output for an RS-232 connection, and it is possible to blow out something in the computer, so be extremely careful when making parallel printer connections to a DB-25 connector. Also, a commonly used computer (the Osborne 1) and at least one printer buffer (the Angel) don't have standard parallel Centronics connectors, so again take extreme care if you make up your own cables because the connections aren't in the Centronics order.

TABLE 1

Standard Centronics-Type configurations for Scotch "Delta" 36-pin connectors.

KEY	PIN	FUNCTION
*	1	DATA STROBE
*	2	DATA 1
*	3	DATA 2
*	4	DATA 3
*	5	DATA 4
*	6	DATA 5
*	7	DATA 6
*	8	DATA 7
*	9	DATA 8
*	10	ACK
*	11	BUSY
#	12	PAPER EMPTY (PE)
#	13	SELECT PRINTER
*!	14	SIGNAL GROUND
*	15	NC
*	16	GND
*!	17	CHASSIS GND
#	18	(CAUTION + +5VDC)
*!	19	PAIR GROUND
*!	20	PAIR GROUND
*!	21	PAIR GROUND
*!	22	PAIR GROUND
*!	23	PAIR GROUND
*!	24	PAIR GROUND
*!	25	PAIR GROUND
*!	26	PAIR GROUND
*!	27	PAIR GROUND
*!	28	PAIR GROUND
*!	29	PAIR GROUND
*!	30	GROUND (GND)
#	31	INPUT PRIME
*	32	FAULT
#	33	NC
#	34	NC
#	35	NC
#	36	NC

There is not necessarily any correlation between printers as far as codes are concerned. Again, the lack of actual standards is plainly evident. Ask any manufacturer of printers about this, and you'll probably be told that they do indeed cleave to rigorous standards—their own! The confusion is borne out when you get down to the hard wiring. To see precisely what can happen, take a look at Table 2.

The printer codes.

Regardless of whether the printer is serial or parallel input and the actual order of the connections, the most frustrating difficulties you're likely to face when installing your printer are the *printer codes*, for which there is essentially no standard other than for the ASCII characters. With virtually no exception, every modern printer can do something more than just print the 96 ASCII characters. Depending on the particular model and type of printer, it's possible to underline characters; boldface through multi-striking and carriage shift; print letters larger, smaller or in itallics (matrix printers); print trade marks, smiling or happy faces; or foreign characters or Greek or electrical symbols. You name it and there's a printer out there that can do it. Your only problem is to tell the printer what you want to do, and that's where printer codes come in. All printers uses standard ASCII codes for the character set and control codes. The ASCII code is numbered from 0 through 127 in decimal, which corresponds to hex 0 through hex 7F. (Printer codes can be either decimal or hex, depending on the particular printer and/or software.The codes from 0 to 31 are non-printing *Control Codes*, meaning they can be used to "trigger" specific computer or printer functions. Decimal code 32 (hex 20) is the *space*. The ASCII codes from 33 (hex21) to 126 (hex 7E) produce the *ASCII character set*: the alphanumerics which can be printed by a printer capable of printing the full 96 character set.

Code 127 (hex 7F) is the old teletype *delete*: The modern printer either doesn't respond to code 127 or prints a "block." Normally, every printer responds to ASCII codes 32 to 126. For example, if the computer sends a 32 (hex 20) to the printer every printer made will space. If the computer sends a 65 (hex 41) to the printer every English-language printer made for use with personal computers will print the letter A. The first problem with printer standards you're likely to run across are the ASCII codes below 32. (See Table 2.) Some are truly standard, for example, 13 (hex OD) is always used for CR (carriage return) while 10 (hex OA) is always used for LF (line feed), and 27 (hex 1B) is always ESC (escape). And that's about where the standards really end. For example, while an 8 (hex 08) will cause most printers to backspace, your printer might not recognize 8 as the backspace control code, hence, any software you have that backspaces with an ASCII 8 for strikeover or underline won't budge your printer; it might require some other code, or use a special code for underscoring. For example, send a 25 (hex 19) to a Smith-Corona TP-1 daisywheel printer and every character will underline. Send a second 25 and the underline will stop. But if you have a Smith-Corona TP-2 printer the second Hex 19 won't do a thing because it requires a 31 (hex 1F) to stop the underline. Tricky? You bet! Unless your software can be modified, or can send user-programmed control codes from within the program, there's no way you're going to get the underline straightened out. And if you think Smith-Corona underline is tricky, try the Epson with Graftrax.

Underscore *on* is ESC-1 (hex 1B 5F 31); underline *off* is ESC-0 (hex 1B 5F 30). (Someone must have been asleep at the design board because one of the most popular personal computers cannot output a control code zero (0) from its word processor.)

Everyone for themselves.

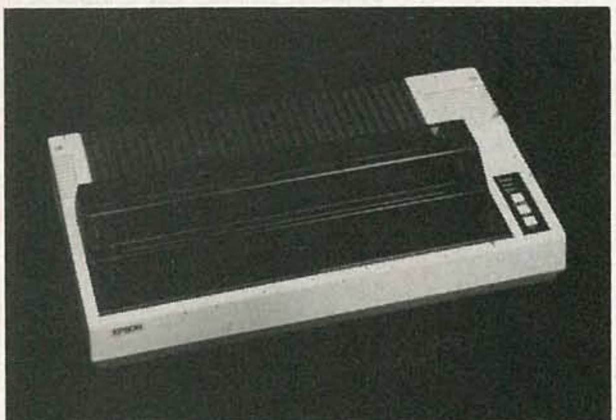
From ASCII 128 and higher it's every manufacturer for themselves. For example, the famed budget-priced Smith-Corona daisy printers do not respond to codes above 127. On the other hand, the Radio Shack model DWP-210 daisy wheel printer has a few additional characters accessed by printer codes higher than 127.

For example, a 169 (hex A9) will produce the single character imprint TM (for Trade Mark), while a 171 will produce the circled-C (©) used to indicate copyright. Similarly, a 222 will produce the ¢, which is not on the standard ASCII keyboard (it is a typewriter character).

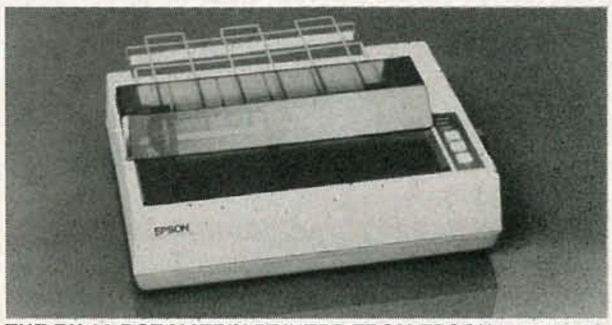
While daisy printers might respond to a few specific printer codes above 127, it's the matrix-type printers

TABLE 2

ASCII	CODE	PRINTER #1	PRINTER #2
0	NUL	NULL	NO RESPONSE
1	SOH	SET LINE SPACING	NO RESPONSE
2	STX	DEFAULT LINE SPACING	NO RESPONSE
3	ETX	NO RESPONSE	NO RESPONSE
4	EOT	NO RESPONSE	END OF TEXT
5	ENQ	NO RESPONSE	NO RESPONSE
6	ACK	NO RESPONSE	AKNOWLEDGE
7	BEL	SOUNDS BELL	NO RESPONSE
8	BS	NO RESPONSE	BACKSPACE
9	HT	NO RESPONSE	TAB
10	LF	LINE FEED	LINE FEED
11	VT	VERTICAL TAB	NO RESPONSE
12	FF	FORM FEED	FORM FEED
13	CR	CARRIAGE RETURN	CARRIAGE RETURN
14	SO	EXPANDED CHARACTERS	NO RESPONSE
15	SI	COMPRESSED CHARACTERS	NO RESPONSE
16	DLE	NO RESPONSE	NO RESPONSE
17	DC1	ACCEPT DATA (X-ON)	ACCEPT DATA (X-ON)
18	DC2	COMPRESSED OFF	TAB SET
19	DC3	DESELECT (X-OFF)	DESELECT (X-OFF)
20	DC4	EXPANDED OFF	TAB CLEAR
21	NAK	NO RESPONSE	NO RESPONSE
22	SYN	NO RESPONSE	NO RESPONSE
23	ETB	NO RESPONSE	NO RESPONSE
24	CAN	NORMAL CHARACTERS	MARGIN RELEASE
25	EM	NO RESPONSE	UNDERSCORE ALL
26	SUB	NO RESPONSE	NO RESPONSE
27	ESC	NO RESPONSE	NO RESPONSE
28	FS	NO RESPONSE	LEFT MARGIN SET
29	GS	NO RESPONSE	NO RESPONSE
30	RS	NO RESPONSE	UNDERSCORE WORD
31	US	NO RESPONSE	END UNDERSCORE



THE NEW FX-100 PRINTER FROM EPSON operates at 160 characters per second, carries a suggested retail price of $895.00.



THE RX-80 DOT MATRIX PRINTER FROM EPSON has tractor and friction feed, prints 100 characters per second, offers two full 96- character ASCII sets plus nine international sets including 128 type styles.

that really get mileage from 127 and higher—and they cause the most standardization problems. For example, connect your old reliable printer to your new IBM-compatible computer and program for a few of the IBM graphic characters. Depending on the particular model printer you might wind up with unusual graphic symbols, or even italic characters, but you won't get the graphic characters that match those in the computer's documentation. The reason, of course, is because only codes 32 to 127 are standard. The Epson printers sold under the IBM label have internal ROMS with a completely different set of graphics than any other model for the codes above 127. To obtain the IBM graphics, whatever matrix printer you use must be specifically programmed from ASCII 128 up to produce the IBM graphics. (That's why IBM can charge so much for a printer you could otherwise purchase for several hundred dollars less.) Similarly, if you try to use an older Radio Shack printer with a new Radio Shack computer something's not going to work when your software attempts to produce graphics, because the late model computers are intended for printers with a different "graphic set" than the earlier printers.

Essentially, if you're into using computer hardware and software from several manufacturers you've got to triplecheck that the graphic ASCII codes are all compatible, else you will wind up with "garbage" or just empty blank spaces on the paper. In Part 2 we'll untangle the serial priners and the parallel-to-serial and serial-to-parallel converters.

COMPUTERIZED OP-AMP CALCULATOR

KIRK VISTAIN

Find all the circuit values for three important op-amp configurations in an instant with this spreadsheet template.

■What electronics hobbyist wouldn't love to be able to calculate all the resistor and capacitor values for a differential op-amp circuit in less than a minute? Better yet, imagine being able to do it for inverting, non-inverting, and differential configurations simultaneously. You can eliminate arithmetic errors, change designs in mid-stream, or perform "what-if" analyses to your heart's content.

Well, the op-amp "calculator" we'll describe in this article helps you do it. It's an op-amp design template written for use with the popular and powerful *Supercalc*, an electronic spreadsheet from Sorcim Corporation. It was developed on a Xerox *820*, with an 80 column display, operating under CP/M, but it should work on any computer running *Supercalc*. Note that you'll need to use horizontal scrolling on a 40-column display.

To use the template, simply load in an installed *Supercalc* program, then load the template, which we've named OPAMPC. Figure 1 shows the screen after loading. At the upper left is the *user choice* selection. The number (no alphabetical prefixes or suffixes, please) of the desired op-amp is typed in, and the gain-bandwidth product (GBP) is automatically returned to the right. (That selection is customized by the user).

Next, the desired input resistance (INPUT R), voltage gain (A_V), low-frequency cutoff (LOW F_C), and high-frequency cutoff (HIGH F_C) are entered. The rest of the operation is automatic.

Resistor and capacitor values are simultaneously calculated for three basic configurations, and automatically rounded to the nearest EIA standard values. Circuit parameters are then recalculated using those values, and displayed in the ACTUAL column. Percent deviation from desired performance is returned in the next column to the right. In most cases, those errors are kept to less than 10%.

Why use *Supercalc*? There are a number of reasons. First, *Supercalc* is a versatile piece of software that can be adapted to many different purposes. For that reason, it is among the first programs a new computer owner buys. Secondly, because of its many logical and arithmetic commands, much of a programmer's work is already done, so designing and entering a template is quicker than writing a program in say, Pascal or BASIC. We could have used *Visicalc*, another electronic spreadsheet, but doing so would have forced us to sacrifice the automatic rounding-to-EIA-standards that makes OPAMPC so convenient. No doubt, some enterprising programmers will come up with ways to adapt this template to their particular spreadsheet program.

Three types of error messages are included, summarized at the upper right of the worksheet. Each amplifier configuration is represented separately, listed under INDEX. If the actual or desired Gain-Bandwidth Product (GBP) is greater than the rated GBP of the selected op-amp, a 1 appears. If not, 0 is returned. A similar function is provided to test whether R2

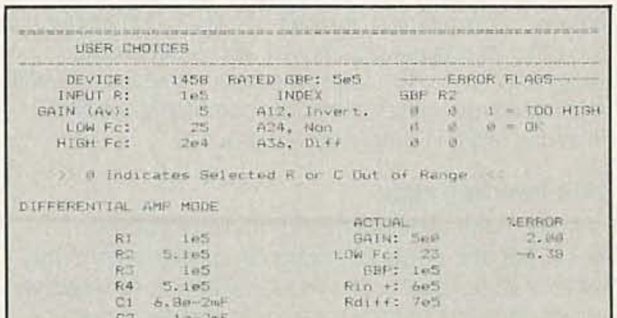


FIG. 1—VIDEO DISPLAY (80 column) as it looks during a sample differential amp calculation using OPAMPC.

(negative feedback resistor) is less than 1 megohm, a necessity for proper DC stability in common bipolar op-amps. If you're using BiFET's, you can change the flag point to account for their lower current requirements. Refer to the device manufacturer's data.

An R2 error will also occur if calculations result in a value out of the lookup table's range. That will be corroborated in the individual amplifier sections.

Structure of OPAMPC

OPAMPC is functionally divided into three sections. In USER CHOICES, device number and desired circuit parameters are entered. GBP and R2 error flags are included, along with an index of the calculation section.

The CALCULATION area of the spreadsheet contains the formulas necessary to determine component values from the user's choices. Inverting, non-inverting, and differential configurations are treated separately. Spacing between the subsections aids readability and quick access when using the window mode.

The LOOKUP TABLES are the key to the rounding function. That section is automatically searched by the CALCULATION area to find the standard resistor or capacitor value closest to the calculated one. Don't be intimidated by its 151-line length! It's quickly built, using *Supercalc*'s automatic functions.

Theory of operation

Figure 2 shows three common amplifier designs, and the formulas used to determine component values. The OPAMPC template is based on an AC model, and was specifically written for audio applications. Power supply connections are not shown, nor are compensation or offset circuits. Many devices use internal compensation, and offset is usually not a big problem. If in doubt, consult one of the many op-amp design books available.

Most of the formulas shown in Fig. 2 were simply converted into *Supercalc* format and entered onto the worksheet (more on that later).

Inverting amp

OPAMPC ignores the negative component of the inverter's output, a common convention. Remember, though, that the output signal will actually be 180° out of phase with the input.

The 1E6 factor in the calculation for C1 produces an answer in microfarads, instead of farads. That applies to the other configurations as well. 1E6 is *Supercalc* shorthand for 1×10^6. Using the optional resistor R3 will minimize input offset, although, commonly, the non-inverting input is simply tied to ground.

Non-inverting amp

In the non-inverting amp, for minimum offset, R3 = R1||R2 (the symbol || means "in parallel with"). The value of R3 is equal to the input resistance, so whatever value you select in the USER section appears opposite R3. We know that the gain of a non-inverting op-amp is 1 + (R2/R1), but how do we use that formula without selecting a fixed value for R2 and R1? Remember that whatever combination of resistors we pick must have a parallel value equal to R3.

The trick is trying to get R1 and R2 solved for two different equations simultaneously in a way *Supercalc* could handle. After trying many of the normal methods for that, unsuccessfully, we hit upon the idea of simply defining R1 + R2 = 1 megohm. That automatically kept the feedback resistor below our design limit of 1 megohm, eliminating an annoying and clumsy term in the calculations to boot.

You may have noticed that an undefined condition will exist if the user selects a gain less than or equal to 1, because $(A_V - 1)$ will then equal 0, by which you can't divide, or a negative number, whose square root is not a real number.

The low-frequency rolloff points of the inverting and non-inverting inputs respectively are $-f_C$ and $+f_C$. The value of $+f_C$ is user-selected and equal to LOW F_C. The value of $-f_C$ is arbitrarily set for five times $+f_C$ in order to minimize low-frequency noise gain.

Differential amp

The calculations for the differential configuration are virtually identical to those for the inverting mode, except that they apply to both inputs. Best CMRR (Common Mode Rejection Ratio) requires $+f_C = -f_C$, where $+f_C$ is the cutoff frequency of the non-inverting input, and $-f_C$ is the cutoff frequency of the inverting input. For simplicity, we let R1 = R3 and R2 = R4. That results in differing input resistances for the inverting and non-inverting inputs.

User-selected INPUT R becomes the resistance of the inverting input, with the non-inverting input R being calculated and returned opposite $r_{in}+$. It will always be higher than the user-selected figure, but that is not generally a problem in signal circuits. The differential input resistance, R_{DIFF} appears in cell F42, and is the sum of $R_{IN}+$ and $R_{IN}-$.

Lookup table

Seldom do calculations yield precise, convenient, standard values for resistors and capacitors. If we intend to translate our design to the real world, however, that is necessary.

Consequently, OPAMPC contains lookup tables, which effectively round calculated values to EIA standards. We use *Supercalc*'s built-in LOOKUP function and some long lists to do this.

Building the worksheet

To ease entry, we've divided OPAMPC into two files, called OPCALC.CAL, which contains amplifier formulas and the user choice section, and LOOKVAL.CAL, the resistor, capacitor, and op-amp lookup tables. Once we've built and saved those two files, we'll combine them into a single template called OPAMPC.CAL. (.CAL signifies a file of *Supercalc* type. The file type is understood and need not be stated when working within the *Supercalc* program.)

Good practice calls for frequent saves and backing up all files on a separate disk.

To build the lookup tables, first enter the headings as shown in Fig. 3. The column widths were selected only so

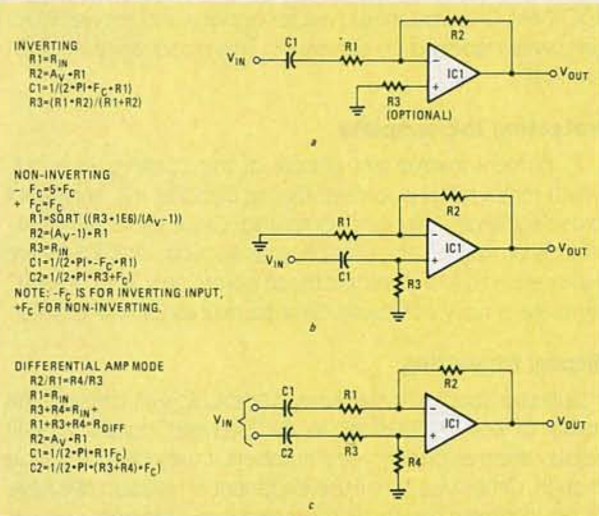


FIG. 2—THREE OP-AMP CONFIGURATIONS. An inverting amp is shown in *a*, a non-inverting amp in *b*, and a differential amp in *c*.

the headings would fit. Once the tables are integrated on the OPAMPC worksheet, column width will be irrelevant.

Next, starting at cell D3, enter the following series of numbers in column D:

1E−5	2.2E−5	4.7E−5
1.11−5	2.7E−5	5.6E−5
1.5E−5	3.3E−5	6.8E−5
1.8E−5	3.9E−5	8.2E−5

Put a 0 in C2 and D2 and enter the formula D3 + C*.9 in cell C3. Replicate it in the range C4:C100. Now, enter the formula D3 + C*10 at cell D15 and replicate it from D16:D100. Enter 0's at the bottom of the capacitor list in cells C101 and D101.

The resistor table is built similarly. Zeros go into cells F2 and G2. The following list is entered into column G, starting at G3:

1	1.8	3.3	5.6
1.1	2	3.6	6.2
1.2	2.2	3.9	6.8
1.3	2.4	4.3	7.5
1.5	2.7	4.7	8.2
1.6	3	5.1	9.1

The formula G3 + C*.95 goes into cell F3 and is replicated from F4 to F150. Similarly, cell G27 gets G3 + C*10, which is replicated in the range G25:G150. Zeros are then entered at F151 and G151.

The op-amp list should be customized for whatever devices you favor. We've shown a few popular ones as an example in Fig. 3. The list can be as short or long as you want, but remember to put a 0 at the beginning and end to avoid ERROR or N/A messages. You will also need to modify the expression in E5 to match the list's range.

You'll notice the resistor list is longer than that used for capacitors. For accuracy's sake, the complete USA Standard C83.2 (formerly EIA GEN 102), Series 10, sequence is used for resistors. That way, no matter what the result of a calculation (assuming it is not out of range) a standard value within ±5% of it can be found. We selected Series 20 values (±10%) for the capacitor list, because "in-between" capacitors are scarce.

```
WIDTH:    12          8        8          12        4      10          5
    :      A     ::   B  ::   C   ::       D     :: E::      F      :: G :
  1: OP AMP LIST MAX GBP CAPACITOR LOOKUP              RESISTOR LOOKUP
  2:           0 0       0        0                    0            0
  3:         324 .2E6    D3*.9    1E-5          mF   G3*.95         1
  4:         741 .2E6    D4*.9    1.2E-5        mF   G4*.95         1.1
  5:        1458 .5E6    D5*.9    1.5E-5        mF   G5*.95         1.2
  6:        1458 5E5     D6*.9    1.8E-5        mF   G6*.95         1.3
  7:           0 0       D7*.9    2.2E-5        mF   G7*.95         1.5
  8:                     D8*.9    2.7E-5        mF   G8*.95         1.6
  9: R and C values      D9*.9    3.3E-5        mF   G9*.95         1.8
 10: are USA Standard    D10*.9   3.9E-5        mF   G10*.95        2
 11: C83.2.              D11*.9   4.7E-5        mF   G11*.95        2.2
 12:                     D12*.9   5.6E-5        mF   G12*.95        2.4
 13: Res. use series 10  D13*.9   6.8E-5        mF   G13*.95        2.7
 14: Caps. use series 20 D14*.9   8.2E-5        mF   G14*.95        3
 15:                     D15*.9   D3*10         mF   G15*.95        3.3
 16:                     D16*.9   D4*10         mF   G16*.95        3.6
 17:                     D17*.9   D5*10         mF   G17*.95        3.9
 18:                     D18*.9   D6*10         mF   G18*.95        4.3
 19:                     D19*.9   D7*10         mF   G19*.95        4.7
 20:                     D20*.9   D8*10         mF   G20*.95        5.1
 21:                     D21*.9   D9*10         mF   G21*.95        5.6
 22:                     D22*.9   D10*10        mF   G22*.95        6.2
 23:                     D23*.9   D11*10        mF   G23*.95        6.8
 24:                     D24*.9   D12*10        mF   G24*.95        7.5
 25:                     D25*.9   D13*10        mF   G25*.95        8.2
 26:                     D26*.9   D14*10        mF   G26*.95        9.1
 27:                     D27*.9   D15*10        mF   G27*.95        G3*10
                            ...To  row  101...     ...To  row 151...
```

FIG. 3—LOOKUP TABLE HEADINGS and general layout, in formula display. The column widths shown were selected only so the column headings would fit. Once the tables are integrated with the OPAMPC worksheet, column width will be irrelevant.

After we've built the lookup table on the worksheet, we'll save it on disk as LOOKUP.CAL. Making another backup copy is an excellent idea. The tired hand or mind, not to mention a faltering powerline, could trash a screen or disk, obliterating many hours of work. If you don't have a backup copy of a file on another disk, you don't have the file.

In order to reduce calculation time when using the worksheet, it is advisable to use only the lookup-table values, not the formulas. Otherwise, every time we hit <!>, the "force calculation" command, the lookup table will recalculate, greatly reducing the speed of the worksheet. So, do another save of the lookup table, but this time with values only. Name the file LOOKVAL.CAL.

```
  :      A      ::    C  ::      D       ::    E  :: F:: G ::    H   :
 1:                            OPAMPC
 2:===============================================================
 3:       USER CHOICES
 4:---------------------------------------------------------------
 5:      DEVICE:              RATED GBP: 2e5     -----ERROR FLAGS-----
 6:     INPUT R:                    INDEX         GBP R2
 7:   GAIN (Av):                A12. Invert.       0   0    1 = TOO HIGH
 8:      LOW Fc:                A24. Non           0   0    0 = OK
 9:     HIGH Fc:                A36. Diff          0   0
10:
11:    >>> 0 Indicates Selected R or C Out of Range <<<
12: INVERT MODE
13:            STANDARD                    ACTUAL              %ERROR
14:            R1                          GAIN:
15:            R2                        LOW Fc:
16:            C1        mF                  GBP
17:            R3
18:---------------------------------------------------------------
19:
20:
21:
22:
23:
24:NON-INVERT MODE
25:                                        ACTUAL              %ERROR
26:          - Fc                          GAIN:
27:          + Fc                        LOW Fc:
28:            R1                            GBP
29:            R2
30:            R3
31:            C1        mF
32:            C2        mF
33:---------------------------------------------------------------
34:
35:
36:DIFFERENTIAL AMP MODE
37:                                        ACTUAL              %ERROR
38:            R1                          GAIN:
39:            R2                        LOW Fc:
40:            R3                           GBP:
41:            R4                          Rin +:
42:            C1        mF               Rdiff :
43:            C2        mF
44:---------------------------------------------------------------
```

FIG. 4—OPCALC.CAL HEADINGS. The headings should be typed in exactly as shown here.

Op-amp calculation area

Now we'll build a worksheet called OPCALC.CAL. It will contain all the amplifier calculations and error messages. Set the worksheet for manual calculation before starting.

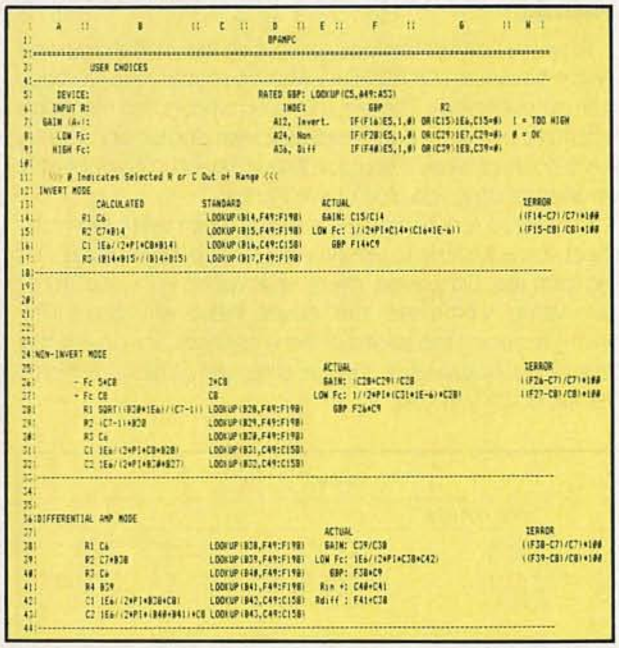
Refer to Fig. 4 and format the columns to these widths:

Column A: 12	Column E: 8
Column B: 0	Column F: 6
Column C: 8	Column G: 5
Column D: 12	Column H: 8

Type in the headings exactly as they appear in Fig. 4, using *Supercalc's* text formatting options as needed.

You'll notice that column B has a width of 0. That effectively hides the unrounded results of the amplifier calculations, so as to avoid confusion. You can still enter formulas, which will then show up on the status line. If ever the need should arise, Column B can be expanded to the standard 9 characters to show the precise results.

After checking your work for accuracy, refer to Fig. 5 for the



```
  |  A  ||      B      ||  C  ||  D  ||  E  ||    F    ||    G    ||  H  |
 1|                              OPAMPC
 2|=========================================================================
 3|          USER CHOICES
 4|-------------------------------------------------------------------------
 5|    DEVICE:                   RATED GBP: LOOKUP(C5,A49:A53)
 6|   INPUT R:                       INDEX           GBP            R2
 7| GAIN (Av):                   A12, Invert.  IF(F16)E5,1,0) OR(C15)1E6,C15=0)  1 = TOO HIGH
 8|    LOW Fc:                   A24, Non      IF(F28)E5,1,0) OR(C29)1E7,C29=0)  0 = OK
 9|   HIGH Fc:                   A36, Diff     IF(F40)E5,1,0) OR(C39)1E8,C39=0)
10|
11|  >>> # Indicates Selected R or C Out of Range <<<
12| INVERT MODE
13|          CALCULATED          STANDARD             ACTUAL                          %ERROR
14|        R1 C6                 LOOKUP(B14,F49:F198)  GAIN: C15/C14                  ((F14-C7)/C7)*100
15|        R2 C7*B14             LOOKUP(B15,F49:F198) LOW Fc: 1/(2*PI*C14*(C16*1E-6))  ((F15-C8)/C8)*100
16|        C1 1E6/(2*PI*C8*B14)  LOOKUP(B16,C49:C150)    GBP F14*C9
17|        R3 (B14*B15)/(B14+B15) LOOKUP(B17,F49:F198)
18|-------------------------------------------------------------------------
19|
20|
21|
22|
23|
24|NON-INVERT MODE
25|                                                   ACTUAL                          %ERROR
26|      - Fc 5*C8               2*C8                  GAIN: (C28+C29)/C28            ((F26-C7)/C7)*100
27|      + Fc C8                 C8                  LOW Fc: 1/(2*PI*(C31*1E-6)*C28)  ((F27-C8)/C8)*100
28|        R1 SQRT((B30*1E6)/(C7-1)) LOOKUP(B28,F49:F198)  GBP F26*C9
29|        R2 (C7-1)*B28         LOOKUP(B29,F49:F198)
30|        R3 C6                 LOOKUP(B30,F49:F198)
31|        C1 1E6/(2*PI*C8*B28)  LOOKUP(B31,C49:C150)
32|        C2 1E6/(2*PI*B30*B27) LOOKUP(B32,C49:C150)
33|-------------------------------------------------------------------------
34|
35|
36|DIFFERENTIAL AMP MODE
37|                                                   ACTUAL                          %ERROR
38|        R1 C6                 LOOKUP(B38,F49:F198)  GAIN: C39/C38                  ((F38-C7)/C7)*100
39|        R2 C7*B38             LOOKUP(B39,F49:F198) LOW Fc: 1E6/(2*PI*C38*C42)      ((F39-C8)/C8)*100
40|        R3 C6                 LOOKUP(B40,F49:F198)   GBP: F38*C9
41|        R4 B39                LOOKUP(B41,F49:F198)  Rin +: C40+C41
42|        C1 1E6/(2*PI*B38*C8)  LOOKUP(B42,C49:C150)  Rdiff : F41*C38
43|        C2 1E6/(2*PI*(B40+B41)*C8 LOOKUP(B43,C49:C150)
44|-------------------------------------------------------------------------
```

FIG. 5—OPAMPC FORMULAS. Columns have been expanded and formula display has been selected in this example. During normal use, the worksheet is formatted as in Fig. 1.

formulas. You'll note the columns are expanded beyond their normal width for clarity. You don't have to do that on your worksheet, since any formula entered in a cell will show up in the status line, regardless of column width.

Use the replicate function to simplify entering the lookup statements in column C. Be sure to select the *ask for adjust* option to prevent REPLICATE from changing the address of the lookup table. Notice that capacitor and resistor lookup tables have different addresses. When done, save the completed worksheet as OPCALC.CAL.

The union

To complete the OPAMPC template, start with a blank worksheet and load OPCALC.CAL (All) onto the screen. Ignore any error indications. Move the cursor to A48 and load LOOKVAL.CAL. You should ask for options and answer P (for part) when queried by *Supercalc*. Then load range A1:G151 into A48.

Protecting the template

To prevent inadvertent erasure of the contents of a cell, which might result in erroneous calculations, it is important to use *Supercalc's* PROTECT command. Once the entire worksheet is protected, the user choices section, cells C5:C9 are UNPROTECTED to allow entry at those points only. The OPAMPC template is now complete. Save to disk as OPAMPC.CAL.

Display formatting

Unless instructed otherwise, *Supercalc* will present the results of any calculations in the "general" format. It will display them as ordinary real numbers if the column is wide enough. Otherwise, it will use exponential notation. We have found that intelligibility is improved if the resistors and capacitors are expressed exponentially. The same is true of the GBP.

Integer notation is preferred for the device number, gain, low f_C, and error flags. Percent of error (%error) requires the <$> (two-point decimal or "dollar sign") format.

Using op-ampc

Invoke the GLOBAL command to set the worksheet for manual calculation by columns. Position row 2 at the top of the screen. Next, use WINDOW to put a horizontal split at row 12. Make sure that both sections scroll independently. Later, when you become more familiar with OPAMPC, you can eliminate clutter on the screen by using the GLOBAL command to suppress the border.

Let's say we wish to design a differential amplifier, using a 1458 IC. Place the cursor into the upper left cell of the bottom window. Looking at the index in the upper window, you can see that the differential configuration starts at cell A36. Use <=> to jump there, then put the cursor back into the upper window and start entering your performance choices in column C. Remember to use only the device number in cell C5. No alphabetical suffixes or prefixes are allowed.

To calculate, invoke the <!> command twice. A quick glance to the right will tell you if any errors have occurred. The error flags section gives information even on configurations not currently displayed. Column C, in the lower window, displays rounded values. To the right, in column F, actual performance, recalculated using the rounded values, is shown. The percentage of deviation from the entries in the user choice section appears in column H.

Input resistance for all except the non-inverting (+) input of the differential amp will be within ±5% of that selected. The high frequency cutoff selection is included only to calculate required GBP, so no error checking is done for it.

OPAMPC is a valuable tool for the electronics hobbyist. It allows a designer to quickly calculate the three most common op-amp configurations at once. Its speed makes rapid design changes and "what if" analyses routine. Of course, it can't eliminate the "fine-tuning" necessary to produce the optimum design, but it does get you well into the ball-park.

If you have any questions about this template, feel free to contact the author on CompuServe. Address your message to Kirk Vistain, user number 72356,1355. OPAMPC is easy to enter and easy to use. Have fun with it!

COMMODORE CASSETTE INTERFACE

Use an ordinary audio cassette recorder with your Commodore 64 or VIC-20!

WALTER G. PIOTROWSKI

■When I saw the advertisement, I couldn't believe it: a computer with a real keyboard for only $84.97. Even if the *VIC-20* was not much of a computer, it had to be worth at least that much, so I bought one.

One afternoon, my son went to work on the computer and, by bedtime, had written a long program. Unfortunately, he wasn't aware at the time that we had no mass-storage device on which to save the program. The next day, we went back to the store where we bought the computer and learned that the least-expensive mass storage device for the *VIC* was a cassette recorder that was priced almost as high as the computer itself. We already had two cassette recorders that were gathering dust, so I hoped that there was some way we could use one of them instead of the relatively expensive *Datasette*.

The VIC cassette port

The *VIC-20's* cassette port is a card-edge connector on the machine's rear. The signals available on the card-edge fingers are shown in Fig. 1. The CASSETTE WRITE output (E-5), and the CASSETTE READ input (D-4), are both logic-level signals. A look at the *VIC's* schematic showed that both signals go to 6522 PIA's (*P*eripheral *I*nterface *A*dapters). I connected my scope to the CASSETTE WRITE output, typed SAVE, and found a five-volt, audio-rate squarewave. Unfortunately, that squarewave can't be recorded directly on audio tape. There are two reasons for that: First, the signal level must be reduced—trying to input this signal directly into the recorder's microphone jack overloads the record amplifier. The second problem is because the waveform is a squarewave. When you try to record a squarewave, the recording process attenuates the high-frequency components. The result is that you don't get a squarewave back when you play the tape. Figure 2 shows the squarewave output of the cassette port. Figure 3 shows the recorded signal—which has little resemblence to the squarewave.

Because the computer expects to see a 5-volt squarewave when it reads the tape, it will not be able to read the tape recorded on a standard cassette

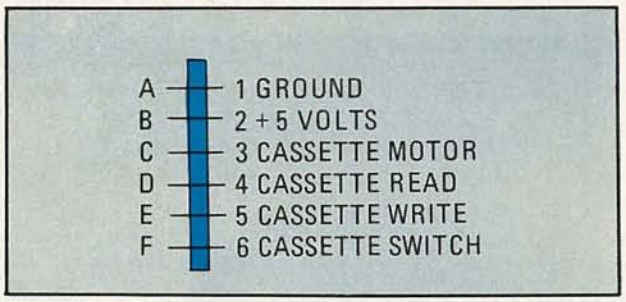


FIG.1—CASSETTE PORT SIGNALS. Note that the CASSETTE SWITCH output is called CASSETTE SENSE on the Commodore 64.

PARTS LIST

Resistors

R1—10K, ¼-watt trimmer potentiometer
R2—10K, ¼-watt, 10%

Semiconductors

IC1—74LS14 hex Schmitt trigger

Miscellaneous

Project Box (Radio Shack 270-220); 6/12 Card-Edge Connector (.156-inch centers); 14-pin IC socket; SPST toggle switch; 2 miniature phone plugs, Coaxial DC power plug (5.0mm O.D., 2.1mm I. D.), etc.

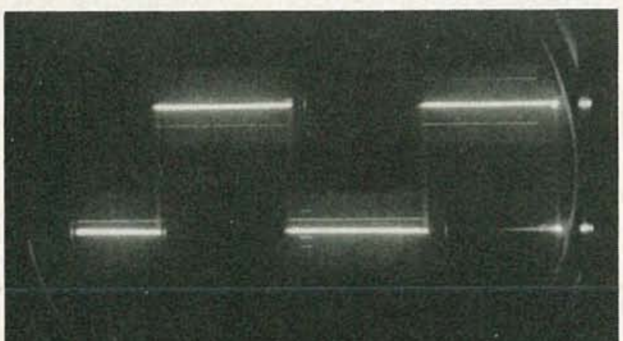


FIG.2—CASSETTE-WRITE OUTPUT WAVEFORM is part of the sync data that preceeds the actual data. When data is being transferred, the duty cycle of the waveform is varied.

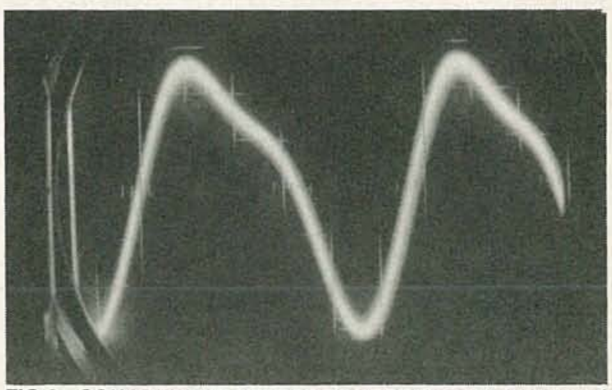


FIG.3—SQUAREWAVE AFTER RECORDING and being played back on a cassette recorder.

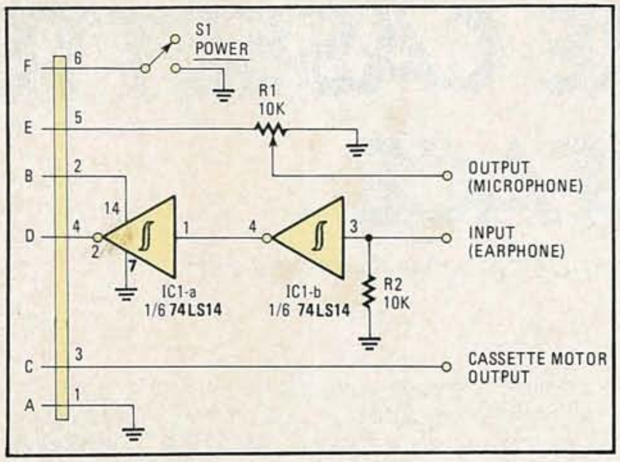


FIG.4—SCHEMATIC DIAGRAM of Commodore cassette interface.

recorder—unless you find a way to turn the recorder output back into a squarewave before the computer sees it.

Before we discuss how to get the squarewave back, let's take a look at the other cassette-port signals, the CASSETTE MOTOR output and the CASSETTE SWITCH (or CASSETTE SENSE) input.

Commodore's *Datasette* recorder doesn't have a power cord. As you might guess, it receives its operating voltage from the computer—specificcally from the CASSETTE MOTOR output on card-edge pin C-3. That output is driven by a a 2SD880 power transistor. The output voltage is 6.4 volts.

My cassette recorders, which are fairly old, have 7.5-volt input jacks, alongside the mike and headphone jacks. The recorders run perfectly on this 6.4 volt output. Most newer recorders operate on 6 volts, so you should be able to use any of them with the *VIC*.

The cassette switch input has to be pulled to ground before the VIC will turn on the cassette motor voltage. If it isn't grounded when you type a command (SAVE, LOAD or VERIFY), you will get a message on the screen that tells you to push a button on the recorder. Apparantly, the *Datasette* grounds the CASSETTE SWITCH line whenever one of its buttons is depressed. (The software checks to see that a button has been pressed before trying to move the tape.)

How the adapter works.

The schematic of the circuit that allows you to use an ordinary tape recorder with your Commodore computer is shown in Figure 4. The playback line contains two Schmitt trigger inverters. The first conditions the tape's output signal back into a squarewave. Since it also inverts the signal, we need the second inverter to fix the signal's polarity.

The switch in the CASSETTE SWITCH line is not essential; things will work right if the cassette switch is always grounded. The switch does, however, provide some extra flexibility in using the recorder.

Any construction method can be used. The only caution is that when you connect the wires to the coax power connector, don't forget that the center is ground!

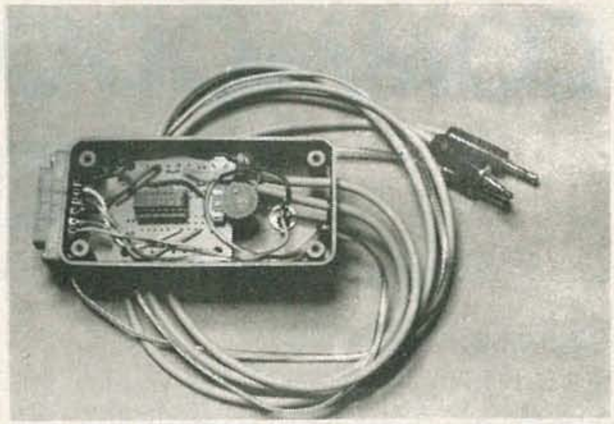


FIG.5—THE INTERFACE mounts nicely on half a standard dual-IC board and fits inside the smallest Radio Shack project case.

You'll find that without even trying very hard, you'll be able to fit everything into into the smallest Radio Shack project case. The prototype's construction is shown in Fig. 5.

Checkout and use

Setting up the adapter couldn't be easier. Simply set potentiometer R1 so that the output (when you're SAVE-ing a program) is about 0.1 volt peak-to-peak or less. (If you don't have an oscilloscope you can measure for about 50 millivolts with a DC voltmeter.) The exact voltage isn't critical, since most tape recorder inputs have automatic record-level circuits. You might have to experiment a bit with the volume and tone controls on playback. With my recorder, I get the best results with the volume control at about ⅞ full and the tone control at maximum treble. Start with those

FIG.6—HOOKED UP AND READY TO GO, the interface needs only to be checked out and then never needs to be touched again.

settings and play back a tape that you have recorded. The volume control setting is the most important, and setting it too high is better than too low. Once it is correctly set, you should not have to adjust it again. Figure 6 shows the completed unit hooked up and ready to go.

You should find that the interface works correctly with pre-recorded tapes as well as those you SAVE yourself.

some current books that deal with countdown, start, fail-safe, shutdown, and protector circuits. But so far, I've had no luck. Can you help me locate books on those topics?—L.M., Wisconsin Rapids, WI

All of the circuits in question are relatively new and as such each manufacturer designs his own particular version (often redesigning them from one model to another). I doubt if we will ever be treated to one book that can cover it all because it would become obsolete with the next model year. Perhaps the best advice that I can offer you is to subscribe to as many of the manufacturer's technical-literature services as you can handle: In that way you can pick up a little information here and there. **R-E**

EQUIPMENT REPORTS

continued from page 45

various CP/M commands and utility programs. For more detailed information, or for users unfamiliar with the CP/M operating system, there's the Osborne book. The version of the book that is supplied with the package is written specifically for the Apple, and will guide you step-by-step through the different CP/M commands and utilities.

The Microsoft BASIC reference manual assumes that the user already has some familiarity with BASIC. Its purpose, as its name implies, is as a reference for all the commands, statements, and functions of Microsoft BASIC.

For those who want to use nonstandard I/O devices, or use software that requires some modifications to CP/M, the information needed to perform those tasks is found in the system programmer's manual. That manual is not included in the package. Apparently to encourage the mailing in of registration cards, which often are simply discarded instead, that manual is sent to you by Microsoft upon their receipt of that card.

The *Premium Softcard IIe* carries a suggested retail price of $395. **R-E**

SERVICE QUESTIONS

COLOR CONVERGENCE

I can't get a Sony KV9000 to converge no matter what I do. I've checked everything and it looks OK. Any help that you can give me will be greatly appreciated.—B.P., Bronx, NY

I wonder if you checked the potential difference between the inner and outer conductors of the (two-conductor) anode lead; one carries the high voltage and the other carries several hundred volts less (adjustable with the horizontal-static control). Make sure that the anode is correctly seated and that the voltage difference exists.

SHORTED FILTER CAPACITORS

I have a GE KE-II chassis that keeps destroying the power-supply filters. When I first got the set, I found C1 and C2 had been replaced. I changed them both a second time, and one week later I found one section of C2 shorted again. What's happening?—A.S., Bedford, OH

The answer I have is so simplistic that I almost hesitate to give it, yet it's the only one that makes sense. Are you observing voltage ratings? Some filter sections are rated at 450 volts and others 350 volts. If the previous service technician crossed them, and you are duplicating his errors, the same breakdowns will keep occurring. Check the actual wiring against the diagram.

BLOWN HORIZONTAL OUTPUT TRANSISTORS

I have a GE19YA chassis that keeps blowing horizontal output-transistors every few days. I feel like hanging it up and going back to painting barns.—F.S., Newton, IL

Sometimes it looks like a pretty good idea, doesn't it? Painting barns, that is. Until then, try replacing C702, which is connected across the transistor. It is recommended that whenever the transistor is found shorted, the capacitor should be changed too. It's a critical component, so get a GE original if you can.

RETRACE LINES

I have two RCA CTC97 chassis in the shop, both with retrace lines in the picture. Parts substitution doesn't seem to help. Any ideas?—G.S. Waco, TX

Try checking R3116. It's the 220-kilohm resistor connected across the low-impedance circuitry, so you will have to lift it before it can be measured. You may find it open. Also check R3043, C2119, Q3019, and Q3020.

DISAPPEARING SOUND

I have a Zenith 19EC45 chassis in which the sound comes on for a few seconds, and then the circuit breaker trips. Please help.—E.J., Alvada, CO

You probably have a short in the horizontal output-circuit. Start by checking the transistor with an ohmmeter. If it's OK, lift the input lead to the high-voltage tripler. If the breaker holds, replace the tripler. Another common breakdown in that set is the feed-thru capacitor, marked C232 on the schematic. That is a post-type component mounted through the chassis pan, and it arcs internally. You can bypass it by using a 100-picofarad, 1000-volt capacitor in its place.

BAD HORIZONTAL AND VERTICAL HOLD

I'm calling for help once more. I have a Zenith 20YC48 chassis that's giving me poor horizontal and vertical hold. I've checked everything and have gotton nowhere. Can you help?— L.P., Potomac, MD

I've seen the vertical integrator (A1) give a lot of trouble in that chassis. Check it by clipping it out and temporarily using a 100,000-ohm resistor in its place. I've seen the dual-diode (X8) and the 68,000-ohm resistor connected to pin 5 of the 6U10 cause horizontal-hold problems. If you're having trouble with both vertical and horizontal lock-in, you must re-examine all components in the sync section. Don't overlook X4, the sound and sync detector.

NEED INFORMATION

I have been trying in my area libraries and book stores to locate

DIGITAL IC TESTER

continued from page 86

You can use the display adapter to view signals that originate outside of the tester. With the test socket empty and the power supply jumpers removed, open the isolation switches and jumper the system signal(s) to the test socket pin(s). Bring in a suitable trigger, crank up the system, and you are ready to observe the chosen signals and their relationship to each other. Be aware that the displayed signals are now driving the additional load presented by the circuitry connected to the test socket—that includes the output drivers, the multi-channel adapter, and, perhaps, additional expansion hardware. System signals that are heavily loaded might not be able to drive that additional load.

The selection or generation of a trigger is most crucial in creating a stable and meaningful display. The trigger pulses should be evenly spaced, and all displayed signals should repeat themselves exactly between triggers. The qualifier can be useful in dealing with complex systems, but proper qualification hinges on your familiarity with the logic system. In general, under-qualified triggers tend to create brilliant but jittery displays. On the other hand, over-qualified triggers yield diminished or even non-existent displays.

In situations where trigger selection is relatively simple, the multi-channel adapter can become a tutorial aid. You can learn a lot by observing signals in a properly operating digital device. As you continue to use the adapter and really get a good "feel" for it, you will probably find many additional uses for the adapter. We'll find even more uses for the IC tester when we continue. R-E

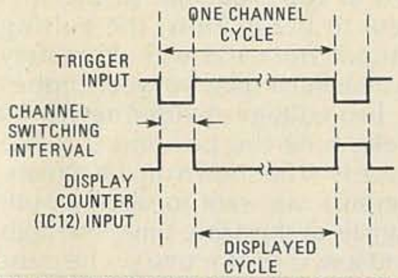


FIG. 8—THE COUNTER COUNTS on the leading edge of a logic trigger, but the scope triggers on the trailing edge. That eliminates the channel-switching lines from the display.

PARTS LIST

All resistors are ¼-watt, 5%
R3—43,000 ohms
R4—22,000 ohms
R5—11,000 ohms
R6—5600 ohms
R7—2700 ohms
R8–R12—330 ohms
R13—1500 ohms
Semiconductors
IC11—74150 1-of-16 selector/multiplexer
IC12—74LS191 binary synchronous up/down counter
IC13—7406 hex inverting buffer
IC14—7420 dual 4-input NAND gate
Other components
S17—SPST switch

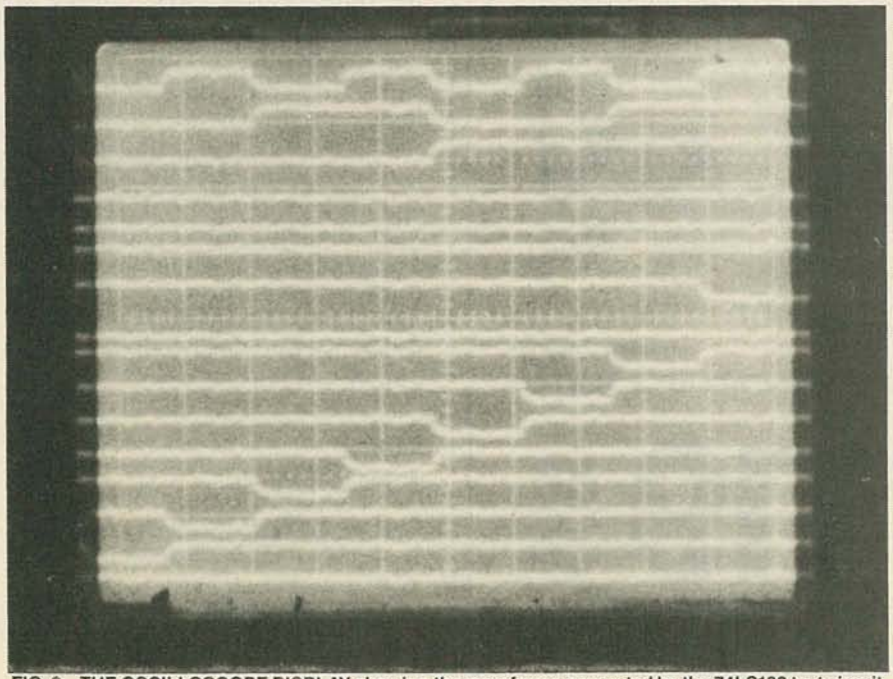


FIG. 9—THE OSCILLOSCOPE DISPLAY showing the waveforms generated by the 74LS138 test circuit. While it may not be the most eloquent logic analyzer, it can be an excellent teaching or learning tool.

STATE OF SOLID STATE

continued from page 101

power-supply rejection ratio (PSRR) is 30 dB.

Figure 4 shows how the ULN-3784B is used as an amplifier with bass and treble controls.

Additional information on both devices is available on request from **Sprague Electric Company**, Semiconductor Division, 115 Northeast Cutoff, Worcester, MA 01606. Refer to Engineering Bulletin 21717.12 for the ULN-3784B and to Engineering Bulletin 21717.23 for the ULN-3705M low-voltage amplifier. **R-E**

NEW IDEAS

continued from page 32

their "contacts" will remain open and no signal will appear at the output. We use the output from pin 3 of IC3 (a 7555 timer) to gate IC2-b and IC2-c. Note that the signal from IC3 is inverted before it is fed to IC2-b but not before it is sent to IC2-c. Thus, the pulsing output from IC3 will alternately switch the display between probes

Two voltage-divider networks determine the position that the trace is to be shown on the screen. Because we want to display both signals at the same time, the high and low levels for one probe must be different from the high and low levels for the other probe. For INPUT 1, the divider is made up of resistors R2, R3, and R4, and for the other, R10 and R11.

The addition of R3 in the first voltage-divider circuit increases the voltage level of both the high-level and low-level inputs from probe 1. Thus, the probe-1 signals will be displayed at the top of the signals from probe 2. The probe-1 trace is displayed between the 3- and 4-volt mark, while the probe-2 trace is shown between zero and one-volt. That can be shown by the following formulas, which assume a high level of +5-volts.

Probe 1:

$$\text{High} \cong \frac{R4}{R2+R4}(V) = \frac{220K}{56K+220K}(5V) \cong 4V$$

$$\text{Low} \cong \frac{R4}{R2+R3+R4}(V) = \frac{220K}{56K+100K+220K}(5V) \cong 3V$$

Probe 2:

$$\text{High} \cong \frac{R11}{R10+R11}(V) = \frac{56K}{220K+56K}(5V) \cong 1V$$

$$\text{Low} \cong 0V$$

With the scope set to trigger on one input, signals up to 50 kHz can be monitored. That makes the circuit ideal for low to medium speed logic-level inputs. Certain frequencies can cause garbage (harmonics of the sampling frequency) to be displayed; however, adjusting potentiometer R6 will correct that.—*Jeff Verive*

BATTERIES

continued from page 58

TABLE 7— BATTERY MANUFACTURERS

Lithium batteries

Altus Corporation
1610 Crane Court
San Jose, Ca. 95112

Tadiran
6312 Variel Avenue
Woodland Hills, Ca. 91367

Varta Batteries, Inc.
150 Clearbrook Road
Elmsford, N.Y. 10523

Lead-acid batteries

Technacell
2117 South Anne St.
Santa Anna, Ca. 92704

Eagle Pitcher Ind., Inc.
PO Box 130
Seneca, Mo. 64865

Gould Inc.
931 N. Vandalia St.
St. Paul, Minn. 55114

Nickel-cadmium batteries

Gould Inc.
931 N. Vandalia St.
St. Paul, Minn. 55114

Varta Batteries, Inc.
150 Clearbrook Rd.
Elmsford, N.Y. 10523

General Electric
Battery Business Dept.
PO Box 861
Gainesville, Fl. 32602

By now you should know enough about all the different battery chemistries to make an intelligent decision as to which battery system (or combination of systems) is best for your application. And if you're not exactly sure, you should have enough information to know what the right questions are. Battery manufacturers will be more than happy to send you data sheets, catalogs, and application notes so you can find out whatever you want to know. Table 7 is a good beginning list of companies you can contact for information. Don't hesitate to write to them—they know more than you do and can save you lots of time and trouble. And a twenty-cent stamp is a pretty cheap insurance policy when it comes to saving twenty dollars worth of batteries. **R-E**

SATELLITE STEREO

continued from page 54

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.

R1, R18—6800 ohms
R2, R19—100 ohms
R3, R17—1 megohm
R4, R6, R7, R10–R13, R20, R22, R23, R26–R29, R44—10,000 ohms
R5, R21—5000 ohms, linear-taper potentiometer
R8, R24—100,000 ohms
R9, R25—1500 ohms
R14, R30–R33—1000 ohms
R15, R16, R34, R35, R39, R42—470 ohms
R36, R38—75 ohms
R37—330 ohms
R40—750 ohms
R41—3300 ohms
R43—4700 ohms

Capacitors

C1—5–55 pF trimmer capacitor
C2, C5–C10, C19–23, C26—0.001 μF ceramic disc
C3, C14, C27—0.01 μF, ceramic disc
C4, C18, C35—22 pF, ceramic disc
C11, C24—39 pF, ceramic disc
C12, C25, C34—0.05 μF, ceramic disc
C13—150 pF, ceramic disc
C15, C28—0.1μF, Mylar
C16, C29—100 μF, 16 volts, electrolytic
C17, C30–C32—2.2 μF, 50 volts, electrolytic
C33—470 μF, 10 volts, electrolytic

Semiconductors

IC1—MC7808 8-volt regulator
IC2—MC10116 triple line receiver
IC3, IC4—NE564 phase-locked loop (Signetics)
IC5—μA4136 quad op-amp
D1, D2—MV2209 varactor diode
LED1—miniature red LED

Other components

L1—12 μH, high-Q
L2—3.9 μH, high-Q
J1–J3—RCA-type phono jacks
J4—miniature phone jack
S1—DPDT push-on/push-off

The following are available from Video Control, 3314 H. Street, Vancouver, WA 98663, (503) 693-3834: Complete kit including all parts, printed circuit board, chassis, AC power adapter, and manual $79.00; PC board and manual only, $19.50; AC power adapter, $10.00. Include $3.50 for shipping and handling for all orders.

minus the L − R subcarrier (the right-channel information).

Building the circuit

Because of the high frequencies involved, using a printed-circuit board is

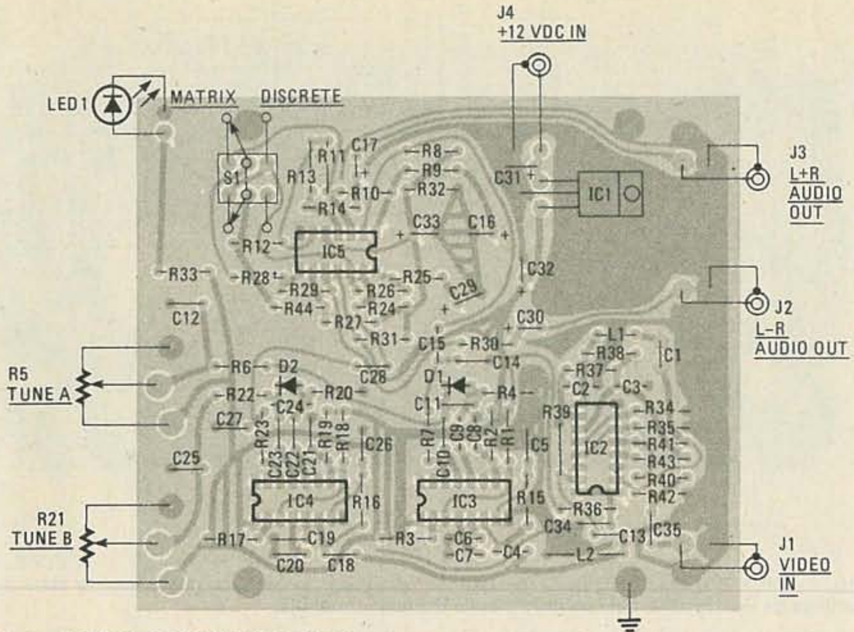


FIG. 7—PARTS-PLACEMENT DIAGRAM. Note that some parts are soldered on the component side as well as the "solder" side. While those places aren't specially marked, you will notice that the groundplane is not etched away in those places.

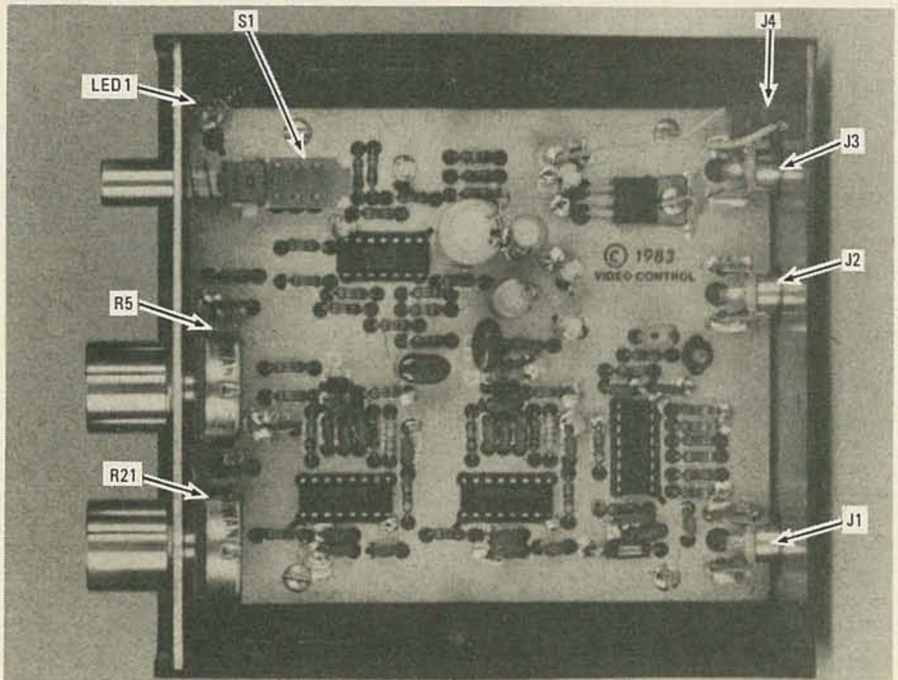


FIG. 8—TO KEEP LEAD LENGTHS SHORT, all the components (except for power-input jack J4) are mounted directly to the board.

essential. The component side of the PC board is shown in Fig. 5 while the solder side is shown in Fig. 6.

Since the circuit is composed of three active sections, with each section operating around the 6.5 MHz range, construction and circuit-board layout is very important. When soldering components to the board, lead lengths should be kept as short as possible to keep the very sensitive front-end (the amplifier in the input stage) from oscillating.

Notice that the component side of the board serves as a ground plane for shielding and reduction of crosstalk. Some of the components must be soldered to the ground plane as well as to the solder side. If you look at Fig. 7, the parts-placement diagram, that is evident wherever the component placement holes are touching the groundplane.

Since you want to keep lead lengths to a minimum, you should start soldering the low-profile parts (resistors, for example) onto the board first. If all of the parts are the same height, simply laying the board on a flat surface will press all the parts flush against the board and your lead lengths can be kept as short as possible. Next solder the higher profile parts such as

FIG. 9—FRONT-PANEL CONTROLS. To make the unit easier to use, you might want to mark the settings for your favorite transponders around the tuning controls.

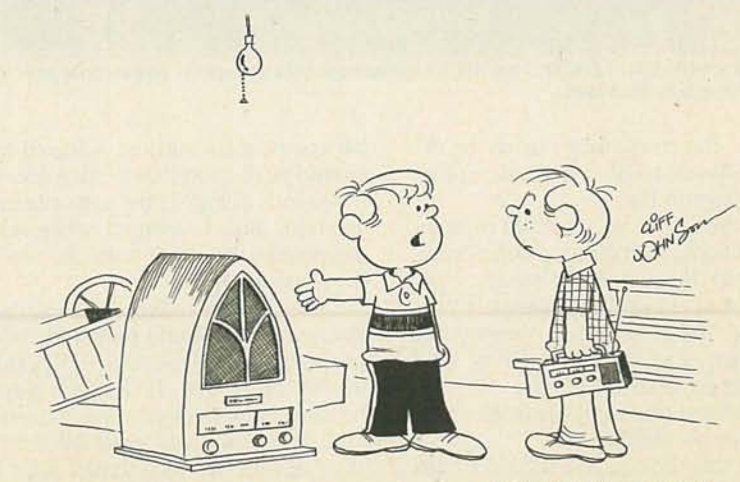
IC's. Do not use IC sockets when you install the IC's. Follow by installing the other components except LED1. (LED1 must poke through a hole in the front panel.)

Calibration

When your construction work is finished, apply power via a wall-mounted AC adapter, and connect the left and right audio-channel outputs to the appropriate stereo receiver/preamplifier audio inputs (AUX IN, for example). The next step is to test the unit by tuning in a satellite TV stereo transponder that has a strong video signal. A good one to start with is MTV (*M*usic *T*elevision)—you can be virtually certain of finding a stereo signal there. (MTV is on Satcom F3, transponder 11.)

To begin, turn up the stereo's volume to a moderate level to where the hiss is not too obnoxious. Push the DISCRETE/MATRIX switch, S1, in the DISCRETE position. Turn R5 (TUNE A) completely clockwise and R21 (TUNE B) completely counterclockwise. Now begin adjusting R21 clockwise until the L – R subcarrier is found. The phase-locked loop will lock onto the subcarrier when R21 is correctly positioned. You should hear a hollow or echo sound when properly locked onto the L – R subcarrier. Now C1 must be adjusted—using a non-inductive tool—until there is the least amount of noise present on the L – R subcarrier. Next begin turning R5 counterclockwise until the L + R subcarrier is located. The proper settings of the front panel controls will be evident when the L – R channel has a lot of "ambience" signals. In other words, it will sound hollow and echo. Now engage switch S1 to the MATRIX position (extended) and listen to the music blend in full stereo. Both TUNE controls (R5 and R21) can now be fine-tuned by ear.

When tuning in a discrete transponder, the procedure is identical, except leave the switch S1 in the DISCRETE (extended) position. Because the audio subcarriers on different transponders are often at different frequencies, you may need to fine-tune front-panel controls R5 and R21. **R-E**



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RESISTORS ¼W&½W5% 3 cents. 1%metalfilms, precision custom wirewounds, $1.00 refundable to: **JR INDUSTRIES,** 5834-B Swancreek, Toledo, OH 43614.

FREE catalog featuring scanner accessories, carrier/subcarrier detectors, voice scramblers, unusual kits. **CAPRI ELECTRONICS,** Route 1R, Canon, GA 30520.

THE Intelligence Library—Restricted technical information & books on **electronic surveillance, surveillance-device schematics, lock-picking, investigation, weapons, identification documents, covert sciences,** etc. The **best** selection available. **Free brochures. MENTOR,** (Dept. Z), 135-53 No. Blvd., Flushing, NY 11354.

CABLE-TV equipment, notch filters for "beeping" channels. Information $1.00. **GOLDCOAST,** PO Box 63/6025 RE, Margate, FL 33063.

RF parts/Motorola transistors. MRF454 $16.00. MRF455 $12.00. Catalog available. **RF PARTS CO.,** 1320-4 Grand, San Marcos, CA 92069. (619) 744-0720.

UP to $500.00 per month. Sell computer software in your home. Write to: **COMPUTER SERVICES,** PO Box 7748, Tucson, AZ 85725.

RECONDITIONED test equipment. $1.00 for catalog. **JAMES WALTER TEST EQUIPMENT,** 2697 Nickel, San Pablo, CA 94806.

TOKO Coil Set (four) $8.00. **BFQ85 substitute** transistor $2.00. **High quality PCB** with plated holes and reflow solder $12.00. Or all for only $20.00. **JIM RHODES,** 1025 Ransome Lane, Kingsport, TN 37660.

CONNECTORS—audio, co-axial, aviation, computer, industrial, and many other types. Send $2.00 for complete price list and ordering information. Largest inventory in country. **CONNECTOR TECHNOLOGY INC.,** 5A Veronica Ave., Somerset, NJ 08873.

WHOLESALE F-59 cable connector $80.00/1000. Free MATV catalog SASE, (212) 897-0509. **D&WR,** 68-12 110 St., Flushing, NY 11375.

CHANNEL 3—60dB notch filter. 63.5MHz. $32.00. **CROSLEY,** Dept. 763, Box 840, Champlain, NY 12919.

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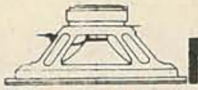

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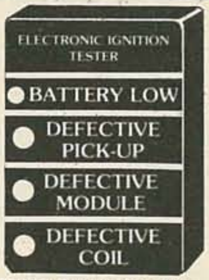

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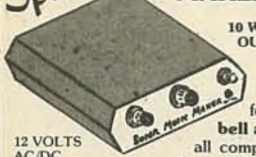

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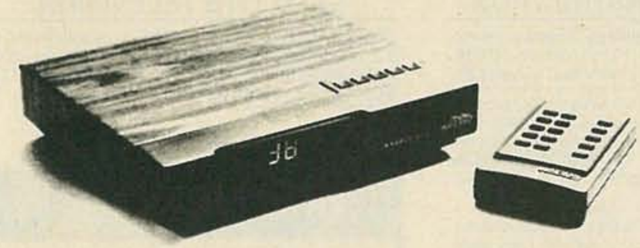

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SCANNERS—discount prices Bearcat BC-100 $279.99; Bearcat 210XL $214.99; Bearcat 300 $335.99; Regency MX3000 $186.99; JIL SX100 $138.99; JIL SX200 $269.99; Bearcat 20/20 $275.99; Spectrum radar detector $214.99; plus $3.00 shipping. Free discount catalog. Lowest prices anywhere on scanners, radar detectors, marine radios, two-way accessories. **SCANNER WORLD,** 10-RE New Scotland, Albany, NY 12208 (518) 436-9606.

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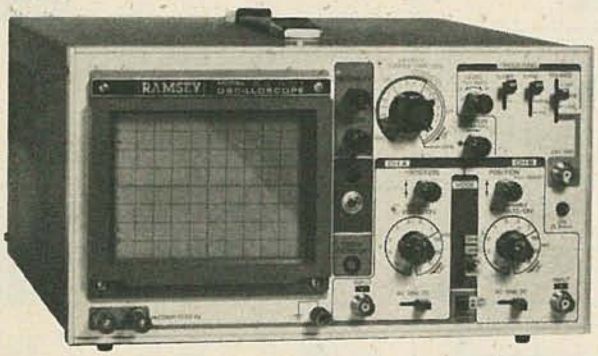

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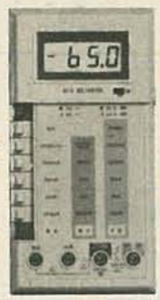

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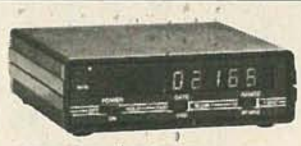

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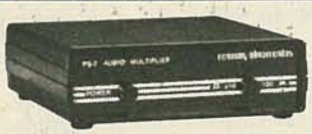

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47	272-121	.39
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220	272-124	.39
470	272-125	.39

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.01	272-131	.39
.05	272-134	.49
.1	272-135	.49

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0.47	35	272-1433	.49
1.0	35	272-1434	.49
2.2	35	272-1435	.59
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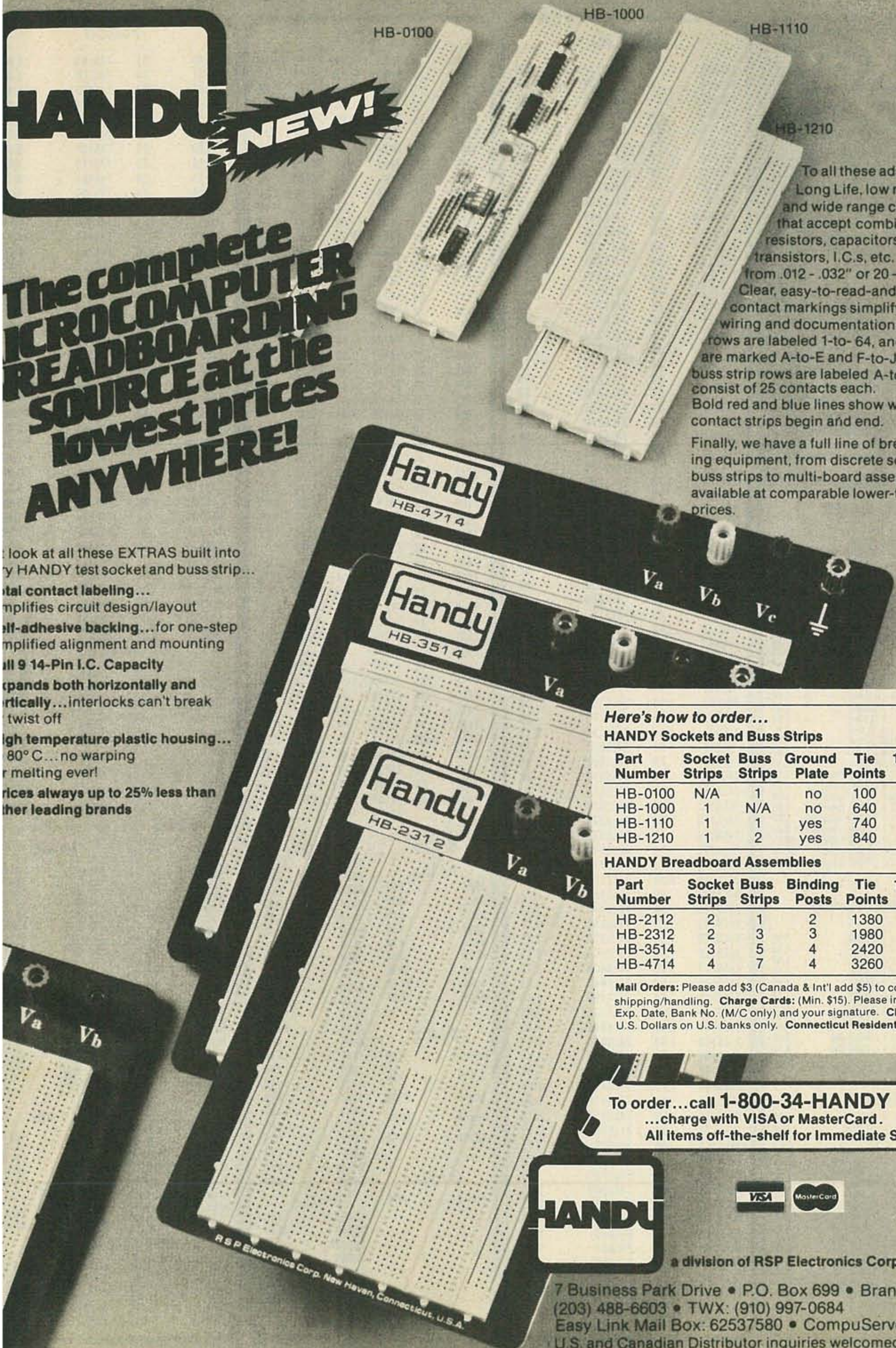

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7805K	1.34	7912K	1.44
7812K	1.34	7915K	1.44
7815K	1.34	7924K	1.44
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24 pin ST	.29	24 pin WW	1.44
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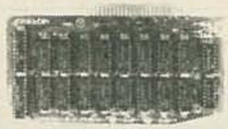

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99¢ EACH — 10/$9 — 100/$84 — 1000/$750

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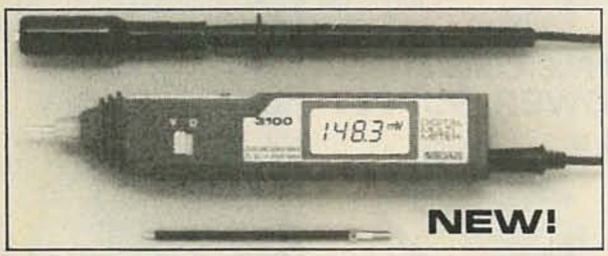

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DESIGNER'S NOTEBOOK

continued from page 97

- If R1 is close to R2, then $f = .56/RC$, where R is the average of R1 and R2.
- If R1 is much larger than R2, then $f = .46/R1C$.
- If R1 is much smaller than R2, then $f = .722/R1C$.

The output will be a squarewave with a duty-cycle that's pretty close to 50/50. That only happens with CMOS inverters because the switching point is the threshold of the inverters and (for CMOS) that's halfway up the supply rail. That switching characteristic also makes the circuit almost immune to power-supply spikes and other nasties.

The output frequency of the circuit is a function of the propagation delay through the gates. That means that the output stability will degrade as the frequency increases. The propagation delay is a constant and the lower the frequency, the smaller it (the delay) will be relative to each output pulse. **R-E**

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LP = Low Power

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5v = Single 5 volt supply

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5v = Single 5 volt supply 21vPGM = Program at 21 Volts

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PN2222		.10
2N2905		.50
2N2907		.25
2N3055		.79
2N3904		.10
2N3906		.10
1N4004		10/1.00
1N4148		25/1.00

74LS00

74LS00	.24	74LS157	.65
74LS02	.25	74LS158	.59
74LS03	.25	74LS161	.65
74LS04	.24	74LS163	.65
74LS05	.25	74LS164	.69
74LS08	.28	74LS165	.95
74LS09	.29	74LS169	1.75
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74LS14	.59	74LS174	.55
74LS20	.25	74LS191	.89
74LS21	.29	74LS193	.79
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74LS126	.49	74LS367	.45
74LS132	.59	74LS368	.45
74LS133	.59	74LS373	1.39
74LS136	.39	74LS374	1.39
74LS138	.55	74LS377	1.39
74LS139	.55	74LS390	1.19
74LS148	1.35	74LS393	1.19
74LS151	.55	74LS640	2.20
74LS153	.55	74LS670	1.49
74LS154	1.90	74LS682	3.20
74LS156	.69	74LS688	2.40

74S00

74S00	.32	74S86	.50
74S02	.35	74S112	.50
74S04	.35	74S124	2.75
74S05	.35	74S138	.85
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74S10	.35	74S175	.95
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7400

7400	.19	7447	.69
7402	.19	7473	.34
7404	.19	7474	.33
7405	.25	7475	.45
7406	.29	7476	.35
7407	.29	7486	.35
7408	.24	7490	.35
7410	.19	7492	.50
7411	.25	7493	.35
7414	.49	74121	.29
7416	.25	74123	.49
7417	.25	74132	.45
7420	.19	74151	.55
7425	.29	74154	1.25
7430	.19	74157	.55
7432	.29	74164	.85
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7442	.49	74192	.79
7445	.69	74193	.79

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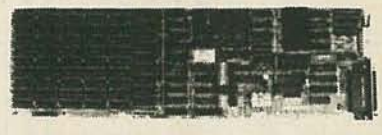

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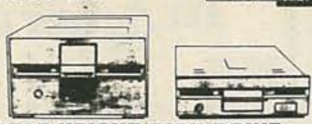

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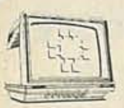

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CIRCLE 74 ON FREE INFORMATION CARD

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TO MAKE IT AN ALARM CLOCK

OPTION #2 .... $4.95
TO MAKE IT A D.C. 12V CLOCK

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ONLY WHEN BOUGHT WITH CLOCK KIT

12 VOLT A.C. ADAPTOR .... Reg. $4.95 - ONLY $2.95
ONLY WHEN BOUGHT WITH CLOCK KIT

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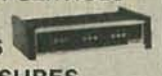

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2708	3.85	2732-250	8.25	2764-200	16.50
2758	4.95	2732-200	9.95	68764	39.95
2716	3.85	2732A4	6.75	68766	41.95
2716-1	5.75	2732A	9.75	27128	27.95
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6820	4.25	6844	25.00	6860	7.75
6821	3.75	6845	14.75	6875	6.25
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74S05	.52	74S136	1.69	74S258	1.29
74S08	.49	74S138	1.99	74S260	.75
74S09	.49	74S139	1.29	74S280	2.79
74S10	.42	74S140	.73	74S287	2.99
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74S15	.42	74S153	1.29	74S373	3.10
74S20	.42	74S157	1.29	74S374	3.10
74S22	.42	74S158	1.29	74S387	2.75
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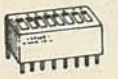

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7422	.29	74109	.37	74185	2.25
7423	1.19	74116	1.25		
7425	.29	74121	.29		
7426	.29	74122	.39	74190	1.15
7427	.25	74123	.45	74191	1.15
7429	.45	74125	.39	74192	.75
7430	.18	74126	.44	74193	.75
7432	.29	74128	.59	74194	.75
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7438	.29	74136	.75	74196	.75
7439	1.19			74197	.75
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4014	.75	4051	.75	4501	.39
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