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Space settlements built from space materials

NASA'S RENDITION OF a 10,000-person space-habitat design.

Last November, President Reagan signed into effect legislation that might help pave the way toward the development of human space colonies within Earth's solar system. The Space Settlement Act, now part of the NASA Authorization Bill, provides for the agency to file regular reports on the technology and economics of space settlements, and the social, psychological, legal, political, and international implications of human settlement of the extra-Earth solar system.

The Space Studies Institute of Princeton, NJ, a long-time advocate of industrial development in space, believes that such settlements can be built in free space from materials that are already in space. Those materials include man-made space debris and lunar resources. Three studies conducted by NASA in the mid-70's suggested that it is feasible to build space colonies from lunar materials. That would make it a lot less expensive to build such colonies.

Volt to change its value in 1990

An international conference of representatives of the world's weights-and-measures community met recently in Sèvres, France, to adopt new "conventional values" for the Josephson constant and the von Klitzing constant. Those are two fundamental physical values used to determine the value of the volt, using the AC Josephson effect, and the value of the ohm, using the quantum Hall effect.

That means that all industrial nations will have—for the first time—a common practical basis for measuring voltage and resistance. The new standards will take effect January 1, 1990.

The changes will not be highly significant to the practical technician; they will change the value of the volt by only about 9.3 parts per million (ppm). They will be important in the international electronics world. At present, there is a slight difference (about 1.2 ppm) between American and most European standards. With the precision required in some technologies, that is enough to make an important difference to U.S. firms wishing to export high-precision equipment to Europe.

Satellite subscribers challenge cable claims

Advertisements abound—in programming guides and newspaper entertainment pages and on TV—that claim to offer exclusive viewing of choice shows to cable subscribers. In reality, that same programming is almost always available to satellite-dish owners (usually for a subscription fee) as well. Those misleading ads are being challenged by the Empire State Dealers Association in conjunction with K-SAT, the satellite-dish owners' consumer advocacy/lobbyist group.

The New York State dealers' organization and Gilroy, CA-based K-SAT have served C-SPAN (the Cable Satellite Public Affairs Network) with a formal "Cease and Desist" notice, with the intention to sue. They consider C-SPAN's advertisements, which include the statements "Exclusively on Cable" and "Only on Cable," to be part of a deliberate "nationwide push by Cable MSO's (multiple systems operators) and their programmers to misinform the public as to the alternatives to cable." Chuck Dawson of K-SAT expects that the challenge will result in an antitrust lawsuit.

K-SAT is also sponsoring "The Cable Subscriber Bill Of Rights;" encouraging dish owners and cable subscribers to withhold payment of their April cable bills for 30 days; and deluging legislators with visits, letters, and phone calls.

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**More LCD projectors.** Eastman Kodak is the brand name on the first projection-TV system to use three LCD's for light valves, using no cathode ray tubes (Radio-Electronics, November 1988). The Kodak unit, which sells to the industrial and commercial market for $3,500, is made by Seiko in Japan. It has resolution of 70,400 pixels, and uses a 300-watt projection bulb as a light source. It's capable of projecting a picture up to 12 feet wide. The unit is focusable, uses only single-lens assembly, and is small enough to fit under an airplane seat. It's designed to project both video and computer graphics, and has digital and analog RGB inputs as well as composite video.

Next fall, Kodak's LCD projector will be joined on the market by a consumer model that is built by Sharp. As we last saw this unit, it had a picture of 92,160 pixels—more detailed than the Seiko/Kodak model, but still a relatively coarse image. At the Japan Electronics Show, Toshiba and Sanyo also showed developmental LCD TV projectors, but supplied no information on availability dates.

An American-developed three-LCD projector is now being demonstrated to potential manufacturers by a New York company called Projectavision.

Eugene Dolgoff, Projectavision's president and the inventor of the unit, has filed a suit against Eastman Kodak and Seiko Epson, claiming that they violated a non-disclosure agreement and are using his projector's principles. Kodak and Seiko deny the charges. Dolgoff hopes to interest American companies in manufacturing his projector.

A completely different kind of projector will be marketed here by Panasonic as an accessory to its combination portable VCR and LCD TV. The projector uses a mirror-and-lens assembly to enlarge the 3-inch LCD picture to about 25-inch size on an external screen in a darkened room.

Meanwhile, direct-view LCD panels are getting larger. At the Japan show, Epson showed (but didn't demonstrate) prototypes of three large sizes—5.3-inch with 160,892-pixel resolution, 7-inch with 460,800 pixels, and 10-inch with 768,000 pixels. Sharp demonstrated a working model of a 14-inch panel with 308,160-pixel resolution.

**Working together on HDTV.** Seventeen companies—only one of them currently involved in television-receiver manufacturing—have agreed to study the possibility of setting up a consortium, presumably with government support, to conduct R&D on high-definition TV receivers. Formed under the aegis of the Silicon Valley-based American Electronics Association, the group includes some of the largest electronics firms in the U.S., such as AT&T, IBM, Hewlett-Packard, Motorola, ITT, Apple, and Zenith. In announcing the project, the firms stressed that they haven't yet decided whether such a plan is practical. The group's stated purpose is to decide whether to set up at least one for-profit partnership "to capture or assist in the capture of a majority of the hardware markets associated with an anticipated U.S. HDTV business." Except for Zenith, none of the firms involved have made any effort to enter the TV-hardware business on their own; Motorola and ITT have previously been in the TV-receiver business and sold out to foreign interests.

The study comes at a time when Congress and the Commerce and Defense Departments have expressed strong interest in domestic HDTV manufacture as a means of reviving American technological leadership and increasing consumption of American semiconductors. The Department of Defense is prepared to invest up to about $30 million to subsidize R&D leading to an efficient, low-cost, high-definition video monitor or receiver. The Defense Advanced Research Projects Agency (DARPA) says that it needs the display for applications in command, control, battle management, training, simulation, and other areas, and that using a system that also has mass-market television uses would save money for the government. Zenith has submitted a proposal for a Pentagon grant to develop its Flat Tension Mask (FTM) computer-display tube into a display for high-definition video systems.
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FLASHING LED's

I've been trying to build a sequential LED flasher using 4017's, but I haven't had much luck. Could you show me how to cascade two more of those devices? Any help would be appreciated.—K. Gordon Knoxville, TN.

The CMOS 4017 is a one-of-ten decoder that's a perfect choice any time you want to build something using sequencing logic. If you only need ten outputs, all you have to do to use the IC is pay attention to the pins, plug in the peripherals, and power up the part. Things get a bit more complicated when you want to increase the count beyond ten because the 4017 wasn't designed with that application in mind. That doesn't mean that you can't do it. It just means you have to think about how to do it.

There are two ways to cascade the 4017. You can use them as decade counters (the job they were intended for), or you can have them do sequential counting (a job they weren't intended for). For decade counting, all you have to do is use the CARRY output (pin 12) of one 4017 as the clock input of the following 4017—that's what CARRY is designed for. A simple implementation of that is shown in Fig. 1, and the same idea can be used to extend the count as far as you need. The first 4017 counts the units, the second the tens, the third the hundreds...but I think you get the idea.

Sequential counting with the 4017 is completely different and it's complicated by the fact that there's no way to turn off all the outputs. The basic idea is to drive all the 4017's with a common clock and then have their outputs go high one after the other. In the ideal circuit, the first 4017 would respond to the first ten clock pulses, the second would handle the second ten, and so on. The seventeenth clock pulse, for example, would light the seventh LED on the second 4017.

The only two control pins on the 4017 are RESET and ENABLE, and even though they're the major players in designing the circuit, you can't
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get around the fact that no amount of logical glue is going to turn off all of the 4017 outputs. The only way to make that happen is to cut the power to the IC. That isn’t as silly as it sounds, because the 4017, being a CMOS part, draws so little power that its +V input (pin 16) can be driven by a transistor. The transistor switch, in turn, can be toggled by the logic controlling the 4017’s.

A simpler way to handle the problem is shown in Fig. 2. Three 4017’s are used to provide 25 sequential outputs. There isn’t room here to go through all the logic but you should draw up a truth table on your own to make sure that you understand how it works. Notice that the lack of a way to turn off the LED’s has caused the loss of one output on the first 4017 and two outputs on the others.

If you use that circuit, be sure to pulse the reset line when you power up, because the 4017 usually has an illegal (and silly) state at its outputs when you first turn it on. If you want to work out some way to use all the outputs, try the transistor-switch approach I mentioned earlier.

TOUCH SWITCH
I’m building a touch switch and I need a way to build a bistable using two op-amps in an LM324. Have you got a simple circuit that I can use?—A. Askey, St. College, PA

Just so that we all know what we’re talking about here, I’m assuming that when you say “bistable” you mean an RS flip-flop. If that’s the case, the easiest way to do the job would be to use a digital flip-flop and be done with it. The circuit would be a lot simpler, much more immune to noise, and you’d be using an IC that’s specifically designed with that in mind.

But I suspect that you’re using half of the 324 for the touch-switch oscillator and you want to keep the parts-count down by using the rest of the IC for the flip-flop. If that’s the case you’re on the right track, since minimizing the parts count is a good thing. If, on the other hand, that’s the only job you want to do with the 324, it makes a lot more sense to use a TTL or CMOS flip-flop—believe it.

Now that we understand each other, the answer is: Yes, it’s not hard to build an astable around a 324. You may have two op-amps available in the IC, but if you take a look at Fig. 3, you’ll see that you only need one to get the job done.

A high pulse on the set input will drive the output high and it will stay that way because the resistor in the feedback loop, R4, causes the op-amp to latch up. If you put a positive pulse on the reset input, the output will drop very close to ground. How close to ground depends on the characteristics of the particular op-amp, but it will easily be within a couple of millivolts of ground level.

R-E

GORDON McCOMB
Canoga Park, CA

MONEY-MAKING TIPS
I contacted Marcie Swampfelder about the mass-transference transmitter and receiver that appeared in “Hardware Hacker” (Radio-Electronics, April 1989). At first, I was skeptical, but it really does work as advertised. The only problem is that it is not quite economical to run in an attended mode. You can get a dollar out for every quarter you put in, but it takes slightly more than 12 minutes. Frankly, I can make better money picking rags at the dump.

So, I got a Heathkit Robotics Experimenter set, which I eventually programmed to take a quarter from a stack and put it in the transmitter unit. I tried mounting the receiving units on a slanted board, but found that the quarters would slip out before they were fully
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TOROIDAL TROUBLE

For those of you who built the high-power audio amplifier (Radio-Electronics, March 1989), you may have had some trouble getting the 12-volt DC power supply working if you tried to wind the toroidal transformer yourself. On page 53 the article stated that the turns ratio between the secondary and the primary was 5-to-1. It also stated on page 55 that the secondary was 19 turns center-tapped, and that the primary was 14 turns center-tapped. That, as you can see, is not a 5-to-1 ratio.

As it turns out, the specifications given for the transformer were mostly incorrect. To start with, the core should be part formed. I had to build a gate, operated by a solenoid, to keep them in.

It works, but I'm still not satisfied with it. I learned the hard way that you have to be very exact in timing the robotic arm. One day I woke up to find that the transmitter unit had energized while the tip of one of the robot's fingers was still in it. Naturally, the robot picked up the fingertip from one of the receivers and stuck it back into the transmitter, so I ended up with a pile of fingertips and no quarters.

Has anyone come up with a patch to get those units to run on the GS?

GARETH TUCKER
Deep River, CT

ATARI FAN

I want to express my gratitude to you for publishing the story on the Atari ST in February's ComputerDigest section. As a 520 ST owner, I have never understood why that powerful, fast, and inexpensive computer hasn't become the home computer of choice in the United States (as it seemingly has in Europe). Indeed, it can emulate the Macintosh (at full speed and with improved graphics) or the PC, but it has so many features of its own that it is nice to use in and of itself. Additionally, software for the ST is plentiful and generally less expensive.

I hope to see more coverage of that versatile machine in future issues of Radio-Electronics.

PETER BARNES
Winchester, MA

DOT'S WHAT'S MISSING

Who would believe it? You know those little dots on our schematics that indicate whether or not there is a connection between two intersecting lines? Well, it seems that one of those dots decided to pack it in early, leaving Fig. 1 of the Alpha/Meditation Goggle story (Radio-Electronics, April 1989) with a definite dot deficiency.

The missing dot belongs at the intersection of R3, C2, and pins 2 and 6 of IC1. We have reprinted a portion of the original schematic, along with the correction, in Fig. 1 above.—Editor

R-E

Fig. 1

NOTE: SW2 and C4 are optional.
EQUIPMENT REPORTS

Lynx 470 Disk Drive Tester and Exerciser

Who says you can’t service floppy-disk drives?

CIRCLE 28 ON FREE INFORMATION CARD

Most computer-repair service calls consist of removing one board and replacing it with another. Even disk-drive problems are “solved” by replacing the drive. Whether the drive problems show up as read errors, write errors, or seek errors, they’re usually caused by improper alignment. By some estimates, up to 90% of all drive problems are caused by misalignment!

We’ve recently found equipment that will allow a service center to reduce its inventory of drives and at the same time cut down on inexpensive, inefficient round trips between your customers and your service depot: the Lynx 470 from Lynx Technology (1241 Dension Street, Markham, Ontario, Canada L3R 4B4; distributed in the U.S. by HMC, P.O. Box 526, Canton, MA 02021). The 470 allows you to solve most disk-drive problems on-site. A floppy-disk drive can be aligned in minutes!

The 470 will work with all 3½-, 5¼-, and 8-inch drives, although adapters are required for some, such as the Commodore 1541. The tester is designed to be used with standard alignment disks; it digitizes the analog signal from the alignment disk so that an oscilloscope is unnecessary.

The tester doesn’t need its own power supply—it gets its power from the drive under test. When the tester is used, it takes complete control of the drive, taking the place of the disk controller.

Some 25 rocker switches let you control the tester’s various functions, and 39 high-intensity LED’s report on the status of the tester and the results of various tests. continued on page 32

Mark-V SM-333 Surround Sound Processor

Bring movie-theater sound to your living room!

The VCR brought feature films and convenient viewing times into American homes more than a decade ago. Stereo TV, introduced only six years ago, brought a greater realization of how a sound track can enhance the TV viewing experience. Although surround-sound processors have been available for several years, they have yet to catch on to any great extent. We think, however, that once people learn about them, family rooms across the country will be converted into home movie theaters with surround-sound processors like the SM-333 from Mark-V Electronics (8019 E. Slauson Avenue, Montebello, CA 90640).

If you’re not convinced that surround sound adds much to the viewing experience, try to remember the last time you watched a movie you had previously seen at a theater equipped with Dolby Surround. Star Wars just wasn’t the same, was it? It’s not just the smaller screen and aspect ratio that gives movies on TV that small feeling—it’s small sound, too.

The SM-333 can expand your enjoyment of watching TV by expanding the depth of the accompanying sound. Although interesting effects can be produced even with monaural inputs, true surround sound requires stereo inputs from sources encoded with Dolby-Surround.

Most tapes that you rent at your local video store are recorded in stereo and include Dolby Surround encoding. If an encoded movie is broadcast by a TV station in stereo, you can also decode the surround channel if you have an MTS stereo decoder as well as a surround-sound processor.

Hooking it up

Provisions for three sets of line-level stereo inputs are included on the SM-333. Two sets of stereo outputs are provided for connection to front and rear amplifiers. The signals for the front channels are fed straight through a unity-gain amplifier to the output, unless DNR (Dynamic Noise Reduction) 

continued on page 32

May 1989
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NEW PRODUCTS

SOLDERING GUN. A new cordless soldering gun, the Z-50 from Zimac Laboratories, Inc, is built to stand up to the rigors of industrial use, and features a recharging holster and a unique tip (shown below). The most significant feature of the Zimac gun is its quick heating time, thanks to its boron carbide heating element. Its rapid cycling time is helped by the placement of its temperature sensor right at the tip.

If you’ve had experience with battery-operated or butane-fueled soldering irons in the past, you might not believe that portable soldering irons are much of a convenience. However, we’ve had an early version of the Z-50 on hand for more than half a year, and have found it to work flawlessly. We found it to be perfect for field service. (Repairing a car stereo was possible without even removing the stereo unit from the car!)

The heat capacity of the gun is also impressive. We have tried soldering large-gauge wires (No. 4 and No. 6) with success.

For the hobbyist, the Zimac gun removes the temptation not to solder a joint because of the normal inconvenience. It makes it possible to make connections that were previously difficult or impossible—for example, a connector up on an antenna tower.

The Z-50 has a suggested retail price in the U.S. of $69.95.—Zimac Laboratories, Inc., Ballard Mill, S. Williams St., Malone, NY 12953.

TV/VCR COMBINATION. Casio’s VF-3100 pairs a UHF/VHF TV set with a VCR that plays standard VHS tapes and can record in either standard or extended mode. The high-resolution TV set features a 3.3-inch screen. Designed for portability, the compact unit measures just 10 2/8 x 7 1/2 x 4 inches, weighs only 6.6 pounds, and can run off a battery pack, household current, or, used with optional adaptors, a car battery.

AMPLIFIED SPEAKER. Designed specifically for use with handheld radios, Naval Electronics’ HTS-1 is a compact speaker with a 10-dB internal amplifier. It can run on batteries or through a DC jack on 6–15 volts DC, and even has built-in NiCd battery charger. The HTS-1 also features automatic shut-off, which conserves batteries by killing power to the amplifier when there is no audio input. When it is switched off manually, the amp is...
RECORDED ACTIVATOR. The Nitelogger allows unattended, professional-quality recording of transmissions received on any scanner radio or other receiver, by providing connection to a standard cassette-tape recorder. The receiver must have a remote-speaker jack and the recorder must have remote-microphone capability. All necessary connector cables are included.

The Nitelogger lets the user listen during recording, and a built-in volume control adjusts the loudness independent of recording levels. For silent recording, the speaker can be turned all the way down. A VOX-level lamp lights when the incoming audio is sufficient for proper operation. To conserve tape, the unit's variable dropout-delay control can be used to determine how long the recorder should run after a transmission has ended.

The Nitelogger scanner-recorder activator costs less than $70.00.—Benjamin Michael Industries, Inc., 1139 East Tower Road, Schaumburg, IL 60173; 312-884-7077.

SCIENTIFIC CALCULATOR. The TI-68—targeted at college students and professionals in the fields of mathematics, science, and engineering—performs 254 functions, including 40 complex-number functions. The calculator solves up to 5 simultaneous equations and has powerful formula-programming capabilities. For ease of use, it features plain-Eng.
English prompting, an alpha display, simple programming of formulas, and straightforward number entry for complex numbers.

The TI-68 also offers last-equation recall; up to 36 memory registers; one- and two-variable statistical functions; decimal, hexadecimal, octal, and binary numbers; number-base and 18 other conversions; and Boolean logic operations. It comes with a 184-page guidebook and a quick-reference card that provides a convenient function summary. A sliding case protects the calculator from damage.

The TI-68 advanced scientific calculator has a suggested retail price of $65.00. — Texas Instruments, Consumer Relations, P.O. Box 53, Lubbock, TX 79408; 806-747-1882.

VOLTAGE-SURGE SUPPRESSOR. Perma Power’s PTC-209 “Cable-Line” protects electronic equipment from transient voltage surges on television cables or receiving antennas, as well as on the AC power line. It can be used on antenna wire or satellite lead-in wires to safeguard television sets, VCR’s, cable converters, satellite receivers, and stereo equipment— with no significant loss of picture signal. The PTC-209, which features gold-plated connectors, won’t cause a snowy picture quality, or loss of picture, even in the UHF frequencies.

The 3½ x 4¾ x 2¾-inch unit plugs into any grounding-type outlet, and features an automatic-shutdown feature that disconnects...
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the power line if the suppressor circuit should fail (although it is designed to have a virtually unlimited lifetime, even when subjected to frequent or high surges). It is rated at 1800 watts, with a let-through voltage of less than 2 volts.

The PTC-209 Cable-Line surge protector costs $59.90.—Perma Power Electronics, Inc., 5601 W. Howard Avenue, Chicago, IL 60648.

HOME-SECURITY SYSTEM. Heath Zenith's SS-6100 is an affordable wireless system that is fully expandable. Dubbed a “supervised” system, it regularly performs self-checks to verify that all components are functioning properly, and it programs its own unique security codes.

The SS-6100 includes a control center, a lamp module, a door/window sensor, and a remote control that arms and disarms the loud alarm in the control center. The control center also has LED’s that indicate in which area the disturbance is occurring, and battery back-up for continued protection in the event of a power failure.

Designed to be easily installed by the user, the system can be expanded to as many as 16 zones of coverage. Available accessories include: additional lamp modules, command units, door/window sensors, a remote siren/dialer connection, an automatic dialer, motion sensors, and lastly a remote dimmer/controller.

The SS-6100 wireless, supervised home-protection system has a suggested retail price of $99.95.—Heath/Zenith, Consumer Products Group, Hilltop Road, St. Joseph, MI 49085.

ROUND-CABLE CUTTER. Paladin's PA 1818 cuts large-scale and multiple cables, up to 750-MCM copper, 1000-MCM aluminum, or 300 pair of copper. Its small size and ergonomic design allow easy one-handed cutting.

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MICROPHONE/MIXER. With Ambico's Model V-0628 "Mike &
Mixer, you can add a rich soundtrack to any video. It accepts 4 inputs, providing full control over the relative volume of each; a master volume control adjusts the overall volume level of the four inputs. All four sources can be played simultaneously, or you can fade in and out between them. The dynamic microphone (which requires no batteries) plugs into one of the inputs, making it easy to add narration.

The model V-0628 Mike & Mixer has a suggested retail price of $49.95.—Ambico, Inc., 50 Maple Street, Norwood, NJ 07648.

SPEECH DIGITIZER. The Speech Thing from Covox is an inexpensive hardware device that allows IBM educational talking software, and other brands of speech-coded software, to operate without a plug-in speech board. The device, which resembles a gender changer, attaches externally at the parallel-printer port and does not affect printer functions. It works with all IBM PC's and compatibles, including laptops. All digitized or synthesized speech and sounds from software sound files are converted to analog format for high-fidelity output. The Speech Thing package includes a speaker with volume control, demo software, and instructions.

Also available from Covox is the Voice Master PC digitizer with voice recognition (not pictured here). The hardware/software development system, which requires MS-DOS 2.1 or greater, 256K RAM, and the Speech Thing for audio playback, provides digital recording of speech, sound, and music, and offers full graphic editing ca-
pabilities. Designed for both experimenters and software writers, it can be used for spoken advisories in business software; instrumentation, language, and other educational training; electronic voice store and forwarding; artificial intelligence applications; and to program ROM's for stand-alone talking robots or toys.

The **Voice Master** hardware comprises a short plug-in board (with external ports for microphone and line-level inputs) that contains a pre-amp and an 8-bit A/D converter. A high-gain, flat-response electret microphone is also included. Speech-recording software includes a graphics-based editor for cutting and pasting of the sound waveform and a real-time digital oscilloscope for viewing the incoming waveform. Results can be saved to disk and linked, to form disk sound files for use with user-written programs. Speech recognition software is also included; the system can recognize 64 user-trained words or phrases.

The **Speech Thing** costs $49.95; the **Voice Master** costs $89.95.—**Covox** Inc., 675 Conger St., Eugene, OR 97402.

**SCOPE CART.** The model 997 scope cart from Kikusui has a compact design, yet is large enough to move an entire test or engineering station. Weighing 74 pounds and measuring just 17.3-inches wide by 21.65-inches deep, the cart has three shelves that can support a combined weight of 77 pounds of equipment.

The top shelf is tiltable, and has trigger-action tilt locks and probe holders.

The 997 oscilloscope cart also features swivel wheel locks, a rugged 14-gauge steel frame, and seam welding for extra rigidity and strength.

The model 997 scope cart costs $795.00.—**Kikusui International Corporation**, 19601 Mariner Avenue, Torrance, CA 90503.
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Four drive select switches let you test drives without changing their configurations. A head load switch loads the head, bringing it into contact with the disk surface, while a head select control lets you choose which head (on two-head drives) is controlled. The enable switch is used to turn on drive motors on some drives.

Eight track address select switches and their associated LED's select and indicate the track where the head is. They can be used in combination with other controls. For example, the step control lets you move the head at one of two speeds, to the track selected by them. The seek TRK 0 switch can be used to step indefinitely back and forth between track 0 and the track selected by the track address select switches.

Other switches include data, which allows one of two patterns to be written to disk, and speed, which is used to select the proper rotational speed. The manual contains various troubleshooting charts and operational flow charts to speed the learning process.

The Lynx 470 is packaged in an extremely rugged 16-gauge two-piece steel cabinet that folds to a compact 8 1/2 x 6 1/2 x 2 inches. It weighs about 4 1/4 pounds.

At $1400, the Lynx 470 disk drive alignment tester should be attractive to anyone who routinely services computers and wants to cut down on the time and expense of drive servicing.
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Lock on business desktops and you’ll find a personal computer or workstation. And right next to it, there’s another business information-processing computer—a telephone.

Remember when a telephone was a few relays, a big mechanical bell, a rotary dial, and a microphone and speaker? Today, office telephones are called station sets; they are computers that also happen to be telephones. They have information displays, keyboards, and so many other features, that a telephone call is no longer just talking—it’s digital signal processing.

Introducing the Milicom Prototyping Telephone. With it, you can explore the ways that modern telephone equipment does more than just transmit and receive voices. You’ll be experimenting with the fundamentals of Integrated Services Digital Network (ISDN) technology.

The prototyping telephone is an electronic, programmable development platform that operates as a TE1, which is an ISDN-compatible piece of telephone equipment. The prototyping telephone makes it easy to experiment with DTMF (Dual-Tone Multi Frequency) encoding and decoding, call-progress information, audio processing for the microphone and speaker, and also shows how TE1’s operate in the ISDN environment. Even if you don’t have ISDN service available, you’ll be able to develop ISDN-like features, and be ready as soon as ISDN hits your area.

The prototyping telephone that we’ll describe is a single board...
that is designed as an add-on for a Telenova station set. The Telenova station set—which you may have seen on Miami Vice, Moonlighting, or the movie Scrooged—is a telephone that is designed exclusively for use on Telenova and Wang PBX’s or PABX’s. It features a 2-line by 40-character display, keys for telephone functions, and live "soft keys" whose functions are determined by software running in the phone.

The Telenova station set is controlled by an Intel 8085 microprocessor with 64K of memory. The processor controls the display, keyboard, and other functions. Installing the prototyping-telephone circuit board and new software in the station set adds several features to it: a serial/parallel interface for connection to a personal computer and a printer, a complete analog telephone on a chip, DTMF encoding and decoding, call-progress monitoring, and, of course, the components that make it a TEI.

It is possible to connect the prototyping telephone circuit board directly to a computer and control it through a parallel printer port. In fact, we’ll show how that is done next month. Now, however, we’ll assume that the kit board will be assembled inside a Telenova station set. The prototyping board connects to the motherboard inside the Telenova station set via a 50-pin connector, and its components are addressable by the station set’s 8085. The kit comes with complete assembly instructions, user manual with experiments, and trouble-shooting guide.

There are only three jumpers that have to be installed between the motherboard and the kit board. The kit board mounts perfectly inside the Telenova station set, it can also be externally mounted and connected to the processor via a ribbon cable.

**Why process phone calls?**

Whether the prototyping telephone is then connected to tip-and-ring, the Telenova digital switch, or an ISDN interface, the incoming and outgoing telephone functions are all available for processing by the user.

Outbound calls should be processed for a number of reasons. Why should you have to listen to ten rings or perhaps a busy signal, when you can let the computer do that? You can have your PC ring a number every few minutes and report on the number’s disposition. You don’t even have to pick up the phone if all you want to do is send a FAX or some electronic mail. You can easily find out how much time you spend talking, and how much time you spend listening.

There are many reasons why in—

![FIG. 1—THE TIP-AND-RING SECTION is the physical interface between the prototyping telephone and an actual phone line. The LB1009AE provides a complete analog telephone on a chip.

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bound calls should be processed, too. Before being interrupted by a ringing telephone, why not have the computer first tell you who’s calling? Many PBX systems have a “do not disturb” mode. With the prototyping telephone and a computer, you can create your own “do not disturb” mode. You’ll be able to tell the machine what incoming numbers to put through, and like many voice-mail systems, a caller can communicate with your phone by pressing numbers instead of talking. You can leave the office, come back two hours later, and look at a list of inbound calls you missed instead of looking through a batch of while-you-were-out slips. Then you can tag the calls you want to return, sort them, and have the computer make the calls for you. Of course all of these features require software. We’ll give examples of features for which the Millcom kit can be programmed, and we’ll also post a few on the RE-BBS (516 293-2283) to get you started. But the real fun comes when you develop new applications that were previously impossible.

FIG. 2—THE MAX232 IS USED to transmit and receive RS-232-C signals. An 8256 MUART provides serial/parallel communications with the outside world.

FIG. 3—THE AM79C30A PROVIDES THE TELENCOVA telephone with TE1 abilities. It is basically the “ISDN microprocessor,” keeping track of all ISDN functions.
The AT&T phone itself face shown Millcom prototyping telephone. Technology being used here, terminal access, and D
face, the controller provides AM79C30A prototyping telephone, en AM79C30A functions.

processor,” basically digital subscriber controller. An SSI
is, subscriber telecommunications which provides your telephone when making busy signals and processes
processed 18 phone

The SSI
is, subscriber
an ISDN device. The SSI 202P
is, an 18-pin IC used to receive DTMF signals (Touch Tones) so that they can be processed as numbers. An SSI 980 processes call-progress data, such as busy signals and the ring back (the ring that you hear in the earpiece of your telephone when making a call).

Figure 2 contains an 8256 UART which provides serial/parallel communications with the outside world. A MAX232 is used to convert the 5-volt serial data inside the phone to 12-volt levels used by RS-232, and vice versa.

Subscriber controller.

Figure 3 contains the device that provides the prototyping telephone with TEI abilities—that is, it makes it
an ISDN device. The AM79C30A digital subscriber controller is basically the “ISDN microprocessor,” keeping track of all ISDN functions.

The block diagram of the AM79C30A is shown in Fig. 4. Driven by the 8085 microprocessor in the prototyping telephone, the AM79C30A digital subscriber controller provides 2B + D channel interface, the “S” reference transceiver, D-channel processing with multiple terminal access, and an audio processor. (If you are unsure of the terminology being used here, don’t worry—we will discuss it in greater detail later on.) It communicates with the companion processor via interrupts and is programmed by reading from and writing to internal registers.

The Line Interface Unit (LIU) connects the AM79C30A to the outside world ISDN “S” reference point. Remember, “S” reference data is digital. Also, some framing and error checking is done in the LIU.

The Multiplexer section (MUX) transfers the data from the LIU to the main audio-processing section (MAP), the interface to the companion microprocessor (MPI), or a serial port.

In the Main Audio Processor (MAP) section, digital-to-analog conversion is done, and tones are generated for DTMF, the alerter, ringback, dial tone, and the busy signal. There are two attenuation/distortion

FIG. 5—the major digital signals from the mother board of the Telenova are brought to the components on the Millcom kit board by J1, and the remaining signals are supplied by J9.
filters, one gain filter in the transmit path, and two gain filters in the receive path, as well as the audio-input ports and the loudspeaker and earpiece drivers.

The Data Link Controller (DLC) handles the layer-1 and partial layer-2 LAPD (Link Access Protocol for the D-channel) processing. Control packets are assembled and received, and some address recognition takes place in the DLC.

The processes inside the AM79C30A are complex, and Advanced Micro Devices' publication 09893 describes them in great detail. However, in a simple fashion, let's follow a bunch of bits to and from the 4-wire ISDN "S" reference point through the AM79C30A for a point-to-point TEL.

Incoming and outgoing bits are grouped into frames of 48 bits. The LIU checks those frames for errors and establishes a synchronization. The LIU determines if the bits from the "S" reference are B-channel data or D-channel data and directs them accordingly. If those bits are D-channel data, the LIU multiplexes the data, which then goes to the DLC. B-channel data would go to the MUX.

In the DLC, more error checking takes place, and rudimentary address recognition is done. D-channel packets are buffered and made available to the companion processor, which further processes the addresses and the packets, decides what to do, then fills the D-channel transmit buffer and the DLC sends the data back to the LIU and out to the "S" reference.

If the LIU found B-channel data, it would give the data to the MUX. The MUX would forward the data for audio processing in the MAP, information processing in the MPI, or to a serial RAM port. In the MAP, telephone signals such as dial tone and DTMF can be prepared and transmitted, or the alerter can be set off. If the B-channel data is voice, then the MAP filters can be modified to provide different loudness and tone for transmit, receive, and sidetone.

While the B-channel is transmitting and receiving the voice data, the D-channel is still busy checking, signaling, framing, multiplexing, addressing, and assembling packets.

While most of the work is done by the Digital Subscriber Controller, a companion processor like the 8085 in the prototyping-telephone kit has to eventually manage the information to make something happen.

I/O and power

As seen in Fig. 4, the major digital signals from the mother board of the Telenova station set are brought to the components on the Millicom kit board by J1, and the remaining signals are supplied by J9. A +5-volt supply is brought out on J9 for external use. A 117-volt AC power adapter is included with the kit, which must be connected to J11. J11 supplies the main power to BR1, which is used for rectification and prevention of polarity reversal. DC power may be supplied directly so that 9 volts appears across the plus and minus terminals of BR1. The signals "ALE" and "READY" must be tapped off the Telenova's 8505 microprocessor, and brought to J9. The -3 volts is also brought out on J9, which must be wired to the display.

For programming, the I/O addresses for the devices on the prototyping telephone are shown in Table 1. Additional access is required during the access of the AM79C30A's internal registers. Therefore, IC2, shown in Fig. 6, is required to insert one wait state during those accesses.

Construction

A Parts-Placement diagram is shown in Fig. 7, (which, unfortunately, will appear in next month's issue) and the foil patterns for the
double-sided PC board are provided in PC Service for those who wish to make their own board. Note that the following instructions apply only if you are installing the Millcom board inside the Telenova station set. Also note that you will need a regular Touch Tone telephone and an active phone line for testing, and that we will refer to the Touch Tone telephone as a plain old "phone."

To start with, the tip-and-ring interface section must be installed and tested. (Test fit all parts before soldering, and observe component polarity wherever necessary.) Solder R4, C14, RY1, T3, and TR1 to the PC board. Then carefully clip the red and green wires that come from the Telenova's RJ11C connector (tip and ring) close to the PC board, and solder them to their new locations on the Millcom PC board (the tip and ring pads are marked on the upper-right hand side of the Parts-Placement diagram.

Connect a "T" adapter to your existing telephone line so that the prototyping telephone can be connected in parallel. Pick up the handset of the phone, and while listening to the dial tone, plug the prototyping telephone into the T-adapter. You should hear no distinct change in the dial tone's volume because the 600-ohm bridge has not yet been installed across the line. Troubleshooting is required if the dial tone is lost completely.

Solder Q1, D1, D2, LED1, and R3 to the PC board. Using an ohmmeter, check the resistance between the +5-volt trace and ground. Reverse the leads and repeat. If either reading is less than 1 megohm, troubleshooting is required.

Solder in IC11, D1, C10-C13, BR1, and J11. Check for at least 10 kilohms between the +5-volt trace and ground. Apply +9-volts DC to J11 and check for a regulated +5-volts DC and -3-volts DC. (A 9-volt battery can be used for this test.) Wire a temporary hookswitch; a switch in series with a 1K resistor. Apply +5 volts to the base of Q1; the relay should energize and the offhook LED should light. Repeat the test with the prototyping telephone connected in parallel (plugged into the "T" adapter). Listen for a dial tone on the regular phone, and then force the prototyping telephone offhook again. The volume of the dial tone should decrease slightly as the relay is energized, and the LED should be on. No unusual sounds should be present on the phone. Break the dial tone by dialing any digit, and, again, listen for any unusual noise. Cycle the relay several times while listening for any noise on the phone. Troubleshooting is required if any noise is heard.

If everything's alright so far, dial your local time-and-temperature number on the phone and note the quality of the reception. Your configuration may require a 150- to 500-ohm series resistor, R, shown in Fig. 1. (If you can't break dial tone, troubleshooting is required.) If you have another Touch Tone phone around, repeat the test using that phone. Leave the prototyping telephone connected to the "T" adapter, off hook.

If the audio is acceptable, hang up the phone, wait 5 seconds, and then pick it up again and listen. If the time-and-temperature recording is still audible, the 600-ohm transformer (T3) is properly bridging tip and ring. Disconnect the prototyping telephone from the "T" adapter.

Next month, we'll present the parts-placement diagram, finish construction, and get on to exploring applications for ISDN.

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**FIG. 6—IC2 PROVIDES THE ADDITIONAL ACCESS TIME required during the access of the AM79C30A's internal registers by inserting one wait state during those accesses.**
REMOTE CONTROL

WHILE THE NUMBER OF FAMILIES THAT have two VCR's in their home is steadily increasing, owning two VCR's is still considered an expensive luxury for most. But now you can get the benefits of having two VCR's for a fraction of the cost with our VCR extender. Our easy-to-build device will let you watch your VCR from any room in your home and still maintain full remote-control capabilities. And the extender is not limited only to VCR's—it will relay any IR-transmitted signal. So even if you have an old manually controlled TV in your bedroom, you'll be able to use all the remote-control features of the VCR in your living room!

The extender mounts next to your TV set and can be operated via your

IR remote control from a distance of 20–30 feet depending on ambient light conditions. The unit uses inexpensive, easy-to-get parts, and does not require RFI or IR shielding. Also, several extenders can be connected in parallel, so that you can extend your VCR to as many locations as you like.

Using the extender unit, remote-control signals can be sent to the VCR via the existing coaxial cable (if you have cable television), as shown in Fig. 1, or by using ordinary two-conductor speaker wire or zip cord. The latter will eliminate the need for the two additional filters that are required for the coaxial-cable system but, of course, will require two lines—one for the out-going IR signals, and a second for the returning video or RF.

Circuitry

Refer to the schematic in Fig. 2 for the description of the basic circuit. A signal from an IR remote control enters phototransistor Q1, where it is converted from IR radiation to a frequency pulse and then passed to decoupling-capacitor C1. Resistor R1 keeps Q1 from saturating too quickly from visible light. Because the IR signals from a remote control are not that strong, Q1 is kept constantly conducting, via IR-LED2, which was added to increase the range during extreme low-light conditions. IR-LED2 is positioned directly behind Q1 and aimed at the base, where it emits a small amount of IR radiation, ensuring that Q1 will continue to conduct without IR or visible light.

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The signal from C1 is amplified by a factor of 1000 by IC1, with gain set by R2 and R3. It is then passed to D1, a 5.1-volt Zener diode, which is used as a voltage shifter. The anode stays low until the input voltage at pin 2 of IC1 rises higher than the reference voltage at pin 3, which is set by R4. When that happens, the output of IC1 goes high and avalanches D1, producing a voltage rise at the anode along with the signal. The signal is then passed to IC2 where it is amplified by a factor of 10. Pin 3 of IC2 is tied to ground. That allows any signal higher than ground to be amplified and sent to pin 5 of IC3 via pull-up resistor R8. IC3 is a comparator, in which the output goes high when the reference voltage at pin 4 (set via R9) is exceeded by the smallest amount.

IC1 and IC2 are independent 741 op-amps. Separate op-amps were used because IC1 is referenced at pin 3 while IC2 is tied to the ground rail at pin 3. Dual or quad op-amps share a common bias network and power-supply leads—that produces noise at the reference point, so very small signals could not be detected. But by using two independent op-amps, the noise level is reduced and the circuit sensitivity is increased.

The output of IC3 (pin 2) is pulled up by R10 and sent through R11 to the base of Q2, which then passes the signal to IR-LED1 at the VCR by one of two methods. The first method passes the signal directly to IR-LED1 via a suitable length of two-conductor speaker wire or zip cord. The second method passes the signal, via a high-pass filter, right onto the existing coaxial TV cable, to IR-LED1 at the other end. R12 sets the maximum current through IR-LED1, which re-transmits the IR signal to the receiving unit’s (the VCR, stereo receiver, etc.) IR window.

The components enclosed in the dashed lines in Fig. 2 are optional. That circuit causes an LED to flash on and off rapidly when the IR-extender circuit is activated by a signal from an IR remote control. The circuit is useful in that LED3 will only flash if a signal is being received from a remote control—that way you know if the IR signal is reaching the extender. The circuit works as follows: When the signal from pin 6 of IC2 exceeds the reference voltage set by R9, the output of IC3 causes Q3 to conduct, driving LED3. That can be either a red or green non-IR LED, and R15 sets its current (brightness level).

**Construction**

A foil pattern is provided in PC Service, and is available separately. (See Parts List.) If you wish to hardwire the circuit, place the external components as close together as possible to keep stray capacitance to a minimum.

The Parts-Placement diagram is shown in Fig. 3. Be sure that pin 1 on all three IC’s faces Q1, and mount Q1 with enough lead length (approximately ¼-inch) so that it will be able to protrude through a hole in the project box. The flat side of Q1 (the collector) is connected to +9-volts DC. Mount IR-LED2 so that it can be positioned directly behind Q1 (that way it can emit a small amount of IR into the base of Q1 during low-light conditions), as shown in Fig. 4. The flat sides (the cathode) of D1, D2, and D3 are attached to ground.

If you are going to use the existing coaxial cable in your home to transmit
the signals, then two filters are required to decouple the DC voltage and to attenuate the transmitted signal. That keeps the TV tuner or VCR from receiving any harmful DC voltages. The only consequence of doing it that way is that there is an interfering between the control signal and the video signal that takes place in the coaxial cable when the extender is activated; that results in a small amount of interference that is visible on the TV screen when a command is being sent.

Both filters must be installed between the last output stage and the tuner of your second TV, as shown in Fig. 5. (If you have an amplifier to boost your VCR output, then the amplifier becomes the last output stage.)

The first filter, located after the last output stage, can be constructed in two ways: The first way—and also the easiest—is to purchase a Radio Shack high-pass filter (PN 15-579). Remove the rubber gromet and slide back the case, as shown in Fig. 6. Take a 4- to 5-foot length of small-gauge two-conductor speaker wire or zip cord, and scrape away enough potting material at the filter's F connector to attach one wire to the center pin and the other to the ground side (see Fig. 6). Run the

**Parts List**

- **All resistors 1/4-watt, 5%**:
  - R1—15,000 Ohms
  - R2, R5, R15—1000 Ohms
  - R3—1 megohm
  - R4, R9—20,000 Ohms, 20-turn potentiometer
  - R6, R8, R10, R13—10,000 Ohms
  - R7—100,000 Ohms
  - R11, R14—4700 Ohms
  - R12—150 Ohms

- **Capacitors**
  - C1—0.01 µF, disc capacitor
  - C2—0.1 µF, disc capacitor

- **Semiconductors**
  - IR-LED1, IR-LED2—SEP 8703-1, infrared light-emitting diode
  - LED3—light-emitting diode, red or green
  - Q1—T1 414 phototransistor
  - Q2—Q3—2N2222, NPN transistor
  - D1—5.1-volt Zener diode
  - IC1, IC2—LM741 op amp
  - IC3—LM339 comparator

- **Other components**
  - T1—120-volts AC/9-volts DC, wall transformer

**Miscellaneous**: 4-40 hardware, standoffs, tape, speaker wire, etc.

The following two filters are needed only for transmitting through coaxial TV cable (see text).

**Parts for the first filter**

- 10.1-µF disc capacitor, 1 100-pF disc capacitor, 1 inductor (see text), 1 chassis-mount F connector, 1 cable-mount F connector, a piece of coaxial TV cable, cardboard, 2 washers, copper tape or aluminum foil.

**Parts for the second filter**

- 10.1 µF disc capacitor, 1 100-pF disc capacitor, 1 inductor (see text), 2 chassis-mount F connectors.

*Note: An etched and drilled PC board is available postpaid for $7.50 in U.S. funds from Fen-Tek, P.O. Box 5012, Babylon, NY 11707-0012. NY residents must add sales tax.*

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**FIG. 3—PARTS-PLACEMENT DIAGRAM.** Mount Q1 so that it can protrude through the project box. Either IR-LED1 or the filter circuit attaches to pads A and B.

**FIG. 4—MOUNT IR-LED2 so that it can be positioned directly behind Q1 as shown.** That way it can emit a small amount of IR into the base of Q1 during low-light conditions.
wire through the case and then slide the case back over the filter. Use RTV silicone to reseal the area where you removed the grommet. Attach IR-LED1 to the other end of the wire. Remember that the wire that you attached to the center pin of the F connector is positive for IR-LED1.

For those true do-it-yourselfers, the other way is shown in Fig. 7. Because solder will not easily adhere to metal plating, file or sand away a small amount of the metal plating on the F connector and washer before soldering. When the filter is finished, wrap a piece of cardboard around it and tape in place. (The cardboard found on a blister pack works well.) The filter should then be wrapped with copper tape or aluminum foil for RF shielding. Make sure that a small piece of copper tape or aluminum foil is in contact with the washers at both ends of the filter to effectively complete the ground shield. You can also build the filter in a small metal case.

The inductors can be obtained in an inductor assortment from Radio Shack (PN 273-1601), or by making your own. If you purchase the inductor assortment, the ½-inch enameled wire-wound inductors have a value of 10 μH. Combined with a 100-pF capacitor, the filter should have a cutoff frequency of about 5 MHz.

If you wind your own inductor, use 22-gauge enameled copper wire, and wind 6½ turns on an 8-32 screw. Remove the screw and coat the outside of the windings with non-conductive RTV silicone. That will keep the windings from deforming during assembly. Scrape and tin both ends of the inductor. The value of the inductor should be approximately 100–200 nH. (It is much more difficult to make a 10-μH coil by hand, and because a 100– to 200-nH coil will do the job, that’s what we’ll make.) When that is combined with a 100-pF capacitor, the cutoff frequency should be about 35–50 MHz. The formula used for calculating the cutoff frequency is:

$$ F = \frac{1}{2\pi\sqrt{LC}} $$

The second filter is located inside the extender box as shown in Fig. 8. Be sure to attach the output wires from the PC board to the side that is coming from the other filter and not the one to the TV set. Label the two F connectors as in and out to make installation easier. If you have a TV set that uses a 75- to 300-ohm matching transformer, then the second filter can be omitted. In that case, just solder a bus wire from the center pins of both F connectors, and attach the positive output lead for IR-LED1 to that bus wire. Then bus-wire the grounds together on the F connectors and attach them to the PC board’s ground.

If you decide to use the two-wire system, you can install a terminal block inside the project case, or you can solder the wire directly to the PC board. Just make sure that the grounded lead gets soldered to the cathode of IR-LED1.

The easiest way to mount IR-LED1 on an appliance is to position it so that it covers ¼ of the IR receiving window on the device that you wish to control. Use a piece of clear tape to secure it to the unit. That way you can still use your remote control in the same room as your receiving unit. Be sure to insulate the legs of IR-LED1 so that they don’t short out.

The PC board is installed inside a small plastic project box, and mounted on ¼-inch stand-offs. If you do not have stand-offs, then 3 nuts on top of each other can be used instead.

The hole for Q1 in the front of the project box is not critical. Just be sure that Q1 fits through the opening and slightly protrudes outward. A smaller hole must be drilled for LED3, if you decide to use it.

Calibration

Apply power and make sure that nothing gets too hot. If anything does, then recheck your connections. Then, connect a voltmeter across IR-LED1. Adjust R9 until the output drops to approximately 0.004 volts. Then attach the voltmeter to pin 3 of IC1. Adjust R4 for 0.55 ± 0.05 volts. Remove the test lead and reconnect it across IR-LED1. Again, adjust R9 until the output goes high, and then back off slowly until it drops to approximately 0.004 volts. If you used the optional LED circuit, then there is no need to connect a voltmeter across IR-LED1, because LED3 will light when the output of IR-LED1 is high, and it goes out when it’s low.

R-E
WHY IS IT THAT SOME BLANK VIDEO TAPES cost twice or even three times as much as others having the same total recording time? How come some major manufacturers of video tape offer as many as six or eight different "grades" of video recording tape? Does it ever pay to purchase the more expensive tapes offered by those companies? What makes some video tapes "better" than others?

For several years now, Video Review Magazine, where the author serves as Technical Editor, has been conducting extensive tape tests, using the facilities known as Advanced Product Evaluation Laboratories, directed by Mr. Frank Barr, who was formerly in charge of the consumer-products testing laboratories of the now defunct CBS Technology Center. Mr. Barr's labs, known by their acronym APEL, have developed a most exacting test system for evaluating the performance of video tape. Industrial, rather than consumer, VCR's are used in the tests, to ensure that the results will not be limited by the performance of the tape recorder rather than the tape itself. By the way, there's no point in using a tape that provides a video signal-to-noise ratio of, say, 45 dB when your VCR's own signal-to-noise ratio is limited to 42 dB!

The most important parameter

When it comes to video performance, there are four major parameters that generally need to be considered. The first, and most important, is dropouts. A dropout on videotape simply means that a measurable amount of signal is missing from the tape. That can be caused by lack of uniformity of the magnetic-particle dispersion on the surface of the tape, or because the tape, for one reason or another, fails to make intimate contact with the rapidly spinning head-drum of the VCR during recording and/or playback. That type of poor contact, in turn, may be caused by an actual bump or lump that appears along the surface of the tape or by an overall lack of smoothness.

The visible effect of dropouts is the appearance of a white speck or even a horizontal streak on your TV screen. Many inexperienced viewers attribute such flecks or streaks to a poor signal-to-noise ratio. That's because those white flecks do resemble video "snow" with which we are all familiar. Actually, it's easy to tell the difference between video "noise" and tape dropouts. Noise, though random in content, appears all over the picture, and usually throughout the entire tape. Dropouts, on the other hand, occur randomly; they may occur frequently, or there may be periods when the screen is free of flecks. Human vision can tolerate noise more readily than dropouts.

Short- vs. long-term dropouts

It takes approximately 63 microseconds for the electron beam of the
CRT in an American TV set to “paint” one line of a picture. That being the case, short-term dropouts have been defined as dropouts of 5 microseconds or less. Those would show up as white flecks along a scan line for about 1/20th of the length of the line or less. Long-term dropouts are defined as those that cause streaks lasting for 15 microseconds or more. Such dropouts show up as streaks occupying at least 1/5th of a scan line and are therefore highly visible and distracting to viewers.

Figures 1–a and 1–b show the short- and long-term dropout count of the very poorest standard-grade video tape, measured in a group of 22 standard-grade tapes, compared with the short- and long-term dropout count for the very best of 22 high-grade tapes. Three dropout values are given in each case because, as a rule, dropout rates are likely to be higher at the beginning and end of a tape than they are at the center (due to the way videocassettes are manufactured). That’s why seasoned video-tape users fast-forward through the first few minutes of their tapes before recording on them. Most tape suppliers provide a bit more than the nominal recording time, so that practice still permits a full 2-hour recording time (at the SP VHS speed) on a T-120 tape. Figure 1 compares the worst standard-grade tapes with the best high-grade tapes; but on an average, high-grade tapes exhibit fewer dropouts than the standard-grade tapes.

Signal-to-noise ratios
In evaluating video-tape performance, signal-to-noise (or S/N for short) ratios are also of some significance, but far less so than dropouts. There are three types of S/N measurements that are worth noting. The first, called luminance S/N ratio, is measured with respect to signal brightness or the black-and-white portion of the video signal. The second is known as chroma AM (Amplitude Modulation) S/N, and it defines the color saturation or intensity. The third measurement is called chroma PM (Phase Modulation) noise, and a poor figure here results in a noticeable lack of color purity or accuracy of hues. Generally speaking, viewers are more sensitive to poor luminance S/N ratios than to the other two readings.

Although many manufacturers boast about the high S/N ratios associated with their high-grade tapes, the truth is that the S/N ratios of most tapes—even the standard grades—are better than the inherent S/N ratios of the home VCR’s upon which they are used. Furthermore, the differences between the best readings for the high-grade tapes and the best readings for the standard-grade tapes are relatively small. The same holds true for the poorest readings of the standard-grade when compared with the poorest readings for the high-grade tapes. Figure 2 shows a comparison between standard- and high-grade best readings as well as the standard- and high-grade poorest readings. Notice that the very best luminance S/N reading obtained from the high-grade tapes (around 50 dB) was only marginally higher than the best reading obtained from the standard-grade tapes—or about 48 dB.

Similarly, even the worst standard-grade tapes, with regard to luminance S/N readings (a reading of about 46 dB), were only slightly poorer than the worst luminance S/N readings from the high-grade tapes. And, the two poorest readings were generally higher than the S/N ratio of most home VCR’s. Home VCR’s generally exhibit luminance S/N ratios for play and record of not much more than 43 to 45 dB, regardless of the tape used. The same thing pretty much holds true for the chroma AM and chroma PM S/N ratios.
HOW VIDEO TAPES ARE TESTED AND EVALUATED*

Tests of video tapes conducted by APEL are as rigorous as those conducted by the tape manufacturers themselves, if not more so. All tape tests are conducted in a 70°F climate-controlled room, with a relative humidity of 60%. The tapes are stored in the room for 48 hours before testing. To ensure accurate results, tapes are bulk-erased and run back and forth in the test deck before testing. Tape decks are thoroughly cleaned after a tape is tested, reducing contamination between samples.

Dropout count

For dropout testing, a one-minute long gray field of 50 IRE intensity is recorded on relevant sections of each tape (beginning, middle, and end). (Video brightness is measured in "IRE." 140 IRE, which is the maximum peak-to-peak brightness level for a video signal, corresponds to a completely bright screen, while 20 IRE is, for all intents and purposes, a black screen.) The tape is then played back and any dropout of 20 dB or more is counted and categorized as either a long or short dropout. The device used to measure dropouts is manufactured by ShibaSoku, a highly respected Japanese manufacturer of precision test equipment. One of the major causes of dropouts and high signal-to-noise ratios is an irregular tape surface. When such surfaces are suspected as being the cause of poor readings, a powerful microscope/camera combination is used to precisely examine and record the tape surface.

Luminance and chroma

Luminance S/N ratio indicates how much snow or video noise you are likely to see on a black and white video picture. A background signal level of 50 IRE (corresponding to a medium shade of gray) is used as a reference level. Using a noise meter, unweighted noise is measured over a video bandwidth extending from 10 kHz to 4 MHz, without the usual “trap” circuit at 3.58 MHz. AM chroma noise is similar to luminance noise and appears along horizontal lines of a color picture. FM chroma noise shows up as a change in color rather than as noise or graininess, and is generally less objectionable than either AM or luminance noise. Both forms of chroma noise are measured by the noise meter.

Frequency response

Frequency response of video tape is tested by using a multiburst signal consisting of frequencies at 0.5, 1.25, 2, 3, and 3.58 MHz. In the case of some of the newer formulations, such as S-VHS, additional, higher frequency bursts would have to be used. Attenuation at those test frequencies is recorded and a response curve for each tape can be drawn. As for the magnetic properties of a tape, normally, a B/H meter is used to measure them. That meter can be used to evaluate signal loss with repeated playing of a tape, and magnetic properties such as coercivity and remanence can be measured.

Mechanical properties

Base materials of video tapes vary considerably. Some tapes, when subjected to tension, will stretch enough to mar picture quality. Others may have such low tensile strengths that repeated use may actually cause them to tear or break. Elongation and breaking strength can be measured using a calibrated tensile tester. R-E

Repeated plays

How long will most video tapes last? If you are using a tape to record a once-in-a-lifetime family event or a major sports event that’s not likely to...
be repeated or available on pre-recorded tape, the question of durability is important. If you are simply recording a program “off the air” for viewing at a more convenient time, after which you plan to record something over it, then durability is of little importance. Most video tapes are excellent in their ability to preserve picture and sound with repeated playing with very little loss of signal level. Furthermore, there seems to be little difference between the standard- and high-grade tapes inssofar as signal loss with repeated playing is concerned. That is illustrated in Fig. 4, where we see that the best standard- and high-grade tapes lost a mere 0.1 dB in signal level after 10 plays, while the worst standard- and high-grade tapes lost less than 1 dB after the same number of plays.

Audio performance
If you own a VHS or Beta VCR that has hi-fi audio, virtually any tape that produces good video with minimum dropout will also deliver wide-response, low-distortion stereo audio. That’s because the audio signals are recorded as FM carriers along with the video signals, on the same area of the tape. The same holds true for 8-mm camcorders or VCR’s where AFM (Audio Frequency Modulation) audio recording is mandatory, even if the audio is only single-channel. Audio troubles arise when you own a VCR that uses the edge of the tape for so-called “conventional” or “linear track” audio recording.

The limited frequency response of the audio electronics of most VCR’s is likely to be poorer than the capability of most tapes. You may also find that some inferior tapes have been slit improperly, and will exhibit dropouts of the sound recorded on the track closest to the edge of the tape. Friction within the cassette housing can also result in high levels of “wow” and “flutter,” or variations in pitch when playing back musical programming.

Which tape to use?
There’s no single answer to that question. It all depends upon the type of recording you do, what you plan to do with it, and how important the finished tape is to you. Dropouts remain the single most important criterion by which to judge video tape. And once you find the brand that suits your needs, stick with it.

R-E
CAPACITORS

Everything you were always afraid to know about capacitors...but wanted to ask

JOSEF BERNARD

ASIDE FROM THE OCCASIONAL HUMAN body or lightning-struck tree that acted as an inadvertent resistor, capacitors were probably the first electronic components. When electricity was discovered and its mysteries were first being explored back in the mid-1700’s, capacitors were the means used to store the mysterious new force.

Of course, they weren’t called capacitors then. They were called Leyden jars (see Fig. 1). A popular diversion at parties of the time was to charge up a Leyden jar, form a ring of people by holding hands (the circuit), and then discharge the jar through the ring. Talk about getting a glow on!

A Leyden jar (named for the city of Leyden in Holland) was a glass container lined with, and covered on the outside with, metal foil. (The first Leyden jar probably had only one plate, a foil lining on the inside. It would have been able to hold something of a charge, but not much. The addition of the second exterior electrode provided a “vessel” for the positive charge that complemented the negative one on the inner electrode.) When the inner foil was charged up (loaded with electrons), the glass prevented them from traveling to the outer foil, and a voltage differential was established. Ignoring the question of leakage, the jar would then hold that electric charge until the charges on the inner and outer foils were equalized—perhaps through a ring of merrymakers or in the form of miniature lightning—a spark—jumping between two pointed electrodes. That was the first capacitor.

We have progressed somewhat since those days, both in the ways we seek our thrills, and in our uses for capacitors and the ways in which we construct them.

How capacitors work

A capacitor (it used to be referred to as a condenser because it seemed to condense, or concentrate electricity) is an apparently simple device. Two plates of metal separated by an insulator, which, when found in a capacitor, is known as a dielectric. You charge up one of the plates with electrons (or create a deficiency of electrons), and the dielectric keeps them from traveling to the other plate, which becomes oppositely charged with respect to the first. The opposite charges attract one another (they would mutually neutralize themselves if the dielectric were not there to keep them apart) and form a stable system.

What actually happens is a little more complicated than that. The dielectric material plays more of a role than just keeping the two plates of the capacitor separated and preventing the charge from migrating from one to the other. For it is the dielectric itself, that actually determines how much of a charge a capacitor can hold. The dielectric material itself can become
A capacitor with a vacuum, whose dielectric constant is expressed as unity, or one. Table 1 shows the dielectric constants of some common materials.

There are three ways in which the capacitance of a device can be increased. The first is merely by increasing the size of the plates so there is room for more electrons. More important, increasing the size of the plates increases the amount of surface area in contact with the dielectric. In today’s microminiature circuits, however, that is not an ideal solution, nor has it ever been. Size and materials are always a consideration.

The second method involves bringing the oppositely charged plates closer together. One way of doing that is to make the plates and the dielectric material as thin as possible. As their proximity increases, the mutually attractive force on them becomes greater as the inverse of the square of the distance separating them. That is, halving the distance between the plates increases the attraction by a factor of four; quartering it increases it sixteenfold. The increased attraction means that more electrons can be held in place. (It should be noted that one of the electrodes of a capacitor is usually connected to ground. That provides it with a practically infinite supply of positive charge.) Unfortunately, there comes a point where the plates of a capacitor would be so close together that the electrons would jump the gap, that would destroy the dielectric in the process, and neutralize any charge that was on the plates.

The third method of increasing capacitance involves using materials with high dielectric constants. Those materials, as we have seen, can by themselves stabilize the charge on the electrodes of a capacitor, and the greater the dielectric constant of a material, the more of a charge can be stored by device in which it is used. It is the improved dielectric materials that have contributed largely to the increase in the capacitance-to-size ratio of today’s capacitors.

Capacitance, the ability of a capacitor to store a charge, is measured in farads, a unit named in honor of electrical pioneer Michael Faraday. (Never use the term “capacity” when speaking of capacitors; it is not interchangeable with the term “capacitance.”) A farad is defined as one coulomb of electricity applied at a potential of one volt. It is no trivial unit, since a coulomb contains $6.25 \times 10^{18}$ (6.25 thousand million billion!) electrons.

Most applications do not require anything close to a farad of capacitance, which is fortunate because until recently it was impossible to make anything near a 1-farad capacitor in a reasonable size (see Fig. 2). Today, even Radio Shack sells 0.1-farad capacitors for just a few dollars.

However, most capacitors are much smaller in value than that. Capacitance is commonly measured in microfarads (millionths of a farad) or picofarads (trillionths of a farad). Picofarads, which are millionths of a microfarad, used to be called micro-microfarads. The term “microfarad” is abbreviated μF, and picofarad, pf. Capacitors with values in that range are sufficiently large for most electronic circuits.

**How are capacitors used?**

Pick up any circuit board, open any power supply, look inside any piece of radio equipment, and you’re going to find capacitors. What are they all doing in there? Well, as you might have guessed, capacitors are more than just solid-state electrical storage devices. When direct current (DC) is involved, that’s more or less what they are. Put a charge on them and they retain it, or as much of it as the inevitable leakage will allow. As such, their usefulness in DC circuits is somewhat limited. But in AC circuits, where the magnitude and the polarity of the voltage is constantly changing, the roles that capacitors play are enormously varied.

Capacitors block DC; once they are fully charged, no current flows into or

---

**TABLE 1**

**DIELECTRIC CONSTANTS (K) OF VARIOUS MATERIALS**

<table>
<thead>
<tr>
<th>Material</th>
<th>K</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air (vacuum)</td>
<td>1</td>
</tr>
<tr>
<td>Paraffin</td>
<td>2-3</td>
</tr>
<tr>
<td>Rubber</td>
<td>2-3</td>
</tr>
<tr>
<td>Polyethylene</td>
<td>2-3</td>
</tr>
<tr>
<td>Paper</td>
<td>2-4</td>
</tr>
<tr>
<td>Oil</td>
<td>3-5</td>
</tr>
<tr>
<td>Mica</td>
<td>4-8</td>
</tr>
<tr>
<td>Porcelain</td>
<td>5-7</td>
</tr>
<tr>
<td>Glass</td>
<td>6-9</td>
</tr>
<tr>
<td>Titanium dioxide</td>
<td>14-110</td>
</tr>
<tr>
<td>Various titanates</td>
<td>15-12,000</td>
</tr>
</tbody>
</table>

---

**FIG. 1—LEYDEN JARS, the earliest capacitors, found their first use outside the laboratory as ice-breakers at parties.**

**FIG. 2—THIS CARTOON was funny a few short years ago, but it has been made obsolete by today’s improved technology.**
out of the capacitor. However, capacitors do pass AC. That is because as the charge on one electrode of the device varies, the charge on the other electrode (even if it does not change) also varies with respect to the first. The system is no longer stable. A varying electric potential is developed across the capacitor and current flows through it.

That ability of capacitors to block DC while passing AC makes them invaluable in places where only one or the other is desired. Digital logic circuits, when they switch from one state to another (say from logic-high to logic-low), frequently generate transients or spikes on the power-supply lines. If not cared for, those transients would influence the operation of the logic circuits and generate unpredictable results. For that reason, for every few IC’s on a board, the power-supply lines are bypassed to ground through despiking capacitors. Those capacitors see the switching transients as a form of AC (which they are) and conduct them to ground. The normal supply voltage, being constant DC, is unaffected by their presence.

In a power-supply circuit, when alternating current is rectified, the result is not immediately pure DC. Rather, it is an alternating voltage having a single polarity. Figure 3-a shows an AC waveform, and Fig. 3-b shows the same waveform after being rectified. The large capacitors, commonly found in power-supply circuits, act as surge tanks. That is, as the voltage applied to them changes upward, they begin to charge. Then, as the applied voltage begins to decrease, they lose some of their electrons to the supply line. Figure 3-c shows the rectified AC waveform after being applied to the large capacitor.

However, there is still an AC component left in the output voltage that cannot be compensated for completely by the large capacitors. That component, called ripple, is a remnant of the original AC voltage (Fig. 3-c). To remove it, smaller capacitors are used to convey the electrons making up the difference between the value of the ripple voltage and that of the mostly DC output voltage to ground. The result (Fig. 3-d) is pure DC.

In many circuits where AC and DC are mixed, it is often desirable to pass one while blocking the other. Such a situation might exist between the stages of an audio amplifier. In order to pass the output of the first stage to the input of the second, without also passing along the high DC collector voltage from the first stage, a coupling capacitor between the two stages is used. It blocks the unwanted DC while passing the AC. Capacitors can also be used to keep the DC component of a signal, and get rid of the AC one. That is done by passing the AC component to ground.

Another place where capacitors play an extremely important role is in timing circuits. The timers involved may be considered long-interval or short-interval ones. Long-interval timers are the type found in clock circuits and other applications where some sort of time-measuring capability, or the generation of a signal used for timing, is involved. Short-interval timing circuits are the sort that generate high-frequency signals such as those used in radio and television transmission, or in microwave devices.

Because capacitors do not charge instantaneously, and because it always requires the same amount of time to charge or discharge a given capacitor to a given state, the charging time can be taken advantage of. By charging or discharging a capacitor through a resistor, or perhaps an inductor, a time constant can be established. That time constant can be related to the pulses of a timing circuit, a resonant frequency, etc.
Capacitor construction

The variety of capacitors, if not infinite, is certainly large enough to be astonishing. Excluding those capacitors used in very specialized applications, there are still enough different types to keep you counting all night. When it comes right down to it, though, there are just a few types of capacitors commonly used in electronic circuits.

Ceramic capacitors are typically represented by the ubiquitous ceramic disc capacitor and its recent offspring, the multi-layer ceramic chip capacitor. An ordinary disk capacitor, as shown in Fig. 4, is little more than two very thin sheets of metal separated by a dielectric—usually a form of titanium dioxide—and encased in a “lollipop” of ceramic. That relatively unsophisticated design is adequate enough to provide up to several thousand picofarads at ratings of up to several kilovolts. (The voltage rating is important; if too high a voltage is applied to a capacitor, the electrode material may be punctured or, even worse, the device may explode.)

Ceramic chip capacitors, sometimes known as printed-circuit capacitors, are similar in principle, but are frequently supplied in leadless form, intended for surface mounting. To achieve their small size with a reasonable degree of capacitance, the electrodes are stacked like a multi-layer club sandwich, as shown in Fig. 5. That, in effect, makes a capacitor with many sets of plates, and by electrically connecting alternate plates, a capacitor with a large electrode area is formed. Rather than using a metal foil to form the electrodes, printed-circuit capacitors actually have the electrodes printed in a metallic ink on a ceramic dielectric, having a dielectric constant of between 2000 and 6000.

Electrolytic capacitors offer much higher capacitances than ceramics, although their voltage ratings are generally lower. While their dielectric constants rarely exceed 25, that is compensated for by the thinness of their electrodes and the consequently large surface area available for electron storage. They are frequently recognizable by their cylindrical (tubular) form, although in the past ten or fifteen years, teardrop-shaped dipped tantalum electrolytics have become increasingly common.

Aluminum electrolytics are probably the most widely used type today, and their construction illustrates how electrolytics differ from other types of capacitors. While the capacitors we discussed earlier use two similar plates, electrolytic capacitors actually have only one plate in the traditional sense. That plate is made of a very thin sheet of aluminum. The other “plate” consists of a conducting electrolyte (hence the term “electrolytic”) applied to a material such as plastic film or (in the early days) paper. Early electrolytes were liquids, but less-messy paste electrolytes rapidly took over for the most part. The two elements of the capacitor are
When the price and availability ever, known for electrolytes. Tantalum capacitors process) throughout electrolyte containing manganese nitrate.

Anodized surface tantalum powder sheet (anode) is, then, sintered tantalum powder with

Electrolytic capacitors differ from non-electrolytic devices in that they are polarized. That is, because of the process used to form the insulating oxide, the metallic electrode is always positive with respect to the electrolyte, and must be connected to a positive voltage. Connecting the positive lead or terminal of an electrolytic capacitor to a negative voltage would quickly, and rather violently destroy it. Because of that, electrolytics are suitable for use only with DC (or at least where the potential does not change from positive to negative).

Most types of capacitors can be destroyed by over- or reverse-voltage situations where holes may be blasted in the plates or the dielectric material. However, electrolytics—although not the tantalum sort—have the unusual ability to heal themselves, at least where the degree of damage is relatively minor (a destroyed capacitor will never work).

Occasionally you will find reference to non-polarized electrolytic capacitors. They are constructed by connecting two ordinary electrolytics back-to-back, frequently using series diodes to prevent reverse-current flow (see Fig. 8). Non-polarized electrolytics are frequently found in audio applications such as in crossover networks.
LET'S DESIGN CIRCUITS AROUND THE STANDARD LM741 op-amp, powered by a ±9-volt supply. Starting with inverting and non-inverting configurations, and how they work, we'll move on to voltage followers, biasing theory, and phase splitters. We'll finish up with active filters. In practice, however, as long as the supply voltage stays the same, any op-amp can be substituted for the LM741 without modifying any of our circuits.

**Inverting op-amp**

Figure 1 shows an inverting DC-amplifier with an overall voltage gain (\(A_v\)) of 10. The voltage gain is determined by the resistance ratio \(R_2/R_1\); by substituting a potentiometer for fixed resistor \(R_2\), the voltage gain can be made variable. The \(V_{\text{OUT}}\) formula shows the gain (\(A_v\)) to be negative because the output voltage is inverted 180 degrees from the input.

Offset nulling via \(R_4\) is used to adjust the output voltage to zero when the input voltage is zero. If the offset-nulling network is removed, the output voltage will be offset by an amount equal to the op-amp's input-offset voltage (typically 1 mV) multiplied by the closed-loop voltage gain (\(A_v\)). For example, if the circuit has a gain of 100, the output may be offset by 100 mV when both inputs are grounded. For offset biasing stability, \(R_3\) should have a value equal to the parallel value of \(R_1\) and \(R_2\).

As shown in Fig. 2, by wiring a coupling capacitor in series with the input resistor \(R_1\), an AC amplifier is created. Notice that offset nulling is not needed and, for optimum biasing, \(R_3\) is given a value equal to \(R_2\).

In the small-signal AC amplifier, the closed-loop BW (bandwidth) is equal to the open-loop BW (\(F_T\)) divided by the gain (\(A_v\)). For example, when the \(F_T\) is 1 MHz and \(A_v\) equals 10, then the closed-loop BW equals 100 kHz. The \(F_T\) value for any op-amp is obtained from the manufacturer's specification sheet: The LM741's \(F_T\) is typically 1 MHz.

**Non-inverting op-amp**

Shown in Fig 3 is a non-inverting \(\times 10\) DC amplifier with offset compensation. The voltage gain is determined by \([R_2/R_1]+1\). If \(R_2\) is given a value of zero (a short circuit), the gain falls to unity. As shown in Fig. 4, the gain can be made variable, over the range of 1 to 101, by replacing \(R_2\) with a potentiometer and connecting the wiper to the inverting input. The parallel value of \(R_1\) and \(R_2\) should ideally (for optimum biasing) be equal to the source resistance of the input signal. A major feature of the non-inverting op-amp is its high input-impedance, which can easily have a value of hundreds of megohms.

Figure 5 shows a \(\times 10\) non-inverting AC amplifier. Notice, here, that gain-control resistors \(R_2\) and \(R_1\) are isolated from ground via the bypass capacitor \(C_2\). At operating frequen-
FIG. 5—NON-INVERTING ×10 AC amplifier with 100,000-ohm input impedance.

FIG. 6—NON-INVERTING ×10 AC amplifier with 50-megohm input impedance.

FIG. 7—DC VOLTAGE FOLLOWER with offset nulling.

FIG. 8—AC-VOLTAGE FOLLOWER with 100,000-ohm input impedance.

FIG. 9—AC VOLTAGE FOLLOWER with 50-megohm input impedance without guard ring, or 500 megohms with the guard ring.

FIG. 10—GUARD RING ETCHED ON A PCB as viewed through the top of the PC board.

FIG. 11—INPUT BIASING of an op-amp.

A voltage follower produces an output signal identical to the input signal. The circuit functions as a unity-gain non-inverting amplifier with 100% negative feedback, where the input impedance is very high and the output impedance is very low. Figure 7 shows a voltage follower with offset nulling; however, there would be an output error of only a few millivolts by eliminating the offset nulling entirely. Notice that, for optimum input-current biasing, feedback resistor R1 should have a value equal to the source resistance of the input signal.

The value of feedback resistor R1 can be varied over a wide range (from zero to 100,000 ohms) without greatly influencing the output accuracy. If an op-amp has a low open-loop BW, the R1 value can usually be reduced to zero. However, many op-amps with a high open-loop BW tend towards instability when used in the unity-gain mode. To reduce the bandwidth and enhance op-amp stability, R1 should be 1000 ohms or greater.

Figure 8 shows an AC version of the voltage follower. Here, the input AC-signal is coupled through C1, and the non-inverting input is tied to ground via R1, which determines the input impedance. Ideally, feedback resistor R2 should have the same value as R1 for correcting input-current offsets. However, if R2’s value is very high, it may reduce the bandwidth too much; that problem can be overcome by shunting R2 with C2. Further stability can be achieved for high open-loop BW op-amps by connecting R3 in series with R2.

Figure 9 achieves an extremely
Biasing accuracy

In Figs. 1 through 9, great emphasis was placed on selecting component values for optimum input biasing. Figure 11 shows a circuit for testing the input-offset bias. Both inputs are tied to ground via resistors R1 and R2; equal input bias currents, I<sub>b1</sub> and I<sub>b2</sub>, are drawn through those resistors, thereby generating equal voltage drops. Because a zero-differential voltage appears across the input, a biasing error of zero volts will appear at the output. If, on the other hand, R1 and R2 do not have equal values, or the input bias currents are slightly different, the voltage drops across each resistor will differ; that will produce an input differential voltage that will be amplified by A<sub>v</sub> to produce an output-offset voltage. How significant is that output-voltage error, really?

In practice, a bipolar op-amp such as the LM741 has a typical I<sub>b</sub> value of about 200 nA (0.2 µA), producing a voltage drop of 0.2 mV across a 1000-ohm resistor. FET-input op-amps have typical I<sub>b</sub> values of about 0.02 nA, producing a voltage drop of a mere 0.02 µV across a 1000-ohm resistor. Therefore, in Fig. 11, if the R1 and R2 values differ by as much as 10,000 ohms, a LM741 op-amp will produce a biasing output error of only 2 mV in a unity-gain voltage follower, or 20 mV for a ×10 amplifier. If a FET-input op-amp is used in place of the LM741, the biasing output error of the voltage follower will be a mere 0.2 µV, and for the ×10 amplifier, a mere 2 µV.

It follows that Figs. 1 through 9 can accept considerable latitude in their biasing component values. With that in mind, let’s look at more circuits.

Current-boosted follower

Most op-amps can provide maximum output currents of only a few milliamperes. However, as shown in Fig. 12, the current-driving capacity of a voltage follower can be easily increased by wiring an emitter-follower transistor to the output. Notice that the base-emitter junction is wired into the negative-feedback loop, which virtually eliminates the effects of junction non-linearity. That technique is not used in Fig. 13, which

![Image of a circuit diagram](image-url)
produces significant cross-over distortion as the output swings past zero volts. The distortion can be eliminated by suitably biasing Q1 and Q2; in which case, the circuit can form the basis of a good hi-fi amplifier.

Adders and subtractors
Figure 14 shows a unity-gain DC-voltage adder, which gives an inverted output voltage equal to the sum of the three input voltages. The current flowing in R4 is equal to the sum of the currents in R1 through R3. If required, the circuit can be made to give a voltage gain greater than unity by simply increasing the value of the feedback resistor R4. Figure 15 is a 4-input audio mixer using AC input-coupling capacitors.

FIG. 20—2ND-ORDER LOW-PASS 10-KHZ equal-value-component active filter.

Balanced phase-splitter
A phase-splitter has two outputs that are identical in both amplitude and form, but one output is phase-shifted by 180 degrees relative to the other. Figure 17 shows a unity-gain DC phase splitter. Here, IC1 acts as a unity-gain non-inverting amplifier, while IC2 acts as a unity-gain inverting amplifier that provides the 180 degrees phase-shifted output.

Active filters
Filter circuits are used to reject unwanted frequencies while passing frequencies that the designer wants. The low-pass RC filter in Fig. 18-a, passes low-frequency signals, but rejects high-frequency signals. Once the output falls to 3 dB at a “break” or “cross-over” frequency, as Fig. 18-b shows, the output continues to roll off at a rate of 6 dB/octave (20 dB/decade) as the frequency increases. For example, a 1-kHz low-pass filter gives 3-dB rejection at 1 kHz, 9-dB rejection at 2 kHz, and, roughly, a 15-dB rejection to a 4-kHz signal (or 20 dB signal voltages, if the component values are chosen such that R2 = R4 and R1 = R3, then the voltage gain, AV, equals 2R2/R1.

FIG. 19—2ND-ORDER LOW-PASS 10-KHZ unity-gain active filter.

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Filter circuits are used to reject unwanted frequencies while passing frequencies that the designer wants. The low-pass RC filter in Fig. 18-a, passes low-frequency signals, but rejects high-frequency signals. Once the output falls to 3 dB at a “break” or “cross-over” frequency, as Fig. 18-b shows, the output continues to roll off at a rate of 6 dB/octave (20 dB/decade) as the frequency increases. For example, a 1-kHz low-pass filter gives 3-dB rejection at 1 kHz, 9-dB rejection at 2 kHz, and, roughly, a 15-dB rejection to a 4-kHz signal (or 20 dB signal voltages, if the component values are chosen such that R2 = R4 and R1 = R3, then the voltage gain, AV, equals 2R2/R1.

Balanced phase-splitter
A phase-splitter has two outputs that are identical in both amplitude and form, but one output is phase-shifted by 180 degrees relative to the other. Figure 17 shows a unity-gain DC phase splitter. Here, IC1 acts as a unity-gain non-inverting amplifier, while IC2 acts as a unity-gain inverting amplifier that provides the 180 degrees phase-shifted output.

Active filters
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Adders and subtractors
Figure 14 shows a unity-gain DC-voltage adder, which gives an inverted output voltage equal to the sum of the three input voltages. The current flowing in R4 is equal to the sum of the currents in R1 through R3. If required, the circuit can be made to give a voltage gain greater than unity by simply increasing the value of the feedback resistor R4. Figure 15 is a 4-input audio mixer using AC input-coupling capacitors.

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FIG. 20—2ND-ORDER LOW-PASS 10-KHZ equal-value-component active filter.

FIG. 18—1ST-ORDER RC FILTERS FREQUENCY RESPONSE CURVES: (a) is a passive low-pass filter, and (b) is its frequency response; (c) is a passive high-pass filter, and (d) is its frequency response.
to a 10-kHz signal). Notice that the octave of 1 kHz is 2 kHz, and the octave of 2 kHz is 4 kHz, each octave causes an added attenuation of 6 dB.

The high-pass RC filter in Fig. 18-c, passes high-frequency signals but rejects low-frequency signals. After the output is 3 dB down at a break frequency, as Fig. 18-d shows, the output continues to roll-off at a rate of 6 dB/octave.

Each of the two filter circuits uses a single RC stage, and is known as the “1st order” filter. If we cascade “n” filter stages, it would be known as an “nth order” filter, and would have an output slope beyond the break frequency of (n × 6 dB)/octave.

Unfortunately, simple RC filters cannot be simply cascaded, because each filter section would interact with each other, resulting in poor performance. All of that can be overcome by incorporating the same filter into the feedback network of an op-amp making what are known as “active” filters. Let’s look at practical designs.

Figure 19 shows a Butterworth 2nd-order low-pass filter with a break frequency at 10 kHz. That design gives unity gain within its passband. To change the break frequency, simply change either the R or the C value. A major disadvantage of Fig. 19 is that the value of C2 must be precisely twice the value of C1 for correct operation and, in practice, that can result in some rather odd component values.

Figure 20 shows an alternative 2nd-order 10-kHz low-pass filter, which overcomes that design snag by using equal capacitor values. Notice here that the op-amp is designed to give a voltage gain (4 dB) via R2 and R1.

Figure 21 shows how equal-value-component filters can be cascaded to make a 4th-order low-pass filter with a slope of 24 dB/octave.

Figures 22 and 23 shows a unity-gain and equal-value component versions, respectively, of 2nd-order 100-Hz high-pass filters. Figure 24 shows a 4th-order 100-Hz high-pass filter. The operating frequency can be changed by increasing either the resistor or capacitor values to reduce the break frequency. Finally, Fig. 25 shows how a high-pass and low-pass filter can be wired in series to make a 300-Hz to 3.4-kHz speech filter that gives 12-dB/octave rejection to all signals outside of that range.
PC SERVICE

THE PROTOTYPING TELEPHONE's component side.
THE IR EXTENDER foil pattern.

THE PROTOTYPING TELEPHONE's foil side.
Hardware Hacker

Phase-plane plots

We seem to be moving once again into a second new golden age of hardware hacking, as more and more people are discovering that there is an incredible variety of new and easy-to-use hardware goodies out there. It's also getting rather painfully obvious that the hardware and software have to work together in this day and age, rather than stand alone.

As you probably know by now, the staff at Radio-Electronics has resurrected the original Popular Electronics, and they fully intend to revive both the spirit and intent of the original.

Besides us, and our Modern Electronics competitors down the street, and all of those various ham-radio and CB magazines, you'll find three new and important hardware-hacking resources.

Steve Ciarcia is going great guns with his new Circuit Cellar Ink magazine. Heathkit has a major new hobbyist magazine in the works. And, Nuts and Volts is a little high-energy shopper aimed squarely at hardware hacking.

While I have mentioned this a time or two before, no serious hardware hacker can afford to ignore any of the electronics trade journals, including EDN, Electronic Design, Electronic Products, EE Times, and Electronic Components News. As usual, you'll find a complete listing of all of the popular trade journals in Uhlrichts Periodicals Dictionary found on the reference shelf at your local library.

Once again, this is your column and you can get technical help and off-the-wall networking per the Need Help? box. Your best calling times are 8–5 weekdays, Mountain Standard Time. As per usual, I have gathered most of the Names and Numbers together into one sidebar. Contact those people directly for more information.

This month, we have a mixed bag of off-the-wall topics. Let's start off with some...

Call-progress detectors

How can an electronic circuit tell if a phone call ever gets successfully completed? That is very important for fax machines, for security and alarm devices, auto-dealers, and attendent BBS communications, and anywhere else that you want some electronics to be able to complete a call without any outside help.

Identifying just what is happening when goes by the name of call-progress detection, and the single-chip integrated circuits that handle that are called call-progress detectors.

Three leading manufacturers of the call-progress detector chips include Teltone, Signetics, and those Silicon Systems folks. We will use the chips from Silicon Systems here.

Call progress gets measured by the presence of one or more supervisory signals on the phone line. There is the dial tone that tells you that the line is ready to use, the busy signal that tells you a call can not be completed, the ringback that simulates the sound of the phone at the other end ringing, and finally, an obscure reorder signal that tells you the call only went halfway through and has to be repeated.

Two methods of detecting a call-progress signal are by the frequency and their cadence. For the most reliable detection, both of those should be used together.

Figure 1 shows you all the standards for those new or precise call-progress signals. They will work for most people most of the time. The dial tone is a continuous mix of 350- and 440-Hz sine waves. The busy signal is a gated mix of 480 and 620 Hz, with the cadence of half a second on and half a second off.

The ringback is a gated mix of 440- and 480-Hz sine waves, having a cadence of two seconds on and four seconds off. Finally, that odd reorder signal is a gated mix of 480-Hz and 620-Hz signals, with a cadence of 0.3 seconds on and 0.2 seconds off.

Figure 2 shows you a typical circuit that uses the 75T982 Call-Progress Detector. The phone line is capacitance-coupled to the input. The sensitivity can be increased by ten decibels by using the XRANG input as shown. Clocking is by way of a built-in oscillator using a low-cost color-TV crystal. There are four separate output lines for dial tone, ringing, busy, and reorder.
There is a separate strobe output on pin 13 that tells you if any output is active.

There is an older and simpler chip known as the 757980 that works with both old and new call-progress tones. However, its detection is not nearly as reliable, and an external cadence measurement must be made to sort out the progress commands.

Pricing is around $7 for the 980 and $12 for the 982 in small hacker quantities. For additional details, see the Communications Products data book from Silicon Systems.

Low-frequency resources
There are all sorts of interesting things going on in those low radio frequencies below the AM broadcast band. Look closely, and you will find time and frequency standards, precise navigation systems, communications devices for cave rescue and for mine safety, metal locators, treasure finders, and bunches of other interesting and oddball stuff.

The DIAL TONE frequencies are a 350 Hertz sinewave and a 440 Hertz sinewave that are continuously present until dialing is begun.

The RINGBACK simulates the phone being rung at the other end. This is a 440 Hertz sinewave and a 480 Hertz sinewave with a cadence of 2 seconds on and 4 seconds off.

The BUSY signal announces the call cannot be completed. This is a 480 Hertz sinewave and a 620 Hertz sinewave with a cadence of 0.5 seconds on and 0.5 seconds off.

The REORDER signal announces the call went only part way through the phone system. Like the busy signal, this is also a 480 Hertz sinewave and a 620 Hertz sinewave. The cadence is 0.25 seconds on and 0.25 seconds off.

FIG. 1—TELPHONE CALL-PROGRESS signals can be detected by both their frequency and their cadence. Here are the US standards for the "precise" or "new" call-progress tones. They are now in use nearly everywhere.

As you might suspect, there are some great little newsletters out there that support any hackers with strong interests in low-frequency communications. Figure 3 gives you a list of the "top five" of those resources.

Of those, far and away my favorite is Speleonic, and many thanks to their editor and publisher Frank Reid, for putting me on to the others.

And hey! Those are all volunteer, labor-of-love nanobudget setups. So, either subscribe outright or else send them a buck and a SASE with any of your inquiries.

SAW devices
There sure seems to be a lot of hacker interest in the SAW, or Surface Acoustical Wave devices. Sadly, all of them are usually custom devices offered only in large quantities. Only rarely will useful devices show up on the sur-
The fast, easy and low cost way to meet the challenges of today's electronic innovations. A unique learning series that's as innovative as the circuitry it explains, as fascinating as the experiments you build and explore.

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plus market. And it does take some smarts to properly apply them.

At any rate, a SAW device consists of a transmitting transducer mounted upon a suitable substrate. That transmitter will create a surface wave that can travel across the device over to the receiver. By carefully controlling the layout pattern of the transmitter and the receiver, you can create a fancy filter, a delay equalizer, or a sophisticated radar signal processor.

The SAW devices are very popular for television and for cable-system filtering, since they can give a fancy response curve in a very small package at low cost. Most important of all, they do not require any alignment, calibration, or adjustment to get or keep the desired response.

SAW filters are inherently lossy. Some are offered with built-in amplifiers and impedance matchers, while others are nothing but the SAW device itself.

A typical SAW device might get used as a 44-MHz filter that can go between the television tuner and its intermediate frequency signal processing. Another use is for the vestigial sideband filters used by some cable television and satellite systems.

One quantity source of low-cost SAW devices is Plessey Signal Technologies. All of their models SW302, SW303, and SW304 are typical channel-2, channel-3, and channel-4 vestigial sideband filters which sell for around $2.50 in thousand lots.

Plessey's minimum order is 500 identical pieces. I know of no retail or low-volume source, except as the catch-as-catch-can surplus in such places as Nuts and Volts. Do let me know if you find any.

An active filter

Active filters form a class of electronic devices that use operational amplifiers, resistors, and capacitors to replace all the cumbersome, lossy, and expensive inductors needed in all the traditional filters. Active filters will now compete against switched-capacitor integrated filters and digital signal-processing techniques, so their use has pretty much peaked, es-

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**Names and Numbers**

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<td>Heath Company</td>
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<td>(415) 968-9241</td>
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<tr>
<td>Teltone</td>
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<td>10801 120th Avenue NE</td>
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**Low Frequency Resources**

**Low Down**

Longwave Club of America
45 Wildflower Road
Levittown, PA 19057
$12 per year

**1750 Meters Update**

% Jim Erisson
226 Charles Street
Sunnyvale, CA 94086
(408) 773-8947
$10 per year

**Speleonics**

% Frank Reid
PO Box 5283
Bloomington, IN 47407
(812) 339-7305
$4 per year

**Northern Observer**

% Herb Balfour
91 Elgin Mills Road West
Richmond Hill, Ontario
CANADA L4C 4M1
(416) 884-5355
$12 per year

**BCRA Radio Group**

% Phil Ingham
49 Highfield Road
Farnworth Bolton
ENGLAND BL4 0AH
(0204) 791918
$10 per year

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FIG. 3—THE LOW RADIO FREQUENCIES below the broadcast band support all sorts of interesting time and frequency services, navigation aides, cave rescue, mine safety, metal location, and treasure-finding services. Here are the main hacker low-frequency newsletters.
especially at high signal levels. You'll find lots of hands-on active-filter design details inside my Active Filter Cookbook. Let us look at a typical "workhorse" active-filter circuit that has a high "Q", high stability, a minimum interaction, and easy tuning. It is known as a state-variable filter, and simultaneously could give you low-pass, band-pass, and high-pass output pins.

Figure 4 is an example of 1-kHz state-variable active filter that uses a quad op-amp to produce a single low-to-high "Q" pole in the audio range. You adjust your frequency range by changing either the resistors or the capacitors, keeping their ratios constant. The "Q" gets adjusted with the resistor as shown. Usually, several of those circuits are cascaded to make a fancier overall response function. Full details appear in the book.

I'm showing you this circuit here, because we will need to use it just as soon as we start talking about...

**Phase-plane plots**

Every now and then, some idea will just sit there, quietly blooming away on the back burners of hackers everywhere, until the time gets ripe to do new and exciting things with it. Let's take a look at one of the oldest of hardware-hacker concepts, and see where it is going today and in which direction we can try and shove it in the future. For fun or cash.

I am talking about phase-plane plots, an extremely old graphic technique that today can be extended into some stunning new art forms, as well as be used to create all sorts of new-age toys and gadgetry.

A phase-plane plot is simply a two- or three-dimensional plot of the amplitude versus the phase angle of some value of some physical or abstract system. Time is a parameter that goes along the curve. As one example, say we gave a damped pendulum a shove and then plotted its phase angle versus time. We would get the spiral phase-plane plot of Fig. 5.

We get a spiral because of the damping. The greater the damping, the faster the swings will die away and the sooner the pendulum will come to rest. Should we have zero damping (or infinite "Q"), we would have an oscillator whose phase plane was a continuous circle. Should the system receive some energy from an outside source, we might even end up with negative damping, and the spiral would expand toward infinity, rather than contract. At some point, however, we will come up against some physical constraint of the system and somehow box ourselves in. Or else self-destruct.

By the way, the apparent distortion in Fig. 5 is quite real. Your eye is expecting circles, and the motion toward the center seems to squash things slightly. That will get far more obvious as the damping goes up.

One of the oldest of the phase-plane plots is called the Lissajous figure. Back in the days when oscilloscopes did not have any de-
cent time bases in them, you measured frequency by inputting an unknown frequency on the x axis and a known one on the y axis. Any time the two frequencies would be some exact fractional multiple of each other, you would get a stationary pattern on the screen. Figure 6 shows you a Lissajous figure of two sine waves which are related in frequency by a factor of precisely 3:2.

Note that we are plotting an "X" amplitude against a "Y" amplitude, and that time that moves along the curve. That is what of servo-mechanisms and power systems. An exciting new study area of the phase-plane plots involves chaos theory. The phase-plane plots can reveal areas where a physical system will behave rationally and other areas where it will behave chaotically.

One of the most famous of chaotic phase-plane plots is called the Lorenz Attractor, otherwise known as the "owl's mask." A good starting point to explore that fascinating subject is Chaos: Making a New Science by James Gleick. There is a very distinct possibility that such chaotic things as weather and stock-market prices are ultimately controlled by those strange attractors. And that gets heavy fast.

I guess I first really got into phase-plane plots back when I was writing my Active Filter Cookbook. We had built the circuit of Fig. 4, and inadvertently connected the real and quadrature outputs to the "X" and "Y" inputs of a scope.

We input some music and then the whole engineering department sat fascinated for hours staring at those wondrous and beautiful waveforms. Things got even more interesting when we substituted a low-frequency function generator for all the music, which gave you several stunningly artistic patterned objects. Many of them appeared in chapter ten of my Active Filter Cookbook. I called those waveforms quadrature art.

I invite you to take the circuit in Fig. 3, hook it up to a scope, and input some music or a function generator and see what you come up with. At the time I did that, visions of exciting newer color-organ and psychedelic-lighting toys danced through my head. Reality struck when I realized that the oscilloscope was essential at that time. And not enough hackers had scopes to bother with.

But today we have low-cost oscilloscopes. We have color computers everywhere. We have plotters and high-resolution printers. We have cameras and VCR's. And, above all, we have that incredible new PostScript graphics language that I am so keen on. We also now can use imaginary, rather than all continued on page 76
Electronics

Radio

967-0726. fail.
We products. Dealers Special combos MLD-$85.00 SCRAMBLERS CABLE P.O. 10507. (914) INDUSTRIES, add $1.50 $4. Hear every sound FM TRANSMITTER SIMPLY FOR Arline Fishman. Limited number Call 516-293-3000 11735. FAX:

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CIRCLE 186 ON FREE INFORMATION CARD
The history and theory of the dynamic loudspeaker

ONCE UPON A TIME, MUSIC WAS ALWAYS a “live” experience. Prior to Edison’s invention of the phonograph in 1877, there was simply no way to store live sound and reproduce it on demand. Edison’s first model used a short mouthpiece horn that terminated in a flexible diaphragm bearing a metal stylus. The free end of the stylus rested on the foil-clad surface of a hand-cranked cylinder. Sounds of sufficient loudness would vibrate the diaphragm, causing the stylus to emboss a track on the rotating foil surface. Playback involved a reversal of the process: The track in the foil would vibrate the stylus and its attached diaphragm and thereby roughly—very roughly—recreate the original sound. In truth, Edison’s phonograph was simple enough that it could easily have been invented by the ancient Greeks more than two thousand years earlier. In any case, the history of the loudspeaker can be considered as starting in 1877. All subsequent developments essentially reflect the attempt to make it play louder and more accurately.

Early history

I suspect that one of the reasons for Enrico Caruso’s popularity as a recording artist was his ability to provide the enormous amounts of acoustic power needed for the “direct-to-disc” or “direct-to-cylinder” recordings of his day. Until electricity got into the act, recordings were made by clustering all the performers around a single, huge recording horn and urging them to play or sing as loudly as possible. During playback, the efforts to make the acoustic phonograph louder and more accurate were limited to improving the mechanical pickup head and enlarging its acoustic horn.

In the early 1920’s, the recording industry was economically jolted by a startling new invention—radio. The annual profits of the Victor Talking Machine Company plummeted from a high of about $23 million to a low of $123,000. However, the good news was that the same technology (electronics) that made radio possible was soon applied to the recording process, with enormous success. Primitive microphones feeding equally primitive vacuum tubes driving electro-magnetic disc cutters achieved a remarkable improvement in recorded fidelity. Unfortunately, the phonophiles of the day had no choice but to play their new “electrical” recordings on purely acoustic phonographs—but that was also about to change.

In the 1920’s, radios usually had separate speakers, whose trumpet-like horns emerged from a base that housed a driven stiff-metal diaphragm not unlike those found in the telephone receivers of the day. But a number of researchers were addressing themselves to the dual problems of volume and fidelity. The breakthrough came about in 1925, spearheaded by the work of two General Electric engineers, Chester Rice and Edward Kellogg.

The moving-coil speaker

Rice and Kellogg’s description of their work, “Notes on the Development of a New Type of Hornless Loud Speaker,” appeared in April 1925 in a leading technical journal. More important, their exposition was shortly backed up by commercial products that were audibly so much better than anything previously available that, within a few years, virtually all other designs were driven from the marketplace. And now, 63 years later, the moving-coil direct-radiator woofer, midranges, and tweeters found in 95% of to...
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ONE OF THE NICE THINGS ABOUT DESIGNING a character generator is that you get a chance to satisfy all kinds of creative urges. Not only do you get the opportunity to design some space-saving (as well as power) circuitry, but it also gives you the chance to make the seven-segment LED's display the characters you want in exactly the manner that you want them displayed.

Unfortunately, you run out of options almost immediately.

We've talked about the limits you run up against when you're trying to display alphabetic characters using a seven-segment display. Some of the characters are easy but there are others, such as "K," "M," "S," and everything from "V" to "Z" are, to put it mildly, impossible. If you spend some time at it, you can probably come up with some sort of unique combination of segments to represent those characters but the chances are good that you'll be the only one who knows what they're supposed to be.

That could very easily mean that you'd have to keep an electronic Rosetta Stone next to the display— not a terrific thing.

After a lot of experimenting on my own and doing some real down
and dirty market research using friends and family, I came up with the character set that was in Fig. 1 in the March issue. Everyone who saw those characters displayed on a seven-segment LED was able to recognize them. The mix of upper- and lower-case took some explanation but once that was understood, everyone who looked at the display was quite able to read it.

But don't take my word for it—set up a small circuit to light the segments and do your own experimenting. If you come up with a more extensive character set, let me know about it.

No matter what character set you decide to use, the procedure for creating the bit pattern is exactly the same. And while designing the character set is creative and fun, working out the bit pattern for the EPROM is tedious and boring.

Once you've made a decision about which address lines will be the inputs and which data lines will be the outputs, the next step is to translate the characters into a series of ones and zeros to store in the EPROM. The chart in Fig. 1 is the programming template for my character set. Notice that all the numbers and the letters "A" through "F" are listed twice. That provides a way to distinguish between the hex digits and the ASCII characters. That may or may not be continued on page 86.
How television got its start.

BEFORE GOING INTO THIS COLUMN, which is mostly about television, a few words of thanks to all the readers of this column—especially those who took the time to correspond. The photos sent in by many readers were really appreciated. I never realized that so many classic antique radios were still in existence. Of special interest was the 1936 Philco Radiobar sent in by one reader. That set looks as if it just came off the showroom floor, and I hope to share it with you in a coming issue.

The roaring 20's

The 1920's was the era when broadcast radio was developed. And, believe it or not, television saw tremendous strides during the same era. While not a household word, television was definitely in the anticipated future. Indeed, by the late 1920's, manufacturers had begun preparing the public for the coming of television.

As shown in Fig. 1, many sets like the Stewart Warner Series-950 screen-grid receiver boasted an adapter for television. We know, of course, that none of those early sets were projecting a TV image like the kind we have today. After all, the early sets didn't have a CRT (Cathode-Ray Tube), but rather, a mechanical device known as a scanning disc. According to the 1928-29 owners' manual: "To provide a satisfactory means of picking up television transmissions, all the series-900 receivers are provided with television receptacles, which contain the RF detector for receiving television broadcasts." Also, as shown in Fig. 2, on the back of the set are television terminals, which provide a means for connecting the necessary amplifier and scanning-disc apparatus.

Later in this column we'll discuss the Stewart Warner Series-950 radio receiver in greater depth. I'm sure that there are still many of those fine receivers and similar sets around. Every time I mention a particular model, I'm overwhelmed by the response; the number of such old sets still treasured by their owners is unbelievable.

Back to the television of the 1920's. Television jacks on the back of the chassis of the 1920's radios, did, of course, plant the possibility of television in the consumer's mind. It appeared that home television sets were just around the corner; especially because public
demonstrations of television seemed to keep pace with the advances in radio.

At the 1929 Chicago Radio show, one of the outstanding attractions was a commercial home Televisor. It was demonstrated at the DeForest Radio Companies booth. The Televisor was an actual production model from the Jenkins Television Corporation, and was said to be the type that would soon be available to the public. In spite of all the hoopla, it became obvious by the early 1930's that television just wasn't ready to enter the home.

The Jenkins Televisor

As shown in Fig. 3, the Jenkins Televisor was in a wooden cabinet. The front panel contained a recessed opening (or shadow box) through which the picture was watched. A magnifying lens (which made a comeback in the 1940's) enlarged the picture, so that many persons could watch at the same time. Below the shadow box was a metal panel where the control knobs were positioned. Two toggle switches (center) to control the loudspeaker and the picture functions, and another switch to start, accelerate and stop the motor for the scanning disc.

At that time, the Jenkins Televisor was said to be commercial, intended for immediate use in the average household. The Televisor was used in combination with a short-wave radio receiver to tune in the television signals, and required a frequency band 100-kHz wide. The RF tuner had to receive all frequencies within that band with equal strength—if it was to have a clear image. When you think about it, the televisor unit was really quite an achievement for that time.

The Baird system

Another name in developing television was John L. Baird, a Scottish inventor. In 1929, the Baird Company announced a demonstration of the Baird Television system in New York City. However, I believe Mr. Baird did some demonstrating of television as far back as 1926.

The Baird system was said to require only the bandwidth used by American broadcasting stations. It was then possible, using the regular-wave bands allotted to speech and music, to transmit images and voices. At the time, that broadcasting was being done through London and Berlin, as well as many other places. They were all using the Baird system.

Whether or not the Baird Television Company was successful in New York, I don't know. But they were obviously very successful in Great Britain, mainly because the moving-picture houses were luring ticket buyers away from the legitimate (live) theaters. And theater organizations were contracting with the Baird Company about installing televisions in their theaters, hoping to draw customers back to the fold. The economics back then between moving-pictures and live theater was similar to what's happening today between television and the cinema, as both media compete for the cash of an entertainment-hungry public.

We have a lot more of early TV to talk about in future editions of "Antique Radios," from the Ikonophone of the late 1920's to the first CRT invented by Dr. Vladimir Zworykin, and other important TV "firsts."
real-world inputs, in just the same way that synthesizers can routinely generate sounds that are nearly impossible to do with a real acoustical system. So now is the time to fire up the old phase-plane plot and convert it into some brand-new art forms or some exotic "new age" toy.

For instance, Fig. 7 gives us an abstract art PostScript phase-plane plot that I recently whipped up. You can do the same thing with the BASIC language and most any computer, printer, and display screen.

So, for the first of this month's two contests, do something with a phase-plane plot and tell me about it. We'll have the usual dozen or so Incredible Secret Money Machine books for the better entries, and an all-expense-paid (FOB Thatcher, AZ) tinaja quest for two awarded to the best of all.

New tech literature
Surplus Traders are the lean and mean channeled reincarnation of the old ETCO operation. You will find some outstanding bargains in their many flyers. Their $24.50 Hitachi VCR front ends look as if they will be most useful for receiving television on a computer monitor. Stock number is RE011.

For "raw iron" surplus, check out Borden's Surplus Center. Those folks have big mutha hydraulics, motors, steppers, pneumatics, and such, all at really great prices.

A free sample packet of porous plastics is now available from Porex Technologies. While both opaque and structurally sound, you could freely blow air or water through those while attenuating noise. As a second contest this month, just tell me about any new or unusual use for a low-cost porous plastic. Speaking of plastics, one good source for plastic gears and belts is Plastock.

From Hewlett-Packard, a latest release on their great Opto-electronic Designer's Catalog. From Teledyne, a new and free Data Acquisition IC Handbook that includes bunch of useful application notes. From Silicon Systems, a Communications Products data book. And, from Supertex, the latest catalog on CMOS and DMOS devices, encoders, and their smoke-detector chips.

If you are into computer-aided design, one of the latest of the free trade journals is MicroCAD News.

Turning to my own products, for much more info on both active filters and phase-plane quadrature art techniques, check out my Active Filter Cookbook. And, yes, we have custom book-on-demand bound reprint sets of all my Hardware Hacker columns that you have seen here, and all my Ask The Guru reprints from my sister column over in the Computer Shopper magazine.

For more on PostScript, we also stock all of the Adobe books and Apple's new fact-filled LaserWriter Reference.

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day's speaker systems do not differ fundamentally from the driver described in Rice and Kellogg's seminal paper.

The basic innovation in the new speaker can be described simply: Instead of a small, magnetically driven, metal diaphragm coupled to a horn, it used a large, stiff-paper cone driven at its apex by a "moving coil." There were (and are) significant advantages to such an arrangement. The horn and diaphragm resonances that severely distorted the sound of almost all previous designs were mostly eliminated, and the new configuration could play louder and had a much wider frequency range.

A schematic view of a dynamic speaker is shown in Figure 1. Except for the use of a ceramic ring magnet instead of an electromagnetic coil of wire—known as a voice coil—that is suspended within the speaker mechanism. The voice coil is connected by very flexible wires to the driver's input terminals. When the voice coil is fed the amplifier's audio signal it produces a magnetic field that fluctuates in both strength and polarity. That varying magnetic field interacts with the fixed field of the permanent magnet, causing the freely suspended voice coil to shuttle rapidly back and forth within the magnetic gap, carrying the speaker cone along with it. The speaker cone sets up a series of compressions and rareifications (vibrations) in the air that is heard as sound. In short, the voice coil moving in accord with the electrical audio signal causes the cone to produce an acoustic audio signal.

Back to the present
The original dynamic speakers had a fairly high-compliance soft-leather or chamois ring supporting the outer edges of the cones. Today, a variety of plastic foams and treated rubbers are used. The edge surround not only must support the cone without unduly restricting the long low-frequency excursions, but it also must damp and absorb the higher frequency vibrations traveling through the cone material.

Most midrange units and tweeters operate on the same principles as the larger low-frequency drivers, but their designers must contend with a different assortment of problems. It should be clear that spurious vibrations, floppiness, or cone or dome movements that are not in direct response to voice-coil movements are going to introduce aberrations in the sound produced. And so will any electrical audio signal that is not accurately converted into equivalent voice-coil movement. There are, in fact, many opportunities for the active drive elements in a speaker system to go wrong that it is truly a wonder—and a tribute to Rice and Kellogg's basic design—that most of them work as well as they do.

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Computers are digital devices. In a computer, all information can ultimately be resolved into bits that are either on or off. The real world, however, is analog. The sun rises gradually, not suddenly. Temperature changes smoothly. Water flows. All human sensory inputs receive data in analog format. However, it's difficult to represent analog values digitally. When people began to design thinking machines, they quickly discovered that devices that operated on analog principles were complicated, sensitive, and unreliable. The problem needed simplification; what greater simplification than to allow no more than two states, on and off?

The problem, of course, is that operation on digital principles erects a fundamental barrier between the computer and the world outside the box. How can the computer, a yes/no device, sense much less control, analog phenomena in the real world?

Two complementary devices make both sensing and control possible: the Analog-to-Digital Converter (ADC) and the Digital-to-Analog Converter (DAC), respectively. As the name suggests, an ADC is a device that converts real-world analog quantities into digital terms that the computer can deal with. Conversely, a DAC

continued on page 81
ble, depending on how adept your word processor is at handling disk errors. With Disk Watcher loaded, however, it would pop up, let you erase some files using a small but competent visually-oriented file/disk manager (Fig. 1), and then let your word processor do its thing.

(2) It’s 3 AM, you’ve just saved the final chapter of you-know-what to your hard disk, and you decide to create a backup copy on diskette. You open a brand new box of disks, type FORMAT C:., and several minutes later start searching for an unerase utility and a bottle of Maalox. If Disk Watcher had been patrolling your PC, it simply would have dumped you unceremoniously in DOS.

than the one on your master system diskette. This is one classic way in which a computer can get corrupted.

If you had had Disk Watcher installed, any attempt to write a file with the name COMMAND.COM would have set bells ringing and lights flashing.

(4) By now you’ve learned your lesson; Disk Watcher is now part of your AUTOEXEC.BAT file. At a computer club meeting, a guy with shifty eyes shoves a disk at you, telling you that the program on it does everything Lotus 1-2-3, dBASE III, and WordPerfect 5.0 combined can do, occupies only 10K of RAM, and costs only $5. You and a hundred other trusting souls buy disks. Needless to say, Mr. Shift Eyes disappears. Even though you’re suspicious, you’ve got Disk Watcher and feel confident. Back at your PC, you start the installation program up and hear your hard disk clicking and buzzing.

A few minutes later, you see a simple message: “Installation is now complete; please reboot and start the program.” You try to reboot and can’t; as panic starts surging, you boot from a floppy. You try to list the directory of your hard disk, but receive only the message “Invalid drive specification.” You realize that your data has gone on to that Big PC in the Sky.

What happened? That virus went straight to your hard-disk controller, and nothing in MS-DOS or the PC’s hardware architecture can protect against that type of sabotage.

Running it

Disk Watcher occupies about 50K of RAM, plus memory for a screen buffer. Depending on your video adapter and on whether you use graphics modes, that buffer can range in size from 4K to 128K. However, it can be located in extended or expanded memory. Hercules, CGA, and EGA text and graphics modes are supported; VGA graphics modes are not.

After installation, Disk Watcher lurks in the background, looking for “suspicious” activities. The latter include trying to modify AUTOEXEC.BAT, CONFIG.SYS, other SYs files, and all program files (COM, EXE, BAT).

If an attempt is made to modify any of those, Disk Watcher pops up to let you decide whether it’s legitimate or not. At that point you can choose among several actions: you can simply shut down the system; a cold boot—either powering down or pressing a reset switch—must then be performed. You can also allow the application program to continue to run, but prevent it from writing to the disk; you can allow it to write just this once; you can allow it to write throughout the remainder of the current session; or you can tell Disk Watcher to remember the program that made the offense, and allow it that type of access in the future.

(Disk Watcher maintains a data file of legitimate programs that perform “suspicious” activities.)

For example, if you edit your AUTOEXEC.BAT file and try to save it, Disk Watcher will pop up. At that point you can allow the save to occur normally, etc.

You can also pop up Disk Watcher at any time to perform basic file and disk management; that is its real strength. As shown in Figs. 1 and 2, you can view, create, and remove directories;

(3) This one’s a little trickier. You download several public-domain utility programs from a local BBS and install them on your hard disk. Several weeks later, you notice that you’re running out of disk space. You clean up those old subdirectories you’d been meaning to get to, but a few days later, you’re out of space again. After a little snooping, you discover that your disk is full of hidden files with odd names. A little more snooping and you find that the COMMAND.COM file on your hard disk is somewhat larger...
copy, move, backup, view, and delete files; format diskettes; and set a pop-up alarm clock that will display a message at a specified time.

In addition, Disk Watcher provides "copy over" protection, i.e., protection from overwriting one file with another of the same name. (By itself DOS provides only the most basic protection of that sort.)

Disk Watcher also monitors several other areas of your system (printer, system clock) to ensure that everything is operating as it should. For example, if Disk Watcher finds the system date set for 1/1/80, it will tell you about it, because that means that your clock's battery may be dead. Or if you accidentally press the PrtSc key (or press it while your printer is off-line), Disk Watcher will allow you to recover gracefully.

A separate program allows you to scan for potential virus programs; the program examines all disk drives for suspicious (hidden) files, and it can "remember" legitimate hidden files (often used by copy-protected programs). Disk Watcher also examines your PC's memory allocation, and will alert you if it finds suspicious holes, at which time you can force the system to halt, ignore the error, etc.

**Does it do it?**

Disk Watcher makes some ambitious claims about its ability to prevent serious damage to your system. Does it live up to those claims?

Partially. Its ability to trap disk-format instructions is only good for programs that use standard resources (the BIOS disk interrupt); anything that goes directly to the hardware cannot be stopped or even detected until it's too late.

On the other hand, the threat of a virus doing serious damage to a single-user PC can be minimized by carefully selecting software. To paraphrase the old adage, *Don't accept software from strangers.* If you need or want to test unknown software, do so very carefully—preferably on a separate system with nothing to lose.

Disk Watcher aspires to monitor and protect your entire system, but it is marred by curious omissions. For example, the Ctrl-Alt-Delete sequence is not trapped; that could be done in a couple of dozen bytes.

There are bugs, too. For example, I told the file manager to move a group of files to a non-existent subdirectory. When the disk thrashing stopped, all the files in the original subdirectory were gone; only a single file (the last one "moved") existed in the root directory; it had the name of the non-existent subdirectory.

Disk Watcher has more serious problems. For example, it does not guard system files with other extensions; for example, BIN, which is used by a popular hard-disk partition manager.

Even more, you can simply REName and DELete sensitive system files from the DOS command line. I renamed COMMAND.COM, modified it using DEBUG.COM, saved it to disk under a new name, and then restored the original name—all while Disk Watcher was loaded. It never noticed. Everything I did could be done via batch file, using only standard DOS commands and programs. to install a faulty system file. Of course, it would be easy to write an "installation" program to accomplish the same thing in a less transparent way.

I expect that the company will solve those problems. Even so, Disk Watcher provides better protection than no protection at all, especially if you're in a situation where you're exposed to lots of untested software.

And DW does provide a useful pop-up disk/file manager. It's not as powerful as full-blown packages but it doesn't use much memory either. And $100 is not a bad price to pay to gain a little extra insurance. (Disk Watcher, RG Software Systems, 2300 Computer Ave., Willow Grove, PA 19090. (215) 659-5300)
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**Disk Technician Advanced** is a hard-disk analyzer/repairer. You must run the program periodically (the company recommends daily use); it scans your disk looking for bad and potentially bad sectors, which it either repairs or locks out. Version 3 ($189.95) is no longer copy protected, can run from hard or floppy disk, allows you to do destructive or non-destructive low-level formatting (with interleave specification), and more. Prime Solutions, Inc., 1940 Garnet Avenue, San Diego, CA 92109. (619) 274-5000.

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D/A CONVERTER

is a device that converts the computer's digital data to analog form, usually current or voltage.

In this article we'll show what a DAC is, how it works, and how it can be used. To illustrate those ideas, we'll present construction details for building a low-cost ($35), high-speed DAC, with as many as eight independent channels. You can connect the DAC to any standard parallel printer port. We'll also discuss the software that controls the DAC, but space precludes printing full listings. However, the software (DAC.ARC) is available on the R-E BBS (516-293-2283). A special feature of the software is an interactive full-screen editor/compiler that functions much like Borland's Turbo and Microsoft's Quick languages.

DAC basics

The most common technique for making an analog signal from a digital value is the R-2R resistor ladder; an eight-stage ladder is shown in Fig. 1. A precision reference voltage (VREF) is applied to the top of the ladder; current then passes through the R-2R resistor network to ground. The strength of the output current (IOUT) is determined by which of the S1 through S8 switches are open or closed.

The maximum IOUT occurs when all the switches are closed, which places one end of all the 2R resistors at ground potential (disregarding the low resistance of ammeter M1). Solving for the equivalent resistance we get R, so the maximum full-scale current is VREF/R. On the other hand, if only S1 is closed (S2–S8 open), then the maximum current is VREF/2R. The current is now one-half the original full-scale current.

It should be obvious to you now that closing any combination of switches will yield a specific fraction of the full-scale current. By rapidly changing the digital word that closes and opens switches S1 through S8, a changing current will be present at IOUT and from the idealized resistor ladder discussed here. Output is provided on two pins as complementary currents, rather than on a single output as shown in Fig. 1. Also, the lower four stages of the ladder are driven separately from the upper four, because the lower stages are more sensitive to error. The fundamental operating principles, however, are the same.

The circuit

The schematic for the circuit is shown in two parts. The first section (shown in Fig. 2) details the digital interface to the PC's parallel port. One analog section is shown in Fig. 3; bear in mind that the digital section can drive eight analog sections.

An eight-bit parallel printer port is an ideal interface for a DAC, because it is typically the fastest standard interface on a PC. The Centronics parallel port has a 36-pin connector, of which the IBM PC family uses 25; our DAC uses only 16 of those. Eight lines are for data, one is for ground, and the remaining seven are for status and handshaking.

Let's discuss the status lines (P/E, BUSY, SELECT, and ERROR) first. When power is applied to the interface, the signal levels on the P/E (paper empty) and BUSY lines are low, and the levels on the ERROR and SELECT lines are pulled high by R1 and R2. Those levels prevent the computer from hanging up, thinking that a printer was out of paper, or busy, or in an error condition. We're able to ignore the busy line because the DAC is so much faster than the computer.

When power is off, ERROR and SELECT go low, thereby indicating to the computer that the DAC is in an error state and not selected. In that way the computer can sense whether or not the DAC is powered and ready for data.

There are three handshaking signals: RESET, STROBE, and ACK. RESET is normally used to reset a printer. In our circuit, however, RESET is used to load the value that defines which of the eight converters will receive the data that follows. The STROBE and the ACK lines handshake data through the par-
parallel port pretty much as they would for a printer. The computer puts a byte of data on DO-D7 and pulses STROBE to tell the parallel device that data is ready. The parallel device reads the data and responds with ACK to signal that everything is fine. To understand what happens in detail, let's walk through a typical data-transfer sequence. Assume that one analog section has already been selected (we'll show how that's done momentarily).

A byte of data enters the circuit and is buffered by IC1, an octal data buffer; IC1 cleans up the signals after their long journey down the cable. The data then proceeds to IC2, an octal data latch; IC2 will latch the data when it gets STROBE from the computer. As for STROBE, it is conditioned by a pair of 74LS14 inverters, IC14-a and IC14-b. It is the rising edge of STROBE that latches the data in IC2.

The output of IC2 is presented to latches IC6--IC13; the latter are what drive the eight converters. Which latch picks up the data depends on the mask stored in IC5, but we'll get to that in a moment. For now, let's look a little closer at what STROBE does.

In addition to latching the data into IC2, STROBE drives a dual one-shot multivibrator, IC4, a

74LS221, which generates a pulse of precisely controlled width—1 μs, in this case. After buffering by IC14-d, that pulse becomes the ACK signal that tells the computer the transaction is complete.

Now let's see how the data latches (IC6--IC13) are selected by IC5, also a 74LS373. When one of IC5's outputs is high, the associated latch will be selected and its outputs will follow the data stream presented to the device. When an output is low, the latch ignores the data stream. In addition, the last value sent (when the latch enable signal was high) is retained in IC5's outputs.

Because of that arrangement,
the same data may be written to several latches simultaneously. For example, a mask of OCh (0000 1100) would enable latches three and four and disable the remaining latches. Subsequently, any data written to the device would put the same data in both latches three and four.

How is the selection mask loaded into IC5? Via the PC's reset line. When reset goes low, section two of IC3, a 74LS74 dual flip-flop, is cleared, and that causes IC5's output enable (OE) line to go high. That in turn causes IC5's outputs to go into a high-impedance state, so the latch buffers (IC6–IC13) retain their current contents on their outputs. Also, those latches will ignore the next byte of data (which will be the latch-selection mask) from the PC.

Now the PC sends that selection byte; the strobe line is pulsed, and that toggles the other half of flip-flop IC3 and also causes IC4 to send a 100-ns pulse to selection register IC5. That pulse latches the selection mask data into the selection register. The selection mask is now where it should be and has been kept out of the places where it was not wanted.

When the next data byte comes, strobe is toggled again, so IC3 returns control of the selection lines to IC5, which now has a new mask. The data is loaded into the converter(s) specified by the new mask.

The purpose of R4 and C1 (between the two halves of IC3) is to guarantee that the second gate is not flipped until two strobe pulses have been sensed. The RC combination delays the response to the first strobe for about 100 ns, leaving it ready to sense the second strobe. Because the time delay is a function of the output drive of Q1 and the input impedance of Q2, substitutions should not be made for functionally equivalent ICs (74HC74, 74S74, 74F74, etc.) without verifying that the time constant remains the same, or using a different resistor or capacitor to maintain the time constant.

The analog circuit

Figure 3 shows one DAC channel. The digital circuitry can handle as many as eight DAC channels, but there's no need, of course, to build more channels than you need. However, because the analog amplifiers (IC16, an LF353) contains two amplifiers per package, it makes sense to add DACs and associated components in pairs.

In the diagram, there are three fundamental components: the DAC, a voltage reference, and an amplifier. The DAC takes the digital number from the latch and the reference voltage from the LM329, and generates a proportional output current that drives the amplifier. Let's look at each component in detail.

The LM329 is a precision temperature-compensated Zener voltage reference. It creates a 6.9-volt source with a long-term stability of 0.002% and a temperature sensitivity of 0.01% per degree Centigrade. Only one LM329 is needed, regardless of the number of converters. However, the dropping resistor (R9) between the LM329 and the +12-
volt power supply should be adjusted for various loads. With two DACs it should be 1000 ohms, with four it should be 510 ohms, with six, 330 ohms, and with eight, 240 ohms. In addition, even though only one dropping resistor and LM329 reference are needed for all eight converters, the 3.3K resistor (R8) and clamping diode (D1) must be duplicated for each converter.

The op-amp is a high-speed, high input-impedance, low power consumption model. It does not have a lot of output drive, but it can produce 10.0 volts across a 2K load. Its strong points are that it is very precise, that it has no offset voltage, and that it can change voltage at the maximum speed of the DAC. The feedback potentiometer (R10) on the amplifier allows you to adjust the full-scale output from 0.5 to 10.0 volts. You’ll want to use a 15-turn potentiometer to make fine adjustments easily.

**Construction**

Unlike some projects, construction details are important. One of the most common failings of mixed analog/digital designs is noisy digital signals corrupting sensitive analog devices. So keep the analog section physically separate from the digital section, as shown in Fig. 4. In addition, keep the analog lead lines short, and make sure that the feedback resistor on the LF353 amplifier is placed close to the IC and far from the digital parts.

Some components can be substituted. A 74LS123 can replace IC4, the 74LS221. Except for IC3, each of the other digital parts can use the corresponding member of another family. For example, 74373, 74C373, 74S373, 74F373, 74HC373, 74HCT373, 74ALS373. Also, an LM1408-8 is a direct replacement for the DAC0808.

The maximum power required when driving eight DAC’s into full loads is +5 volts at 250 mA, ±12 volts at 100 mA, and −12 volts at 100 mA. Of course, the supply voltages must be regulated too. Power-supply bypassing is also a must. Put a 2.2-μF tantalum capacitor (C5–C7) between ground and each of the three power supplies.
TABLE 1—DACL PROGRAM STATEMENTS

<table>
<thead>
<tr>
<th>Statement</th>
<th>Meaning</th>
</tr>
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<tbody>
<tr>
<td>or ;</td>
<td>The rest of the line is a comment.</td>
</tr>
<tr>
<td>use [tp]</td>
<td>Use parallel port 'p' for the converter.</td>
</tr>
<tr>
<td>reset</td>
<td>Reset the converters on the current port to 0.00</td>
</tr>
<tr>
<td>scale, n, val</td>
<td>Use 'val' as a full scale value for converter 'n'.</td>
</tr>
<tr>
<td>set n, exp</td>
<td>Set value of converter 'n' to expression.</td>
</tr>
<tr>
<td>wait t [msec, sec, min, hr]</td>
<td>Wait until hh:mm:ss.</td>
</tr>
<tr>
<td>wait until hh [msec, sec, min, hr]</td>
<td>Wait until hh:mm:ss.</td>
</tr>
<tr>
<td>do index, start, stop, step</td>
<td>Loop on index from start to stop by step.</td>
</tr>
<tr>
<td>do forever</td>
<td>Do forever or until user presses ESC.</td>
</tr>
<tr>
<td>enddo</td>
<td>Close innermost do loop.</td>
</tr>
<tr>
<td>nop</td>
<td>Do nothing except update display.</td>
</tr>
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</table>

Now calibrate the system. Unplug the device from the computer's parallel port and turn it on. Attach a voltmeter to the output terminals of the first DAC, and adjust it for the desired full-scale value. Repeat the adjustments on the second DAC and continue until all have been set.

Use

It's easy to send data and selection masks to the converter. Loading a selection mask takes three steps: First, pulse the reset line low, then high. Second, load the selection mask on the data lines. Last, pulse the strobe line low then high. Sending data to the converter is a two-step process. First, load the data on the lines. Second, pulse the strobe line low, then high.

Unfortunately, we don't have space to present program listings here. However, sample driver programs are included in DAC.ARC, which is available on the R-E BBS (516-293-2283). Two drivers are provided: DACGEN.ASM and DACPAR.ASM. DACPAR.ASM controls the parallel port directly. It is the fastest method, but requires close compatibility with the IBM standard. The other driver, DACGEN.ASM, uses the BIOS to control the parallel port. DACGEN.ASM should run on any IBM compatible, but it will transfer data at a slower rate because of the BIOS overhead.

Functionally, the drivers are identical. Each provides three function calls: one to obtain the status of the DAC; one to send a selection mask to the DAC; and one to send data to the DAC.

In addition, the author has developed a special programming language called DACL (Digital to Analog Control Language), and an integrated programming environment that allows you to experiment with the hardware. DACL's program statements are listed in Table 1.

The environment is illustrated in Fig. 5. With it, program development is as easy as in an interpreted language like BASIC: but run-time speed rivals that of a compiler. As shown, a full-screen editor is on the left, and current DAC status is shown on the right. Help is available by pressing Alt-H. The compiler produces plain English error messages, and leaves the editor pointing to the offending line. Debugging tools permit single-stepping through the source program. DACL comes in two versions, generic MS-DOS and IBM compatible. The first offers hardware generality, the second provides speed of execution. Sample programs and a manual are provided in DAC.ARC.
a useful thing for you—it depends on how you plan on using the EPROM character generator.

If you don’t have any use for making that kind of distinction, you can eliminate whatever you want from the programming chart; but you won’t be gaining any advantage, since there’s more than enough room in the EPROM for just about every character you could want.

The difference between the hex and ASCII characters is shown on the display by using the decimal point. The bit pattern is arranged so that the decimal point lights up whenever an ASCII character is sent to the display. Once you get used to the character representations, you can eliminate it, but take it from me: It comes in handy at the beginning while you’re still getting used to what the characters look like.

Since there’s so much room in the EPROM, I’ve set things up so that the chip can drive either common-cathode or common-anode displays. By using the high-order address line A10 (pin 19) as a toggle, we can select either the common-cathode bit pattern (A10 low) or the common-anode pattern (A10 high).

Using a character generator like that takes a bit of getting used to, because a large number of the ASCII characters aren’t built into the chip, so they won’t be displayed. I’ve already mentioned that the decimal point is used to indicate an ASCII character, and it also provides a way to handle the missing characters. The bit pattern is set up so that all the undisplayable characters are represented by a decimal point. That may make things somewhat cryptic when you try to put some words up on the display, but it can be a really terrific thing if your spelling’s not too good.

Just kidding.

There are lots of ways to burn EPROM’s. At the bottom of the scale is a setup with just a power supply and some switches but, having done that kind of thing a long time ago, let me tell you that it’s really a guaranteed ticket to the funny farm. A much better way to do it is with some sort of commercial EPROM burner. Once upon a time, those were exotic and expensive things to have on the bench, but the advent of the home computer has changed all that.

There are EPROM burners available for just about every home computer on the market.

Apple and IBM EPROM burners range in price from about fifty dollars at the bottom of the scale to whatever the market will bear at the top of the scale. All of them, however, can handle 2716’s. Building a custom character generator is only one way of using an EPROM to make life at the bench easier. A properly planned EPROM can take the place of acres of silicon in logic designs. That means that a circuit can be smaller, cheaper, run cooler, use less power, and last but not least, be much, much easier to debug. And if you make a programming mistake at three in the morning you can always erase the chip and start all over again.

Try doing that with something like a bipolar PROM. They may be faster, but it’s really hard to repair a niche fuse. Even with a lot of equipment, it would be difficult.

Most EPROM programmers want a binary file—the actual hex bytes listed in the program template—to load in the EPROM. Once you’ve decided on the final appearance of the character set, you’re ready to program the EPROM. If you’re using a computer-based programmer (as most of you probably are), you’ll have to type in the bytes in the hex column. If you have a modem, you can save yourself a bit of work by calling the Radio-Electronics Bulletin Board (516-293-2283) and downloading the file called CHARGEN.BIN. It’s a 2K file that can be directly burned into a 2716.

Once you have the EPROM programmed, most of the work is done, as putting it to work in a circuit is simple and straightforward. The schematic shown in Fig. 2 is a typical example of how to use the EPROM to drive a multiplexed display. The EPROM’s enable inputs are all tied to keep the chip enabled all the time and the data outputs directly drive the anodes (or cathodes in a common-anode display) of the display. The 4051 multiplexer controls which digit will be turned on, and by constantly strobing the 4051’s address pins, the circuit will handle up to eight digits.

There are other multiplexers you could use in place of the 4051, but it has the advantage of being able to have its outputs either active high or active low. Since we’re making a character generator that can handle both common-anode and common-cathode displays, the chip we use for a multiplexer has to be able to handle both types of displays as well. If you use common-anode displays, both of the switches in the circuit should be connected to +V, and if you’re using common-cathode displays, the switches should be connected to ground. Although there’s no reason why you can’t use two separate switches, a double-pole double-throw switch will do the job and keep you from making any mistakes.

And not making mistakes is always a good thing.

Needless to say, that kind of circuit arrangement is far from being complete, since there is no arrangement to latch the individual seven-segment displays and some work has to be done to make sure that the appropriate data is sent to the EPROM at the same time that the 138 is addressing the correct digit—otherwise, nothing is going to work properly.

In order to see how the EPROM works, you’re much better off setting up the circuit shown in Fig. 3. That simple design can drive one digit only, but even if your application is going to call for more than just one digit, it’s still useful to see how the characters we’ve programmed into our custom-character generator actually look on the seven-segment display.

Your job is to get the EPROM programmed and try it out, using the circuit in Fig. 3. When we get together next month, we’ll flesh out the multiplexed circuit, make it self-latching, and then see how it can be used as a general-purpose display add-on for just about any circuit you might come across that needs a display.

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<td>34 ($105.40)</td>
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May 1986
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<table>
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### Microprocessor Components

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### Miscellaneous Chips

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### Static RAMs

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### Dynamic RAMs

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### CD - CMOS

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### ECL Chips

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### Solderless Standard Pin & Header Plug Connectors

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### Microsectional Components

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### Potentiometers

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### Ledas

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### Ic Sockets

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### Linear

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<th>Model</th>
<th>Part Number</th>
<th>Description</th>
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<td>TL071</td>
<td>TL097</td>
<td>32K RAM</td>
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### MICROPROCESSORS

<table>
<thead>
<tr>
<th>Model</th>
<th>Part Number</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>6502</td>
<td>8031</td>
<td>8031 Processor</td>
<td>$29.95</td>
</tr>
<tr>
<td>6502B</td>
<td>8025</td>
<td>8025 Processor</td>
<td>$29.95</td>
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<tr>
<td>6502C</td>
<td>8026</td>
<td>8026 Processor</td>
<td>$29.95</td>
</tr>
<tr>
<td>6502D</td>
<td>8028</td>
<td>8028 Processor</td>
<td>$29.95</td>
</tr>
<tr>
<td>6503</td>
<td>8053</td>
<td>8053 Processor</td>
<td>$29.95</td>
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### SIMM MODULES

<table>
<thead>
<tr>
<th>Model</th>
<th>Part Number</th>
<th>Description</th>
<th>Price</th>
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</thead>
<tbody>
<tr>
<td>128KAB-15</td>
<td>256K x 8</td>
<td>256K x 8 RAM</td>
<td>$59.95</td>
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<tr>
<td>128KAB-12</td>
<td>128K x 8</td>
<td>128K x 8 RAM</td>
<td>$39.95</td>
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### PARTIAL LISTINGS ONLY! CALL FOR COMPLETE CATALOG

<table>
<thead>
<tr>
<th>Model</th>
<th>Part Number</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAX232</td>
<td>7.95</td>
<td>RS-232 Serial</td>
<td>$19.95</td>
</tr>
<tr>
<td>78157</td>
<td>10.95</td>
<td>78157 Voltage</td>
<td>$19.95</td>
</tr>
<tr>
<td>82C53-5</td>
<td>3.95</td>
<td>CMOS PROGRAMMABLE INTERVAL TIMER</td>
<td>$19.95</td>
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### V-20 SERIES

<table>
<thead>
<tr>
<th>Model</th>
<th>Part Number</th>
<th>Description</th>
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<tbody>
<tr>
<td>V20-4</td>
<td>4.95</td>
<td>V20-4 Shorting</td>
<td>$4.95</td>
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<tr>
<td>V20-6</td>
<td>6.95</td>
<td>V20-6 Shorting</td>
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### STANDBY MODES

<table>
<thead>
<tr>
<th>Model</th>
<th>Part Number</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>7805</td>
<td>4.95</td>
<td>7805 Voltage</td>
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<tr>
<td>7806</td>
<td>6.95</td>
<td>7806 Voltage</td>
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### PALS

<table>
<thead>
<tr>
<th>Model</th>
<th>Part Number</th>
<th>Description</th>
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<tbody>
<tr>
<td>MC14003</td>
<td>4.95</td>
<td>MC14003 Timer</td>
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<td>MC14004</td>
<td>6.95</td>
<td>MC14004 Timer</td>
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### CRYSTALS

<table>
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<tr>
<th>Model</th>
<th>Part Number</th>
<th>Description</th>
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<tbody>
<tr>
<td>7593</td>
<td>4.95</td>
<td>7593 Crystal</td>
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<td>7595</td>
<td>6.95</td>
<td>7595 Crystal</td>
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### STD. CMOS LOGIC

<table>
<thead>
<tr>
<th>Model</th>
<th>Part Number</th>
<th>Description</th>
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</tr>
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<tbody>
<tr>
<td>74HC406</td>
<td>5.95</td>
<td>74HC406 Buffer</td>
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</tr>
<tr>
<td>74HC245</td>
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### SHORTING BLOCKS

<table>
<thead>
<tr>
<th>Model</th>
<th>Part Number</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>2K0400</td>
<td>10.95</td>
<td>2K0400 Shorting</td>
<td>$10.95</td>
</tr>
<tr>
<td>2K0400</td>
<td>12.95</td>
<td>2K0400 Shorting</td>
<td>$12.95</td>
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### Bypass Caps

<table>
<thead>
<tr>
<th>Model</th>
<th>Part Number</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>10µF</td>
<td>0.95</td>
<td>Ceramic Disc</td>
<td>$0.95</td>
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</table>

### Complete Customer Satisfaction, Superior Service, Friendly, Knowledgeable Sales Staff
POWER SUPPLIES
135 WATT POWER SUPPLY
UL APPROVED
5V @15A, +12V @ 4.2A, 20V @ 5A, 12V @ 5A
PS-135 $59.95
PS-150 150W SUPPLY $59.95
200 WATT POWER SUPPLY
UL APPROVED
5V @ 20A, +12V @ 7A, 20V @ 5A, 12V @ 5A
PS-200 $99.95
APPLE TYPE SUPPLY
WITH APPLE CONNECTOR
5V @ 6A, +12V @ 3A
PS-A $49.95
35 WATT POWER SUPPLY
UL APPROVED
5V @ 15A, +12V @ 7A
PS-3545 $12.95

SOLDER/DESOLTER STATION
FLOWER VACUUM PUMP
TEMP ADJUSTS (121°F-300°F)
& VACUUM (50-60 CMHG)
WITH GUN-REST COLD TRAY.
WIRE BRUSH & TIP CLEANER ROD
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ROTARY SWITCH TEMPERATURE
CONTROL (200°F TO 700°F RANGE)
LED TEMPERATURE READOUTS
INCLUDES COOLING TRAY
XY9-60L $399.95

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TIP TEMPERATURE READOUT
REPLACEMENT TIPS @ $2.95
168-35 $59.95

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TYPE # OF POS. PARALLEL SERIAL PRICE
PUSHBUTTN 2 WAY A0.P $35.95
ROPER 3 WAY RSP-2 $35.95
ROPER 4 WAY RSP-4 $39.95

WIREWRAP PROTOTYPE CARDS
F4-4 EPOXY GLASS LAMINATE WITH GOLD PLATED EDGE CARD FINGERS AND SILK SCREENED LEGENDS

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Computer Hookups

- Fig: Description
- (1) Female D-Sub 25
- (2) Female D-Sub 25
- (3) Female D-Sub 25
- (4) Female D-Sub 25

ICs for Experimenters

- VCP200 Voice Recognizer. Easy-to-use LSI device understands seven preset motion and start/stop commands. With data. #276-1094 9.95
- TDA7000 FM Receiver, RF, mixer, 70 kHz IF and demod stages in one IC. With data. See project in July 88 Hands On Electronics. #276-1304 3.95

Solar Project Kit

- Harness The Sun! Great for scouts or school science class! Includes mini solar panel, motor, color wheel, propeller, project booklet. #277-1201 9.95

Capacitor Bargains

- 0.1 μF Monolithix, 50 WDC. High capacity in a tiny size—ideal for on-board noise cleanup. #272-1094 Pkg. of 51/1.79
- 20μF Assortment, 50 ceramic disc, hard-to-find values from 1 μF to 33 μF. 50 WDC. #272-806. Pkg. of 50/2.99
- (3) 95-420 pF Trimmer. #272-1350 1.99

Antenna Components

- (1) 50 Feet of RG-58 52-Ohm Cable. Top quality and prewired PL-259 plug at each end. #278-303 11.95
- (2) Shortwave Antenna Kit. 75 feet of copper antenna wire, 50 feet of lead-in, window feed-through and insulators. #278-758 6.95

Resistor Values

- (1) Precision Thermistor. Range: -50 to +110°C. #271-110 1.99
- (2) 15-Turn Trimmer Pots. Select from 1k, #271-342. 10k, #271-343. Each 1.49
- (3) 8-Ohm Non-inductive Resistor. 20W. #271-120 1.39

Bench Helpers

- (1) Head Light. Really handy—puts light where you look! Comfortable band. #21-2510 3.99
- (2) Anti-Static TV/RF Alignment Tool Set. #64-2230 3.99

Handy Tools

- (1) Adjustable Project Holder. For easier soldering, gluing and assembly. #64-2093 7.99
- (2) Dual-Wattage Soldering Iron. Go from 15 to 30 watts with the flick of a switch. Replaceable tip. 81/2" long. #64-2055 8.95

Logic Probe and Pulser

- Probe. LEDs and tones reveal logic states in digital circuits. #22-303 16.95
- Pulser. Teammate for the probe. Produces a single pulse or a continuous pulse train at the push of a button. #22-304 17.95

Clamp-On AC Meter

- Measures AC current without direct connection to circuit and AC voltage with included test leads. Plug-in inductive pickup/multiplier for testing devices with an AC cord. #22-161 49.95

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www.americanradiohistory.com
3 to 6 Vdc MOTOR with GEARBOX
Probably designed for children toy. Lever selects 2 forward and one reverse speed. 1st gear approx. 120 rpm/vdc, 2nd gear approx. 300 rpm/vdc. Reverse approx. 120 rpm/vdc.
3.35" X 1.75" X 3.25" CAT#: DCM-10 $6.00

CASSETTE MECHANISM
Alpine cassette transport mechanism. Includes stereo tape head. Mitsubishi # M1P-3TFB 13.2 Vdc motor, belt, pulleys, capstan, fast-forward, rewind and eject actuator. Does not include amplifier section. 6.1/2" X 1.14" X 1.34". CAT#: CM-125 $15.00 each

6 VOLT D.C. 9.5 AMP/HOUR GEL-CELL
Epower # 695
6 volt, 9.5 amphour rechargeable gel-cell battery. 4.25" X 2.75" X 5.5". Quick connect terminals.
CAT#: GC-695 $18.00 each

LED'S
STANDARD JUMBO
DIFFUSED T 1-3/4 size
RED CAT#: LED-1 $10.00 each
10 to $50.00
GREEN CAT#: LED-2 $10.00 each
10 to $50.00
YELLOW CAT#: LED-3 $10.00 each
10 to $50.00

FLASHING LED with built-in flashing circuit. Operate on 5 volt RED
100 each $1.00 each
GREEN 100 each $1.50 each
YELLOW 100 each $2.00 each

Bi-Polar LED
Lights RED one direction, GREEN the other. Take care to install polarities correctly. CAT#: LED-4 2 for $1.00 LED-5 2 for $1.25

SWITCHES
ITF PUSH BUTTON
ITF # 1001 3/4 X 1/2 gray rectangular push button. Push to close. RATED: 0.1 amp switching, 0.25 amp carry current. P.C. mount. CAT#: PB-2 10 for $4.00 - 100 for $38.00

10 POSITION MINI-ROTARY
Gray Style # M110-11-15MC
Mini rotary switch. 10 positions. 125 volt. Shank X 2 1/2 long. 3/16" through the panel depth. P.C. mount is standard. CAT#: R-10015 $1.00 each

SPDT PUSHBUTTON
Marquardt # 16M4
Rated Switches @ 120/250V Vac. Black plastic construction. Switch body. 3/8" X 3/8" X 5/8" CAT#: PB-18 1 for $1.45 each - 10 for $13.50 each

SPDT (ON-OFF)
All plastic body. Standard size toggle. 3/16" threaded mounting. Copper contacts. Flanged arm @ 12V CAT#: TS-15 $1.00 each 10 for $8.60 - 100 for $76.00

10 AMP SOLID STATE RELAY
Electrolytic
Rated 1.5 & 10 Vdc (not connect or 3.32 Vdc). LOAD: 10 amp @ 240 Vac 2 1/4" X 3 1/4 X 1 1/2 CAT#: SS181 $48.00 each 10 for $175.00

QUANTITY DISCOUNT
50 for $300.00 - 100 for $600.00

1/4 WATT RESISTOR KIT
Ideal for the workshop. This 1/4 watt resistor kit contains 10 pieces of each 4 of 120 & 2 of the most popular values (120 pieces) to include a divided box and a parts storage. CAT#: SS181 $16.00 each

15 VALUES OF ELECTROLYTICS
Combine both size and radio style from 1 mfd. CAT#: GRABC $1.00 per box

MAIL ORDERS TO:
ALL ELECTRONICS, P.O. BOX 567
VAN NUYS, CA 91408
TWX-5101010163 (ALL ELECTRONICS)
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INFO: (818)904-0524
FAX: (818)781-2653
MINIMUM ORDER $1.00
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SOUND CONDITIONER / OUTPUT LEVEL 800kHz TO 20kHz TO BE CONNECTED TO TRANSFORMER RF INPUT POWER SUPPLY 12V D.C. 150MA.

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TSM 69

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TSM 108

MOGADISHU REBELLION POWER SUPPLY 12V D.C.

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FUNCTION GENERATOR, FREQUENCY RANGE 100 Mhz TO 1000 Mhz PRODUCES SIGNALS SQUARES PULSE WAVE FORMS, POWER SUPPLY 12V D.C.

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TSM 100

DUAL STATION INTERCOM WITH SPEAKER ADJUSTABLE PICK-UP AND SPEAKER ADJUSTABLE VOLUME POWER SUPPLY 9V D.C. 2.2A.

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TSM 102

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TSM 85

RADIO FREQUENCY TRANSFORMER 12V D.C. 60mA.

TSM 80

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TSM 81

INPUT MAX POWER STEREO 2 X 15W PEAK POWER, 15W

TSM 82

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TSM 108

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- Extra-large LCD display

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- 11 function, 38 ranges including: Logic Level Detector, Audible and Visual Continuity, Capacitance & Conductance measurements.

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<td>Reg. $87.50, Our Price $79.95</td>
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**ALL-PURPOSE 92-PC. TOOL CASE**
- Complete kit for home, workshop and auto
- Includes 92-pc. socket set with extenders
- 2 tool pallets with roomy rear storage compartments
- Attractive, rugged carry case.

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<td>FTK-28</td>
<td>Reg. $169.95, Our Price $129.95</td>
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**DUAL TRACE OSCILLOSCOPES**

**A.W. SPERRY 20 MHz OSCILLOSCOPE**
- Built-in component checker
- Z-axis input
- Low power consumption
- TV Video sync filter
- High-sensitivity X-Y mode
- Front panel trace rotator
- Includes 2 test probes

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<td>620C</td>
<td>Reg. $899.95, Our Price $598.00</td>
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**HITACHI 35 MHz OSCILLOSCOPE**
- 19 calibrated sweeps
- 6° CRT with internal graticule, scale illumination & photographic bezel
- Auto focus
- X-Y operation
- TV sync separation
- Includes 2 probes (10:1 and 1:1)

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<td>V-35E</td>
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