Radio-Electronics

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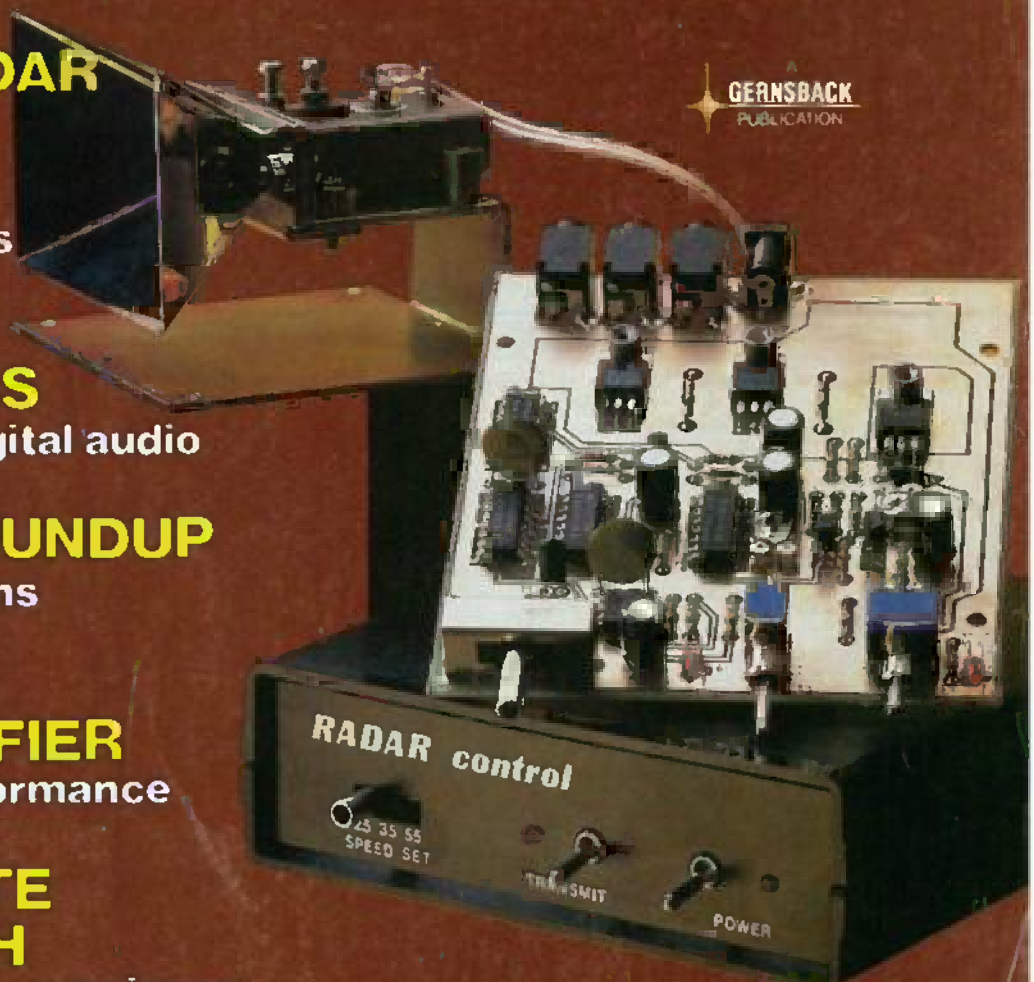

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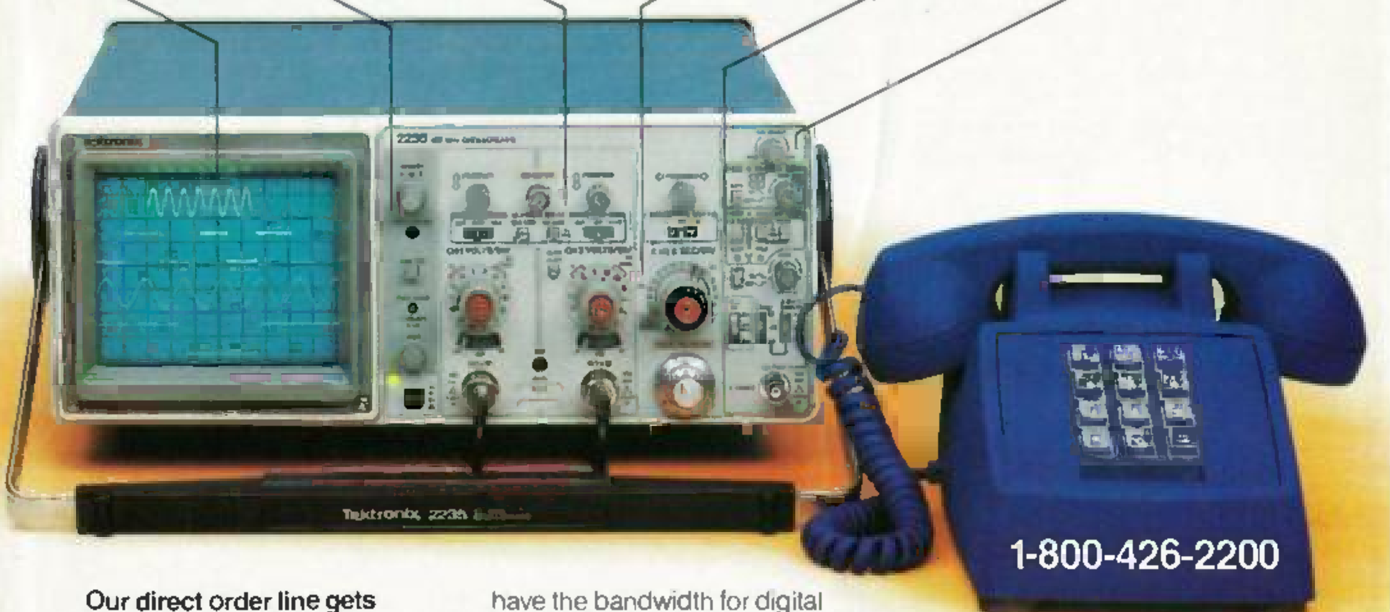

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AUGUST '86

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COVER 1

Here's an easy-to-build instrument for calibrating radar speed guns. Simply set the calibrator's output to 25, 35 or 55 miles per hour, and your radar speed-gun should show the proper reading. A different reading indicates that your speed gun is out of calibration. The calibrator works by outputting a pulsed carrier on either the X or K radar bands. The signal appears to the radar gun to be the reflection of a speeding object.

Even if you have no need for a calibrator, this article is a good way to learn about Gunn diodes and radar technology.

NEXT MONTH

THE SEPTEMBER ISSUE IS ON SALE AUGUST

BUILD A PLANT-WATER MONITOR
Keep your plants thriving.

TV SIGNAL SCRAMBLING
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Radio-Electronics

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Microfilm & Microfiche editions are available. Contact circulation department for details.

Advertising Sales Offices listed on page 108.

NEW! Lower Price Scanners

Communications Electronics,™ the world's largest distributor of radio scanners, introduces new lower prices to celebrate our 15th anniversary.

Regency® MX7000-EA
List price $699.95/CE price $399.95/SPECIAL
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Frequency range: 25-550 MHz. continuous coverage and 800 MHz. to 1.3 GHz. continuous coverage.
The *Regency* MX7000 scanner lets you monitor Military, Space Satellites, Government, Railroad, Justice Department, State Department, Fish & Game, Immigration, Marine, Police and Fire Departments, Broadcast Studio Transmitter Links, Aeronautical AM band, Aero Navigation, Paramedics, Amateur Radio, plus thousands of other radio frequencies most scanners can't pick up. The *Regency* MX7000 is the perfect scanner to receive the exciting 1.3 GHz. amateur radio band.

Regency® Z60-EA
List price $299.95/CE price $179.95/SPECIAL
8-Band, 60 Channel • No-crystal scanner
Bands: 30-50, 88-108, 118-136, 144-174, 440-512 MHz.
The *Regency* Z60 covers all the public service bands plus aircraft and FM music for a total of eight bands. The Z60 also features an alarm clock and priority control as well as AC/DC operation. Order today.

Regency® Z45-EA
List price $259.95/CE price $159.95/SPECIAL
7-Band, 45 Channel • No-crystal scanner
Bands: 30-50, 118-136, 144-174, 440-512 MHz.
The *Regency* Z45 is very similar to the Z60 model listed above however it does not have the commercial FM broadcast band. The Z45, now at a special price from Communications Electronics.

Regency® RH250B-EA
List price $674.30/CE price $329.95/SPECIAL
10 Channel • 25 Watt Transceiver • Priority
The *Regency* RH250B is a ten-channel VHF land mobile transceiver designed to cover any frequency between 150 to 162 MHz. Since this radio is synthesized, no expensive crystals are needed to store up to ten frequencies without battery backup. All radios come with CTCSS tone and scanning capabilities. A monitor and night/day switch is also standard. This transceiver even has a priority function. The RH250 makes an ideal radio for any police or fire department volunteer because of its low cost and high performance. A *60 Watt* VHF 150-162 MHz. version called the **RH600B** is available for $454.95. A UHF 15 watt version of this radio called the **RU150B** is also available and covers 450-482 MHz. but the cost is $449.95.

NEW! Bearcat® 50XL-EA
List price $199.95/CE price $114.95/SPECIAL
10-Band, 10 Channel • Handheld scanner
Bands: 29.7-54, 136-174, 406-512 MHz.
The Uniden Bearcat 50XL is an economical, hand-held scanner with 10 channels covering ten frequency bands. It features a keyboard lock switch to prevent accidental entry and more. Also order part # **BP50** which is a rechargeable battery pack for $14.95, a plug-in wall charger, part # **AD100** for $14.95, a carrying case part # **VC001** for $14.95 and also order optional cigarette lighter cable part # **PS001** for $14.95.

NEW! Scanner Frequency Listings
The new Fox scanner frequency directories will help you find all the action your scanner can listen to. These new listings include police, fire, ambulences & rescue squads, local government, private police agencies, hospitals, emergency medical channels, news media, forestry radio service, railroads, weather stations, radio common carriers, AT&T mobile telephone, utility companies, general mobile radio service, marine radio service, taxi cab companies, tow truck companies, trucking companies, business repeaters, business radio (simplex) federal government, funeral directors, veterinarians, buses, aircraft, space satellites, amateur radio, broadcasters and more. Fox frequency listings feature call letter cross reference as well as alphabetical listing by licensee name, police codes and signals. All Fox directories are $14.95 each plus $3.00 shipping. State of Alaska-**RL021-1**; State of Arizona-**RL025-1**; Baltimore, MD/Washington, DC-**RL024-1**; Buffalo, NY/Erie, PA-**RL009-2**; Chicago, IL-**RL014-1**; Cincinnati/Dayton, OH-**RL006-2**; Cleveland, OH-**RL017-1**; Columbus, OH-**RL003-2**; Dallas/Ft. Worth, TX-**RL013-1**; Denver/Colorado Springs, CO-**RL027-1**; Detroit, MI/Windsor, ON-**RL008-3**; Fort Wayne, IN/Lima, OH-**RL001-1**; Hawaii/Guam-**RL015-1**; Houston, TX-**RL023-1**; Indianapolis, IN-**RL022-1**; Kansas City, MO/KS-**RL011-2**; Long Island, NY-**RL026-1**; Los Angeles, CA-**RL016-1**; Louisville/Lexington, KY-**RL007-1**; Milwaukee, WI/Waukegan, IL-**RL021-1**; Minneapolis/St. Paul, MN-**RL010-2**; Nevada/E. Central CA-**RL028-1**; Oklahoma City/Lawton, OK-**RL005-2**; Orlando/Daytona Beach, FL-**RL012-1**; Pittsburgh, PA/Wheeling, WV-**RL029-1**; Rochester/Syracuse, NY-**RL020-1**; San Diego, CA-**RL018-1**; Tampa/St. Petersburg, FL-**RL004-2**; Toledo, OH-**RL002-3**. New editions are being added monthly. For an area not shown above call Fox at 800-543-7892. In Ohio call 800-621-2513.

NEW! Regency® HX1200-EA
List price $369.95/CE price $214.95/SPECIAL
8-Band, 45 Channel • No Crystal scanner
Search • Lockout • Priority • Scan delay
Sidelit liquid crystal display • EAROM Memory
New Direct Channel Access Feature
Bands: 30-50, 118-136, 144-174, 406-420, 440-512 MHz.
The new handheld *Regency* HX1200 scanner is fully keyboard programmable for the ultimate in versatility. You can scan up to 45 channels at the same time including the AM aircraft band. The LCD display is even sidelit for night use. Order **MA-256-EA** rapid charge drop-in battery charger for $84.95 plus $3.00 shipping/handling. Includes wall charger, carrying case, belt clip, flexible antenna and nicad battery.

NEW! Bearcat® 100XL-EA
List price $349.95/CE price $203.95/SPECIAL
9-Band, 16 Channel • Priority • Scan Delay
Search • Limit • Hold • Lockout • AC/DC
Frequency range: 30-50, 118-174, 406-512 MHz.
The world's first no-crystal handheld scanner now has a LCD channel display with backlight for low light use and aircraft band coverage at the same low price. Size is 1⅜" x 7½" x 2⅝." The *Bearcat* 100XL has wide frequency coverage that includes all public service bands (Low, High, UHF and "T" bands), the AM aircraft band, the 2-meter and 70 cm. amateur bands, *plus* military and federal government frequencies. Wow...what a scanner!

Included in our low CE price is a sturdy carrying case, earphone, battery charger/AC adapter, six AA ni-cad batteries and flexible antenna. Order your scanner now.

Bearcat® 210XW-EA
List price $339.95/CE price $209.95/SPECIAL
8-Band, 20 Channel • No-crystal scanner
Automatic Weather • Search/Scan • AC/DC
Frequency range: 30-50, 136-174, 406-512 MHz.
The new Bearcat 210XW is an advanced third generation scanner with great performance at a low CE price.

NEW! Bearcat® 145XL-EA
List price $179.95/CE price $102.95/SPECIAL
10 Band, 16 channel • AC/DC • Instant Weather
Frequency range: 29-54, 136-174, 420-512 MHz.
The *Bearcat* 145XL makes a great first scanner. Its low cost and high performance lets you hear all the action with the touch of a key. Order your scanner from CE today.

TEST ANY SCANNER
Test any scanner purchased from Communications Electronics™ for 31 days before you decide to keep it. If for any reason you are not completely satisfied, return it in original condition with all parts in 31 days, for a prompt refund (less shipping/handling charges and rebate credits).

NEW! Bearcat® 800XLT-EA
List price $499.95/CE price $317.95
12-Band, 40 Channel • No-crystal scanner
Priority control • Search/Scan • AC/DC
Bands: 29-54, 118-174, 406-512, 806-912 MHz.
The Uniden 800XLT receives 40 channels in two banks. Scans 15 channels per second. Size 9¼" x 4½" x 12½."

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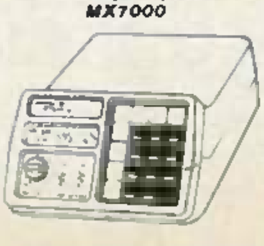

Regency HX1200

CIRCLE 79 ON FREE INFORMATION CARD

WHAT'S NEWS

AM-stereo maker believes Motorola violates FCC rules

Kahn Communications, Inc., a Westbury, NY manufacturer of AM-stereo transmitters and receivers, has filed a complaint with the Federal Communications Commission, requesting an investigation of possible violations of FCC rules by the Motorola Corporation.

Kahn Communications is a competitor of Motorola. A substantial number of AM-stereo broadcast stations in the United States, Canada, and Mexico make use of Kahn equipment.

The complaint was based on measurements of the Motorola equipment, which showed that it exceeded the prescribed bandwidth, and also on a statement that appeared in a brochure bearing the Motorola logo. That passage in question reads: "It is possible to force the system to exceed the FCC bandwidth limits...by a few decibels." FCC rules state that the transmitted signal must meet the occupied bandwidth specifications "under all possible conditions of program modulation."

Motorola's type acceptance, says Kahn, was based on an application that shows measurements up to only 75% modulation, and at frequencies not exceeding 5,000 Hz. While those measurements may account for the acceptance of the Motorola application, they cannot possibly be considered to represent "all possible conditions of modulation;" broadcasters modulate up to at least 100% and to 15 kHz.

Kahn Communications has requested that—if the FCC confirms the violations—Motorola's type acceptance be revoked. That would require all stations using Motorola equipment to discontinue stereo broadcasting and would also require Motorola to immediately cease marketing the broadcasting equipment in question.

Unique electronic device can curb perspiration

A device that will keep people with heavy sweating problems of the hands, feet, or underarms dry for periods of up to six weeks has been announced by General Medical Co. (1935 Armacost Ave., Los Angeles, CA 90025).

NO SWEAT with *Drionics* from General Medical. That device is claimed to stop perspiration for up to six weeks.

Excess perspiration has long been an awkward social problem. In electronics and other high-technology industries it can also cause professional problems—in some industries people who perspire heavily are being banned from many production positions because they present a possible source of contamination.

The device, called the *Drionic*, consists of two metal plates that are placed close together but are insulated from each other. A mild electric current passes from one plate into the skin and from the skin into the other plate. The current tends to inhibit the action of the sweat glands in the skin, essentially plugging them for periods of up to six weeks.

The *Drionic* is available by prescription only.

Amateurs man superstation at Vancouver World's Fair

A state-of-the-art amateur station is one of the features of Expo 86, the World's Fair of Transportation and Communication, held in Vancouver, British Columbia, Canada from May 2 to October 13 this year. The station is in the main hall of the Canada Pavilion, which is dramatically located in a spectacular harbor setting linked to the rest of Expo by a rapid-transit "SkyTrain."

The station operates on all bands, from 1800 kHz (160 meters) through 1.2 GHz, and in all modes, including SSB, CW, RTTY, AMTOR, Packet, FM, ATV, and SSTV. The station's call sign is VE7EXPO. Operation is from 10 am to 10 pm local time daily; it should provide an interesting introduction to amateur radio for many of the more than 13 million visitors expected at Expo 86. A computer system that permits the public to ask questions about amateur radio is also featured.

Station VE7EXPO is manned entirely by volunteer amateur operators, providing not only a massive public-relations opportunity for ham radio, but an information center for many non-local amateurs. Local repeaters on 146.94, 224.30, and 443.525 MHz are monitored. Visiting hams who wish to take part as a group or to arrange contacts for special events may reach the VE7EXPO Amateur Radio Society at 202-13640 67 Ave., Surrey, BC, Canada V3W 6X5. R-E

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1302	2@30v/1a5v5a	299.00
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4050	0-40v/5a	595.00

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GLOBAL		
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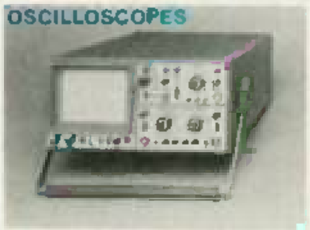

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VIDEO NEWS

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

• **Upsurge for VHS-C.** It now appears that virtually the entire VHS group will embrace VHS-C, the miniature version of the the VHS standard, as a weapon against the 8mm-video system offered by Sony, Kodak, and others. To date, Matsushita (Panasonic and Quasar), Hitachi, Mitsubishi, Sharp, Toshiba, and Zenith, as well as JVC, the developer of both VHS and VHS-C, are backing the format. The action of that group of Japanese manufacturers came in response to pressure from JVC, which warned that adoption of the 8mm format by videocassette recorder manufacturers would deal a serious blow to the dominant VHS system.

Sony insists 8mm is the format of the future, and that it will eventually replace both VHS and Beta. The VHS group, on the other hand, sees 8mm as a threat only in the combination camera-recorder, or camcorder, field. The new, super-miniaturized VHS-C camcorder with the added extended play mode (one hour per cassette) is their answer.

It will be some time before we know which side is correct. Indeed, the industry continues to wonder just how big the camcorder market really is. The VCR came to prominence as the result of its time-shift and movie-showing capabilities. Its viability as a home-photography medium is yet to be proved in the marketplace.

• **Movies for 8mm.** If 8mm video is indeed the all-purpose videocassette medium of the future, as Sony insists, it will need pre-recorded material. Sony and Eastman Kodak have long been wooing the movie people to put their products on 8mm, and finally they have met with some success. Sony has reached agreement with Paramount Pictures and Kodak with Embassy Home Entertainment to release some of their more popular films on 8mm, to retail at about $30.00.

Although initially there will be relatively few films available, both film makers have agreed to release more movies in the future, and both Sony and Kodak are using these new agreements as pump-primers to lure more programmers into the 8mm medium.

• **Happy VCR owners.** In the 10 short years it's been on sale, the VCR has seemingly become a household necessity. A new survey by the Electronics Industry Association (EIA) asked 2,749 VCR-owning families what they'd do if their recorders should fail "beyond repair." About 95% said they'd buy another.

Based on that response, and the responsibilities to its other questions, the survey indicated that a large replacement and second-VCR market is developing. Some 37% of all households surveyed said they planned to buy VCR's in 1986; that included 41% of non-owners and 32% of those who currently own VCR's. Some 17% of VCR owners bought a second machine in 1985. In a typical week the average household uses its VCR for 8.1 hours of recording and 9.3 hours of playback. (The playback of purchased or rental prerecorded videotape accounted for the discrepency between those two figures.)

About 7% of VCR's receive service in the first year after purchase, 43% within the first 5 years—but 39% of all repairs were made without charge to the owner, presumably because the units were under warranty.

Of the VCR's requiring service, head cleaning was the most common reason (cited by 32% of VCR owners), followed by repair of the rewind mechanism (by 15%), head replacement (by 11%) and audio repair (by 9%).

• **Stereo-TV survey.** Another survey, this one by the National Association of Broadcasters, queried 200 TV stations that are broadcasting with multichannel TV sound. It found that 74% were broadcasting network stereo programs, averaging nine hours weekly; 63.5% were broadcasting syndicated stereo programming, averaging 5.1 hours; and 47% were putting on their own local stereo programming, averaging 5.6 hours.

On the other hand, the survey found that only 8.5% of stations were making use of the Secondary Audio Program (SAP), although another 16.5% said they planned to start using SAP "in the near future." The most common application of SAP was for bilingual programming.

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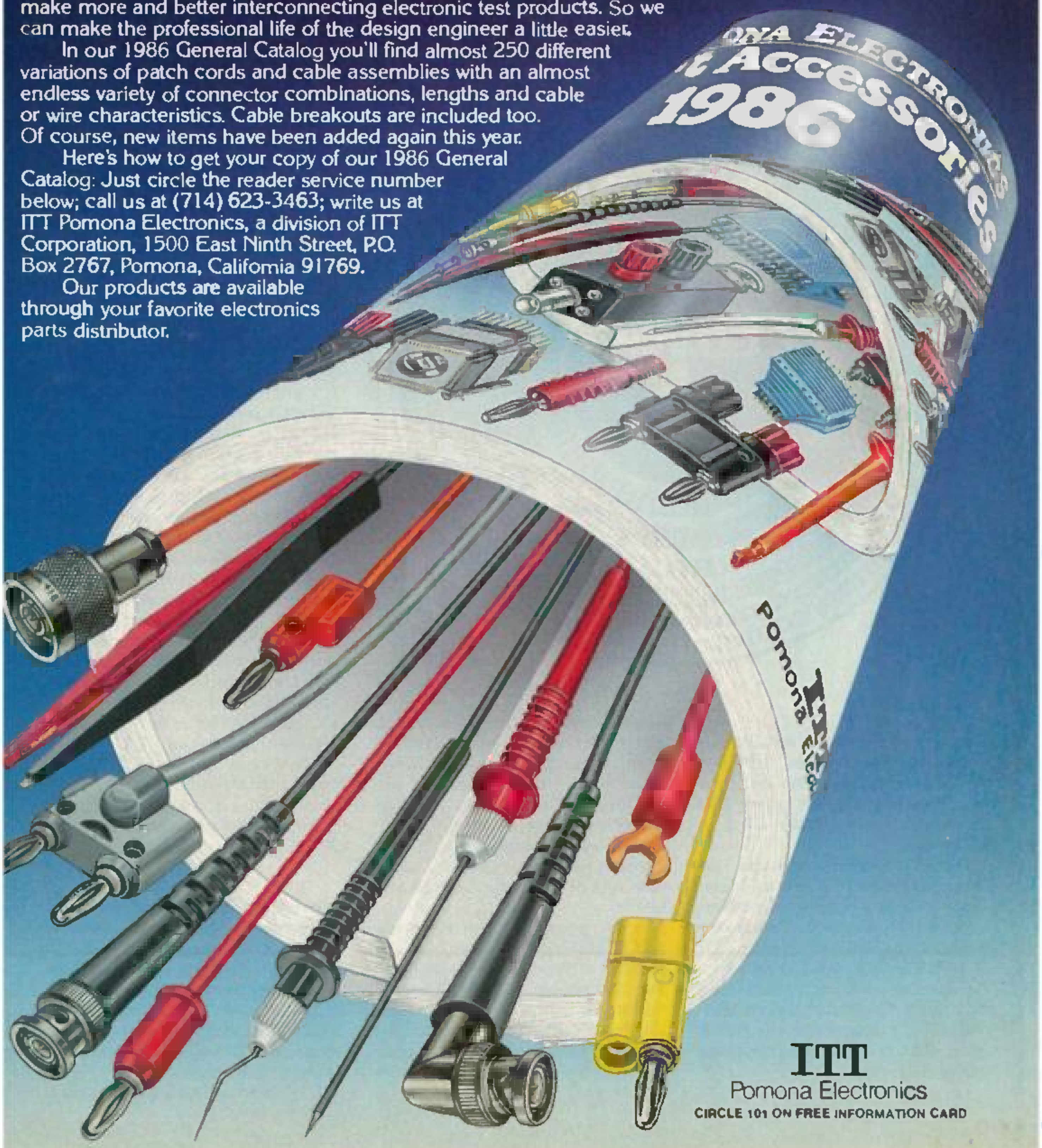

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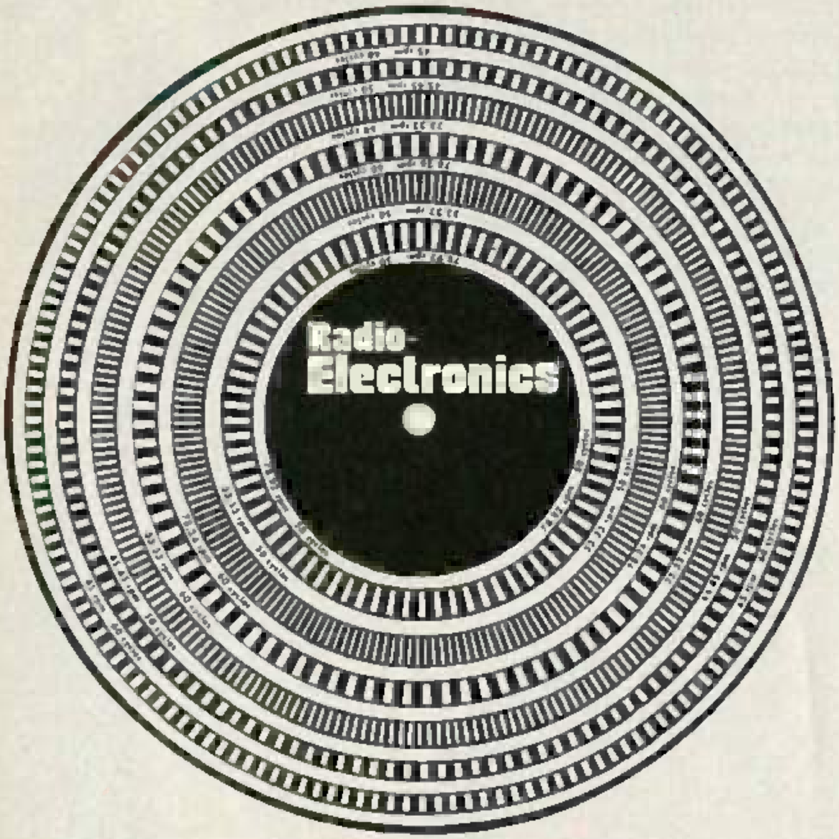

FIG. 1

SIMPLE STROBOSCOPE

Please print the circuit details for a simple hand-held strobe light that can be used for checking the speed of a turntable. Dealers in my area don't stock a useful strobe.—R. J. E., Delta, OH.

Here's a stroboscope you can throw together in a few minutes. You can use a commercial neon-lamp tester or you can assemble your own by wiring a 220K resistor in series with an NE-2 lamp and a 117-volt line cord. For convenience and safety, assemble the components in a plastic tube; the barrel of an old felt-tip or ball-point pen will serve nicely.

If your turntable has stroboscopic markings around its perimeter, you're all set. Otherwise, cut out the disc shown in Fig. 1 and mount it on a piece of stiff cardboard. Our disc has markings for RPM's of 33⅓, 45, and 78, and it can be used in both the U. S. and Europe, because it contains separate sets of bands for both 50 and 60 Hz.

Apply power to your turntable and hold the neon-tester near the band of interest. The markings on the disc should appear to be stationary, or very nearly so. Use your turntable's speed control to adjust speed so that the markings appear perfectly still. That's all there is to it!

COMPOSITE VIDEO FROM RGB INPUT

Is there a simple circuit for deriving a composite-video signal from a computer's RGB output? I'd like to feed the composite signal into a VCR.—R. W. L., Pittsburgh, PA.

The MC1377 color-television RGB to PAL/NTSC encoder IC from Motorola should give you a good start. It generates a composite TV signal from baseband red, blue, green, and sync inputs. It is ideal for encoding signals from color cameras and graphics generators. It appears that all you must do is provide a source of composite-sync signals that will be combined with the encoded video to produce the composite-video output.

I haven't located an IC to generate the composite sync; perhaps a reader can help. In the meantime, you might experiment with using an old TV set as a sync generator. Some of the older tube-type models had excellent sync separators. Horizontal and vertical sync signals stripped from an off-the-air TV signal should be more than stable enough for your VCR.

For a copy of the MC1377 data sheet and information on the availability of the IC, write to Motorola Semiconductor Products, P.O. Box 20912, Phoenix, AZ 85036.

BALUN FOR TV RHOMBIC

I am using a rhombic antenna to receive two TV stations. Reception is good but I believe that it will improve if I improve the match between the antenna and my 300-ohm transmission line. How do you make a balun that matches a 600-ohm antenna to a 300-ohm line?—T. P. L., Sturgis, Saskatchewan.

The balun will be a quarter-wave

section of transmission line having a characteristic impedance equal to the square root of the product of the two impedances it is to match. In other words,

$$Z_B = \sqrt{Z_A \times Z_L}$$

where Z_B is the impedance of the balun, Z_A is the impedance of the antenna, and Z_L is the impedance of the line to the TV set. So:

$$Z_B = \sqrt{300 \times 600} = 425\Omega$$

The characteristic impedance (Z_O) of an air-insulated (open-wire) parallel-conductor line is:

$$Z_O = 276 \log (b \div a)$$

where *b* is the center-to-center spacing between the conductors and *a* is the radius of the conductors. Also, *b* and *a* must be measured in the same units.

To solve the equation, you'll need a wire table and a table of common logarithms. For your specific case, you can use 14-gauge wires spaced 1¼ inch apart, or 12-gauge wires spaced 1½ inch apart, 10-gauge wire spaced 2 inches apart, or ¼-inch tubing spaced 4½ inches center-to-center.

The balun should be one-quarter wavelength long at the desired frequency. Allowing for a velocity factor of 0.90, the quarter-wave section will be 2656/*f* inches, where *f* is the center frequency of the desired channel (in megahertz). The section will be approximately 41 inches for a low-band TV rhombic, 14.25 inches for a high-band rhombic, and 4.25 inches for a UHF rhombic.

If you want to build either a single- or a multi-channel balun, Fig. 3-*b* and Fig. 3-*c* should give you a few ideas. You'll have to use spacers of some sort to hold the conductors apart. The spacers can be cut from any suitable insulating material such as fiberglass, polystyrene sheets, rods, or tubing, bamboo rods, or wooden dowels that have been waterproofed with several coats of shellac or polyurethane varnish. The wires can be passed through drilled holes or laid in slots cut in the spacers.

The size, weight, and strength of the spacers, as well as the wire diameter are interrelated. Spacers that are too heavy can stretch the wires or cause them to break in bad weather. Similarly, large diameter conductors will soon snap spacers that are too light. One good combination is to use 14-gauge wire for the conductors and spacers made from ¼-inch dowels or plastic rods.

For a single-frequency balun, the distance between spacers is not critical, but there should be enough spacers so that the wires do not change position as the transmission line sways in the wind.

A multi-frequency balun is more difficult to build. The space between the wires will be difficult to hold unless you put spacers about an inch or so apart. Even so, it may be hard to hold to an exponential curve.

So, you may do as one transmission-line maker did in the early days when TV stations were few and far between, and most TV viewers were DX'ers. Take a sheet of acrylic plastic or polystyrene that is about ¼ inch thick, 6 inches wide and 55 inches long. Lay out the exponential curves and anchor the wires along them with a heavy application of plastic cement. R-E

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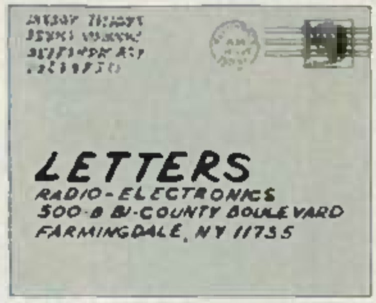

TESLA SYMPOSIUM

This is to inform your readers that the 1986 International Tesla Symposium will commemorate the 100th anniversary of Nikola Tesla's first U. S. patent; the patent was for an electric arc lamp. The symposium will provide a forum for the review and exchange of ideas pertaining to the many concepts that Tesla developed and patented. Topics to be discussed include: Tesla's life and times; electromagnetic theory; the tesla coil and high-voltage power-supply design; electric power generation and transmission; radio and telecommunications; lightning, weather and geophysical phenomena; ball lightning; nucleur fusion containment; Tesla turbine technology; curl-free magnetic vector potential (the ability to penetrate Faraday-shielded systems; see "Gravity Waves?" in the April 1986 issue of **Radio-Electronics** for more information); Ampere-Neumann theory of conduction in metals; aerospace and defense applications; social implications of Tesla technology.

The symposium will be held from July 30 to August 3, 1986 at Colorado College, Colorado Springs, CO. For additional information contact The International Tesla Society, 330-A West Uintah Street, Suite 215, Colorado Springs, CO 80905-1095.

TOBY GROTZ, CHAIRMAN
1986 International Tesla Symposium

GRAVITY WAVES

This letter is in response to the article, "All About Gravity Waves," by Gregory Hodowanec, in the April 1986 **Radio-Electronics**. I read that article with interest. Careful scrutiny and further research has led me to some very basic disagreements with the author.

If the cosmology described is indeed a true representation of reality, then several questions arise:

1. If the edge of the universe is a perfect reflector, and if the sum total of the background flux in the universe gives rise to the background microwave temperature of 3° K, then, because of the multitude of fusion and fission reactions in the universe at all times, the background temperature should be increasing. No evidence of that rise in temperature can be proven at this time.

2. Which type of monopole does the circuit described in the article measure? There are two known types of monopoles: positive and negative. Due to the alignment of C1 in the input, the circuit detects positive monopoles.

The basic flaw in Mr. Hodowanec's theory is that, because he has chosen an inverting circuit, the output is 180 degrees out of phase with the input. He is, therefore, actually measuring "anti-rhysmons."

After building the device and performing rigid tests, the data was examined by several colleagues and me. The data was as described in the article. However, when two such circuits were built and placed some distance apart, and the two outputs were examined on a dual-trace oscilloscope, the modulating waveforms were not the same. That indicates that Hodowanec's measurements were off, and that the monopole gravitational waves are in a much smaller grid pattern than he described.

Those findings, along with the work done in Rohnert Park and

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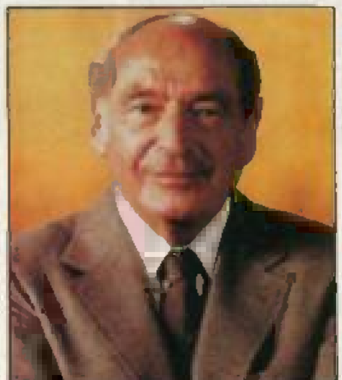
(It is important that anyone wishing to start a diet program consult his or her physician.)



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Santa Rosa by Professors Frank Nance, Brian Ekias, Jay Johnson, and John Macri support the hypothesis that, in order to prove Hodowanec's theories, not only must the logical complement be proven, but the entire concept of 1/f noise must be disproven without any doubt.

Further thought leads to the idea that gravitational waves can be transmitted and that they can be modulated to produce intelligent signals instantaneously at all places in the universe at any time. That would solve many of today's communications problems and would open up an area of intergalactic monopole gravitational-wave propagation theory. Among the questions to be discussed are: what would the antennas look like? What kind of attenuation takes place at various distances from the antenna? The antenna, of course, would be called a "Monopolic Rhysmonic Gravitational-Wave Transducer."

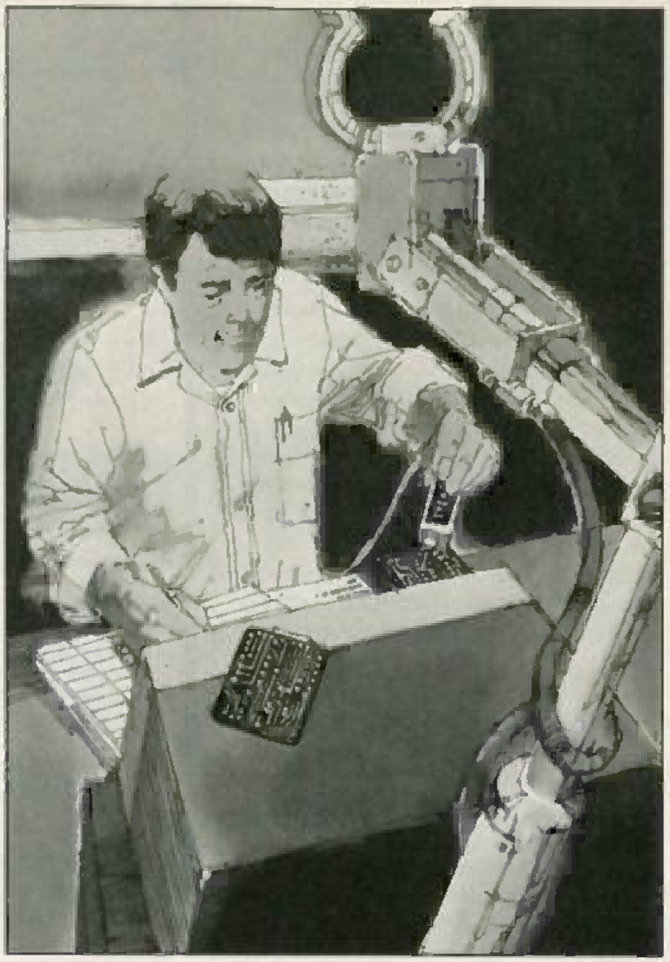
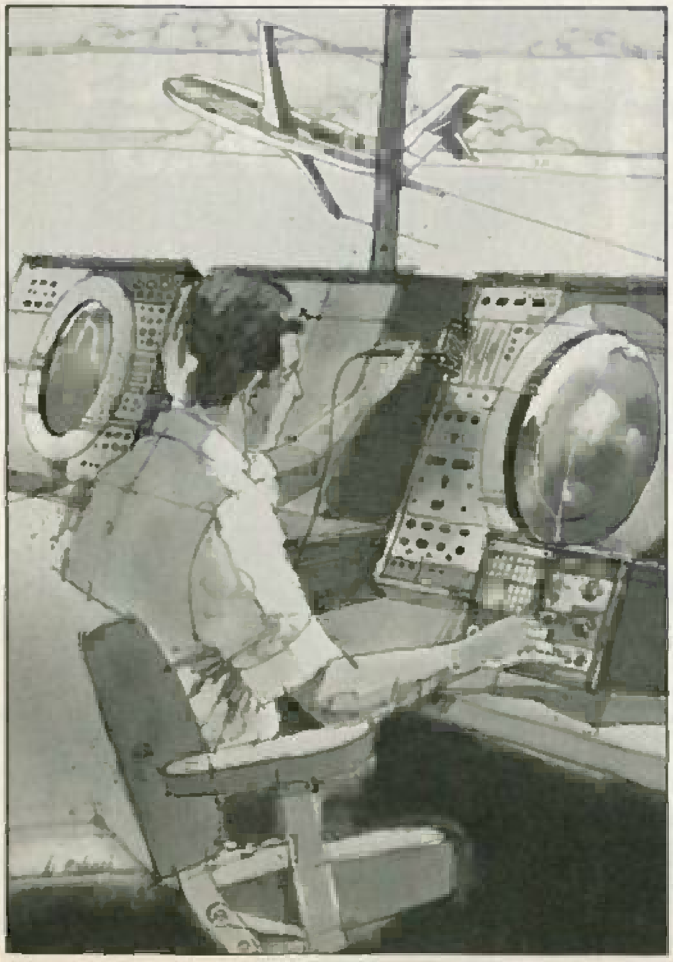
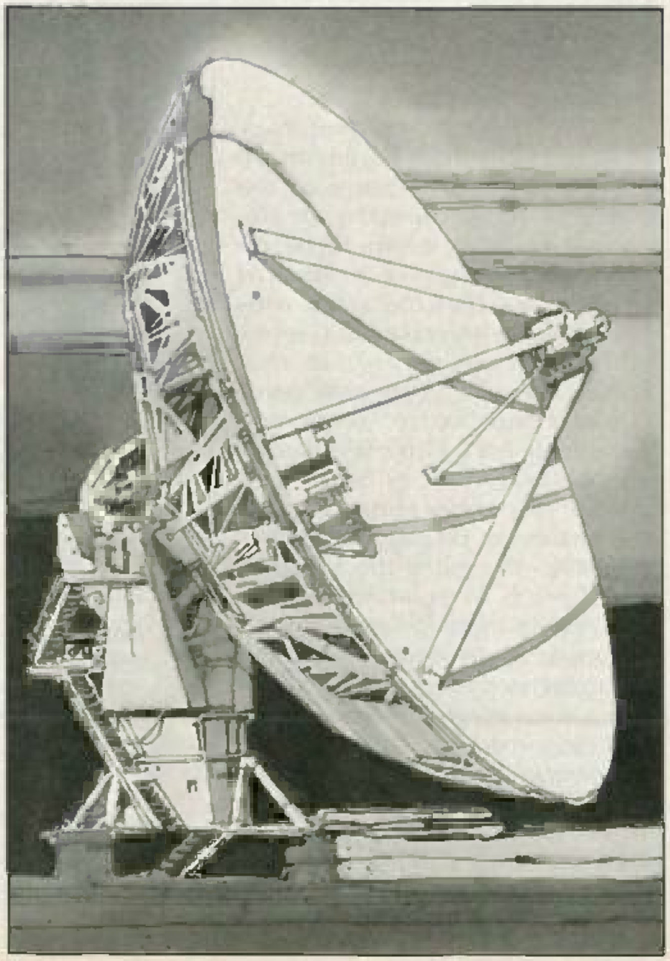
I hope that my research has shed some light on the weighty topic of gravity waves. Remember that the difference between brilliant and crazy is often no more than the Nobel Prize.

JIM STERN
Petaluma, CA

While rhysmonic cosmology does not deny that the microwave background temperature of the universe could increase (or decrease) in time, it should be remembered that in terms of rhysmonics that radiation processes in the universe are 1) reversible to some extent, in that radiation could create new particles and thus "freeze" some radiant energy back into mass, and 2) electromagnetic energy "degrades" to a cooler temperature in the process of propagating in this universe. Therefore the universe could reach an equilibrium state and remain there for eons.

Simple audio stereo-type tests, using two detectors (operating under similar electrical conditions) will demonstrate a large measure of correlation between the detectors. Since the detectors have a fine "pencil-width beam response," they can detect other effects when widely spaced. A

continued on page 20

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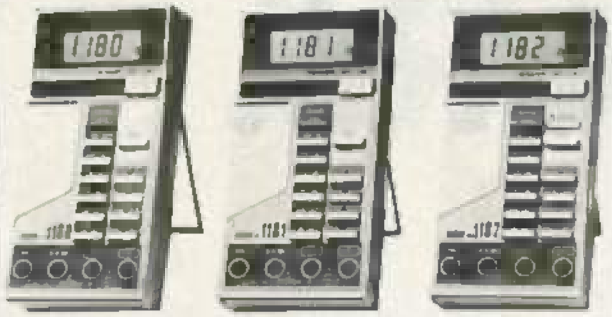


more definitive correlation experiment can be performed with two detectors, A and B and a CMOS switch. The switch is used such that detector A is switched on by a pulse from detector B and vice versa. The outputs are fed to a difference amplifier. Under such conditions, full correlation between the 1/f signals would result in no output from the difference detector. In practice, somewhat less than full correlation is seen due to the extreme resolution of the detectors, and the highly random nature of the gravity waves.

Gravitational signal communications are closer than you think. Feasibility on a laboratory scale has already been demonstrated by the author.—Gregory Hodowanec

EGO BUSTER

The April 1986 issue of Radio-Electronics was an ego buster. I think I was had three times. Always liking physics, I read the article about gravity waves with great interest, because the ideas discussed there seemed in line with rumors about transmitting signals with curved transmission patterns, and other rumors about high-voltage capacitors (with electronic bleeder circuits) that re-charge to a high voltage after being discharged. The explanation of the latter phenomenon is dielectric absorption (DA), true cap leakage, and the effect that the sea of 60-Hz electromagnetic waves we live in has on the plates of the capacitor.

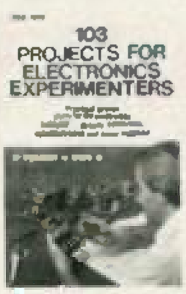
The article about co-photon absorption at first had me until I remembered my blow-up-the-universe theory, which states that if light has infinite mass, then if you could stop light dead in its tracks, you could release infinite energy. One could point to black holes, but to learn the history of astronomy you see that it has been been a comedy of errors as formulae were developed to describe the motions of the stars and the planets.

Our universe is amazing and I believe that *the* universe has a medium faster than light.

Thinking about gravity was interesting. Force = Mass × Acceleration. $P = I \times E$, $P = I^2R$, $E = MC^2$. It's truly amazing.

W. WEST
Minneapolis, MN

Radio-Electronics mini-ADS



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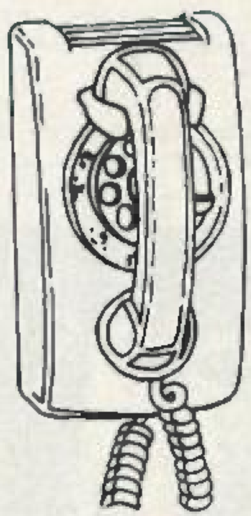

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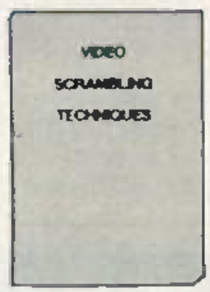

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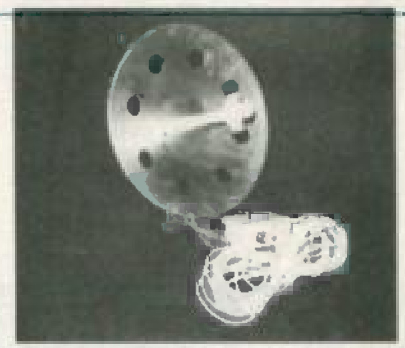

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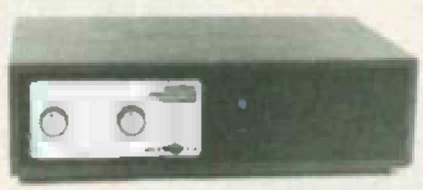

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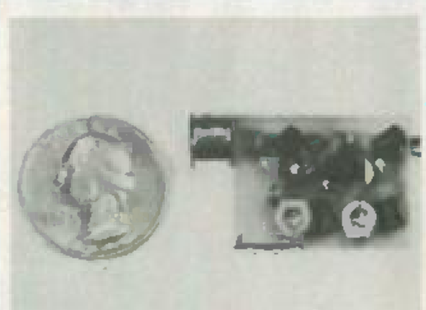

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EQUIPMENT REPORTS

B + K Dynascan TTL IC Tester

Test TTL IC's in circuit.

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THANKS TO AN EXCITING NEW DEVICE from B + K Dynascan (6460 W. Cortland St., Chicago, IL 60635), the prayers of those that regularly troubleshoot and service digital equipment have just been answered. That new device is the model *550* TTL IC tester, a compact, easy-to-use hand-held instrument that can also serve as a 20-pin logic monitor. It is capable of testing, in circuit, most 54- and 74-series TTL devices including standard TTL, Schottky, low power Schottky, advanced Schottky, advanced low-power Schottky, high speed, and *FAST* families. The model *550* has a retail price of $395.00.

When used as a logic monitor, the unit indicates the logic state of each pin of a TTL IC with 20 or fewer pins. A logic high is indicated by turning on an LED; a logic low is indicated by turning off an

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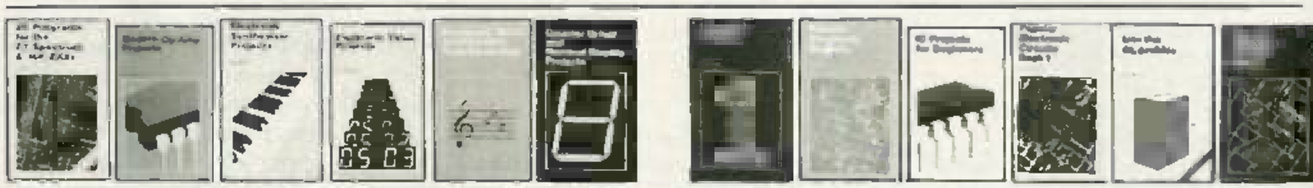

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LED. The advantage of the model *550* over a standard logic probe is that the former can monitor the states of all pins of a device simultaneously and continuously. That, of course makes for much faster troubleshooting.

However, the true power of the unit is as an in-circuit TTL-IC tester. The tests are made by comparing the logic states of the suspect device with those of a known good reference IC. If all of the logic states are the same, a GOOD LED indicator lights. Otherwise, individual LED indicators light to show the user which pins do not match.

The advantages of being able to test IC's in circuit are obvious. First, the risk of damaging the IC or board during removal or re-installation of a device is eliminated. Second, troubleshooting is made much faster if the time required to remove and re-install each suspected IC is saved.

The unit does not use batteries or an AC adapter. Instead, it draws power from the circuit in which the IC to be tested is located. Connections are made to +5 volts and ground via permanently attached red and black test clips, respectively. If the power exceeds +5 volts, or the polarity of the connections is reversed, the tester will not turn on.

The advantage of that power set up is, since there are no batteries, there are no dead-battery problems to deal with. However, there is a down side. The tester's current requirements are low, on the order of 125 mA, but there may be instances where that draw exceeds what the circuit-under-test's already-loaded power supply can provide. The only recourse then is to hook a second +5-volt supply in parallel with the first. On a bench, that should present little more than an inconvenience. In the field, it might turn out to be an impossibility. Fortunately, unless you are dealing with a poorly-designed circuit or system, situations where power supplies are taxed so severly do not come up often.

Using the tester

Assuming the IC follows the convention of V_{CC} at the last pin of the second row (i.e. pin 14 in a 14-pin DIP, pin 18 in an 18-pin DIP, etc.) and ground at the last pin of the first row (i.e. pin 7 in a 14-pin DIP, pin 9 in an 18-pin DIP, etc.) set up is a simple procedure. Just connect the tester to power and ground and attach the appropriate IC clip to the IC to be tested.

Two such IC clips are provided. One is for use with IC's of 20 pins or less; the other, which is especially designed for use in close quarters, is for IC's of 16 pins or less. In even closer quarters, however, it is possible that neither clip will serve. The manufacturer has provided in the manual (which, incidentally, was very well done) a source for compatible clips for those instances. Next, select the appropriate package type (14, 16, 18, or 20) using the row of pushbuttons located at the bottom of the front panel. Then press the TEST switch. If the GOOD LED lights, you can proceed with the testing.

Note that a GOOD indication at that stage (before a reference IC has been placed in the tester)

merely indicates that some connection between ground and the IC clip has been established. It is not a fail-safe confirmation that all connections have been made properly. To be sure connections are made correctly, the clip should be attached carefully, but firmly.

To use the unit as an IC tester, a known-good reference IC must be placed in the *Z*ero *I*nsertion *F*orce (ZIF) socket located at the center of the front panel. Be sure to use only an identical IC. Do not choose a functionally equivalent IC from a different family. For example, when testing 7402, do not use a 74LS02 as the reference IC.

Once the reference IC is secured in the ZIF socket, the test is performed by pressing the TEST button once again. If all logic levels at the test and reference IC's match, the IC is OK. That is indicated by a lit GOOD LED. If the logic levels don't match, the IC is defective. In that case the GOOD LED remains dark, but individual LED's at each pin indicate where the mismatches have occurred.

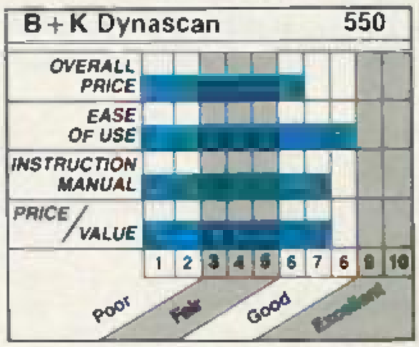
If you are using an IC that does not follow the power/ground pin convention as previously discussed, one additional step needs to be performed. That is to set the tester to accept non-standard power and ground pins. That is done using a pair of DIP switches located at the top of the unit's front panel.

Use as a logic monitor is even easier. Simply connect the tester to power, place the clip on the IC to be monitored, and press the LOGIC/LED TEST switch. No reference IC should be used.

Limitations

As you might expect, the *550* is not without its limitations. Those are clearly spelled out in the excellent instruction manual that accompanies the tester. First of all, sequential logic devices present more of a problem for the tester than do combinational logic circuits. That's because combinational circuits usually change outputs simultaneously (for all practical purposes) with changes in inputs. In sequential devices there is usually a built-in delay of some type. For a sequential device to be tested using a logic comparator technique, which is the technique used by the *550*, the device under test and the reference device must be synchronized and contain the same data.

Further, as outlined in the manual, there are many conditions that could cause incorrect results. For instance, the tests should be performed under dynamic conditions. That is, all inputs and outputs should be changing. Other conditions or factors that could affect testing include open-circuit outputs, the presence of external timing components, and loading beyond rated fan-out. Also, the nature of the device itself must be considered in doing the tests. For instance, if a counter or flip-flop does not test good at first, all that may need to be done is to reset the device. Other types of devices present more serious obstacles; potential trouble spots are open-collector devices, three-state devices, edge-triggered devices, and storage devices.



On the whole, however, we liked the unit. It has some limitations, but those are outweighed by its usefulness, especially to those involved with the troubleshooting and repair of digital circuits. Our only complaints, and they are relatively minor, are the potential problems that could arise from the power-supply scheme used and the use of DIP switches for configuring the tester for non-standard IC's; this reviewer finds those switches an inconvenience.

Note that the *550* will not test CMOS devices. For those, Dynascan has another model, the *552* CMOS IC tester; that unit was not reviewed by us.

The model *550* is covered by a one-year warranty. R-E

IF YOU'VE BEEN LOOKING FOR A CONVENient, portable PA system, or a way to bring your stereo system outdoors, or for a way to play your electric guitar at the beach, you'll want to take a look at the *WTS-1* wireless speaker system from Nady Systems, Inc. (1145 65th Street, Oakland, CA 94608).

The *WTS-1* consists of two wireless amplifier/speakers, (which we'll call wireless speakers) and a stereo transmitter with microphone. The system has a range of about 100 to 200 feet.

Wireless amplified speakers

The wireless speakers, model *WS-2*, are housed in sturdy, vinyl-covered particle-board cabinets that are obviously designed to take a beating. Each wireless speaker consists of three sections: the receiver, the amplifier, and, of course, the speakers. The receiver section of the *WS-2* has switch-selectable frequencies of 49.830 MHz or 49.875 Mhz. As you might expect, those frequencies correspond to the transmitter's outputs.

The amplifier section has a power output of 15 watts into 4 ohms with a THD rated at 1% (at full power). The rated signal-to-noise ratio is greater than 60 dB, and the frequency response is 40 Hz to 15 kHz. Obviously, the system is designed more as a PA system than for hi-fi reproduction. However, we don't really think that's a problem. We think that these speakers will probably be used most at outdoor parties, etc., where high fidelity is not of the greatest importance. The speaker section consists of a 6½-inch woofer and a 1¼-inch cone-type tweeter.

The *WS-2* wireless speakers are not limited to receiving and amplifying 49-MHz signals; they can also can be used as PA systems or musical-instrument amplifiers. They accept low-level signals (from, for example a microphone or electric guitar) through its MIC jack, and they also accept line-level inputs (from a tape deck) through its LINE IN jack. If signals are applied to both input jacks, they will be mixed automatically.

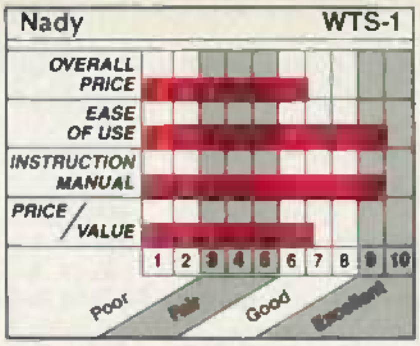
Each wireless speaker features volume, tone, and squelch controls. The squelch control, if used properly, is very useful for eliminating the background hash that's inherent in 49-MHz systems.

There are six LED's on the front panel: One LED indicates that power is on. A TXON LED indicates that a signal is being received from the transmitter and a bank of 4 green LED's indicate the amplifier's output power. As you might expect, the speaker also includes a telescopic rod antenna.

The *WS-2* can be powered by eight "D" cells, 12 volts DC from, for example, a car's electrical system, or by 12 volts AC from the supplied wall transformer. That transformer can also be used to charge internal Ni-Cd batteries; the *WS-2* includes overcharge-protection circuitry.

FM stereo transmitter

The WLT wireless stereo transmitter has an output power of 40 mW (or a field strength of 30,000 microvolts/meter at 3 meters), which is the maximum output allowed by current FCC regulations. Two transmitter frequencies are switch selectable: 49.830 and 49.875 MHz. A three-position slide switch allows operation at either—or both—of those frequencies.



Unless stereo operation is a must, only a single output should be used. That's because the transmitter draws double the current in the stereo mode, and you will be forced to use the 9-volt DC wall-mount adapter instead of a battery.

The transmitter is pocket-sized (about 2½ × 4¼ × 1¼ inches) and weighs just over ½ pound. The belt clip makes it comfortable to wear. A lavalier microphone is included. (Lavalier microphones are inconspicuous chest-mounted pickups.) The transmitter, like the wireless speakers, accepts either line-level or low-level inputs. So the system can be used as a way to free an electric-guitar player from his amplifier cable.

If signals are applied to both inputs, they can be mixed using the transmitter's VOLUME control (which affects only the low-level input). A small patch cord allows you to input stereo signals from line-level sources.

The Nady *WTS-1* wireless speaker system lives up to the claims of its manufacturer. Because of its less-than-Hi-Fi performance, we wouldn't recommend it as a way to add an extra set of speakers to your stereo system. But we think it works great as a portable PA system. It's also an excellent way to set up stereo speakers for those summer outdoor parties and barbecues. The speakers' 15-watt outputs hold up very well outdoors.

One drawback of the system is that it cannot be AC-powered outdoors. (The adapters are UL approved for indoor use only.) We think that Nady should have included on-board power supplies in their speakers. (We don't particularly care for those cumbersome wall-mount transformers anyway.) The system's 100- to 200-foot range should be sufficient for most applications. The *WTS-1* system sells for $299. The individual components are also available separately. R-E

NEW IDEAS

Simple cable tester

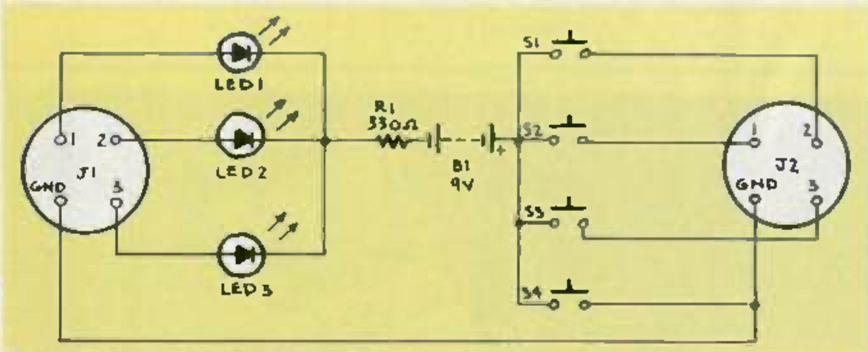


FIG. 1

AS ANY BROADCAST OR RECORDING engineer knows, microphone and other cables have a tendency to give out just when you need them most. Of course you can field-test a cable before a recording session or concert is supposed to begin, but by then it may be too late. It would be better to test all cables before laying them out and hooking them up. That's why I built the simple cable tester described here. I use it primarily for audio applications, but it could be adapted for use anywhere reliable cabling is a necessity—video circuits, computer circuits, etc.

As you can see in Fig. 1, the circuit is a continuity tester. Two jacks are provided that match the ends of the cable to be tested. An LED and a separate momentary switch are wired in series with each line. A separate switch (S4) is provided to test for a ground-line fault. With the cable to be tested plugged in, switches S1–S3 are pressed one at a time. If the corresponding LED lights up, that conductor is good; if the LED doesn't light up, that conductor probably has an open circuit. Switch S4 helps determine if a conductor is shorted to a connector's housing. When you press S4 (with no other switch depressed), no LED should light; if one does, there is a short.

The tester can also be used to indicate whether a cable is correctly wired. If, for example, switch S1 is pressed, but LED2 lights up, two or more conductors have been wired incorrectly.

When testing a cable, it's usually a good idea to flex it near any connectors and splices while watching the LED's. If an LED blinks, that cable has an intermittent that *could* cause trouble, and probably *will* cause trouble at an inopportune moment.

Construction

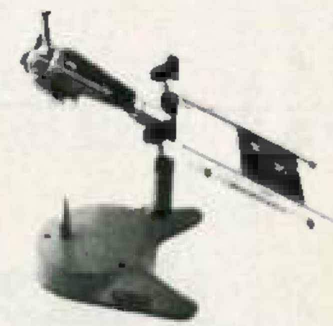
You can build the tester in any convenient enclosure. If your jacks are the non-insulated type, be sure to insulate them from any metallic chassis or cover plates, or the ground-fault test circuit won't work properly. It's probably best not to use slide switches, because if more than one switch were on at the same time, an erroneous reading could result. But you could use a rotary switch. Any common junkbox parts should suffice for the other components.

To increase functionality of the tester, you could wire a number of different jacks in parallel so that you could test a number of different cables with one tester. Just label each connector and switch clearly.—*Roger Doering.*

NEW IDEAS

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

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



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The model *FX-7000G* has a suggested retail price of $69.95.—Casio, Inc., 15 Gardner Road, Fairfield, NJ 07006.

CLOSE-FIELD PROBE, the model *HP 11940A*, is a calibrated magnetic-field sensor that helps locate sources of electromagnetic emission and makes repeatable measurements from 30 MHz to 1 GHz.

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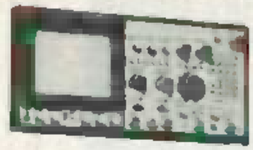

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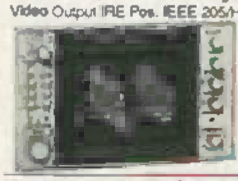

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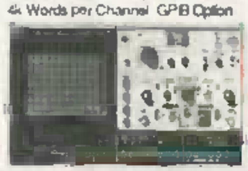

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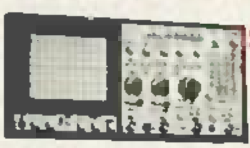

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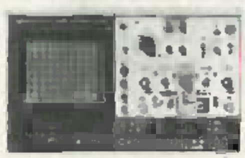

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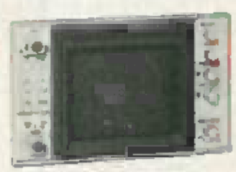

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ated field of an emission is sensed magnetically by the probe, which is passive, so it does not require a power supply.

The probe can also be used as a localized magnetic-field source for indentifying susceptibility problems. A voltage fed into the probe creates a small magnetic field at the loops. For that application, the maximum input power is 0.5 watts.

The model *HP 11940A* is priced at $500.00.—**Hewlett-Packard Company**, Inquiries Manager, 1820 Embarcadero Road, Palo Alto, CA 94303.

SPEAKER ENCLOSURE, the *SpeakerMates IV,* made of Acoustifoam™, is designed for 4" round speakers. A 5" passive radiator is optional. The passive radiator version offers about 3 dB more low-frequency output (a 50% improvement) and about ⅓-octave deep-base extension.

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The standard model lists for $29.95, and the passive radiator model for $39.95.—**SpeakerMates**, 129 S. E. 9th Street #5, Bend, OR 97702.

DMM, the model *3430,* is a 4½-digit, hand-held, multi-function instrument with 13 different functions and three operating modes. It is a 25,000-count instrument, which allows full 4½-digit resolution to the second decimal place for readings such as 240.15 volts AC. The unit measures true rms for both AC voltage and current.

Special features include: a relative mode that uses the input applied when that mode is selected as a zero reference point for subsequent measurements; digital display of dBM values referenced to 600 ohms (1 mW is 0 dBM); autoranging, manual, and, for fast survey measurements, 3½-digit modes; data hold; peak hold; temperature measurement with external probe; 100 kHz frequency counter; diode test; and audible continuity checker.

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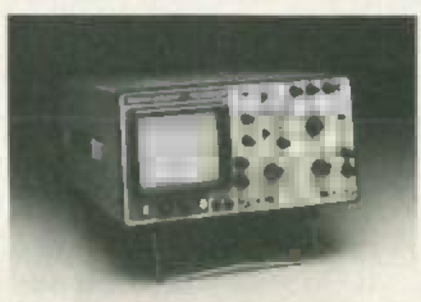
The model *3430* is priced at $339.00. The model *3450* is similar except that its AC measurements are based on average, not rms values, and the meter has no peak hold and temperature measurement capabilities. The model *3450* lists for $299.00.—**North American Soar Corp.**, 1126 Cornell Avenue, Cherry Hill, NJ 08002.

OSCILLOSCOPE, the model *9020,* is a compact, dual-trace oscilloscope with a maximum speed of 50 nanoseconds per division



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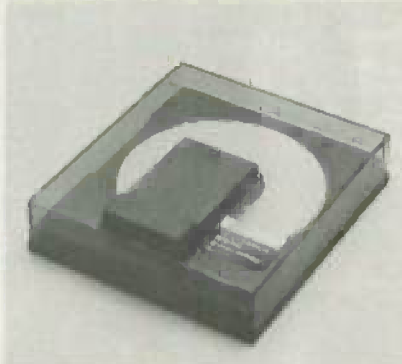
and 1 millivolt per division sensitivity. The six-inch CRT provides a variety of displays: channel 1 only (normal or inverted), channel 2 only, alternate, chop, or channel 1 plus channel 2. An XY feature has been incorporated into this model as well as a "hold-off" feature, which maintains a stable, easy-to-read display. The model *9020* is priced at $495.00 (suggested retail), including operations manual and two ×1/×10 probes.—**Beckman Industrial Corporation, 630** Puente Street, Brea, CA 92621.

COMPACT DISC CLEANER, the model *AT6030*, is designed to keep compact discs in immaculate playing condition while preventing accidental surface damage. The disc to be cleaned is placed label-side down on the system's turntable. A hinged, transparent dust cover is then closed, and a slide lever on top is moved back and forth. Each movement rotates the disc about 30°. As the disc revolves, it makes gentle contact with a soft, specially-constructed cleaning pad.



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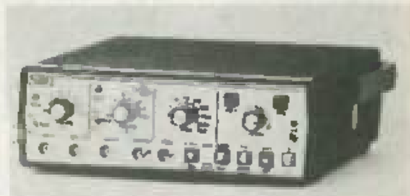
The motion is repeated until the disc makes a complete revolution.

A fine-bristled brush, included, is used to remove dust and dirt from the pad, and an extra pad is included, permitting replacement when the original becomes soiled.

Although the system is used dry, a special cleaning fluid and cleaning paper are included for careful hand treatment of especially obstinate dirt and spots. The model *AT6030* is priced at $27.95.—**Audio-Technica U.S., Inc.,** 1221 Commerce Drive, Stow, OH 44224.

DUAL-TRACE SCOPE MEMORY, the model *602*, is an add-on device that converts an analog oscilloscope into a dual-channel digital storage scope. Easily connected to any standard dual-channel scope, the unit is an economical alternative to the purchase of a complete new scope.



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The model *602* stores both analog and digital signals in a single sweep. It features 18 selectable sample times with a 1.4-MHz maximum sampling rate. Each input is selectable in 8 ranges and a 2K memory for data storage.

The model *602* is priced at $895.00.—**Sibex, Inc.,** 3320 U.S. 19N, Suite 410, Clearwater, FL 33519. R-E

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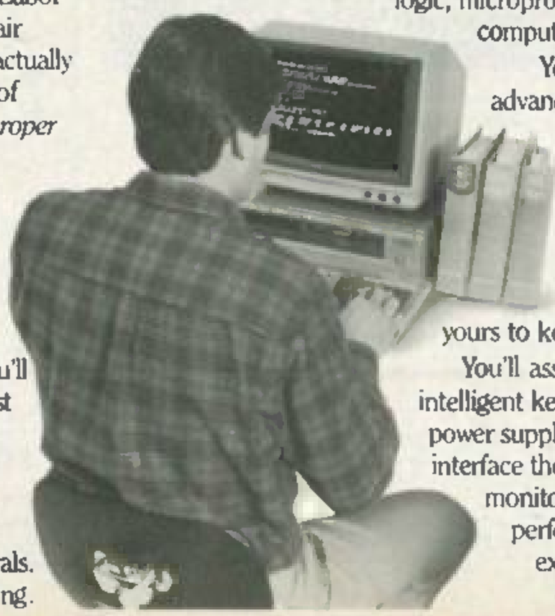

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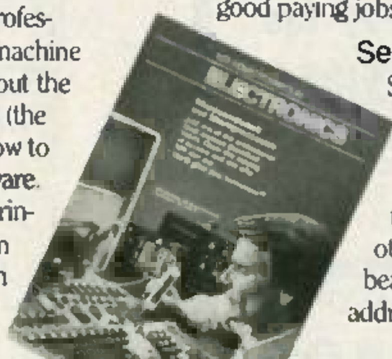

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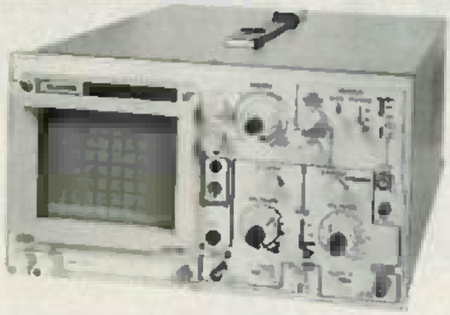

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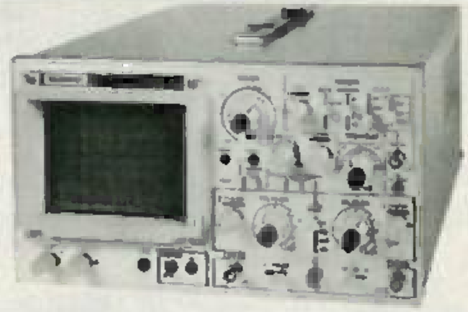

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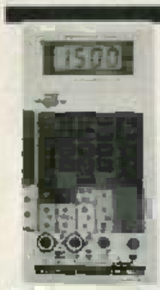

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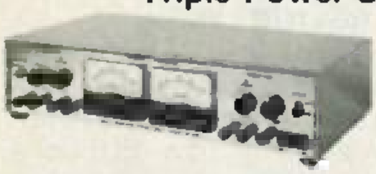

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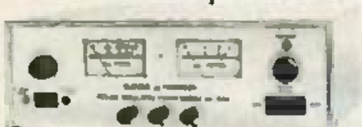

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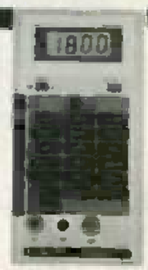

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RADAR SPEED-GUN CONTROLLER

ANTHONY STEVENS

This false-target generator is ideal for testing and calibrating radar speed guns.

SINCE THE FCC HAS ALLOWED THE COMMercial and private use of some radar frequencies, interest in those frequencies has greatly increased. Amateur-radio operators are actively experimenting with radar for communications. On the commercial front, the burglar-alarm industry has turned to radar for intrusion-detection alarms. Boaters are using radar to guide their crafts through hazardous fog. Even professional baseball teams are getting into the act with radar guns being used to time the speed of their pitchers' deliveries. And of course everyone is familiar with radar through its use by highway police to enforce the speed limit.

As with all other electronics equipment, radar guns need to be calibrated and tested periodically for accuracy. Here is an inexpensive portable calibrator for radar equipment. It works by generating a false target.

Radar false-target generators are used by the military as electronic camouflage on our stealth aircraft to fool the enemy's radar-tracking missiles. A similar technique is used in this radar gun calibrator. To better understand the technique, we should first understand how radar speed-guns work.

How radar works

The police have been using radar to measure vehicle speed since the late 1940's. A block diagram of a typical radar speed-gun is shown in Fig. 1.

A radar gun uses the *Doppler effect* to determine the speed of a moving object. Its output consists of a steady, unmodulated carrier. The signal travels in a tight beam toward a target whose speed is being monitored. That target can be any object, such as a speeding baseball—or a speeding motorist. Because of the nature of microwave transmissions, the signals are reflected by the target back toward their source.

Because of the Doppler effect, the frequency of the reflected signal is slightly higher than the original transmitted signal. For each mile per hour an object is travelling toward the radar speed-gun, the reflected signal received by the gun will be shifted about 31 Hz higher. In the radar gun, the return signal is mixed with a sample of the original transmitted wave to produce a difference frequency. That difference frequency is analyzed and converted to produce a direct readout of speed.

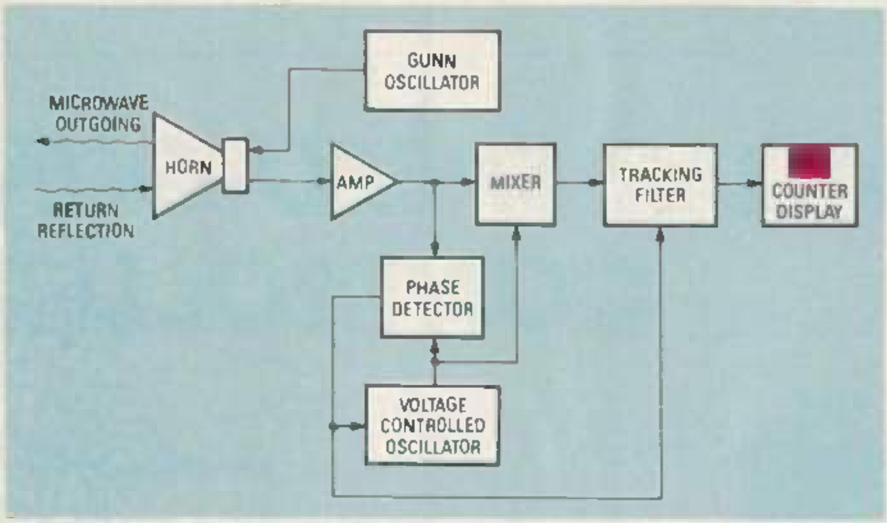


FIG. 1—SPEEDING FASTBALLS, or speeding motorists, can be timed using a radar speed-gun. A block diagram of such a unit is shown here.

WARNING

This radar calibrator may interfere with police radar, CB units, radio receivers, etc., up to 1000 feet away. Thus its use should be restricted to laboratory use or for educational, scientific, informational, or calibration purposes. The illegal use of a transmitter can subject the user to a $10,000 fine, a jail term, and the seizure of transmitting equipment.

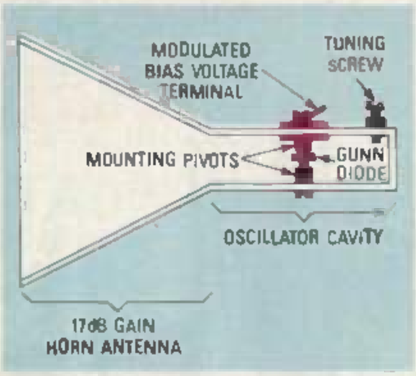


FIG. 2—THE HEART OF A RADAR SPEED-GUN used by the police, and others, or a radar false-target generator is a microwave Gunn diode. Here, the proper way to mount such a diode in a microwave horn is shown.

As shown in Fig. 2, the heart of a radar speed-gun—and our radar calibrator—is a Gunn diode oscillator. Typically those oscillators can generate an output level of about 100 mW. With that output level, and with a highly directional transmitting antenna, the range of a radar speed-gun is about ⅓ of a mile.

Until recently, high-output Gunn diodes were expensive; most cost several hundred dollars or more. Now, however, a Gunn diode can be obtained for as little as $60. That certainly makes it attractive to hobbyists for experimentation.

How the calibrator works

Our circuit generates a false target that can be used to calibrate radar speed-guns, such as those used to time the speed of a baseball player's throw. Let's examine Fig. 3 to see how the calibrator can be made to force a speed gun to read a desired speed. As is shown in Fig. 3-*a*, the outgoing reference transmission and the incoming reflected transmission are both present inside the antenna cavity. Because, as described earlier, they are of slightly different frequencies, they interfere with each other in such a way that a difference signal (at a *beat frequency*) is created. That signal is detected by a mixing diode, and the low-frequency beat that results is passed on to be analyzed.

To force a speed gun to read a particular speed, all a false-target generator need do is to produce a difference signal that simulates the one that would be created by an object travelling at a certain speed. See Fig. 3-*b*. Assuming the output-power level is sufficient, it will "capture" the receiver, preventing it from detecting any other signal that might be present, including the Doppler-shifted reflection.

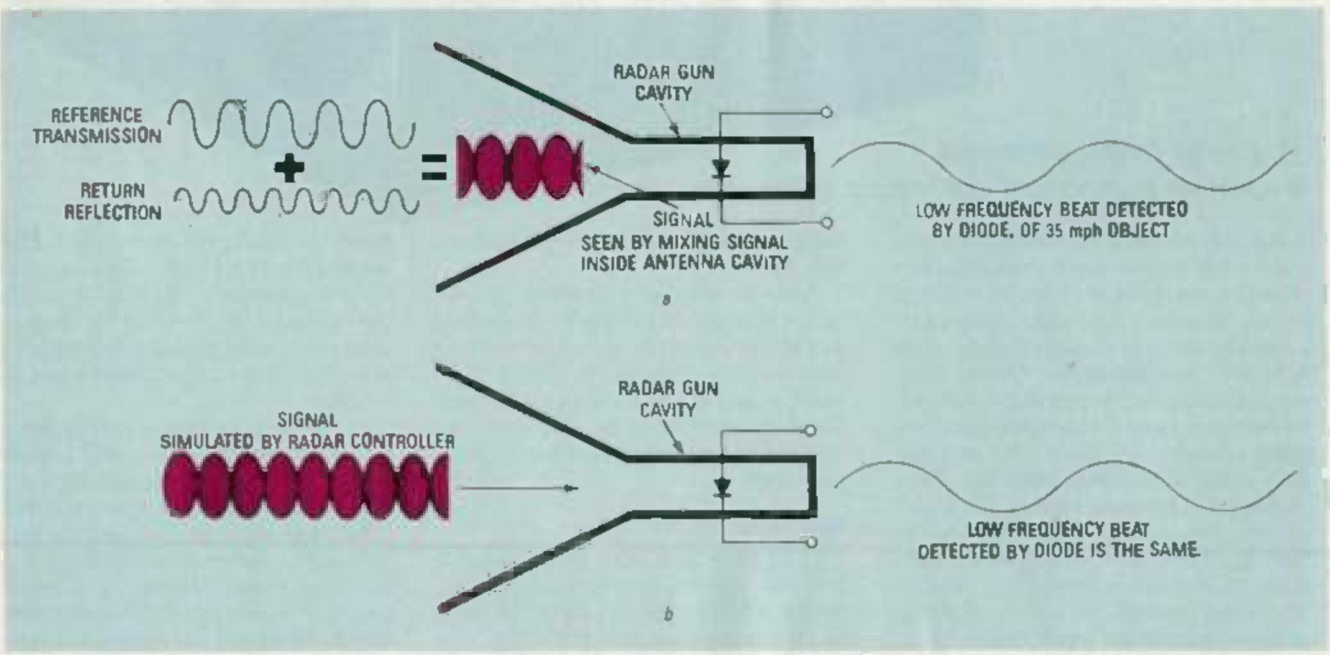


FIG. 3—WHEN THE TRANSMITTED AND REFLECTED SIGNALS are mixed in the horn's cavity, the resulting low-frequency beat can be used to determine the speed of the reflecting object, as shown in *a*. The calibrator works by generating a signal that simulates the one that would result if the transmitted signal were reflected by an object moving at a specified speed, as shown in *b*. As a result, the low frequency beat detected by the diode is the same as the one in *a*.

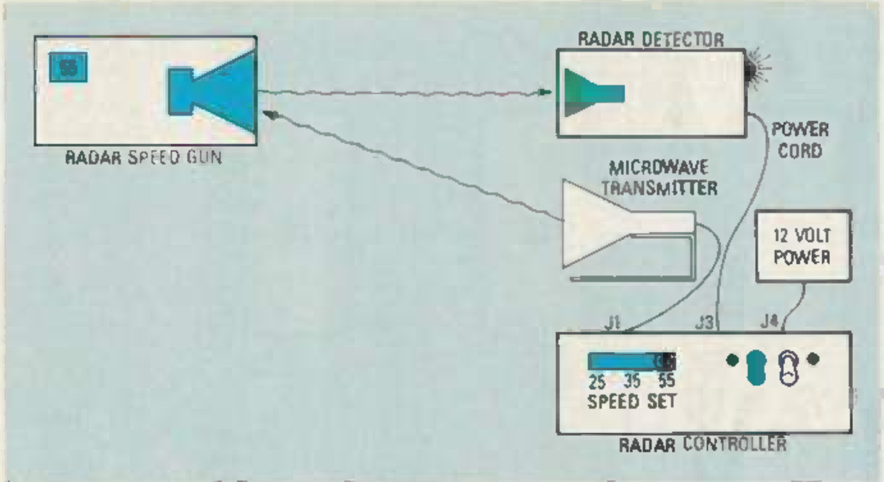


FIG. 4—USE THIS SET-UP to calibrate a radar-speed gun. The speed gun can be forced to read 25, 35, or 55 miles-per-hour by altering the setting of a switch on the calibrator.

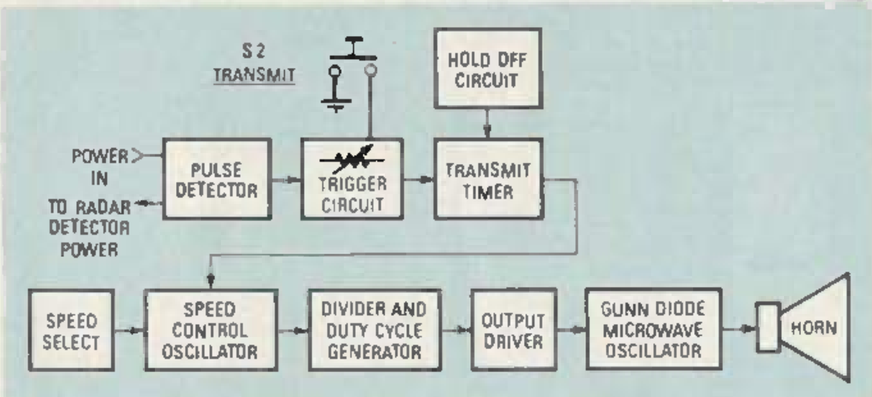


FIG. 5—THE RADAR CALIBRATOR is shown here in block diagram form.

Creating a difference signal that causes a speed gun to read a desired speed is not difficult. It's done by pulsing a carrier whose frequency is in the passband of the speed gun's receiver. Speed is simulated by varying the pulse rate. That is, the pulse rate is set at 31.4 pulses-per-second per mile-per-hour of desired reading. For a desired reading of 55 miles-per-hour the pulse rate would be 31.4 × 55 = 1727 pulses-per-second.

The basic set-up for calibrating a radar gun is shown in Fig. 4. A block diagram of the false-target generator is shown in Fig. 5. Note that the false-target generator is designed to work in conjunction with an automotive radar detector. The radar detector is used to make the operation of the calibrator almost automatic. When the radar detector senses a transmission from a speed gun, it sounds a buzzer or turns on a light as a warning. In doing that, the detector draws more current than normal from its 12-volt power source. The false-target generator's pulse-detector circuitry detects that surge, amplifies it, and, via the trigger circuit, triggers the transmit timer. The timer turns on the speed-control oscillator for approximately ten seconds. Using such a short transmission time is necessary to keep the Gunn diode from overheating.

A manual TRANSMIT switch (S2) is included for those not wanting to use a radar detector to trigger the Gunn oscillator. The switch is a momentary type, and it also triggers the one-shot for ten seconds.

The speed-control oscillator drives a divider network that generates the appropriate frequency and duty cycle for the output driver, which supplies voltage to the Gunn-diode oscillator. After ten seconds the transmitter timer locks itself off for a couple of seconds to give the radar detector time to settle down and reset.

About the circuit

The schematic diagram of the calibrator is shown in Fig. 6. Power is applied through J4. Power switch S1 applies power to the internal circuit through IC6, an LM317 voltage regulator; power is also applied to J3, the V_{OUT} jack, through R2, a 1-ohm sensing resistor. The voltage drop across R2 is amplified by Q1, which is slightly forward biased by R16, the TRIGGER SENSITIVITY control. Transistor Q2 amplifies the trigger signal and applies it to pin 5 (the trigger input) of one half of IC2, a 4538 dual timer. That half of the timer package is configured as a one-shot with a period of about ten seconds.

The period of the other half of IC2 is determined by C3, R19, and R11. The output of that timer, pin 9, is used to reset the first timer via pin 3. Trimmer R11 is used to adjust the hold-off time of the trigger circuit to prevent false retriggering. False retriggering can occur when the calibrator output-signal is detected by the radar detector, which in turn retriggers the calibrator. You will have to experiment with R11 to find the setting that will prevent false retriggering.

The output of the first half of the 4538, pin 6, is used to enable IC1, a 555 timer that's configured as an astable multivibrator. The oscillating frequency of IC1 is determined by R6, R7, R8, and C8. The

PARTS LIST

All resistors ¼-watt, 5%, carbon film unless otherwise noted
R1—4700 ohms
R2, R24, R25—1 ohm
R3, R10—10,000 ohms
R4, R21—2200 ohms
R5—2000 ohms, 1%
R6—6650 ohms, 1%
R7—4420 ohms, 1%
R8—2210 ohms, 1%
R9, R15, R22, R23—1000 ohms
R11—1 megohm, trimmer potentiometer
R12, R18, R19—100,000 ohms
R13—1 megohm
R14, R17—47,000 ohms
R16—5000 ohms, trimmer potentiometer
R20—270 ohms
Capacitors
C1–C5—10 µF, 25 volts, electrolytic
C6, C7—0.1 µF, ceramic disk
C8—470 pF, 5%, 100 volts, mylar
C9—0.0047 µF, 100 volts, mylar
Semiconductors
IC1—555 timer
IC2—4538B dual precision timer
IC3, IC4—4522B decimal divide-by-N counter
IC5—4518B dual synchronous divide-by-10 counter
IC6—LM317 voltage regulator
Q1—2N3906 PNP transistor
Q2, Q3—2N3904 NPN transistor
Q4, Q5—TIP120 NPN power transistor
D1—1N4004
D2, D3—1N4148
D4—MA49159, Gunn diode
LED1, LED2—Red LED
Other Components
S1—DPDT, 3 amps, 110 volts
S2—SPDT, momentary toggle
S3—DP4T, slide switch
J1, J2, J3—3.5 mm phone jack
J4—2.1 mm phone jack
Miscellaneous: PC board, hardware (7 each—4-40 screws, 3 each—4-40 nuts), microwave horn, case, wire, solder, etc.
The following are available from Microwave Control, 1701 Broadway, Suite 236, Vancouver, WA 98663, (1-260-693-6843): Complete kit including tested Gunn diode, microwave horn, PC board, case, and all parts, $169.50; tested Gunn diode, microwave horn, $117.00; etched and drilled PC board, $19.50. Please add $4.50 for shipping and handling. Washington state residents add 7.4% for sales tax. Allow 4-6 weeks for delivery.

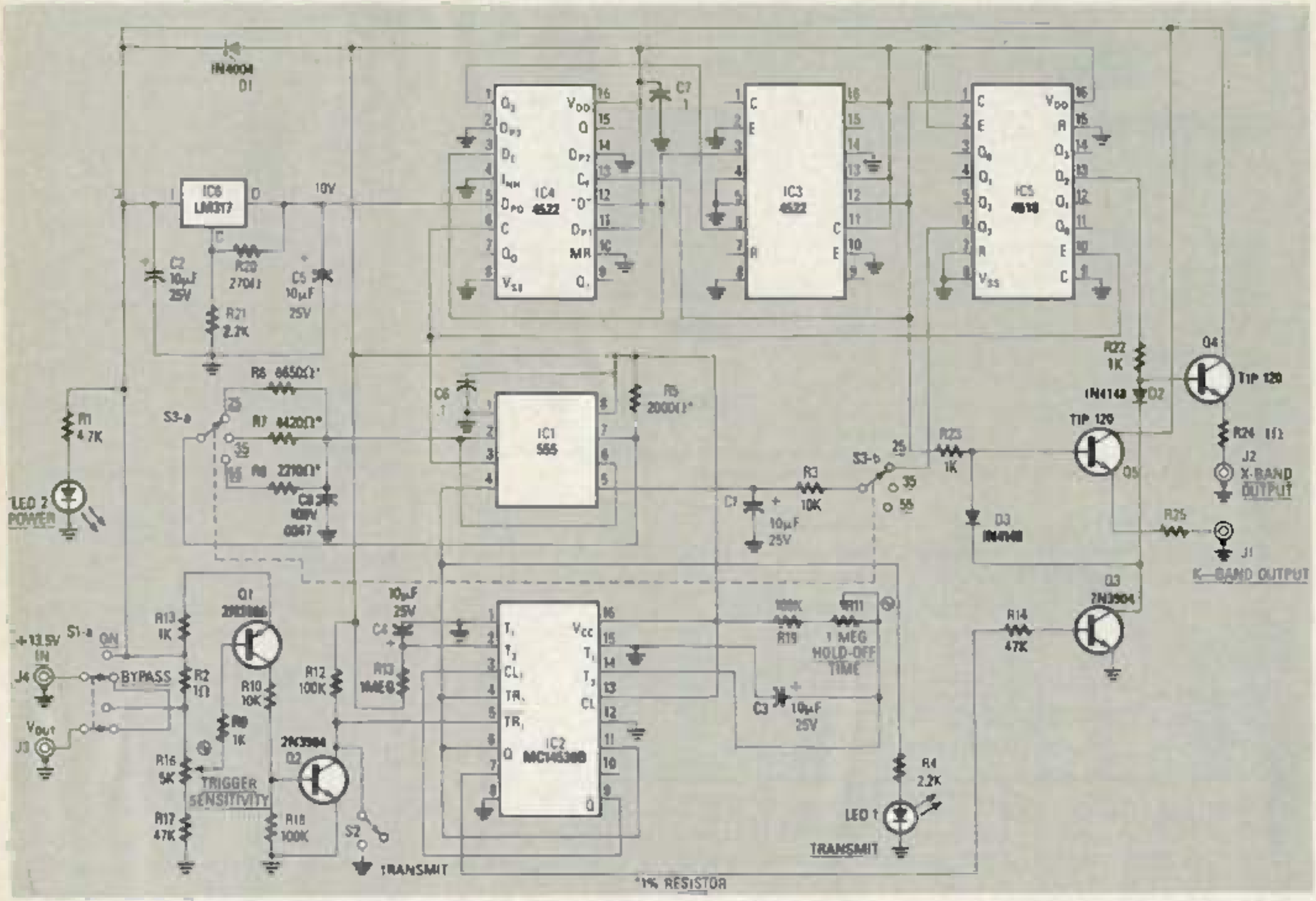


FIG. 6—ONE OUTPUT OF THE radar-calibrator circuit (J1 or J2) is fed to a Gunn diode mounted in a microwave horn. Outputs are provided for each of the two most popular speed-gun frequencies.

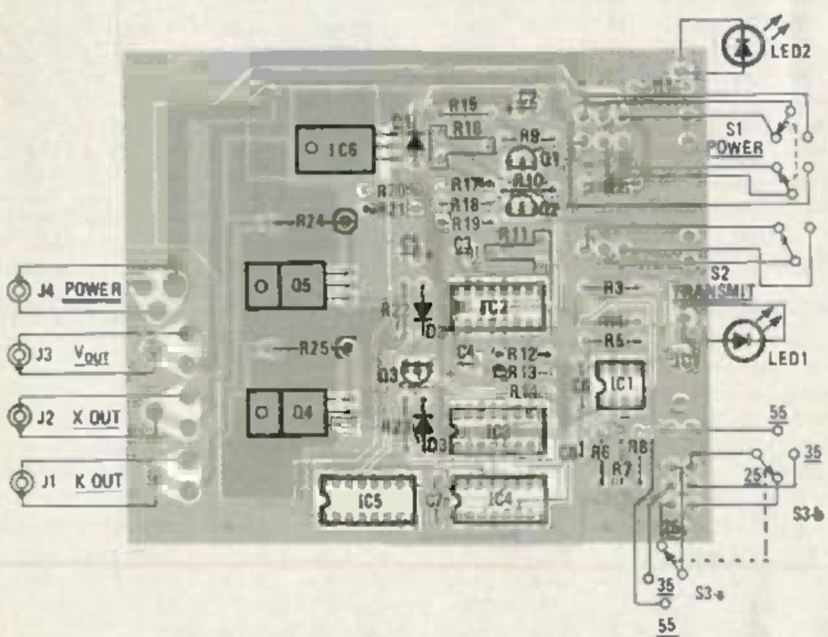


FIG. 7—THE CIRCUIT SHOULD BE MOUNTED on a double-sided PC board. The patterns can be found in the PC Service section, of this magazine.

output of the oscillator drives the divider string consisting of IC4, IC3, and IC5.

The output from each divider is a square-wave with a 40% duty cycle.

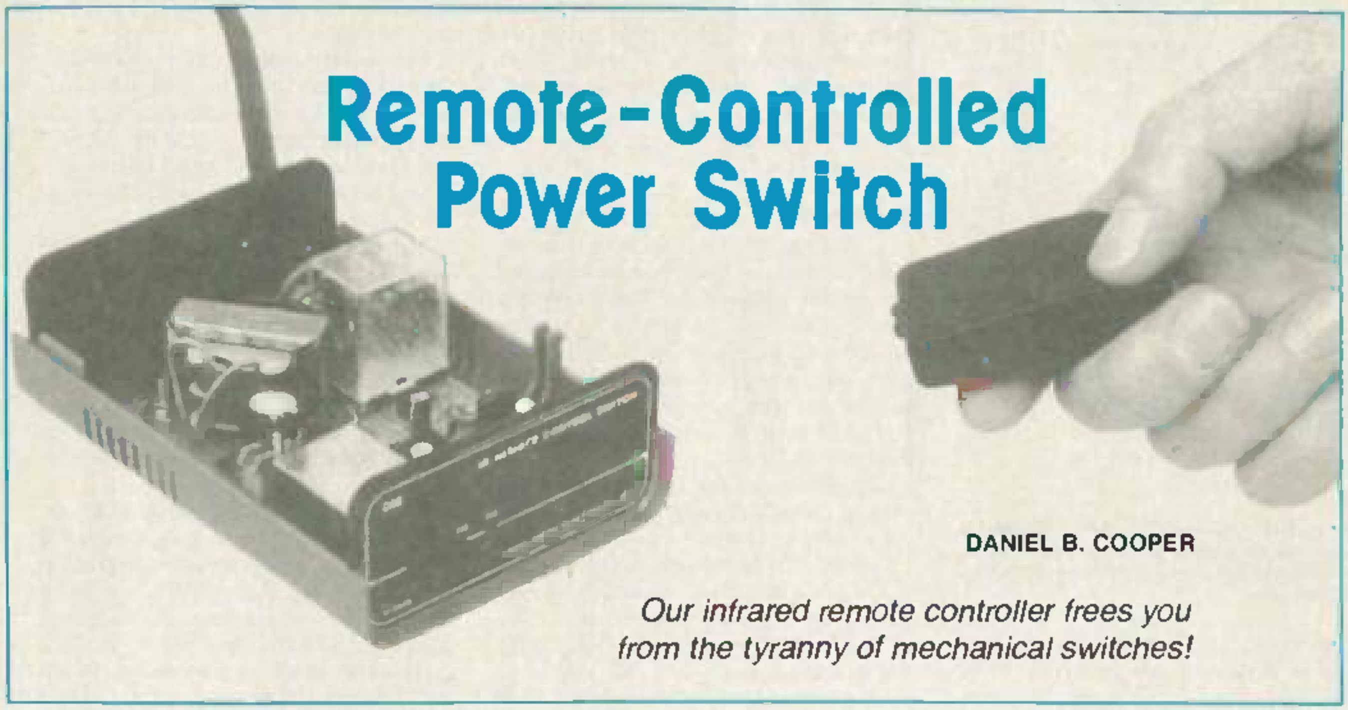
There are two outputs taken from the divider string. One, taken from pin 13 of IC5, is emitter coupled to J2, X-BAND OUTPUT, via driver transistor Q1. The 1-ohm resistor, R24, is included to ensure stability. The other output, taken from pin 13 of IC3, is emitter coupled to J1, K-BAND OUTPUT, via driver transistor Q2. A 1-ohm resistor, R25, is included to ensure stability. The J1 or J2 output, as appropriate, is applied to the Gunn diode. Although optional, and not shown in the illustrations, for best results a small, 0.47-pF mylar capacitor, C9, should be installed across the Gunn diode.

Diodes D2 and D3, in conjunction with transistor Q3, help ensure that the driver transistors remain off when the unit is not triggered. When switch S1 is at its slow speed settings, 25/35, the output if IC5 is divided further and fed back through R3 and C1 to modulate IC1.

Building the unit

We recommend the use of a printed-circuit board. If you wish to etch your own, an appropriate double-sided layout is provided in our PC Service section. Also, you can purchase a board from the supplier mentioned in the Parts List.

continued on page 85



Remote-Controlled Power Switch

DANIEL B. COOPER

Our infrared remote controller frees you from the tyranny of mechanical switches!

IT SEEMS A CRIME THAT SLEEK, SEXY stereos, VCR's and other electronic appliances must be operated by something so crude as a mechanical switch. There's really nothing wrong with a switch, but you must be within arm's reach to operate it. And when you're sitting comfortably in an easy chair and want to turn a TV, a stereo, or a lamp across the room on or off, it's mighty inconvenient to have to stand up, walk over to the device, and flip its switch.

Of course, if you're fortunate enough to own a remote-controlled TV or stereo, then you're *partly* free of the tyranny of mechanical switches. But what about radios, lamps, and the myriad of other devices that must be operated manually?

We've got the solution. The easy-to-build IR (*I*nfra-*R*ed) control system described here can be built for under $40. You can then control any device that draws as much as 1500 watts of power. The device can be 30 or more feet away.

Our controller consists of a *very* small (2 × 1½ by ½ inches) battery-powered transmitter and an AC-powered receiver that measures only 5½ × 3½ × 1½ inches. To use the controller, just plug the receiver into a wall outlet near the device you want to control, and then plug that device into the receiver. Then use the hand-held transmitter to turn the device on and off at your convenience. That's all there is to it!

How it works

The schematic diagram of the transmitter is shown in Fig. 1. As you can see, the transmitter is built around two CMOS 555 timer IC's (TLC555's). The TLC555 is quite similar to its bipolar cousin, but it requires less than 100 µA of supply current, and that's important when a circuit must be powered from a very small battery, as our transmitter is.

The transmitter generates a modulated 35-kHz IR signal. The 35-kHz carrier frequency is generated by IC2, and the 1500-Hz modulating signal is generated by IC1. The 1500-Hz output of IC1 appears as in Fig. 2-*a*; the modulated output of IC2 appears as in Fig. 2-*b*. An expanded view of each spike in that waveform is shown in Fig. 2-*c*.

The output of IC2 drives LED1 through resistor R5; that LED provides visual indication that the transmitter is working. In addition, IC2 drives transistor Q1, which in turn drives the two infrared LED's (LED2 and LED3).

The transmitter is powered by a miniature 12-volt battery, which is sometimes called a "lighter" battery from its use in electronically-ignited cigarette lighters. Although the battery supplies sufficient voltage for the circuit and is small enough to fit in a tiny case, it cannot directly source the high current needed to drive the two IR LED's. To provide that current, we pre-charge capacitor C6 and then dump all the charge it contains when S1 is pressed. When S1 is not pressed, power to the IC's is cut off. However, C6 is kept charged via R8. Then, when S1 is pressed, the current stored in C6 can be used to drive the LED's for as much as ½ second. That's plenty of time for the receiver to pick up a signal.

When C6's charge is exhausted, the

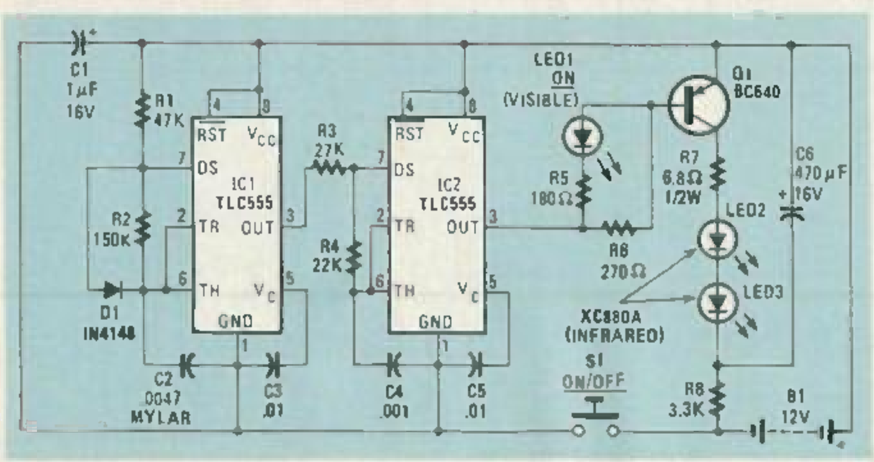


FIG. 1—THE TRANSMITTER IS BUILT AROUND TWO CMOS 555's that generate a modulated 35-kHz signal; that signal is transmitted by the two infrared LED's, LED2 and LED3.

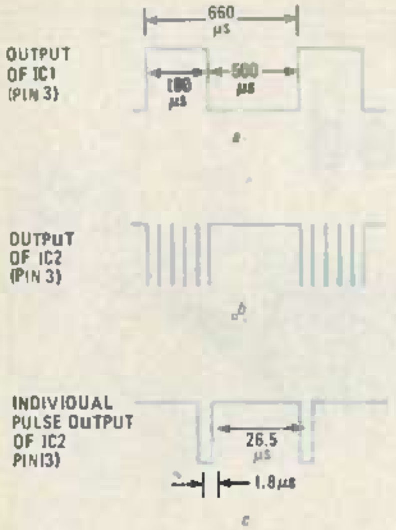


FIG. 2—THE 1500-Hz MODULATING SIGNAL is shown in a; the modulated 35-kHz carrier signal is shown in b; and one cycle of the 35-kHz bursts is shown in c.

output of the LED's drops to about one-third of their peak power. When S1 is released, C6 begins to recharge; it reaches 90% of capacity in about one second, and full capacity in five to six seconds.

At distances under ten feet, that charge time will be of no consequence because, at that distance, the receiver can pick up the reduced signal. At greater distances, though, it may be impossible for the receiver to respond twice in a very short period of time—less than about a second. But you should have no trouble if you wait for several seconds between each use of the transmitter.

The receiver

It is relatively easy to design an IR remote-control system, but most simple designs are hampered by either low sensitivity or high susceptibility to noise. The outstanding feature of our receiver is its high-sensitivity, low-noise input preamplifier, which is built around an µPC1373 IR remote-control preamplifier (IC1 in Fig. 3).

The IC is contained in an eight-pin SIP (*S*ingle *I*nline *P*ackage), and it incorporates circuitry that not only conditions a signal from a photodiode, but also varies the bias on the diode to accommodate changing lighting conditions. The µPC1373 also has a sensitive 30–40 kHz tuned detector, automatic gain control, a peak detector, and an output waveshaping buffer.

All that circuitry allows the the weak signal picked up from photodiode D2 to be output as a clean, logic-level demodulated signal; that signal is, in fact, an exact replica of the signal produced by IC1 in the transmitter!

The preamp stage is very sensitive to various forms of noise and RF interference, so, for maximum accuracy, the entire preamp circuit should be shielded and bypassed. Our PC-board layout, discussed below, has been optimized for low-noise performance.

The demodulated signal from the preamp stage is sent to IC4-a, a 74C14 Schmitt trigger. The squared-up 1500-Hz signal is then sent to the clock input of IC5-a, half of a 4013 dual "D" flip-flop. The flip-flop is configured as a binary divider, so the frequency of its output signal is exactly half the frequency of its input signal, but it has a duty cycle of exactly 50%.

That 750-Hz signal is clipped to approximately 0.7 volts p-p by diodes D3 and D4. The clipped signal is then fed to IC6, a 567 tone decoder. The output of that IC goes low whenever the frequency of the signal fed to it is within its lock range—the range of frequencies within which the IC will respond—of its internal VCO (*V*oltage-*C*ontrolled *O*scillator).

The center of the VCO's lock range is set by components R16, R17, and C17. The trimmer potentiometer (R16) allows

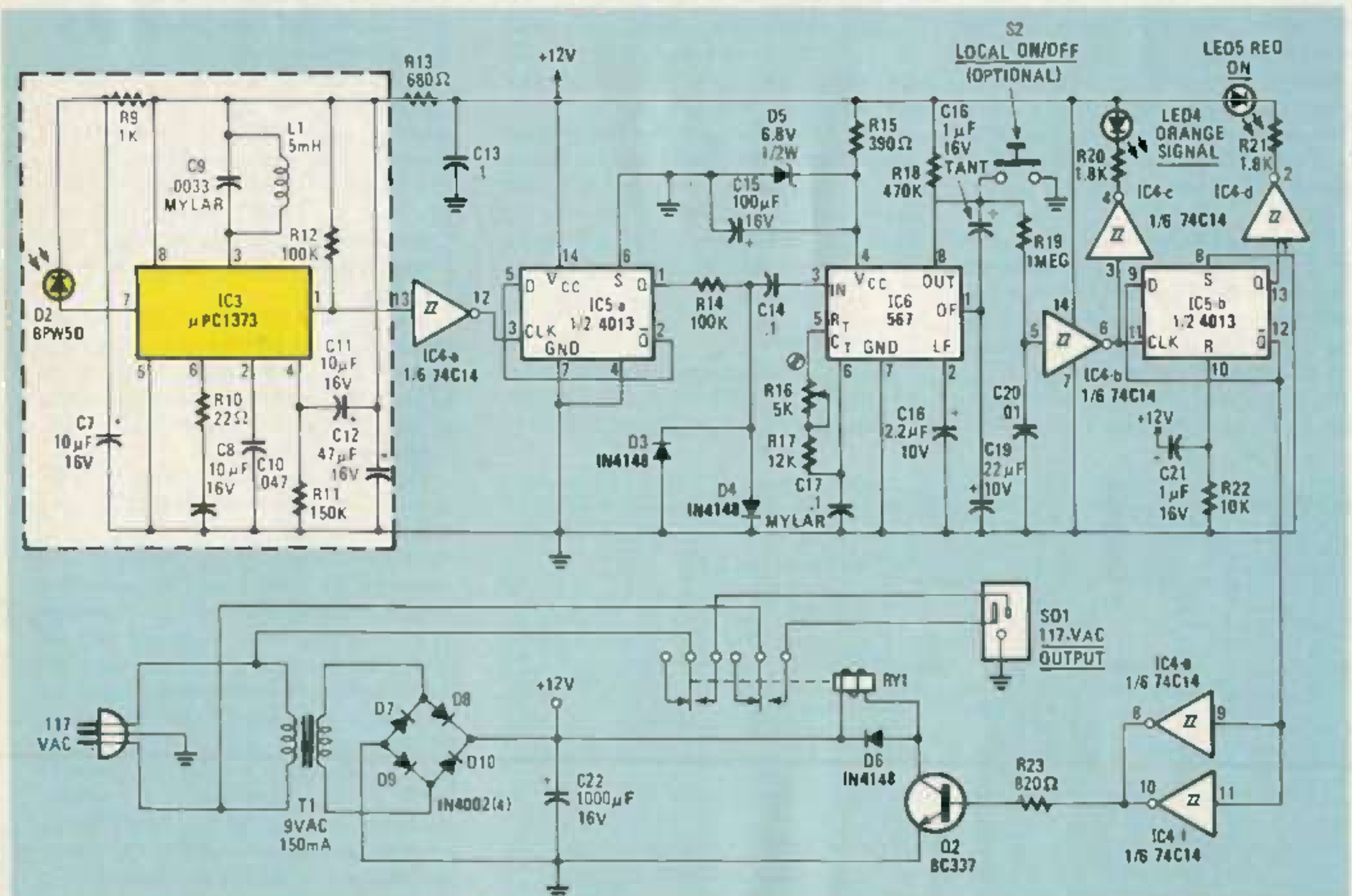


FIG. 3—THE RECEIVER FEATURES A SHIELDED PREAMP, shown here inside the dashed lines. The output of the preamp is squared up and fed to a PLL tone-decoder (IC6); the output of the PLL is fed through a bi-stable latch (IC5-b), which provides the ON/OFF function.

you to vary the center frequency to match the output of your transmitter. The lock range of the VCO is set by C18. We use a 2.2 µF capacitor here for a moderately narrow lock range—about 110 Hz. That provides an overall range of 750 Hz ± 55 Hz. The length of time a signal of that frequency must be present to obtain output is set by capacitor C19; the 22-µF value sets that time at about 10 ms.

When IC6 detects a signal of the proper frequency, pin 8 goes low. Since that output is an open-collector transistor, a pull-up resistor (R18) is required for proper operation. The output signal is fed through another Schmitt trigger (IC4-b), which drives another "D" flip-flop, IC5-b. That flip-flop is configured as a bistable latch; each successive input causes the output to change state.

Schmitt trigger IC4-b also drives IC4-c, which in turn drives LED4, SIGNAL, which lights up whenever a signal is received. The Q output of IC5-b drives IC4-d, which in turn drives LED5, ON, which lights up whenever the output is in the *on* state. The $\bar{Q}$ output of IC5-b drives two parallel-connected inverters, IC4-e and IC4-f; they turn transistor Q2 on when $\bar{Q}$ goes low. That transistor energizes the relay; its contacts switch the device you're controlling on and off. Diode D6 is wired across the coil of the relay to suppress the reverse spikes generated by the coil whenever it is de-energized. Without D6, Q2 might be destroyed.

Components C21 and R22 are connected to the latch's R input; they provide a power-on-reset function. In other words, they ensure that the relay will be off when power is first applied to the receiver. At power-up, C21 is effectively a short circuit, so R is high. In that reset state, the Q output of the flip-flop is low, the $\bar{Q}$ output is high, so Q2 and the relay are off. But, as C21 charges through R22, the voltage across C21 increases, and eventually the R input drops to ground and allows the IC to respond to input signals.

We have made provision for an optional LOCAL ON/OFF switch, S2. Since the 567 has an open-collector output, S2 can be used to force the inverter's input low and thus alternate the state of the latch without damaging the 567.

The receiver is powered by a nine-volt, 150-mA transformer that delivers about 12-volts DC after rectification by diodes D7–D10 and filtering by C22. Since most of the receiver circuit is voltage-independent, no regulator is used. However, the 567 requires a supply voltage less than nine volts. Therefore, resistor R15, capacitor C15, and Zener diode D5 are used to provide a regulated, filtered 6.8-volt DC source.

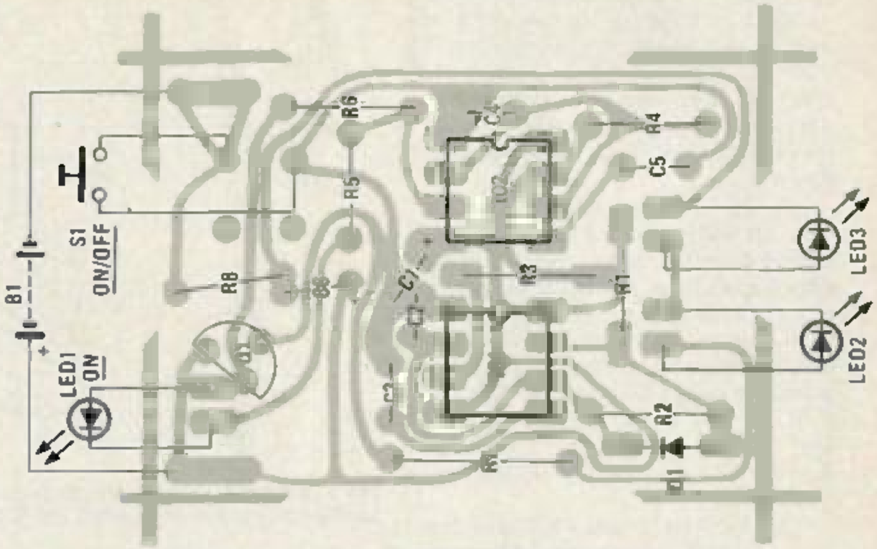


FIG. 4—COMPONENTS MOUNT ON THE TRANSMITTER BOARD as shown here.

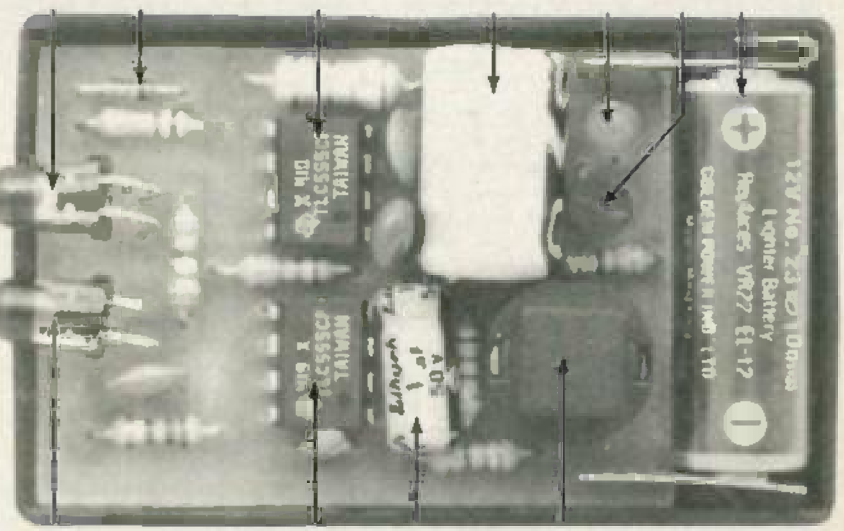


FIG. 5—THE COMPLETED TRANSMITTER appears as shown here. The legs of the electrolytic capacitors (C1 and C6) must be bent horizontally for those capacitors to fit in the case.

Construction

We recommend that you use PC boards, especially for the receiver, as the performance of its preamp can be degraded by improper layout. You can etch your own boards using the foil patterns shown in PC Service; pre-etched boards are included with the kits sold by the source mentioned in the Parts List.

When your boards are etched, inspect them for shorts and opens. Correct any problems and clean the boards with steel wool. Now build the transmitter. Install all components except the battery clips and the three LED's according to the diagram in Fig. 4. Take care to orient the capacitors, the IC's, D1, and Q1 correctly. As you can see in Fig. 5, the leads of C1 and C6 must be bent at a right angle; the capacitors are then mounted horizontally. The flat edge of S1 should face Q1.

Next solder the battery clips to the board. The bump on the negative clip should face inward, and the hook on the positive clip should face outward. Now insert LED1 into its holes with the flat side toward the positive battery clip, but do not solder it in place yet. Lay the PC board in the top half of the case, adjust the position of the LED to line up with its mounting hole, and then solder the LED in place.

Now insert the two IR LED's (LED2 and LED3) into their holes with their flat sides toward the side of the board the negative battery clip is mounted on. Solder them in place about ¼ inch above the surface of the PC board. Carefully bend their leads so that they are parallel with the board and with each other, and so that the center of each LED is about ⅛ inch above the surface of the board.

Lay the board in the lower half of the case and carefully mark where the center of each LED touches the front edge of the case. Remove the board and use a small rattail file or a similar tool to cut out a precise half-circle for each LED. Check your progress often to avoid overcutting.

Snap both halves of the case together without the board in place and mark where the edges of the holes meet the upper half of the case. Take the case apart and carefully file out the holes in the upper half to match those in the lower half of the case.

Now lay the board in the case. Then insert B1 and press S1: LED1 should remain lit for as long as S1 is pressed. If the LED doesn't light, make sure the battery is inserted correctly. If it is, use a frequency counter or an oscilloscope to verify that both TLC555's are oscillating. If they are, make sure that LED1 is mounted correctly. If you still haven't isolated the problem, you may have installed Q1 incorrectly, or you may have installed Q2 by mistake.

When the board is debugged, complete assembly of the transmitter. Insert the board into the lower half of the case and then snap both halves together. If desired, the IR LED's can be pushed back into the case so that they do not protrude.

Building the receiver

Since the components are not so closely spaced, building the receiver is somewhat easier. Referring to Fig. 6, solder all electronic—not mechanical—components to the board, except for LED4, LED5, D2, and T1. Be careful to orient all polarized devices correctly; IC3 should be mounted with the bevel oriented toward the transformer. Don't forget to solder the jumpers in place.

Bolt T1 to the board with its secondary wires toward C22. Keeping the leads as short as possible, solder the primary and the secondary wires to the appropriate pads. To prevent shorts, ensure that all strands of each wire pass through its hole. Clip off and insulate the transformer's center tap.

Solder three 3-inch pieces of 18-gauge wire to the output pads near the relay. Connect the opposite ends of those wires to the appropriate terminals on SO1.

Now solder D2 in place with its base about ⅛ inch above the surface of the board and with the beveled corner toward the center of the board. Mount LED4 and LED5 with their flat sides facing each other; the center of each LED should be about ¼ inch above the board. The LED's will be parallel to the board and to each other if they are mounted correctly.

Now solder four thick pieces of bus wire to the four holes where the shield will mount. The shield can be bent as shown in Fig. 7 from a thin piece of tin. Also, cut a ⅞- × 1⅞-inch piece of tin plate for the bottom of the PC board. However, don't solder either shield in place until you have verified that the preamp circuit works exactly as intended.

Strip the sheath of the AC cord so that one inch of each conductor protrudes; strip, twist, and tin ¼ inch of each conductor. Pass the cord through the rear panel, insulate it with a grommet, and solder the leads to the board. Then press SO1 into the rear panel and solder the three wires to the correct terminals. Your receiver should resemble the one shown in Fig. 8.

Now insert the red plastic IR filter into the front panel so that its legs are horizon-

continued on page 84

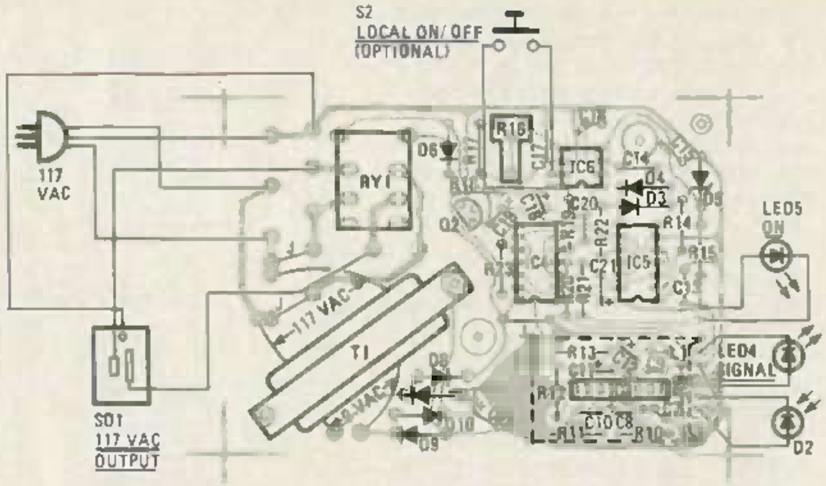


FIG. 6—COMPONENTS MOUNT ON THE RECEIVER BOARD as shown here. One shield must be soldered to each side of the board after testing confirms that the preamplifier works.

PARTS LIST

All resistors are ¼-watt, 5% unless otherwise noted.

R1—47,000 ohms
R2, R11—150,000 ohms
R3—27,000 ohms
R4—2200 ohms
R5—180 ohms
R6—270 ohms
R7—6.8 ohms, ½-watt
R8—3300 ohms
R9—1000 ohms
R10—22 ohms
R12, R14—100,000 ohms
R13—680 ohms
R15—390 ohms
R16—5000 ohms, trimmer potentiometer
R17—12,000 ohms
R18—470,000 ohms
R19—1 megohm
R20, R21—1800 ohms
R22—10,000 ohms
R23—820 ohms

Capacitors

C1—1 µF, 16 volts, electrolytic
C2—0.0047 µF, mylar
C3, C5, C20—0.01 µF, ceramic disc
C4—0.001 µF, ceramic disc
C6—470 µF, 16 volts, electrolytic
C7, C8, C11—10 µF, 16 volts, electrolytic
C9—0.0033 µF, mylar
C10—0.047 µF, ceramic disc
C12—47 µF, 16 volts, electrolytic
C13, C14—0.1 µF, ceramic disc
C15—100 µF, 16 volts, electrolytic
C16—1 µF, 16 volts, tantalum
C17—0.1 µF, mylar
C18—2.2 µF, 10 volts, electrolytic
C19—22 µF, 10 volts, electrolytic
C21—1 µF, 16 volts, electrolytic
C22—1000 µF, 16 volts, electrolytic

Semiconductors

IC1, IC2—TLC555, CMOS 555 timer
IC3—µPC1373, IR photodiode preamplifier
IC4—74C14, hex Schmitt trigger
IC5—4013, dual "D" flip-flop
IC6—567, tone decoder
D1, D3, D4, D6—1N4148, signal diode
D2—BPW50, infrared photodiode
D5—1N5526A, 6.8-volt, 400-mW, Zener diode
D7–D10—1N4002, rectifier diode
LED1—visible miniature red LED
LED2, LED3—XC880A, infrared LED
LED4—visible miniature orange LED
LED5—visible miniature red LED
Q1—BC640 (ECG383)
Q2—BC337 (ECG159)

Other components

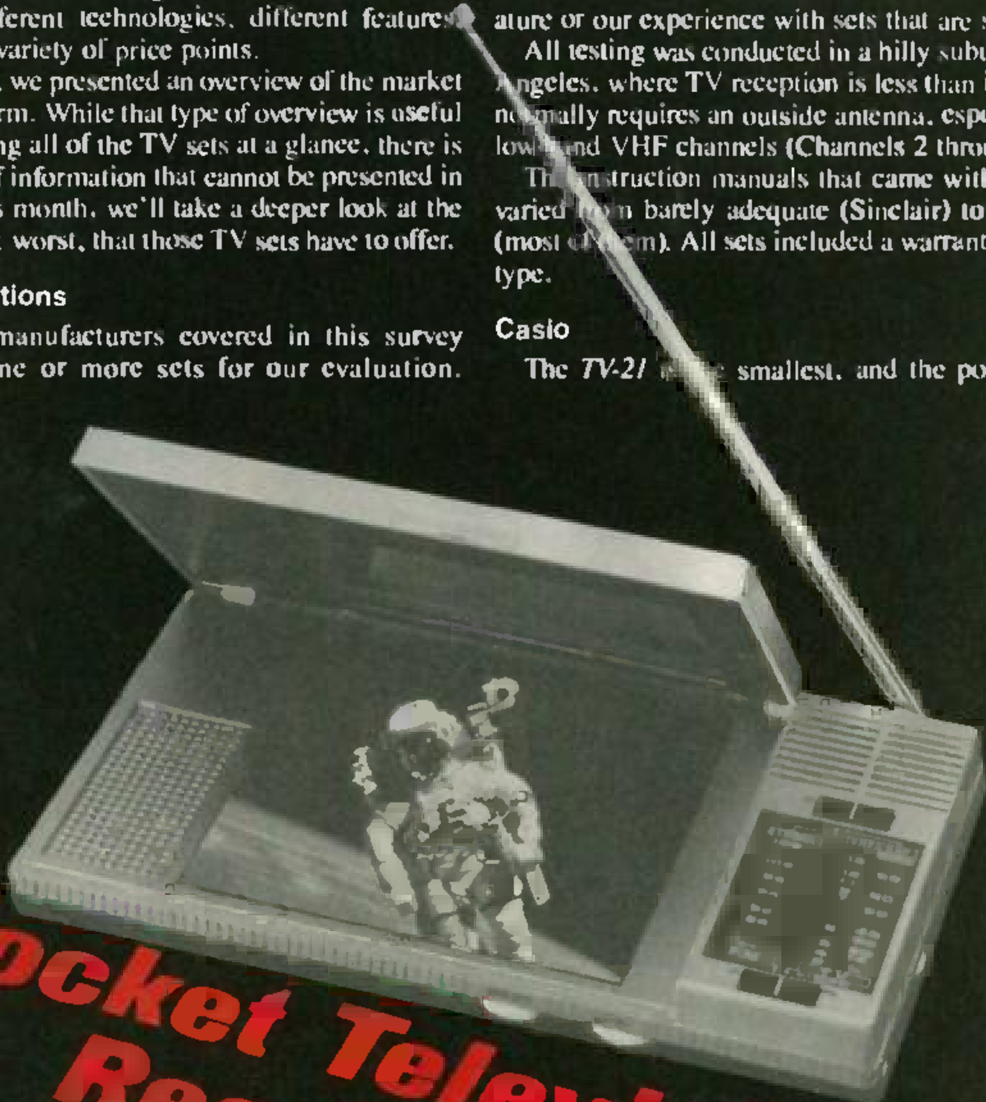
B1—12-volt miniature "lighter" battery
RY1—relay, DPDT, 10-amps, 12-volts
L1—5 mH inductor
S1—miniature SPST momentary pushbutton
S2—miniature SPST momentary pushbutton (optional)
T1—9-volt, 150-mA, PC-mount transformer

Note: The following kits and components are available from Dick Smith Electronics, P. O. Box 8021, Redwood City, CA 94063: Complete receiver including all parts, case, and mounting hardware, no. K-3428, $32.00; transmitter including all parts, case, but less battery, no. K-3429, $7.95; transmitter battery, no. S-3335, $1.19; receiver case, no. H-2503, $5.95; transmitter case, no. H-2497, $1.95; $2.50; BPW-50 IR photodiode, no. Z-1956, $2.50; µPC1373 IR photodiode preamplifier, no. KZ-6174, $2.50; twelve-volt relay, no. S-7200, $4.95; nine-volt transformer, no. M-2840, $2.50. All orders must add $1.50 plus 5% of total price for shipping and handling. California residents must add 6.5% sales tax. Orders outside the U. S. must be in U. S. funds and add 15% of total price.

Pocket Television Receivers

Here's a no-punches-pulled look at pocket TV, one of the hottest segments of the consumer-electronics market.

FRED BLECHMAN



Part 2 WITHOUT A DOUBT, POCKET-TV has become one of the hottest segments of the consumer-electronics marketplace. It can also be a bewildering one, with manufacturers offering different technologies, different features, and a wide variety of price points.

Last time, we presented an overview of the market in tabular form. While that type of overview is useful for comparing all of the TV sets at a glance, there is quite a bit of information that cannot be presented in a table. This month, we'll take a deeper look at the best, and the worst, that those TV sets have to offer.

Our evaluations

All the manufacturers covered in this survey provided one or more sets for our evaluation. However, some sets were not available at the time this report was written. Untested sets are noted (see Table 1 in the July issue of **Radio-Electronics**) and our comments on those are based on manufacturer's literature or our experience with sets that are similar.

All testing was conducted in a hilly suburb of Los Angeles, where TV reception is less than ideal, and normally requires an outside antenna, especially for low-band VHF channels (Channels 2 through 6).

The instruction manuals that came with each set varied from barely adequate (Sinclair) to excellent (most of them). All sets included a warranty of some type.

Casio

The *TV-21* is the smallest, and the poorest performing set we tested. To operate the unit, you flip up a panel that contains the LCD display and a translucent back panel. Light penetrating the back panel (together with the setting of the brightness control) determines image contrast. The screen image is reflected by a mirror, giving the effect of a screen tilted for easy viewing.

An optional backlight clips onto the back of the flip-up screen. Powered by the set's batteries, it contains an electroluminescent panel for use when the ambient light is not sufficient.

To keep the size of the unit small, Casio provides no speaker or retractable telescoping antenna. Instead, an earphone is proved; its wire lead doubles as the set's antenna. With that arrangement, if you move while watching, the earphone-lead/antenna whips around and the picture becomes unstable.

Another choice made in the interest of user simplicity (and to eliminate a tuning dial) is the incorporation of automatic signal-seeking for channel selection. When you turn on the set by selecting either VHF or UHF, a small black cursor appears at the top right side of the screen and starts moving downward, seeking a signal. Up-arrow and down-arrow buttons, marked AUTOTUNING, let you change cursor direction. When a signal is found, the cursor stops, and the picture and sound (usually) lock in. The picture quality, at best, is like a very bad newspaper photo.

The trouble with the automatic tuning is that the set does not discriminate well enough between good and bad signals. It will even lock in on scrambled subscription-TV signals, commonly found on the UHF band. On weak channels, it sometimes locks-in in such a way that video can be seen but sound can not be heard. Since the unit lacks a fine-tune control, there is no way to tweak up reception. Furthermore, the search for the next channel is very slow. Worst of all, if you move the earphone wire and the signal level drops, the set unlocks and starts searching for another channel!

That set, which appears to be identical to Radio Shack's *Pocketvision-2*, might be adequate in a strong signal area, and for watching at a desk where the antenna lead will not be subject to much movement. It is probably great for watching daytime soaps at the office during lunch or break time.

The *TV-60*, not tested, appears to be a *TV-21* with an AM/FM radio added.

The *TV-1000* is an LCD color set with reasonably good performance. It has a built-in fluorescent backlight for indoor viewing. Outdoors you can drop down a reflective back panel to collect sunlight—and we mean sunlight, not just daylight, because that set requires quite a lot of illumination.

Screen viewing angle is restricted with that set. At anything other than the the best viewing angle, the picture either gets dark or washes out. You can partially compensate for that by using the brightness control.

The color is fair, with a surprising degree of sharpness. Thumb-adjusted color and tint controls let you set the degree and shade of color to your liking.

The *TV-1000* also uses automatic tuning, but the tuner appears to be much more sensitive, and a regular telescoping whip antenna is used. The result is a stable picture.

RADIO SHACK *POCKETVISION-20*

Video and audio inputs are provided, allowing for improved performance when used with a VCR. That also means that the unit could be used as a computer monitor, though because of the small screen size such use is likely to be impractical.

That unit is apparently identical to the Radio Shack *Pocketvision-20*.

The *TV-5000*, not tested, appears to be a *TV-1000* with an AM/FM-stereo radio added.

Citizen

The *03TA* was one of the first decent LCD sets in the marketplace. Now discontinued, that small, slim set with a built-in AM radio remains available at discount prices at many stores.

Despite poor contrast, a common problem with LCD sets, that unit has much to recommend it. The picture is relatively large and surprisingly good, at least until you compare it with that produced by a CRT. The video input makes the set easy to use as a monitor. Included accessories include an AC adapter and a 3½-foot plug-in wire antenna.

The flip-up panel and mirror provide a comfortable viewing angle, the drum tuning dial is fast and easy to use, with clear markings, and slide controls for volume and brightness are well-marked and easy to set.

The *05TA* color set is another story. The book-style carrying case is beautiful, and the set itself has a great look and feel. Its performance, however, leaves something to be desired. In fact, it was the poorest performing color set we evaluated; in fairness, it was also the least expensive. Indoors, the color picture is fair. But outdoors the picture becomes completely washed out; you almost have to use the built-in backlight (which greatly shortens battery life), since it takes a lot of external light bouncing off a tilt-down back reflector to produce an acceptable picture on the screen.

Reception is limited with the 2-foot telescoping whip antenna, but improves considerably with the 3½-foot clip-on wire antenna that is provided. The video/audio inputs allow you to monitor a VCR or camera indoors.

The *06TA* and the *08TA* were not available for testing. In those sets, Citizen claims to be using a special "black matrix" process that produces a screen with a

CITIZEN *06TA*

contrast ratio of 5:1 (compared with 2.5:1 for their earlier LCD sets, and 10:1 for a typical CRT screen, according to Citizen).

The *06TA* is replacing the *03TA*; it has a list price of only $100. It is a little smaller than the *03TA*, and has no radio, but it does have a higher pixel count and a smaller screen, which provides better resolution. With its combination of improved contrast and low price, that set could fast become an LCD favorite.

The *08TA*, using a 3.5-inch screen with even greater pixel density, improved contrast, and an FM-stereo radio, also could be a winner.

Epson America

The *ELF ET-20* (and its Seiko equivalent, the *LDV012*) were, without question, the best LCD units tested. The resolution was remarkable for an LCD screen, with a brightness and contrast approaching that of a CRT.

EPSON *ELF ET-20*

The *ET-20* uses reflective LCD TFT (*Thin-Film-Transistor*) technology, so no backlight is required. Furthermore, an acceptable picture is produced with normal room lighting, and the picture does not fade outdoors. The unit is very small, easily fitting in a typical shirt pocket.

However, several design compromises were made that reduce the effective use of that set. Although the sound quality is good, the speaker is at the back, so all sound projects rearward. Since the speaker is so small to start with, the *ET-20* only has sufficient volume for viewing in a quiet area. Making things worse, when an earphone was used, at least on the model tested, there was an annoying low hum. Also, the wire stand provided allowed the set to tilt too far back for convenient viewing. Perhaps that's why the Seiko version left the stand off altogether.

The color *ELF ET-12* has had a lot of favorable reviews—with good reason. The picture offers surprisingly good color, tint, contrast, and resolution. Brightness, color, and tint are adjustable to your liking. The relatively large front-mounted speaker provides good sound.

The picture is watchable outdoors, but is better inside. A reflective panel tilts down from the back for use in locations where the lighting is sufficient. Otherwise, the built-in fluorescent backlight provides sufficient illumination.

Magnavox

The *BF3901BK* is an exceptional set in almost every way. It appears to be identical to the Sony *FD-30A* (we'll get to the Sony sets in a moment).

The specially-designed FD (*Flat Display*) CRT's picture resolution and contrast are excellent. For even better video quality, a video input is provided (however, there is no audio input); surprisingly, an 80-column computer display was readable. The video input also will allow the unit to be used as a video-camera or portable-VCR monitor. The front-mounted speaker and stereo headset provide good sound.

Since the unit is a CRT set, no external source of light is needed. The best viewing conditions are indoors, with subdued room lighting. Outdoors your eyes become adjusted to the ambient lighting and the picture appears washed out. Direct sunlight on the screen washes the picture out altogether. That's why the carrying case is designed with two flaps; those flaps are held in position with Velcro tabs to form a sunhood for outdoor viewing. The set includes a swing-out stand.

The tuner is about as sensitive as those of most of the other sets tested. There is no provision for an external antenna.

The *BF3900BK* was not tested, but appears to be the same as the *BF3901BK* except for an AM/FM-stereo radio; we assume that its performance is comparable. It does not have a video input and is not supplied with an earphone.

Panasonic

The *TR-1030P*, and its sister *CT-101* (more on that in a moment), both use a conventional-design CRT that has the smallest screen size of any of the units in this report. Despite that, the sets are among the largest reviewed. To accommodate the long neck of the CRT, the tube was positioned so that the screen is viewed at what would normally be one of the side panels.

We're impressed with the *TR-1030*. Although the screen is small, the display is clear and bright. An included magnifier is a worthwhile accessory. Although there is no external antenna input, the tuner has better sensitivity than most of the sets and provides a clear picture even on the weaker channels. The fact that it comes with rechargeable batteries and an AC adapter/charger is also a definite plus. (Note that the charger uses a special plug; that makes it impossible to plug the wrong charger/adapter into the TV set.) In fact, all accessories, including a cigarette-lighter adapter (for car use) and earphones, are included.

Our reaction to the *CT-101* color set was similar. The color, brightness and contrast of that CRT set were far superior to those of any other color set reviewed.

All accessories are included. Among those are a magnifier, an AC adapter/charger, rechargeable batteries, headphones, an audio/video patchcord, and a car cord. Panasonic even includes a matching transformer to allow you to connect either 300-ohm twin-lead or 75-ohm coaxial cable to the antenna input. At a list price of $450 the *CT-101* is the most expensive set in this report, but you get what you pay for.

Radio Shack

The *Pocketvision-2* is similar to the Casio *TV-21*. It differs in that the case and backlight are included; batteries are not included.

CASIO *TV-1000*

The *Pocketvision-3* (not tested) at first appears to be similar to the Citizen *03TA*, without the radio, AC adapter, or a video input, but with a backlight. However, Citizen claims that the unit they build for Radio Shack "uses a black screen rather than a white screen, giving better contrast, but a sepia-toned picture."

The *Pocketvision-20* (not tested) appears to be the same as the Casio *TV-1000*, but it includes a wire antenna and doesn't include batteries.

Seiko (Hattori)

The Seiko *LDV012* differs from its sister Epson *ET-20* only in cosmetic details—it has batteries but no stand, and is turned on by pulling down a screen cover (there is no conventional on/off switch).

SEIKO *LDV-012*

The *LDV202* is a color LCD set with a good picture and a built-in LCD alarm-clock module. That module slips out of the case and has its own battery. That set is the smallest of the color sets tested, and worked very well. The screen tilts up to allow light to bounce off a silver reflector to the back of the screen. Typical room lighting appears to provide sufficient illumination. It works well outdoors in the daytime, and for night (or dark room) viewing, a backlight is included. The backlight, which normally draws power from its own batteries, simply snaps onto the back of the screen. When using the AC adapter or car cord, a small included patchcord connects the external power source to the backlight.

Sinclair

Sinclair's *Flat Screen TV*, available in England for over a year, was recently introduced in the United States as the *FTV2*. Because the unit had to be redesigned for use in this country (the British do not use the U.S. VHF frequencies), its performance is markedly better on UHF channels (although its VHF performance is certainly adequate).

INSIDE THE Sinclair *FTV2*. That set uses a flat-screen CRT display.

The flat-screen CRT produces a very

good picture, though it is not as good as the one produced by the Sony/Magnavox TV sets. Further, it is the least expensive miniature CRT-type TV set available.

We should note that this set does not use alkaline cells for power. Instead it requires a flat Polaroid *Polapulse* lithium battery. That P-500 version of that battery, which is included, can power the unit for up to 15 hours. The P-100 version of the battery, which is available at many hobby stores, will run the set for 2 hours. Unfortunately, those batteries are not rechargeable and are not inexpensive; sinclair offers a package of three of the P-500's for just under $10.

The only accessories provided with the *FTV2* are a thin vinyl slip-over case and an earphone. No handstrap is provided or available.

Sinclair does not sell an AC adapter in the U.S. for the set, but you can use the Radio-Shack *Universal AC-to-DC Adapter* (Cat. No. 273-1650). For car use, you'll want the Radio-Shack *Universal DC Auto Adapter* (Cat. No. 270-1560).

The set is generally a good value but does suffer from some deficiencies, mainly poor sound from the small side-mounted speaker, and inaccurate dial markings. It can also be difficult to obtain locally. If you run into trouble, the set is available from a few mail-order dealers. One such dealer is Curry Computers, 5344 West Banff, Glendale, AZ 85312-5607.

Sony

The Sony *FD-2A* and *FD-30A* use the same 2-inch FD flat CRT as the Magnavox units mentioned earlier. Therefore, it's not surprising that the picture quality of both sets is just as good as that of the Magnavox units.

The *FD-2A* is the only set tested that allows the reception of TV sound without picture, for greatly extended battery life. A rechargeable battery pack is not available, but you can use individual rechargeable cells (penlight type).

The small front-mounted speaker produced fair sound; no earphone is supplied with the unit. Contrast levels (low, medium, or high) are selected using a three-position switch. There is a separate rotary brightness control. There is no video input but there is an external antenna input. The carrying case that comes with the unit is simply an unpadded silver-color bag with a drawstring at the top.

The *FD-30A* is essentially identical to the Magnavox *BF390IBK*. The *FD-30A*, however, comes with batteries and Sony offers a number of optional accessories not offered by Magnavox (note that those will also work with the *BF390IBK*). Among those accessories are an external battery case (which uses four C-size alkaline cells for about ten hours of operation), higher quality stereo headphones than those supplied with the set, a speaker system, a video-camera monitor cable, and a screen magnifier.

The *FD-40A* uses a large 4-inch diagonal flat-display CRT. It is stretching a point to call that set a "pocket TV," but is included here for those whose interest is in the ultimate in portable monitors. For such applications, that set (and its Zenith clone, the *BT044S*, which we will get to next) may be the most practical choice.

The *FD-40A* screen seems enormous when compared with that of the other sets tested for this report, and it was a pleasure to watch. No stand is required; the base of the unit is wide enough for the unit to stand by itself. The screen is located near the bottom of the unit and is slanted for comfortable viewing from about 2½ feet away. The relatively large speaker produces good quality sound; no earphone is included.

On the down side, the image produced did not seem as sharp as that produced by the other Sony sets, although that may have been due solely to the fact that the screen is larger. Also, the video/audio puts are non-standard and require the of a special adapter cable that's not included; it is available as an option. Finally,

SONY *FD-30A*

the set goes through batteries at a fairly fast rate; no AC adapter is supplied.

Optional accessories include a rechargeable battery pack, car cord, earphone, external antenna connector, gutter-mounted car antenna, and roof-mounted car antenna.

Zenith

The *BT044S* is functionally identical to the Sony *FD-40A*, although there are some minor cosmetic differences. The unit comes with an AC adapter and an earphone, but no batteries or carrying case. Zenith does not offer many of the accessories offered by Sony, such as the rechargeable battery pack, but it appears that those offered by Sony will work with the *BT044S*.

ZENITH *BT044S*

What was a bit surprising, especially considering the set's similarity to the *FD-40A*, was the poor quality of the picture—it was rather gray and fuzzy.

Summary

After testing all of the units, and examining the specifications and brochures of those not tested, we've formed some opinions about the units.

If you are interested in just having a pocket TV for occasional use, and want to keep the cost low, consider the Citizen *06TA* or Sinclair *FTV2*.

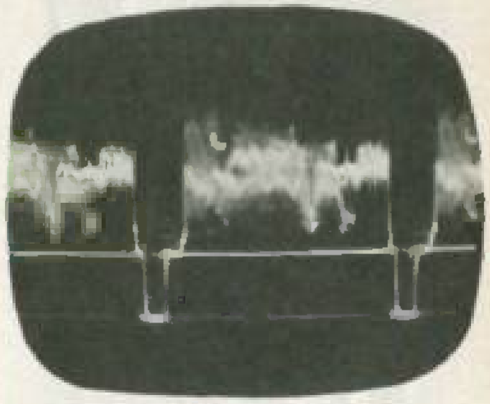
For a better picture, but also a higher cost, consider the Magnavox *BF3900BK* or Sony *FD-2A*. If you want to add stereo FM, get the Citizen *08TA*, the Sony *FD-30A*, or the Magnavox *BF3901BK*.

For monitoring video from a camera or VCR, the Sony *FD-40A* or Zenith *BT044S* will give you the largest picture. If you can get by with a smaller monitor, consider the Sony *FD-30A* or Magnavox *BF3901BK*.

If you can't get by without color, be prepared to pay a lot more for a lot less in picture quality. Of the color sets, the Panasonic *CT-101* is tops, followed by the Seiko *LDV202* and Epson *ET-12*.

In this report we've tried to fairly point out each TV set's strengths and weaknesses. Balancing those against your needs should lead you to the unit that's right for you. Also, the judgments presented here are the author's. Just as you would for any other type of electronics equipment, you should evaluate a set's performance for yourself before making a purchase. R-E

TV SIGNAL DESCRAMBLING



This month we turn our attention to several practical descrambling circuits.

WILLIAM SHEETS AND RUDOLF F. GRAF

Part 3 NOW THAT WE'VE looked at the theory behind several possible scrambling systems and several systems now in common use, it's time to turn our attention to some real-world circuits. For the most part, we will confine our discussions to those systems using fixed scrambling algorithms. Those systems include gated-pulse, sinewave, and *S*ync *S*uppression and *A*ctive *V*ideo *I*nversion (SSAVI). Although those systems are different, they do share some common circuits. Let's start off by looking at some of those common circuits.

Over the next few months, **Radio-Electronics** will be presenting a series of articles describing the techniques used by pay-TV and cable companies to scramble their signals. While specific circuits for specific scrambling systems will be discussed, they are presented for *informational and experimental purposes only*. Therefore, parts lists, parts suppliers, and additional technical support *will not be available* for those circuits.

Basic circuits

One simple circuit that crops up in a variety of scrambling/descrambling systems is the video clamping circuit. That circuit is used to establish a DC or base reference for a video signal.

Consider the situation shown in Fig. 1. There, the video signal shown in Fig. 1-*a* is fed to the "AC-coupled" network of Fig 1-*b*. Note that the output waveform shown in Fig. 1-*c* follows the input, but that the DC level has shifted down about two volts. The result is that, for the portion of the waveform shown, the grays would appear white and the blacks would appear gray. Also, because of the suppressed level of the sync tips, the picture might roll.

The missing reference level can be re-established by modifying the network as shown in Fig. 2. A small portion of the signal is rectified by the clamp diode, D1, and appears as a DC bias that shifts the DC level automatically as required. Assuming that the diode is ideal, the video output can go no further negative than the reference voltage; the video signal is be said to be "clamped" to that reference voltage.

Another circuit found in almost every descrambler is the modulator. In the simplest of terms, a modulator is a circuit that superimposes one waveform on another. In a descrambler, the modulator is used to re-insert components of the video waveform that have been removed, or to restore components that have been altered.

In the gated-sync system, the effect of the scrambling is to reduce the amplitude of the sync pulses. That could also be looked at in another way: The video level is increased so that it is much too high for the sync pulse.

We could restore the proper signal either by reducing the video gain between sync pulses, or by increasing the video gain during the sync pulses. Ideally, we need a circuit that has different gain (or attenuation) for video and sync signals.

Two basic approaches can be used to restore the proper relationship between video and sync signals. One is to use a variable attenuator; the other to use a variable-gain amplifier. The choice of approach is pretty much up to the designer as either is practical and effective.

Variable attenuators

Figure 3 shows four different attenuator networks. The one shown in Fig. 3-*a* is a basic, fixed design. The circuits shown in Figs. 3-*b* and 3-*c* feature continuously variable attenuation. The transistor switched circuit of Fig. 3-*d* has an "on/off" attenuation characteristic. In that last circuit, Q1 switches R2 in to and out of the circuit. When the transistor is conducting, the attenuation is equal to R1/(R1 + R2). Of course, at other times it is less.

Note that, in all of the circuits of Fig. 3, R1 and C1 should be chosen so that the time constant that results is 0.1 second or greater. That will allow the circuit to pass the lowest-frequency video components. Typical values for R1 range between 20 and 150 ohms. For video applications, C1 ranges from 1000 to 5000 µF; for RF it should be between 100 pF and 0.01 µF. The value for R2 should range from 5 to

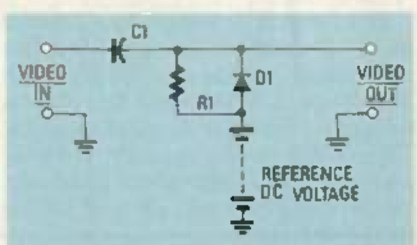


FIG. 2—THE DC REFERENCE-LEVEL can be re-established using a clamping circuit.

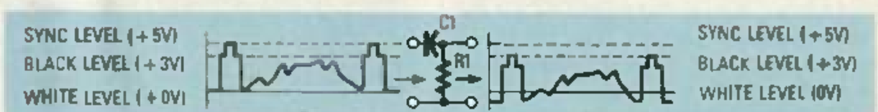


FIG. 1—WHEN A VIDEO SIGNAL is fed through an AC-coupled network, the DC reference-level is lost.

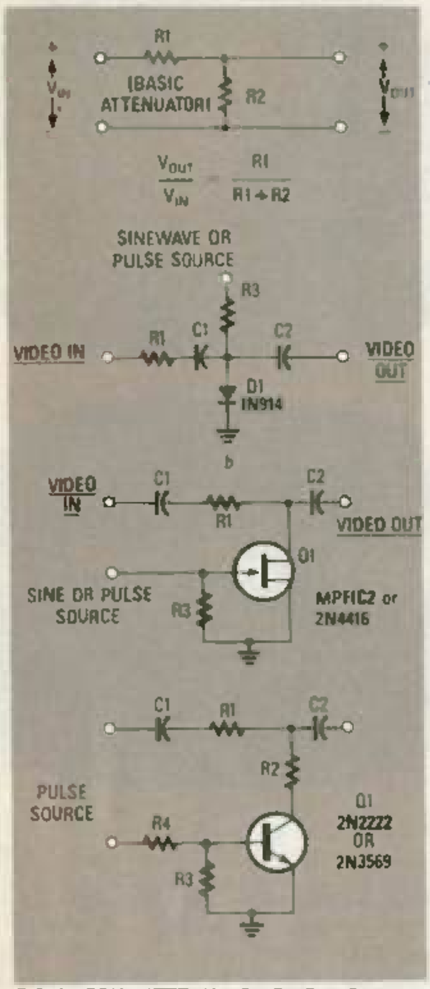


FIG. 3—FOUR ATTENUATOR CIRCUITS. A basic fixed attenuator is shown in *a*. The attenuators shown in *b* and *c* are continuously variable. The attenuator in *d* has an on/off operating characteristic.

50 ohms, while the values for R3 and R4 can fall between 1000 and 22,000 ohms.

Any of the variable attenuators could be used to restore the proper video waveform for a gated-pulse, sync-suppression, or video-inversion type of scrambled signal. However, because we need some degree of "linearity" to deal with sinewave encoded signals, the switched circuit of Fig. 3-*d* would not be appropriate to decode such signals.

Descrambling could be done either at the RF or video level, although it is perhaps simplest to do it at the RF level. That's because RF descrambling, either at broadcast VHF/UHF frequencies or the TV set's IF frequency (typically 45 MHz), allows the use of lower-valued, physically smaller capacitors (100 pF–0.01 µF vs. 1000–5000 µF).

All of the variable attenuators require that the active element be biased on (be conducting) during the periods when the video signal is present. The result, of course, is that the level of the video signal is reduced. During the interval when the sync signals are present, the active elements are biased off and attenuation is reduced or removed so that the sync-signal level, blanking-pulse level, and color-burst signal are not affected. Biasing is provided by a pulse or sinewave source as appropriate. (In some cases, a predistorted sinewave is required; we'll look at that a little more deeply later on in this series.) The net result is that the normal relationship between the video and the sync levels is restored.

We can now look at our first, basic descrambler. It is shown in Fig. 4. That

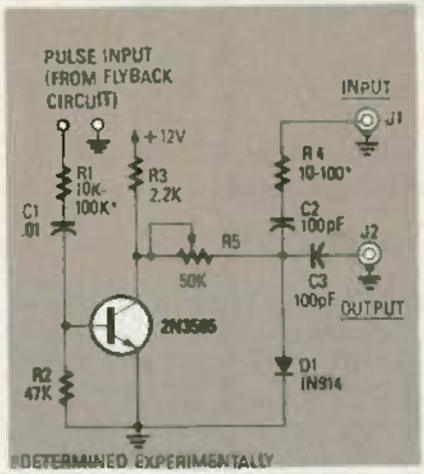


FIG. 4—THIS SIMPLE DESCRAMBLER is based on a continuously variable attenuator. Though difficult to align, it can be made to work.

circuit can be used to decode a gated-sync scrambled signal. It will not work on other types.

Let's see how that circuit works. A small sample of the flyback pulse is used to control the operation of Q1. As a result, during the scan interval the transistor is cut off, allowing a current of about 1 mA to flow from the power supply. That current biases D1 on. The impedance of the diode is determined by the amount of current flowing through it. The amount of current, and thus the impedance of D1, can be controlled by varying R5.

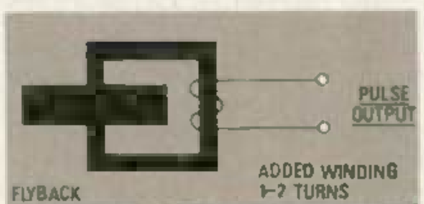


FIG. 5—USE THIS SCHEME to derive the flyback pulse required by the circuit in Fig. 4.

During the retrace interval, however, Q1 is biased on by the flyback pulse, which must be positive. That diverts the current from the power supply to ground, removing the bias from D1.

The amount of attenuation that that circuit provides depends on the impedance of D1. During retrace, the diode is cut off and there is little attenuation. During scanning, attenuation takes place because D1 acts as a low resistance that shorts part of the signal to ground.

We've received reports that circuits similar to the one shown in Fig. 4 have been used to decode *VideoCypher II* video; as we have had no direct experience with that, we make no promises or guarantees. Further, neither that circuit, nor any other that we've heard of is capable of restoring proper audio to a *VideoCypher*-scrambled signal.

The circuit of Fig. 4 is not without its problems. It is difficult to adjust and noise prone. Also, it requires digging into the TV receiver to obtain the flyback pulse. On the other hand, it is a good experimental project because its parts are low cost and can, for the most part, be reused later in a more advanced descrambler.

Perhaps the most difficult aspect of getting the circuit working is obtaining the flyback pulse. Unless you know what you are doing, you could damage the TV set or expose yourself to **dangerous high voltages**. For those who would like to give it a try, Fig. 5 shows a method for obtaining the flyback pulse. Be sure to use heavily insulated wire and, if possible, operate the set from an isolation transformer during your experiments. Once again, **you will be dealing with high voltages, so be extremely careful.**

Variable-gain amplifiers

The other approach to restoring a video waveform is to use a variable-gain amplifier. In that approach, the gain of the decoding circuit is controlled by a decoding signal in such a way that the output consists of a proper video waveform. Two circuits that are appropriate for that ap-

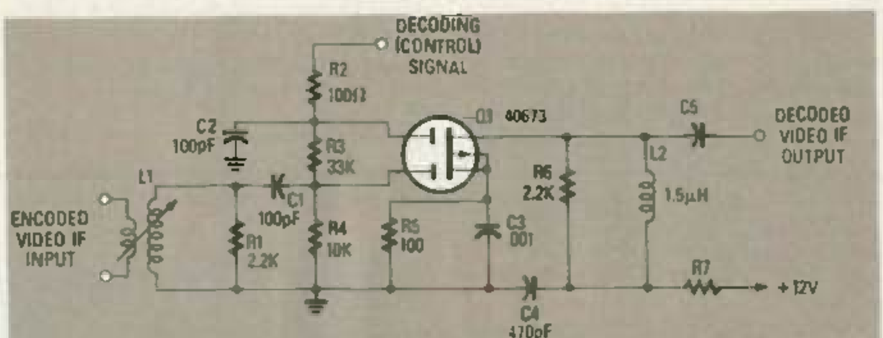


FIG. 6—THIS DESCRAMBLER IS based on a variable-gain amplifier. The decoding signal is used to determine the amount of the gain.

plication are shown in Figs. 6 and 7.

In Fig. 6 a standard video RF-amplifier circuit is used as a video IF-amplifier at 44 MHZ (that's a standard TV IF frequency). The input signal, which is taken from the tuner or a following IF stage, is made up of a video signal and a superimposed scrambling signal. The gain of the amplifier is altered by changing the bias at gate 1 (or gate 2) of Q1. That technique is normally used in AGC circuits, but if the bias is a DC voltage with a superimposed decoding signal, we can vary the gain in such a way that the encoding signal is canceled. For proper operation, the DC voltage and the decoding signal level must be carefully chosen. Ideally, the output of the circuit should be an amplified version of the video signal, with all traces of the encoding signal removed.

The circuit in Fig. 7 is built around an LM733 video amplifier. That two-stage, differential-input, wideband video-amplifier is designed for use in a wide variety of video applications. It has a bandwidth of over 120 MHz and selectable gain.

A differential amplifier has the property of producing an output signal that is the product of the gain of the amplifier and the difference between the two input signals. By grounding one input of the LM733, the amplifier can act as a conventional amplifier. The output can be either balanced or single-ended with respect to ground, and the device can be set up to provide two identical output signals that are 180° out of phase, as has been done in the circuit of Fig. 7.

Let's see how the circuit of Fig. 7

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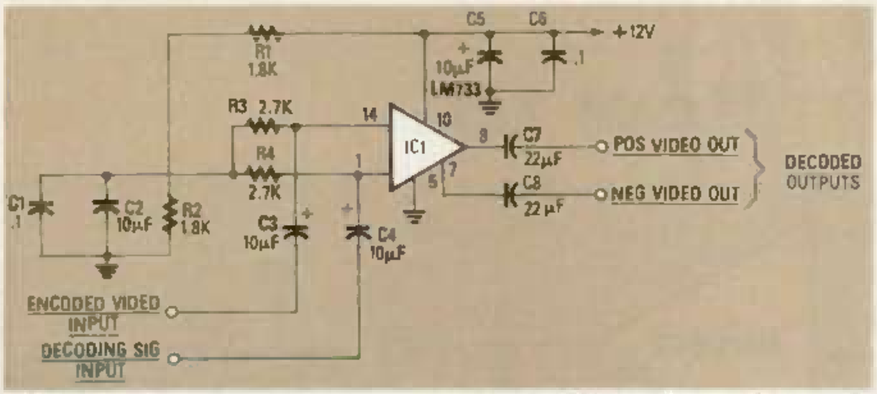


FIG. 7—ANOTHER VARIABLE-GAIN descrambler. this circuit is built around an LM733 video amplifier. Note that both positive and negative outputs are available.

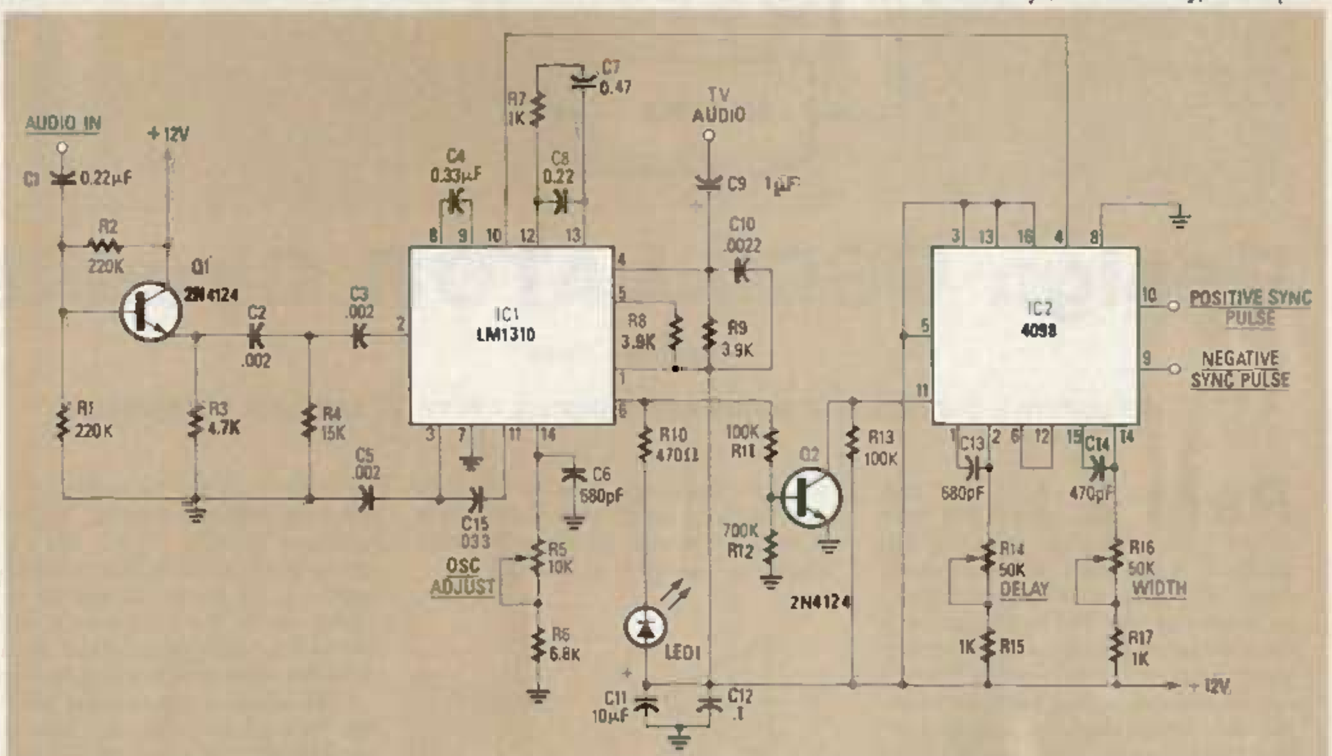


FIG. 8—FOR SYSTEMS WHERE a 15.75-kHz decoding signal is hidden in the audio channel, this circuit can be used to reconstruct a missing sync signal. Note that while IC1 was designed for FM stereo applications, when configured as shown it can be made to operate at 15.75 kHz.

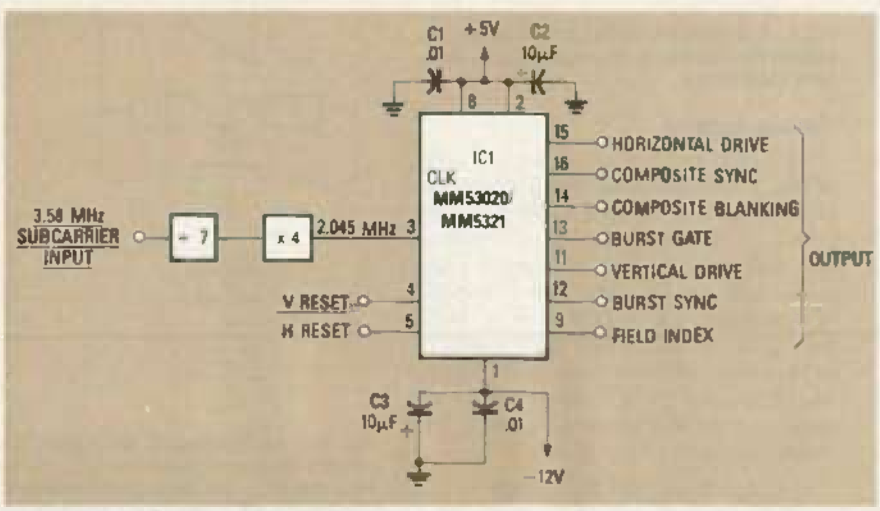
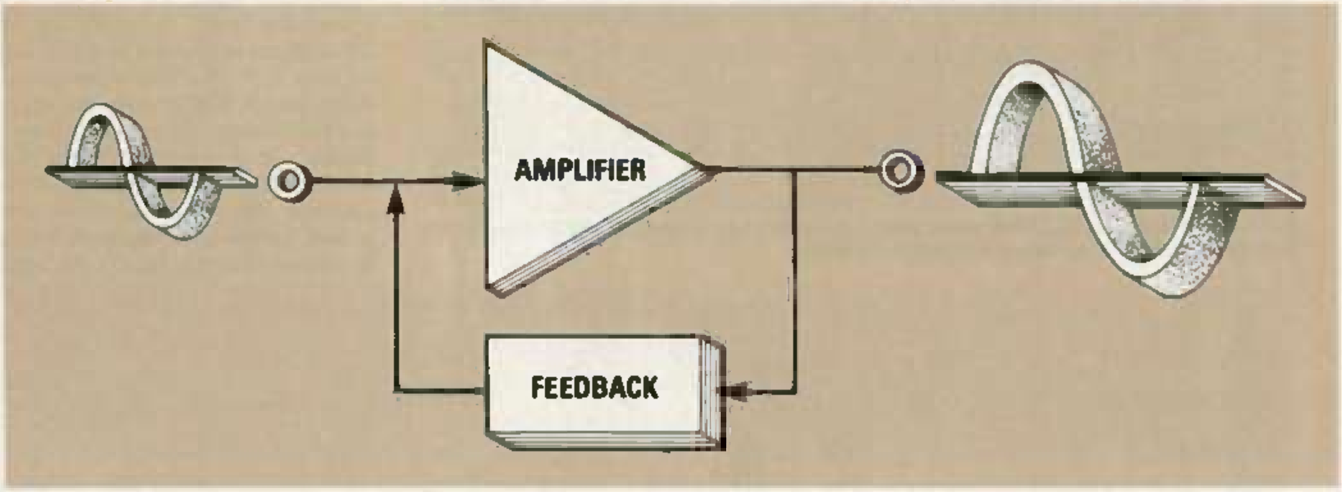


FIG. 9—IF NO DECODING SIGNAL IS AVAILABLE, this circuit can use the 3.58-MHz color-burst signal to reconstruct all of the components of an NTSC sync signal.

How to



Design OSCILLATOR Circuits

JOSEPH J. CARR

We continue our oscillator series with a discussion of LC feedback oscillators.

Part 2 LAST TIME WE learned that there are two types of oscillator: relaxation and feedback. A relaxation oscillator is built from a neon lamp, a UJT, a tunnel diode, or another device. The non-linear resistance characteristics of those devices are what cause oscillation to occur. Below a certain potential, a neon lamp, for example, does not conduct; but, after that potential is exceeded, the device breaks down and provides a discharge path for a timing capacitor. When that capacitor discharges below the lamp's holding voltage, it stops conducting, and voltage starts to build up across the lamp again. That build-up continues until the threshold voltage is exceeded once again. Oscillation thus continues as long as voltage is present.

A feedback oscillator, on the other hand, is built from a transistor, a tube, an op-amp, or some other active (amplifying) device. Oscillation is brought about by applying a portion of the amplifier's output signal to its input. That feedback signal must be applied in phase with the original input signal. The reason is that, because the amplifier is usually an inverter that provides 180° of phase shift by itself, an additional 180° of phase shift must be provided through some other means.

There are many different ways of providing that phase shift; we'll show several of the more popular below. But first, we'll finish up our theoretical discussion of oscillator circuit gain, and then talk about how oscillation gets started.

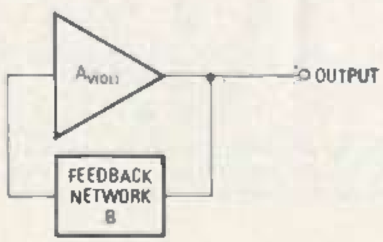


FIG. 1—A FEEDBACK OSCILLATOR may be considered theoretically as an amplifier and a feedback network.

Gain equations

The basic feedback oscillator is shown in Fig. 1. The triangular block represents an amplifier that has an open-loop gain of $-A_{V(OL)}$, where the minus sign implies a 180° difference in phase between the circuit's input and its output. The feedback network has a gain factor *B*; in most cases, that "gain" is really a loss. If the circuit is to oscillate, we must make the closed-loop gain, A_V, greater than or equal to unity. As we discussed last time, the closed-loop gain of the circuit is:

$$A_V = A_{V(OL)}/[(1 + A_{V(OL)} \times B]$$

Finding the value of B is easy, given the right circuit. In Fig. 2-*a* is shown a typical three-leg feedback network. We call the reactance elements Z1, Z2, and Z3, implying that they can be either capacitive or inductive reactances, depending on our design needs. For convenience we have shown the amplifying element as an op-amp, but other devices could be used.

Take a look at Fig. 2-*b* and you'll see that the feedback factor, B, can be stated in a form that resembles the equation describing a resistive voltage divider:

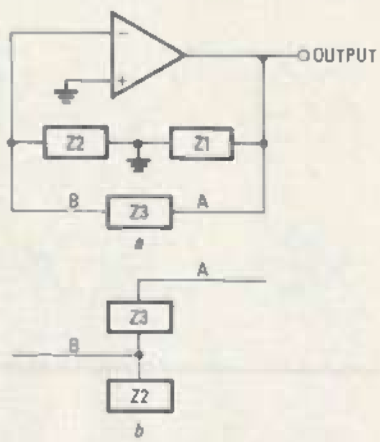


FIG. 2—THE FEEDBACK NETWORK is often composed of three impedances, Z1, Z2, and Z3, as shown at *a*. For purposes of mathematical analysis, Z2 and Z3 may be treated similarly to a resistive voltage divider (*b*).

$$B = Z2/(Z2 + Z3)$$

Commonly Z1 and Z2 are the same type of reactance, and Z3 is of the "opposite" type. For example, if Z1 and Z2 were capacitors, then Z3 would be an inductor; if Z1 and Z2 were inductors, then Z3 would be a capacitor.

Whichever feedback technique we use, however, there is still one unanswered question: How does oscillation begin? If oscillation depends on feeding the output signal back to the input in phase, then how can the process begin when there is no output signal to feed back? To use a mechanical analogy, consider a tuning fork. It needs a mechanical stimulus—a sharp rap—to start oscillating. Is there an electrical equivalent to that rap that will get an oscillator running?

The answer, of course, is yes. First, no circuit is ever perfectly noise free. In fact, transistors, tubes, and other active devices have an abundance of noise that initially "rings" the circuit. Second, there is also a variable output voltage that is caused by the varying collector (or drain) current as the device "comes alive." In many cases that change in current is sufficient to ring the circuit into oscillation. However, if the circuit were very quiet or very slow to turn on, it is possible that the circuit would be unable to start oscillating. But, assuming it does start, we usually want oscillation to occur at a specific frequency.

There are many methods of controlling frequency; we'll look now at several ways of controlling frequency using coils and capacitors.

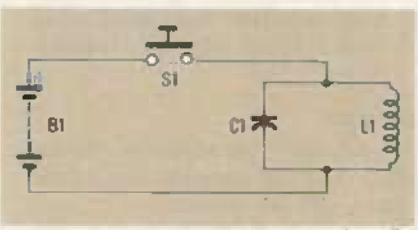


FIG. 3—AN LC TANK CIRCUIT determines the frequency at which many circuits oscillate.

LC oscillators

Let's digress a moment and talk about how a basic LC circuit works. In the circuit shown in Fig. 3, after S1 has been closed for a period of time, current will flow through L1, and that will store energy in the inductor. But when S1 is opened, the magnetic field of the inductor collapses. That collapse induces current into the circuit, and that current charges C1.

After C1 charges fully the process reverses. The capacitor begins to discharge and that builds up the magnetic field in the inductor. But this time, circuit losses have reduced the amount of available energy, so the field is weaker than before. The field collapses, C1 charges, and so on, until all the energy of the circuit has been spent. That steadily-reducing, or damped, oscillation would appear on an oscilloscope as shown in Fig. 4.

Each time the LC tank circuit is "pulsed" by closing S1, the oscillations will begin and have a frequency *f* that is given by the standard resonance equation:

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

All LC oscillators function according to the damped-oscillation model discussed above; the frequency at which any given LC circuit oscillates can be described by the equation just given. So, keeping those basic ideas in mind, let's take a look at several popular LC oscillators.

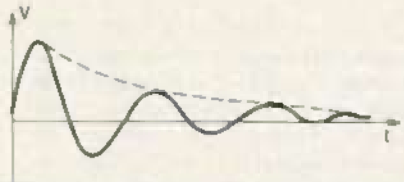


FIG. 4—WHEN PULSED, AN LC tank circuit produces a damped ringing signal as shown here.

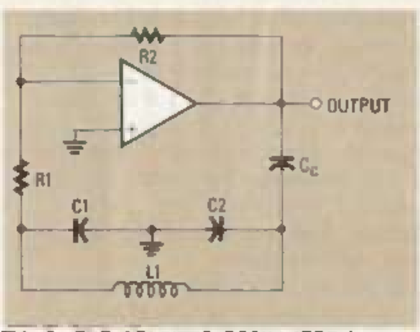


FIG. 5—THE COLPITTS OSCILLATOR is composed of a two-capacitor, one-inductor feedback network.

The Colpitts oscillator

The basic Colpitts oscillator is shown in Fig. 5. Referring to our model circuit in Fig. 2-*a*, reactances Z1 and Z2 correspond to capacitors C1 and C2, respectively, and reactance Z3 corresponds to inductor L1. The circuit's frequency of oscillation is given by the standard resonance formula given above. Values are specified in henrys for coils, and farads for capacitors. Also, the term *C* in the equation must be calculated from the series combination of C1 and C2 in the standard manner:

$$C = (C1 \times C2) / (C1 + C2)$$

The nominal gain of the colpitts oscillator is expressed as the ratio R2/R1, and minimum gain is expressed as the ratio C1/C2. We must make the value of C2 greater than the value of C1 if that gain is to be less than unity. In practice, the C1/C2 ratio is a trade-off between amplitude and stability.

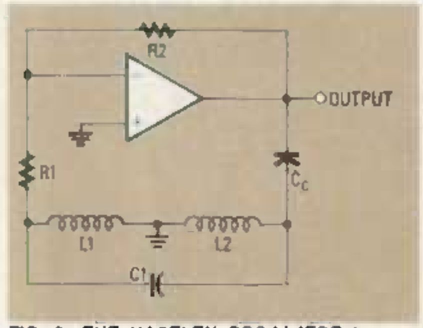


FIG. 6—THE HARTLEY OSCILLATOR is composed of a two-inductor, one-capacitor feedback network.

The Hartley oscillator

The classic Hartley oscillator is shown in Fig. 6. The principal difference between the Hartley and the Colpitts oscillators is the type of reactance elements used for Z1, Z2, and Z3. In the Colpitts oscillator, Z1 and Z2 are capacitive, but in the Hartley version they're inductive. A Hartley oscillator may use a tapped inductor, but it's still a Hartley oscillator. Further Z3 is inductive in the Colpitts, but capacitive in the Hartley. The circuit in Fig. 6 will oscillate at a frequency given by:

$$f = \frac{1}{2\pi\sqrt{(L1 + L2)C1}}$$

Like the Colpitts oscillator, nominal gain of the Hartley oscillator is R2/R1, and minimum gain is L2/L1.

Practical circuits

A discrete-transistor implementation of the Colpitts oscillator is shown in Fig. 7-*a*. The split-capacitor voltage divider that provides feedback consists of C2 and C3. In general, C3 has a larger value than C2; typical values are 82 pF for C2 and 0.001 µF for C3. Resistor R3 biases the transistor, and R1 provides stability. The output signal is developed across R1. The frequency of oscillation is determined by resonant tank circuit Z, which is connected to the base of the transistor via C4 as shown.

The tank circuit is composed of a coil and a capacitor, which may be connected in series, as shown in Fig. 7-*b*, or in parallel, as shown in Fig. 7-*c*. The series circuit is called a Clapp oscillator because it resembles the series-tuned Clapp oscillator that was popular in the 1950's.

A Hartley oscillator may be built as shown in Fig. 8. Again, a bipolar transistor is the gain-producing element. Resistors R1 and R2 bias Q1, and play no

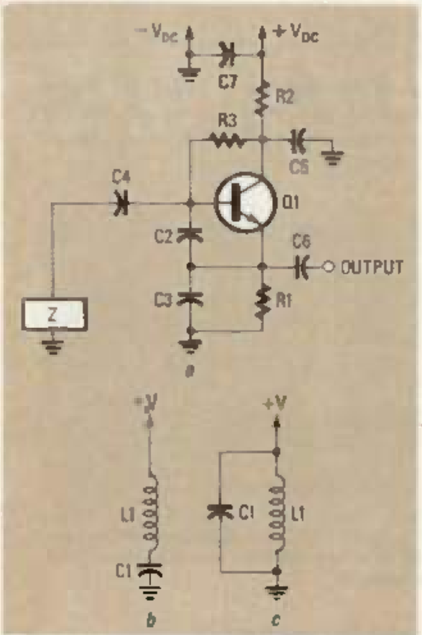


FIG. 7—A COLPITTS OSCILLATOR can be built using a transistor (a). The block marked *Z* should be replaced by the network shown in *b* (for a Clapp oscillator) or *c* (for a pure Colpitts oscillator).

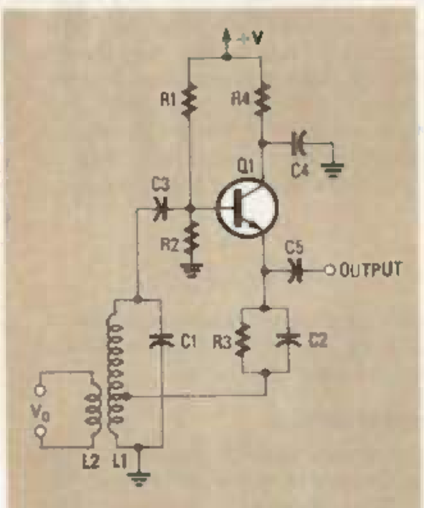


FIG. 8—A HARTLEY OSCILLATOR can also be built using a transistor; oscillating frequency is set by L1 and C1.

other role. Oscillating frequency is determined by the resonant tank circut that is made up of L1 and C1, and the output signal can be taken either from the emitter of the transistor via C5, or from coil L2, which is coupled to L1. The position of L1's tap is a trade-off between the stability and the amplitude of the output signal.

As a final word before we move on, both Hartley and Colpitts oscillators are common-collector circuits, because the collector of the transistor is at AC ground by virtue of the presence of a bypass capacitor—that capacitor is C5 in Fig. 7-*a*, and C4 in Fig. 8.

The Armstrong oscillator

There are many additional types of LC oscillators, but two are particularly interesting, historically speaking. The Armstrong oscillator is named after Major Edwin Armstrong, who invented the regenerative detector, the superheterodyne radio, frequency modulation, and other things. A modern version of the Armstrong oscillator is shown in Fig. 9. That circuit uses a FET as the amplifying element; the original Armstrong circuit used a tube. Another popular name for the Armstrong oscillator is the "tickler oscillator;" we'll see why in a moment.

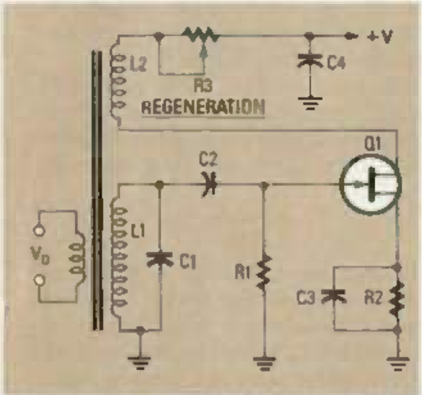


FIG. 9—THE ARMSTRONG OSCILLATOR is the basis of many circuits including the regenerative radio receiver.

The Armstrong circuit's frequency of oscillation is determined by the values of the components in the parallel-resonant tank circuit composed of C1 and L1. A feedback coil, or "tickler" coil, L2, is closely coupled with L1, and the tickler serves to feed part of the output signal back to the input. Care must be taken to be sure that the mutual inductance between L2 and L1 is of the proper "polarity." Otherwise feedback will occur, and the circuit won't oscillate.

The amount of feedback, or regeneration, is controlled by variable resistor R3; that resistor controls the amount of current flowing in the tickler coil. In older circuits, the tickler coil was wound on a mechanism that permited the position of the coil to be varied with respect to L1. When coupling was maximum, so was feedback. The frequency of oscillation of the Armstrong oscillator may be calculated by plugging the values of L1 and C1 into the resonance equations that we cited earlier in this article.

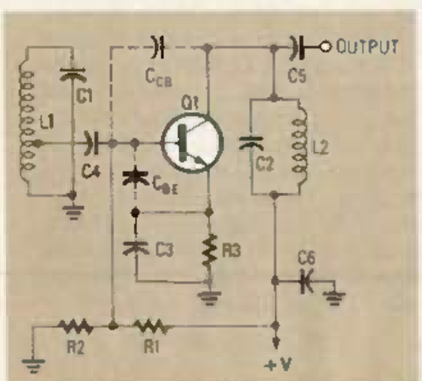


FIG. 10—THE TITO OSCILLATOR uses an LC tank at both the input and output of the circuit; the two tanks are tuned near, but not precisely at, the same frequency.

The TITO oscillator

Our final LC oscillator has been called by several different names in the past. In older texts that illustrate the use of vacuum-tube circuits, the circuit is called a *T*uned-*G*rid-*T*uned-*P*late (TGTP) oscillator. More recently it has been called a *T*uned-*B*ase-*T*uned-*C*ollector (TBTC) oscillator. Perhaps now that we have so many types of amplifying devices, the circuit should be called a *T*uned-*I*nput-*T*uned-*O*utput (TITO) oscillator.

Whatever we call it, it looks something like the circuit shown in Fig. 10; the frequency of oscillation of the circuit is set by both the L1/C1 and the L2/C2 tank circuits. Most textbooks recommend that the two tank circuits resonate at almost equal, but slightly different, frequencies.

Feedback in the TITO oscillator is brought about through inter-element capacitance in the transistor. In other words, C_{BE} (the capacitance between base and emitter) and C_{CB} (the capacitance between collector and base) are not external capacitors: they are part of the structure of the transistor. That is why they have been shown in dashed lined in the illustration.

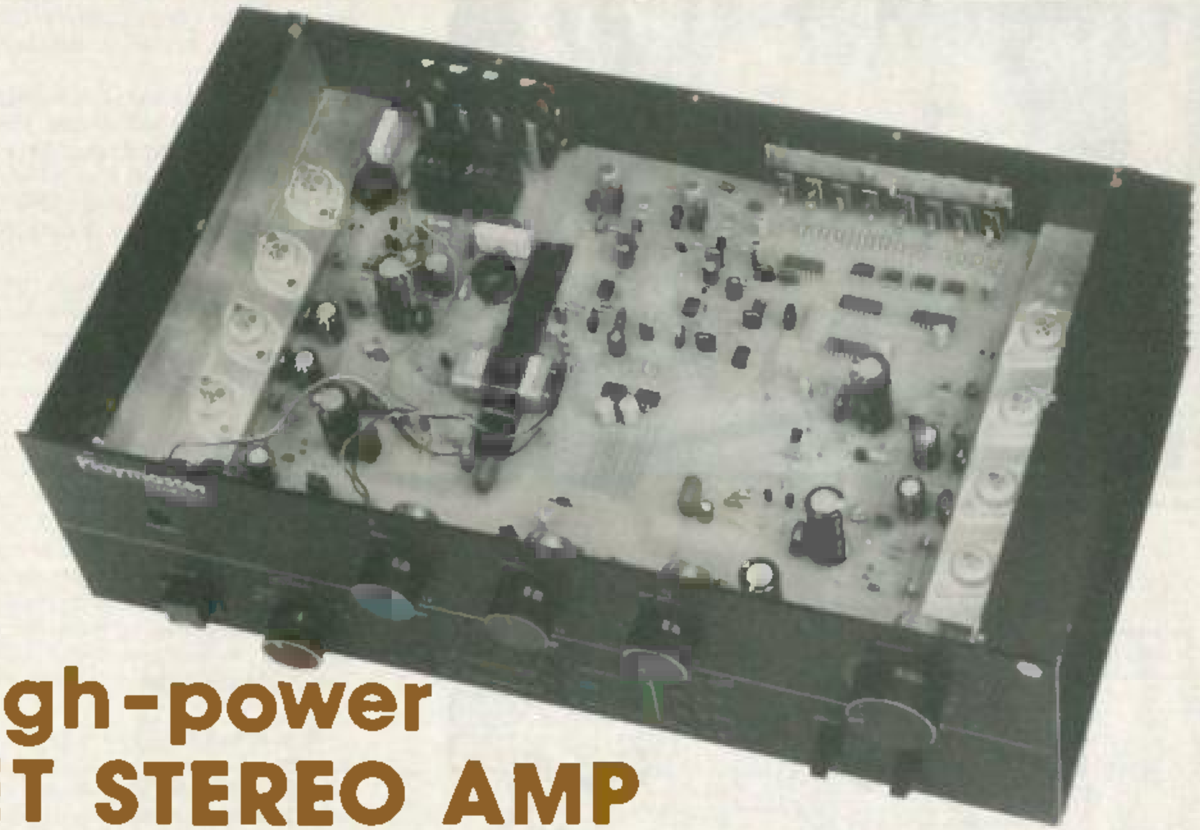
The TITO oscillator is rarely used these days, even though the local oscillators in some TV and FM receivers are, implicitly, the TITO type. That sort of circuit may appear to have no capacitors and only inductors but don't be fooled. The designers of the circuit intended for stray device and circuit capacitance to be sufficient to produce oscillation at the desired frequency.

Conclusion

We've covered quite a bit of ground this month, so let's take a moment to step back and recap what we've done.

After deriving the gain equation of a generalized oscillator circuit, we discussed how oscillation may be initiated by start-op currents in the circuit, or even by random circuit noise. Then we reviewed the operation of LC tank circuits. With that theoretical background, we then went on to look at Colpitts and Hartley oscillators. After examining them theoretically, we discussed several practical circuit implementation. Finally we discussed several historically interesting circuits: the Armstrong oscillator and the Tuned-Input-Tuned-Output (TITO) oscillator.

When we continue next time, we'll discuss RC oscillators that are built from op-amps. R-E



High-power FET STEREO AMP

After several months of theoretical discussion, it's time to get our hands dirty and build this audiophile's dream amplifier!

LEO SIMPSON AND JOHN CLARKE

Part 3 WE'VE SPENT SEVERAL months talking about how the amplifier works and the philosophy behind its design. We've all had enough theory—so let's start building an amplifier!

Mechanical overview

First of all let's talk about PC boards. Two are required: the control board, which contains most of the digital input-switching circuitry, and the main board, which contains the vast majority of all other components. If you want to etch your own, we show the foil patterns for both boards in this issue's PC Service; alternatively, you may purchase boards from the source mentioned in last month's Parts List. In any event, we don't recommend that you try to build the amplifier without PC boards; success using any other construction technique is highly doubtful.

As you can see in Fig. 10, the mechanical arrangement of our amplifier is rather unusual in that two large heatsinks serve both as endpanels and as supports for the main PC board. That arrangement allows the output transistors to be bolted to the heatsinks and their leads soldered directly to the appropriate pads of the PC board. In addition, the front and rear panels bolt directly to the heatsinks, and so do the top and bottom panels. Both the top and the bottom panel also have flanges that help secure the front and rear panels making for a mechanically stable cabinet.

The terminals of the tape input/output jacks, the main input jacks, and the speaker connectors are soldered directly to the rear of the PC board; the jacks themselves protrude through cutouts in the rear panel, to which they are bolted. Similarly, on the front panel, the shafts of the PC-board mounted BASS, TREBLE, BALANCE, and VOLUME control potentiometers protrude through holes in the front panel, to which the potentiometers are secured using nuts.

Unlike the other switches and the potentiometers, the POWER, SPEAKER SELECT, MONO/STEREO, and MUTE switches are not soldered directly to the PC board. They are connected to it using short lengths of hookup wire and they are secured to the front panel with the appropriate mounting hardware.

The control board attaches to the front panel by means of three short threaded bushings. The bushings are attached to the component side of the PC board; the board is then screwed to the front panel. The lower screws pass through flanges on the base plate.

As shown in Fig. 9 last time, the high-voltage power supply components (T1, BR1, C8–C11) are mounted on the base plate of the amplifier, below the main PC board. Several screw-terminal strips are also attached to the base plate to facilitate interconnections between C7, S1, the line cord, and T1.

Electronic assembly

Construction is straightforward and mostly involves installing parts on the two PC boards. Before mounting any components, inspect both boards for shorted or open traces. Repair any faults before proceeding. A few minutes spent correcting faults on the PC board now could save considerable frustration—and cash—

*Adapted from material published by *Electronics Australia*

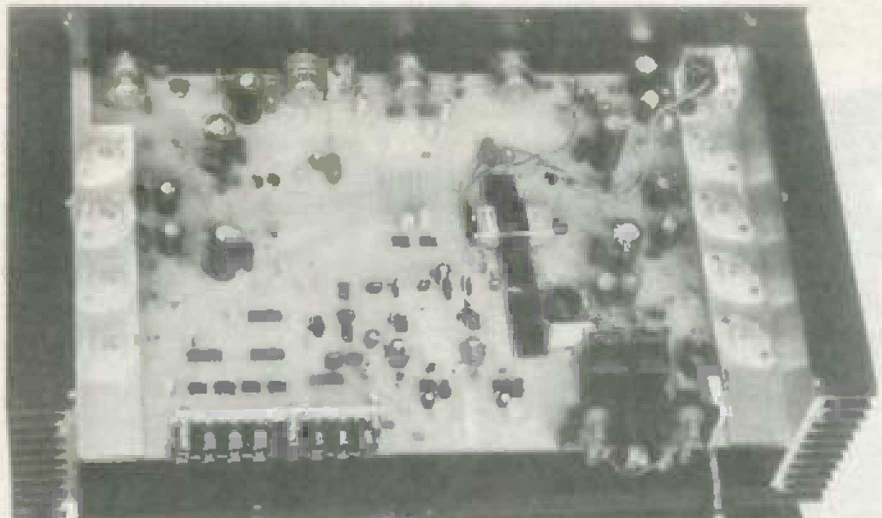


FIG. 10—MOST SWITCHES AND POTENTIOMETERS are soldered directly to the PC board; that eliminates much tedious wiring by hand.

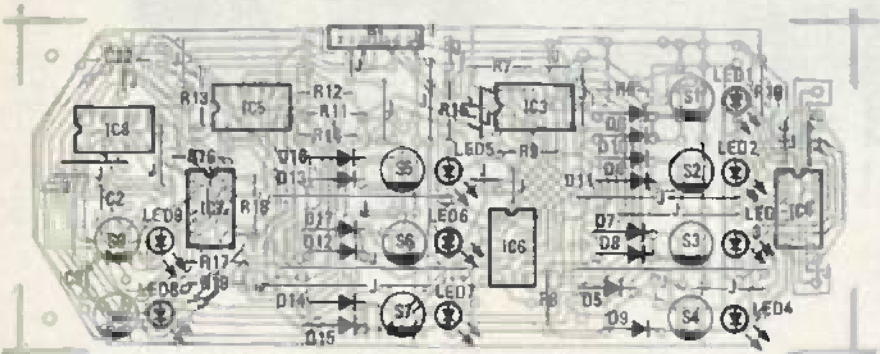


FIG. 11—MOUNT THE CONTROL-BOARD COMPONENTS as shown here. The switches and LED's mount with their flat sides down, and P1, if used, mounts to the back side of the board.

later on.

First let's build the control board. Follow the component overlay shown in Fig. 11 when installing the parts. Start with the jumpers and the diodes, then insert the resistors and the capacitors, the IC's, and the switches (S1–S9). Make sure that all semiconductors and the electrolytic capacitor (C22) are oriented correctly. The proper orientations are shown in Fig. 11. The two 0.047-µF capacitors (C2 and C3) must be pressed flat against the board; otherwise it will not mate with the front panel correctly. The switches should be oriented so that the flat side of each switch faces the edge of the PC board that mounts closest to the main board.

Last, install the LED's. The tops of the LED's should be the same height above the board as the tops of the switches. Before moving on, make sure that the LED's are oriented correctly—the flat side of each LED goes toward the bottom of the board.

After all parts are mounted, check everything carefully. After you're sure everything has been installed correctly, remove flux from the back of the board and solder a nine-pin SIP header plug in the space allotted for P1—but on the solder side of the board. Since the PC board is not double-sided, it has no pads on the component side, so you'll have to leave a enough space between the body of the connector and the PC board for the tip of your soldering iron to fit in. To solder the connector in place, tin pin 1 of P1 and the pad to which it will be soldered. Then melt the solder on the pad, insert the plug, and adjust it so that the body of the plug is parallel to the board. Remove your soldering iron. If the plug moves, re-heat the joint, and re-adjust the position of P1. When it is in place properly, solder pin 9 to the board. Then solder the remaining pins.

Wire up a nine-conductor cable with nine-conductor SIP sockets on both ends. Rather than use plugs and sockets, you could just hard-wire a nine-conductor cable from the control board to the main board. In either case, make sure the cable is long enough to reach both boards when they are installed in the chassis! Your completed board should appear as in Fig. 12. As you can see, for our prototype we hard-wired the cable and didn't use a plug-and-socket; use whichever arrangement suits you best.

The main board

Obviously it will take considerably longer to build the main board than it took to build the control board. The chances for error are also considerably greater. So take your time, be careful, and check your work often!

Refer to Fig. 13 and start installing the jumpers, resistors and diodes. Take particular care with the diodes. Don't confuse the 5.6- and 9-volt Zener diodes, and make sure that you install the 1N4002 and the 1N914 diodes in their designated positions.

The IC's and the transistors can be installed now, but don't mount the power transistors yet. Many different types of transistor are used in this circuit, so make sure that the correct one is inserted at each location. When mounting the IC's, make sure that they are oriented correctly and solder the power-supply pins first. Power is applied to pins 4 and 7 of the op-amps (TL071, NE5534), and to pins 7, 8, and 16 of the CMOS analog switches (4052, 4053). Then go on and solder the signal-carrying pins. After soldering, check for solder bridges between every pin and its neighbor. A little time spent doing that now could save a lot of time and money later.

Now install the capacitors. Since we use several capacitors with the same capacitance but different voltage ratings, take a few extra moments and be sure that you install the correct unit at each location. And be sure that the polarized capacitors are oriented correctly; the proper orientations are shown in Fig. 13.

The fuse clips, relays, trimmer potentiometers, and all the other small board-mounted components except the power transistors can be installed next. For best results, observe the recommendations that follow.

Now cut the shafts of the potentiometers to a length of about ½ inch. Then solder the potentiometers to the board. The lugs of the potentiometers should be inserted into the PC board all the way so that the shafts will line up with the holes in the front panel.

The strip of RCA jacks (J100–J107, J200–J207) supplied with the kit includes a ground lug that must be removed. Then cut the strip to an overall length of about 4¾ inches with a hacksaw. Last, drill a hole directly above the last RCA jack at the same height as the other mounting holes in the strip. Once all of that has been done, mount the strip on the PC board and solder the lugs.

The loudspeaker terminals can be installed now. Make sure that the two plastic locating lugs that are on those loudspeaker terminals mate with the appropriate holes in the PC board.

We used PC stakes to terminate wiring from the switches, the jumpers, and the power supply. Since most of those connections terminate on the underside of the

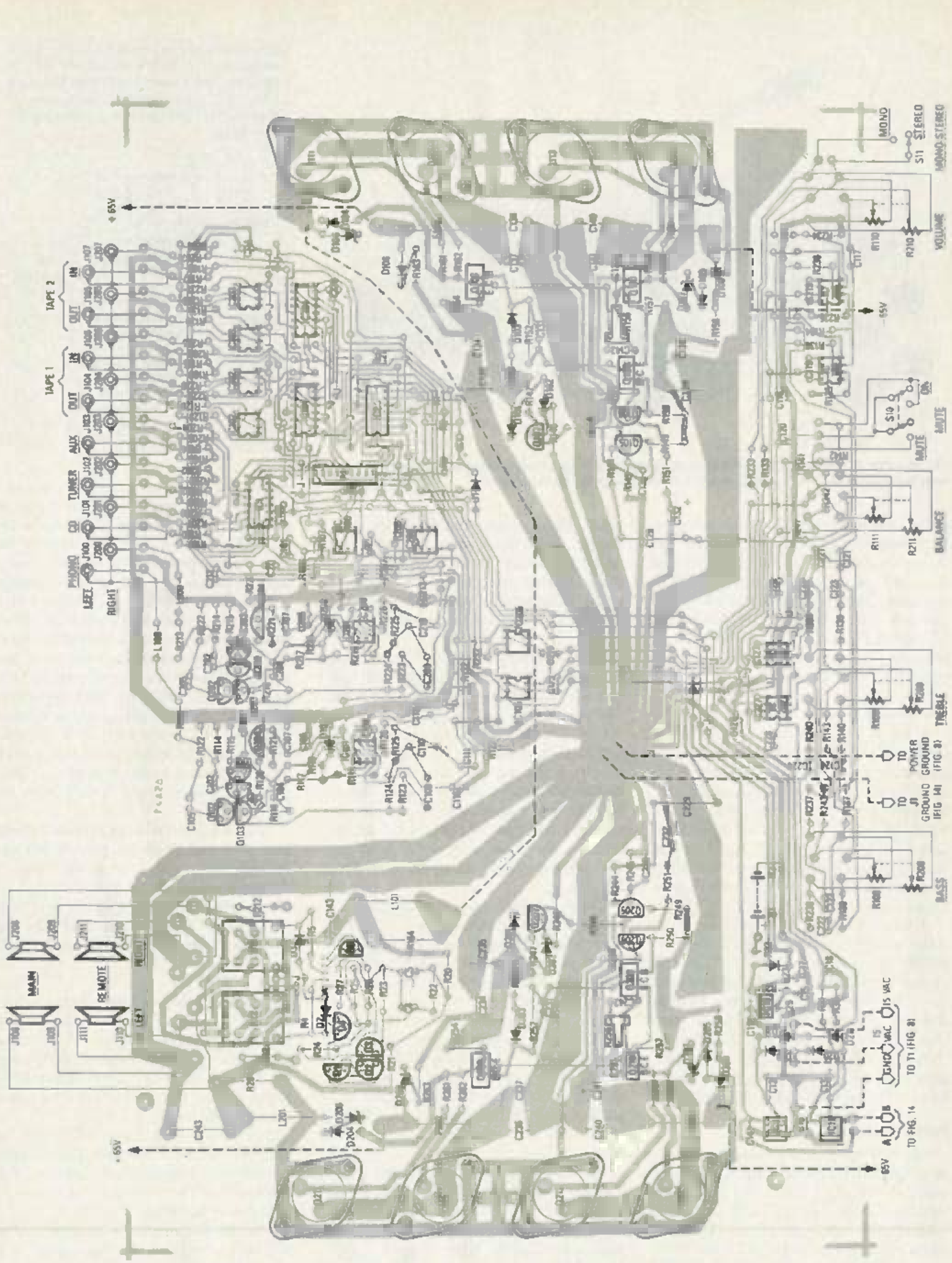


FIG. 13—MOUNT THE MAIN-BOARD COMPONENTS as shown here. A heavy jumper wire must connect the pad near Q111 to the pad to which R164 and L101 are soldered. Also, several additional wires (shown at the front left side of the board) are routed beneath the board.

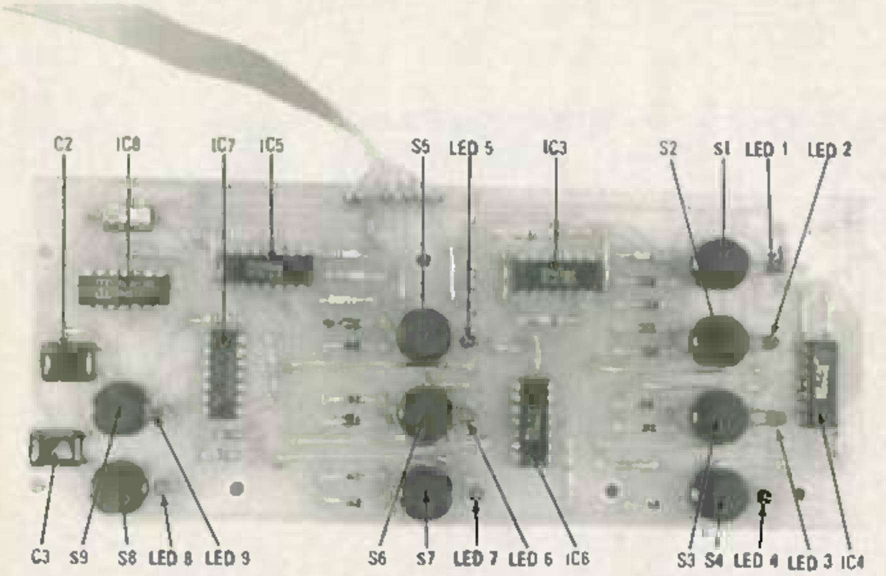
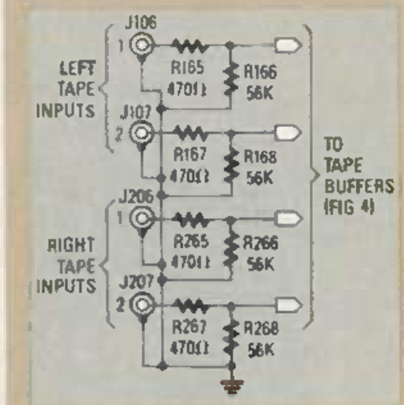


FIG. 12—THE COMPLETE CONTROL BOARD appears as shown here. Capacitors C2 and C3 must be bent flat against the board so that it won't interfere with the front panel.

Inadvertently the resistors in the figure shown here were not shown in Fig. 1 (in the June 1986 issue). In addition, the Parts List in that issue contained several errors. The correct Parts List was published in the July issue.



board, the stakes should be mounted on the underside. The exceptions are the stakes that the Ni-Cd batteries (B1 and B2), the headphone jack (J1), and the 7815 regulator (IC9) are connected to—those components are wired to the top of the board, so the stakes should be inserted from the top of the board and then soldered from the bottom.

Winding the coils

A small hand-wound coil is wired in series with the input of each phono preamplifier. Wind each coil by feeding 5.5 turns of 28-gauge enameled copper wire through the center of the small ferrite bead. When complete, about ½ inch of wire should exit from each end of the bead. Remove about ¼ inch of insulation from each end of the wire and then solder the coil in place.

A larger 6.8 μH choke is connected in series with the output of each power amplifier. Wind each coil with 24.5 turns of 18-gauge enameled copper wire around a 7/16-inch plastic coil form. You'll have to wind three layers; the ends of the wire should exit from either side of the form 180° apart. Remove about ¼ inch of insulation from both ends, bend the leads down 90°, and solder the coil in place.

Power transistors

The MOSFET power transistors must be isolated from the heatsink using mica washers, silicone grease, and insulating bushings. Note that the heatsink which supports the right side of the PC board must be notched slightly in order to provide clearance for the VOLUME control. The power transistors are secured to the heatsinks with no. 6 screws and nuts. After each transistor is mounted, use your multimeter to make sure that there is no continuity between its case and the heatsink. When you're sure there's no continuity, solder the leads of the transistors to the PC board. You should also solder the mounting nuts to the PC board to ensure reliable long-term contact between the case of each transistor and the copper traces.

Finish building the main PC board now by installing the three voltage regulators and the headphone jack. The 7915 and 7805 regulators are soldered directly to the PC board. The 7815 is bolted to the left-hand heatsink and it must be electrically insulated from it using a mica washer, silicone grease, and an insulating bushing. Once again, use your multimeter to make sure that the metal tab of the regulator is isolated from the heatsink. The regulator leads are soldered to three PC stakes.

The headphone jack is mounted on a small L-shaped bracket that is bolted to the left-hand heatsink above the 7815. The barrel of the headphone jack must not make contact with either the heatsink or the front panel.

Now wire the MONO/STEREO (S9) and the MUTE (S11) switches to the appropriate pads on the PC board as shown in Fig. 13. Connect the beneath-board jumper from the output of the right-channel power amplifier to the appropriate pad near the relays. That wire should be at least 16 gauge.

Connect the other two beneath-board jumpers now. Those jumpers connect two pads at the front left of the board (shown in Fig. 13) to two pads in the row of five pads in front of the relays (shown in Fig. 14). Then connect wires to headphone jack (J1) and SPEAKERS switch S12.

Power supply assembly

Work can now proceed on the power supply components. Follow the wiring diagram in Fig. 8 (shown in the July issue) carefully since any errors here could be disastrous. Use insulating sleeves on the 0.01 μF capacitor (C7), and insulate the pins on the power switch with several turns of plastic tape or heatshrink tubing.

Bolt the transformer to the case with a bolt, a metal disc, and two large rubber washer. One washer is sandwiched between the transformer and the base, and another between the transformer and the disc. The four 8000 μF filter capacitors (C8–C11) are secured using aluminum brackets. The bridge rectifier is smeared on both surfaces with heatsink compound; then it is bolted to the base plate. Complete the power-supply wiring with 16-gauge wire.

Secure a 3-screw terminal block to the base plate and attach the 117-volt hot and neutral leads to it. The ground lead is soldered to a solder lug bolted to the base plate. Make the ground wire longer than the others so that this lead will be the last to break if the power-cord is pulled out.

Final assembly

With the base panel wiring completed, connect the 9-conductor ribbon cable from P1 on the control board to P2 on the foil side of the main PC board. Then make the connections between the high-voltage power supply, the 15-0-15 tap on T1, and the main PC board.

Use heavy duty cable—16 gauge or greater—for the ±65-volt power-supply connections. Run separate leads from the terminals of the 8000-μF capacitors to each power amplifier.

The chassis can now be assembled. The first step is to secure the base panel to the heatsinks using six machine screws. Four adhesive rubber feet can then be fitted in the corners.

Secure the power cord in place using a grommet, then fasten the rear panel to the heatsinks and to the base panel.

Next secure all loose switches to the front panel, and then attach it to the main assembly.

Then mount the front panel and make sure that the switches, the LED's, the potentiometers, and the headphone socket line up with the panel holes correctly. It may be necessary to shift the control board to one side or the other slightly to ensure that the switches align with the holes in the front panel. The front panel is secured to the heatsinks using countersunk, painted, self-tapping sheet-metal screws. Finally, nuts can be threaded onto the shafts of the potentiometers, and the knobs can be press-fitted.

Testing

STOP! Before going further, carefully check your work against the wiring and parts-placement diagrams.

Assuming everything checks out, remove the four five-amp fuses and apply power, but do not connect any signal sources or loudspeakers yet. One or more LED's on the front panel should light up immediately after power is applied.

Using your multimeter, check the outputs of the power supply. You should be able to measure ±65 volts at the fuse clips. Pins 7 and 4 of each op-amp should have +15 and −15 volts, respectively, and pins sixteen and seven of the CMOS switches should have +7.4 and −7.5 volts, respectively. The +8-volt supply can be checked by measuring the voltage at the output of the 7805 (IC10). That voltage can be reduced if necessary by reducing R29 from 130 to 120 ohms. If any supply voltage differs by more than 10% from its nominal value, remove power immediately and locate the fault.

When all power-supply voltages are correct, measure the voltages at several critical points in the circuit. There should be about 4.8 volts across R120, the 2.7K current-limiting resistor connected to the drain of Q104, which is the FET constant-current source in the phono preamplifier. Also, there should be about 4.9 volts across the collector of each transistor (Q100–Q103) in the input stage of the phono preamplifier. Those voltages should also be present in the corresponding right-channel components (R220 and R200–Q203).

In the power amplifier stages, there should be 0.6 volt across R147, the 680Ω emitter resistor of Q107. You should also measure about −55.5 volts at the collectors of Q105 and Q106. In addition, you should measure about 0.6 volts across R154, the 100Ω emitter resistor of Q108. Those voltages should also be present in the corresponding right-channel components (R247, Q205, Q206, and R254). If any of the voltages you measure differ by more than 10% from the values given, track down the source of the problem before continuing.

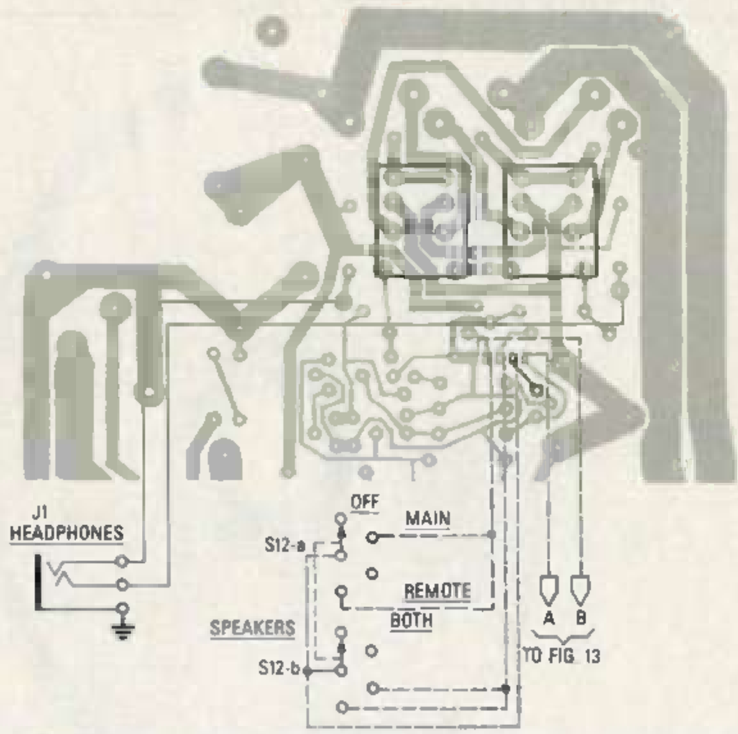


FIG. 14—THE LEFT REAR CORNER OF THE MAIN BOARD is shown here. The headphone jack (J1), the speaker switch (S12), and two jumpers are wired to the row of pads in front of the relays. The wires to J1 are routed above the PC board; the remainder are routed below the board.

Setting quiescent current

When all voltages are correct, remove power and monitor the +65-volt supply at F100. After the supply falls below +5 volts, install a fuse there. Then connect a 1-amp ammeter F101's fuse clips. Rotate R156 fully counter-clockwise, and then apply power. Adjust R156 so that the meter indicates a current of 100 mA.

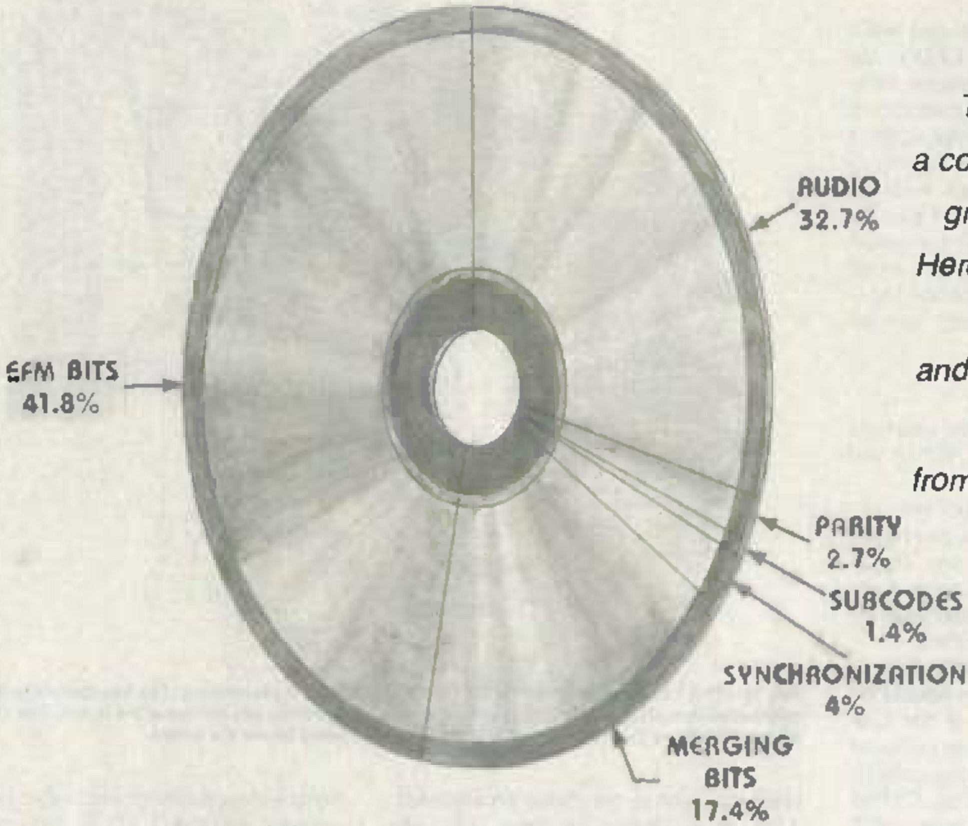
Remove power, and then wait two minutes for the voltage to drop. Remove the meter and install a fuse there. Repeat the procedure for the right-channel.

Now check the operation of the control switches. The LED associated with each switch should illuminate as that switch is pressed; no other LED in that section of the front panel should be lit. Also test the MONITOR and DUBBING switches and LED's.

Next, the Ni-Cd battery pack can be connected. Use a small rectangle of double-sided adhesive tape to secure the battery pack to the PC board. With the batteries in place, make sure that the switch settings are stored when power is removed. Note that the stored settings will change if the switches are pressed while power is off.

If the switches do not operate correctly, check the power supply connections to the IC's on the control board. If the correct voltages appear, then the problem possibly lies with the digital control lines from the control board to the main board.

Finally, connect a pair of loudspeakers, apply power, and listen for hum or other unpleasant sounds. If everything is working correctly, you should hear only a very slight amount of hum when the PHONO input is selected and the VOLUME control is fully advanced. Connect a tuner or a turntable and verify that the VOLUME, BASS, TREBLE, and TONE controls work correctly. Similarly, verify that the SPEAKER, STEREO/MONO, and MUTE switches all work correctly. Make sure signals from each of the four main inputs (PHONO, CD, TUNER, and AUX) can be heard through the speakers. Last, connect a pair of tape recorders to the appropriate jacks and verify that the MONITOR and DUBBING switches work correctly. R-E



There's a lot more on a compact disc than just great-sounding music. Here, we see what all of that other "stuff" is, and the role that it plays in getting the music from the disc to your ear.

JOSEF BERNARD

COMPACT DISCS Bit-By-Bit

EVERYONE KNOWS THAT CD'S, COMPACT Discs, contain a lot of information—maybe even millions and millions of bits. But as we'll soon see, "millions and millions" is only a drop in the bucket for a CD.

In one second, a CD player processes 1,460,000 bits of audio information. That's just a hair under 6.5 billion bits during a CD's maximum playing time of 74 minutes. But that is still only the tip of the iceberg, because those 6.5 billion bits represent just the audio information contained on a disc. There's twice as many more, most of which you are never aware of. But without those bits, the music would never find its way off a CD.

That extra information is used for modulation, synchronization, and error correction, and for index, track, and sector data that helps a CD player to reproduce audio in the proper sequence and to locate a requested selection. There are 2,861,800 bits of non-audio information processed for every second of music you hear—10,302,500,000 bits for each hour of music. In all, a compact disc can contain a total of just under 20 billion bits—19,918,878,200 to be precise. To say the least, that's impressive!

Now that we've whetted your appetite, we're sure that you are curious about what purpose all that data serves. Well, read on.

CD Information

Whether it was originally recorded in analog or in digital form, what you hear from a CD goes onto that disc in digital form. The music, or whatever else was recorded, is transferred from its original recording medium to a digital master tape.

In preparing the master tape, all the information that will appear on the finished compact disc is put onto it. That data consists of:

- audio information
- error-correction information
- index, track, and sector information
- synchronization information

All of those are converted into an intricate and carefully woven string of ones and zeroes.

Just as personal computers work with bits in groups of 8 or 16, compact discs use data groups called frames. Each frame (Fig. 1) contains 588 bits; by examining the use of those bits we can discover how data is stored on a compact disc.

Before dissecting a frame, though, let us take some time to discuss the error-correction scheme used in CD's. That is important, because it allows us to understand what happens to the "pure" audio information.

Error correction

Manufacturing compact discs is a deli-

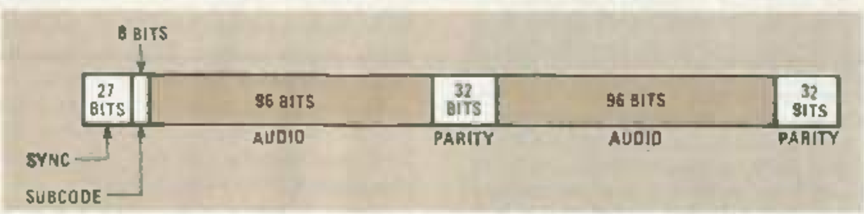


FIG. 1—MOST, BUT BY NO MEANS ALL, of the information in a frame of CD data is dedicated to the audio program.

cate process, requiring extreme cleanliness and very tight tolerances. Because of that, it is nearly impossible to make a "perfect" disc. With just under 20 billion bits involved in a lengthy recording, something is bound to go wrong somewhere, whether it's a piece of dust trapped under the disc's protective transparent plastic coating, or perhaps a scratch in the coating itself.

To cope with the inevitable, the audio information on CD's is encoded using error-correction techniques that allow a CD player to recover from any errors that crop up. Sometimes the player can reconstruct the lost or incorrect audio (which is usually very short in duration); at other times it mutes its output until the error passes.

The muting process, by the way, is interesting—the player can detect an unrecoverable error before it becomes audible, so it slowly (on *its* time scale) lowers the output level before the error and slowly raises it again after it. That fade-out/fade-in process makes the dropout less noticeable to the listener.

The system used to encode the error-correction information is based on a *C*ross-*I*nterleave *R*eed-Solomon *C*ode, or CIRC. According to strict rules, information from any given section of the audio is broken up and placed in several different frames located at different places on the disc. During playback, the information is reconstructed in the proper order. The process used is rather involved, so in the interest of space we will not detail it here. In any event, what's important is that the process ensures that an error will usually not destroy a passage completely, since all the information pertaining to that passage is not clustered in one spot.

Error detection, which is of course necessary before error correction can be performed, is made possible by the generation of two 32-bit sets of parity bits. Those parity bits give an indication of the numeric value of the data they are responsible for. If there is a discrepancy between that value and the value indicated by the parity bits, it is almost certain that an error has occurred and that corrective action has to be taken.

The two sets of parity bits are used for different purposes. One set, called the P bits, is used to detect and correct errors due to dropouts. The other set, the Q bits, allows a player to determine whether a correctable error has occurred, and assists in correcting it.

Using the CIRC, errors as long as 4000 bits can be fully corrected. Errors up to 12,300 bits long can be compensated for by the interpolation of data—a CD player's way of "faking" the missing or erroneous information by reconstructing it from the information that precedes or follows the fault. Out of a single frame's 588 bits, 64—or approximately 10.9%—are used for parity checking.

What's in a frame

With most of the more exotic stuff out of the way, we can now examine a single CD data-frame. Note that a disc contains nearly 34 million of them.

Let's look once again at Fig. 1. That illustration shows the makeup of a frame of data. The biggest part of it (192 bits—about 33%) is audio information, stored as two sets of 12 blocks of 8 bits each. As shown in Fig. 2, blocks are arranged alternately as left channel, right channel, left channel, and so forth. That helps to explain why the channel separation on CD's can be 90 dB or greater—the left- and right-channel information blocks are stored separately.

FIG. 2—STEREO AUDIO INFORMATION is recorded in alternating, right-/left-channel blocks. That is one reason for the high level (90 dB) of stereo separation.

code bits make up only about 1.4% of a frame's total.

Now let's count up the bits in a frame. Here's what we have, based on what we know so far: Audio, 192; Error correction, 64; Synchronization, 24; and Subcodes, 8. Adding those up gives us a total of 288 bits.

But wait a minute! There are supposed to be 588 bits in each frame, and we've only accounted for 288 of them. What about the other 300? Stand back; here they come!

Eight-to-fourteen modulation

Contrary to what you may believe, the pits and lands (the flat areas between the pits) on the surface of a CD do not, themselves, represent ones and zeroes. Rather, as shown in Fig. 3, each transition between a land and a pit, or a pit and a land, represents a one. Any other part of the disc, whether it be its shiny surface or the bottom of a pit, is taken to be a zero. The

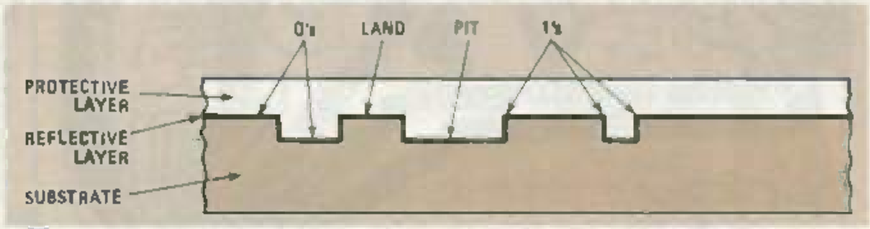


FIG. 3—DIGITAL INFORMATION IS ENCODED on a CD using a system of pits and lands. Every transition between a pit and a land, or a land and a pit, is a logic one; the lands and pits themselves are logic zeros.

The parity bits make up the next largest collection of information; each frame contains 32 P and 32 Q bits. Those 64 bits account for, as was mentioned previously, almost 11% of the disc's capacity.

The third largest part of a frame contains the 24-bit synchronization code. That code is used to indicate the beginning of a frame. When a CD player sees the synchronization code, it knows that a frame will follow immediately, and is able to assign the bits that come next to their proper functions.

The last major bit-group contains the subcodes. There are eight subcodes, P through W, and every frame contains eight subcode bits: one from each group. The P and Q subcodes, which are the ones of interest to us here, have no connection with the P and Q parity bits; the similarity in names is just coincidence.

The subcodes are collected during playback 98 frames at a time. The P bits indicate to the player which portions of the disc are for lead-in and lead-out, and which portions contain playable passages. The Q bits contain information indicating track and index numbers (which are used by programmable CD players to locate the selections you've programmed) and timing data for each selection, and for the disc as a whole. That information can be displayed by some players. The eight sub-

length of a pit (or the land between two pits) determines the number of zeroes in the number. The method used on CD's to create the numbers represented by those strings of ones and zeroes is called EFM, for *E*ight-to-*F*ourteen *M*odulation.

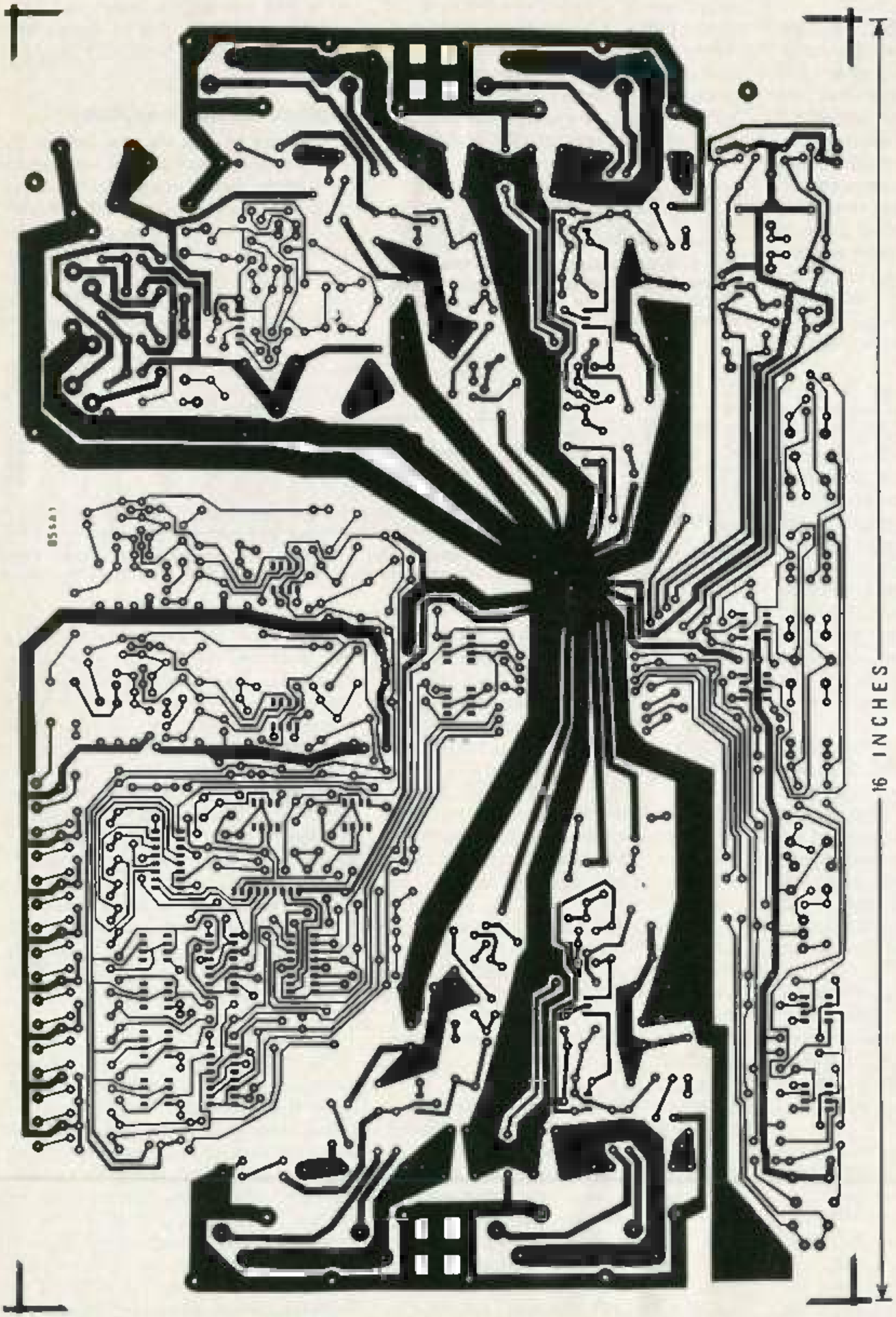
The data on a compact disc was originally organized as 8-bit bytes. Why convert those to 14-bit words? The reason is that longer words allow for the greatest number of zero-to-one and one-to-zero transitions that can be obtained while optimizing the lengths of the pits and the lands for the best usage of the disc's "real estate." Despite its longer words, EFM is actually about 25% more efficient than recording done using an 8-bit format.

The missing bits

One of the characteristics of eight-to-fourteen modulation is that each 14-bit (formerly 8-bit) word has 3 more bits, called merging bits, added to it. Those additional bits are necessary for EFM to work properly. Disregarding for the moment the 24-bit synchronization word, we can see that we have a total of 33 8-bit words per frame: 24 audio words, 8 parity words, and 1 subcode word. Those require a total of 99 merging bits. The 24-bit synchronization word also requires 3 merging bits, bringing the total to 102

continued on page 85

PC SERVICE



BECAUSE OF ITS LARGE SIZE, the PC pattern for the main board of the FET power amp is shown here half sized. Also, the board is shown as a direct (*not* X-ray) view. Thus, the pattern *can not be used directly to etch a board.*

One of the most difficult tasks in building any construction project featured in **Radio-Electronics** is making the PC board using just the foil pattern provided with the article. Well, we're doing something about it.

We've moved all the foil patterns to this new section where they're printed by themselves, full sized, with nothing on the back side of the page. What that means for you is that the printed page can be used directly to produce PC boards!

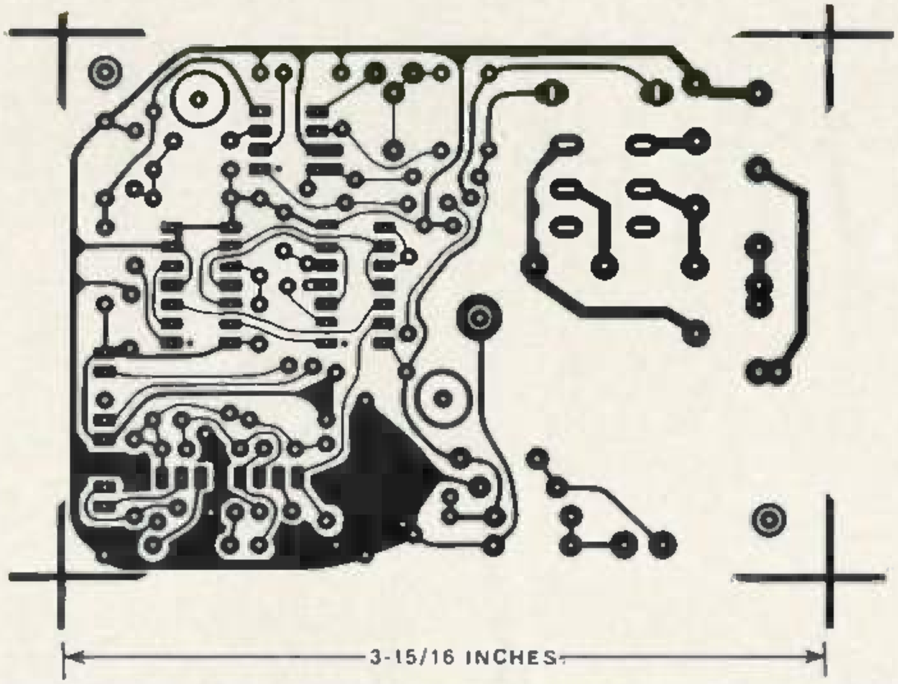
Note: The patterns provided can be used directly only for *direct positive photoresist methods.*

In order to produce a board directly from the magazine page, remove the page and carefully inspect it under a strong light and/or on a light table. Look for breaks in the traces, bridges between traces, and in general, all the kinds of things you look for in the final etched board. You can clean up the published artwork the same way you clean up you own artwork. Drafting tape and graphic aids can fix incomplete traces and doughnuts, and you can use a hobby knife to get rid of bridges and dirt.

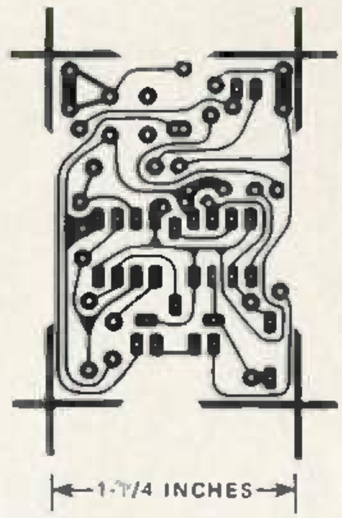
An optional step, once you're satisfied that the artwork is clean, is to take a little bit of mineral oil and carefully wipe it across the back of the artwork. That helps make the paper transluscent. Don't get any on the front side of the paper (the side with the pattern) because you'll contaminate the sensitized surface of the copper blank. After the oil has "dried" a bit—patting with a paper towel will help speed up the process—place the pattern front side down on the sensitized copper blank, and make the exposure. You'll probably have to use a longer exposure time than you are probably used to.

We can't tell you exactly how long an exposure time you will need but, as a starting point, figure that there's a 50 percent increase in exposure time over lithographic film. But you'll have to experiment to find the best method for you. And once you find it, stick with it. Don't forget the "three C's" of making PC boards—care, cleanliness, and consistency.

PC SERVICE

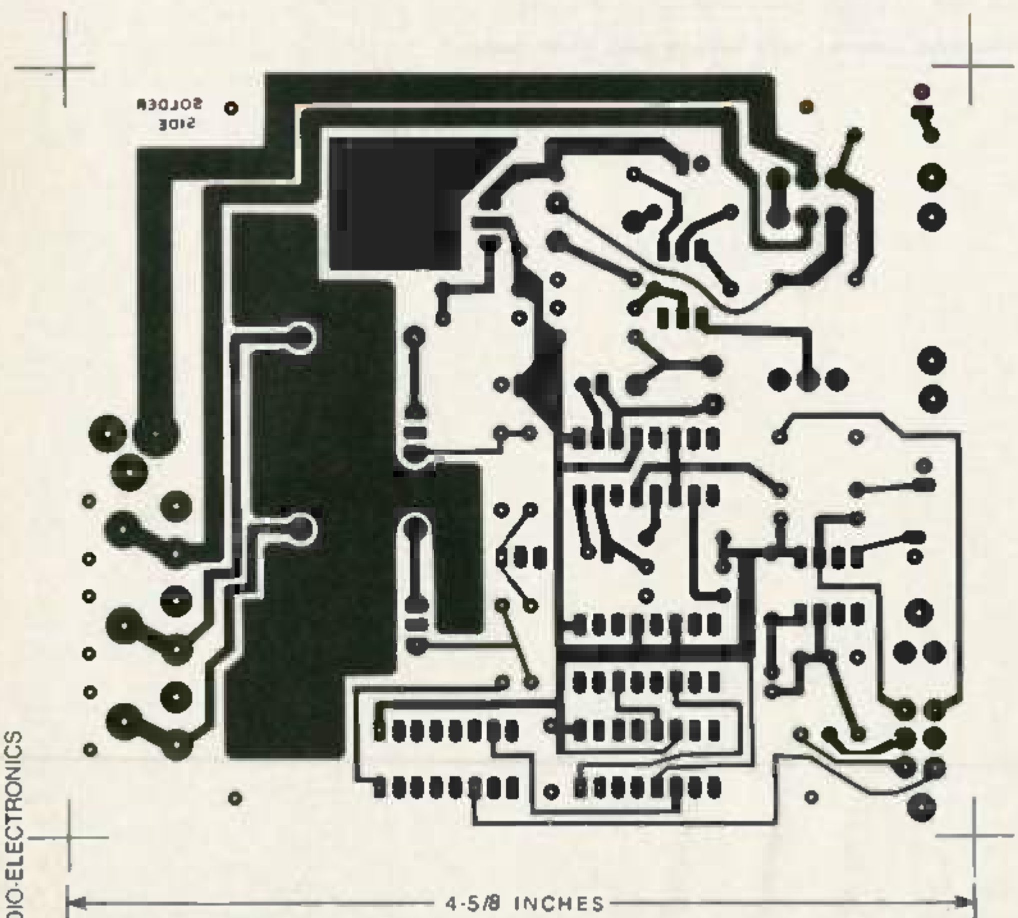


FREE YOURSELF from the tyranny of mechanical switches with our IR remote switch. The PC pattern for the receiver section is shown here.



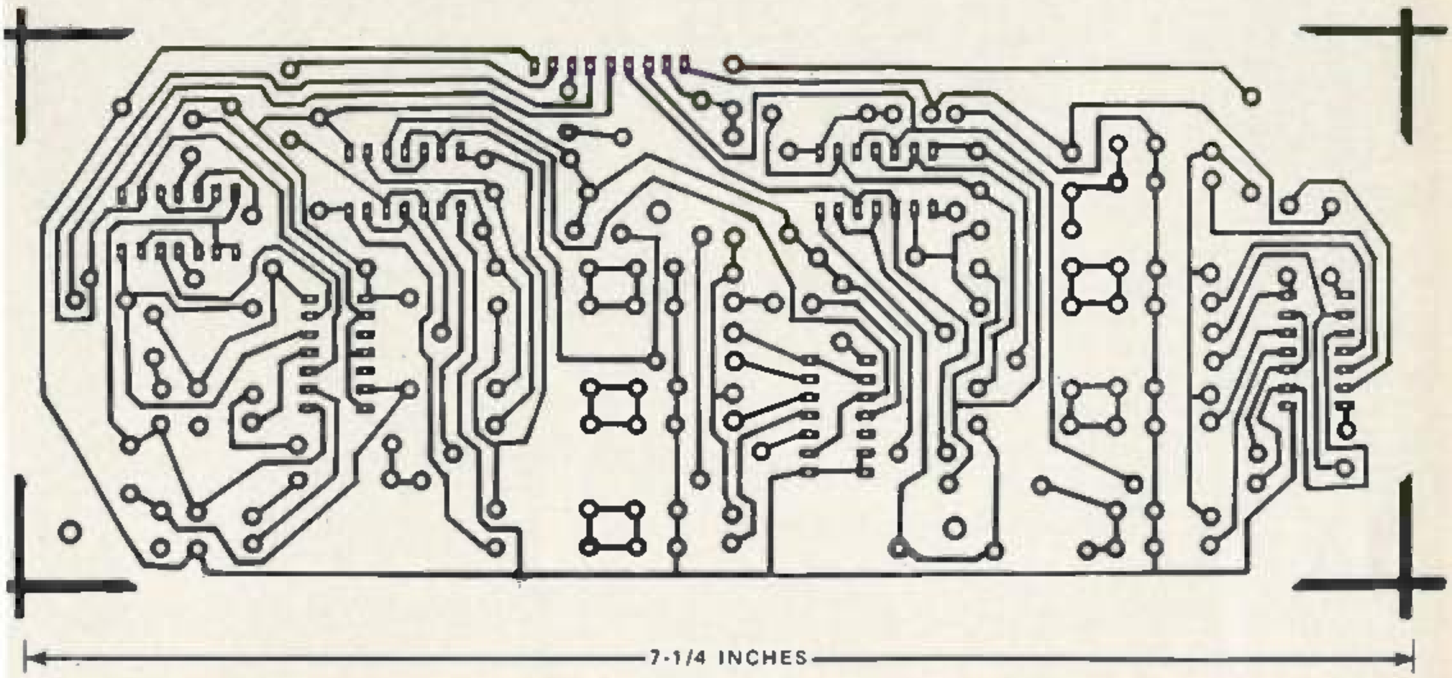
PC PATTERN for the IR remote switch's hand-held transmitter

PC SERVICE



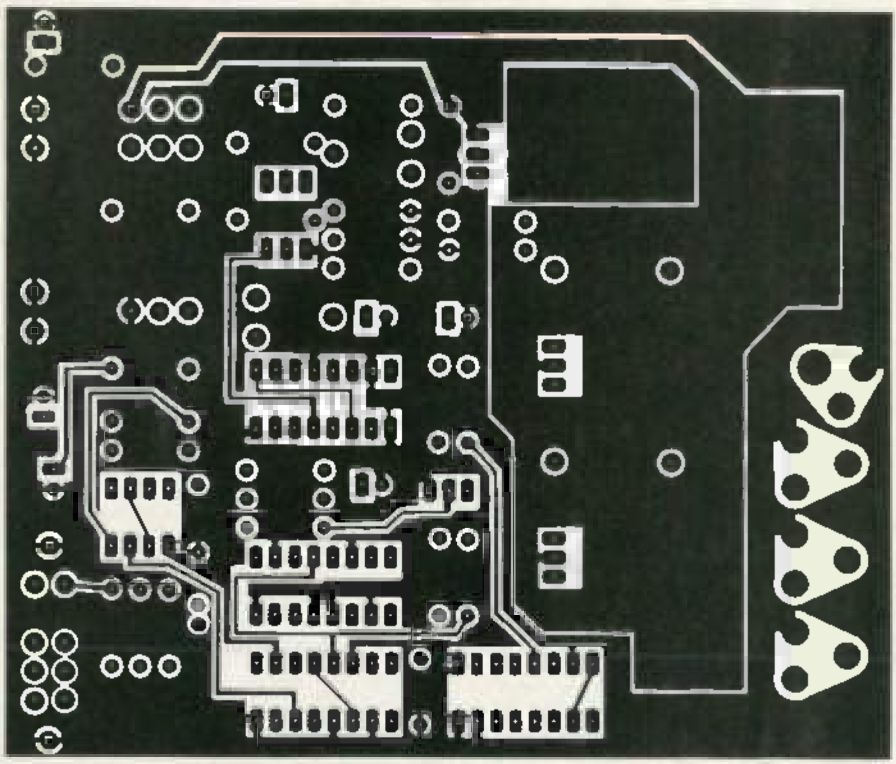
THE RADAR CALIBRATOR requires the use of a double-sided board. The pattern for the solder side is shown here.

PC SERVICE



THE CONTROLLER BOARD for the **FET** power amplifier can be built using this single-sided PC board. The pattern for the main board is shown on page 64.

PC SERVICE



4-3/4 INCHES

THE COMPONENT SIDE of the double-sided radar calibrator board is shown here. The solder side is found on page 66.

VOL. 3 NO. 8 AUGUST 1986

ComputerDigest

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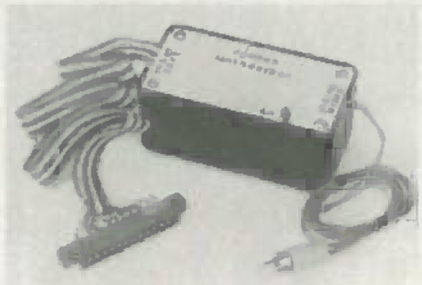
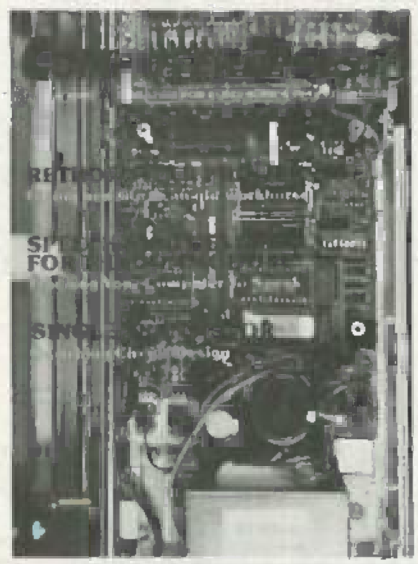


See Page 10

ON THE COVER

While the innards of any computer product might look like a confused maze, the article on retrofitting printers helps clear things up sufficiently so that you will have no problem in completing this work and having done so, you will have upgraded your printer. See page 6.



COMING NEXT MONTH

We've got an excellent mix of articles that should appeal to almost everybody. Leading off the next issue is an article on how to use your computer as a scanner for the CB bands that takes out all the usual frustration of channel-hopping. And you'll learn how to soup-up your computer so it performs as if it were supercharged. And to wrap things up, a build-it-yourself power controller that turns things on—and off—one at a time.

EDITORIAL

RM5241...

■Don Stoner has been an electronics writer all his life. As such, he's been keeping his finger on the pulse of hobby electronics, and for my own part, when Don says something, I listen.

Right now, Don is saying something, and it's important. It's important to everybody that's interested in computers, so if you're reading these words, it's important to you. One of the newer areas of technology in computer science, is Packet Radio. You've seen articles on this same subject in **ComputerDigest**. And you probably realized that to take advantage of this, you require an amateur radio operator's license. If you *have* such a license, you probably were more than passingly interested in the article. If you didn't have, you may have wondered at the feasibility of getting such a license, just to make better use of packet radio techniques with your computer.

To oversimplify, packet radio permits you to transmit data from place to place without the use of a modem or telephone line.

Don Stoner has peitioned the FCC to create a band for use by the general public, for packet radio. It will operate at 500 kilobytes instead of 1200 baud, and most important, would make packet radio technology available to any computer owner without his having to take an amateur radio operating examination or posess such a license.

I haven't seen the details of Mr. Stoner's petition, but I'm certainly behind the spirit and general principles of it. I urge you to write to the Federal Communications Commission, Washington, D.C. 20554 and express support of RM5241. It's going to be good for us all.

Byron G. Wels

Byron G. Wels
Editor

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LETTERS

Last call

As you may know, SAMS publishes Computerfacts™ technical service data for the Timex-Sinclair 1000 ZX-81 computers as well as for many other personal computers, disk drives, printers and monitors. Our package for the Timex-Sinclair units is product #08969-6 with a $19.95 retail price. We'd like to be included in your listing.—Dwayne Gott, Howard W. Sams & Co., Indianapolis, IN.

Mr. Gott, the list wouldn't be complete without offering the fine Sams publications. For those who need it, the full address is 4300 W. 62nd St., Indianapolis, IN 46268. And for you others who may have put off writing, move fast. We're ready to start preparing it now.

Which is best?

Our local computer club has been arguing about which is best, WordStar, PeachText or pfsWrite. Which do you like best?--R.W., Bloomington, IL.

Never argue about politics, religion or word-processing programs. I use PeachText because I'm most-familiar with it, having learned on that. But recently I used a friend's new Tandy 1000 with pfsWrite, and had no problems. I like that too. I never did get to try WordStar.

Home made?

Why is it that home-brew projects always seem to *look* home-brew? Why can't they be "dolled up" to look like commercial equipment?—P.T., Yuma, AZ.

They can—and should! But experimenters are usually satisfied if something they build just works. A little paint, some nice decals, and a little thought, and you can put together a project that looks as if you bought it!

Getting older

How long has **ComputerDigest** been around now? I certainly enjoy the concept of a "magazine within a magazine" and hope it continues.—S.B., Lyndhurst, NJ.

The first issue was published in May, of 1984. We're now in our third year, and still going strong. Thanks for asking. It certainly doesn't seem that long!

A saver!

I've been using my computer for quite a while now, and store everything to floppy disk. Result? A huge collection of disks, many of which contain information I no longer need. How can I save what I *do* want, and re-use those disks?—W.P., Miami, FL.

Simply transfer the desired info to a blank, formatted disk and then format the old disk for re-use. Just save the files you want to keep.

COMPUTER PRODUCTS

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

CIRCLE 11 ON FREE INFORMATION CARD

PORTABLE COMPUTER PROTECTION, is provided by the Modem/Power/Static/Pac model *MPS-1*, which combines broadband AC power filtering, extended range spike suppression, modem RF filtering, modem spike suppression, and a static discharge plate.

Power is available from a conventional three-prong outlet and a CEE-22 universal portable computer power connector. A 6' power cord is provided. Modem connection is through standard modular RJ-11 connectors. Static discharge is integrally designed into the unit. The model *MPS-1* is priced at $199.95.—**Electronic Specialists, Inc.,** 171 South Main Street, Natick, MA 01760.

DISPLAY ADAPTER, *The Modular Graphics Card*®, achieves complete compatability because it looks like an IBM color graphics card to a PC system and its software and supports PC-compatible monochrome, RGB color, or composite monitors. Monochrome monitors portray colors as shades. *The Modular Graphics Card* displays up to 16 colors (on color monitors; up to 16 shades on monochrome monitors),

CIRCLE 12 ON FREE INFORMATION CARD

full-screen graphics, high-resolution test, and flicker-free scrolling.

Documentation includes tables of jumper and DIP-switch settings for optimum rersults from most popular monitors; for monitors not listed, a special software utility (also included) determines settings based upon on-screen displays. The card includes connectors for a light pen and an RF modulator. In addition, the card comes with RAM disk and print spooler software.

The Modular Graphics Card is priced at $395.00.—**Paradise Systems, Inc.,** 217 East Grand Avenue, South San Francisco, CA 94080.

TAPE BACKUP SYSTEM, model *WD60Ti*, is a 60-megabyte, ¼" internal, tape-backup system that enables IBM, PC, XT, AT, and certain compatible users to backup data from a hard disk.

The model *WD60Ti* comes with menu-driven, user-friendly software utilities; it draws its power from the host CPU's power supply, and does not require any additional power supply when operating inside an IBM PC AT. It uses a standard QIC-36 interface.

CIRCLE 13 ON FREE INFORMATION CARD

Mirror-image backup with the model *WD60Ti* takes only one minute per 5-megabytes. The unit also performs selective file backup, which saves tape space and allows the user to select what data to backup. The model *WD60Ti*'s built-in intelligence means that the user does not have to remember the last file modified to back it up. The model *WD60Ti* has a suggested retail price of $1495.00.—**Western Digital,** 2445 McCabe Way, Irvine, CA 92714.

IN-CIRCUIT EMULATORS, are designed especially for Repair Technicians and Design Engineers. Small and compact (3" × 3" × ½"), these high-function emulators draw their power from the target system. (Optional power supplies are available with some models.) Since they plug right into the design board, the user gets full-speed emulation—with none of the attendant target disturbance inherent in traditional emulator designs.

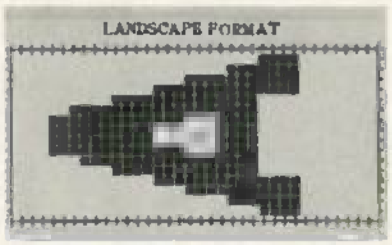
CIRCLE 14 ON FREE INFORMATION CARD

Despite the small size and low price (models start at $500.00) these emulators are powerful. Their two-microprocessor design offers the user access to all memory addresses, software breakpoints, print points, both Hex and ASCII displays, assembly and disassembly of memory, and the ability to modify a memory location (or fill RAM w/constant) and read and load Hex files.

In addition the IAM In-Circuit Emulators provide the user with easy-to-use commands that execute, delay, and/or repeat instructions for thorough system testing. Models presently available are the *8085, 8088, Z80,* and the model *NSC800.*—**IAM,** PO Box 2545, Fair Oaks, CA 95628.

FONT UTILITIES, for the Hewlett-Packard LaserJet Plus includes the *FontGen Utility*, the *Font Printer Utility*, and the *Landscape Utility* (shown).

The *FontGen Utility* is a font editor/generator that allows HP users to modify existing donwloadable fonts and to create new font designs. The user can design special symbols, such as logos, signatures, or technical symbols and add them to a font. Characters from different fonts can be combined. The user can also alter existing fonts using func-



CIRCLE 15 ON FREE INFORMATION CARD

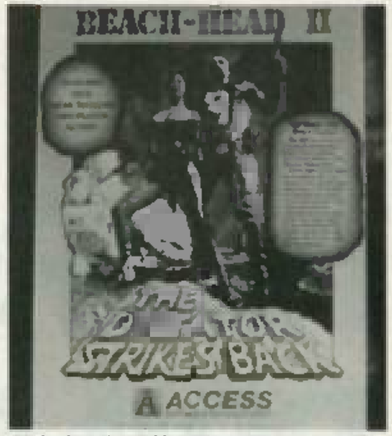
tions such as italicize, enlarge, reduce, or reverse image. The *FontGen Utility* has a suggested retail price of $250.00.

The *Font Printer Utility* allows the HP user to print a hard copy of the character's bit map, as well as a listing of the components, such as the baseline position or left boundary. A single character, or a range of, can be displayed using the laser printer or a standard printer. The *Font Printer Utility* has a suggested retail price of $50.00.

The *Landscape Utility* rotates characters, allowing a typeface to be used in the landscape mode. The software also revises the font header and character header, providing the user with a landscape version of any downloadable font. The *Landscape Utility* has a suggested retail price of $50.00.—**VS Software,** 2101 South Broadway, PO Box 6158, Little Rock, AR 72216.

ACTION/STRATEGY GAME, *Beach-Head II*, is subtitled, "The Dictator Strikes Back."

Beach-Head II features true action for two players or one player against a com-



CIRCLE 16 ON FREE INFORMATION CARD

puter opponent. The game has multiple playfields, scrolling playscreens, hi-res graphics, various difficulty levels, and a "practice" mode. It is available on disk with a price of $34.95.—**Access Software Inc.,** 2561 South 1560 West, Woods Cross, UT 84047.

PROFESSIONAL COMPUTER, the 1-800-Floppys, model *XT*, is designed for the experienced computer user; it is a dual disk drive, 640K, IBM-compatible personal computer, and comes with everything needed to run IBM-compatible software packages. There is a 135-watt

CIRCLE 17 ON FREE INFORMATION CARD

power supply, TTL monochrome monitor with a Hercules-type graphics card, eight slots for adding boards, a parallel port board plug, and a Keytronics-type keyboard.

The model *XT* comes with a 120-day warranty, which includes all parts and labor, and the customer may use the system up to 30 days in order to test its compatibility with his or her software. Should it prove incompatible, the customer is entitled to a complete refund, including return freight charges. The model *XT* is priced at $999.00.—**1-800-Floppys,** 22255 Greenfield Road, Southfield, MI 40875.

RETROFITTING PRINTERS

Making new printers even better.

Herb Friedman

■Unlike the printers that use typewriter-style elements with fully-formed characters, such as a daisy wheel, a matrix printer uses a pattern of dots to create characters and graphic symbols. In the low-cost printers used with personal computers the dots are generated by 7 to 24 solenoid-activated wires contained in a print head. Regardless of how the electromechanical system moves the printhead and "fires" the wires to produce printed dots, the decision as to how to move the print head and what wires to "fire" to create a specific character or graphic is generated by a microprocessor in the printer. The programming for the actual character/graphic pattern is stored in one or more ROMs; or in RAM when the printer lets the user design his own character set (font). In some modern printers the user can combine characters stored in ROM with user-generated characters stored in RAM.

Often, the difference between printers and character sets is the ROM, all else is the same. For example, the Epson MX-80 printer originally provided the ASCII character set and the block graphics of the Radio Shack TRS-80 Model I computer. When the Model I was displaced as the number 1 personal computer a new generation of Epson MX-80, called the MX-80+, and a later model called the MX-80 *Graftrax* (or MX-80 III) provided the ASCII character set and italic characters.

The difference between models of the MX-80 was the ROM(s) programmed for the characters, graphics and functions. In later models the ROMs were programmed to provide a backspace, then a conventional underscore, super and subscripting, new graphics, and new printing enhancements.

Later, the MX-80 became the IBM Graphics Printer, and although the ROM provided the conventional ASCII characters and control codes, instead of the italic characters and Epson-type graphics, the printer was programmed for the IBM foreign character set, the IBM Greek and math symbol set, the special IBM characters, and two distinct character/symbol/graphic sets. The label on the panel now said IBM rather than Epson. The printer was still an MX-80, but by substituting an "IBM ROM" the printer now generated a new set of characters, symbols and graphics.

More than characters

The ROM generates more than characters and graphics; It determines the features that can be accessed through software-driven printer codes and—depending on the printer—the functions of the operating controls, which are usually the three pushbutton switches for the *ON LINE, FORM FEED* and *LINE FEED* functions. If you could program your own ROM you could force a printer to respond differently to the three pushbuttons. You could, for example, program the ROM so that pressing the *ON LINE* switch three times caused the printer to automatically shift to double-width characters, while pressing the button six times might cause the printer to automatically skip over the perforations of continuous-form (pinfeed) paper.

Fingerprinting

If you could program your own ROM it wouldn't be worth the effort because for about $60. you can retrofit most popular printers with a custom ROM kit called a "Fingerprint" (Dresselhaus Computer Products, 837 E. Alosta Ave., Glendora, CA 91740), which can make an old workhorse emulate the character/graphics set of the latest printers (really the IBM character set), provide the most-popular operating features, and allow you to directly access the most popular printer functions through what is normally the three operating pushbuttons—rather than software.

Beep for special functions

A Fingerprint converts the printer's three operating pushbuttons into a special function selector. If you touch the *ON LINE* button, it switches the printer on or off line. Hold the button down for one second, and it switches the printer to Fingerprint mode and beeps. You are now able to select many printer functions by beeping the *ON LINE* button. The chosen function depends on the number of beeps.

If you're using an FX-80 printer and want proportional printing, from the chart supplied, you know three beeps means proportional. Press the *ON LINE* button for three beeps, then press the *FORM FEED* button which programs the printer for the beeped function, in this case, proportional printing. Pressing the *LINE FEED* button ends the beep programming mode and restores the normal functions to the buttons. You can stack several functions. For example, three beeps for proportional printing, then four beeps for emphasized printing, to produce emphasized proportional printing.

Custom Fingerprint retrofits are available designed to use the particular capabilities of the most commonly used matrix printers: The Epson MX, FX and RX, the IBM Graphics Printer, The C. Itoh Prowriter I and II, the NEC 8023A, the Star Gemini 10 and 15, the Okidata Microline Series, and the Apple Dot Matrix printers.

Many functions

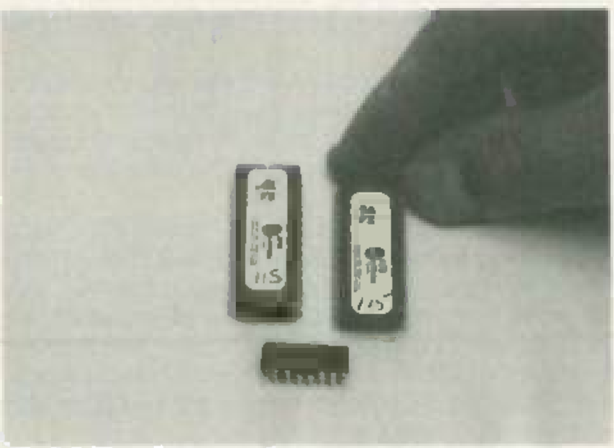
The functions you can program through Fingerprint depends on the printer. Because of improvements in printers, Fingerprint provides more features in later printers than in older models. For example, the MX-80 family of printers and IBM Graphics Printers provide:

BEEPS	FUNCTION
1	Reset
2	Compressed
3	Double-wide
4	Emphasized
5	Double-strike
6	Perforation Skipover
7	Left Indent
8	8 lines/inch
9	Italics
10	Fine print

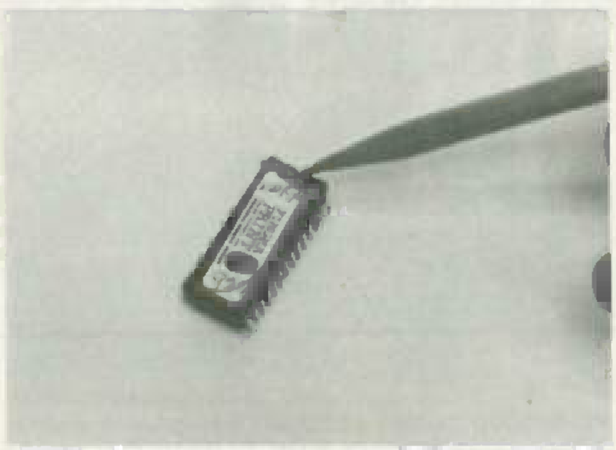
A more-modem printer such as the RX-80 and RX-80+ series can provide:

BEEPS	FUNCTION
1	LetterWriter(NLQ)
2	Condensed
3	Elite
4	Double-wide
5	Emphasized
6	Double-strike
7	Perf-skip
8	Left indent
9	Italics
10	Underline
11	Fine print
12	8 lines/inch
13	Paper out disable
14	Slash zero
15	8 ½ inch paper

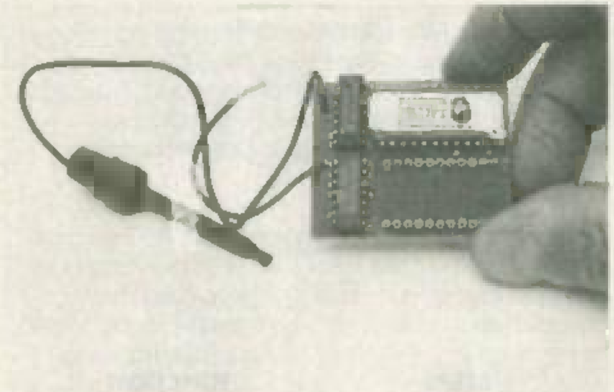
The *LetterWriter* function in the list is Near Letter Quality



ON NEWER PRINTERS, three plug-in replacement ROMs form the entire printer retrofit. Substitute them for the existing ROMs and they provide up to 15 one-touch features including NLQ printing quality.



WHEN THERE ARE SEVERAL VERSIONS of a printer the Fingerprint ROM is pre-wired with a strapped resistor that is either left in place or cut with diagonal cutters. This avoids having to modify existing wiring in the printer.



THE IBM GRAPHICS PRINTER and other MX -80 based models need a small printed circuit assembly that substitutes for the existing printer ROM. The parallel rows of terminals on the board create a 24-pin socket to which the original ROM is moved. The mini-clip provides a solder-free connection to exislting printer wiring.

A LABEL AFFIXED TO THE FRONT of the printer tells what functions can be programmed directly from the printer's controls. This label for the IBM Graphics Printer shows 10 beeped functions.

(NLQ), a character set which doesn't exist in this particular printer as supplied. In some printers, Fingerprint can synthesize both NLQ characters as well as the special IBM character set, graphics and symbols. If you have an older printer and an IBM-compatible computer your old printer will reproduce the IBM characters and graphics if Fingerprinted.

Stacking functions

You aren't limited to programming one Fingerprint function at a time. Any functions listed that aren't mutually exclusive can be stacked. Suppose you are printing the listing of a BASIC program to be stored in a ring binder. You could program emphasized characters for clarity, left margin offset to clear the rings and perforation skipover. Or if you'd like to print a 132 column spreadsheet with as many lines as possible on standard paper. Use Fingerprint to program both compressed/condensed characters and 8 lines/inch spacing. But you couldn't program *emphasized compressed characters* because they are usually mutually exclusive—the printer won't recognize the commands and will default to standard size for 10-pitch characters.

Turn them off

Fingerprint functions are turned off by entering the beep code a second time. If your Fingerprint retrofitted printer provides the option of conventional zeroes or slashed zeroes, when you want slashed zeroes, set the printer *OFF LINE* to stop the printing, program the slahed zeroes and resume printing. When you want to go back to conventional zeroes, stop printing, program the conventional zeroes and resume printing. The second slashed zero program turns the function off. This can be repeated as often as you like.

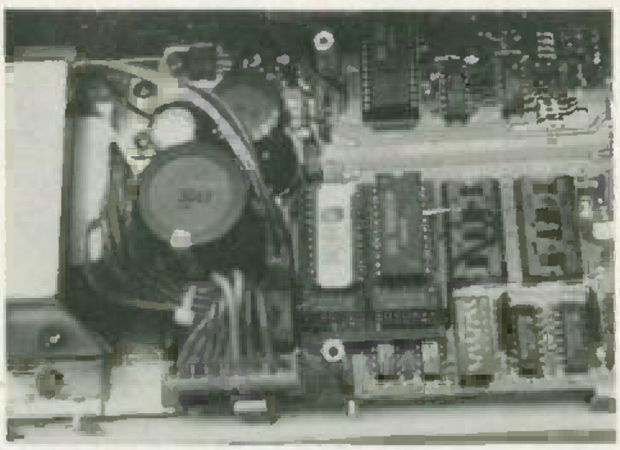
Installing the retrofit

A Fingerprint retrofit is a simple task because it only involves opening the case and replacing or moving one to three ROMs which are socketed—no desoldering is involved. Sometimes the retrofit is a direct swap for the existing ROM, in other cases it's a small printed circuit assembly that substitutes for the existing ROM, with the original factory-installed ROM moved to a socket on the PC board. In the newer printers, like the FX and RX-80s you simply swap ROMs. In the MX-080 based printers and the IBM Graphics Printer you remove the main ROM (there can be one to three), substitute a small printed circuit assembly, and install the original ROM in an empty socket on the circuit board. Then you connect a lead with a mini-clip to another IC terminal.

Of all the retrofits, the one with the printed circuit is the most difficult. "Difficult" being a relative term. The photos of a retrofit for an IBM Graphics Printer Fingerprint installation show it's an easy and not troublesome job if you don't rush it.

Imagine the printed circuit board is a new ROM. Using a large screwdriver, work the main ROM out of its socket, a little at a time so you don't damage the leads. Then seat the printed circuit in the now-empty socket, attach the mini-clip, and install the ROM in the empty socket on the board. If the printer had been one of the newer models, you would simply have discarded the old ROM and substituted the Fingerprint ROM.

Finally, install the case and apply a provided plastic sticker—listing the Fingerprint functions and their beeps, to the front of the printer.



THE PRINTED CIRCUIT ASSEMBLY fits on top of existing hardware. Depending on the printer, the two empty sockets to the right of the Fingerprint might be filled with ROMs: Just ignore them. They don't get in the way because the circuit board sits above them.

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SPEECH SYNTHESIZER

How to add a voice to your Commodore 64.

Ricardo Jiminez and Adrian Valle

■ If you want to increase the potential of your Commodore 64 with a speech synthesizer this project is for you. When your computer talks, you can have many advantages; for example, if you are processing information with numbers or letters, it will be a lot easier, because you will hear the number pressed on the keyboard without looking at the screen. And your children can learn to speak and spell by looking at the letters and numbers while they are listening to the correct pronunciation. Another advantage is that all the components for this project are available at any Radio Shack store.

Construction

The construction of the circuit is not critical, since only two chips are involved. You can assemble a working version on a solderless breadboard in less than two hours. We assembled the project in a small plastic experimenter's box. The 3.12 MHz crystal XTAL-1 can be replaced by a 3.14 MHz crystal, part number X004 for $1.35, distributed by Digi-Key Corp. (P.O. Box 677, Thief River Falls, MN, 56701-9988).

Crystal XTAL-1 and capacitors C1 and C2 should be placed as close to IC1 as possible. A 12/24 pin card-edge connector was used to interface the electronic circuit with the C64 computer.

About the audio output; If you own the Commodore video monitor model 1701 you don't have to use an external speaker, just plug the audio output cables into the audio input of the monitor (located at the rear of the screen) via a phono plug. In this case the volume is controlled by the volume control of the monitor.

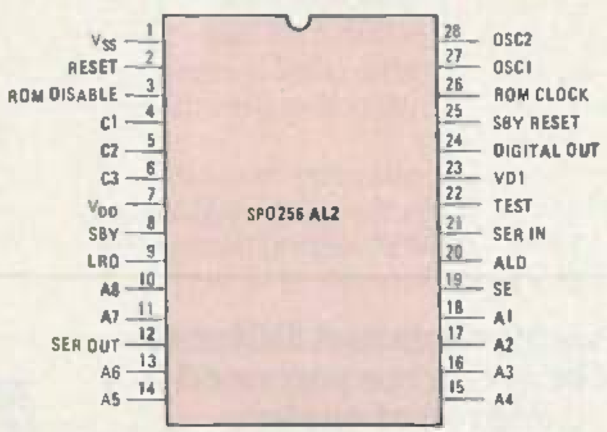
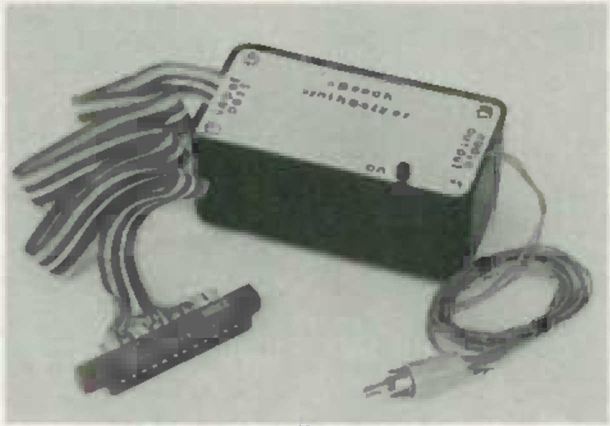


FIG. 1—PINOUT DIAGRAM for the SPO256-AL2. Refer to text for a detailed explanation.



THE COMPLETED SYNTHESIZER packaged and ready for use. As you can see, it's a compact unit that doesn't occupy much space considering the big job that it does.

Finally, the 5-volt DC power supply is provided by the Commodore 64 (pin 2 of the user port), which delivers a maximum current of 100 mA. Since the circuit has a current consumption of 90 mA, such power is suitable for this project.

About the SPO256-AL2

The speech processor (SPO256-AL2) is a single chip N-Channel MOS LSI device that is able, using its stored program, to synthesize speech or complex sounds. Figure 1 shows the pin configuration. We will look at the most important functions of the SPO256-AL2 which permit us to interface with the C64 computer.

A1-A8: 8-bit address which defines any one of 256 speech entry points. ALD: ADDRESS LOAD. A negative pulse on this input loads the 8 address bits into the input port and starts a speech command. This input is controlled by PC2 from the C64 computer.

SBY: STANDBY. Stays high until an addrress is loaded, then it goes low until the chip stops talking. This output indicates to the C64 computer when the chip is ready.

DIGITAL OUT: Pulse width modulated digital speech output which, when filtered by a low-pass filter and amplified, will drive a loudspeaker.

Let's start with some basic linguistic terms in order to understand how this project works.

Phoneme. This is the basic unit of distinctive sound. It represents different sounds depending on its position within a word. Each of these positional variants is an allophone of the same phoneme.

How to use allophones

When you use allophones you have to think in terms of sounds, not letters. And because each sound is acoustically different depending upon its position within a word, this method is called "Allophone Speech Synthesis." With this technique you can synthesize an unlimited vocabulary by addressing the 59 allophones plus 5 pauses in the appropriate sequence. Figure 2 shows the 64 allophone address table which are contained in the 16K ROM of the SPO256-AL2. The first column (decimal address) is the respective binary address for each particular sound. Since there are 64 addresses only, you will need six

DECIMAL ADDRESS	ALLOPHONE	SAMPLE WORD	DURATION
000	PA1	PAUSE	10MS
001	PA2	PAUSE	30MS
002	PA3	PAUSE	50MS
003	PA4	PAUSE	100MS
004	PA5	PAUSE	200MS
005	/OY/	Boy	420MS
006	/AY/	Sky	260MS
007	* /EH/	End	70MS
008	/KK3/	Comb	120MS
009	/PP/	Pow	210MS
010	/JH/	Dodge	140MS
011	/NN1/	Thin	140MS
012	* /IH/	Sit	70MS
013	/TT2/	to	140MS
014	/RR1/	Rural	170MS
015	* /AX/	Succeed	70MS
016	/MM/	Milk	180MS
017	/TT1/	Part	100MS
018	/DH1/	They	290MS
019	/IY/	See	250MS
020	/EY/	Beige	280MS
021	/DD1/	Could	70MS
022	/UW1/	To	100MS
023	* /AO/	Aught	100MS
024	* /AA/	Hot	100MS
025	/YY2/	Year	180MS
026	* /AE/	Hat	120MS
027	/HH1/	He	130MS
028	/BB1/	Business	80MS
029	* /TH/	Thin	180MS
030	* /UH/	Book	100MS
031	/UW2/	Food	260MS
032	/AW/	Out	370MS
033	/DD2/	Do	160MS
034	/GG3/	Wig	140MS
035	/VV/	Vest	190MS
036	/GG1/	Got	80MS
037	/SH/	Ship	160MS
038	/ZH/	Azure	190MS
039	/RR2/	Brain	120MS
040	* /FF/	Food	150MS
041	/KK2/	Sky	190MS
042	/KK1/	Can't	160MS
043	/ZZ/	Zoo	210MS
044	/NG/	Anchor	220MS
045	/LL/	Lake	110MS
046	/WW/	Wool	180MS
047	/XR/	Repair	360MS
048	/WH/	Whig	200MS
049	/YY1/	Yes	130MS
050	/CH/	Church	190MS
051	/ER1/	Starter	160MS
052	/ER2/	Bird	300MS
053	/OW/	Close	240MS
054	/DH2/	They	240MS
055	* /SS/	Vest	90MS
056	/NN2/	No	190MS
057	/HH2/	Hoe	180MS
058	/OR/	Store	330MS
059	/AR/	Alarm	290MS
060	/YR/	Clear	350MS
061	/GG2/	Guest	40MS
062	/EL/	Saddle	190MS
063	/BB2/	Business	50MS

FIG. 2—ALLOPHONE ADDRESS TABLE. This will prove extremely handy when setting up your synthesizer.

input address pins to make all these combinations. The second column represents all the allophone sounds (except pauses PA1 to PA5). The third column shows how each allophone sounds in a sample word. The fourth column is the duration in milliseconds for each.

Allophones marked with an asterisk can be doubled; in the word "four" the "f" sound is long, therefore, this word must be formed as follows: "FF, FF, OR, PA5." Note that PA5 is not a sound, is a pause necessary to make the chip stop talking the last allophone.

Each allophone has its own address and sound. To demonstrate this let's see how it happens. The initial K sound (KK3, address 8), used in words like "comb" sounds different from the K's in words like "can't." These small variations are due to the vowel which follow them, in this case, "o" and "a."

The computer controls the SPO256-AL2 with simple software. Let's look at the important instructions used in the programs. First we need to access the user port as follows. Pin C, D, E, F, H, and J (PBO to PB5) in the output mode. Pins K and L (PB6 and PB7) in the input mode. This is made with the statement.

POKE 56579,63

Where PBO to PB6 send the desired address to the speech processor IC1 (see Fig. 3). And PB6 receives the logic status of the STANDBY output (pin 8 of IC1). Remember that the decimal number 63 is equal to 00111111 in binary code. Therefore, when we send an address the $\overline{\text{ALD}}$ input is activated and the chip (IC1) starts talking. Then the computer reads the user port to know the STANDBY status (PB6) which tells the computer when the chip is ready to be triggered again. The instruction PEEK(56577) reads the user port, but we need to read PB6 only which represents the decimal number 64. This is made by using the AND function. If PB6 is a logic "1" then the computer sends a new address.

Testing the speech synthesizer

As was mentioned before, the poke statement (line 20) is used to access the user port. Let's begin with the program shown in Fig. 4. With this program you can listen the particular sounds of the 59 allophones. The FOR-NEXT loop (line 30) is used to increment the value

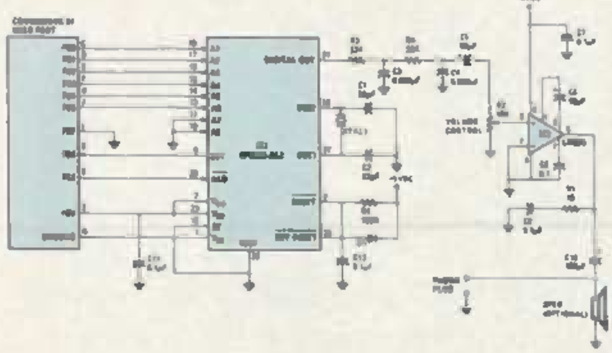


FIG. 3—SCHEMATIC DIAGRAM is relatively simple, uses only few components. Refer to the text for a full and complete explanation.

```
10 REM ALLOPHONES EVALUATION
12 REM BY R. JIMENEZ AND A. VALLE
20 POKE 56579,63
30 FORA=0 TO 63:PRINTA
40 POKE 56577,A
50 POKE 56577,0
60 PB=PEEK(56577)
70 F=PBAND64
80 IF F<>64 THEN 60
90 NEXT A
100 POKE 56577,1
120 END
```

FIG. 4—THIS SIMPLE, BRIEF PROGRAM allows you to evaluate the 59 available allophones.

of A from D to 63. The purpose is to use the variable A in the POKE statement (line 40) in order to address each allophone. The poke 56577,0 clears and prepares the user port for the next data. The PEEK statement (line 60) reads the user port, storing its value in the variable PB. Then PB is compared with the number 64 on the IF statement (line 80). If F is not equal to 64, that means that the speech synthesizer is not ready to receive new data. And the computer goes back to line 60 automatically. Otherwise, new data is sent.

The POKE Statement 56577,1 makes the chip (IC1) stop saying the last allophone. If you wish to listen to the allophones slowly, just press the (CTRL) control key.

Using the speech synthesizer

Making words with the SPO256-AL2 is easy, all you have to do is to look for the sounds you need from the Allophone Address Table. Figure 5 shows a program which makes the speech synthesizer say the sentence "I am a talking computer." This program works like the first one (fig. 4), using the same instructions to write and read by means of the user port. The only difference is that the data (lines 103-110) are going to be sent with the READ statement (line 70). Note that the data are written in decimal numbers. The words used in this sentence were taken from the dictionary included with the SPO256-AL2 package.

Figure 6 shows a routine that can be used for data processing. This routine makes the speech synthesizer say numbers from 0 to 9 when you press the respective key number. Lines 65 to 100 are used exclusively to assign the data found in lines 100 to 128 to the dimensioned variables A (I) and B (I,J). Here you can

```
10 REM I'M A TALKING COMPUTER
60 POKE 56579,63
65 FORJ=1TO 27
70 READ A
80 POKE 56577,A
85 POKE 56577,0
90 PB=PEEK(56577)
94 F=PBAND64
96 IF F<>64 THEN 90
100 NEXT J
102 DATA 24,6,0:REM     I
104 DATA 7,7,16,2:REM   AM
106 DATA 24,2:REM       A
108 DATA 13,23,23,2,42,12,44,0:REM TALKING
110 DATA 42,15,16,9,49,22,13,51,1,4:REM COMPUTER
160 RESTORE
170 FORT=1 TO 500:NEXTT:GOTO 65
200 END
```

FIG. 5—USE THIS PROGRAM, and you'll hear your computer actually say the words "I am a talking computer."

PARTS LIST

Resistors

All resistors ¼watt, 5% unless otherwise specified
R1—100,000 ohm
R2—10,000 ohm trimmer potentiometer
R3, R4—33,000 ohm
R5—10 ohm,

Capacitors

C1, C2—22pF., ceramic disc
C3, C4—0.022µF., ceramic disc
C5, C6—10µF., 10 volts, electrolytic
C7, C8, C9, C11, C12—0.1µF., ceramic disc
C10—100µF., 10 volts, electrolytic

Semiconductors

IC1—SP0256-AL2 speech processor (Radio Shack 276-1784)
IC2—LM386 audio amplifier (Radio Shack 276-1731)
D1—1N914 switching diode

Other components

XTAL-1—3.12 MHz crystal (see text)
SPKR—8-ohms (optional, see text)
12/24 pin card-edge socket (Jameco Electronics)
1.5 ft. - 14-conductor ribbon cable
Insulated phone plug (Radio Shack 274-321)
Experimenter box (Radio Shack 270-231)
Experimenter's IC perfboard (Radio Shack 270-150)
28 pin IC socket
8 pin IC socket

```
12 REM DATA PROCESSING
15 REM BY R. JIMENEZ AND A. VALLE
50 PRINT"(SC)"
60 POKE 56579,63
65 FOR I=0 TO 9
70 READ A(I)
75 FOR J=1 TO A(I)
78 READ B(I,J)
100 NEXT J,I
110 DATA 4,43,60,53,4 :REM              ZERO
112 DATA 5,57,15,15,11,4:REM             ONE
114 DATA 3,13,31,4 :REM                  TWO
116 DATA 4,29,14,19,4    :REM          THREE
118 DATA 4,40,40,58,4  :REM             FOUR
120 DATA 5,40,4D,6,35,4:REM             FIVE
122 DATA 8,55,55,12,12,2,41,55,4:REM SIX
124 DATA 8,55,55,7,7,35,12,11,4:REMSEVEN
126 DATA 4,20,2,13,4   : REM           EIGHT
128 DATA 5,56,24,6,11,4   :REM          NINE
150 V=V+1
160 IF V=10 THEN V=0 : PRINT"(SC)"
170 PRINT"  VALUE OF X(";V;")";
200 GET C$:IF C$="" THEN 200
205 C=ASC(C$)
210 IF C<48 OR C>57 THEN 200
215 C=C-48 : PRINTC
217 POKE 56577,0
220 FOR I=1 TO A(C)
230 POKE 56577,B(C,I)
240 POKE 56577,0
250 PB=PEEK(56577)
260 F=PB AND 64
270 IF F<>64 THEN 250
280 NEXT I : POKE 56577,1
290 GOTO 150
300 END
```

FIG. 6—THIS PROGRAM will cause your computer to clearly speak each number when the appropriate number key is pressed.

see how A (I) contains the data that the speech synthesizer will use to pronounce a particular word. In this case ten numbers can be pronounced. For example, A (I) holds the number 4 when the variable "I" has a value of 0. And the statement READ (line 70) is executed by the computer. That means that the word "zero" will be spoken by the speech synthesizer, by just sending the four data contained in the vector B (I,J) for values of "I" equal to zero with "J" varying 1 to 4.

The FOR-NEXT loops are used as an auxilliary to the statement READ. Observe how A (I) holds the first data to be used as a variable of the statement FOR (line 75), in order to read to exact quantity of data for each spoken number. Data from lines 110 to 128 are the decimal number values which we need to make the speech synthesizer talk. Vector A (I) will store the first data contained in such lines (4, 5, 3, 4, 4, 5, 8, 8, 4, 5), which as we said before indicates the data contained in the vector B (I, J) respectively. We recommend that you compare these numbers with the allophone address table (fig. 2). For example, the data of line 110 forms the word "ZZ YR OW PA5" where the respective data are 43, 60, 53, and 4.

Lines 150 to 215 give an example of how to make the speech synthesizer more versatile. The screen will display "VALUE OF X (V)?" where V varies from 0 to 9.

The A (C) works as a variable in line 220 of the statement FOR, which means that "I" varies from 1 to the A (C) value, where C indicates the number that will be spoken. Line 217 POKEs a zero so that the new data can be accepted without problems. Line 240 serves the same purpose. And lines 250 to 270 are used to read the STANDBY condition as we explained before.

Finally, the capacity of the speech synthesizer depends upon the imagination of the user. And we hope you enjoy this project as much as we did.

SOFTWARE REVIEW

TELEPATCH—

It seems that just about everything, from business documents to a student's homework, to family announcements, is polished to perfection with a word processor. By the time one adds up the cost of the computer, disk drives and software needed for word processing they're into big bucks—way beyond what word processing is worth to a small service shop, or a student, or the typical family of 3.85 persons.

Because word processing isn't cheap, one of the best-selling professional-quality word processing systems has been the budget-priced Radio Shack Color Computer (known as the CoCo) and an inexpensive word processing program, Telewriter-64. Together, they provided most of the modem word processing features long before they were available for the IBMs, Apples, and other "office computers." Since Telewriter-64 can intermix tape and disk text files it far outclasses anything for small business and home-and-family use because the user can grow from a cassette-based word processor into a disk system without losing the cassette files.

The only problem with the CoCo system is that compared to the most modem high-performance word processors, such as WordStar 2000 and pfs:WRITE, Telewriter-64 lacks a few conveniences, such as a pure block move instead of a block copy and delete. Thanks to an enhancement software known as TELEPATCH, Telewriter-64's limitations are almost entirely eliminated, and in the process the CoCo has been made into a hassle-free single disk drive word processor (It is difficult to do word processing with a single-drive system.)

TELEPATCH (Spectrum Projects Inc., 93-15 86th Drive, Woodhaven, NY 11421) is a self-installing patch for the disk version of Telewriter-64. If you have a single-drive disk system it takes a number of disk swaps to install the patch, but when you're finished you have an upgraded version of Telewriter-64 (the source version isn't destroyed or modified) having thirteen new features, ten of which make the tight-budget CoCo/Telewriter into a powerhouse. The big ten are: 1) All disk I/O in memory (which permits the program disk to be removed); 2) A true block move; 3) Visible carriage returns, which are just great when setting up tables and charts; 4) Key repeat of all characters and the space; 5) Locked-on justified printing (doesn't turn off after a file has been printed); 6) A true RESET which permits a 64K Color Computer to be reset if everything else goes wrong without leaving the editor (no losing your work); 7) Lowercase off on boot (useful when writing BASIC programs); 8) Fast cursor movement (for zipping across the screen); 9) Either overstrike or insert mode (original program provides only for insertion); 10) A type-ahead buffer for people who type faster than the computer can handle the data: if your typing gets ahead of the computer the screen will catch up.

The memory-resident disk I/O requires the most explanation. The problem with most word processing software used with computers having only one disk drive is that the data disk—the one that contains only text files—must be swapped with the program disk when using disk I/O disk routines, such as saving a file, or reading a file, or appending a file: Frequent reads and appends can lead to considerable disk swaps. TELEPATCH eliminates the frustrations of disk swapping by moving all disk routines into memory along with the editing program so that it is never necessary to swap disks for disk I/O. The user can load the TELEPATCHed Telewriter-64, substitute the data disk for the program disk, and go through a complete editing session without having to remount the program disk.

One of the powerful features of the new disk I/O is that the user can instantly determine whether a save will be in binary or ASCII, selecting the one that will be most efficient at the time the document is saved to disk. For example, ASCII is generally preferred if the document will be run through a spelling checker, or is to be transmitted by modem; binary is recommended when maximum speed is wanted for writes and reads.

In order to retain the instant-access of the original Telewriter-64 the user-controlled TELEPATCH functions are command rather than menu driven. For example, a block move is instantaneous when CLEAR-T ("T" for transport) is pressed, similarly the insert/overstrike toggles when CLEAR-O is depressed.

TELEPATCH comes with a new loader that is written in BASIC so the user can conveniently configure the boot so the program comes up with the most desired features as the default. A complete list of pokes for the new features are provided along with the appropriate loader program line number. Among the user-set defaults are black/white or black/green screen, insert or overstrike mode, page numbering sequence, line spacing, lines per page, justified printing, "one page" printing, characters per line, upper, bottom, right and left margins, printer baud rate (300 through 9600), key repeat rate, repeat delay, fast cursor speed, number of disk drives in system (1-3), automatic case (upper or lower), disk verify, default disk drive, and ASCII disk menu.

TELEPATCH also permits the user to specify a disk stepping rate of 6 to 30 milliseconds. This means that you can get the maximum disk access speed if you have splurged for one of the latest model disk drives. On the other hand, it also means that the program will work with one of the original 30 mSec. "clunkers" you might have picked up surplus for something like $25.

The primary limitation of TELEPATCH is that installing the disk I/O in RAM reduces the text buffer size from Telewriter's usual 24,889 characters to 20,793. If, for some reason, you need the extra RAM, or have a two drive system to begin with, you can install TELEPATCH without the disk I/O in RAM.

SINGLE TRANSISTOR SWITCHING CIRCUIT DESIGN

Jeff Holtzman

■Hobbyists dealing with digital circuits are terrified by interfacing. But for computers to do useful things, they must have a way of talking with outside circuits: relays, motors, lightbulbs, LED's, etc. Things aren't so bad when dealing with standard TTL outputs, but what do you do when you have to connect a 5-horsepower motor to a CMOS inverter? Doing that is simple; we'll show you how to do the design calculations, and we'll present a short BASIC program that does the work. One feature of that program is that after making the calculations, it outputs the value of the closest standard resistor.

To design a switching circuit, before doing any calculations, make sure that a single transistor will do the job. There are no calculations involved, just a little common sense. If your driving device is a 6522 VIA, or a Z80 PIO, or similar, and you want to control an NC (Numerical Control) lathe with a 5-horsepower motor, you'll need a few transistors to build up enough drive to control a relay large enough.

If you need to turn an LED on and off, you may be able to use a transistorless driving circuit. You may get by using just a current-limiting resistor, although doing that may not allow the LED to glow at full brightness.

If a one-transistor circuit will do the job for you, choose a transistor. Double the voltage and current requirements of your load device, and then search your databooks and catalogs for a transistor that meets those specifications. Find several that will do, in case your first choice is unavailable, or expensive.

Every transistor has a DC-gain factor, called HFE. Unfortunately, HFE varies from device to device, even between devices of the same type. HFE also varies with load and temperature. Since many applications aren't critical, a few assumptions can be made to get things off the ground. Those will allow you to arrive at tentative values suitable for breadboarding; remember that slight adjustments may have to be made later.

With specifications handy, choose a value for HFE halfway between the minimum and maximum values given in the databook. If you don't have the specs, you can assume a value of 100 for a small-signal transistor, or 10 for a power transistor. That lets you estimate the value of the current-limiting resistor in the base circuit (R1 in Fig.1). As base current is defined as the collector current over HFE, you can get the base current by dividing the collector current by 100, or by 10, depending on the type of transistor. Before finding the value of R1, we have to find the value of R2.

Making the calculations

To calculate the values of the resistors in the switching circuit shown in Fig. 1, work backwards from the load. You have to know how much current the load will draw, and its resistance, to calculate the voltage drop, V(L), that will appear across it. According to Kirchoff's law,

$$V(CC) = V(L) + V(R2) + V(CE)$$

V(CE) is the voltage dropped across the collector and emitter leads of Q1; that voltage is often about 0.3 volt, so it may be ignored. By making that simplification and rearranging our equation we find that V(R2) = V(CC) - V(L). We need the resistance of R2, and by Ohm's law that is equal to the voltage across R2 divided by the current flowing through it, or, R2 = (V(CC) - V(L)) / I(L). If the load is an LED, we can assume that V(L) is 1.5 volt. If not, V(L) must be expressed as I(L) * R(L). In the latter case, the value of R2 would be expressed as R2 = (V(CC) - [I(L) * R(L)]) / (I(L))

To calculate the value of R1, we use the value of HFE we found above. Since HFE = I(C) / I(B), I(B) can be expressed as I(B) = I(C) / HFE.

By Thevenin's law we know that I(C) must equal I(L), so I(B) = I(L) / HFE. Again, by Kirchoff's law we know that V(IN) = V(R1) + V(BE), where V(BE) is the base-emitter voltage drop. For the sake of simplicity, we can assume that V(BE) is zero, so the voltage dropped across R1 must equal the input voltage. Therefore, the value of R1 can be simply expressed as R1 = V(IN) / I(B). Since I(B) can be expressed in terms of collector current, R1 = V(IN) / [I(C)/HFE].

The unknown quantities (R1 and R2) are expressed in terms of the known quantities, so it's time to plug the values into the equations and solve them. Rather than bang those values out your calculator, type the program shown in Listing 1 into your computer and save it for the next time you need to design a switching circuit.

The program provides features you may find convenient. For example, that program can be used to design a circuit with any driving voltage, but if you happen to be using TTL, the program assumes a value of 2.4 volts for V(IN). Likewise, if you will be driving an LED, the program assumes a load current of 15 mA, and a 1.5 volt drop across the LED.

The program was written in MBASIC-80, and it should be simple to translate into other dialects of BASIC. The main routines have been written as

```
10 REM switching transistor circuit
20 REM design  jh  10-22-85  for RE
30 FIRST = -1
40 PRINT CHR$(27);"*";
50 GOSUB 1000
60 PRINT
70 INPUT "Another? ", YESNO$
80 IF LEFT$(YESNO$,1) = "Y"
   OR LEFT$(YESNO$,1) = "y"
   THEN GOTO 50
90 END
1000 REM get and print data for
     switching circuit
1010 PRINT
1020 INPUT "Enter supply voltage
     (VCC) in volts: ", VCC
1030 INPUT "Enter HFE of
     transistor: ", HFE
1040 INPUT "Is load an LED
     (y/n) ? ", YESNO$
1050 YESNO$=LEFT$(YESNO$,1)
1060 IF YESNO$="Y"
     OR YESNO$="y"
     THEN VL=1.5: IL=15: GOTO 1100
1070 INPUT "Enter load
     resistance (RL): ", RL
1080 INPUT "Enter load
     current (IL) in mA: ", IL
1090 VL=IL*.001*RL
1100 IL=IL*.001
1110 INPUT "Does TTL drive this
     circuit (y/n) ? ", YESNO$
1120 YESNO$=LEFT$(YESNO$,1)
1130 IF YESNO$="Y"
     OR YESNO$="y"
     THEN VIN = 2.4: GOTO 1150
1140 INPUT "Enter driving
     voltage (VIN): ", VIN
1150 IB=IL/HFE
1160 R1=VIN/IB
1170 RIN=R1:GOSUB 10000:R1=ROUT
1180 R2=(VCC-VL)/IL
1190 RIN=R2:GOSUB 10000:R2=ROUT
1200 PRINT:PRINT "R1 =";R1;
     "ohms, R2 =";R2;
     "ohms, I(B) =";IB*1000;"ma"
1210 RETURN
10000 REM get closest standard
      resistor value
10010 REM input = rin
10020 REM output = rout
10030 REM sf = scale factor
10040 REM 25 standard values follow
10050 DATA 1.0, 1.1, 1.2, 1.3,
      1.5, 1.6, 1.8
10060 DATA 2.0, 2.2, 2.4, 2.7
10070 DATA 3.0, 3.3, 3.6, 3.9
10080 DATA 4.3, 4.7
10090 DATA 5.1, 5.6
10100 DATA 6.2, 6.8
10110 DATA 7.5, 8.2, 9.1, 10.0
10120 IF NOT FIRST THEN 10190
10130 FIRST = 0
10140 AMAX = 25 : REM must equal
      no of entries in table above
10150 DIM A (AMAX)
10160 FOR I = 1 TO AMAX
10170 READ A(I)
10180 NEXT I
10190 X = RIN
10200 SF = 0
10210 WHILE X > A(AMAX)
10220 X = X/10
10230 SF = SF + 1
10240 WEND
10250 I = 1
10260 WHILE X > A(I)
10270 I = I + 1
10280 WEND
10290 IF X-A(I-1) <= A(I)-X
      THEN X = A(I-1) ELSE X = A(I)
10300 ROUT = X * 10^SF
10310 RETURN
10320 END
```

subroutines for easy integration into your programs. Lines 1000-1210 get the data and calculate the resistor values; lines 10000-10320 select the closest standard resistor values. Lines 10-90 drive the main routine following line 1000. Line 30 sets a flag for the standard-value routine, so that it doesn't read the data contained in lines 10050-10110 in every time a set of calculations are made. Line 40 clears the screen of my CRT (an ADM 20); you'll probably have to use another method.

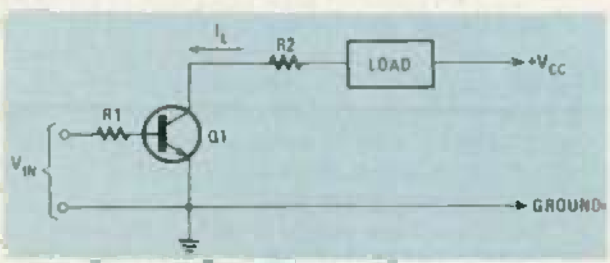


FIG. 1—R1 IN DIAGRAM ABOVE is used for current limiting and must be estimated. (See text.)

If your BASIC doesn't have the WHILE . . . WEND statements, you can simulate them by using an IF . . . THEN statement and a dummy loop. For example, the code below could be substituted for the loop running from line 10210 to line 10240: 10210/IF X <= A(MAX) then 10250

```
10220 X = X/10
10230 SF = SF + 1
10240 IF X > A(AMAX) THEN 10210
```

That's about all there is to calculating the values of the resistors in this simple switching circuit. Of course, you should verify that the calculated values actually do the job before building 10,000 duplicate circuits. Also, note that the program prints the value of I(B) the circuit will draw. That was done as a protective measure. If your driving circuit is CMOS, and I(B) is greater than a milliamp or so, you'll have to do one of two things: use a Darlington, or add another transistor that will provide a bit of "preamplification." If you opt for a Darlington, you can use our program as is.

SATELLITE TV

Scrambling and TVRO systems

BOB COOPER, JR.
SATELLITE-TV EDITOR

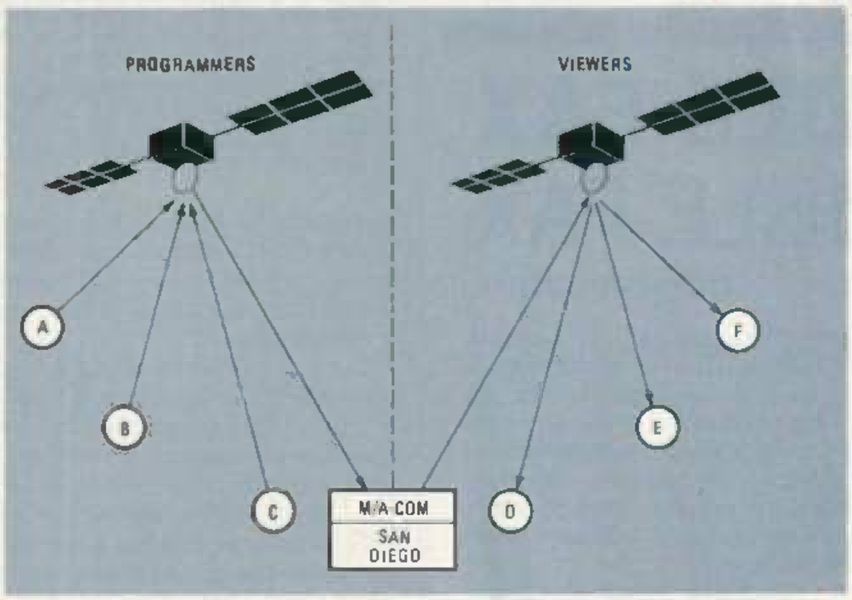


FIG. 1

M/A-COM HARDWARE HAS BECOME THE *de facto* standard in scrambling and descrambling. M/A-Com has accomplished that feat by being first to market a relatively secure scrambling system and by delivering both the uplink scramblers and the downlink descramblers in quantity. However, M/A-Com has suffered in the *home*-TVRO market.

The reason is that, before scrambling and descrambling became so important, M/A-Com was a major supplier of home-TVRO systems. Consequently, home TVRO owners had come to depend on M/A-Com, so they have been immensely dissatisfied with M/A-Com's role in the scrambling wars. But the scrambling furor has cost M/A-Com a significant amount of business not only because consumers refuse to buy, but because dealers refuse to handle M/A-Com products.

System overview

If you've just tuned in, here's a brief summary of how M/A-Com's system works. One of the key features of *Videocipher* descrambler is its addressability. Each descrambler, whether located at a cable-system supplier, a hotel MATV system, or a TV in a private home, has a unique, one-of-a-kind electronic address. That address allows each descrambler to be controlled individually by remote control from a central uplink location. This means that a descrambler can be sent private messages, or turned on or off.

As shown in Fig. 1, addressing is done by a master control center that is located near San Diego and operated by M/A-Com. Each program supplier is linked to the command center's computer via satellite; each programmer injects his command signals in his uplink signal at his own site.

There are two types of commands that can be sent to *Videocipher* units in the field. One command enables all subscribers in a programmer's "universe" to receive descrambled signals; the other enables only specific subscribers to do so.

The first type of command is called *open key;* it refers to a master code that is recognized by every *Videocipher* unit. Programmers don't normally use the open key, since it prevents them from using *Videocipher* as a gate counting or collection tool.

The second type of command is called *closed key*. When a *Videocipher* unit receives its own particular closed key, it will begin descrambling, and it will deliver viewable and listenable signals to the subscriber. The closed key is composed of digitally encoded numbers and letters. There are actually two stages of decoding: the first deciphers the address code, and the second deciphers the audio and video signals.

To date, most programmers who transmit scrambled signals began operating in the open-key mode. For example, super station WOR began full-time scrambling (in the open-key mode) on March 17th of this year. However, WOR switched to the closed-key mode in May, and that made their signal unavailable to home TVRO viewers.

The reason why WOR began operation in open-key mode is that additional time and equipment are required to broadcast signals in the closed-key mode. So the station began broadcasting in open-key mode and changed to closed-key mode when the equipment and programming was set up.

Legality

Some policies of the super stations, including WOR (New York), WTBS (Atlanta), WPIX (New York), WGN (Chicago), and KTVT (Dallas), have raised difficult legal questions. For example, by law, no TV station can itself directly purchase satellite transponder time to distribute its signals nationwide. The FCC considers that an unauthorized expansion of a station's broadcast coverage area. So, an intermediate company, a common carrier, must be used.

A common carrier is a firm that contracts with a cable system or another business entity to pick up a broadcast signal at a distant point and then deliver it to the customer's premises. A Los Angeles TV station, for example, that is seen on a cable system in El Paso is transmitted from Los Angeles to El Paso by a string of common-carrier-operated microwave relay stations. Stations along the way may also tap the signal.

By law the common carrier is authorized to sell its services only to a special class of users. Cable-TV distributors and broadcast-TV stations belong to that class, but individual homes do not. Therefore, a firm such as Eastern Microwave, who uplinks WOR's signal, says it cannot sell WOR's signals to individual homes because the law says it cannot do so.

Eastern Microwave is showing the cable-TV world that it is "cable-friendly," that it is anxious to court the favor of the cable operators by preventing home-TVRO owners from watching the signals it transmits. Of course that has generated considerable resentment on the part of both owners and sellers of TVRO equipment.

The TVRO industry's trade association, SPACE (the *S*ociety for *P*rivate *A*nd *C*ommercial *E*arth stations), is asking the federal courts to forbid Eastern Microwave from scrambling its signals unless it also offers them to home-TVRO viewers. The case is complicated because the root of Eastern Microwave's contention that it cannot sell to individuals is a 1976 modification of the U. S. copyright law. The law makes a special provision for common carriers and establishes guidelines that appear to sanction Eastern's actions to date.

SPACE and the TVRO industry hope that, at the very least, the courts will suggest to Congress that the 1976 copyright law be revised and clarified. In the meantime, TVRO owners will be unable to receive the sports, movies, and other programs to which they had become accustomed. **R-E**

Interested in TVRO?

For nearly two years Bob Cooper has provided a no-charge kit of printed materials that describes the challenges of and opportunities in selling TVRO systems today. With the present intense interest in scrambling systems, Coop's *CSD* has made available a new no-charge service.

The SCRAMBLE FAX hotline is a 24-hour-per-day telephone service that provides accurate, detailed, and hard-to-find facts concerning the changeover to scrambling in the satellite communications industry. Information describing satellite receivers tested for scrambling compatibility, sources for authorized descramblers, wholesale rates of scrambling equipment and services—all are provided on the SCRAMBLE FAX hotline. There is no charge for that service, other than your long-distance telephone expenses. Simply dial (305) 771-0575 for a concise and timely three-minute capsule report that covers the latest in scrambling news.

ROBOTICS

Tactile sensing

MARK J. ROBILLARD,
ROBOTICS EDITOR

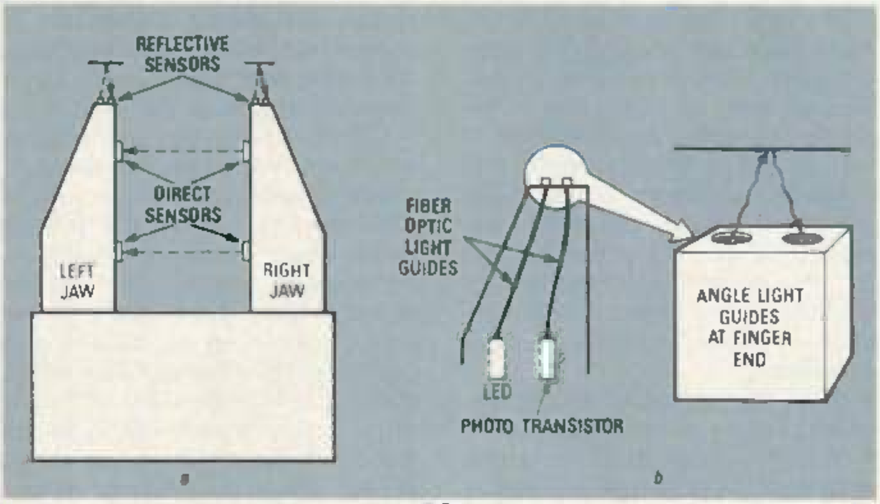


FIG. 1

MAN IS BLESSED WITH FIVE SENSES, AND one really proves its worth on a dark, cold winter morning. You roll out of bed and grope around for your slippers and bathrobe. Then you stumble into the kitchen, feel around for the light switch, and only then can you see what your hands and feet have been telling you. Oh that sense of touch!

Touch is important in robotics too. Most robots must move around to accomplish their tasks. Hence they need directions about where to go under different conditions. So they need to be able to acquire information about their surroundings. That information is obtained through a myriad of sensors—light sensors, sound sensors, and touch sensors, among others.

Different kinds of tactile information are important for different purposes. For example, often a robot must know how much force its gripper should apply to grasp an object. If too much force is applied, an object may be crushed. It too little force is applied, the gripper may not be able to maintain contact when it tries to lift the object. In additon, bump sensors around the perimeter of the robot's base can be used to detect collisions. The underlying technology of both kinds of tactile sensing can be the same. Let's see how.

Limit sensing

The simplest touch sensor is the common microswitch. A microswitch is often activated by either a long flat lever or a lever with an attached roller. Pressing the lever "makes" the connection. Actuation force is relatively small, so it takes little force for the robot to "feel" whatever the switch is contacting.

A robot gripper might be equipped with two microswitches, one in each jaw. With no object between the jaws, both switches would be open, but when an object is gripped, one or both switches will close. A computer interface could monitor the signals generated by those switches and it could use the various voltage levels to make decisions regarding the next action the robot should take.

Terence Thomas of Venice, FL sent a schematic diagram of a circuit that uses three microswitches. Two are used to detect obstacles around the perimeter of the body; a third indicates whether contact with the floor is being maintained. A floor sensor could be important to prevent a robot from making a perilous journey down a flight of stairs. Of course, the location of the floor sensor on the robot's body is critical. Two side-mounted microswitches provide direction control; when a switch on one side is activated, the robot turns in the opposite direction.

Optical sensors

Some sensing functions accomplished by switches can be accomplished better by another type of sensor. For example, rather than try to mount bulky, massive switches in the jaws of a gripper, you might use LED/phototransistor pairs, as shown in Fig. 1-*a*.

If you've ever been bowling, that setup should look familiar. The foul line sensor works on the same principle. It consists of a visible (or infrared) beam of light and a photo-detector. When your body breaks the beam, a light or a buzzer comes on.

Note that the sensors illustrated in Fig. 1-*a* are used in two different ways. The sensor pairs mounted between the jaws work like the bowling alley's foul-line sensor: an alarm condition is raised when the beam is interrupted. The sensor pairs mounted on the front edges of the jaws work on the opposite principle: an alarm condition is raised when the beam from the LED makes contact with the phototransistor.

As shown in Fig. 1-*b*, each member of the reflective pairs should be angled slightly inward so that a nearby object will reflect light from the LED back to the phototransistor. The phototransistor would be connected to a computer interface or other controller.

The reflective pairs can provide more than just an object-is-present/object-is-not-present signal. The amount of light that is reflected provides an indication of how close the object is to the end of the gripper. So the output of the reflective sensors could be processed by an A/D converter and fed to a controlling device which would then be able to locate objects. A control sequence might go as follows.

- Move the gripper to the approximate position of the target object.
- Scan the gripper from left to right until the object is detected by the reflective sensor at the tip of the right jaw. The gripper must be open so far.
- Move the gripper right until the object is detected at the tip of the left jaw.
- Move the gripper left again until neither jaw detects the object. The object is centered left-to-right now.
- Move the arm forward until the first inside-the-jaw sensor detects the object.
- Move the arm forward until the second inside-the-jaw sensor detects the object.
- Retract the arm until neither sensor detects the object, or until both detect the object if it is large. The object is centered front-to-back now.
- Close the gripper.

There is one flaw in that sequence of gripper motions. As the last step, the robot is to close the gripper to capture the object. But how does the robot know when to stop closing? In some cases, the maximum gripping force of a lightweight arm can be applied to the object. But that's not always the case. And how does the robot know when it has a good grip?

A force sensor

There are several ways to build a force sensor. One simple way is to use a spring and a microswitch. The spring is attached to a cable that winds around the shaft of a drive gear as motion occurs. The cable goes past the lever of a microswitch. When tension in the cable exceeds the actuation force of the microswitch, the switch contacts close. The device controlling the robot must then act on that signal. The spring in that sort of sensor must be selected carefully, according to the amount of force required to actuate the switch.

Other approaches use optical feedback. For example, the patented approach of Heath's *Hero 2000* uses two optical encoder disks. One is attached directly to the gripper, and the other is fastened by a spring to the first. As long as there is no resistance to the motion of the gripper's jaws, both disks spin together. But when an object is grasped, the disk attached through the spring slows down, while the directly-connected disk continues at its normal rate. The system's microprocessor can detect that speed difference by counting the slots etched in each disk; that information can be used to determine the force applied as well as the size of the object.

Other approaches use integrated circuits that incorporate a strain gauge and special pressure-sensitive resistive paint. In fact, a simple pressure sensor can be built from the conductive foam that MOS IC's are packed in. That foam has a finite, measurable resistance; when the foam is compressed, resistance decreases. By mounting a piece of foam between two metallic plates, a simple strain gauge could be built.

All those methods of tactile sensing comprise a field of inquiry that is as large as robotics itself. The science of tactile sensing is one in which the home experimenter might achieve a breakthrough by discovering new ways of measuring real-world quantities. So go to it! R-E

DRAWING BOARD

ROBERT GROSSBLATT,
CIRCUITS EDITOR

Bank-switching

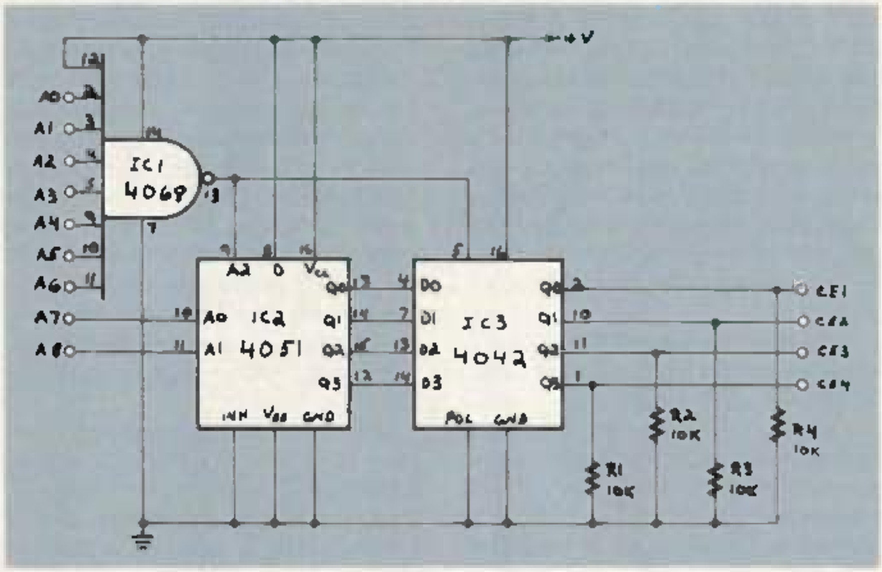


FIG. 1

WHEN WE LEFT OFF LAST TIME WE HAD just finished designing a basic memory-management circuit. If you breadboarded the circuit, you may have questions about how it works or how to use it. Before we discuss usage, let's discuss a few of the nitty-gritty details of circuit operation we couldn't get to last time.

Except for the addition of resistors R1–R4, the circuit shown in Fig. 1 here is quite similar to the circuit shown in Fig. 3 last time. We'll discuss why we need the resistors below; for now let's look at the circuit just in terms of logic.

Since the CMOS data selector we're using is a 4051, we can send either a high or a low to the selected output (Q1–Q4), depending on what the 4051's DATA input (pin 3) is connected to. In this case, it is connected to the positive supply rail.

When the low-order address line (A0–A6) are high, IC1's output goes low. Then, depending on the state of A7 and A8, a high will be fed to one of the outputs of the 4051. That high will be clocked into four-bit latch IC2. That signal provides an active-high memory-enable signal.

Active-high or active-low?

Each of the four banks of our memory system is made up of four 5101's. The circuit was shown in Fig. 1 of the April 1986 issue of **Radio-Electronics**, and it contains one subtle error that could be confusing in light of the bank switching circuit presented here. The pins marked CE1 in that figure should be marked $\overline{\text{CE1}}$. The active-low *vs.* active-high issue wasn't important there, but adding additional banks as we're doing now requires careful attention to the level of the enabling signal.

That aside, if you examine that circuit, you'll see that we're doing memory banking there as well. Each bank is composed of two IC's, and the $\overline{\text{CE1}}$ pin of each IC is used for bank selection. Our circuit uses a nine-bit address bus; the high bit of that bus allows us to switch 256-byte banks transparently, yielding a 512-byte system.

What we want to do now is add three additional 512-byte banks to the system. To do that, we'll have to use the 5101's other enable pins. If the IC had only one enable pin, we'd be faced with a fairly complex gating problem, but, fortunately for us, the 5101 has *three* separate enable pins. We discussed how they work in the April column.

We use pin 19 to select a 256-byte page in a bank, so we'll use pin 17 to select the bank as a whole (512 bytes). If that sounds confusing, it may help you to think of each 512-byte page as a separate section.

If you bring pin 17 of the 5101 low, the IC "goes to sleep." Actually, it goes into a low-power mode in which all data are retained and power requirements are reduced to less than 10 microamps. So, by using pin 17 as a bank selector, we get reduced current drain as a freebie! The point is that the banking circuit must put a high on the enable pin of the bank we want to select and a low on all the others. That's why we tie the DATA input (pin 3) of the 4051 high.

The reason we need resistors R1–R4 is to ensure that the memory's enable pins are in a well-defined state. We wouldn't want those pins to float; data in the RAM might be garbled if the IC were accidentally accessed for even a brief period of time. Since we need active-*high* enable signals, we need to use pull-*down* resistors.

To use the bank-switching circuit shown here with the memory circuit shown in the April column (**Radio-Electronics**, April 1986), tie pin 17 from all 5101's in each bank together and connect that line to one of the CE outputs of the circuit shown here. That gives us four banks of memory, each of which is selectable by flipping a soft switch located at an address ranging from 1FC to 1FF.

How can we select a memory bank? And how can we initialize the system properly? Those questions are interrelated, as we'll see. It would be difficult to generate a reset signal that would ensure that only one bank was enabled at power up. However, if we use our Z80 circuit as the system controller, the solution to the problem is simple.

When we designed the Z80 system, we made sure there was an RC-generated reset pulse produced at power-up. Among other things, that forces the Z80 to begin execution at location 0000. That being the case, to initialize the system all we have to do is have the Z80 flip one of the soft switches before it tries to access any RAM. To do that, the Z80 can execute any instruction that causes the address of the soft switch to be put on the address bus. The system's hardware will take over the task from that point.

Any of the Z80's "load" instructions is a good choice. For example, if the first instruction in your program is LD A,(01FF), the Z80 will obligingly put 01FF on the address bus and cause our circuit to enable one of the memory banks. Believe it or not, that's all you have to do to flip a soft switch. And it doesn't matter which instruction is used as long as it results in the appearance of a soft switch's address on the bus.

Other uses

We mentioned last time that there are several ways to set up alternate banks of memory in a system. Soft switches are a neat way to organize memory, but they can be used for other things as well. And there are other ways of generating banking signals too. Let's look at some of those.

For example, if you're using only seven bits of data, you could use the eighth bit as a select line. Set the bit to talk to one bank of memory, and reset it to talk to the other. A more reasonable alternative would be to use an otherwise-unused Z80 control signal—an unused address line, perhaps, would serve well.

An externally generated signal may be a good choice in some systems. For example, if you're sensing and recording real-world data, some predetermined condition could be used to switch memory banks. For example, suppose you connected the bank switching system to a low-battery or power-failure alarm. A signal produced by a circuit of that kind could cause data to be transferred from volatile dynamic memory to battery-backed-up CMOS RAM. And yes, it's perfectly reasonable to mix two different memory types in one system.

Using that sort of scheme to capture data is a common practice. Commercial airlines, for example, use it in flight recorders, and a similar setup is used by recorders for unattended remote data gathering.

There are a few things to keep in mind when you set up a banked-memory system. The IC's you use in your switch circuitry must match or exceed your system's operating speed. The CMOS NAND gate we used is slow—about 150 nanoseconds. You could use a high-speed CMOS or TTL part to increase that speed by about a factor of 10.

If you're really interested in microprocessor system design, put the circuit together and connect it to the Z80 demo system we've been discussing. Of course, the Z80 has a 16-bit address bus, so switching 512-byte banks of memory is unnecessary, but you'll learn a great deal by making the system work. And that knowledge could be put to real-world use by designing a banking system that switches between 64K banks—and a memory system of that sort can be very useful. **R-E**

SERVICE CLINIC

Replacing transistors

JACK DARR
SERVICE EDITOR

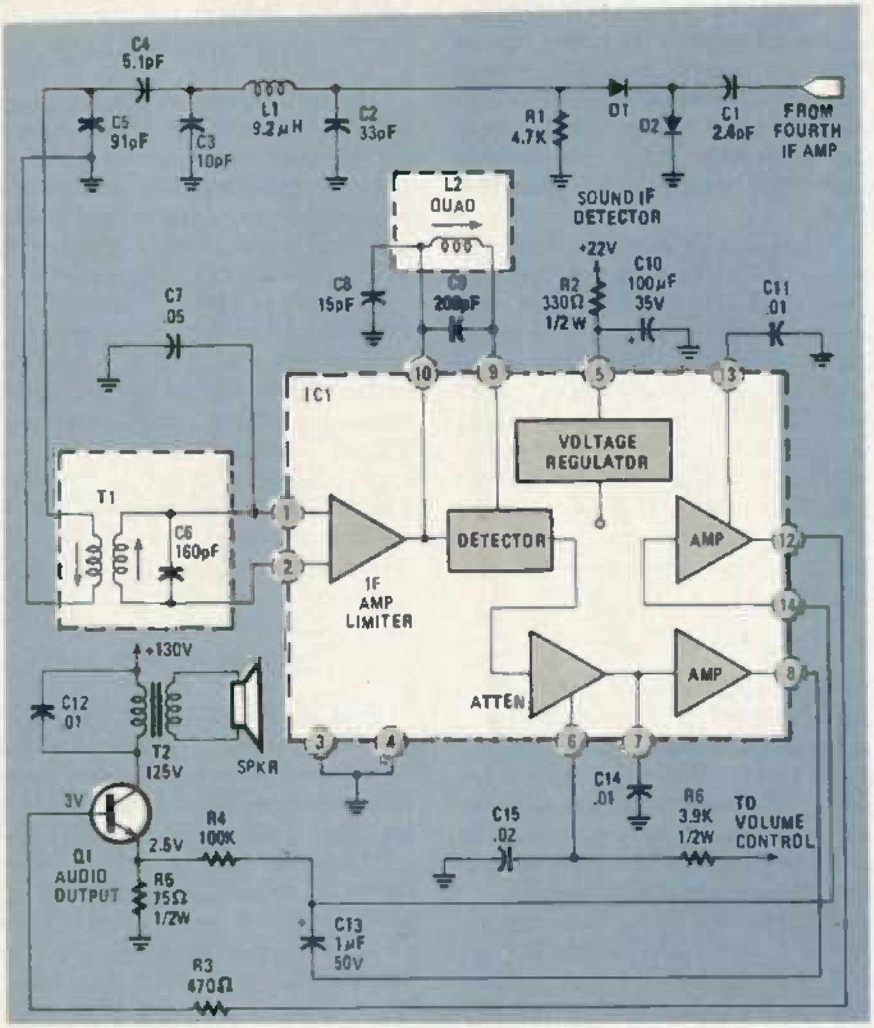


FIG. 1

SELECTING A SUITABLE REPLACEMENT for an unknown transistor is not as difficult as you might think. First get a good transistor substitution/specification handbook. Then, for example, if you're dealing with a low-level signal-amplifying stage, find a transistor that is classified as a general-purpose amplifier. The main parameters you'll want to be wary of are voltage and current ratings, and cutoff frequency. A sync circuit, for example, requires a transistor with a fairly high cutoff frequency in order to prevent the sync signals from being rounded off. Just to be sure, examine the sync on a scope, and make sure that it looks clean. If not, try a higher-frequency transistor.

In many applications you won't have any trouble with cutoff frequency. Most general-purpose replacement transistors have cutoff frequencies high enough to prevent problems. However, to take another example, in a video output stage, make sure that your replacement has a peak voltage rating well above the applied B+.

A high-power circuit might use a power transistor, such as Q1 in the audio amplifier shown in Fig. 1, for output. You probably won't have any problem with cutoff frequency there, but power dissipation could be a problem. Therefore you'll have to make sure that your replacement can handle the voltage and current the circuit produces. Don't try to use a five-watt transistor in a fifteen-watt audio output stage!

A common problem is an audio output transistor that blows as soon as power is applied. The way to locate the problem is with a Variac. Before you turn the TV on, reduce the Variac's output to zero. Turn on the TV, and gradually bring the voltage up as you monitor the current flowing through the transistor. Many schematics indicate the amount of current that should be flowing.

Most audio stages work in either class-B or class-C mode in which quiescent (no input signal) current drain is far less than full-load current drain. So, if you measure any appreciable current drain with the Variac set for a low output voltage, remove power and locate the problem. Otherwise you may destroy several big, expensive power transistors. It takes only a skillionth of a second to blow out a new transistor, so play it safe. Run it at reduced voltage until you're sure it's safe to run it at full voltage.

After you know that quiescent current is normal, try running the amp at about half volume. Current drain will be quite a bit more than with no signal, but check the value against the value specified in the schematic. Even if you have no service literature, one thing you can be sure of is that the maximum-current rating of your replacement transistor can't be exceeded! Try to run power transistors at half or less of maximum. That should help protect you from an unpleasant surprise!

Identifying an unknown device

Replacing a transistor is usually not too difficult a job to do—especially if you have a schematic of the set you're working on. Even if you have a schematic, however, you may not know much about a transistor, including its type or pinout. Some foreign sets, for example, use parts that you can't cross reference. So you may know whether it's an NPN or PNP (or FET, etc.) transistor, but little else.

If you have a schematic, verify each step outlined below as you perform it. If you don't have a schematic, and if you have no reason to suspect otherwise, start off by assuming that you're dealing with an NPN transistor in a common-emitter circuit.

First turn the power on; the transistor can be in circuit or out. Now measure the voltages where each lead connects to the PC board or chassis. If our previous assumptions were correct, the lead with the highest voltage is the collector, so the two remaining pins must be the base and the emitter. Using a scope you should be able to see some sort of signal where one lead connects; that's the base. The remaining lead is the emitter, which is usually connected to ground, possibly through a bias resistor.

Now and then you'll run into a set with an uncommon circuit. For example, in a common-base amplifier, the input signal is fed to the emitter. (I don't know why they do that; just to annoy servicemen, I think. You've gotta watch those engineers; they'll play some funny tricks on you if you're not careful.) Be that as it may, in the absence of any circuit information, by tracing out the wiring of nearby components you can make a schematic diagram that will help you see what's going on. Servicing should be a snap after that. **R-E**

SERVICE QUESTIONS

SLOW GUNS

We are having a problem with an old Fleetwood color set that is defying logic. The symptom is all green on the left edge of the raster, caused by a slow coming on of the red and blue guns. Picture and color are otherwise perfect. We've checked every part in the RGB circuit, demodulator and video output.—P.D., Waterloo, Ont.

Anything that might be wrong in the signal circuits would be evident over the entire screen, not just one side. Your statement about the slow emission of the red and blue makes me think of a poor kine. Why not run a purity check to see if you can clean up the raster? Another thought: You might have defective blanking or filtering, showing up as green simply because that is the strongest component.

TRIPPING BREAKER

The circuit-breaker keeps tripping on this GE M772. After all the parts in the power supply checked good, I found that if I disconnected C1702A, one of the filters, the set worked, although the picture was weaving and was short on the right side.—R.A., Brampton, Ont., Canada

C1702A is the input filter capacitor, and without it in the circuit, B+ is reduced. Consequently, total current drain is lowered, and the breaker is holding. You could have nothing more than a faulty breaker, here. Try replacing it with a 2-amp fuse temporarily. If that doesn't do it, a variable transformer would make the job of troubleshooting a little easier.

NO VERTICAL DEFLECTION

I am having trouble with a Sylvania, model CC4152W. There is no vertical deflection. I have checked waveforms up to the yoke, then I lose it. Help!—L.B., Washington, D.C.

I can understand your dismay. I studied the diagram for a long time before I found the yoke return. One has to follow the bottom leg of the vertical yoke winding, through the convergance board, exiting at V_{CC}, until he locates C342 and R342. Check them!

TRACTOR-RADIO PROBLEMS

A Bendix tractor radio, 8BT, came to the shop recently. The Sams schematic goes as far as 7BCX and then jumps to 17K2. Can any readers help?—Corwin Arndt, Box 178, Oshkosh, NE 69154

HOT FLYBACK

The 6JE6 current in this set is normal at 210 millamps. I have a good picture with good brightness and no picture shrinking. Yet, the flyback transformer runs hot to touch after 30 minutes of operation. What could cause this?—V.G.T., Phillippines

In every instance that I can remember, a hot flyback meant a defective flyback, and that usually also meant shrinking picture, focus problems, and low high-voltage. Heat can be a relative thing. What you feel is "hot to touch" may be normal heat build-up after 30 minutes of play. My advice is to do nothing for now. Just observe. If the flyback is on the way out, you'll know.

REPAIRING VCR's

With the proliferation of VCR's in the home, there seems to be a real opportunity growing. In your opinion, what equipment is basic in VCR servicing?—J.J., Haddon Heights, NJ

The basic equipment is what every TV repair shop should already have. A good meter is, of course, essential, as is a wide-band scope and color generator. Then there is a matter of quality: An NTSC color generator is more useful than a keyed-rainbow generator and a triggered scope more useful than a conventional one. For high-output and high-grade VCR servicing, one would need to go into a frequency counter and sweep/marker generator for alignment purposes. An analyst, or signal-injector, would make the high-tech workbench complete.

continued on page 82

ANTIQUE RADIOS

RICHARD D. FITCH
CONTRIBUTING EDITOR

Antique test equipment

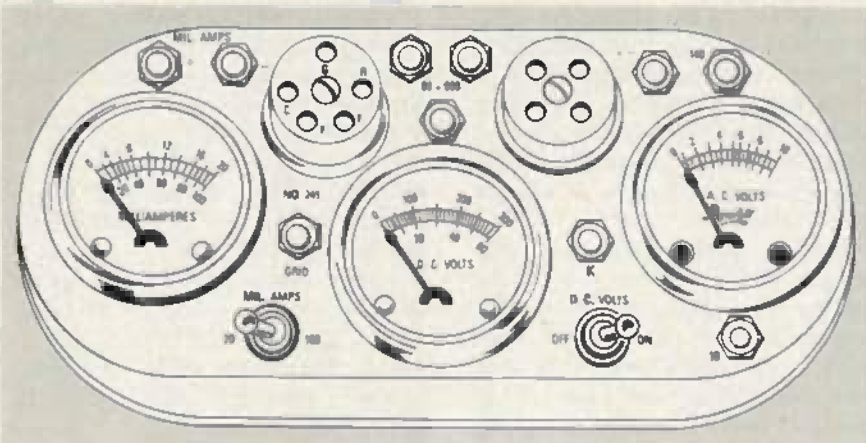


FIG. 1

TEST EQUIPMENT HAS BEEN NECESSARY as long as there have been radios, and advances in test equipment have paralleled advances in radio. But in many respects, early test instruments differ little from much of the equipment we still use every day.

Of course, when antique service equipment is mentioned, the first thing that comes to mind is the tube tester. However, many other types of service equipment were used in the early days, too. Because we've discussed tube testers in previous columns, we'll focus on other types of test equipment and early service techniques this time.

Typical problems

Opens and shorts were probably the most common problem with antique radios, but weak batteries and inadequate antennas were also very troublesome to the radioman of the 1920's and the 1930's. But during the 1930's battery problems were becoming less common due to greater distribution of AC power. And built-in antennas helped increase signal pickup without the use of an outdoor antenna.

There were then, as there are now, specific procedures for troubleshooting. Those procedures could be learned in a technical or vocational school, or even in a correspondence school. Some schools pre-date the first commercially-scheduled broadcast.

There were two types of repairmen in the early days. The trained radio repairman or "radiotrician" (of which I am one) followed specific procedures for diagnosing various symptoms. The untrained man was referred to as a tube changer. No matter what the problem was, he would immediately begin changing tubes. The radioman of the 1920's needed to carry about a dozen tubes on a service call. Those tubes took up about as much space as 100 of the miniature tubes that became available later.

Most early radiomen had little in the way of test equipment. And even a well-equipped shop didn't always have a well-trained service man. Often a radioman settled for one "pet" instrument which he mastered.

Among the equipment available was a shirt-pocket sized "illumination tester." That interesting device was very advanced for its day. It was handy for preliminary testing, anyone could afford it, and it could even test the spark plugs in your Model A! A built-in neon lamp could be used to indicate a short, an open, or the polarity of a DC voltage source.

Another valuable test instrument was the hydrometer. Yes, in the early days, when battery receivers were popular, the hydrometer was an important piece of test equipment. It is used to check the specific gravity of the electrolyte (the acid) in a battery. A weak "A" battery was the primary suspect when a radio appeared to be dead. Often a battery could be rejuvenated by adding distilled water. More than half of the problems with battery sets originated from the batteries, so most service calls were relatively routine.

And, in the later 1920's, a furniture touch-up kit was necessary to keep the elaborate cabinets that were being produced then in good shape.

Many early radiomen preferred working on battery-powered sets. They were used to them, and they felt safer working on a battery set than on an unfamiliar "electric" set. If a radio didn't operate after the batteries were serviced, the radioman would have to resort to more sophisticated means of locating the problem.

To do that, he might use one of several test meters, or, more likely, a combination meter called an analyzer. The analyzer was the "in" piece of equipment for the radioman in the mid and late 1920's. An analyzer could cost $10, which was a great deal of money at the time.

The analyzer, which is still popular (and still expensive) for TV and other servicing, combined several meters and a component tester. Part of the reason that the analyzer was popular in the early days was that few radiomen had a car to lug a complete kit of instruments and parts on a service call. Some analyzers were so complicated to use that many servicemen never got the full benefit of them. Many analyzers were transportable.

There were many styles of portable analyzers. The tester shown in Fig. 1, for example, measures about 8 inches across and it has a leather top in which probes and test leads could be stored. The instrument could be carried in a coat pocket. It allows you to measure voltage and current in several ranges; the two sockets are for testing four- and five-prong tubes.

It's easy to see how such a light, compact unit was suitable for many of the early radioman's needs on a house call. The power supply voltage(s) could be verified, tubes could be tested either out of circuit or in (by connecting a cable from the tube socket to the analyzer). And the continuity test (even today) is the easiest method of locating shorts and opens.

After batteries, tubes were the most likely suspect in a non-functional radio. Tubes could be checked in-circuit with an analyzer, or continuity could be measured between suspected filaments. Ohmmeters were not usually a separate instrument; often a small battery was wired in series with a voltmeter to check continuity.

Often a weak tube could be rejuvenated. There's a real art to rejuvenating tubes; except for rejuvenating picture tubes, that art has gone by the wayside. Not all types of tubes were worth rejuvenating; nor could all tubes be rejuvenated. Tube filaments that were coated with oxide would emit electrons as long as some oxide remained. After the oxide evaporated, the remaining element required a greatly increased temperature to emit electrons, and that was impractical. That type of tube was usually disposed of with no attempt at rejuvenation.

On the other hand, tubes with thorium-coated elements could be rejuvenated several times. Even when the thorium coating was spent, rejuvenation was possible, because some thorium that had mixed with the metal in the filament could be brought to the surface to extend tube life. That process could be repeated until there was no thorium left. Early radiomen destroyed their share of tubes by applying an excessive voltage to the filament (a process known as flashing) trying to "wake up" some electrons that simply weren't there.

Flashing (and a similar, slower process called aging) was done with the B+ supply disconnected. That prevented the "new" electrons from being emitted right away rather than being stored for emission later. Tubes such as the WD11, the WX12, the UX171, and the UX227 have oxide-coated filaments; those tubes cannot be rejuvenated.

Even after restoring a set to minimal operation, the early radioman might find that the customer had tried to fix his own set by tampering with the set's alignment. One way of restoring alignment was to tune in a weak station and then slowly adjust trimmers for the best signal. A meter could be helpful in judging signal strength.

But for accurate alignment a test oscillator is required. Test oscillators that deliver modulated signals have been available since the 1920's. Some models then could operate from commercially-distributed AC, DC, and batteries.

Much early test equipment was well-built and housed in a fine cabinet. Much of it is still around and in perfect working condition. And it is as collectable as the antique radios we're used to talking about. Just make sure that the insulation on the wires is intact. Replace all suspect wires before attempting to use *any* antique.

As time passed, analyzers became even more important. Most radio components and terminals were moved under the chassis. Inserting test leads through holes in the tube socket became the only practical way to make measurements without removing the chassis. By 1930, a chassis might consist of three or more bulky sections that would require considerable effort to remove.

Haves and needs

Again, thanks to everyone who took time to write. Your suggestions and corrections are welcome. Please understand that I am unable to supply tubes, parts, schematics, etc. Try contacting one or more of the individuals and firms listed below for those.

- Maurer TV Sales (tubes), 29 S. 4th St., Lebanon, PA 17042.
- Byron Ladue (tubes and schematics), 13 Revere Drive, Rochester, NY 14624.
- John Grey (new and used tubes), 3348 Wildridge Rd. NE, Grand Rapids, MI 49505.
- E. G. Roundtree (parts and information), Box 269, Norris City, IL 62869.
- Antique Radio Tube Co. (tubes, parts, information), 1725 W. University, Temple, AZ 85281.
- The Vestal Press (books and information), Box 97, 320 N. Jenson Rd., Vestal, NY 13850.
- Scaramella (schematics), 37 Earl St. P. O. Box 1, Woonsocket, RI 02895-0001.
- Comtech Electronics (pre-1939 Rider manuals), P. O. Box 686, Wyandotte, MI 48192.
- Richardson Electronics (antique tubes), 3030 North River Rd., P. O. Box 424, Franklin Park, IL 60131, Attn. Ian Stewart.
- Alvin Sydnor (information), 806 Meetinghouse Rd., Boothwyn, PA 19061.
- Unity Electronics (tubes), P. O. Box 213, 107 Trumbull St., Elizabeth, NJ 07026.
- Carlos Queitoz (exchange parts and information), P. O. Box 1064, Belo Horizonte, MG Brazil.
- E. V. Schwartz (Firestone, Silvertone information), 4277 Motor Ave., Culver City, CA 90232.
- B. R. Pohue (information on antiques), Rte. 1, Box 786 No. 8, Thatcher, AZ 85552. **R-E**

STATE OF SOLID STATE

"Chop-amps"

ROBERT F. SCOTT,
SEMICONDUCTOR EDITOR

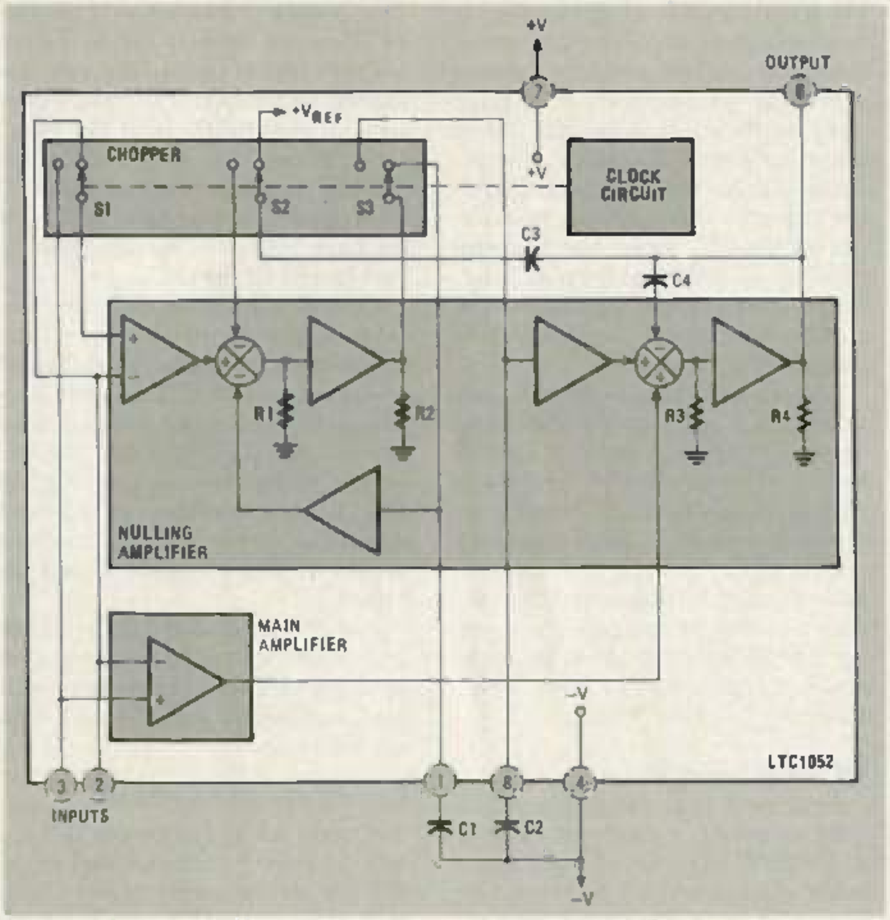


FIG. 1

WHEN YOU NEED AN OP-AMP THAT HAS low input-bias current, extremely low input-offset voltage, excellent long-term stability, and a good temperature coefficient, two new devices to be considered are the LTC1052 and the LTC7652 chopper-stabilized op-amps from Linear Technology Corporation. The chopper-stabilization scheme constantly monitors and corrects offset-voltage errors that develop over time, along with errors due to variations in temperature and common-mode voltage. That error correction, coupled with input currents in the picoampere range, gives those devices exemplary performance and makes them worthy of use in many applications of consideration.

The LTC1052 and the LTC7652, sometimes called "discrete-time" or "sampled-data" amplifiers, are available in the metal can "H" package, and in 8- and 14-pin hermetic and plastic DIP's. In various packaging configurations, the op-amps are direct replacements for similar devices from Intersil.

Both op-amps feature a maximum offset voltage of five μV and a maximum offset drift of 0.05 μV/°C. In addition, maximum input bias current is 30 pA. Other specifications include: minimum gain of 120 dB; minimum CMRR of 120 dB; and minimum PSRR of 120 dB. Either op-amp can be operated from a single-ended power supply (maximum of 18 volts); and both are rated to operate over the −40 to +85°C range.

Chopper stabilization works like this. As shown in Fig. 1, the main amplifier is connected at all times between the input and the output of a circuit. A nulling amplifier, controlled by a chopping-frequency oscillator and a clock circuit, is cross-connected to the main amplifier circuit—input to output and output to input. The chopper can be thought of as several ganged switches (S1–S3), and the amplifiers as transconductance amplifiers. Two external capacitors (C1–C2) function as sample-and-hold circuits; the value of each capacitor normally ranges from 0.1 to 1.0 μF.

The null amp alternately nulls itself and the main amplifier. During half of the clock cycle (the autozero phase), the null amplifier inputs are shorted and a voltage equal to the amplifiers's offset voltage is stored on capacitor C1. During the following half-cycle of the clock (the sampling phase), the main amplifier's inverting and non-inverting inputs are compared and a voltage equal to the input-offset voltage is stored on capacitor C2. In other words, the two capacitors store the potentials needed to null the offset voltages of both the null and the main amplifiers. The nulling scheme operates over the full common-mode and supply-voltage ranges, so CMRR, PSRR, and large-signal voltage gain are extremely high. A constant DC voltage for nulling the input offset is produced by switching between the sampling and the nulling phases at a frequency much lower than the frequency of the input signal.

When the null amplifier inputs are shorted together during the auto-zero cycle, they are also connected to the main op-amp's inverting input. Hence, nulling the input-offset voltage while common-mode voltage is present results in an extremely high CMRR. Power supply variations are nulled in a similar manner, and that's what gives the excellent PSRR mentioned above.

During the sampling cycle, the output of the first stage of the main amplifier is summed with the sampling circuit signal and then applied to the input of the second stage of the main amplifier. As the frequency of the input signal increases, error signals develop as the result of heterodyning (mixing of the input signal and the sampling signal). That produces error signals at a frequency f_E equal to the sum of or the difference between the sampling frequency, f_S, and the input frequency, f_I.

$$f_E = f_S \pm f_I$$

The *summed* error signal is of little concern because it is a high frequency that can be filtered out easily. However, when the input frequency approaches the sampling frequency (typically 330 Hz) the *difference* frequency approaches zero and that can cause DC errors—the problem that a chopper-stabilized amplifier is supposed to eliminate.

The solution is to filter the input to the sampling loop so that the circuit never sees any frequency that is near the sampling frequency. At a frequency well below the sampling frequency, the circuit forces the current out of the first stage of the null amplifier to equal the current through C1. The difference between them is zero, so the gain of the sampling loop is zero at that frequency, and at higher ones. Hence we have a low-pass filter whose cutoff frequency is determined by components in the output stage.

Each op-amp has a separate high-frequency amplifier; the −3-dB turnover frequencies for both the DC and the high-frequency paths are identical and equal. Therefore overall frequency response is smooth and free from sampling noise.

Practical considerations

Circuit-board layout and the choice of external components both require careful consideration if low offset drift and bias current are to be maintained. A 20-page data application note has three pages of detailed applications information for the LTC1052/LTC7652. Included is information that explains how to avoid the harmful effects of thermoelectric junctions, temperature transients, circuit-board leakage, and leakage in the holding capacitors.

Also included are eighteen practical circuit applications including a precision instrumentation amplifier, a thermocouple amplifier with cold-junction compensation, a thermocouple-to-frequency converter, a 16-bit A-D converter and a voltage-to-frequency converter. A copy of the data sheet can be obtained from **Linear Technology Corp.**, 1630 McCarthy Blvd., Milpitas, CA 95035-7487.

Precision op-amps

Four new high-reliability precision op-amps, processed to MIL-STD-883B specifications, have been announced by Solitron Devices. They feature high speed, low noise, low offset voltage and low drift. The OP-01 is a high-speed op-amp that features an 18 volt/μs slew rate, and a 0.7 μs switching time. The OP-07 is an ultra-low-offset-voltage op-amp that features 10 μv offset voltage, and drift of only 0.2 μv/°C. The OP-01 is available in a dual version (the OP-201), as is the OP-07 (the OP-207). The OP-01 and OP-07 conform to 741 pin-outs.

The op-amps are available in a variety of packages, including chip carriers. Military versions are available in hermetic metal cans as well as ceramic mini-DIP's and chip carriers. Commercial version are priced from $1.39 in quantities less than 1000; military versions start at $5.25 in the same quantities. Complete information and specifications from **Solitron Devices**, Sales Dept., 1177 Blue Heron Blvd., Riviera Beach, FL 33404.

Low on-resistance transistors

The 2N7010 and 2N7011 *FETlington* devices (recently JEDEC-registered by Siliconix) offer greatly reduced on-resistance and increased power dissipation. The newest members of the *FETlington* family of low-cost MOSPOWER products are designed to replace Darlington configurations with one compact DMOS device. The miniature TO-237 package offers a low-cost alternative to the larger TO-220 package, without changing the circuit-board design.

On-resistance of the new devices is 0.35 ohm and they have breakdown voltages of 60 and 40 volts, respectively. They can handle continuous drain current of 1.3 amps. Maximum continuous power dissipation is one watt in free air, but dissipation doubles when the device is soldered to a conventional printed-circuit board.

The 2N7010 and 2N7011 are $1.00 and $0.92 each, respectively, in 1000-piece lots.—**Siliconix, Inc.**, 2201 Larelwood Rd., Santa Clara, CA 95054.

Circuit design handbook

Circuit Ideas For Linear IC's is a new 34-page handbook that offers 102 practical circuits using linear IC's and MOSFET's. Each circuit uses one or more of each type of device.

The handbook is divided into nine sections of industrial and consumer applications. Among them are sections on timing, measurement, modulation, power control, data conversion, communications, and alarm/monitoring. Several indexes are provided.

A full schematic of each circuit idea is shown along with a brief circuit description. For a free copy write to **RCA Solid State**, P.O. Box 2900, Somerville, NJ 08876. **R-E**

COMMUNICATIONS CORNER

Spikes and cures

HERB FRIEDMAN,
COMMUNICATIONS EDITOR

COMPUTER CIRCUITS OFTEN ENHANCE communications systems, but they also create new problems of their own. Chief among those problems is susceptibility to transient voltage surges, or what we generally call spikes.

Unlike vacuum tubes, solid-state devices are extremely sensitive to the transient voltage surges that appear on power and signal lines. Unless it is directly struck by lightning, communications gear built from tubes is seldom disturbed by a surge, whether it's picked up by the power lines, the telephone lines, or even an antenna. A lightning arrester usually provides tube gear with sufficient protection from lightning strikes.

But solid-state equipment is another story. A TV set, a CB radio, a ham rig, a commercial VHF transceiver—everyone knows that just one surge can wipe out data memory or stored programming; a particularly bad surge could even destroy the device as a whole. For example, a lightning strike hundreds of feet away could cause a surge in the power lines strong enough to zap a solid-state power supply, or a lightning strike in the next county, or the start-up of an oil burner—which can generate a spike of almost 2000 volts—could cause a glitch in a computerized receiver, transmitter, or control center.

Whether it appears on the power lines, the telephone wires, an antenna, or the electrical system of a motor vehicle, a transient spike can be very dangerous. Because of its shape, a spike contains a great deal of high-frequency energy—which can flow through or around filters from one circuit to another—as well as a high-voltage component. The high-frequency energy could disturb data memory or modify programming, and the high voltage could destroy solid-state components.

Figure 1 shows how transient spikes on the AC power line might appear. The voltage at any instant in time depends on which part of the AC cycle the spike is superimposed on, as well as the direction of the spike. For example, a positive-going spike that occurs at the positive crest of the waveform results in a transient that is the sum of the two signals. Since the spike could range from several hundred to several thousand volts, depending on what generated it, the peak instantaneous voltage could exceed the peak voltage rating of a solid state device easily.

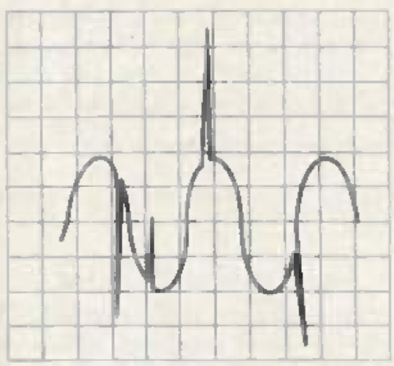


FIG. 1

What makes a spike so insidious is that it lasts for a very short period of time and that it is composed of signals that are often too high to be by safely bypassed by a circuit's normal "interference filter." Also, those high-frequency signals can be capacitively coupled from wire to wire and circuit to circuit because, at high frequencies, a small amount of capacitance provides a low-impedance path for whatever happens to come along.

Spike remedies

A spike is usually best dealt with by a device generically known as a "surge suppressor." A surge suppressor may be built from a bi-directional Zener diode, or more commonly, from one or more MOV's (*M*etal-*O*xide *V*aristors).

A bi-directional Zener simply clips any spike that exceeds a predetermined value, usually 150 to 180 volts. They're effective, but they can't dissipate much power, so if the transient lasts for more than a few microseconds the heat that is generated can destroy the diode.

An MOV, on the other hand, is a resistor whose value decreases sharply when the applied voltage exceeds a predetermined level. MOV's used on AC power lines commonly trip at 150 to 180 volts. Although the MOV does not respond to spikes quite as fast as the Zener diode, it can dissipate more power than a bi-directional Zener. Since MOV's are reliable and inexpensive, they are used in a broad range of suppression devices intended for both power and telephone lines. A MOV can be connected directly across the power line, as shown in Fig. 2-a, or from each side to ground, as shown in Fig. 2-*b*.

Modern modems and digital telephones usually have a MOV wired between ground and the

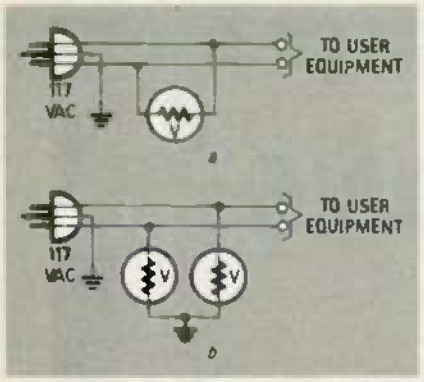


FIG. 2

point where the device connects to the telephone line; that helps prevent transient disturbances generated in the telephone network from entering the sensitive equipment and wreaking all sorts of havoc. Generally, the MOV is connected to the user's side of the ring detector so that the 90-volt ringing signal doesn't affect the MOV. That's done because the MOV is generally rated at 25 to 50 volts in order to protect the signal circuit, which usually operates at a loop voltage of 5- to 10-volts DC.

Power-line interference

Telephone equipment has problems with spikes, but AC power lines have even more problems due to interference from sources other than transient spikes. For example, low-frequency RF interference that cannot be suppressed with a spike suppressor is generated when the electric utility switches a capacitor on or off the power line to maintain the power factor. Further, a ham or CB transmitter can radiate substantial amounts of RF into the power line.

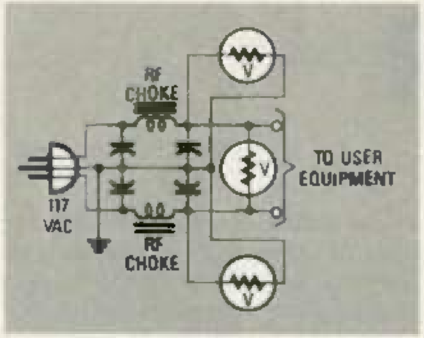


FIG. 3

As a general rule, when a piece of equipment is subject to both transient spikes and RF interference, we use a device that has both transient surge suppression and RF filtering, like the "power line filter" shown in Fig. 3. The MOV's handle the spikes while the RF chokes prevent RF from passing either in to or out of that piece of equipment.

Although much modern communications equipment contains filtering for the types of interference we've been discussing, much older gear was manufactured before the effects of transients and RF hash.

There's no guarantee that filtering of that sort will solve your problems, however. The reason is that transient interference may not be the cause! Verifying the presence of spikes and other interference can be quite difficult because signals like those are often brief.

So, if you have no good ideas about what might be causing seemingly random malfunctions of digital equipment, or if you just want to play it safe, adding a surge/RF suppressor to your equipment may be a good idea. **R-E**

SERVICE QUESTIONS

continued from page 76

INTERMITTENT BRIGHTNESS

Recently the brightness on an RCA CTC92C became erratic. Voltage measurements indicated that the trouble was in the red section of the kine driver module. After replacing Q4, the red bias transistor and C4 (a 4.7 μF electrolytic), the problem cleared up. But, when the parts that I'd removed were checked using an ohmmeter, they tested good. Can you shed a little light on what's happening?—J.N., Dalton IL

I have a feeling that you have not done a thorough job in checking. Component failure in the red-driver circuit shows up as changes in the red gun *only*, and not as a brightness problem.

If the trouble returns (and I don't doubt that it will), look to the luminance section. Something in that section must be malfunctioning, causing a rise and fall in the voltage entering pin 4 of the driver module. That voltage sets the bias of all three outputs, and is also responsible for the brightness level.

SHUTDOWN PROBLEM

The Panasonic NMX-P3A chassis that I've been working on has an overload in the video section, which causes the set to shut down at turn-on. I thought that IC102 was bad. But after changing that IC, I had no picture at all. When the original was placed back in the set, the overload condition returned. Could the replacement have been bad?—P.S., E. Northport, NY

Welcome to the club: You've just experienced one of the worst things that can happen to a repairman—changing a part, only to wind up with a worse problem than you began with. Yes, it is within reason to suspect that the replacement part was defective, but there is always the possibility that you missed a solder joint.

Nevertheless, I agree with your original diagnosis. I've seen IC102 cause the condition that you described. Bear in mind, however, that IC101 contains all the AGC circuits, so look to it as the next most likely trouble spot. But, before anything else, check the AGC controls with an ohmmeter.

CAN'T TUNE CHANNEL 13

I can't get Channel 13 to come in on an Admiral TV (chassis number 28M55) with touch tuning. After sending the tuner out for repairs, I was able to get Channel 13 for about 2 weeks and then it quit again. Can you help me?—B.T., Delta, IA

You are dealing with a varactor tuner, which uses different voltages to tune each channel—the one for 13 being 3 volts higher than the Channel 11 voltage. You stated that you cannot get Channel 13 in any position. Well that eliminates the selector switch and the number 13 potentiometer as possible trouble spots.

If you can't get 20.8 volts on the potentiometer wiper arm, then perhaps the 33-volt supply that feeds all the potentiometers is low. If the voltage is correct, I would talk to my tuner repairman to find out what voltage he's using to pull in Channel 13 (which is obviously not being supplied. **R-E**

DESIGNER'S NOTEBOOK

ROBERT GROSSBLATT,
CIRCUITS EDITOR

An audio oscillator

AT VARIOUS TIMES I'VE PRESENTED YOU with several handy-dandy oscillator circuits of one kind or another. But if you're into building your own equipment you know the truth of Grossblatt's fifteenth law: *You can never have too many oscillators.*

An oscillator can be built from just about anything ranging from a handful of transistors to a rusty door hinge, but one circuit usually works better in a particular application than others. Some oscillators produce nice clean logic-level pulses; others are better suited for generating audio tones, etc. While reviewing past installments of this column, I realized that I've never shown you an oscillator that will drive an eight-ohm speaker. This month's circuit will correct that deficiency.

An audible tone generator is a useful circuit to have in the back of your drawer. It could be used as an alarm, a microphone tester, or any of a bunch of other things. For example, if you've ever done any recording that uses more than three or four microphones, you know how much trouble it is to keep the cables straight and to set uniform levels on the mixer. By attaching a battery-operated beeper to a microphone with a rubber band, the task will be much easier.

The oscillator shown in Fig. 1 is built around the popular and easily-obtainable LM386 low-voltage audio amplifier. Even Radio Shack carries it as one of their ever-dwindling stock of IC's. As you can see, the circuit requires only a handful of parts. The LM386 is such an even-tempered IC that it doesn't really care how you put those parts together. You could design a PC board to hold the parts, but the circuit will work just as well with wire-wrap construction.

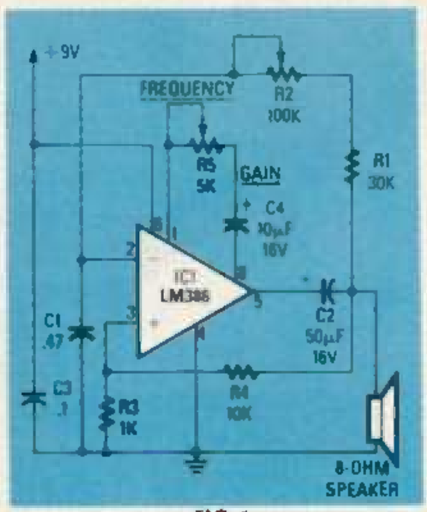


FIG. 1

The circuit's frequency of oscillation can be calculated easily from this formula: $f = 2.8/[C1 \times (R1 + R2)]$. If you use the values I've indicated, you'll be able to vary the output from 60 Hz to 20 kHz by rotating potentiometer R2. There will be some droop in output at either end of R2's rotation, but, for microphone testing, that's not a problem.

How it works

A portion of IC1's output voltage is fed to its non-inverting input (pin 3). That voltage serves as a reference for capacitor C1, which is connected to the non-inverting input (pin 2) of the IC. That capacitor continually charges and discharges around the reference voltage, and the result is a squarewave output. Capacitor C2 decouples the output so you get a nice AC signal to drive the speaker.

With GAIN control **R5** at maximum, the circuit will deliver a fairly loud signal—about 40 dB according to my sound level meter. The LM386 has a 1350Ω resistor connected internally between pins 1 and 8. That resistor limits the minimum gain of the IC to about 20 dB. The 10-µf capacitor, C4, bypasses the resistor and allows you to vary the gain with an external control. If you don't need a gain control, just short pins 1 and 8 together.

Varying the size of output decoupling capacitor C2 also affects overall circuit gain. To change gain, you could experiment with its value, but you'll find that using a potentiometer and a capacitor across pin 8 is the easiest way to alter gain.

As with all circuits presented in this column, you can use them just as they appear here, but chances are that they'll be a lot more useful to you if you experiment with them to meet the needs of your specific application. **R-E**

POWER SWITCH

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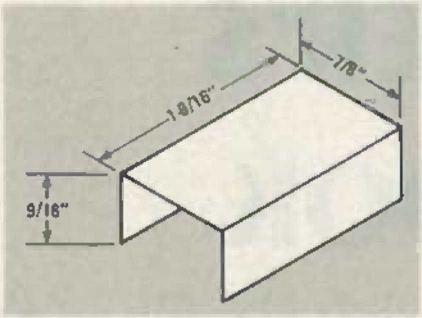

FIG. 7—CUT AND BEND THE UPPER SHIELD from a thin piece of tin as shown here.

until you get some response from the circuit. Don't worry about making an exact adjustment. The adjustment we're doing now is preliminary; the receiver must be fine-tuned to obtain maximum range of about 30 feet.

After you get a response, solder the shields in place. The easiest way to do that is to melt a small amount of solder in each corner of the shield. Then set the shield in place and heat each corner in turn to let the solder flow onto the pin.

To fine-tune the receiver, set it up in a position where you can get a clear line of sight to it for a distance of about 30 feet. Position yourself about five feet from the receiver, point the transmitter at the receiver, and press the TRANSMIT button.

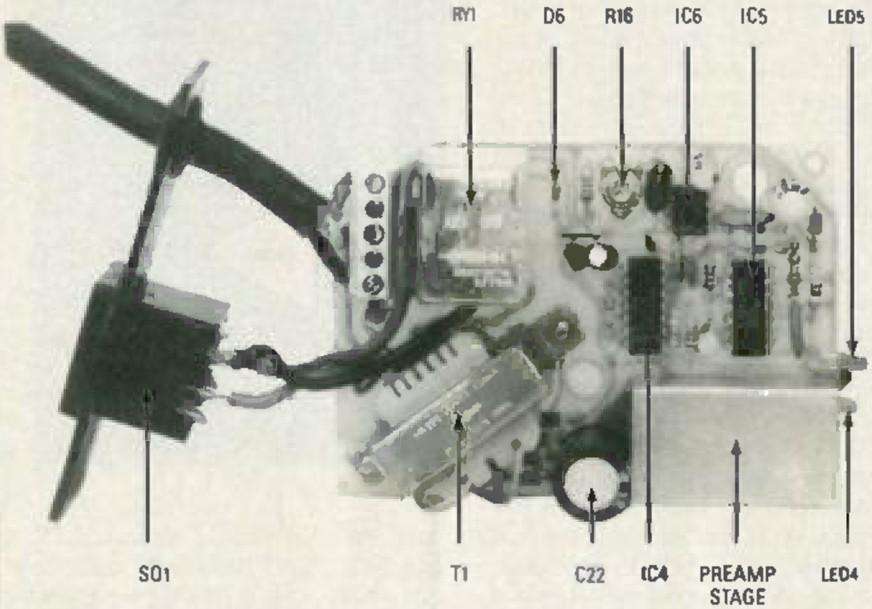

FIG. 8—THE RECEIVER'S PC BOARD should appear as shown here after all components have been mounted.

tal. Then fit the panel over the two LED's so that the legs of the filter fit around the photodiode. Insert the panel-board assembly into the bottom half of the receiver case.

Testing and alignment

Plug the receiver into an AC outlet. The SIGNAL LED should light briefly and then go out, and the ON LED should remain off. Set trimmer potentiometer R16 to the center of its range.

Now aim the transmitter at the photodiode and press S1. With a little luck, the center frequency of the 567 will be close enough to the transmitter's output frequency that the SIGNAL LED will light up temporarily. The ON LED should light up and stay lit, and the relay should latch on. A second press of the button will turn the LED and the relay off—that is, of course, only if you're lucky.

If the receiver doesn't respond, adjust R16 slightly and try again. Repeat that

If the receiver responds, back up another five feet and try again. Remember to let the transmitter recharge for a few seconds between transmissions, particularly when you're standing back at distances of ten feet or more.

Continue backing up in five-foot segments until you reach a point where the receiver will not respond. At that point, adjust R8 slightly and try again. An assistant to handle the transmitter would be helpful.

Even under worst-case conditions, the receiver should be able to respond when the transmitter is 20 feet away. If you can adjust it to respond to signals only up to a certain distance but no farther, your problem is likely due to overly bright lighting, electrical or RF noise, or something else. Don't blame the receiver!

Assemble the case and plug the device you want to control in. You're now free to operate that device at your convenience, free from the tyranny of its switch! **R-E**

COMPACT DISCS

continued from page 63

merging bits per frame.

Using EFM, the 33 8-bit words become 33 14-bit words (462 bits) plus three bits each for merging bits (99 bits), plus another 27 bits for the synchronization word and its merging bits. And there, finally, is our total: 462 + 99 + 27 = 588.

Dividing It Up

With the numbers now at hand, let's examine the percentages once again. We can do that by comparing the number of bits used for each purpose in a frame with the total number of bits—588—in that frame.

What we're most interested in is the audio information on the disc. Not surprisingly, after all we've been through, we find that all the bits used in a frame for audio—192 of them—account for only 32.7% of its information content. See Fig. 4. That's all there is; everything else is there to make sure that the music comes through to you as easily—and sounding as good—as it can.

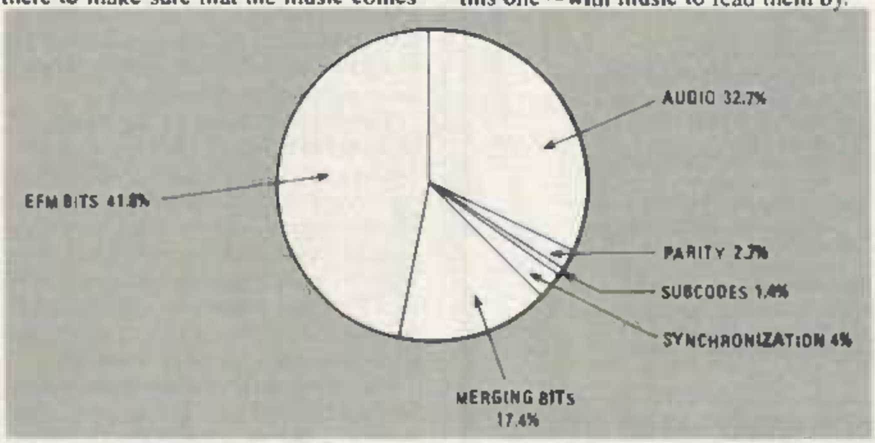

FIG. 4—THIS CHART shows the relative sizes of the subgroups that make up a frame of CD information. Note that the relationship between the "housekeeping" bits and the audio information is roughly 2:1.

The 64 bits of parity information make up about 2.7% of the total, and the synchronization bits account for just over 4%. The 102 merging bits take up 17.4 % of the space in a frame and, finally, the 8 subcode bits occupy a little under 1.4%.

Of course, that only adds up to 58.2%! What we are forgetting about again is EFM. Expanding the 8-bit words to 14 bits accounts for the missing 41.8%. On the surface that seems inefficient, but overall it works out for the best.

In the end, it takes a total of 588 bits of information to represent 192 bits of audio. That's more than a ratio of 2:1 for the overhead, which may at first seem wasteful. But once you've listened to a compact disc, you'll agree that it's worth it.

For the theory behind CD player operation, you may want to read the 5-part **Radio-Electronics** series about CD player service (November and December 1985, and the January through March 1986 issues). We have prepared a special reprint of the series, called *Repairing Compact Disc Players*. It's available from the **Radio-Electronics Reprint Bookstore**, 500-B Bi-County Blvd., Farmingdale, NY 11735 for $5.00 plus $1.00 shipping.

Postscript

There are still a few bits we haven't looked at at all yet. They're the R through W bits of the subcode, six bits that aren't used for anything at all on an audio disc. Why are they there?

When the standard used to record information on CD's was devised, some forethought was given to future needs. The R–W subcode bits were included so that the disc could be used for storing things other than audio.

Those 200 million or so bits worth of unused space can hold about 20 megabytes of data, as much as the standard hard disc drive in an IBM *PC/AT*. At 2000 characters per page, that's 10,000 pages of text, or about 1250 articles as long as this one—with music to read them by.

Many CD players are already equipped with a subcode output that could easily be connected to a decoder to present such things as the historical background of a piece of music, or an analysis of the score, while the music was playing.

That same subcode space on a compact disc could also be used to store some 700 digitized still video images; a new one could be displayed every five seconds. We could have still-music-video CD's, or, on a higher plane, show the actual score of the piece being played, or scenes—not graphics, but real video pictures—from operas or Broadway musicals.

And that's how all those "millions and millions" of bits on a CD are used. It may be disappointing to find out that so little of the available space actually stores audio, but it's reassuring to know that just about all the rest of what's on the disc is there to ensure that you hear music that is reproduced as faithfully as possible. **R-E**

RADAR CONTROLLER

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Once you've etched or purchased the board, mount the components on the board as shown in the parts-placement diagram, Fig. 7. Be sure that all components are oriented as shown. Bolt the regulator and power the transistor to the circuit board for heat sinking.

The Gunn diode, which is mounted in a microwave horn, draws up to 1 amp of current, so use number 18 wire for the connection between the circuit and the horn, and keep the length to 10 feet or less. *Under no circumstances* should you connect DC voltage to the Gunn diode or reverse the polarity of the connections to the diode (power is fed to the anode side; the cathode side is grounded). Doing either will almost certainly blow out that $60.00 component.

When mounting the microwave horn, be sure that metal objects are kept away from the opening (plastic will do no harm). The power supply for the unit should be able to supply 12-volts DC at 2 amps; most automotive electrical systems are capable of meeting that requirement.

After construction and hook-up, test the unit by aiming it toward an automotive radar detector and depressing the TRANSMIT switch. That should cause LED2 to light. Also, the radar detector should react as appropriate (a buzzer should sound or an LED should flash) to the presence of a radar signal. Verify the oscillating frequency of the 555 timer by connecting a scope or frequency counter to pin 3 of that IC. With the S3 set to ss, the frequency measured should be 39,600 Hz.

Warnings

While the radar calibrator can be a useful diagnostic tool in aligning radar speed-guns, if used for illegal purposes and/or by unlicensed individuals, it can be the cause of a great deal of trouble. (Penalties of up to $10,000 and a year in jail are some of the possible consequences of such use.) Further, because of possible interference to police radar, communications services, etc., the unit should only be used in a laboratory, and only for educational or calibration purposes.

It may be possible for certain individuals, such as licensed amateur-radio operators, to use the calibrator legally in the workshop, the laboratory, or the field, but it is left to the individual user to ascertain the requirements for such use, and to meet them.

In any event, any willful interference to another service by any individual is punishable with stiff penalties under Federal law; other local, state, or Federal penalties may also be applicable. We strongly discourage use for such applications. **R-E**

TV SIGNAL DESCRAMBLING

continued from page 53

works. Encoded video is applied to pin 14 of the LM733, while a suitable decoding signal is applied to pin 1. Note that both of those signals are capacitively coupled into the LM733 so that they do not interfere with the biasing of that device. The output of the LM733, at pin 8, is a signal that is proportional to the difference of the two inputs. An inverted version of the signal at pin 8 is available at pin 7. Having both signals can come in handy, particularly when a signal that inverts intermittently must be decoded; such a signal occurs when video is encoded using the SSAVI system. The two outputs can be fed to an electronic switch that is used to select the signal with the proper polarity.

Either of the two variable-gain circuits can be used as a video or RF modulator. While such variable-gain circuits are obviously more complex than the attenuator circuits previously discussed, they are also more linear and easier to control. That is particularly important when dealing with sinewave-encoded signals.

Restoring the sync pulse

When the sync signal is suppressed (or missing entirely) the sync pulses must be generated at the receiver. Naturally, those pulses should be identical to the sync pulses that were originally present in the video signal. That means that the recreated sync signal must have the proper phase and that the pulses must have the proper amplitude and width.

In the simplest cases, the original sync signal is merely reduced in amplitude. For those, all that needs to be done is to increase the amplitude of the sync pulses with respect to the video information.

Other times, the sync has been completely removed. If that has been done, the receiving circuitry must reconstruct the missing pulses using information that is "hidden" elsewhere.

Let's look at two circuits that can be used for reconstructing missing sync pulses. The circuit in Fig. 8 is for systems that have a 15.75-kHz subcarrier encoded within the audio channel.

The heart of the circuit is IC1, an LM1310 PLL FM-stereo demodulator. While that IC was designed for 19-kHz FM-stereo pilot-carrier regeneration, when configured as shown it can be made to operate at 15.75 kHz. (The operating frequency is adjusted using R6.)

The output from the TV set's audio detector is fed to pin 2 of IC1 via an emitter follower and a filter circuit. A 15.75-kHz squarewave output appears at the pilot monitor output, pin 10. Note that if the program audio has been stripped away from the main audio channel and placed on a 31.5-kHz subcarrier as discussed in the first part of this series, the program audio is available at pin 4 of the PLL.

The pilot-monitor output is too wide to be used directly as a gating pulse. Because of that, it is next fed to IC2, a CD4098BC dual monostable multivibrator. One half of the IC is used to delay the pulse so that the sync signal is "in phase" with the encoded video signal. The output of that half of the IC is used to trigger the second half. The second half of the IC is used to set the proper pulse width. The output of that half of the IC is the reconstructed sync signal. Note that both positive and negative going outputs are available.

If the sync signal is missing, and there is no encoded 15.75-kHz signal available in the audio, a circuit like the one in Fig. 9 can be used. The heart of the circuit is an MM5320/MM5321 video-camera sync generator. That device needs only a 2.0457-MHz clock signal to recreate all the components of an NTSC sync signal. The needed clock signal can be derived from the video signal's 3.58-MHz colorburst signal as shown.

Next time we'll look more closely at using PLL's to extract decoding subcarriers from the video signal. **R-E**

MARKET CENTER

SATELLITE TV

CABLE TV SECRETS-the outlaw publication the cable companies tried to ban. HBO, Movie Channel, Showtime, descramblers, converters, etc. Suppliers list included. $8.95. **CABLE FACTS**, Box 711-R, Pataskala, Ohio 43062.

SATELLITE Descrambler Schematics: Oak Orion PD-400C $20.00; VideoCipherII $20.00; VideoCipherII Patent $15.00; actual VideoCipherII descrambler $550.00; actual Oak Sigma descrambler $350, Catalog $5.00; send money order to **ELECTRONIC PRESS**, PO Box 10009, Colorado Springs, CO 80932.

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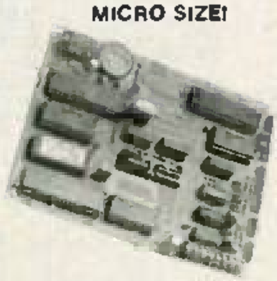

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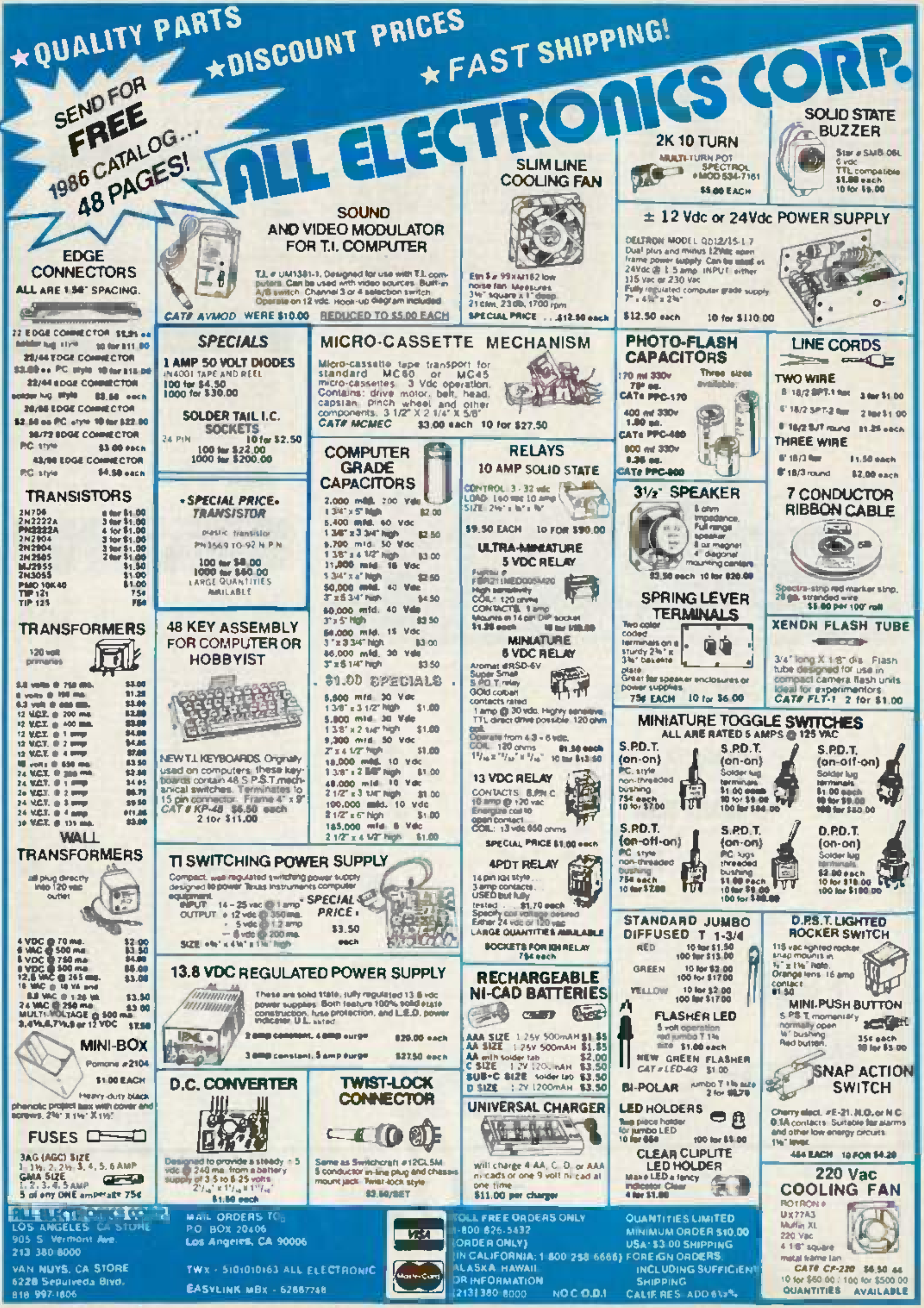

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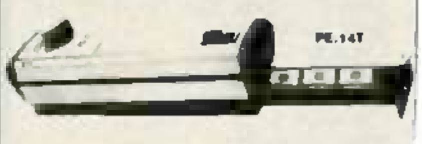

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74HC: Operate at CMOS logic levels and are ideal for new, all-CMOS designs.

74HC00	.59	74HC148	1.19
74HC02	.59	74HC151	.89
74HC04	.59	74HC154	2.49
74HC08	.69	74HC157	.89
74HC10	.59	74HC158	.95
74HC14	.79	74HC163	1.15
74HC20	.59	74HC175	.99
74HC27	.59	74HC240	1.89
74HC30	.59	74HC244	1.89
74HC32	.69	74HC245	1.89
74HC51	.59	74HC257	.89
74HC74	.75	74HC259	1.39
74HC85	1.35	74HC273	1.89
74HC86	.69	74HC299	4.99
74HC93	1.19	74HC368	.99
74HC107	.79	74HC373	2.29
74HC109	.79	74HC374	2.29
74HC112	.79	74HC390	1.39
74HC125	1.19	74HC393	1.39
74HC132	1.19	74HC4017	1.99
74HC133	.69	74HC4020	1.39
74HC138	.99	74HC4049	.89
74HC139	.99	74HC4050	.89

74HCT00

74HCT: Direct, drop-in replacements for LS TTL and can be intermixed with 74LS in the same circuit.

74HCT00	.69	74HCT166	3.05
74HCT02	.69	74HCT174	1.09
74HCT04	.69	74HCT193	1.39
74HCT08	.69	74HCT194	1.19
74HCT10	.69	74HCT240	2.19
74HCT11	.69	74HCT241	2.19
74HCT27	.69	74HCT244	2.19
74HCT30	.69	74HCT245	2.19
74HCT32	.79	74HCT257	.89
74HCT74	.89	74HCT259	1.59
74HCT75	.95	74HCT273	2.09
74HCT138	1.15	74HCT367	1.09
74HCT139	1.19	74HCT373	2.49
74HCT154	2.89	74HCT374	2.49
74HCT157	.99	74HCT393	1.69
74HCT158	.99	74HCT4017	2.15
74HCT161	1.29	74HCT4040	1.59
74HCT164	1.39	74HCT4060	1.49

74F00

74F00	.69	74F74	.79	74F251	1.95
74F02	.69	74F86	.99	74F253	1.95
74F04	.79	74F138	1.69	74F257	1.95
74F08	.69	74F139	1.69	74F280	1.75
74F10	.69	74F157	1.69	74F243	3.95
74F32	.69	74F240	3.29	74F373	4.25
74F64	.89	74F244	3.29	74F374	4.25

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4013	.35	4511	.89
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4016	.29	4518	.89
4017	.49	4522	.79
4018	.89	4526	.79
4020	.59	4527	1.95
4021	.89	4528	.79
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4025	.25	4532	1.95
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4028	.65	4541	1.29
4035	.69	4553	5.79
4040	.69	4585	.79
4041	.75	4702	12.95
4042	.59	74C00	.29
4043	.85	74C14	.59
4044	.69	74C74	.59
4045	1.98	74C83	1.95
4046	.69	74C85	1.49
4047	.69	74C95	.99
4049	.29	74C150	5.75
4050	.29	74C151	2.25
4051	.69	74C161	.99
4052	.69	74C163	.99
4053	.69	74C164	1.39
4066	2.19	74C192	1.49
4060	.69	74C193	1.49
4066	.29	74C221	1.75
4069	.19	74C240	1.89
4076	.59	74C244	1.89
4077	.29	74C374	1.99
4081	.22	74C906	10.95
4085	.79	74C911	8.95
4086	.89	74C917	8.95
4093	.49	74C927	4.49
4094	2.49	74C923	5.95
14411	9.95	74C920	7.95
14412	8.95	80C97	.95

7400/9000

7400	.19	74147	2.49
7402	.19	74148	1.20
7404	.19	74150	1.35
7406	.29	74151	.55
7407	.29	74153	.55
7408	.24	74154	1.49
7410	.19	74156	.75
7411	.25	74157	.55
7414	.49	74159	1.65
7416	.25	74161	.69
7417	.25	74163	.69
7420	.19	74164	.85
7423	.29	74165	.85
7430	.19	74166	1.00
7432	.29	74175	.89
7438	.25	74177	.75
7442	.49	74178	1.15
7445	.69	74181	2.25
7447	.89	74182	.75
7470	.35	74184	2.00
7473	.34	74191	1.15
7474	.33	74192	.79
7475	.45	74194	.85
7476	.35	74196	.79
7483	.50	74197	.75
7485	.59	74199	1.35
7486	.35	74221	1.35
7489	2.15	74246	1.35
7490	.39	74247	1.25
7492	.50	74248	1.85
7493	.35	74249	1.95
7495	.55	74251	.75
7497	2.75	74265	1.35
74100	2.29	74273	1.95
74121	.29	74278	3.11
74123	.49	74367	.65
74125	.45	74368	.65
74141	.65	9368	3.95
74143	5.95	9602	1.59
74144	2.95	9637	2.95
74145	.60	96S02	1.95

74S00

74S00	.29	74S163	1.29
74S02	.29	74S168	3.95
74S03	.29	74S174	.79
74S04	.29	74S175	.79
74S05	.29	74S188	1.95
74S08	.35	74S189	1.95
74S10	.29	74S195	1.49
74S15	.35	74S196	1.49
74S30	.29	74S197	1.49
74S32	.35	74S226	3.99
74S37	.69	74S240	1.49
74S38	.69	74S241	1.49
74S74	.48	74S244	1.49
74S85	.95	74S257	.79
74S86	.35	74S253	.79
74S112	.50	74S258	.95
74S124	2.75	74S280	1.95
74S138	.79	74S287	1.89
74S140	.55	74S288	1.69
74S151	.79	74S299	2.95
74S153	.79	74S373	1.69
74S157	.79	74S374	1.69
74S158	.95	74S471	4.95
74S161	1.29	74S571	2.95

VOLTAGE REGULATORS

TO-220 CASE

7805T	.49	7905T	.59
7808T	.49	7908T	.59
7812T	.49	7912T	.59
7815T	.49	7915T	.59

TO-3 CASE

7805K	1.39	7905K	1.49
7812K	1.39	7912K	1.49

TO-92 CASE

78L05	.49	79L05	.69
78L12	.49	79L12	1.49

OTHER VOLTAGE REGS

LM323K	5V	3A	TO-3	4.79
LM338K	ADJ	5A	TO-3	3.95
78H05K	5V	5A	TO-3	7.95
78H12K	12V	5A	TO-3	8.95
78P05K	5V	10A	TO-3	14.95

LINEAR

TL066	.99	LM733	.98
TL071	.69	LM741	.29
TL072	1.09	LM747	.69
TL074	1.95	LM748	.59
TL081	.59	MC1330	1.89
TL082	.99	MC1350	1.19
TL084	1.49	MC1372	1.95
LM301	.34	LM1414	1.59
LM309K	1.25	LM1458	.49
LM311	.59	LM1488	.49
LM311H	.89	LM1489	.49
LM317K	3.49	LM1496	.85
LM317T	.95	LM1812	8.25
LM318	1.49	LM1889	1.95
LM319	1.25	ULN2003	.79
LM320 see 7900		XR2206	3.75
LM322	1.65	XR2211	2.95
LM323K	4.79	XR2240	1.95
LM324	.49	MPQ2907	1.95
LM331	3.95	LM2917	1.95
LM334	1.19	CA3046	.89
LM335	1.40	CA3081	.99
LM336	1.75	CA3082	.99
LM337K	3.95	CA3086	.80
LM338K	3.95	CA3089	1.95
LM339	.99	CA3130E	.99
LM340 see 7800		CA3146	1.29
LM350T	4.60	CA3160	1.19
LF353	.59	MC3470	1.95
LF356	.99	MC3480	8.95
LF357	.99	MC3487	2.95
LM358	.59	LM3900	.49
LM380	.89	LM3909	.98
LM383	1.95	LM3911	2.25
LM386	.89	LM3916	2.39
LM393	.45	MC4024	3.49
LM394H	4.50	MC4044	3.99
TL494	4.20	RC4136	1.25
TL497	3.25	RC4558	.69
NE555	.29	LM13600	1.49
NE556	.49	75107	1.49
NE558	1.29	75110	1.95
NE564	1.95	75150	1.95
LM565	.95	75154	1.95
LM566	1.49	75188	1.25
LM567	.79	75189	1.25
NE570	2.95	75451	.39
NE590	2.50	75452	.39
NE592	.98	75453	.39
LM710	.75	75477	1.29
LM723	.49	75492	.79

H=TO-5 CAN, K=TO-3, T=TO-220

DATA ACQ / INTERFACE

ADC0800	15.55	8T26	1.29
ADC0804	3.49	8T28	1.29
ADC0809	4.49	8T95	.89
ADC0816	14.95	8T96	.89
ADC0817	9.95	8T97	.59
ADC0831	8.95	8T98	.89
DAC0800	4.49	DM8131	2.95
DAC0806	1.95	DP8304	2.29
DAC0808	2.95	DS8833	2.25
DAC1020	8.25	DS8835	1.99
DAC1022	5.95	DS8836	.99
MC1408L8	2.95	DS8837	1.65

IC SOCKETS

	1-99	100+
8 PIN ST	.11	.10
14 PIN ST	.11	.09
16 PIN ST	.12	.10
18 PIN ST	.15	.13
20 PIN ST	.18	.15
22 PIN ST	.15	.12
24 PIN ST	.20	.15
28 PIN ST	.22	.18
40 PIN ST	.30	.22
64 PIN ST	1.95	1.49
ST=SOLDERTAIL		
8 PIN WW	.59	.49
14 PIN WW	.69	.52
16 PIN WW	.69	.58
18 PIN WW	.99	.90
20 PIN WW	1.09	.98
22 PIN WW	1.39	1.28
24 PIN WW	1.49	1.35
28 PIN WW	1.69	1.49
40 PIN WW	1.99	1.80
WW=WIREWRAP		
16 PIN ZIF	4.95	CALL
24 PIN ZIF	5.95	CALL
28 PIN ZIF	6.95	CALL
40 PIN ZIF	9.95	CALL

ZIF=TEXTOOL (ZERO INSERTION FORCE)

EDGECARD CONNECTORS

100 PIN ST	S-100	.125	3.95
100 PIN WW	S-100	.125	4.95
62 PIN ST	IBM PC	.100	1.95
50 PIN ST	APPLE	.100	2.95
44 PIN ST	STD	.156	1.95
44 PIN WW	STD	.156	4.95

36 PIN CENTRONICS

MALE

IDC1N36	RIBBON CABLE	6.95
CEN36	SOLDER CUP	4.95

FEMALE

IDCEN36/F	RIBBON CABLE	7.95
CEN36PC	RT ANGLE PC MOUNT	4.95

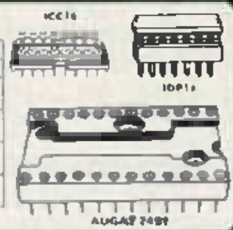
INTERSIL

ICL7106	9.95
ICL7107	12.95
ICL7660	2.95
ICL8038	4.95
ICM7207A	5.95
ICM7208	15.95

DIP CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 8	14	16	18	20	22	24	28	40
HIGH RELIABILITY TOOLED ST IC SOCKETS	AUGATxxST	.62	.79	.89	1.09	1.29	1.39	1.49	1.69	2.49
HIGH RELIABILITY TOOLED WW IC SOCKETS	AUGATxxWW	1.30	1.80	2.10	2.40	2.50	2.90	3.15	3.70	5.40
COMPONENT CARRIES (DIP HEADERS)	ICCxx	.49	.59	.69	.99	.99	.99	.99	1.09	1.49
RIBBON CABLE DIP PLUGS (IDC)	IDPxx	---	.95	.95	---	---	---	1.75	---	2.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE BELOW



DIODES/OPTO/TRANSISTORS

1N751	.25	4N26	.69
1N759	.25	4N27	.69
1N4148	25/1.00	4N28	.69
1N4004	10/1.00	4N33	.89
1N5402	.25	4N37	1.19
KBP04	.55	MCT-2	.59
KBU8A	.95	MCT-6	1.29
MDA990-2	.35	TIL-111	.99
N2222	.25	2N3906	.10
PN2222	.10	2N4401	.25
2N2905	.50	2N4402	.25
2N2907	.25	2N4403	.25
2N3055	.79	2N6045	1.75
2N3904	.10	TIP31	.49

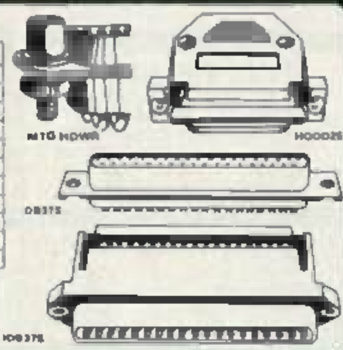
D-SUBMINIATURE

DESCRIPTION		ORDER BY	CONTACTS 9	15	19	25	37	50
SOLDER CUP	MALE	DBxxP	.82	.90	1.25	1.25	1.80	3.48
	FEMALE	DBxxS	.95	1.15	1.50	1.50	2.35	4.32
RIGHT ANGLE PC SOLDER	MALE	DBxxPR	1.20	1.49	---	1.95	2.65	---
	FEMALE	DBxxSR	1.25	1.55	---	2.00	2.75	---
WIRE WRAP	MALE	DBxxPWW	1.69	2.56	---	3.89	5.60	---
	FEMALE	DBxxSWW	2.76	4.27	---	6.84	9.95	---
IDC RIBBON CABLE	MALE	IDBxxP	2.75	2.95	---	3.98	5.70	---
	FEMALE	IDBxxS	2.92	3.20	---	4.33	6.75	---
HOODS	METAL	MHOODxx	1.25	1.25	1.30	1.30	---	---
	GREY	HOODxx	.65	.65	---	.65	.75	.95

ORDERING INSTRUCTIONS: INSERT THE NUMBER OF CONTACTS IN THE POSITION MARKED "xx" OF THE "ORDER BY" PART NUMBER LISTED.

EXAMPLE: A 15 PIN RIGHT ANGLE MALE PC SOLDER WOULD BE DB15PR

MOUNTING HARDWARE $1.00



LED DISPLAYS

FND-357(359)	COM CATHODE	.362"	1.25
FND-500(503)	COM CATHODE	.5"	1.49
FND-507(510)	COM ANODE	.5"	1.49
MAN 72	COM ANODE	.3"	.99
MAN 74	COM CATHODE	.3"	.99
MAN 8940	COM CATHODE	.8"	1.99
TIL-313	COM CATHODE	.3"	.45
HP5082-7760	COM CATHODE	.43"	1.29
TIL-311	4x7 HEX W/LOGIC	.270"	9.95
HP5082-7340	4x7 HEX W/LOGIC	.290"	7.95

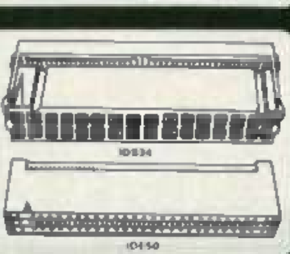
DIFFUSED LEDS

		1-99	100-UP
JUMBO RED	T1¾	.10	.09
JUMBO GREEN	T1¾	.14	.12
JUMBO YELLOW	T1¾	.14	.12
MOUNTING HDW	T1¾	.10	.09
MINI RED	T1	.10	.09

IDC CONNECTORS

DESCRIPTION	ORDER BY	CONTACTS 10	20	26	34	40	50
SOLDER HEADER	IDHxxS	.82	1.29	1.68	2.20	2.58	3.24
RIGHT ANGLE SOLDER HEADER	IDHxxSR	.85	1.35	1.76	2.31	2.72	3.39
WW HEADER	IDHxxW	1.86	2.98	3.84	4.50	5.28	6.63
RIGHT ANGLE WW HEADER	IDHxxWR	2.05	3.29	4.22	4.45	4.80	7.30
RIBBON HEADER SOCKET	IDSxx	.79	.99	1.39	1.59	1.99	2.25
RIBBON HEADER	IDMxx	---	5.50	6.25	7.00	7.50	8.50
RIBBON EDGE CARD	IDExx	1.75	2.25	2.65	3.75	3.95	3.95

FOR ORDERING INSTRUCTIONS SEE D-SUBMINIATURE ABOVE



SWITCHES

SPDT	MINI-TOGGLE ON-ON	1.25
DPDT	MINI-TOGGLE ON-ON	1.50
DPDT	MINI-TOGGLE ON-OFF-ON	1.75
SPST	MINI-PUSHBUTTON N.O.	.39
SPST	MINI-PUSHBUTTON N.C.	.39
SPST	TOGGLE ON-OFF	.49
BCD OUTPUT	10 POSITION 4 PIN DIP	1.95

DIP SWITCHES

4 POSITION	.85	7 POSITION	.90
5 POSITION	.90	8 POSITION	.95
6 POSITION	.90	10 POSITION	1.29

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Sincerely, Nicholas Chabra

RIBBON CABLE

CONTACTS	SINGLE COLOR 1'	SINGLE COLOR 10'	COLOR CODED 1'	COLOR CODED 10'
10	.16	1.60	.30	2.75
16	.28	2.50	.48	4.40
20	.36	3.20	.60	5.50
25	.45	4.00	.75	6.85
26	.46	4.10	.78	7.15
34	.61	5.40	1.07	9.35
40	.72	6.40	1.20	11.00
50	.89	7.50	1.50	13.25

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TRACK DENSITY	48 TPI	48 TPI	48 TPI

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74LS30	.19	74LS243	.69
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HM6264LP-12	8192 x 8	(120ns) LP CMOS	4.29
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HM6264LP-15	8192 x 8	(150ns) LP CMOS	3.89
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74HC04	.39	74HC240	
74HC08	.39	74HC244	
74HC10	.39	74HC245	
74HC14	.59	74HC253	
74HC30	.39	74HC259	
74HC32	.49	74HC273	
74HC74	.49	74HC373	
74HC75	.69	74HC374	
74HC76	.69	74HC393	
74HC85	1.19	74HC595	
74HC86	.59	74HC688	
74HC123	1.19	74HC4040	
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74HC139	.79	74HC4511	
74HC154	1.95	74HC4514	
74HC163	.89	74HC4538	
74HC174	.89	74HC4543	

74C—CMOS

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74C04	.25	74C221	
74C08	.35	74C240	
74C10	.29	74C244	
74C14	.49	74C373	
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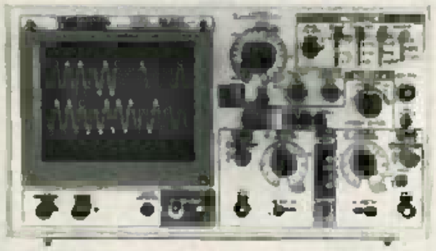

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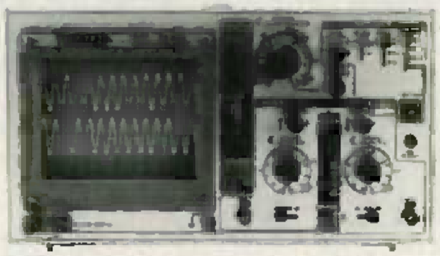

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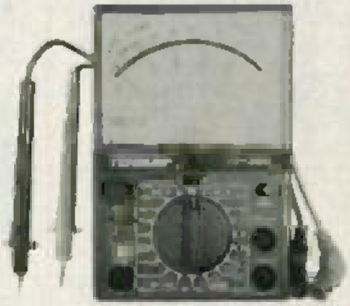

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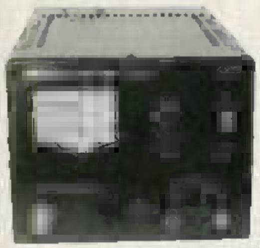

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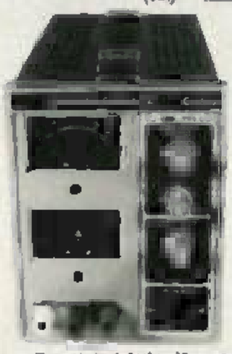

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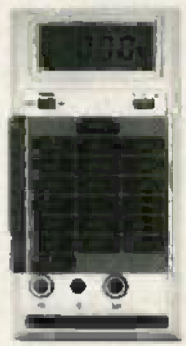

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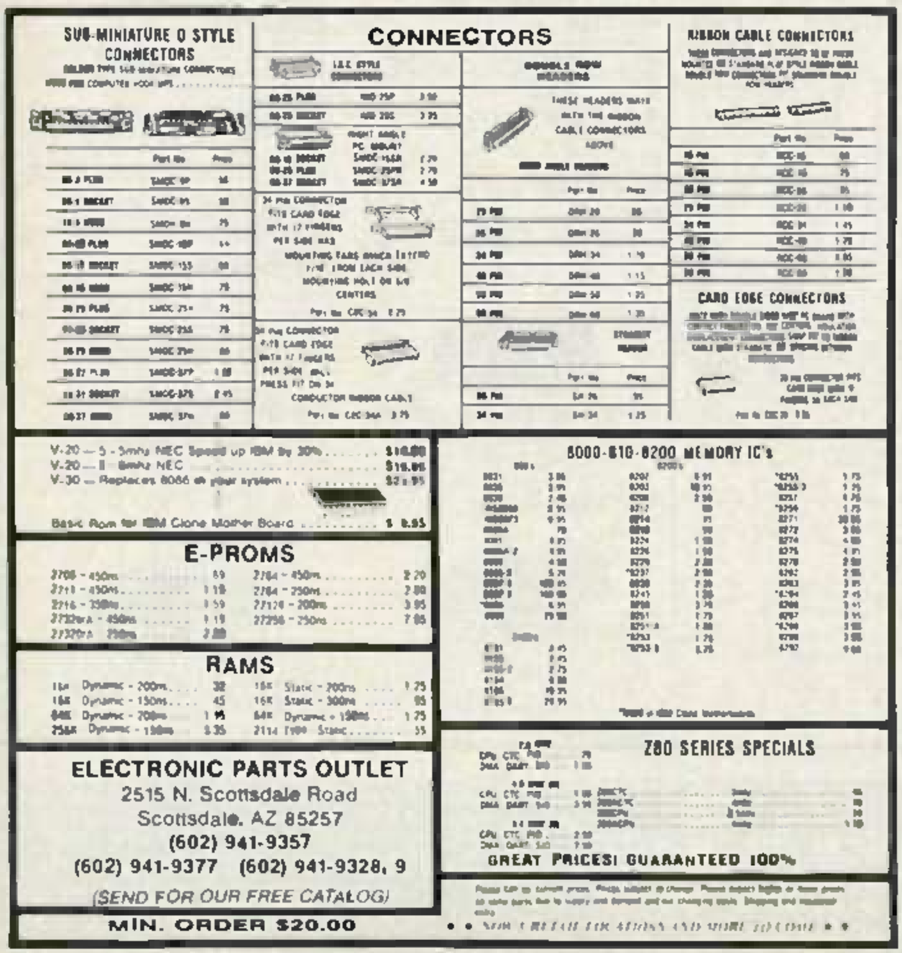

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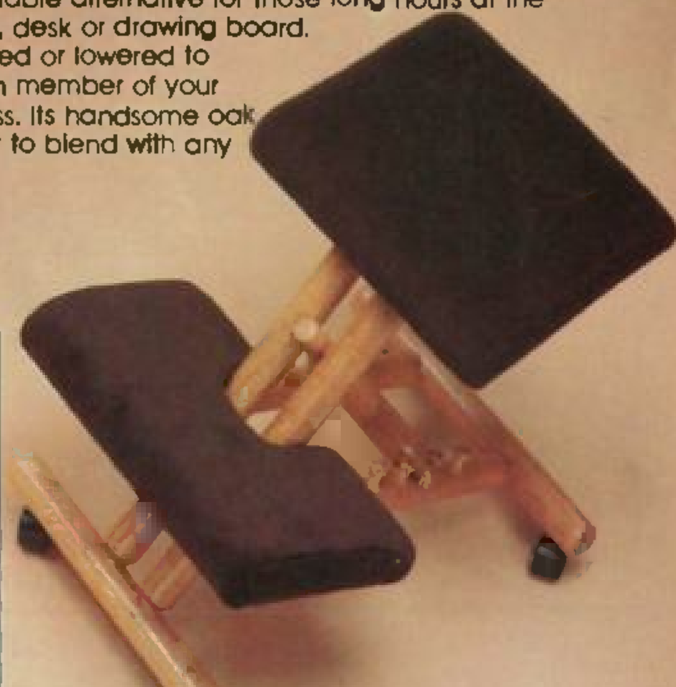

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