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- Patented in all industrialized countries.

DiscTraker greatly enhances the performance of fine record playback systems; another example of Discwasher's leadership and innovative technology.
It's a telephone answering computer. The Ford Code-A-Phone 1400 has the first large-scale integration of solid-state componentry—a major change in telephone answering systems since the first mass consumer models appeared five years ago. This means more features, lower cost and greater dependability. Here are some of its exciting features:

Forget about tapes. There are no tapes to buy. The Ford unit has a special polymer-based magnetic tape that will record over 25,000 phone calls without replacement. That's over five solid years of use. There are no cassette tapes to buy, wear out or replace.

Forget about microphones. When you want to change or record your message, just press a red button, record your message and let go. The message (any length up to 20 seconds) will record and be immediately ready to playback since the message tape does not have to recycle. There are no separate microphones or level controls since the built-in microphone automatically adjusts to your voice.

Forget about touching it. You can adjust your unit to answer on either one or four rings. When the unit is set on four rings and you reach the phone before the 1400 answers, you will not activate the unit. But let us say you're outside or indisposed. No problem. Code-A-Phone will automatically answer after four rings. This means that your unit can always be "alive" in the four-ring position so you never have to remember to set it whenever you leave your home or office.

 Forget about going home. Just bring your optional remote control pager with you. If you want your messages while you're on vacation or away, call your number and the coded pager will remotely signal your unit to playback all your messages.

Forget about service. If you've owned a telephone answering device for more than a year, there's a good chance that it's been in service at least once. The Code-A-Phone, however, is solid state and built with the same heavy duty components used in commercial units. It should dependably stand up to years of heavy usage. (Ford Industries is the world's largest supplier of telephone answering equipment for the Bell System.) If service is ever required, there are over 200 authorized service centers plus a service-by-mail center. There's also a toll-free "Help-Line" number to call 24 hours a day for advice or suggestions, and your unit has a limited ninety day parts and labor warranty.

PLenty more features

Code-A-Phone has a monitor feature—you can listen to the caller leave his message and pick up the phone to intercept the call. If you want to skip over a message on the tape, just tap a button and it fast-advances to the start of the next call. It has a selectable erase feature that lets you erase a specific message or the entire tape if you wish.

KNOW HOW MANY CALLS

With other answering machines, you never know how many calls you receive until you play them back. With Code-A-Phone you have a call counter—once that displays the exact number of calls you've received when you arrive home. If you now own another answering machine, you can really appreciate this convenient and exclusive feature.

STANDING BEHIND A PRODUCT

JS&A lets you use the 1400 in your home or office for one full month. Use it to screen your calls, take messages while you're gone or as a back up system when you're busy. Use the remote pager and retrieve calls while you're out. See how easy it is to change the message in seconds, and see how much it uncomplicates your life. Use it under your everyday conditions at home or at your office and then decide after one month whether or not you want to keep it. If you decide to keep it, you'll own the best. If not, return your unit for a full and prompt refund. There is no risk. Even if you already own a phone answerer, it would pay for you to see how much better the Code-A-Phone performs.

JS&A is America's largest single source of space-age products and a substantial company—assurance that your purchase is protected. The Code-A-Phone comes in two models: the Remote Control unit for $259.95 called the 1400 and the same unit without the pager but with all the other features for $179.95 called the 1200. Simply select the unit you want and send your check for the correct amount to the address shown below. Credit card buyers may phone in their orders by calling our toll-free number below. (Illinois residents add 5% sales tax.) There are no postage and handling charges.

By return mail, you'll receive a Code-A-Phone complete with all connections and instructions (extra pagers are available for remote unit) plus your ninety day limited parts and labor warranty. The unit measures 3 1/4" x 8 1/2" x 12" and weighs six pounds.

Code-A-Phone compares to units that sell for much more but do not have the simplicity and the advanced electronics. Don't be confused. Code-A-Phone is the finest telephone answerer you can buy at any price and is years ahead of all other conventional systems.

JS&A gives you everything you could possibly expect from a telephone answering system: 1) A unit years ahead of every other unit at a very reasonable price. 2) A service network that covers the United States with repair centers and free telephone assistance. 3) The chance to buy a unit in complete confidence, knowing that you may return it without being penalized with a postage and handling charge if it's not exactly what you want. You can't lose.

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ON THE COVER

Another great construction project from Radio-Electronics. This one updates your TV set with an on-screen digital readout of the time. The clock is built around a character generator from National Semiconductor that provides you with a choice of either a 4- or 6-digit readout of the time. Get started today; turn to page 35.

**ELECTRONIC SLOT MACHINE** you'll want to build. Digital readout of the score plus realistic odds makes this a great addition to your game room. Construction details start on page 39.
First 1978 TV’s: General Electric was first to demonstrate its 1978 TV-set models, and they’re highlighted by the addition of a random-access digital remote tuner linked to the set by infra-red light rather than ultrasonics. The calculator-like remote tuner uses an 82-channel digital frequency synthesizer, using phase-locked-loop (PLL) circuitry with a quartz crystal reference to select VHF and UHF channels. The tuning panel also contains volume, off-on and mute controls, and adds about $140 to the price of the set as compared with a mechanically tuned non-remote version.

GE has also extended the VIR “broadcast-controlled” color feature to more sets in its line, and most of its color sets without VIR have a different automatic color system, which GE hints is directly competitive with RCA’s ColorTrak and Zenith’s Color Sentry.

RCA chooses: Once again, RCA and Zenith find themselves on opposite sides of the fence. You’ll recall that Zenith chose to market the new Sony-developed Betamax system that records two hours on the same cassette. (Radio-Electronics, May 1977.) Now RCA has selected a different, non-compatible system, but one that can crum four hours of recording onto a single cassette not much larger than that used in the Betamax.

RCA’s system is the VHS, developed by Japan Victor Co. (JVC) as the leading contender against Betamax. However, the version picked has been re-engineered by JVC’s parent company, Matsushita Electric, and the tape speed cut in half and track width reduced, with a special noise-reduction circuit added to maintain a signal-to-noise ratio comparable to that of the shorter-playing machine. This is believed to have been accomplished in a manner similar to Sony’s speed-reduction program—in fact, Matsushita and Sony are both members of a patent-pooling consortium for home videocassette recorders.

The machine that RCA will introduce late this summer has outstanding tape economy. Since the half-inch tape loafs along at about 0.66 inches-per-second, it uses only about 8.35 square feet of tape per hour in the four-hour mode (it has a two- and four-hour switch), as compared with 10.3 square feet for the two-hour Betamax.

When marketing of the two new machines begins in earnest this fall, it should result in a battle royal, key-ed by the ancient Zenith-RCA rivalry. Prices hadn’t been announced at press time, but it’s logical to expect the machines to list at $1,000 or more—at least until competition brings them down. Meanwhile, other manufacturers are choosing up sides, and will offer one system or the other—either manufacturing them themselves or buying the decks, as RCA and Zenith plan to do.

In the Sony “Beta format” camp are Sony, Zenith, Sanyo, Toshiba, Pioneer and Sony subsidiary Awa. Siding with Matsushita are RCA, Matsushita’s subsidiaries Panasonic and JVC, Hitachi, Mitsubishi (MGA) and Sharp. Uncommitted U.S. TV manufacturers include Magnavox and Sylvania, expected to make up their minds soon, and G-E, which may wait till the dust settles.

If you’ve already bought a one-hour Betamax, Sony is expected to help you extend its recording time with the offer of a two-cassette changer. Although two of Matsushita’s American subsidiaries—JVC and Panasonic—are expected to offer the VHS here, the third, Quasar, is continuing to market a third system that it calls The Great Time Machine with a two-hour recording time per cassette but incompatible with the other two systems.

Games via cable: Subscribers to Manhattan Cable TV now have the opportunity to match skill with each other in video games, thanks to an enterprising non-profit group called Experimental TV Cooperative (ETC). “The Game Show” is presented once a week on the cable’s public-access channel and lets viewers use Touch-Tone telephones in their homes to operate the games. Here’s how it works: The viewer calls the phone number displayed on the screen and he’s asked what game he wishes to play. After instructions on playing, the playing field is superimposed on the screen, and the caller competes against other callers.

In the game of pinball, the telephone’s “1” button activates the right flipper, the “3” the left flipper. In Pong, pressure on “1” moves the paddle down, “3” moves it up. ETC President Dan Fodor, a studio engineer, designed and built the circuitry for the remote game-playing. It processes the frequency tone from the Touch-Tone phone and translates it from a digital to an analog signal for Pong—changes in voltage drive the paddle up or down. In pinball, the digital signal is used without conversion to analog. Other possibilities are being studied, and Fodor says he hopes to develop more complicated games using more Touch-Tone buttons.

And another one: One American and two German manufacturers have tentatively decided to build a completely different type of home videocassette recorder, but it’s not expected to be available before 1979, if then. The manufacturers are Bell & Howell in the U.S. and BASF and Robert Bosch (Blaupunkt) in Europe. The system, developed by BASF, is called LVR (Longitudinal Video Recording). It uses ¾-inch tape with 28 parallel video tracks, moving past a stationary head at 120 inches-per-second. When one track has made a complete pass of the head, the tape reverses and the head is switched to the next track. After 28 passes are completed, two hours of recording have been made in a single cassette. Claimed advantages of the system are simplicity and low cost. It’s believed the LVR may not be offered as a competitor to Beta and VHS.
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• This price buys you a complete new tuner built specifically for this purpose.

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CIRCLE 1 ON FREE INFORMATION CARD
Movie makers seek injunction against video recorder sales

MCA's Universal Studios and Walt Disney Productions are seeking a court order to stop the sales of Sony Betamax color TV recorders. The grounds: By selling machines capable of recording copyright material, Sony is unlawfully inducing the public to violate copyright law.

The suit seems odd because the law has recognized the individual's right to copy broadcast material ever since tape recorders came on the market. Sony counsel asserts that the movie makers, in licensing their productions for transmission "over the public airwaves," have given implicit consent to have them recorded for private non-commercial use.

According to Sony spokesmen, the film makers are attempting to enforce their copyright not to protect their material, but to pre-empt the market in audio-visual playback disc machines (in which MCA has a substantial investment) and to deprive the public of a technological advance which MCA has been unable to achieve.

The issue is important since Betamax is probably only the first of several video recorders that may appear in the near future. For example, Zenith plans to introduce a system based on Sony technology this year. RCA also has a record-playback system in the works, using Matsushita VHS (Video Home System) video cassettes.

Scientists get atomic fusion with carbon dioxide LASERS

Researchers at the Los Alamos, NM laboratory have achieved fusion reactions on a small scale by bombarding fusion-fuel pellets with carbon dioxide (gas) LASER beams.

The pellets contain a mixture of deuterium and tritium, which join to form helium, giving off great amounts of energy in the process.

Obtaining energy by atomic fusion instead of by fission would have several advantages. A fusion plant would not produce the wide range of radioactive byproducts generated by fission plants; thus, containing radiation hazards would be simpler. The fuel supply would also be practically inexhaustible.

It had been thought previously that the carbon-dioxide type of gas LASER could not be used to produce fusion, that its beams would penetrate too deep into the fuel pellet before its heating effects would be felt. Experiments were therefore made with the much more costly and less efficient glass LASER. However, experiments demonstrated that the heating effect of a carbon dioxide LASER does actually take place near the pellet's surface. Thus the gas LASER, which is ten times as efficient while only one-fourth as expensive as a glass LASER, can be used.

The present experimental system has two converging beams, each delivering 200 joules of energy to the pellet in about one-billionth of a second. (200 joules is roughly the amount of energy required to lift 150 pounds one foot, or to raise 50 grams of water one degree Celsius.) It is expected that the power of each beam can be increased to 900 joules, and that more than two beams can be converged on the fusion fuel.

National organization offers service manager certification

A certification exam and qualification program for consumer electronics service shop owners, managers and operators has been developed by NESDA, the National Electronic Service Dealers Association. Called the Certified Service Manager (CSM) program, the examination will test the business knowledge and management skills of service managers and operators in such areas as customer relations, advertising and promotion, record keeping, financial understanding, demographics of the service business, personnel management, product sales, safety and shop layout and design.

Approval of the program was given at the NESDA House of Representatives meeting in Indianapolis in January.

Radio Commission tells boatmen how to get help when in trouble

The Radio Technical Commission for Marine Services has issued, in cooperation with the FCC, a 72-page handbook to help boat owners with marine radios use their equipment efficiently when they are in difficulties. "Knowing how to use your radiophone in an emergency could save your life or your boat," advises the Commission.

US Coast Guard ships and stations listen for calls on Channel 16 (156.8 MHz), the distress, safety and calling channel in the VHF/FM band, and on 2182 kHz in the medium-frequency band, which is now single sideband. Citizens band radios are not marine radiotelephones, and the Coast Guard does not monitor CB frequencies.

There are three emergency calls. Most urgent is MAYDAY (French: m'aidez, help me), used only if a vessel or its occupants are in "grave and imminent danger." The boatman, after checking to see that his Continued on page 12
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The Sabtronics Model 2000 is an impossible $59.95! And that price still includes phenomenal accuracy, range and professional features.

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So you end up with a professional quality 3½ digit DMM for the unheard-of price of less than $60. From Sabtronics, specialists in digital technology. And manufacturers of the impossible.

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**SPECIFICATIONS:**
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- AC volts in 5 ranges: 100µV to 1000V
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- AC current in 6 ranges: 10nA to 2A
- Resistance in 6 ranges: 1Ω to 20MΩ
- Input Impedance: 10MΩ
- Display: 9mm (36") LED
- Power requirements: 4.5 VDC to 6.5 VDC (4 "C" cells - not included)
- Size: 8"W x 6.5"D x 3.0"H
(203W x 165D x 76H mm).

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radio is on the right frequency, and that there is a break in the traffic, calls MAYDAY three times, gives his craft’s name three times and his call sign once. He then gives his message, first telling where he is in relation to known land points. For example: “MAYDAY, MAYDAY, MAYDAY. This is Blue Duck, Blue Duck, Blue Duck, WA-1234. MAYDAY, Blue Duck; Dungeness Light bears 185 degrees magnetic, distance two miles. Struck submerged object. Need pumps, medical assistance and tow. Three adults, two children aboard. One person compound fracture of arm. Estimate can remain afloat two hours. Blue Duck is a 32-foot cabin cruiser, blue hull, white deck house. Over.”

PAN, the next most urgent call, is used when the safety of a vessel or its crew is threatened, as in the case of a man overboard. The SECURITY emergency call is used for an important weather or navigational warning.

NATESA Annual Convention will be held August 25–28

The 28th annual NATESA convention will take place at Carson’s Nordic Hills Resort in Itasca, IL (between O’Hare Airport and Chicago) from Thursday, August 25 through Sunday, August 28. A full program of service business management and a “New in Technology” seminar will be included with a program of interesting tours for the ladies and a visit to an area TV plant.

A single fee of $25 covers all functions. A special block of rooms (at a cost of $33 single and $38 double) have been reserved on a first-come first-served basis. As in the past, meals from Friday breakfast through Sunday brunch are being sponsored by major set manufacturers.

For details, write NATESA, 5908 Troy St., Chicago, IL 60629.

NEDSA estimates more than 200,000 electronic service technicians

The number of electronic service technicians in the United States at the beginning of 1977 was 207,212, an increase of 5%, reports National Electronic Service Dealers Association in its annual Electronic Service Industry Business & Manpower Survey. The number of consumer electronics firms also increased, from 66,000 to 70,526, a gain of 6% over 1976.

The NEDSA estimate is compiled from official state and city license records. Since the participating license boards serve a population of 58,920,000, or about 28% of the total population, the extended figures are somewhat arbitrary.

Nevertheless, they are useful in accounting for the demographic features of the service industry. For example, it was determined that:

1. Nearly 50% of the businesses are owner-operated, one-man shops.
2. Nearly 50% engage in product sales.
3. Many licensed technicians spend the greater part of their time in sales or management duties.
4. A majority of the businesses hire part-time service technicians to supplement their technical labor force.
5. Many businesses are operated by a technician who holds a full-time job elsewhere.
6. Because license fees are low ($10 in Indiana, for example) many carry a license rather than let it lapse, even though little or no time is devoted to service work.

EIA to run electronics seminars for high school instructors

Sixteen consumer electronics seminars in 14 states are being offered to high school and vocational instructors by the service committee of the Electronic Industries Association (EIA). The courses are designed to help teachers upgrade their curriculum in consumer electronic product service techniques; they emphasize diagnosis and repair of the latest consumer electronic solid-state and other products. Several schools also feature CB service techniques. College credit is offered for completion of the course.

Locations and dates are: Los Angeles Valley College, Van Nuys, CA, August 8–19; University of Northern Colorado, Greeley, CO, July 5–15; Morehead State University, Morehead, KY, July 18–29; Louisiana Vocational & Technical Institute, Shreveport, LA, June 27–30; Macomb County Community College, Warren, MI, June 20–23 and June 27–30; Bemidji State University, Bemidji, MN, July 5–9 and August 1–12; Appalachian State University, Boone, NC, June 20–July 5; Tennessee State University, Johnson City, TN, July 18–29; Prince William County Schools, Manassas, VA, late summer; Peninsula Community College, Port Angeles, WA, June 20–July 1; Fairmont State College, Fairmont, WV, June 20–July 1; Milwaukee Area Technical College, Milwaukee, WI, July 11–22.

The summer seminar program is sponsored by the Consumer Electronics Show, the industry’s biannual trade show, in cooperation with the Electronic Industries Association, Consumer Electronics Group. For a copy of the seminar schedule and contact names and telephone numbers write EIA/Consumer Electronics Group, 2001 Eye Street, N.W., Washington, DC 20006.


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In my two articles on telephone accessories ("Turn-On Appliances Via Long Distance" appearing in the April 1977 issue and "Amplifier For Hands-Off Telephone" appearing in the May 1977 issue), you omitted a reference stating that these articles were extracts from my book Telephone Accessories You Can Build. This book is published by the Hayden Publishing Company, 50 Essex St., Rochelle Park, NJ 07662, and priced at $3.95.

Any readers who found these articles of interest will find many more related projects in my book.

JULES GILDER

VIDEO GAME SCREEN BURN

The "burning in" of television game outlines on the phosphor screen could be reduced by incorporating a circuit in the game to slowly move the entire image around the screen. (Older types of TV camera tubes used in studio cameras such as the RCA TK-14 and TK-42 use a device called an orbiter, which either electronically moves the scanning or optomechanically moves the image.) The movement must be slow enough to be relatively unnoticeable, especially from play to play, and be of sufficient amplitude to displace the image slightly more than the maximum image line width. Additional hardware and/or software will be required to implement this system.

In a hardware game system, counters and a variable delay would move the image down one-scan-line-per-n vertical sweeps. The same counter could control a variable delay in horizontal positioning; however, another counter would allow more random positioning. When the image reaches the lower position limit, the counting (hence the positioning) is reversed. A software game system must accomplish the same steps, and therefore the hardware counters and delays could be used. A complete positioning cycle will likely have a period of about ten seconds, requiring long delay-timing loops and the associated memory requirements.

Although the increased hardware or software required would result in higher cost, the end result should be beneficial to both manufacturer and consumer.

TOM SCHULTZ

Kernersville, NC

OUTSIDE BURGLAR ALARM

I have been enjoying Radio-Electronics for many years, especially the articles relating to the fabrication of burglar alarms using SCR’s and IC’s. Every car, home and office needs effective burglar protection, and your publication fills a great need in a burglar-conscious world.

Many readers would appreciate information on how to construct and hook up a peripheral wire which could be buried around the edges of a property and would indicate the presence of any intruder. We also need information on a short-range FM transmitter, activated when a car parked outside the house is disturbed, which would register data at a receiver inside the house.

We would also appreciate more articles on pulsers or flashers that produce an interrupted warning noise or light rather than continuous operation; these should be adaptable to alarms, etc.

R. A. MATTMUELLER
Arlington, VA

SETTNG THE METER MOVEMENT STRAIGHT

Your series “All About Analog Voltmeters” is very good. However, the discussion on the meter movement in the March issue should be clarified. A taut-band meter movement is a D’Arsonval meter movement too. A D’Arsonval meter movement is one with a coil that moves through a strong magnetic field supplied by a permanent magnet. “Taut-band” refers to the method of suspending the moving coil.

In a taut-band meter movement, the moving coil is suspended by two thin metal ribbons, one on each side of the coil. These ribbons provide the restoring torque for the coil and the electrical connections to the coil.

continued on page 16
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The other method of suspending the moving coil is called pivot-and-jewel. Two tiny pivots, one on each side of the coil, ride in jeweled bearings. The restoring torque and electrical connection to the coil in a pivot-and-jewel meter movement are provided by hairsprings connected to the moving coil.

The major advantage of a taut-band meter movement is elimination of friction. While this does not necessarily improve accuracy, it does allow repeatable measurements. The repeatability of a measurement can be very important when trying to match components or balance circuits.

Another way to improve repeatability of measurements is to add a mirror to the dial. The addition of a mirror does not necessarily improve accuracy or resolution, but it does help eliminate a human reading error, parallax. Parallax error is caused by not looking at the meter from directly in front of it. By lining up the reflected image of the pointer directly behind the pointer, this error can be eliminated. Thus, a mirror dial may be needed if component matching and circuit balancing are required.

GLEN A. LITTLE, Project Engineer
Bluffton, OH

NEW ENERGY SOURCE?

Cut a one-inch square each from an aluminum and a steel pop can. Put a small button magnet at their center. (You may have to tape the magnet to the aluminum.) The magnet will attract a steel ball bearing from about one-quarter inch away through the aluminum, but it will not attract the ball through the steel sheet.

Today we can use a very low power signal to rapidly change germanium or silicon from a conductor to a nonconductor and vice versa. The magnetic bubble memory is now a reality. If we could find some other material that we could change from magnetic (steel) to nonmagnetic (aluminum) with a low power signal, we could solve our energy crisis.

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JONATHON TITUS, PETER RONY, AND DAVID LARSEN*

THIS MONTH, WE WILL DISCUSS COMPUTER interrupts, with emphasis upon the hardware and software associated with the vector interrupt. The three signals that you use in vector interrupt circuits include INT (input pin-14 on the 8080A), INTE (output pin-16), and INTA (not available on the 8080A but derived externally with additional logic).

The interrupt operation proceeds as follows: An interrupting device supplies a positive-going clock pulse to the INT (interrupt request) input of the microprocessor. The microprocessor recognizes the interrupt request either at the end of the current instruction being executed or while the CPU is in the halt state. Once an interrupt request is recognized, the CPU is inhibited by an internal flip-flop from recognizing another interrupt request. This internal flip-flop can be set (enabled) or cleared (disabled) with the aid of microcomputer instructions: The interrupt flip-flop is disabled (mnemonic DD) by instruction 363, and it is enabled (mnemonic EI) by instruction 373.

When cleared, the interrupt enable flip-flop inhibits interrupts from being accepted by the CPU. The flip-flop is automatically cleared when an interrupt is accepted; it is also cleared by the RESET input-signal applied at pin-12 of the 8080A IC. Output pin-12 (INTE, or interrupt enable) indicates the logic-state of the interrupt enable flip-flop.

An INTA (interrupt acknowledge) control signal is generated by applying the INTA (interrupt acknowledge) and DBIN (data bus in) control signals to a two-input NAND gate (Fig. 1). A logic 1 at DBIN (output pin-17 on the 8080A) indicates to external devices that the data bus is in the input mode. The INTA control signal is a positive clock-pulse that is generated as a status output with the aid of a status latch connected to the 8080A microprocessor. The interesting aspect of the INTE control signal is that it permits you to "jam" an interrupt-vector instruction byte directly into the instruction register within the 8080A. This can only be done during an interrupt, but nevertheless it is a unique and highly interesting operation that is possible with the 8080A microprocessor.

A simple circuit that demonstrates how a single-byte instruction can be jammed into the instruction register is shown in Fig. 2. Assuming that the interrupt enable flip-flop has been previously enabled by instruction 373, the interrupting device must supply a logic 1 input at INT in order to generate an interrupt request. The microcomputer finishes the current instruction, and then generates the interrupt acknowledge signal, INTA, that jams the desired vector instruction-byte on the data bus and into the instruction register. Although any instruction byte can be jammed into the instruction register during an interrupt, usually the eight following instructions are used to produce a useful result:

<table>
<thead>
<tr>
<th>Call the subrou-</th>
<th>Instruction Mnemonic that starts at:</th>
</tr>
</thead>
<tbody>
<tr>
<td>307 RST 0</td>
<td>HI = 000 and LO = 000</td>
</tr>
<tr>
<td>317 RST 1</td>
<td>HI = 000 and LO = 010</td>
</tr>
<tr>
<td>327 RST 2</td>
<td>HI = 000 and LO = 020</td>
</tr>
<tr>
<td>337 RST 3</td>
<td>HI = 000 and LO = 030</td>
</tr>
<tr>
<td>347 RST 4</td>
<td>HI = 000 and LO = 040</td>
</tr>
<tr>
<td>357 RST 5</td>
<td>HI = 000 and LO = 050</td>
</tr>
<tr>
<td>367 RST 6</td>
<td>HI = 000 and LO = 060</td>
</tr>
<tr>
<td>377 RST 7</td>
<td>HI = 000 and LO = 070</td>
</tr>
</tbody>
</table>

*This article is reprinted courtesy American Laboratories, Dr. Rony, Department of Chemical Engineering, and Mr. Larsen, Department of Chemistry, are with the Virginia Polytechnic Institute & State University. Mr. Titus is president of Tychon, Inc.
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<table>
<thead>
<tr>
<th>Feature</th>
<th>Fluke 1910A</th>
<th>2nd choice</th>
<th>Fluke 1911A</th>
<th>2nd choice</th>
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<tbody>
<tr>
<td>Price:</td>
<td>$395*</td>
<td>$295</td>
<td>$495</td>
<td>$495</td>
</tr>
<tr>
<td>Range:</td>
<td>125 MHz</td>
<td>80 MHz</td>
<td>225 MHz</td>
<td>250 MHz</td>
</tr>
<tr>
<td>Sensitivity:</td>
<td>15 mV/25 mV</td>
<td>25 mV/30 mV</td>
<td>15 mV/25 mV</td>
<td>25 mV/30 mV</td>
</tr>
<tr>
<td>Trigger-level control:</td>
<td>Yes!</td>
<td>(sorry) Yes!</td>
<td>Yes!</td>
<td>(sorry) Yes!</td>
</tr>
<tr>
<td>Autoranging:</td>
<td>Yes!</td>
<td>(sorry) Yes!</td>
<td>Yes!</td>
<td>(sorry) Yes!</td>
</tr>
<tr>
<td>Battery Option:</td>
<td>Yes!</td>
<td>(sorry) Yes!</td>
<td>Yes!</td>
<td>(sorry) Yes!</td>
</tr>
<tr>
<td>Multi-function:</td>
<td>f, p, pa, tot.</td>
<td>f only</td>
<td>f, p, pa, tot.</td>
<td>f only</td>
</tr>
</tbody>
</table>
The first sixty-four memory locations are reserved for interrupt service routines or pointers. These are extremely short programs, often consisting of only a single jump instruction, that tell the 8080 microcomputer what to do or where to go for a specified interrupt condition. Such routines precede the main program and associated subroutines in memory. If interrupts or restart instructions are not used, this portion of memory does not have any special significance.

Figure 3 is probably the simplest priority-encoder interrupt circuit that can be used with an 8080 microcomputer. The Intel 8212 IC is used as an 8-bit three-state buffer that inputs the instruction byte into the instruction register. The 74148 8-line-to-3-line priority-encoder IC has the following truth table:

<table>
<thead>
<tr>
<th>Inputs</th>
<th>Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 1 2 3 4 5 6 7</td>
<td>C B A E0</td>
</tr>
<tr>
<td>X X X X X X X 0</td>
<td>0 0 0 1</td>
</tr>
<tr>
<td>X X X X X 0 0 1</td>
<td>0 0 1 1</td>
</tr>
<tr>
<td>X X X X 0 0 0 1</td>
<td>0 1 0 1</td>
</tr>
<tr>
<td>X X X 0 0 0 0 1</td>
<td>0 1 1 1</td>
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<tr>
<td>X X 0 1 0 0 0 1</td>
<td>1 0 0 1</td>
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<td>X 0 1 1 1 0 0 1</td>
<td>1 0 1 1</td>
</tr>
<tr>
<td>0 1 1 1 1 1 1 1</td>
<td>1 1 0 1</td>
</tr>
<tr>
<td>1 1 1 1 1 1 1 1</td>
<td>1 1 1 0</td>
</tr>
</tbody>
</table>

The letter X means that the logic state is irrelevant.

The purpose of the circuit in Fig. 3 is to input the restart instruction, 3Y7, into the microcomputer. Five of the eight inputs to the 8212 IC are tied to a logic-1 state. The remaining three bits supply the encoded vector-address of the restart subroutine. By virtue of its truth table, the 74148 priority encoder provides eight priority levels. The inputs to this IC should be latched. The IC provides the three-bit binary output that corresponds to the highest valued priority input that is at a logic-0 state. The inverters invert this information to supply the three-bit "Y" component of the restart instruction.

If there is a logic 0 at any of the inputs to the 74148 IC, a logic-1 output will be generated at the E0 output (pin 15). This output serves as the input to the interrupt request pin. INT, on the 8080A chip. Upon receiving an interrupt request, the microcomputer responds with an interrupt acknowledge output, INTA, that strobes the selected highest-priority restart instruction into the instruction register.

R-E

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Calibration is easy. Just set the slide switch to the CALIBRATE position and adjust the scope controls to get a diagonal line on the screen that runs about half the width of the screen (not critical). This line can slant either way; it makes no difference.

Now you're ready to go. With a known transistor, insert the transistor leads into the socket or clip to the test leads to the transistor. Set the two switches to the JUNCTION and B-E positions. If the transistor is good, you'll see a sharp right-angle pattern on the screen. This may go from the center of the screen to the right and down, or from the left and up. Again, it makes no difference—all you want to see is the "angle." This indicates this junction is good. Now, set the lower slide-switch to the B-C position: the angle should flip 180°, just opposite to what it was.

If this happens, both junctions in the transistor are good. If you get a vertical line in either position, the junction is shorted. A horizontal line shows it's open (or that one of the clip leads has fallen off).

You can use this test to identify the leads of an unknown transistor. Just hook them up in any order and try the switches. If you get horizontal or vertical lines, swap two of the leads and try again. If you can find a hook-up that will give you the normal "flip" reaction, you can identify the transistor terminals from the colors.

Gain can be checked by setting the switches to GAIN and B-C. A horizontal trace with a "droop" will be seen. The longer the trace before the droop, the higher the gain. For leakage, set the switches to LEAKAGE and B-C. Very high leakage is shown by a vertical line.

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EQUIPMENT REPORT
continued from page 26

cathode to black. If it's good, you'll see the angle pattern. If the vertical part of the trace slants, this diode has excessive forward resistance. If the horizontal part slants, it has too much reverse leakage. Germanium diodes will sometimes show higher leakage, but silicon diodes should show a very sharp angle.

This test can come in very handy for those very small glass diodes that you need a microscope to see the color coding. Hook the diode up. If you see a vertical line (conducting or short) reverse the leads. If you get a good angle now, the diode is hooked up black lead to cathode, yellow to anode. Tunnel diodes will make a "lazy-S" pattern, this is due to the negative-resistance characteristic of these diodes. SCR's can also be tested: red lead to anode, black to cathode and yellow to gate. You'll see an angle pattern with a small loop near the bend. Shorting on the SCRs are being gated on. (All these patterns are shown in the instruction manual.)

Junction FET's may also be checked, but it is not recommended that JFET's or other MOS devices be tested. Several IC's can be checked, especially the transistor arrays and diode arrays, if the basing is known. Photo-transistors, photodiodes and photocells can also be checked on the model CT-751.

This unit can also be used for in-circuit transistor and diode testing. The patterns you get will depend on how much shunt impedance there is across the junctions in the circuit. In general, a thin vertical line indicates a short and a horizontal line indicates an open circuit. If you can get a good angle on any one of the junctions in-circuit, the transistor is apt to be good. Some will show almost the same patterns as the out-of-circuit tests, others will show only a slight "bend" in the trace.

Small capacitors can be checked in- or out-of-circuit. Use the black and yellow leads, and set the switch to B.E. If the capacitor is good, the pattern will become an ellipse. Very large capacitors will show an almost perfect vertical line.

Variable resistors larger than 6,000 ohms can also be checked. They should show a slanting line. Moving the control shaft should make the line move smoothly from vertical toward horizontal. If the control is noisy, the trace will jitter.

While playing with this instrument, we found another very handy feature. You can check many iron-core inductors—power transformers, vertical output transformers, audio output transformers, filter chokes, etc. If the inductor is good, you will see an ellipse. The higher the inductance, the nearer to perfectly round. If one of the windings on the transformer is shorted, you'll see only a vertical line. Use the largest winding for best results. For example, on an autotransformer vertical output, the primary makes a good ellipse. Short the leads to the yoke winding and the display should be a thin vertical line. To check low-inductance windings, the horizontal gain of the scope may have to be increased. You'll see a long, thin ellipse, but if it is definitely an ellipse, this inductor is good.

The model CT-751 is a very compact, versatile little instrument that saves a lot of time and won't take up too much space on the bench.

NATESA warns that TV games may complicate tube warranties

As every technician knows, phosphor picture tube faces can be damaged if a fixed pattern at fairly high intensity is left on the tube. Oscilloscopes have also been damaged when a line or dot has been etched into the tube face.

Video games now being used with TV sets raise this potential for damage. As competition increases, it's possible that inferior game design will require increasing the brilliance for adequate viewing. This will also help cause such damage.

This puts service people in a vulnerable position in cases of tubes damaged by etching. Manufacturers' policies on replacing within-warranty tubes in which game-etched faces are the only defect differ widely.

NATESA believes servicers must, in all cases needing within-warranty picture tube replacement, inform set owners that this replacement will depend on the policy of the picture tube producer or marketer. Since in many cases, defective CRT'S are simply accepted by the warrantor subject to later inspection and approval, servicers are cautioned not to deliver sets in such cases, unless the warrantor issues irrevocable credit.
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All ranges are well protected against overloads. Even if you should accidentally apply +1000VDC to the 2800 while switched to an ohms range, no instrument damage will result. All DC and AC voltage ranges are protected up to ±1000 volts DC or AC. The current ranges receive the double protection of diodes and a series fuse.

For accurate in-circuit resistance measurements, the 2800 measures with high- or low-power ohms ranges. At low-power ohms, less than 0.2 volt is developed across the measured resistance. To forward bias semiconductor junctions, the high-power ohms ranges develop about 2 volts.

B&K-PRECISION also has a full complement of optional accessories for the 2800. Accessories include a carrying case, wire tilt stand, AC adapter/charger, high-voltage probe, direct/isolation probe NiCad Batteries and 10-amp current shunt.

The B&K-PRECISION 2800 may be a mystery to our competitors, but for you—it takes all the mystery out of which DMM to buy.

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DYNASCAN CORPORATION

34 CIRCLE 68 ON FREE INFORMATION CARD
HERE'S A DIGITAL CLOCK YOU CAN BUILD that displays its numerals on a TV screen. If you own any black-and-white or color TV, you can build the on-screen TV digital clock described here, available in kit form for $29.95, and install it in your TV.

**How it works**

The schematic is shown in Fig. 1. The MM5318 (IC3) is a Digital Clock IC with multiplexed BCD (Binary Coded Decimal) outputs. A transformer-powered full-wave rectifier (D1 and D2) provides an unregulated 12-volt DC output that is filtered by C1, C2 and R10. A low-voltage 60-Hz signal is fed into pin 19 of the MM5318 as the timebase signal. Line voltage transients are removed from this signal by R9, D3 and D4. Pin 13 is either connected to ground for a 12-hour display format, or +12 VDC for a 24-hour display. Switches S2, S3 and S4 are for time-setting.

The outputs of the MM5318 are fed directly to IC4, a MM5841 TV Time/Channel Generator IC. (Note: The channel display feature is not used in this project.) This IC contains counters, shift registers, ROM's (Read-Only Memories) and many other circuit functions for displaying the numerals on the TV screen. The video signal is available at pin 15 of IC4 and is applied to the TV set through C10, R14, Q3 and R15. (Specific data for this and all other IC's used in this project is available from National Semiconductor Corporation, 2900 Semiconductor Drive, Santa Clara, CA 95051.)

Three gates of IC1, a 74COO CMOS (Complementary-Metal-Oxide-Silicon) IC quad 2-input NAND gate, and C5, R11 and R12 form an external oscillator for the MM5841. This oscillator controls the height of the displayed digits. Another 74COO, IC2, together with C8, C9, R13 and R18, provides timing and gating to control how often and for how long the digits are displayed. Potentiometer R18 determines display interval, and S1 allows you to "call-up" the display on command.

To display the digital characters on the TV screen, the circuit must synchronize with the TV scan. This is done by connecting the TV Clock vertical and horizontal sync inputs to the proper points in your TV circuitry, as described later. Transistors Q1 and Q2 feed these synchronizing pulses to the MM5841 where they trigger outputs on pins 16, 17, 20 and 21. Trimmer R16 controls the horizontal position of the digits on the TV screen, while R17 controls the vertical position.

**Construction**

This entire project can be built on a perforated board and hand-wired, but the circuit layout and lead lengths...
would be critical at these frequencies. It is better to use a printed circuit board; the foil pattern is shown in Fig. 2.

Using the PC board and the parts layout shown in Fig. 3, assembling this project is easy. Carefully identify each resistor and be very sure to observe polarity when installing the diodes and those capacitors that are polarized. The transistors must be installed with the flat sides as shown.

Start by installing the components on the PC board. Do not install R2, R4, R6 or R8 at this time; they will be installed later. Next mount the transformer to the PC board with two No. 6-32 × ¼ screws and nuts. Solder power diodes D1 and D2 (be careful not to confuse these with the smaller signal diodes) to the two top outside lugs of the transformer, with the cathodes (banded end) soldered into the PC board holes below. Various jumper wires are needed to complete the wiring and select options. Most jumpers are on top of the board. Run a jumper wire from the upper center transformer terminal to the PC board hole below. Also add jumper wires from the two bottom transformer terminals to the holes below them. Jumper point N on the PC board to the junction of D2 and the transformer terminal. (If your transformer is not the one specified in the parts list, you can determine the proper connections by referring to the schematic and the PC board layout.) Jumper points E and C on the PC board.

R-E TRIES IT

The On-Screen TV Digital Clock was tested by connecting it to a Heathkit GR-25 color TV receiver. The performance was completely satisfactory. When first connected, the time display was located in the center of the screen. There was some de-focusing from right to left with the seconds digits as sharp as you would want, the minutes slightly out of focus and the hours badly blurred.

The positioning pots were adjusted to place the display in the upper right corner of the screen. Next, we experimented with the video output (whiteness) control to see what effect it had on the display. By backing off the control, we reduced the distortion in the display so all digits were equally sharp and bright without a trace of color.

Connections

After reading the input-signal requirements, we studied the waveforms available at various points in the GR-25 and examined the chassis for possible connecting points on the top side of the PC board. Both grids of the vertical multivibrator were driven by sawtooth waves with a fast falltime. We installed R2—as instructed in the article—and tacked the vertical sync lead on to pin 2 of the 6567 vertical multivibrator.

A reversed sawtooth with a fast risetime was present at the junction of the two horizontal phase detector diodes. Since this was a test point, it proved to be a convenient spot to pick up the horizontal sync signal. Resistor R6 was installed on the clock PC board as directed.

The clock's video output was fed into the set's video output circuit through test point TP7 at the output of the video amplifier. Since, in this set, this point is also connected to a terminal on the service switch, this would be an equally convenient point to feed in the video.

*NOTE IC1 & IC2 - 74C00

FIG. 1—ON-SCREEN DIGITAL CLOCK requires vertical and horizontal sync pulses from TV circuitry.

117VAC
PARTS LIST
All resistors are 1/4-watt, 10% or better, unless otherwise noted.
R1, R5, R14—22,000 ohms
R2, R4, R6, R8—56,000 ohms
R3, R7—47,000 ohms
R9, R13—100,000 ohms
R10—100 ohms
R11—1000 ohms
R12—430 ohms
R15, R17—120,000-ohm trimmer.
horizontal PC mount
R16—50,000-ohm trimmer, horizontal PC mount
R18—500,000-ohm, horizontal PC mount
C1, C8—1000 µF, 16-volt, electrolytic
C2—100 µF, 16 volt, electrolytic
C3, C4—0.0033 µF, disk or Mylar
C5—33 pF, disk
C6—1000 pF, disk or Mylar
C7—0.1 µF, Mylar
C9—47 µF, 16 volt, electrolytic
C10—270 pF, disk
Q1, Q2—2N2222 or equal
Q3—MP5A42 (Motorola) or HEP S0027
Q1, D2—1N4001 or equal
D3—D6—1N914 or equal
IC1, IC2—74C00 Quad 2-Input NAND Gate
IC3—MM5318 Digital Clock (National)
IC4—MM5841 TV Time/Channel Generator (National)
S1-S4—SPST pushbutton switch
T1—117-volt primary; 16 volt, 150 mA, secondary. (Signal Transformer No. 241-3-16 or equal)
The following parts are available from Interfab, 27963 Cabot Rd., Laguna Beach, CA 92677: A complete kit of parts, including PC board, for $29.95 plus S1 shipping. Order No. DC-12 TV Clock Module. A PC board is available separately for $4.25 plus S0C shipping. California residents add state and local taxes as applicable.

Printed-circuit trace (+12V) that runs between pins 11 and 12. Also, using a single bare wire that “snakes” from point-to-point, connect IC4 pins 1, 22, 23, 24, 25, 26, 27 and 28 (numbered 1-8 on the PC board) to ground near point 8.

Now you have to select some options. Do you want 4 digits (hours and minutes) or 6 digits (hours, minutes and seconds) to appear on the screen? For 4 digits, jumper point M (pin 7, MM5841) to ground. For 6 digits, jumper M to +12V. Do you want a 12 or a 24-hour display format? Jumper point R (pin 13, MM5318) to ground (point S) for a 12-hour format, or to +12V (point T) for a 24-hour display.

Four switches are used, and they can all be mounted on a single panel or in a small plastic box. Switch S1 should be readily accessible since it is used to manually call-up the display. It is a pushbutton type switch; if you want to be able to leave the clock display on for extended periods, use a slide or toggle SPST switch instead. The other switches are used for time setting and can be less accessible—you might even want to hide them behind a panel to prevent tampering. Using multiconductor or ribbon cable, wire one side of all switches to ground. Then wire the other switch terminals as follows: S2 to point G; S3 to point F; S4 to point H. These are pins 18, 17 and 16, respectively, of the MM5318.

Installation
Installing the TV Digital Clock into
your TV involves both physical and electronic connections. Caution: When installing this project in your TV set, remember that most TV's have a "hot" chassis wired directly to one side of the AC line. Make sure the chassis is at ground potential before you start working on it.

To begin with, you must connect the TV Clock board to a constant source of 117-VAC 60-Hz power—it must be powered even when the TV is off. You could do this by running a separate line cord to a wall socket, but it really makes more sense to connect the TV Clock board to the points in the TV where the AC power enters. Wire these points to the 117-VAC input pads on the TV Clock PC board. Also, be sure to connect a wire from the TV Clock board ground to the TV set ground.

Vertical sync can be taken from the vertical oscillator or vertical amplifier. You are looking for either a positive-going sync pulse with a fast risetime or a negative-going sync pulse with a fast falltime used for vertical retrace. A positive-going sync pulse requires R4 to be installed; a negative-going pulse requires R2. The pulse needed at point A (IC4, pin 19) is shown in Fig. 4. This results from a positive-going pulse fed into C4. Fig. 5 shows a typical vertical amplifier circuit. If you can't locate a positive-going pulse with a fast risetime (there's one there somewhere!) and the output signal from Q1 is the inversion of the one shown in Fig. 4, there's a spare inverter section (IC1-a) at points J and K on the PC board. Use R2 and jumper B to J and K to A to invert the signal. If you find the preferred signal with a fast risetime, use R4 and jumper B to A directly.

Similarly, the horizontal sync is taken from the horizontal oscillator, with a typical TV circuit shown in Fig. 6. Look for a positive-going pulse with a fast risetime used for horizontal retrace, and install R8. Figure 7 shows the input needed at point W (IC4, pin 18) resulting from a signal with a fast risetime fed into C3. If you can't locate a signal with a fast risetime right away, keep looking, since there's only one spare inverter on the Clock PC board! If you used a positive-going signal for the vertical sync, then you can use a negative-going signal and inverter here, jumpering X to J and K to W, and installing R6 instead of R8. It's simpler, however, to find a positive-going horizontal signal and use R8 with a jumper.

Using the TV Clock

With the TV set in operation, press switch S1. The digital time should appear somewhere on the screen for approximately 4 to 6 seconds, as determined by the time constant of R13 and C9. The time will appear automatically every 1 to 8 minutes, determined by C8 and the setting of potentiometer R18. Adjust R18 to a comfortable interval. To adjust the location of the display on the screen, hold down S1 and adjust potentiometer R17 to control the vertical position of the display, and potentiometer R16 for the horizontal position. The brightness (whiteness) of the display is adjusted by R15.

To set the time, use a known time standard, such as the number provided by your phone company. Pressing S2 advances the hours once a second, pressing S3 advances the minutes once a second, and pressing S4 "freezes" the display until it's released. Simply advance the time slightly ahead of real time, and depress S4 to hold the count until the real time "catches up" with the displayed time.
ANYONE LOOKING FOR A UNIQUE AND CHALLENGING project will find this Electronic Slot Machine well worth the time and energy. Costing only $50 to $60 for parts, this digital project yields a form of entertainment that few people have access to.

One of the primary considerations in designing this project was that it must lend itself entirely to those of us endowed with vast quantities of natural laziness. This being the case, the arm that is normally pulled to initiate a “play” is replaced with a remote push-button switch. The numerical readout of an internal accumulator keeps a running tabulation of all winnings and automatically decrements each time the PLAY pushbutton is depressed.

The actual display consists of 35-mm slides (unmounted) of whatever object you wish to use. The standard display symbols used in slot machines are: cherries, oranges, plums, bells, and the word jackpot. Also watermelons, lemons, genies, and others are often used. The slides are arranged in 3 columns of 5 slides each. Each slide is mounted over an individual lamp for illumination.

To start, a RESET pushbutton located on the back panel is depressed. This presets the numerical readout to a count of 10. With the slot machine reset, a PLAY lamp located above the display symbols lights and a play cycle can be initiated by depressing the PLAY pushbutton. During the play cycle, one slide in each column lights sequentially—one slide in the first column, then one slide in the second column and finally, a third symbol in the last column. At this point, if the combination of symbols results in a payoff, the numerical readout is incremented accordingly. The PLAY lamp lights automatically to enable another play cycle.

When the power is first turned on, the digital circuitry quickly assumes a quiescent state and the readout displays some large number. It is necessary to clear the accumulator and preset a count of 10 by depressing the RESET pushbutton.

How it works

Referring to the block diagram shown in Fig. 1 and the complete schematic shown in Fig. 2, the RESET pushbutton...
triggers reset one-shot IC3. The output of the reset one-shot clears the up-down counters IC42, IC43 and IC44. The accumulator is comprised of these three up-down counters. The readout is now 0-0-0. The output of the reset one-shot triggers one-shot (IC4) to generate a delay, which insures that the accumulator is reset before the payoff sequence is initiated. The trailing edge of the delay-pulse triggers a payoff one-shot (IC34) that gates ten pulses into the up-down counters, setting the accumulator to 0-1-0. Each time a play cycle is completed, the accumulator is decremented by 1. After the reset pushbutton is depressed, ten play cycles can be completed with no payoffs before a 0-0-0 is displayed and the play cycle is disabled.

With the slot machine reset, the play lamp is on and the play pushbutton can initiate a play cycle when depressed. The play pushbutton triggers IC1. The output of IC1 enables five other circuits. Simulating a coin being played, IC1 decrements the accumulator by one count, resulting in a readout of 0-0-9. The three wheel-spin one-shots (IC9, IC10 and IC11) are also triggered at this time. The wheel-spin one-shots allow the display to give the appearance of spinning wheels. The time duration is set so that they stop in sequence, each being on longer than the previous one by a few seconds.

The oscillator enable one-shot (IC2) enables IC8-a, which allows the pulses to enter the three decade counters IC12.

### PARTS LIST, MAIN BOARD

- **All resistors are 1/2-watt, 10%, unless otherwise noted**
  - R1, R4, R13-R27, R35, R43-1,000 ohms
  - R2-10,000 ohms
  - R3, R5-33,000 ohms
  - R6, R7, R11-20,000 ohms
  - R8-300 ohms
  - R9-1100 ohms
  - R10-13,000 ohms
  - R12-27,000 ohms
  - R28-3900 ohms
  - R29, R30, R32-12,000 ohms
  - R31-17,000 ohms
  - R33-36,000 ohms
  - R34-130,000 ohms
  - R36-15,000 ohms
  - R37, R39, R41-240,000 ohms
  - R38, R40, R42-510 ohms
  - C1, C10, C11-100 µF, 6 V, electrolytic
  - C2, C3, C7-9, C14, C15, C16-220 µF, 6 V, electrolytic
  - C4, C5-10 µF, 6V, electrolytic
  - C6, C18-1.6 µF, 6V, electrolytic
  - C12, C13-150 µF, 6V, electrolytic

- IC13 and IC14. These counters have their decoded outputs connected to the odds-determining gates IC18 to IC21. The gates are wired to give a pre-determined number of chances for each display symbol to light. The output of the oscillator enable one-shot also dis-
ables the PLAY lamp to indicate that a cycle is in progress and the PLAY pushbutton will have no effect if depressed.

The outputs of the odds gates feed the inputs of gates IC22-IC25, IC26-IC28 and IC30. These gates determine if a winning combination is displayed after the wheels have stopped. On the trailing edge of the oscillator enable output, the win-gate enable IC5 is triggered to generate a narrow strobe pulse that enables all the win combination lines to see if any winning combination exists. If there is no winning combination, the PLAY lamp will light and the machine will be ready for a new cycle to be initiated. If a winning combination does exist, the appropriate number of pulses are gated into the accumulator.

**Construction**

Construction is straight-forward. The main circuit board (Fig. 3) is assembled first. Over one hundred jumpers are to be installed, as shown in Fig. 4. This number could have been reduced by using a double-sided circuit board, but the added cost and effort did not justify its use. After all the jumpers are in place, install the IC sockets or Molex type pins, then mount the components.

The power supply may be laid out on a separate PC board or in spare places in the cabinet. Mount the regulator and pass transistor on small heat sinks for cooling.

The display can be fabricated from whatever materials are available. I used a PC board because it is sturdy and easy to work with. After piecing the display together in egg-carton fashion with the squares the size of 35-mm slides, holes are drilled in the center of each square through the back panel to accommodate the lamps. The lamps can then be press-fitted into the holes and the flanges soldered to the foil of the back panel, eliminating all wires connecting to the common supply bus of the lamps. When all circuits are wired it is ready to test. First check the power supply output voltages before connecting it to the main circuit board. If all voltages check out, then connect the power supply to the machine and check its operation. If the same combination repeats numerous times, it may be necessary to alter the values of the oscillator components slightly. They are C6, R8 and R9. The payoff rates are adjusted with the timing resistors as described previously.

The payoffs are shown in Table 1 along with the corresponding odds. The payoffs are the same as many real
machines while the odds are far better. Due to the large value tolerances in electrolytic capacitors such as those used for the payoff one-shots, resistors R28-R34 will have to be changed to obtain the payoffs listed in the table. (A variation of 20-30% from the capacitance values listed is not uncommon.) In addition to the payoff one-shots, the wheel one-shots and oscillator enable one-shot (IC9, IC10, IC11 and IC22, respectively) may also need to be fine-adjusted to obtain a satisfactory pulse duration.

FIG. 3—PRINTED CIRCUIT LAYOUT for the Electronic Slot Machine, shown half size.

NOTES:
1. MATERIAL SPECIFICATION: 1/16" (1.5875mm) COPPER-CLAD BOARD.
2. DIMENSIONS IN INCHES ARE EXACT; METRIC MEASUREMENTS ARE APPROXIMATE AND ARE FOR FAMILIARIZATION ONLY. ALL DIMENSIONS FOR BOARD CONSTRUCTION ARE GIVEN "CENTER TO CENTER."
FIG. 4—THE BOARD LAYOUT, showing jumpers and leads to components mounted on panel.

FIG. 5—THE POWER SUPPLY circuit.

PARTS LIST, POWER SUPPLY

<table>
<thead>
<tr>
<th>Component</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>R1</td>
<td>2-7 ohms, 1 W</td>
</tr>
<tr>
<td>R2</td>
<td>10,000 ohms, 1/2 W pot (fixed resistors may be substituted)</td>
</tr>
<tr>
<td>R3</td>
<td>5-10,000 ohms, 1/2 W</td>
</tr>
<tr>
<td>C1</td>
<td>5-5,000 µF, 16 V, electrolytic</td>
</tr>
<tr>
<td>C2</td>
<td>47 µF, 50-V disc</td>
</tr>
<tr>
<td>C3, C4</td>
<td>8 µF, 250 V, electrolytic</td>
</tr>
<tr>
<td>C5</td>
<td>250 µF, 6 V, electrolytic</td>
</tr>
<tr>
<td>IC1</td>
<td>7805 or LM309, 5 V, 1 A voltage regulator</td>
</tr>
<tr>
<td>D1</td>
<td>IN4005 or similar</td>
</tr>
<tr>
<td>Q1</td>
<td>PNP 2N4398 or equivalent</td>
</tr>
<tr>
<td>S1</td>
<td>SPST power switch</td>
</tr>
<tr>
<td>T1</td>
<td>transformer, 12.6 V center tapped, 1 A</td>
</tr>
<tr>
<td>T2</td>
<td>transformer, 6.3 V, 0.6 A</td>
</tr>
</tbody>
</table>

To check the payoffs it is necessary to trigger the payoff one-shots manually or the play cycle would have to be initiated many times. The one-shots are triggered by momentarily applying a ground to pin 5 of the circuit to be tested and observe the accumulator to note the payoff. Simply increase the resistor for more counts or decrease for less.

The remote PLAY switch should be located no more than a few feet from the machine. Use grounded shielded cable because of the normally high input of the play one-shot.

The schematic shows a potentiometer on the high-voltage output. This control is used to set the brilliance of the display tubes. Adjust it for minimum setting needed to prolong the life of the tubes. After the control is set, it can be replaced with fixed resistors if desired.

Many extra features can be added, such as a lamp to indicate a jackpot, or an audible alarm to indicate a jackpot or any payoff. A mechanical arm can be constructed or a slot to accept coins could be made, which would cause a play cycle each time a coin was deposited. A word of caution on the use of coins: it is illegal to gamble in most states and a heavy fine or imprisonment could result if the slot were used for other than hobby purposes.

R-E
How To Design

Automotive Anti-Collision Systems

Part I—An in-depth look at the different types of systems and the various design considerations, with enough information for the advanced hobbyist to build his own

MARTIN BRADLEY WEINSTEIN

with just a little insight into the problems and technologies involved, it is now altogether possible for the average electronics hobbyist to design and construct a relatively sophisticated automotive anti-collision system at reasonable cost.

We're going to take a look at the history of electronics in collision-avoidance systems; at how the various present-day technologies can be put to use and at some of the hardware that is available today. We will define the problems that are encountered when designing collision-avoidance systems and take a look at fully active systems that almost drive your car for you. Finally, we will look at what goes into designing a personal system for our own use and at constructing some of the hardware we'll need.

The History of Collision Avoidance

Every car today carries the original piece of hardware designed specifically to reduce the chance of a collision: the horn. But operation of the horn is entirely too dependent on operator judgment, and does little to enhance his awareness of conditions around him. Similarly, the headlight and other lamps nevertheless assumes that all other drivers on the road are competent.

But more interesting things started happening in the late 1960's and early 1970's. Researchers at Bendix, Ford, Sylvania, RCA and elsewhere were working on approaches to the collision-avoidance problem using RADAR's, LASER's and ultrasonics.

In these days before fuel embargos, the major threat to the future of the automobile was a lack of roadspace. Since anti-collision devices were designed to avoid collisions, their main objective was to permit a greater traffic density. Thus, the same roads could handle more cars.

The Ford Plan

Ford Motors established a Transportation Research and Planning Office to analyze America's transportation needs into the twenty-first century, to coordinate other corporate studies and to administer their development and execution. They saw a need for what would eventually become an Automatic Highway.

Here, some form of mechanical or electronic control, centrally located, would coordinate conventional vehicular traffic (for automobiles equipped as required by legislation with the necessary interfacing and control equipment) to move smoothly at high speed even when closely spaced.

Before the boldly optimistic Automatic Highway could be achieved, however, two other plans seemed likely candidates for interim development. These were called Automatic Headway Control (AHC) and Minigap. Both were designed to avoid rear-end collisions and make long-haul driving a little less of a chore.

AHC used a cruise-type speed control, a RADAR and an on-board computer. It kept the vehicle at the preset speed until the RADAR saw the car ahead getting too close. Then, under computer control, the brakes would be applied to slow the vehicle and maintain a safe following distance. The prototype, unfortunately, was not a very smooth-operating system. It would pull the car forward at full speed, apply full braking, and keep repeating this jerky process as long as there was a car ahead.

Under Minigap, whole trains of cars are linked up electronically to a specially-equipped lead vehicle, specifically designed to travel the freeways just to let you leave the driving to them.

But credit is certainly due Ford's Electronic Systems Research Department for getting so far so soon. Ford, by the way, also worked with an infrared diode LASER and a side-by-side solid-state infrared semicon-ductor sensor. It was mounted near the rear of the vehicle and pointed backwards. A tricycle, toddler or terrier, for example, would reflect the low-power LASER back to the sensor and trigger a buzzer. The system was activated with the ignition key inserted and the transmission in Reverse, Park or Neutral. The buzzer would sound for three seconds and a warning lamp would light up until the obstacle disappeared. The system was designed for an effective range of about 10 feet.

The Sylvania Approach

The Sylvania Wakefield Development Laboratory, meantime, was working on another approach. Since LASER and RADAR systems must first illuminate their targets with RF or light, they are called active systems. Sylvania was looking at using ultrasonics in a passive system.

The Sylvania system generated no ultrasonics of its own, as some SONAR's and, more specifically, SODAR's used in such applications do. Instead, it concentrated on listening for the ultrasonic sounds generated by such vehicle functions as tire against roadway, engine operation and exhausts.

One natural advantage of the Sylvania approach is, of course, that trees and billboards and stop signs and guard rails and such don't generate ultrasonics, so they can't cause false triggering. They can cause false triggering in RADAR and LASER systems, as well as in active ultrasonic systems.

The prototype was designed to be installed in an all-light assembly or sideview mirror pod, facing towards the rear of the car to
detect oncoming vehicles. While it would respond to vehicles travelling at about 35 MPH or faster, its maximum range was only about 25 feet. A little math shows that even its best-case warning for a situation where the vehicle it is following is stopped is under a half second before a collision occurs. For a situation where both vehicles are in motion with a relative velocity of just under 1 MPH, this response improves to almost 20 seconds. So clearly, where the threat is the worst, the system is worst-suited to warn of it.

The RCA RADAR system

One of the more technically sophisticated, if bulkier designs to come along was proposed and prototyped by RCA. It involved a 9-GHz vertically-polarized transmitter, an 18-GHz horizontally-polarized receiver and a special license-plate-size reflector. The reflector included microstrip diode filters and acted as a frequency doubler, retransmitting the vertically-polarized 9-GHz signal as a horizontally-polarized 18-GHz signal.

The transmitted signal was about 100 mw with a 4 to 5-degree beamwidth to restrict coverage to the same lane. The electronic package was 17 x 8 x 2 inches and designed for mounting at the center front of the car.

One advantage of the RCA design was the immunity it demonstrated against false triggering from such objects as trees and signs. And the frequency doubling scheme also minimized mutual interference from oncoming vehicles similarly equipped.

The system was intended to provide both relative speed and relative distance, with speedometer information fed into a signal processor to reduce the chance of false triggering from stationary vehicles.

The system involved several disadvantages, however. For one, the electronics package was too big to be practical. If placed high, it blocks necessary air flow to the vehicle cooling system. Higher, it blocks the driver’s vision. Lower and it blocks the front license plate as required in many states and becomes susceptible to stones, gravel and other road hazards.

Furthermore, at 100 mw, the RCA RADAR is two to five times as powerful as many similar aircraft altitude RADAR’s. Granted, the earth is a big target than a car, but RADAR altimeters have to work over several miles, not just the 100 yard range of the RCA system. The unavoidable spectrum cluttering at 9- and 18-GHz would certainly have unwelcome side effects. So this very ambitious, very sophisticated approach appears to be an unfortunate example of overkill.

Bendix ASC system

Adaptive Speed Control (ASC) is the Bendix system that ties together a cruise-type speed control with what Bendix and the National Highway Traffic Safety Administration call the Automotive RADAR Brake, or simply RADAR Brake.

The Bendix system is the most difficult to outline, but only because it has gone through a great deal more development. In fact, Bendix has just been contracted by the NHTSA to construct two prototype RADAR-brake-equipped vehicles for actual driver testing.

While several different microwave frequencies have been used during the course of Bendix RADAR brake development, a few salient points have emerged that are common to all approaches.

The systems have all been designed for a minimum 300-ft operating range. Both range and range rate (relative speed) information is determined through a combination of AM and FM modulation of the transmitted signal and some very sophisticated analysis of the return echo. The systems have been developed to limit the possibility of mutual interference to one occurrence in every hundred million encounters (roughly once in a lifetime).

And probably most important, the system designs call for only aiding the driver—warning him first that the collision is oncoming, and then only in the absence of an override signal or an affirmative driver reaction (like hitting the brakes himself) will the system engage braking itself. When it does, it brake hard to discourage driver dependence on the system.

Much of the technical and human factors that will be considered here on the subject of electronic design for collision avoidance is with the support and insight engendered by the people and publications Bendix so kindly provided.

The state-of-the-art

The purpose of this article is to provide you, as an individual hobbyist, with insight to get you started building if not at least thinking about your own electronic anti-collision system. So far, though, we’ve looked at what large corporate and government efforts have provided. Now we have to look at what was we can do, affordably. And for that matter, just what we can do on our own, period.

As we discuss the various hardware approaches to sensing, analysis and control, we will from time to time refer to specific pieces of equipment and their approximate prices. You are, however, encouraged to investigate any other competing merchandise you can find, and to share new information as well as project ideas with other readers by submitting it to: “Letters to the Editor” Radio-Electronics, 200 Park Ave. South, New York, N.Y. 10003.

We will deal, specifically, with infrared diode LASER, Doppler RADAR, ultrasonic SODAR, control and display interfacing, and microcomputer analysis. But, as in any design problem, a definition of the problem is our first requirement.

The operating environment

The rigs of environment within a car can make many modern technologies unusable or very difficult to use without special precautions. Environment in a passenger compartment in a Northern climate might experience a temperature range from –40°C (–40°F) to 80°C (175°F). Consider that exterior temperatures tend to hit –10 or –20°F at least once or twice a winter up North. And on days when it’s 90°F in the shade, the glass windows of today’s make things even worse. True, a system may not have to operate at quite those extremes. Nevertheless, designing for a temperature range less than –20°F to 140°F (–30 to 60°C) may be unwieldy. Under the hood, temperatures can reach 300°F.

Passenger compartment vibrations are in a range from roughly 10 to 60 Hz at 5 g’s or less. Shock acceleration, however, can reach 30 g’s sustained over 10 milliseconds. These are quite severe, however, and a design that permits operation against a 10-g shock should be adequate.

Also, consider the environmental difficulties exterior to your car. Fog can disperse, diffuse, reflect and otherwise inhibit systems based on visible light. Infrared systems see through most fogs and mists, so your system should include infrared light if any. The LASER that we will discuss assumes infrared operation.

RADAR’s too can be inhibited by atmospheres, like raindrops and snowflakes. As the object size approaches the RADAR’s microwave wavelength, it presents a viable target and a return echo.

Bendix, in their recommendations, suggested that the 25-GHz RADAR they first tried (because of favorable antenna size and comparative ease of beam shaping) was too susceptible to backscatter returns. They found an additional 6 dB of noise immunity to this clutter by going to a longer-wavelength 22.125-GHz RADAR. Our RADAR system operated at 10.525 GHz. And, of course, there’s the problem of making the installation waterproof.

Stopping the car

Just how sensitive a collision-avoidance system has to be depends on just how much reaction time it has to allow. That includes not only the time it needs to recognize a threat and react to it, but also, of course, how long it takes to bring your car to match-speed, often a full stop. And that’s different for every car, every road and every kind of weather.

Worse-case analysis is no good here. The difference between good brakes on a good dry road and sloppy brakes on a bad, icy road can be a factor of five. Nor can we assume the maximum speed you will ever go to be 35 MPH. Typical coefficients of friction for dry, wet and icy surfaces are 0.825, 0.3, and 0.15, respectively. To give you an idea of just how much “friction” that is, assuming a top-notch braking system capable of stopping at 90% of the maximum surface coefficient of friction, a vehicle travelling at 50 MPH would take 120, 300, or 600 feet, respectively, to come to a full stop on dry, wet or icy roads.

Vehicle speed

Your speed can do more than just tell you how fast you’re going. In conjunction with a PROM lookup-table, it can tell you how far your car will travel under full braking before coming to a complete stop. When added to the relative speeds of the car in front of you and the car behind you, the same PROM can tell you their braking distances, too.

Your vehicle’s speed can also be used as the basis for a notch filter to help eliminate returns from overhead signs, bridges, guard rails and such. This can be done through software in a microcomputer-based system or through analog/ digital or other conversion techniques in less “intelligent” systems. Remember, Doppler microwave RADAR’s compare their received and transmitted frequencies and output a difference signal. This signal represents 31.4 Hz or 0.0314 MPH of relative velocity. If your vehicle is doing between 10 and 60 MPH, relative to stationary objects, a Doppler will output 314 to 1884 Hz. This is in the low audio range and easily filterable.
Your vehicle speed can be coupled with other data for useful outputs unrelated to collision avoidance. Coupled to a fuel flow gauge, miles per gallon is an easy first output. And when connected to the fuel tank gauge, a plethora of outputs becomes available. Imagine for example a video display in your car reading: LOW FUEL! ONLY 1.5 GAL LEFT AT 45 MPH AND 15.6 MPG, YOU HAVE 21.4 MILES 31 MINUTES TO EMPTY.

**Vehicle speed data**

The easiest way of obtaining speed information is from the type of generating transducer available through Quest Electronics (P.O. Box 4430, Santa Clara, CA 95054). It is, in fact, a small generator that fits into the speedometer cable line either at the transmission or at the speedometer, depending on the car. It generates a voltage related to speed that can be coupled to a 566 Voltage Controlled Oscillator to produce a frequency related to speed. Proper locking and latching of that frequency gives a direct BCD latched output that can be used, displayed, or queried by software.

Sometimes, though, it isn’t desirable to display every mile-per-hour increment. Where speeds can change rapidly, as in the 0 to 15 MPH range, readouts that occur only every several MPH (0.2, 5.8, 10, 12.15, for example) may be less confusing. Or simply leaving the original equipment speedometer installed and operating in conjunction with the digital display, if used, may offer a more suitable alternative.

The BCD speed information (1-MPH increments) can be used to address a Braking Distance Look-Up PROM directly. The PROM can then be made to output in tens of feet, BCD, in its four least significant bits (assuming an 8-bit PROM word length), and in hexadecimals of feet in its four most significant bits. This permits an output range from 0 to 1590 feet, in 10-foot increments, more than enough at even illegal highway speeds.

The stopping-distance information listed in the table below indicates a driver reaction time of 0.75 seconds and a vehicle braking distance of approximately 0.035 times the square of the vehicle speed (speed in MPH, distance in feet).

The use of a data selector and three separate lookup tables is strongly recommended. One table would indicate braking conditions under the penalties of an icy highway, one for wet roads and one for dry. Logic outputs from Schmitt triggers hooked to temperature and humidity sensors just inside the car’s front bumper could drive the data selector/demultiplexers directly or through an addressed data bus. The block diagram for the stopping-distance circuit is shown in Fig. 1. It is recommended that the results of the PROM lookup be latched, either through specific gate hardware or in RAM, so that the entire system can be strobed regularly, rather than continuously queried.

In any discussion here of stopping distance, it is interesting to note the approach taken in the Bendix ASC system. A system from other sensors to determine the validity of a blip.

The units themselves are infrared diode LASER’s. Infrareds were chosen because of their necessary ability to see through most fogs, rains and snows. The LASER is modulated at an audio rate generated by the Voltage Controlled Oscillator section of a phase-locked-loop. (The block diagram of a basic LASER system is shown in Fig. 3.) The infrared photodetector at the PLL input is then sensitive only to this particular infrared

**FIG. 1—STOPPING DISTANCE circuit. Speed information**

is used to address PROM’s that contain digitalized stopping distance charts. Parallel memories are included for braking distance under various road conditions (i.e., dry, wet or icy). Road condition sensors determine which parallel memory will be selected.

The units themselves are infrared diode LASER’S. Infrareds were chosen because of their necessary ability to see through most fogs, rains and snows. The LASER is modulated at an audio rate generated by the Voltage Controlled Oscillator section of a phase-locked-loop. (The block diagram of a basic LASER system is shown in Fig. 3.) The infrared photodetector at the PLL input is then sensitive only to this particular infrared

**FIG. 2—LASER SENSOR PLACEMENT. Infrared LASER’S are modulated and decoded to prevent false triggering. The LASER’S are placed and aimed strategically about the vehicles body so that any adjacent vehicle will be detected by at least one LASER.**

from other sensors to determine the validity of a blip.

The units themselves are infrared diode LASER’S. Infrareds were chosen because of their necessary ability to see through most fogs, rains and snows. The LASER is modulated at an audio rate generated by the Voltage Controlled Oscillator section of a phase-locked-loop. (The block diagram of a basic LASER system is shown in Fig. 3.) The infrared photodetector at the PLL input is then sensitive only to this particular infrared

**FIG. 3—LASER MODULE uses a 567 PLL tone-decoder IC to modulate the infrared diode. Infrared photodetector receives the modulated infrared if there is an object present to reflect it.**

LASER return. Furthermore, the phase-locked-loop can be programmed to delay before indicating. This filters out fleeting returns from picket fences, telephone poles and the like. The 16 LASER PLL outputs are assigned to two 8-bit addresses for software interrogation.

*continued next month*
TIM Distortion—
how it affects your system

Why does a tube amplifier sound better than a transistorized one? The answer lies in the recent discovery of a new type of distortion

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

JUST WHEN THE AUDIO INDUSTRY WAS smugly settling back with the knowledge it had succeeded in reducing harmonic distortion and intermodulation distortion to almost unmeasurable (and certainly inaudible) levels, our self-satisfaction was rudely interrupted by the discovery of a new form of distortion called TIM (Transient Intermodulation Distortion). Not that its discovery came as a surprise. Audio experts had long been puzzled by the fact that two amplifiers having identical frequency response, identical harmonic and intermodulation distortion and even identical power output capabilities still sounded different—even when connected to identical loudspeakers. Obviously, we weren't measuring everything that needed to be measured.

Gradually, the puzzle began to be pieced together. Some of the pieces related to that elusive difference between the sound of tube-type amplifiers and latter-day solid-state amplifiers. Strangely, the best of the old tube amplifiers never was able to boast the low percentages of THD and IM claimed by the new generation of transistorized equipment and yet, to many ears, they still sounded better. Terms such as "warmer" sound were used (the warmth, in this case, having nothing whatever to do with the heat generated by those energy-wasting tube filaments) to denote the special nature of tube sound. It was thought at first that the difference in transfer characteristics between tubes and linear solid-state devices was responsible in some subtle way for the differences in sound perceived by critical listeners. But designers were able to make solid-state amplifiers which, when tested with steady-state signals at least, displayed exactly the same transfer characteristics and overload waveforms as did the earlier tube amplifiers; and still the audible differences persisted.

As early as June, 1972, Matti Otala of Finland began publishing papers on TIM (Journal of The Audio Engineering Society, Vol. 20, No. 5), and he as well as others have been investigating this phenomenon ever since. Studies seem to correlate the relationship between a high TIM level and the poor sound quality we have been attributing to certain amplifier designs for many years.

What is TIM
As most readers know, solid-state amplifiers use negative feedback to improve frequency response and reduce harmonic distortion. Solid-state amplifiers in the past were designed with greater amounts of feedback than in earlier tube designs. This practice stemmed in part from the fact that earlier transistors were limited in bandwidth capability and the application of

FIG. 1—SINUSOIDAL SIGNAL applied to the input of an amplifier is shown in a. Feedback signal is half the amplitude of the input signal and delayed by an additional 45° as shown in b. Resultant input to first stage of amplifier is shown in c.
huge amounts of feedback helped to flatten frequency response and extend it to beyond audible limits.

In general, the feedback signal is subjected to a finite time-delay caused by reactive components and by the transit time of the amplifying devices themselves, so that the feedback signal arrives at the input somewhat delayed in time. As shown in Fig. 1, if a pure sinewave is fed to an amplifier and the delay amounts to as much as 45° of lag between the input signal and feedback signal, the net signal will still be perfectly sinusoidal in shape.

To illustrate this, let's assume that the sinewave in Fig. 1-a is the input signal, and that the out-of-phase feedback signal is one-half the amplitude of the original signal and is shown in Fig. 1-b. In this case, if the feedback signal is exactly 180° out-of-phase with the input signal, the input would be reduced in amplitude by 6-dB. However, due to the reactance of the feedback loop, the feedback signal is delayed by an additional 45°. The feedback signal is now 225° out-of-phase with the input signal. Because of the additional 45° phase shift, the net input signal is now reduced by something less than 6 dB (Fig. 1-c) but it still retains its exact sinusoidal shape—somewhat displaced in time from the original input. The feedback has not fully performed its function, but neither has it introduced any new form of distortion beyond any that already existed in the original input waveform.

Now let's consider what would happen under the same circumstances if the input signal had been a step-function, such as a squarewave. Musical signals have often been compared to such steep-rising functions, especially when the music contains a high degree of transient information or fast instrument attack-times.

Figure 2 shows a squarewave input signal of the same frequency used in our earlier sinewave example. Again, for simplicity, we are assuming that circuit and feedback delay is the same as in the earlier example. The input signal is shown in Fig. 2-a and the time-displaced feedback signal (which should have uniformly reduced the net input level by half) is shown in Fig. 2-b. Because of the step-function nature of the waveform, the net input amplitude has actually increased in the positive going direction by 6 dB for the first eighth of a cycle. This is because the instantaneous amplitude of the feedback signal is in-phase with the input signal and adds to it rather than subtracting from it, as shown in Fig. 2-c.

Even if the step function we had selected were a short-term nonrepetitive one (as in music), while the net input amplitude might not have increased initially, the desired input-signal amplitude reduction that the feedback should have accomplished would not have taken place because of the time-delayed feedback.

For example, if the amplifier in question had an input sensitivity of 1 volt for full-rated output and if a properly reduced input signal (by feedback) were well within that limit, the absence of feedback could drive the amplifier well beyond its clipping level for that short period of time. Remember, too, that in our examples we used a very moderate 6-dB feedback, whereas in practical situations the loop feedback might well be 40 dB or even more. If, in the presence of non-time-delayed feedback, a given input signal was enough to drive an amplifier to, say, its rated output of 20 watts, absence of the required 40 dB of feedback for however short a time period would, in theory, require that the same amplifier produce an instantaneous peak-power output of 200,000 watts—something it obviously cannot do.

In Fig. 3 we have artificially created this kind of situation. A step-function was fed into an amplifier where the feedback network produced a time-delay so that the sharp, positive-going leading edge of the waveform was not subjected to the required feedback. We see that the leading edge of the waveform drives the amplifier severely into clipping, even though a short time later, the amplitude is reduced by the late-arriving feedback to an acceptable nonclipping level. (The lower trace of Fig. 3 is the amplifier output; the upper trace is the input signal.)

In an actual music-listening situation, things become a lot more complicated. For one thing, we are not dealing with simple step-function signals, but with complex signals in which step-functions at one frequency may be mixed with other sinusoidal signals or step-functions at higher frequencies. One means of detecting the presence of T1M would be to use an input signal consisting of a 500-Hz squarewave mixed with a 6000-Hz tone whose amplitude is one-fourth or one-fifth that of the lower frequency squarewave signal. Figure 4 shows such
a TIM test signal. If this TIM test signal is applied to an amplifier and levels are adjusted so that the peak power output is somewhat lower than the amplifier can deliver on a continuous sinewave basis, evidence of TIM would appear as shown in Fig. 5. During the fast risetime and falltime of the 500-Hz squarewave, the momentary absence of properly out-of-phase feedback has "blurred" the first cycle of the superimposed 6000-Hz signal, because the amplifier has been driven into clipping.

Another method of viewing TIM has been proposed using a spectrum analyzer. Again, the basic squarewave/sinewave composite signal is used as a test signal fed to the amplifier. The test signal shown in Fig. 4 was fed to a spectrum analyzer. The result is shown in Fig. 6, which shows the odd harmonics of the squarewave component of the test signal while at the center of the screen we see the 6000-Hz component.

Figure 7 shows a partial spectrum analysis of the output waveform that reveals sideband components to either side of the 6-kHz center-spike which were not present in Fig. 6. These extraneous components are indicative of TIM, although they do not easily lend themselves to numerical interpretation. In both Figs. 6 and 7, linear frequency sweep was used, and the frequency notations appearing at the top of the screen should be ignored.

A single number for TIM

While several methods for detecting TIM have been described, no single method lends itself to its quantization. It would be desirable to express TIM as a number, in much the same way as we do with harmonic or intermodulation distortion. A relatively simple way to come up with a meaningful TIM number has been suggested by the engineering staff of Lux Corporation of Japan. In this proposal, the same sort of combination squarewave/sinewave test signal is used. The same squarewave source (onto which the higher-frequency sinewave is superimposed) is also applied to a unity-gain inverter stage. The test signal is then fed to one channel of a stereo amplifier, while the inverted squarewave is fed to the opposite and identical channel. Outputs from both channels are then combined in a summing network (which may be made up of passive components), adjusted so that the out-of-phase squarewave components are cancelled as perfectly as possible. What remains is the 6-kHz component that contains distortion every time the rapid step-function of the composite test signal took place. This residual 6-kHz signal is then simply fed to a conventional harmonic distortion analyzer and its distortion content is read as a simple percentage. The entire suggested setup is shown in Fig. 8.

Using this suggested method of TIM measurement, Lux Corporation has already introduced an amplifier with a published TIM specification of 0.05%.

This first attempt at quantifying TIM may not be perfect. Obviously, if the noninverting and inverting amplifier channels are not completely identical, differences in the shape of the out-of-phase squarewave components of the two signals will prevent perfect squarewave cancellation, and non-TIM related distortion components will affect the analyzer's reading. Nevertheless, the approach is fairly simple and can be duplicated in reasonably well-equipped test and service laboratories for at least a "first look" at TIM in a quantitative way.

R-E

Service agencies are warned on warranty service contracts

With the new California warranty legislation, and pending warranty bills in other states, service agency contracts will probably be revised to keep within the new laws. But states NATERSA (National Alliance of Electronic and Television Service Associations): "We are appalled with the wording of some contracts servicers are being asked to sign, and caution all service agencies to study such contracts, and possibly seek legal counsel before signing."

Among the "potentially dangerous clauses" is an agreement "... to adhere to service policies as set forth from time to time..." The servicer agrees, in other words, to conditions the warrantor may set up at a future date.

Another dubious clause is "... use only genuine parts." This could force the servicer to stock a complete line of resistors, capacitors, etc., carrying the brand name of each warrantor who insisted on it, rather than using such parts out of the servicer's stock, as is present practice. It could also mean long delays in completing service, while parts were back-ordered.

The servicer is even asked to agree "to indemnify and hold the product warrantor blameless against any demand, claim suit by any action or omission for the service station ... or otherwise." The "otherwise" could cover an almost infinite range of cases. Such provisions, NATESA warns, would put the entire "monkey" on the servicer's back.

Some clauses on agreed rates, worded so as to be subject to a wide range of interpretation, could result in real financial trouble for the servicer.

The NATESA warning concludes it is not the intent of servicers that warranty service agency contracts should not protect the interests of the warrantor. "We believe they should protect the interests of the product purchaser and the servicer as well. Servicers should not sign contracts that do not provide such tri-partite protection."
Tests Fisher RS-1080 AM/FM Stereo Receiver

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

FISHER CORPORATION, HAVING COMPLETED ITS corporate reorganization, has now undertaken the job of recapturing its proper share of the high-fidelity component market. The company recently introduced a new line of receivers as part of its long-famed "Studio Standard" line, the most powerful and expensive being the model RS-1080 shown in Fig. 1. The design is new, including a light-colored front panel using a gold background behind the slightly dial-area cutout and dark-colored frequency calibration numerals for easy visibility. Above the blue frequency numerals is a series of red indicator words that illuminate to denote program source, activation of the FM Dolby decoding feature and reception of a stereo FM signal. A 0-to-100 linearily calibrated logging scale below the FM and AM frequency scales helps pinpoint favorite stations.

To the left of the frequency scales, but within the dial opening area, are three separate meters: one for AM and FM signal strength; a center-of-channel FM tuning meter and a multipath indication meter that is adjusted for a minimum indication while orienting an outdoor FM antenna.

All controls are located across the bottom of the panel: A toggle-type power on/off switch, a speaker selection switch (that selects one or two out of three pairs of speakers or headphones only), bass, treble and balance controls; an extra bass selector switch plus an associated bass range boost control; and a tape monitor switch with positions for two tape decks and for dubbing from one deck to another. Seven small toggle switches come next, centered on the lower portion of the panel. These switches take care of tone-control defeat, mono/stereo mode selection, low- and high-cut filter switching, loudness circuit, FM muting and Dolby decoder switching. A master volume control calibrated in discrete dB steps has an illuminated pointer for easy viewing of volume settings. There is also a program selector switch, followed by a large station tuning knob (coupled to a highly effective flywheel/dial pointer) and a pair of jacks for possible connection of a third tape deck.

A hinged, pivorable AM ferrite-bar antenna on the rear panel (Fig. 2) swings down and out to disclose the external AM, 75-ohm coaxial and 300-ohm antenna terminals as well as the phono and auxiliary input jacks. Chassis ground terminals are located below, while centered on the rear panel are the two

MANUFACTURER'S PUBLISHED SPECIFICATIONS

FM TUNER SECTION:
Usable Sensitivity: Mono: 1.7 μV (9.8 dB); Stereo: 4.3 μV (17.9 dB). 50-dB Quieting Sensitivity: Mono: 2.5 μV (13.2 dB); Stereo: 34 μV (35.8 dB). Signal-to-Noise Ratio: Mono: 72 dB; Stereo: 70 dB. Distortion: Mono: 0.15% at 1 kHz, 0.15% at 100 Hz, 0.18% at 6 kHz; Stereo: 0.25% at 1 kHz, 0.3% at 100 Hz, 0.4% at 6 kHz. Capture Ratio: 0.8 dB. Selectivity: 75 dB. Image Rejection: 100 db. Spurious Rejection: 100 dB. AM Suppression: 65 dB. Stereo Separation: 1 kHz: 50 dB; 10 kHz: 36 dB. Subcarrier Rejection: 70 dB. SCA Rejection: 66 dB.

AM TUNER SECTION:

POWER AMPLIFIER AND PREAMPLIFIER SECTION:
Power Output: 170-watts minimum continuous watts per channel, 20 Hz to 20 kHz, 8-ohm loads. Total Harmonic Distortion: 0.1%. Damping Factor: 30. Input Sensitivities: Phono 1 & 2: 2.0 mV; Aux and Tape: 150 mV. Phono Overload: 300 mV. S/N Ratio: Phono: 70 dB, Aux and Tape: 82 dB. Residual at minimum volume: 100 dB. Tone Control Range: Bass: ± 12 dB at 100 Hz; Treble: ± 12 dB at 10 kHz. Filt Response: Low Cut: -6 dB at 30 Hz, High Cut: -6 dB at 5 kHz.

GENERAL SPECIFICATIONS:

PHOTOGRAPHY
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TABLE I

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: Fisher

Model: RS-1080

FM PERFORMANCE MEASUREMENTS

<table>
<thead>
<tr>
<th>SENSITIVITY, NOISE AND FREQUENCY FROM INTERFERENCE</th>
<th>R-E</th>
<th>R-E</th>
</tr>
</thead>
<tbody>
<tr>
<td>IHF sensitivity, mono: (µV) (dBf)</td>
<td>1.7 (9.8)</td>
<td>Excellent</td>
</tr>
<tr>
<td>Sensitivity, stereo (µV) (dBf)</td>
<td>16.0 (29.3)</td>
<td>Fair</td>
</tr>
<tr>
<td>50-dB quieting signal, mono (µV) (dBf)</td>
<td>2.7 (13.8)</td>
<td>Excellent</td>
</tr>
<tr>
<td>Harmonic distortion, 1 kHz, mono (%)</td>
<td>0.19</td>
<td>Good</td>
</tr>
<tr>
<td>Harmonic distortion, 1 kHz, stereo (%)</td>
<td>0.12</td>
<td>Superb</td>
</tr>
<tr>
<td>Harmonic distortion, 100 Hz, mono (%)</td>
<td>0.10</td>
<td>Excellent</td>
</tr>
<tr>
<td>Harmonic distortion, 100 Hz, stereo (%)</td>
<td>0.20</td>
<td>Good</td>
</tr>
<tr>
<td>Harmonic distortion, 6 kHz, mono (%)</td>
<td>0.06</td>
<td>Superb</td>
</tr>
<tr>
<td>Harmonic distortion, 6 kHz, stereo (%)</td>
<td>0.22</td>
<td>Excellent</td>
</tr>
<tr>
<td>Distortion at 50 dB quieting, mono (%)</td>
<td>0.75</td>
<td>Excellent</td>
</tr>
<tr>
<td>Distortion at 50 dB quieting, stereo (%)</td>
<td>0.55</td>
<td>Excellent</td>
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</tbody>
</table>

STEREO PERFORMANCE MEASUREMENTS

<table>
<thead>
<tr>
<th>Stereo threshold (µV) dBf</th>
<th>16.0 (29.3)</th>
<th>Poor (see text)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separation, 1 kHz (dB)</td>
<td>53</td>
<td>Superb</td>
</tr>
<tr>
<td>Separation, 100 Hz (dB)</td>
<td>46</td>
<td>Excellent</td>
</tr>
<tr>
<td>Separation, 10 kHz (dB)</td>
<td>38</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

MISCELLANEOUS MEASUREMENTS

| Muting threshold (µV) (dBf) | 20 (31.2) | Poor (see text) |

EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION

<table>
<thead>
<tr>
<th>Control layout</th>
<th>Excellent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ease of tuning</td>
<td>Excellent</td>
</tr>
<tr>
<td>Accuracy of meters or other tuning aids</td>
<td>Excellent</td>
</tr>
<tr>
<td>Usefulness of other controls</td>
<td>Excellent</td>
</tr>
<tr>
<td>Construction and internal layout</td>
<td>Excellent</td>
</tr>
<tr>
<td>Ease of servicing</td>
<td>Excellent</td>
</tr>
<tr>
<td>Evaluation of extra features, if any</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

OVERALL FM PERFORMANCE RATING

Excellent

Circuitry

Eleven separate major circuit boards are used. A five-gang variable capacitor is used in the FM front end, which also uses two dual-gate MOSFET RF stages, a dual-gate MOSFET mixer and a local oscillator with a separate buffer stage. The phase-linear IF section of the receiver has solid-state preamplified ladder-type filter circuits followed by a double-tuned quadrature detector. The stereo multiplex decoder contains a phase-locked-loop circuit. The circuit for driving the multipath meter also uses a phase-locked-loop arrangement.

Each preamplifier-equalizer circuit uses a differential amplifier input, followed by single-ended push-pull output stages. The familiar Baxandall tone control circuit is preceded and succeeded by buffer amplifier stages. Complementary push-pull output stages in the main amplifier section of the receiver contain four power transistors in each channel, two of which are paralleled for the positive and negative halves of the drive circuits. A separate protector circuit assembly using a power relay protects speakers from possible damage.

FM performance measurements

Results of our FM measurements are listed in Table I. Evidently, the stereo threshold settings, as well as the signal strength required to overcome the otherwise effective nulls of tape-out and tape-in jacks. Preamplifier/main amplifier-in jacks, three sets of piano-key spring-loaded speaker terminals and one switched plus two unswitched AC receptacles are at the right of the rear panel.

The internal layout is shown in Fig. 3. Power amplifier modules are mounted adjacent to symmetrically positioned massive heat sinks on either side of the large power transformer and electrolytic filter capacitors.

Figure 4 shows the variety of associated equipment that can be used with this receiver.

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Muting circuit of this tuner section, were somewhat misadjusted. Signal strengths required were considerably higher than specified. In all other respects, however, the tuner section performed well, providing 50 dB of quieting with only 2.7 µV (13.8 dB) of signal applied in mono and 33 µV (35.6 dB) for the same quieting in stereo. Signal-to-noise in mono was 77 dB, while in stereo the best quieting was 70 dB—as good as many high-priced receivers are able to do in mono. Total stereo harmonic distortion was almost as low as in mono for all but the highest audio test frequencies, with readings of 0.12% at 1 kHz, 0.2% at 100 Hz and a very low 0.22% at the higher 6-kHz test point.

Figure 5 shows the frequency response
signal selector and range overload. showing equalizer section measurements. The at 20 Amplifier section evaluated output. while plex section of the receiver. Vertical divisions on the scope face correspond to 10 dB; the upper trace represents the desired-channel output, while the lower trace shows the attenuated output from the opposite channel.

**Amplifier section**

The power amplifiers delivered 182 watts per channel, at mid-band frequencies, with both channels driving 8-ohm loads. Even at 20 Hz, the amplifiers delivered a bit more than their rated 170 watts-per-channel and, at actual rated output, distortion for a 1-kHz signal was a mere 0.0085%. Table II lists these and other amplifier and preamplifier section measurements. The phono preamp-equalizer section was virtually impervious to overload, showing audible distortion with input signals as high as 330 mV, as against 300 mV claimed.

The bass and treble tone control range is shown in Fig. 7. The extra bass control selector and range controls referred to earlier introduce controllable amounts of bass boost at selectable frequencies of either 45 Hz or 80 Hz. Figure 8 shows the maximum amount of boost available at these center frequencies. However, it should be understood that by adjusting the bass range control, any degree of lower-bass boost up to and including the curves shown can be introduced. This bass-boost circuit is extremely useful in compensating for loudspeakers that are somewhat deficient in bass at their lower octaves and does not seriously affect upper bass or mid-range frequencies.

While the low-frequency filter was designed with a slope of 12 dB-per-octave (see Fig. 9), the designers chose to limit the slope of the high-frequency filter to a more moderate 6 dB-per-octave. This filter is less effective in removing hiss and scratch than a more steeply sloped high-frequency filter. However, Fisher engineers maintain that too steep a slope at the high end of the response curve tends to cause audible distortion in musical fidelity when the latter filter is used.

**Summary**

Our overall product analysis for this high-powered receiver, along with summary comments, will be found in Table III. In general, the unit performed well both as a high-powered preamplifier/amplifier component and in its AM and FM tuner functions. The Model RS-1080 seems well worth its suggested selling price and ranks high among the ever-expanding new group of superpowered receivers.

Table III appears on page 84.
Here's a rundown of the important facts that every user and potential purchaser of digital multimeters should know.

What You Should Know About DMM's

CHARLES M. GILMORE

THERE ARE A GREAT MANY DIGITAL MULTIMETERS ON THE MARKET, EVERYTHING FROM POCKET SIZE TO EXPENSIVE LAB-GRADE INSTRUMENTS. IT IS IMPORTANT FOR EVERY POTENTIAL PURCHASER OF THESE INSTRUMENTS TO KNOW WHAT MAKES ONE INSTRUMENT DIFFERENT FROM ANOTHER AS WELL AS EVERY USER TO KNOW THE LITTLE NUANCES THAT COME INTO PLAY WHEN TAKING READINGS.

General features

Often the features are what make one instrument stand out from another. The potential DMM buyer should have a good knowledge of an instrument's features and how he can use them. The purchaser often needs to make a tradeoff between features, so careful consideration of one feature against another is in order if he is to gain maximum use from the DMM investment.

The digits. One of the strange terms developed by the DMM manufacturers is an expression "half digit." It is perfectly clear what a three-digit DMM is, and what a four- or two-digit "machine" (as they are sometimes referred to) is, but a three-and-one-half-digit machine sounds like something run through a saw. The term "half digit" has been coined to indicate a DMM with 100% overrange capability. This is also referred to as "1999" (three-and-one-half-digit) capability. In a similar manner, the term three-and-three-quarter-digit machine has come to mean a DMM with 3999 capability. Whenever terms such as these are used, it is wise to inspect the specifications very carefully to determine their exact meaning. Good specifications give a numerical upper limit to each of the instrument's ranges, and also specify overrange capability.

The resolution of the instrument is directly limited by the number of digits in the display. A three-and-one-half-digit DMM has a resolution of one part in two thousand or 0.005%. For example, the 1-volt range has a full-scale value of 1999 millivolts, and the resolution is one millivolt. Four-and-one-half-digit machines have resolutions of one part in twenty thousand or 0.0005%, but unless the noise is very low, this resolution may not be usable; there may be instability in the last few digits at all times. The two-and-one-half-digit instrument has a resolution of one part in two hundred, or 0.5%.

A two-and-one-half-digit or a three-digit DMM should be considered as a replacement for a good analog multimeter, as far as accuracy and resolution are concerned. Accuracy generally lies between 0.5% and 1.5% with 0.5% resolution or more. The three-and-one-half and four-digit machines generally have accuracies between 0.5% and 0.05%, with 0.05% resolution. Such resolution and accuracy generally suffice for even the most exacting service work and home experiment. Four and one half digits or more generally indicate an accuracy of 0.05% or better with 0.005% resolution and should be considered laboratory instrumentation.

Power sources. Most DMM's today offer battery as well as power-line operation. A few, either the very exotic or the very inexpensive, do not. The battery is often an option at extra cost, especially if the batteries are rechargeable. In a few DMM's the batteries are required for operation, as the AC supply/charger does not have the current capability to operate the DMM alone.

When considering battery operation, note the type of cells used. Replacing an odd-sized cell may be both difficult and expensive. Rechargeable cells that are physically and electrically interchangeable with zinc-carbon or alkaline cells have an advantage. Temporary substitution permits portable operation, even if the batteries were not charged the night before. All cells have a finite life expectancy, and today none are particularly cheap. Therefore, if there is no need for a portable instrument, and expense is a consideration, battery operation may not be worth the price. Battery operation is not confined to field use; even in the bench situation, it may be an advantage in making a voltage measurement with the DMM floating at a potential above the allowable common-mode voltage of the instrument.

For truly portable operation, the operating time from a full charge is an important specification. For extremely constant use, an operating time of eight hours may be needed from a single overnight charge. If the DMM is to be operated intermittently during the course of a working day, and is to be kept on a charger overnight, an operating time of four to six hours will be quite satisfactory and probably cheaper.

Status indication. Digital multimeters have many modes of operation. With either an autoranging instrument, or one being operated at some distance from the user, some form of status indication is convenient. Status indication displays the DMM function and range being used. Usually this takes the form of lighted indicators in the display window. Overrange decimal point and polarity are the most frequently included status indicators. Be certain these three indications are easily...
understood. Blinking or blanking of the display is frequently used to indicate an overrange condition. Illuminated + and − symbols most frequently indicate the polarity of the DC measurements.

The sample rate specification indicates the number of conversions in one second. Commonly this figure is about three to five per second. With seven-segment displays, sample rates in excess of five per second may create readings that are difficult to read.

Warm-up time. Many instruments specify a period of time required before the instrument is warm to specifications. Quick warmup may cost extra, but if high accuracy and rapid portability are required, as in certain types of service work, it may be a feature worth paying for.

Operating temperature range. The accuracy specifications of a DMM have a temperature dependency. This is usually specified in one of three ways. First, a temperature range over which the DMM may be operated within its published specifications may be stated. Second, the DMM may be given an accuracy specification at 25°C, and a derating figure applies for temperatures other than 25°C. Third, the permissible operating temperature range of an instrument regardless of accuracy is important. Cold climates may find the instrument kept in an unheated portion of a service truck. The instrument with an operating temperature range of zero degrees or lower and above may well not operate on a moderate winter day.

Size and weight. The physical characteristics of a DMM make it portable. They also contribute to price and complexity. Again, keep the intended application in mind to make the best cost/value tradeoffs.

Displays. The light-emitting diode (LED) is one of the most popular displays in use with DMM's. Other displays in use are the seven-segment neon display (Nixie®), the seven-segment neon display, fluorescent display, and liquid crystal display (LCD). LED's are popular because of their good brightness, excellent contrast and low cost. Neon displays, both ten-character and seven-segment, have the highest brightness but at a slightly higher cost, combined with the requirement for a high-voltage power supply. Neons also tend to generate some slight RF noise. Fluorescent displays have never been too popular, although they generally require less power than LED's or neon. Fluorocents are subject to interference from static electricity and have poor contrast. Extremely low-power operation make LCD's popular. They also have a potentially low cost, but also, however, have the lowest contrast ratio. Certain types of LCD's don't wash out in direct sunlight, but most will freeze at moderate temperatures and become completely useless. The life expectancy of LCD's is one hundredth or less that of the neon or LED displays.

When considering displays, size must be given some thought. DMM displays will run from 0.1 inch high to displays with a character height of 0.75 inch or more. Often the user is never more than the length of the test leads from his DMM. In such cases, small displays are no hindrance, and permit a smaller, more portable design. On the other hand, if readings may be required at a greater distance, larger displays are necessary. Again, the instrument's use must be considered.

Specifications

The number of specifications associated with the DMM is extensive. Unfortunately, many of the variations from DMM to DMM are the subtly specified nuances that make all the difference to the user when the instrument is on the workbench.

The DC voltmeter

Ranges. One of the first questions facing the potential buyer is defining full scale on a particular multimeter. They are specified one of two ways: either with full scale being a multiple of 10 (1, 10, 100, 1000, etc.) with usable overrange capability specified as a percentage (typically 100%); or full scale is specified as the maximum possible reading encompassing the ranges (often 1999). For example, a DMM may be specified as having 1 volt full scale with 100% overrange, thus indicating useful operation to 2 volts, or the same DMM may be simply specified as having a 2 volt full scale. These ranges are further limited, as the full indicated capability of the meter may not be useful on the highest voltage range. For example, a DMM with a 1999 full scale may not be able to read over 1000 volts DC and even lower on AC, even though 1999 volts is apparent at first glance. This is usually due to the danger of voltage breakdown of internal components.

Accuracy. Specifications differ by manufacturer as well as by the accuracy of the meter being specified. A meter specified with very high accuracy will have more sophisticated accuracy specifications as compared to those of the meter with limited accuracy. Simple accuracy specifications are given as ±% of full scale, ±1 digit." The "plus/minus one digit" portion of the specifications is caused by an error in the digital counting circuits, the "plus/minus percentage of full scale" includes ranging and A/D conversion errors.

One of the most sophisticated specifications is ±% of reading, ±% of full scale, ±1 digit." Such a specification is usually confined to instruments in the 0.05 to 0.01% class.

An additional specification may qualify the accuracy of the instrument at temperatures other than 25°C. Temperature specifications are of two forms: either a temperature coefficient, per cent per degree centigrade, with which the user may calculate the exact deviation from the 25-degree specification, knowing the ambient temperature; alternatively, accuracy is specified over a complete temperature range such as 25°C to 35°C.

Other limitations may be placed on the accuracy of the instrument. These include the effects of line voltage variations, humidity, altitude and time. These limitations are of little interest to the person making general use of the multimeter. However, some manufacturers, not knowing where their instruments will be used, issue all-encompassing specifications. One thing you can be sure of—the more inclusive the specifications, the higher the cost of the instrument.

Input impedance. Most DMM's have a 10-megohm DC input impedance. A few have an input impedance of one megohm. Input impedance may have a tolerance specified. This is important when using the meter with an external multimeter. Some voltmeters offer very high input impedance on the lowest DC input ranges. Input impedances on such DMM's may be in the 100 to 1,000 megohm range.

Response time. This consists of two factors: first, the basic cycle rate of the A/D converter; second, the time required to charge capacitances in the input circuits. This time may be long if there is input filtering. Response time is the number of seconds required for the instrument to settle to its rated accuracy. In lieu of response time, some manufacturers simply give the number of conversions per second.

Protection. Specifications indicate the amount of line frequency AC overload each range will tolerate without damage. This is especially important when using the instrument in industrial or semi-industrial applications, where accidental contact with 120 or 240-volt AC is possible.

Normal mode rejection ratio. NMRR indicates the amplitude of AC (usually line frequency) interfering signal impressed on the DC being measured that will affect the least significant digit (see Fig. 1). The ratio of the interfering signal to the voltage represented by the least significant digit is usually expressed in decibels (dB). For example, an instrument reading 100.0 millivolts DC is specified to have 60 dB NMRR. The least significant digit indicates 100 microvolts. Thus 100 mV (100 millivolts) will not affect the reading in the least significant digit; any signal greater than 100 mV may. NMRR depends upon the instrument timing and may have to be adjusted for changes in power-line frequencies: 50, 60 or 400 Hz.

Common Mode Rejection Ratio. CMRR specifies the instrument's ability to reject signals applied between earth ground and a point common to the high and low input terminals of the instrument. There is no CMRR specification if the instrument's low terminal is at earth ground. Fig. 2 indicates

RADIO-ELECTRONICS

FIG. 1—TEST SETUP FOR NMRR (Normal Mode Rejection Ratio). Amplitude of the AC series signal is increased until the least significant digit of the display is changed.

FIG. 2—COMMON MODE REJECTION ratio is measured in much the same way as NMRR. Neither terminal of the meter may be grounded during the measurement.
the common method of measuring CMRR. The one kilohm resistor in series with the low terminal is generally included with any CMRR specification. This resistor represents a typical source of resistance of DC signals under actual measurement conditions. Current flowing in the common mode path flows through the 1,000-ohm resistance. The voltage generated across the resistor is converted to a normal mode signal, which is rejected by the instrument’s NMR. Occasionally CMRR is given less than NMR. Generally, the CMRR includes NMR. As with NMRR, CMRR is given at power-line frequencies. CMRR worsens with increasing frequency.

DC CMRR, or the floating capability of an instrument, is often limited by the breakdown of its input circuitry. This specification indicates the greatest DC potential the low terminal of the voltmeter may have above earth ground.

The AC voltmeter
Range specifications are identical in nature to those given for the DC voltmeter. The high-voltage range may have an upper voltage limit considerably less than expected from a front panel reading; 750 volts is common. Accuracy. AC voltmeter accuracy is generally given in the same way as the DC voltage accuracy. However, accuracies are normally only for measurements of sinusoidal signals with less than a specified amount of harmonic distortion (usually 1%). AC to DC converters, which are normally average or peak responding but RMS reading, require this limitation; if other than sinusoidal waveforms are measured, the accuracy specification no longer holds. This is not true if the instrument employs a true RMS converter. These are not common and are very expensive. The normal range for AC accuracy is 0.5% to 1% for the average or peak responding RMS calibrated instruments.

Most AC voltmeters specify frequency response, indicating the instrument’s ability to measure high-frequency signals, and the expected inaccuracies over a specified frequency range. The limits to AC frequency response are normally from 20 Hz to 10 kHz or 50 kHz, depending on the instrument. Input impedance specifications of the DMM should include not only the resistive value to be expected (usually 1 or 10 megohms), but also the value of capacitance between the input terminals. This is generally about 100 pF.

Response time. AC voltmeter response time includes all time specified in the DC voltmeter as well as the response time of the AC converter. AC response time may be six to ten times greater than in the DC voltmeter. Input protection indicates the amount of voltage overload which may be applied to any range without damage. A separate DC limit may be indicated to cover input coupling capacitor breakdown. Overloads from sources outside the specified frequency range of the DMM may not have as great a protection range.

Common mode rejection ratio. AC CMRR is defined and measured in the same manner as it is for the DC voltmeter.

Noise. Some of the very good voltmeters indicate the RMS value of noise contributed by the converter, the input amplifier, and any other source within the instrument. A noise specification is required only on very high resolution, sensitive instruments.

Ammeters
Ranges. Ammeter ranges are given as full scale readings, and may include an overrange specification. A number of instruments do not have extensive ammeter ranges; other meters commonly extend to 1 amperc full scale. Some instruments have DC capabilities only. Ammeter ranges vary extensively, so these specifications must be carefully read. An ammeter range may be specified as an overrange capability, therefore, a 1-ampere meter usually gives 2-ampere capability.

Accuracy. Ammeter accuracies will be slightly lower than those of the associated voltmeter, as the accuracy of the shunt must be included. The instrument accuracy may be further degraded with high-current shunts.

Voltage drop. When inserted into the circuits, the ammeter shunt causes a maximum voltage drop when measuring full-scale currents somewhat larger than the full-scale value of the lowest voltmeter range of the instrument. This may be as much as 10 or 20% higher than the voltage range, to cover resistance in series with the shunt, especially on the highest current ranges where the shunt value is usually 0.1 ohm. On very low current ranges, the shunt resistance is relatively high. For example, a 200 pA range on a 200-mV meter will have a 100-ohm shunt.

Protection. Most DMM’s have a fuse in series with the ammeter shunts that opens if the maximum current is exceeded. It is wise to note fuse types. A few DMM’s use very unusual fuses, and keeping a few spares on hand may save time and trouble.

Response time. The ammeter response time should be similar to that of the corresponding voltmeter.

The ohmmeter
Ranges. The lowest ohmmeter range on most DMM’s is higher than expected. Usually the first range is 100 ohms. A 100-ohm range will give 0.1 to 1 ohm resolution. The upper limit of the ohmmeters found in DMM’s is either 1 or 10 megohms, 10 megohms being more desirable. Ohmmeter ranges are found in decade steps between 100 and 16 megohms. All ranges have full overrange capability, so a 10-megohm meter normally gives 20 megohm capability.

Accuracy of the ohmmeter measurements is related to the accuracy of the DC voltmeter and the precision of the constant-current source. The current may be somewhat reduced for measurements on the uppermost range, but for most ranges the error is no greater than twice the DC error.

Measurement currents. Some DMM manufac-
turers only specify the current applied by each resistance range to the unknown resistance, while others specify both the current and the maximum open-circuit voltage applied to the circuit being tested. Some DMM’s have special low voltage ranges that do not forward-bias semiconductor junctions.

Response Time. Resistance measurements normally have a response time close to that of the DC voltmeter. The uppermost range, however, may have a response time considerably slower than that of the other ranges.

Protection of the ohmmeter is important, as the constant-current generator is easily damaged if a high external voltage reaches it. Protection may differ for AC and DC, and may vary to some extent with the resistance range being protected. Protection against the power line is especially desirable. Accidental contact with this high potential is not at all uncommon, and a DMM without 120-volt AC ohmmeter protection is vulnerable to extensive damage. Many DMM ohmmeter circuits employ a very small fuse as part of the protection. Once again, this fuse may be difficult to locate and obtaining a few spares is wise.

Applications, error sources
An applications section on DMM’s seems almost extraneous. After all, the instrument measures current, voltage and resistance. While this is true, there are a few special situations in which the DMM is used that are worth discussion.

Probably the first impression after using the DMM is the feeling: “How did I ever get along without this instrument?” This attitude results from increased convenience. A three-and-one-half-digit, autopolarity machine rarely needs range changes when working with most circuits. One range, such as the 20-volt one, gives all the information required. Without having to reach for the polarity switch, there is nothing to do but take measurements.

For example, a three-and-one-half-digit machine on the 10-volt range has a full-scale reading of 19.99 volts. Most power supplies of modern analog circuits can easily be checked to the nearest 10 millivolts, and the base-emitter voltage drop of transistors still checks to two significant figures (again the nearest 10 millivolts). Such measurements give much better accuracy of measurement. A DMM with 10-millivolt resolution are in the range of voltage for a forward-biased diode that changes with temperature.

Needless to say, the DMM is not without its pitfalls. Erroneous actions based on DMM readings, assuming more accuracy than exists, or readings with too much resolution are frequent. For example, instructions in one Heathkit oscilloscope manual directs the kit builder to adjust a control until voltage on the collector of each of two deflection transistors is equal; then adjust another control to set both collectors at 10 volts. A number of kit builders have found this task particularly frustrating and next to impossible. The reason: a DMM was being used which had far more resolution than called for. Adjustments were being made to the nearest few tenths of a volt which never made it within a few volts. Adding a factor of ten to the readability of a control can make the difference between one that is simple and one that is difficult to adjust.

In a similar case, an error is often made when a voltage is not exactly the value that is continued on page 82
Extra Hands For The Hobbyist

Built from commonly available parts, these devices will make printed-circuit board assembly easier and more pleasurable

WHEN ARE TWO HANDS AND TEN FINGERS NOT ENOUGH? WHEN ARE two eyes and tri-focal glasses not enough? . . . Right!--when you are working on solid-state circuits.

As parts have undergone the change from small and miniature to sub-mini and even micro, my normal-size fingers and otherwise adequate eyes have caused more and more problems. I just can't seem to be able to hold a board, a part on that board, solder and an iron all at the same time. I can't see those minute solder bridges or what's happening on one side of the board while making adjustments on the other. [In fact, I never could see around corners!]

Does all this sound familiar to you? Have you looked longingly at some of those expensive construction aids that have limited use potential? Well your frustration is over. On these pages you will find a system of aids that is as inexpensive or as expensive as you choose to make it. Best of all, it is endlessly versatile.

This system is based upon the fact that a thread size of $1/4 \times 20$ has become standard in a number of applications. As you will see, I have raided photography, science laboratory and plumbing supply houses as well as hardware stores to find parts for the system. Because of the same-size threads, all the parts are completely interchangeable. Just a few of the possible combinations are shown here.

FIG. 1—BASE SUPPORTS for the holders and viewers.

FIG. 2—CONNECTORS for attaching various components of the system.

FIG. 3—FLEXIBLE JOINTS allow exact positioning of parts.

FIG. 4—HOLDING DEVICES firmly grasp just about any type of part or tool.

EARL R. SAVAGE, K4SDS
FIG. 5—PIN VISE is converted into PC board holder by drilling and tapping.

FIG. 6—VIEWING DEVICES are a great aid when doing close-up work.

My system began several years ago and has grown as I discovered new and useful parts. Undoubtedly, I have only begun to explore the possibilities. Once you get started, you will turn up many additional useful components and combinations.

Each holder and viewer consists of certain basic parts: base, connectors, joints, and the holder or viewer, itself. Let’s look at each of these and then at some of the many ways they can be put together.

**Bases**

Several types of bases are shown in Fig. 1. The C-clamps and photography clamps (with universal joints) are very useful. They can be attached to the top of the workbench or shelf, to the lip of a cabinet or chassis, or even to a brick on the bench. The tripod with its universal head has a wide base and can be placed on any surface.

The most useful bases are of the homebrew variety. One is a rectangular block of metal cut to about 2.5 x 5 x 7 centimeters, then drilled and tapped with ½ x 20 threads. Lead blocks may be cast for this purpose. The other is a pipe cap also drilled and tapped. Pipe caps are available in many sizes and may be filled with lead to increase weight and stability.

**Connectors**

The connectors shown in Fig. 2 come from a variety of sources. Some are pieces of laboratory apparatus that will not only clamp on rods and the like but are, themselves, threaded with our standard ½ x 20.

The rods are made from sawed-off bolts, threaded rod stock and bathroom tank float rods. Various types of nuts should be in your collection. The “connecting nut,” just to the right of the hexagon nut, is especially useful. It is about 3-cm long and threaded all the way through.

**Flexible joints**

A joint of one kind or another must be used in each assembly or the device would be of very limited value. Several types are shown in Fig. 3. The simplest is, of course, a piece of heavy wire between two alligator clips.

Two different ball-and-socket joints and three tripod heads are also shown. They will permit movement in any direction. The small flexible rod is extremely useful.

Of special interest is the joint in the lower left corner of Fig. 3. It is made with two standard eye-bolts, two of washers and a bolt. This joint is quite inexpensive and versatile but not as convenient to use as a ball-and-socket or tripod head.

**Holding devices**

A number of different types of devices for holding wires and small parts are shown in Fig. 4. Several require special comment. One of the larger self-closing tweezers has been drilled and tapped on one side of the handle.

The PC board holder was made from a pin vise. Figure 5 shows how this was done. The handle was removed by pulling the holding pin. After the projecting shank of the vise was sawed off, the new base was drilled and tapped. When attached to a universal joint, this holder will position a board or other large component in any conceivable manner.

**Viewing devices**

Many kinds of viewing devices are of help to the hobbyist. A few of these are shown in Fig. 6. The 8 x 14-cm mirror is very useful for watching the results on one side of a board or panel while working on the other side. The small dental mirror will often prevent your having to disassemble equipment to check an otherwise inaccessible spot or part.

*continued on page 83*
Step-by-step TV Troubleshooters Guide

There are many, many circuits in a modern color-TV chassis. If we are to service them as fast as possible, we must know each one of them, and what they do. We also have to know what they do when they're not working. These are the "fault-reactions," and are the key clues to the location of the trouble. One of the most important (and one that the customer notices quickest if it goes bad!) is the sync separator. Like all the others, if we pick it out of the schematic and look at it all alone, it is not very complicated. It has a very simple purpose: it clips off the sync pulses from the TV signal and distributes them to the two sweep oscillators. That's all.

Most of them are now called "sync separat- ors." At first, they were called "sync clipper" which is really more descriptive. A composite video signal is shown in Fig. 1. The bottom 75 percent of its amplitude is the video signal; the top 25 percent is the sync. The sync-separator literally clips off the top 25 percent which is nothing but sync. The "sync porches" shown are at the black level; above that level the picture tube is cut off. (Actually, most sync separators are set to clip just a little above the black level. This keeps the video out of the sync, and vice versa. More on this later.) The video signal used for this is usually picked off somewhere in the video output stage. You may find that the video portion is slightly compressed; that's all right since we're going to throw it away anyhow. The sync must never be compressed. Fig. 1 shows the "clip-line" for proper sync-separation.

How do we clip the sync off? We feed the video signal into a stage which is biased so that it won't conduct at all until the signal reaches a certain level. Let's say the grid signal has a P-P amplitude of 50 volts and we want only the top 12.5 volts of it. So, we simply put a negative bias of about 37.5 volts on the grid of the sync separator tube. The tube will remain deep in cutoff until the signal reaches a voltage high enough to make the grid positive. At 37.5 volts, it will conduct only during the sync interval and neatly clip off the top 25 percent of the signal. Most sync-separators will amplify the signal; so we'll find a "composite sync" output that will run somewhere around 35-40 volts P-P in tube stages. Figure 2 shows this waveform at a 30-Hz sweep rate. Remember it. We said "tube"; transistors do exactly the same thing. Only the DC voltages are different as well as the polarity. Transistors are excellent sync-separators due to their characteristics. They love to clip.

The smaller pulses in Fig. 2 are the horizontal sync. The larger ones are the vertical sync. These can be hard to see in some cases, but look for them. They'll usually make a notch in the top of the composite sync waveform.

Having clipped off the two syncs, we now have to get them to the proper sweep oscillators—vertical and horizontal. This is easy: we take advantage of the fact that we have a very low-frequency sync, at 60 Hz for vertical, and a high-frequency sync at 15,750 Hz for horizontal. These can be separated quite simply. (In fact, the actual "separation" of the syncs into individual parts is done in the sync-separator output circuit, by the components shown in Fig. 3.)

The vertical sync is cleaned up by feeding it through an RC network. This is an integrator. (If you want to go far enough back into basics, the vertical sync pulse is actually made up of quite a few horizontal sync pulses! This circuit puts them back together so that the output is one clean sync pulse at the vertical frequency.) It does that by developing a charge on the shunt capacitors and discharging through the resistors. The high-frequency horizontal sync pulses see a very low impedance in the shunt capacitors, so they are grounded.

The horizontal sync is even simpler. All we have to do is feed it through a very small coupling capacitor that offers a very high-impedance to the low-frequency vertical sync, which doesn't get through. We get enough of the horizontal sync through to do the job. This is how it works, when it's working. Now let's see what can happen to it and what symptoms it causes when it's not working. Knowing the fault reactions is very important in finding out what's wrong.

Normal reactions.

We have two different types of reaction in the vertical and horizontal sync circuits. The horizontal sync "works on phase." It's fed into a phase detector where it's compared to a reference pulse from the oscillator output. If the phase is different (oscillator trying to go off-frequency) the phase detector develops a small DC correction voltage. This is applied to the oscillator to pull it back in phase. It doesn't take a great deal of sync voltage to make it work.

The vertical sync is different. The oscillator is actually fired or triggered by the sync itself. The oscillator will have a stage with a gradually rising voltage curve. The sync comes in on this curve so that it fires the oscillator just a split microsecond before it would normally trigger itself. This makes the oscillator lock with the sync. In the absence of sync, it can free-wheel.

This gives us one of our key reactions to help us locate the cause of the trouble. If a fault in the sync-separator causes a loss of sync amplitude, you will see this show up as a vertical sync problem long before the horizon- zontal sync is affected at all. It's possible to lose much vertical sync that the picture won't even try to lock, yet the horizontal oscillator will be quite stable.

This is one of the easier ones. A weak tube, a leaky transistor, an off-value resistor or leaky capacitor, and you can lose sync amplitude. In older sets with separate parts in the integrator, the shunt capacitors usually leaked and pulled down the sync amplitude. The newer type integrators can do the same thing if they're defective, so check them if this kind of trouble is found.

Since the horizontal sync circuits are so simple (one little coupling capacitor), loss of horizontal sync is also pretty simple. If the coupling capacitor isn't open, the conductors on the PC board may have a hairline crack somewhere between the sync-separator out-
Faults in the horizontal and vertical sync circuits can be isolated quickly if you know the symptoms and follow a logical step-by-step troubleshooting procedure.

JACK DARR
SERVICE EDITOR

Typical symptoms

The Well-Calibrated Eyeball can be quite

TROUBLESHOOTING CHART—Sync circuits

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<thead>
<tr>
<th>LOSS OF VERT SYNC ONLY</th>
<th>LOSS OF BOTH VERT &amp; HORIZ SYNC</th>
<th>LOSS OF HORIZ SYNC ONLY</th>
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<tr>
<td>CHECK RASTER CONTROLS FOR OVERSCAN</td>
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<td>SCOPE SYNC-SEP OUTPUT FOR CORRECT AMPLITUDE OF COMPOSITE SYNC</td>
<td>TUBE-TRANSITOR GOOD NO HELP SYMPTOMS</td>
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<td>CHECK VERTICAL INTEGRATOR FOR LEAKY CAPACITORS, DRIFTED RESISTORS</td>
<td></td>
<td>CHECK CONTINUITY FROM SYNC-SEP OUTPUT, CHECK COUPLING GAP</td>
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</table>

Put and the center tap of the AFC diode unit. A good quick-check for this is to take the diode unit out and check on the center terminal for the horizontal sync pulses. Cold solder joints are a good cause for this, too.

Let's pause for a moment. Note that I have frequently mentioned the use of a scope. This is because the scope is the only instrument you can use in these circuits to actually measure and verify the presence of the syncs. The DC voltages are important, of course, but the scope is the only instrument that will tell you exactly what is happening and where the trouble is. There are several eyeball tests that are very handy, which we'll get to soon, but for the formal analysis and fault-location you must use a scope until someone develops an IC instrument with a readout that says, in a sweet recorded voice, "You have 27.9 volts of vertical sync at this test point, with a slight distortion of the top."

A help. Look at the picture and move the two hold controls to see what they do. If both controls have the normal effects on the picture, the sweep oscillators are working. If you have only one picture visible, but it floats up, down or sideways without locking, you have lost all sync. Since this is obviously a complete loss of both the horizontal and vertical sync, you check the only stage that handles both of them at once—the sync separator.

If the vertical sync is weak and unstable but the horizontal sync is good, this could be due to a loss of sync amplitude. Scope the sync-separator output and check the P-P voltage. This isn't shown on all schematics, but a ballpark figure for tube sets is something like 20-40 volts P-P. If this voltage is up to normal or close, the vertical sync is OK at the integrator input. Follow it through to the integrator output. This can be done much more easily if the vertical oscillator is disabled. Ground the grid of the output stage after turning the brightness down. Now you can see if you are getting any vertical sync at all through the integrator. Polarity of the vertical sync is determined by the point where it is fed into the oscillator. If it goes to a grid, it's usually positive going; to a plate, negative going.

If the integrator output is too low, lift one of the legs and the ground. It can be checked with an ohmmeter. Normal resistance end to end will be somewhere around 1800k, give or take a few. From either end to the ground terminal, a very high resistance. A low resistance reading here indicates leakage in the shunt capacitors. Too much resistance end-to-end indicates a bad resistor. If the integrator goes up to 2-3 megs, you'll lose sync amplitude.

Caution: before making any tests for vertical sync, check the vertical size and linearity controls. If these are set so that the raster is overscanned too much, you'll have a case of "fake sync trouble." This distorts the oscillator waveform at the firing point so that the sync can't trigger it properly. Set up the raster so that it is overscanned not more than 1/2-inch top and bottom, then go on with the troubleshooting.

Eyeball test. With the vertical hold control, roll the picture slowly downward. When the blanking bar gets to a point about two inches from the bottom of the screen (minimum), the picture should snap into sync momentarily then keep on rolling. That snap indicates that vertical sync is present. If the picture rolls smoothly on through from the bottom without even slowing down, there is no vertical sync.

Second clue: Due to the nature of the waveform, the picture should lock-in when the hold control is turned the opposite way, until you reach the "break-out" point. It should then go upward very rapidly. This is common terminology, because of this reaction a picture going down is "rolling," and one going upward very fast is "flipping." Try this on a working set and you'll see. If you can make the picture go upward very slowly, once again you have no vertical sync at all. Start with the composite sync; if it's present check the integrator.

Horizontal sync

The horizontal sync has a different kind of reaction. Most of the troubles in horizontal sync turn out to be due to bad parts in the oscillator or AFC. If you do have one of the rare cases where there is a loss of the horizontal sync pulse, the reaction will be like this: the oscillator will make a single picture. The hold control will make this "set up" and maybe even hold for quite a few seconds. However, when you move the horizontal hold control even a little bit in either direction, out you go. Normal reaction should be a good hold for quite a bit of rotation of the hold control before it falls out.

Make this check. Kill the horizontal AFC by grounding the AFC grid of the oscillator, or the AFC diode unit in transistor sets. Now, adjust the horizontal hold control until you get a single straight-sided picture that will hold momentarily, though it will drift slowly from side to side. This tells you that the horizontal oscillator is able to run on frequency, and is reasonably stable. Take the ground off the AFC and the picture should lock in tight and hold for quite a bit of rotation of the hold control. Check for stability by changing channels; this interrupts the horizontal sync. However, if the picture falls out of sync when you put the AFC back, there is an AFC problem.

Unbalanced AFC diode units cause most of these problems. It's faster to take the old one out and put in a new one. If this clears it up, fine. There are three types of AFC diode units—common-cathode, common-anode and series. It is much better to use an exact duplicate of the original! If it gets worse after you replace the diodes, make sure that you got the correct type! The first two are not polarized; the series type definitely is!

Odd sync problems

If the sync seems to be fairly steady, but the picture jitters in either direction, you could have a fault in the sync separator. Once again you'll have to use the scope. This can be caused by incorrect clipping action, which lets some of the video signal get through with the sync. Sync must always be clean pulses; the video signal is constantly varying and it is this variation in the sync that causes the jitters. Check all DC voltages on the sync separator. If the set uses a noise-canceller circuit, check the setting of the control. If it is set too tight, instead of punching out noise pulses, it punches out most of the sync as well. Set it completely off and see if that helps.

Thermal drift of resistors in the sync-separator stage can cause problems like "It continued on page 81"
Automatic Noise Blankers—How they work

Many circuits have been developed and incorporated into CB transceivers to automatically reduce noise. Here's an in-depth look at several of these circuits and how they work.

ROBERT F. SCOTT
TECHNICAL EDITOR

In an earlier issue, we discussed automatic noise limiters and described typical circuits as used in CB radios. We saw how noise—either "hash" or hiss on one hand and impulse-type noise pulses on the other—is limited in audio circuits so it does not exceed the level of audio signals resulting from the detection of RF carriers with an average percentage of modulation.

Figure 1-a is a representation of a 100% modulated carrier with superimposed noise pulses. For the convenience of illustration, the noise pulses are held down to about twice the level of the modulated carrier. Actually, noise may be hundreds or thousands of times stronger than the desired signal.

Figure 1-b shows how a noise limiter—adjusted to clip at the 100% modulation level—clips noise peaks so they do not exceed the amplitude of the audio signal recovered from the incoming Citizens band signal.

The automatic noise limiter is most effective in combating hiss and "hash" which are composed of continuously overlapping random pulses of the type generated by neon signs, small electric motors and power-line leakage. The automatic noise limiter circuit is usually set to a level corresponding to 70-80% modulation. Remember, however, that the interference cannot be completely eliminated, it is simply limited to a level where it does not make the average incoming signal totally unreadable.

Impulse noise is generally produced by electrical circuits. The noise peaks often have very high amplitudes with durations seldom exceeding 50 to 60 microseconds. The repetition rate may vary from spasmodic to a continuous 400-Hz.

In addition to having an adverse effect on signal readability, high-amplitude noise pulses develop AGC action that desensitizes the receiver. In some cases, when the noise level is high, receiver sensitivity is reduced until only the strongest signals can be received.

Although the duration of the average impulse-type noise pulse may be less than 25 microseconds and seldom exceeds 60 µs, some pulses are of longer duration. One unfortunate characteristic of impulse noise is that a very narrow pulse is delayed and broadened as it is passed through highly selective circuits. The greater the circuit selectivity, the more the pulse is stretched and delayed.

FIG. 2—IMPULSE-TYPE NOISE PULSE is shown in upper trace. Middle trace shows noise pulse after it is amplified by IF amplifier with a 5-kHz bandwidth. Lower trace shows effect of IF amplifier with a 2-kHz bandwidth.

FIG. 3—NOISE BLANKER uses a gate in series with the IF signal. Gate opens for duration of noise pulse.
FIG. 4—NOISE PULSES superimposed on carrier is shown in a. Output of IF amplifier with noise blanker operating is shown in b.

FIG. 5—NOISE BLANKER CIRCUIT used in the Midland model 13.882C.

FIG. 6—NOISE BLANKER CIRCUIT used in the Pace model CB145.

This is caused by amplifier overload and ringing in the tuned circuits.

Figure 2 is a representation of an impulse-type noise pulse (top trace) as it is delayed and lengthened by IF amplifiers with 5- and 2-kHz bandwidths. We can see that as selectivity is increased, the pulses are lengthened.

How noise blankers work

The noise blanker—also called an RF or IF noise silencer—is most effective when combating impulse-type noise. It is a concept developed by J. J. Lamb and described in the technical press early in 1936. Basically, the noise blanker (Fig. 3) taps off a portion of the incoming signal close to the receiver input—before it gets to the highly selective IF circuits. Filters and detectors extract the noise peaks which are shaped and amplified. The pulses are then polarized so as to open a gate in series with the IF signal path for the duration of the noise pulse.
The duration of the individual noise pulse is very short compared to the interval between pulses. Thus, the receiver is silenced or muted during the noise period. The upper trace in Fig. 4 represents a modulated carrier with high-amplitude noise pulses superposed. Figure 4-b represents the signal at the output of the IF amplifier with the noise blanker operating.

**Practical noise blankers**

The noise blanker used in the Midland model 13.882C is one of the simplest that we've seen (Fig. 5). It is connected between the outputs of the first and second mixers. The composite IF signal and noise voltages are picked up at the output of the first mixer. A voltage doubler-type detector strips the noise pulses off the incoming signal and shapes and feeds them to Q1, the noise pulse amplifier. Q1 is biased so it conducts only during the duration of each noise pulse. As it does, Q2 is driven to conduction so it appears as a momentary short circuit across the primary of the first IF transformer.

In this application, the noise signal is tapped off a wideband 10.695-MHz IF transformer whose selectivity is not great enough to appreciably delay or broaden the noise pulses.

Figure 6 shows the noise blanker used in the Pace model CB145 transceiver. The signal at the collector of the first mixer is the IF composed of 23 discrete frequencies centered around 10 MHz. A portion of this signal is amplified in the first IF amplifier and then fed to the 1N60 noise-gate diode (D4) in series with the primary of the 455-kHz IF transformer.

A portion of the signal at the first mixer is passed through L-C filter networks to accentuate the noise and then fed to the noise-amplifier IC where it is amplified still further. Noise amplifier Q1 feeds the noise signal to a voltage-doubler-type pulse detector.

The noise information is detected and shaped and fed to the anode of noise gate D4. When a negative-going noise pulse reaches D4, the diode cuts off for the duration of the pulse so that noise on the IF carrier cannot be further amplified and detected to adversely affect readability and receiver sensitivity.

**A pre-IF noise blanker**

The Tram model D201 base transceiver uses the noise blanker in Fig. 7. Noise is picked off the antenna input and is detected, amplified and rectified to develop signals that ground the input to the first mixer.

Noise is picked up from the primary of the antenna transformer and fed through a capacitance network and a 25-MHz RF transformer to the NC1350 IC used as a high-gain 25-MHz amplifier. The amplified 25-MHz noise signal is fed to the base of Q1. This transistor is normally biased to cutoff by the voltage drop across the 2.5K potentiometer in its base circuit. Positive-going noise pulses turn on Q1 and turn off Q2 so its collector swings to $V_{cc}$ (+ 14 volts DC). This 14 volts, dropped through R3, is fed to the base of Q3. Transistor Q3 turns on instantly and the voltage on its collector drops to zero.

Normally D1 is back-biased and is not conducting. As Q3's collector approaches zero, the reverse bias is removed from the noise-gate diode. Diode D1 now appears as a closed switch that shunts all signals to ground through transistor Q3 for the duration of the noise pulse.

By detecting the noise pulse at the antenna terminals, ahead of the selective and high-gain circuits in the receiver, noise-pulse delay and duration are kept to a minimum.
Digital techniques are not only at work in sophisticated telephone switching centers but are finding their way into home and office telephone equipment as well. Off-the-shelf integrated circuits can be wired into a standard telephone to convert it to keypad operation. Not the same as Touch-Tone, the system simulates the sequential pulsing of the dial mechanism it replaces. Redialing capability is built in and expansion to repertoire and many other features are possible.

Binary to phone-pulse converter

The new Motorola MC14408/MC14409 IC's take a parallel binary or BCD input and produce a chain of output pulses compatible with conventional telephone circuits. Parallel input data originates from digital control electronics, keypads or memory circuitry. The number of output pulses is equal to the normal 1-2-4-8 weighting of the 4-bit binary input with one exception. Input codes 0001 (1n) through 1001 (9n) produce one through nine output pulses, respectively. The exception is 0000. This does not produce zero pulses but transforms to ten pulses corresponding to the operation of the zero on a telephone dial.

Figure 1 shows the MC14408/MC14409 pulse-converter wired to the companion MC14419 2-of-8 keypad-to-binary encoder. The MC14419 scans a keypad with up to four rows and four columns of switches and converts contact closures to the appropriate 4-bit encoded outputs.

The pulse converter has an on-chip oscillator that is tuned by an external L-C network. The oscillator frequency determines the dialing rate. When adjusted to 16 kHz, the oscillator output is divided for a 10 pulse-per-second dialing rate. Doubling the frequency to 32 kHz doubles the dialing rate to 20 pulses-per-second. One of the two oscillator pins is the clock output that drives the clock input of the MC14419.

Keypad switches mechanically oscillate or bounce when they are closed. There is a time interval measured in tens of milliseconds after the initial switch closure during which the contact status is indeterminate. Debounce circuitry must be used to delay the sensing of the switch to ensure reliable operation. Time delays are conventionally generated by monostable timing circuits or by defining time intervals with digital frequency divider chains. Driving the clock input of the keyboard-to-binary encoder with the output from the pulse-converter oscillator provides the necessary debouncing.

Valid input data is indicated by a positive going pulse on IC2 pin 3. When IC1 switches this lead high, IC2 reads the data encoded on the four input lines. The four-bit word is entered into a memory register. Classified as a FIFO (First In, First Out) memory, the digits are recalled and transmitted in the same sequence in which they were entered. The digits are stored until a new number is keyed in. When redialing the number, the stored number is recalled and transmitted without re-entering it. If the called number is busy or the call is interrupted, IC2 pin 10 is switched low causing the redial operation. The pulse on pin 3 enters each digit up to a maximum of 16. If more than 16 digits are entered, the circuit ignores them.

FIG. 1—PHONE DIALER uses two IC's to drive a standard rotary-dial telephone line from a keypad.
FIG. 2—AUTOMATIC VOICE ACTUATED SWITCHING circuit switches car speaker from broadcast radio to CB transceiver when a CB call comes in.

![Diagram](https://via.placeholder.com/150)

FIG. 3—HYSTERESIS CHARACTERISTIC of Schmitt trigger.

One possible feature prompted by the redialing capability is an automatic resequencing arrangement. External logic can be designed so reception of a busy signal will continually trigger redialing until the call is completed.

The MC14408/MC14409 IC's include a facility for controlling the interdigit pauses. Raising the voltage on pin 9 inserts pauses between the digit pulse-groups. The pause does not take effect until any in-progress digit pulsing is completed. More complex systems use this feature to lengthen the interdigit pauses according to specific requirements.

The output pulse-train appears inverted on IC2 pin 11. Typically, it drives the base of a transistor that replaces the telephone dial contacts. This transistor also inverts the pulses to the correct polarity.

Interdigit timing is controlled by the logic level on IC2 pin 14. When pin 14 is at a logic 0 level, the interval between digits is 300–400 milliseconds at the 10 pulse-per-second dialing rate and 150–200 ms at the 20 pulse-per-second rate. Connecting pin 14 to V<sub>DD</sub> (the positive supply) increases the interdigit interval to 800–900 and 400–450 ms, respectively.

The make-break ratio (duty cycle of the output pulse-train) is determined by the voltage on pin 15. When pin 15 is tied to V<sub>DD</sub>, the duty-cycle is 33 percent. Connecting pin 15 to a logic 0 level changes the duty-cycle to 39 percent.

Differences between the MC14408 and MC14409 relate to the output of pin 12. This output indicates that a dialing sequence is taking place. The MC14408 keeps pin 12 high over the full dialing sequence while the MC14409 switches to a low level between digits.

The power supply voltage is connected between pins 16 and 8 and can be 3–6 volts over the -40 to +85 degree Celsius temperature range. Current drain of the MOS (Motorola CMOS) is low, under 550 microamperes with a 5-volt supply.

The circuits are packaged in plastic or ceramic DIP's. Quantity pricing is $6.98 for plastic and $9.08 for the ceramic package in quantities of 100 to 999 units. More information is available from Motorola Inc., Integrated Circuit Division, Technical Communications Group, 3501 Ed Bluestein Blvd., Austin, TX 78721.

AVASC system

Mobile CB'ers often want to monitor a channel while listening to their broadcast receiver, tape deck or whatever. Project Support Engineering has developed an automatic voice actuated switching circuit (AVASC).

Figure 2 is the schematic of the unit which connects between the CB and the audio output terminals of the broadcast radio, and the automobile speaker. It gives priority to the CB set by disconnecting the broadcast radio whenever the audio output from the CB radio is above a variable threshold.

The six inverter-like symbols in Fig. 2 are the six Schmitt triggers in the single 74C14 hex Schmitt trigger IC. Inside each of the triangular symbols is a representation of the two-state hysteresis characteristic of the Schmitt trigger circuit. Figure 3 shows this characteristic. The output voltage is either 0.22 or 3.3 volts over the full input voltage range except for the short regenerative switching times (vertical traces). Between the 1.7-volt positive-going threshold and the 0.8-volt negative-going threshold, the output can be either of its two stable states depending on the previous input.

Assume the output voltage is high and input increases towards 1.7 volts along the upper horizontal line in Fig. 3. When the input equals or exceeds 1.7 volts, the device switches and forces the output low as indicated by the arrow on the vertical line on the right. Once this state is reached, the output will not return to the high state until the input drops to 0.8 volts along the lower horizontal and leftmost vertical lines.

Referring back to Fig. 2, the first Schmitt trigger (IC1-a) detects the audio output of the CB receiver. Feedback around the stage is a convenient method of controlling input sensitivity. The sensitivity control varies the amount of feedback. Sensitivity is adjusted similar to squelch so that noise is just below the trigger level. CB receiver squelch will actually take care of the noise problem making this a noncritical adjustment.

The output of the first stage is rectified by D1 and stored in capacitor C1. Notice that the polarity of D1 is such that detected signals pull the capacitor voltage toward ground. To delay the circuit recovery, the diode acts as a peak detector and the capacitor is returned to the +12-volt supply through the 2-megohm delay potentiometer and 470,000-ohm resistor. The delay circuit keeps the CB output connected to the speaker from 0–15 seconds after the circuit is activated so that pauses or drop outs do not result in truncated syllables. The peak detector action pulls the capacitor quickly toward ground and then rises more slowly when the detector diode is back-biased. Increasing the resistance of the delay control decreases the charge rate and increases the time delay before the circuit switches back to the car radio.

From capacitor C1, the signal moves on to IC1-b and then the paralleled group of the four remaining Schmitt triggers. Relay R1 is driven by the increased current capacity of the paralleled devices. The relay coil is connected to the positive supply and pulls in when the outputs of IC1-c through IC1-f are low.

Suggested retail price for the AVASC unit is $29.95 and inquiries should be directed to Project Support Engineering, 750 N. Mary Ave., Sunnyside, CA 94086.

Microcomputer update

Ohio Scientific Instruments has formally released their
protoyping and development systems for the MOS Technology 6502 and Motorola 6800 microprocessors. The line includes CPU, 4K RAM, I/O, video graphics, floppy disk and prototyping boards.

The $29 model 400 (board and documentation only) is an 8 × 10-inch board that can be equipped with a microprocessor, 1024 bits of RAM, and a front panel in its minimum configuration. It can be expanded to include 512 bits of ROM, an RS232 or TTY interface, and a 1/O Peripheral Interface Adapter. The $139 model 412-A version has a 6502 microprocessor, eight 2102 memories, a monitor PROM and a teletype interface.

The model 420 Memory Board is equipped with 4096 of either 8- or 12-bit words built up from 2102 memory ICs.

They also have a unique learning plan in which you start out with their model 315 Computer Trainer and then trade it in for a kit of computer system boards. The company is developing high-level languages, subroutines and games. For more information, write Ohio Scientific Instruments, 11679 Hayden Street, Hiram, OH 44234.

New modules have been added to TI's Microprocessor Learning System. A total of four modules are now available including the basic microprogrammer.

The LCM-1001 Microprogrammer Module uses Texas Instruments 4-bit slice parallel-processor with manual stepping and LED monitor indicators. Microinstructions are stored in the LCM-1002 Controller Module. Each microinstruction is made up of 8 or 16 microinstructions. Instructions are stored in a 256 × 20-bit PROM distributed on 5 ICs. The LCM-1002 has a memory data register, instruction register and a program counter. Random Access Memory is contained in the LCM-1003 Memory Module. The read/write memory is organized into 1024 12-bit words. The third add on is the LCM-1004 Input/Output Module with four 4-bit input and four 4-bit output ports.

Details are available from Texas Instruments Incorporated, Inquiry Answering Service, P.O. Box 5012, M/S 308, Dallas, TX 75222.

Switching regulators

Switching regulators have long been recognized among the most efficient methods to regulate power. Practical systems tend to get complicated and once again the integrated circuit has come to the rescue.

ARINC ACROSS CAPACITOR

I keep getting an arc across C123 in this Admiral 14K2085S-9 chassis. This is the capacitor on the bottom of the high-voltage winding of the flyback. I replaced it with a 0.004 but it still arcs over.—S.G., Franklin, NC.

Your best bet would be to replace the capacitor with either an Admiral part or an exact replacement; for example, Centrabab's GAP-4102 should do. Also, check the high-voltage rectifier tube just for luck.

(Feedback: "It was a bad 3DF3 high-voltage rectifier tube. I got an exact replacement part for C123, and all is rosy now.")

METER CAUSES HIGH-VOLTAGE LOSS

After finding several other problems in a Philco 3CR41 hybrid (some other technician had been at it), I tried to check the horizontal output tube cathode current. When I put the milliammeter in series, I lost the high voltage and everything.

Silicon General's SG1524 has all the control circuitry for a switching regulator on the single 16-pin IC. Figure 4 shows the block diagram of the device. The IC has an internal 5-volt reference regulator. An externally tuned R-C oscillator is the timebase for the system and provides pulse outputs for driving external switching transistors. A second signal from the oscillator is sawtooth shaped to form an input to the comparator.

found the problem in the low-voltage regulator circuit. Are these really critical? Still don't know why my meter killed the high voltage.—G.B., APO, Seattle, WA.

The easy one first: your milliammeter killed the high voltage because it needs something like a 0.5 μF bypass capacitor across it. In quite a few sets, the inductance of the meter coil is evidently enough to upset this circuit.

Second question: Yes. All of the low-voltage supplies in these hybrid sets are critical. That's why they use the regulator circuits. Operation is directly proportional to the value of the low DC voltages, especially in sets with solid-state horizontal output stages.

VIDEO DETECTOR FAILURE

The video detector diode goes out after about a week of operation on this G-E. I've checked everything I can think of with no success. I seem to remember reading something about this a good while ago.—J.M., Nashville, TN.

You did read this, and this is the place. I ran into the same problem quite a while ago, in the same set. The cure is to replace the diode with a high-voltage RCA type 125844.

You'll find the same problem in some small solid-state Truetone sets, too. In these, the detector diode is inside the last IF shield can. (Never did find out why these diodes blew out!)

BOOST-BOOST VOLTAGE LOW

I have a weird problem. My B+ voltage in this set ought to be +1100 volts, and it's only about +700 volts. The boost voltage is normal at about +850 volts and the high voltage and sweep are OK. I don't understand it.—P.Q., Detroit, MI.

I don't either, but here's a suggestion. Check to make sure that you have installed that boost rectifier correctly. If it's backward, you'll get just this symptom. (If you have done this, you owe me fifty cents royalty; I invented this trick several years ago.)

(Feedback. "Here's fifty cents.")
Focus troubles

Out-of-focus circuits

JACK DARR
SERVICE EDITOR

THE CLINIC MAILBAG HAS BEEN PACKED lately with quite a number of problems that are obviously in the focus circuitry. Oddly enough, checking my reference books shows little coverage on this. This is a very important part of the set. Even more important, focus problems can cause symptoms that can mislead you.

Example: If you lose the focus voltage completely, the raster will be absent though the high voltage will probably still be up to an acceptable level. If you forget this fact, you may be running around checking the picture tube bias voltages and so on for some time.

While we're here, let's clear up a common misconception. This is "I get good focus on a close-up shot but on a long shot it's not focused." This isn't possible. All the focus voltage does is focus the raster. If you can see the horizontal scanning lines sharp and clear, the focus circuitry is good. It makes no difference whether the picture is a closeup or long shot. If you hear this complaint from the customer, check the raster; if the scan-lines are sharp at all times, there's no focus problem. The discrepancy between a closeup and long shot is due to the lens of the TV camera.

With that out of the way, let's look at the two major circuits used to obtain the focus voltage in color TV sets. The old original circuits use a small rectifier tube; IV2, etc. The rectifier tube is fed from the high-voltage pulse developed at the plate of the horizontal-output tube. This pulse has an amplitude of at least 5–6 kV. The pulse is rectified and filtered and used as the source for the focus voltage. Normal should be between 4500 and 5500 volts. Figure 1 shows a typical circuit. Focus voltage on most of the larger picture tubes must be from 16.8- to 20-percent of the high voltage.

Here's a handy-dandy clue that is obtained with two simple measurements. Since the high voltage and focus are always fed from the same source (the pulse from the horizontal-output tube), if you find a set that does have high-voltage but no focus voltage, you can instantly eliminate everything but the focus circuit itself, which has about 6 components. This works the other way, too. If you have normal focus voltage but no high voltage, you have a problem in high-voltage rectifier alone; only about 3 components here. This will apply to practically all tube and hybrid sets, and to many solid-state sets. The focus coil shown in Fig. 1 should really be called a focus transformer, but no one does. This circuit works by comparing the phase relationship of two pulses in the windings, it holds the focus voltage down to the proper value. One set of pulses is taken directly from the flyback. So, if you find a set with all the symptoms of a shorted flyback, such as high cathode-current in the horizontal-output stage, and so on, be sure to check the focus coil before you replace the flyback. The test is easy. Disconnect the two leads going to the flyback (marked "X" in Fig. 1), turn it on and recheck the current. If the current goes down and the high voltage goes up—the focus transformer is shorted. The focus voltage will rise to about 5500 volts and the chances are you'll have a pretty well focused raster.

One of the more common troubles is burning up of the focus-rectifier tube socket. Some of these are very hard to fix; the optimists riveted them in. Now there is a fast-fix for this. Clear up the mess and cut the heater leads. Tape these well and put them away. If there is a contact or two left on the socket, move the plate supply lead to it. If not, install continued on page 68
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a terminal strip. Now, just hook in one of the solid-state focus rectifiers and away you go. The only thing to watch is clearance from ground so that it won't arc. It also helps to install the new rectifier with the right polarity.

The solid-state rectifiers are used in all solid-state sets and quite a few hybrids. These are made of great many tiny selenium diodes stacked on one another in a very small tube. It is possible for a number of these diodes to short or develop leakage. If this happens, the focus voltage will go away down although the high voltage will stay up. This gives you the typical symptom of no raster, but great globs of fuzzy color moving around on the screen. You'll probably find the focus voltage down to around 2,000 volts. The globs of color are the objects in the picture, very badly defocused.

One more problem that can be a fooler. If the picture defocuses (loses the scanning lines) only in white or highlight areas that gets worse as brightness is raised, this is not a focus problem. It's quite apt to be a very weak picture tube; brightness is apt to be quite low at the same time. For a definite test, read the focus voltage. (I should have said this before, but focus voltage should always be read with a high-voltage probe, so that you do not load the circuit too much.) Check the picture tube for emission.

Some time ago, while looking for a cheaper way (or trying to get around a patent) another focus circuit showed up. This was pretty simple in theory; a huge voltage-divider was connected right across the high-voltage supply to ground, and tapped off the focus voltage. A good sized variable resistor was included so the focus voltage could be varied. To avoid loading the high voltage supply, these resistors are up into hundreds of megohms; 250–400 megohms is typical with a 15-megohm variable for adjustment. In some, high-value fixed resistors were added below the focus control, with instructions to jumper across them if the focus voltage couldn't be set high or low enough. If this circuit is "designed in", OK; however, I wouldn't recommend doing this in cases where you can't get the focus voltage right. The divider is almost sure to be defective if the high voltage is correct. Figure 2 shows this.

The first of these were made up of small resistors in series. (One friend assured me with a straight face that they contained 27 million 470-ohm resistors...)

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FIG 2

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**How much focus?**

One reader had a problem in the focus circuit. He had about 20 kV of high voltage, and the focus read about 1.5 kV (His was a small set using a 10VABP22 picture tube.) For some reason the focus voltage was not given on the schematic; it used a divider and was marked “Do Not Measure.” This is nonsense since it can always be read with a high-voltage probe, just like the high voltage. Anyhow, the 10VABP22 tube spec’s showed 20 kV for typical operation, with focus voltage between 3200 and 4300 volts. So, this one was easy; didn’t even have to wipe off the crystal ball. I recommended replacing the focus divider resistor. If you run into a similar situation, with an unfamiliar picture tube, check the spec’s in the book to make sure.

**Intermittent focus**

The focus circuit is normally considered a “dry circuit”—no current flow. There is a very small current in the 66-megohm resistor used in the older circuit, and a small current through the focus divider. However, the picture tube’s focus electrode acts like a grid—continued on page 74
The best way to qualify for top positions and top pay in electronics is obviously with college-level training. The person with such training usually steps more quickly into an engineering level position and is paid considerably more than the average technician who has been on the job several years.

A regular college engineering program, however, means several years of full-time resident training—and it often means waiting several years before you can even start your career. This, of course, is difficult if you must work full time to support yourself and your family.

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SERVICE CLINIC
continued from page 69

all it needs is a high potential to develop the correct field.

You can have intermitents here too, as in any other circuit. The key clue will be defocusing of the scanning lines. Check the focus voltage at the source to see if there is any variation. One possible cause of this is burning of the series resistor used between the focus-voltage source and the picture tube. In one system the voltage is about 4.7 megohms. There is normally a very small drop across this, mainly due to meter loading. However, if this breaks down and almost opens up, it can cause problems. This is easy to check, by taking a reading from pin 9 on the picture tube socket to the focus voltage source. If it's high, change it.

Another oddball is intermittent loss of focus, though there is no change in the supply. In one case, this happened at intervals of almost exactly 1.5 seconds. If you run into this, pull the socket off the picture tube and check the focus pin which is usually pin 9. If this shows a light-greenish powdery substance, look out. Check the socket contact and clean it. This is some kind of weird oxide that forms on conductors carrying a high voltage. It is mildly corrosive and will cause a high (and variable) resistance

**Figure 3**

G1 (30V)
G2
G3-FOCUS ELECTRODE
G4 (25KV)

CATMODE
(+30V)

VERY CLOSE SPACING

FIG 3

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between the socket contact and the base pin. If you can't clean up the socket contact, you should replace the socket. This was the cause of the 1.5-second flashing just referred to, and it has been known to cause other focus problems.

**High focus voltage**

Speaking of oddballs, some of you may remember a Clinic a while back. It dealt with a case in my own shop. There was intermittent loss of focus, and I read more than 10 kV on the focus on two different voltmeters with high-voltage probes. (The first thing I suspected was my meter.) I wrote this up and asked for ideas on where the double focus voltage was coming from. I got a lot of answers. There were quite a few different solutions, all of them entirely possible.

It turned out that the 66-megohm glass-film resistor was open with definite signs of arcing between 2 or 3 turns of the spiral. However, the same symptom showed up with this resistor completely out, and then with a new resistor. All other parts checked out by substitution. Some time during the proceedings, the trouble disappeared, and after cooking, the set was sent home and is still working.

Later, after the column was published, I discovered something about the construction of color picture tubes that I honestly did not know. (Of course, this takes in a wide area, but I had never had occasion to look it up—found it while looking for something else, as usual.) Figure 3 shows the design of the electron guns in the standard color picture tube. G1 is the control grid, G2 the screen and G3 the focus "grid." I knew what the DC voltages should be on these. Now, here's the one I didn't know. Look at G4, which is very closely spaced to G3. The DC voltage on G4 is 25,000 volts! I was always under the vague impression that the high voltage was applied only to the shadow mask, screen and inner dag coating.

So, here was a very likely explanation of the source of the high voltage on the focus. There was a particle short between G4 and G3; somehow, I accidentally managed to blow it off or knock it loose. Aren't they simple after we find out what happened? Thanks very much to all of the nice guys who wrote in about that.

So there you are. In cases where you seem to have high-voltage problems, always remember to check the focus voltage. You can do it at the same time you're reading the high voltage since you should always use the high-voltage probe anyway.

One more thing. The newer sets using voltage triplers and quadruplers for the high voltage usually pick off the focus voltage from a tap on the tripler. The same tests still apply.

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*R-E*

Readers Questions on next page

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I'm having trouble keeping an RE-315G transistor working. It returns to its original condition after running for a few minutes. I've changed it three times in two months. I've noticed that the car's electrical system is running hot, and I suspect that my RE-315G transistor is the cause. I have no idea if it could possibly be the cause. Can you see why this is happening?

I have no idea if it could possibly be the cause. Can you see why this is happening?

This RCA KC-156A chassis has me stopped. I haven't had much experience with this kind of equipment, and I'm not sure how to proceed. Can you help me?

The RCA KC-156A chassis has me stopped. I haven't had much experience with this kind of equipment, and I'm not sure how to proceed. Can you help me?

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as a diode. The DC voltages (0.2 volt) from base-to-emitter indicate that this one should be a germanium type. The number probably should be 2SD65. Try a new one here; if this is bad it could be killing your emitter followers.

(Feedback: "Bingo. Actually, I took the audio driver transistor, which is a 2SD64, tried it and the thing works fine. Subbed G-E-59 for the audio transistor, and it works too.")

**AFC DIODES ACTING UP**

Here's one for your dog files. An Electrohome C-7 came in with the classic symptoms of AFC trouble. So I checked the AFC diodes. Fine. Checked all the other parts, comparison pulse, sync, etc. No dice. Came coffee time and I pulled the cheater cord. My VTVM was still hooked to the AFC grid of the horizontal oscillator.

When the cord was pulled, the voltage should have dropped to zero. Instead, it went to 4 volts and stayed there. Coffee postponed; sat there and scratched my head. It finally dawned on me. It had to be those diodes. I clipped each one and checked. The voltage on the AFC grid disappeared but one of the diodes read 4 volts. It was acting like a battery. A new AFC diode unit fixed the set. I wonder if things like this could be behind some of those horizontal dogs that we run into? I have since seen one other AFC diode unit, of a well-known make, do the same thing.

Thanks to Ed Pugh, of Grenfell, Saskatchewan, Canada, for this wild, weird one.

**HIGH-VOLTAGE PROBLEM**

I've had a Heath IO-104 scope since 1974. The problem is repeated failures in the +1400-volt supply. The rectifier diodes and the filter capacitors short out. These have been replaced several times with the same results. Please help.—A.E.B., Palma de Mallorca, Spain.

The answer to this kind of problem would be a generous dose of derating. The diodes can be replaced with something like a color TV solid-state focus rectifier that has a rating of 8000 volts. These are typically rated at 2.0 mA, and the CRT beam current in a scope shouldn't be more than about 250 μA maximum.

The 1800-volt capacitors used aren't rated high enough. An 1800-volt type used on a 1400-volt supply doesn't leave too much margin; only 400 volts, and this obviously isn't enough. You could put two in series, but I dislike this on general principles. Try something like a 2000- or 2500-volt type. With the low current drain from this supply, the capacitor may not have to be that big. A great many similar power supplies use only 0.05 μF filter capacitors.

(Feedback: "The scope is now working. Thanks!)"

---

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PM 3212 priced at $1155.00 includes cover and probes. Pouch shown is optional.
new products

More information on new products is available from the manufacturers of items identified by a Free Information number. Free Information Card follows page 88.

STEREO RECEIVER, Model AR-1515 has an output of 70 watts, minimum RMS, per channel into 8 ohms with less than 0.08% total harmonic distortion from 20-20,000 Hz. FM sensitivity is 1.8 mV, and selectivity is 100 dB. Hum and noise are 65 dB below full output in the phono mode, and 80 dB below full output on high level sources. The AR-1515 is $549.95 in kit form. The unit offers digital frequency readout with AM and FM broadcast frequencies displayed in 1/4-kHz steps. Includes monaural AM and FM broadcast frequencies displayed in 1/4-kHz steps. The unit also includes a built-in reference clock, and provides accurate timekeeping for your microcomputer; a giant clock for your microcomputer; a giant clock for your microcomputer.

CIRCLE 50 ON FREE INFORMATION CARD

ELECTRONIC MULTIPLE-PLAY MANUAL TURNTABLE, Model 1000 incorporates two synchronous motors to drive the turntable, and a second motor to control the cue and change cycle. The turntable stops rotating when cued or in cycle to facilitate reading the record label and provide a more precise cueing control. The unit has an optional remote control that duplicates all of the functions performed by the touch buttons on the unit plate, including cue, pause, reject, and change of records. Other features include electronic speed control using frequency to control speed through a Wien bridge oscillator; the B.I.C. tone-arm system, refined with a new CD-4 position on its anti-skating control; and computer-designed shock mounts.

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controls. Calibrated tuning
output impedance
Discrete
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OCTAVE EQUALIZER (stereo). Model SE-10 has
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for each octave of frequency. The equalizer
uses eight IC’s, 2 FET’s, and 5 transistors plus
an IC-regulated power supply and offers inde-
dependent channel gain control from -12 dB to
+6 dB. There is a low-impedance (600-ohm)
output and 16 operational amplifiers in the four
low-frequency sliders of both channels. The kit
is $249.00, assembled, $349.00. Wood cabinet is
optional—Dynaco, Coles Rd., Box 86, Black-
wood, NJ 08012.

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anything digital.

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CIRCLE 42 ON FREE INFORMATION CARD
NMOS MICROCOMPUTER KIT, Educator II, is an 8-bit microcomputer system in kit form. The Educator II contains an NMOS 8-bit MPU, PIA, 128 × 8-bit static RAM, two TTL 512 × 4-bit ROM’s and a TTL clock circuit. The NMOS components are the HEP versions of the popular M6800 microcomputer products. Educator II uses the full instruction set and address modes of the MC6800 MPU. The clock frequency is approximately 625 kHz. An executive program, residing in the ROM’s, contains routines for examining and modifying memory locations and MPU registers, servicing interrupts, transferring programs to and from cassette tapes, searching tapes for specific locations, and a routine to test the finished kit. The executive uses 14 bytes of RAM for a scratchpad; the remaining 114 bytes are for user programs. An optional 128 × 8-bit RAM can be added to the PC board for larger user programs. Included with the kit is a comprehensive construction/instruction manual. Educator II retails for $169.95—Motorola Semiconductor Products, Inc., Box 20924, Phoenix, AZ 85036.

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works fine for about an hour and then the picture falls out or begins to jitter, etc. To speed up locating these parts, try heating and cooling all resistors in the sync circuitry. This will save all that waiting time. No normal part will be affected by this; if heating or cooling any of the resistors causes a change in the picture, change it. You can apply heat by holding the tip of a soldering iron on the body of the part. You can cool them with spray-coolant. Don’t get too enthusiastic with the heat on transistors! You can overheat them and cause damage. Just a little heat is enough. Cooling them doesn’t seem to do any particular damage. You will often find thermal transistors, which will get hot, then go bad. Some of them will come back when cooled!

Sync clipping
It is possible for the AGC setting to cause sync problems. If there is something wrong in the AGC or video stages, you can clip off the sync instead of the video. Needless to say, this will show up instantly on the scope. In all cases of oddball troubles, be sure to scope the video signal applied to the input of the sync separator. Too many of us overlook this. If you suspect AGC problems, clamp the AGC with a bias box and see if this won’t clear up the trouble.
DIGITAL MULTIMETER
continued from page 35

expected. For example, the output voltage of a regulated power supply is specified to be 15 volts plus or minus 0.5% (7.5 millivolts). On inspection, with a DMM, the voltage is found to be low: 14.90 volts. Here is a case for concern if circuits powered by this supply are not meeting specifications.

However, it is well to do a little thinking before immediately repairing or adjusting the supply. First, is the problem the circuit is showing likely to be caused by a power supply 25 millivolts below spec.? The likelihood is not. Therefore, the real problem must be determined first. Once the major problem is discovered and repaired, all specifications can be checked. If all specs are fine, it may be that readjusting the power supply to its correct voltage will do no more than throw off the calibration. The product may well have been initially calibrated and adjusted with the low power supply.

The caution being implied in both examples above may be stated as “Don’t overuse your DMM!” DMM’s are like calculators in this respect. Most of the electronics we work with is designed about ten per cent tolerances. When needed, the DMM has high accuracy and resolution. But when it is not needed, learn to disregard it.

Peaking and zeroing are two adjustments common to electronic circuits, especially those employing tuned circuits. Peaking or zeroing with a digital instrument is not easy. The analog meter gives a very good idea of trend. On the other hand, to use a digital meter for this purpose the mind must act somewhat like a digital computer. First, it must take one reading, then a second. Second, it must compare the two readings and determine which of the two is the larger. Then and only then can one know if the adjustment is in the right direction.

Often the resolution of the DMM shows the strangest things. Some of these are good, and some bad. The DMM with a millivolt resolution easily shows voltage drops across a printed circuit foil. Perhaps this voltage drop is the culprit. Then again, perhaps the circuit will completely ignore this minute voltage, and so should you. As noted before, the DMM often exposes variations in semiconductor components with temperature. Unless the circuits being analyzed are extremely critical in nature, few if any problems occur from this source.

Circuit loading becomes much more noticeable when the DMM is used. A DMM with 10 megohms input impedance will load a 50-kilohm circuit by 0.5%, unnoticeable on the analog voltmeter, but a sizable change with 0.05% resolution.

AC measurements are especially susceptible to erroneous readings. Frequently, the accuracy of the AC measurement is an order of magnitude (factor of ten) less than the resolution of the instrument. For instance, a reading may be taken to the nearest 10 millivolts; however, the accuracy may be only 100 millivolts. As noted in specifications, the total harmonic distortion of the sinusoidal signal being measured must be low enough to insure the rated accuracy. Remember, the eye can just notice distortion of 3% or more on an oscilloscope, so don’t be fooled by a clean-looking sinewave.

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Test probes designed by your needs — Push to seize, push to release (all Kleps spring loaded).
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SUBMINIATURE CONNECTIONS AND SOLDER BRIDGES CAN BE SEEN EASILY WITH A MAGNIFYING LENS. SOME FIT ON EYEGLASSES, SOME FIT LIKE AN EYESHADE, SOME ARE HAND HELD AND SOME WILL ATTACH TO THE CONNECTORS.

PUTTING IT ALL TOGETHER

BY THIS TIME IT SHOULD BE OBVIOUS THAT THE ONE GREAT ADVANTAGE OF THIS SYSTEM IS VERSATILITY. THERE IS NO END TO THE ODDS AND ENDS OF PIECES YOU WILL FIND TO ADD TO THE SYSTEM. THERE IS NO LIMIT TO THE DIFFERENT WAYS YOU WILL DISCOVER TO PUT THEM TOGETHER. FIGURE 7 SHOWS A PC BOARD HOLDER MADE FROM AN OLD TEST-TOUCH CLAMP. IT WILL ALSO HOLD A SMALL CHASSIS OR OTHER SIMILAR PARTS EVEN A PENCIL SOLDERTING IRON.

FIGURE 8 SHOWS AN INVOLVED BUT USELESS SET-UP. THE PC BOARD IS HELD FIRMLY WHILE THE TWEEZERS HOLD A WIRE OR PART TO BE SOLDERED. THE MAGNIFYING GLASS LETS YOU REALLY SEE WHAT'S GOING ON AND THE MIRROR PROVIDES AN UNOBSERVED VIEW OF THE REVERSE SIDE. ALL THIS AND YOU STILL HAVE TWO HANDS TO DO THE WORK!

THAT'S JUST HOW EASY AND USEFUL THIS SYSTEM IS. PICK UP SOME PARTS AND ASSEMBLE THE HOLDERS AND VIEWERS YOU NEED. STOP CALLING ON WIFE, CHILDREN AND FRIENDS ONLY TO HASSLE THEM BECAUSE THEY DON'T HOLD THINGS IN THE RIGHT PLACE AND MOTIONLESS. BE INDEPENDENT: HOLD YOUR OWN!

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HIGH BLOOD PRESSURE.
TREAT IT...AND LIVE.
THE NATIONAL HIGH BLOOD PRESSURE EDUCATION PROGRAM, U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE.

SYSTEM 5000

THE NEW PROGRAMMABLE CLOCK KIT FROM DIGITAL CONCEPTS. $29.95

SYSTEM 5000 is the programmable clock kit that makes it "building new electronics" easy. This system has been designed to be a real "plug and play" operation. Numerous functions are included and are designed for minimum hassle and unnecessary complexity. And as you can see, it is used to construct many different families of time stamping and timing devices.

SYSTEM 5000 can be used in a cordless camera, computer, personal computer, clock, or all three in one full system (optional). The Quartz is true Regulator. The monostable and astable timers. True Time Gains such as CRF, 5 day timer, 10 day timer capability is included for memory storage. A 31 day time span is available for high precision applications. The digital output capability is very helpful and is a unique feature of this kit.

SYSTEM 5000 can be used in a cordless camera, computer, personal computer, clock, or all three in one full system (optional). The Quartz is true Regulator. The monostable and astable timers. True Time Gains such as CRF, 5 day timer, 10 day timer capability is included for memory storage. A 31 day time span is available for high precision applications. The digital output capability is very helpful and is a unique feature of this kit.

FEATURES AND SPECIFICATIONS

- 7 in Day Register
- 5 in Week Register
- True 286 x 168 Ams
- Hold Pull Buttons
- 10 to 200 Hz Pulse
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- 5 and 10 Day Time Gains
- One More Than Counters
- Bright 5 Digit Flashed Power
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- Full Guarded Outputs
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- One Microamp

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Includes 10 such relays and 10 such relays in DC or AC pfwisms with one optional contacts, etc.

QUARTZ TIME BASE OPTION - $6.95
This accessory is required for the correct operation of all the above listed circuits, etc.

ORDER THIS EXCITING KIT TODAY AND PUT ELECTRONIC TIMEKEEPING TO WORK FOR YOU!

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WORKBENCH ACCESSORIES

continued from page 57

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UNIVERSAL TEST RIG DOES IT ALL

33KV $229.95
PJS-298 C.R.T. Included

- 33KV Lead Glass CRT
- 40KV Meter
- Build-In Speaker
- Obsolete-Proof

The PJS-298 Universal Test Rig for tube and Solid State TV's designed for servicing high voltage chassis. Built in speaker for convenient audio checking, 40KV-50Ua sensitivity meter constant monitoring of the anode voltage. Up-dating is accomplished by means of plug-in modules. (Extension cables included).

FOR FAST TROUBLE SHOOTING . . . .

"FERRET" TV MINI-ANALYZER

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S G-785

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CIRCLE 51 ON FREE INFORMATION CARD

July 1977
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An exceptional price on an applications oriented 6503 based micro-processor system

$149.95

THE IDEAL, LOW COST SOLUTION TO IMPLEMENTING THOSE WIDELY COMPUTER BASED CONTROL SYSTEMS
YOU'VE BEEN DREAMING OF!
PAIA software currently available or under development includes: Music synthesizer interface; Home applications package including: multi-zone fire/burglar alarm, real time clock, energy saving heat/air conditioning control, computer generated "door bell"; Model 8400 real road controller and more..................................

8700 COMPUTER/CONTROLLER KIT $149.95 (requires 6V, 12V, 15V, @150 ma.)
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CIRCLE 10 ON FREE INFORMATION CARD

R-E TESTS FISHER RS-1080
continued from page 52

TABLE III
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: Fisher Model: RS-1080

OVERALL PRODUCT ANALYSIS

<table>
<thead>
<tr>
<th>Category</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail Price</td>
<td>$899.95</td>
</tr>
<tr>
<td>Price Category</td>
<td>High</td>
</tr>
<tr>
<td>Price/Performance Ratio</td>
<td>Very good</td>
</tr>
<tr>
<td>Styling and Appearance</td>
<td>Excellent</td>
</tr>
<tr>
<td>Sound Quality</td>
<td>Excellent</td>
</tr>
<tr>
<td>Mechanical Performance</td>
<td>Very good</td>
</tr>
</tbody>
</table>

Comments: In designing and marketing a high-powered receiver, Fisher did not concentrate solely on audio power, but created a well-balanced full-featured receiver that, in many ways, rivals the performance obtainable from separate components costing considerably more. The unusual circuit driving the separate multipath meter more effectively minimizes multipath interference through careful orientation of one's outdoor FM antenna than do dual-purpose meters or even those extra scope output jacks intended for connection to a separate oscilloscope. Built-in Dolby decoding (including the correct 25 µs de-emphasis characteristic) adds to the value of the receiver, particularly if there are such programs broadcast in your listening area.

The extra bass-boost control, with its variable center frequencies of 45 Hz and 82 Hz, helps enormously in bringing out that last octave of bass from speakers that could not be improved using a conventional bass-boost control without disturbing upper-bass and lower mid-tones.

Our sole criticism of measured performance was of factory settings of audio threshold and the muting threshold, both of which, we later learned, were not set within manufacturer's limits (but easily could have been). We would hope that ours was the rare case rather than typical.

The RS-1080 has more than enough power output for driving even the most inefficient loudspeaker system. Sound from records was particularly good, with music and transients coming through uncolored and with little apparent distortion. The front panel is engineered for ease of use, despite the many controls/features provided—a good job of human engineering. Of course, any receiver of this power output had to be big—so big that shelf-mounting it would be impractical unless you own shelves that are over 18" deep, and capable of supporting its 65-pound weight.

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next month
AUGUST 1977

■ Videocube
It’s an RF modulator that interfaces a video game or microcomputer directly to the antenna terminals of your TV set. This easy to build device meets FCC type acceptance specifications.

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This one includes a countdown timer, alarm, date and time, with a simultaneous readout of all four functions. The timer can easily be interfaced to a relay for controlling appliances.

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PRINTED CIRCUIT KITS
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ONLY Vector kits contain:
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 4 types of art aids: rub transfers, ink, tape, cut and peel—use 1 or all.
 1:1 circuit art rub transfers—IC sets, pads, lines, connectors, symbols, letters, and numbers.
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 and process choices—make circuit on copper and etch for 1 card. Make circuit on film, expose, develop and etch for 1 or many cards.

32XA-1 kit makes 7 PC cards, $28.00, 32X-1 starter kit makes 2 cards, $11.50

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FREQUENCY METER
for testing mobile transmitters and receivers

— Tests Predetermined Frequencies 25 to 1000 MHz
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— Pin Diode Attenuator for Full Range Coverage as Signal Generator
— Measures FM Deviation

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The FM-2400CH with its extended range covers 25 to 1000 MHz. The frequencies can be those of the radio frequency channels of operation and/or the intermediate frequencies of the receiver between 5 MHz and 40 MHz.

Frequency Stability: ±.0005% from +50° to +104°F.

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Self-contained in small portable case. Complete solid state circuitry. Rechargeable batteries.

FM-2400CH (meter only) .................. $595.00
RF crystals (with temperature correction) ... 24.00 ea.
RF crystals (less temperature correction) ... 16.00 ea.
IF crystals .................................. catalog price

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$16.95 KIT

50,000 Satisfied Clock Kit Customers Can't Be Wrong!

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ALL 7001 KITS FIT CABINET AND ACCEPT QUARTZ CRYSTAL TIME BASE KIT #TB-1

MOBILE LED CLOCK

12/24 HR. 4" DIGITS!

MODEL 12 VOLT AC or #2001 DC POWERED

- 8 JUMBO .4" RED LED'S BEHIND RED FILTER LENS WITH CHROME RIM
- SET TIME FROM FRONT VIA HIDDEN SWITCHES + 12/24 HR. TIME FORMAT
- STYLISH CHARCOAL GRAY CASE OF MOLDED HIGH TEMP. PLASTIC
- BRIDGE POWER INPUT CIRCUITRY—TWO WIRE NO POLARITY HOOK-UP
- OPTIONAL CONNECTION TO BLANK DISPLAY (Use when Econ DM in Car. Rd. etc.)
- TOP QUALITY PC BOARDS & COMPONENTS - EXCELLENT INSTRUCTIONS
- MOUNTING BRACKET INCLUDED

COMPLETE KIT $29.95
COMP.$27.95
MOS $25.95

ASSIGNED UNITS W/6 TESTED L.E.D.'S. (LENS & FROSTED LED'S)
6 FOR 12 OF 15 OR MORE ($2.95 EACH)

ORDER BY PHONE OF MAIL COD ORDERS WELCOME

Orders Under $15 Add $1.00 Handling Res. Please Add 4% Sales Tax

WE PAY ALL SHIPPING IN CONTINENTAL US--OTHERS ADD 5% (10% FOR AIRMAIL)--SEE OUR BOOTH AT THE ATLANTA HAMFEST--JUNE 18-19, 1977

CIRCLE 33 ON FREE INFORMATION CARD
SUPER LED's

This family of LED's are mounted on a 2x5 header with a 0.32 threaded stud to secure to a heat sink. The 25K Trimmer permits continuous current rating (heat sink). The LED's can be pulsed at up to 2mA with low duty cycle. Data supplied w/order.

25K Trimmer
Printed Circuit Board Type
10 for $1.50

RESISTOR ASSORTMENTS
100 assorted values of 1/4W or 1/2W must $1.50 w/PCB cut leads-specifically Specify VR $1.00

Example:
HE219 Resistor 1/4W 0.033 200 OHM $0.95
HE219 Resistor 1/4W 0.033 200 OHM $0.95

FULL RANGE OF CARBON RESISTORS AVAILABLE

150 Mhz PRESCALER

Use your low frequency counter to measure VHF or UHF frequencies. This kit will divide the input signal by ten (10) or by 100 with additional option. Kit contains drilled circuit board, 2 IC's, all parts needed and instructions.

150/1500kHz Kit $12.50

650MHz option with IC001 IC $27.50

- requires $5.00 for power supply and case are not part of kit---

SALES TAXES

Add $1.75 sales tax to all prices unless noted.

FREE DATA CATALOG

New 77 Pages! With $25.00 PREPAID ORDER

25K Trimmer
Printed Circuit Board Type
10 for $1.50

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SALES TAXES

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POLY PAK'S EXCLUSIVE
SURE FIRE WAY TO FIGHT
BARREL KITS®

- SHIELDED CABLE 50-ft., $1.98
- HALF INCH REELS 750 each, 15 for $1.98
- GLOW IN THE DARK PANELS 3 for $1.98
- BARREL KIT 2157 AUDIO ICS 30 for $1.98
- BARREL KIT 2735 MAGNIFIER M 35 20 for $1.98
- BARREL KIT 2135 MICRO MINI LAMPS 50 for $1.98
- BARREL KIT 2111 MICRO MINI LEDS 40 for $1.98
- BARREL KIT 2791 NATIONAL PC BOARD 100 for $1.98
- BARREL KIT 2127 TRANSISTOR 10 SMD 50 for $1.98
- BARREL KIT 2129 TRANSISTOR 10 DIFFERENT 50 for $1.98
- LED RING LAMPS 50 for $1.98
- $1.98 ALARM KIT Includes LED, battery, case, and instructions.
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## SPECIAL SUMMER SALE

(GOOD THRU AUGUST)

### DIGITAL

<table>
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<th>Part Number</th>
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### SPECIAL DEVICES

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### SHIFT REGISTERS

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<tr>
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### KEYBOARD

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<tr>
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<tr>
<td>2512</td>
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</table>

### UNIVERSAL BREADBOARD

Accommodates 8, 14, 16, 20, 24 & 40 pin IC's. 2 triple rows of 27 holes for DIP IC's.

### LED $s

<table>
<thead>
<tr>
<th>Description</th>
<th>Price</th>
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<tbody>
<tr>
<td>Red, Green, Blue, Yellow</td>
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### EDGE CONNECTOR

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<th>Description</th>
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<tr>
<td>ECG Modular Unit 6/99</td>
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### CENTRAL PROCESSING UNIT

<table>
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<tr>
<th>Model</th>
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<tbody>
<tr>
<td>8008</td>
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<tr>
<td>8080A</td>
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### TV GAME CHIPS

<table>
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<th>Model</th>
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<tr>
<td>AY-3-8501</td>
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### DUAL SLOPE ANALOG BUILDING BLOCK

<table>
<thead>
<tr>
<th>Model</th>
<th>Price</th>
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<tbody>
<tr>
<td>2102</td>
<td>$1.29</td>
</tr>
</tbody>
</table>

### RESISTOR KIT

- Carbon film ± 5%
- 1/4 or 1/2 watt
- 555 resistors, 44 values supplied in a 15 drawer
- 60 component storage cabinets table or wall
- Mount, Ready to use

<table>
<thead>
<tr>
<th>Value</th>
<th>Price</th>
</tr>
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<tbody>
<tr>
<td>1%</td>
<td>$19.95</td>
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### SPECIAL DEVICES

<table>
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<th>Description</th>
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### IC SOCKETS

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<th>Description</th>
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<td>8 pin</td>
<td>$0.89</td>
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<tr>
<td>14 pin</td>
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### WIRE WRAP - gold plated

<table>
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<tr>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 pin</td>
<td>$0.49</td>
</tr>
</tbody>
</table>

### FREE CATALOG AVAILABLE ON REQUEST

Satisfaction guaranteed. Shipment will be made postage prepaid within 3 days from receipt of order. Payment may be made with personal check, charge card (include card number and exp. date), or Money Order. Phone Orders - Both M/C & E/Check or C.O.D.

Add $1.00 to cover shipping and handling if order is less than $10.00.

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CARMEL, VALLEY, CA 93924 USA

PHONE (408) 659-3171

---

CIRCLE 30 ON FREE INFORMATION CARD

---

101
CUBE
STOCK NO.5516R Tennis board
Size 10W x 3 1/2H x 9D

STOCK NO.6544M
4 1/2"x4 3/16"x3 3/4"

SUPER
VALUE!

• ICS Socketed
• Push button Switches on Main PC Board
• Open chassis for Easy Assembly

DELUXE METAL CABINET

COMBINATION

FREQUENCY COUNTER

STOCK NO.17
30 MHZ KIT
$89.95

FC-6H
250 MHZ KIT
$129.95

2 in 1 DMM-COUNTER
FCM-8
8 DIGIT
250 MHZ KIT
$219.95

Size 7W x 3H x 8D

PERFECT FOR CBERS, HAMS, HOBBYSTS, TECHNICIANS.
HI Z INPUT, 50 OHM SENSITIVITY.
FREQUENCY 10 Hz TO OVER 30 MHZ.
FC-6 (6) AND 100 TO OVER 250 MHZ.
FC-6H (6H). CRYSTAL TIMEBASE, 5 PPM.

CAPACITANCE COUNTER

NOW, IT IS EASY TO MEASURE YOUR CAPACITORS.

Size 7W x 3H x 8D

±1% ±1 count (±1 pf below 100 pf.)
Four ranges from picofarads to several thousand microfarads. Features crystal timebase reference for stability.

LIN CORP. 15311 S. Broadway, Gardena, California 90248 (213) 532-8809

CIRCLE 61 ON FREE INFORMATION CARD

TV HOCKEY/SOCCER GAME


STOCK NO.5495R $27.50 2/50.00

TV TENNIS GAME BOARD

These logic boards are from a TV tennis game. They contain all the ICs needed to low power Schottky, 2 CMOS, and a 555 timer. These chips are NOT soldered, so that they may be removed by just pulling them off. We sell the boards for the parts, but it is possible to finish the game, as we provide a circuit diagram, and next month will list the additional parts we have to complete the game.

STOCK NO.5516R Tennis board with circuit diagram 3.50 3/10.00

PROGRAMMABLE TRANSFORMER, Eleven 5 V, 10A, secondaries. Many voltage combinations possible. Complete data supplied.

STOCK NO.6544M 1 $16.95 ea. 2/30.00

BAC & Mastercharge accepted. Include sufficient postage. Excess refunded. Minimum order $5.00, credit card $15.00.

Visit our retail outlets, DELTA ELECTRONIC HOBBIIES, 5151 Buford Hwy, Doraville,(Atlanta) Ga, DELTA ELECTRONICS, Warehouse Outlet, 590 Commonwealth Ave, Boston, Mass.

DELTA ELECTRONICS P.O.Box 1, Amesbury, Mass. 01913 Tel,(617) 388-4705

CIRCLE 38 ON FREE INFORMATION CARD

A Logical Solution to your Digital Logic Problems!

• Multi-family
• Pulse stretching
• Open circuit detection
• High input impedance
• Replaceable tip and cord

THE NEW CATCH-A-PULSE® LOGIC PROBE!

COMPATIBLE WITH RTL, TTL, CMOS, MOS, AND MICRO-PROCESSORS USING A 3.5 V TO 15 V POWER SUPPLY. THRESHOLDS AUTOMATICALLY PROGRAMMED FOR MULTI-LOGIC FAMILY OPERATION.

AUTOMATIC R‘SETTING MECHANISM FOR SMALL OR MULTI-PULSE DETECTION. NO ADJUSTMENT REQUIRED. VISUAL INDICATION OF LOGIC LEVELS, USING LEDs TO SHOW HIGH, LOW, BAD LEVEL OR OPEN CIRCUIT LOGIC AND PULSES. HIGHLY SOPHISTICATED, SHIRT-POCKET PORTABLE (PROTECTIVE CAP OVER TOP AND REMOVABLE STIFF CORD). ELEMINATES NEED FOR HEAVY TEST EQUIPMENT. A DEFINITE PLUS IN TIME AND MONEY FOR ENGINEER AND TECHNICIAN.

$29.95 No 37 shipping & handling

NEW 60-600 MHZ PORTABLE COUNTER

4.5"x4"x1.125"

FREE catalog. Solar cells, Nicad's, kits, calculators, digital watch modules, ultrasonics, strobes, LED's, transistors, IC's, unique components.

CHANEY'S, 27038, Denver, CO 80227

AMAZING ELECTRONIC PROJECTS AND PRODUCTS:
• Lasers Super Powered, Burning, Cutting, Rifle, Pistol Pocket, See in Dark-Shotgun Directional


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MANUALS for Govt. surplus radios, test sets, scopes. List 504 (coin) BOOKS, 7218 Roanne Drive, Washington, D.C. 20021
CLOCK PARTS and Kit

Line: 1-800-527-2304.

Memorex computer boards with IC’s, diodes, transistor, etc. 5 Boards containing 100 - 200 IC’s
ONLY $4.25

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