a look at
NEW HI-FI GEAR
for tomorrow's audiophile

get rid of it—
RF INTERFERENCE
in your hi-fi

build a portable
ACTION FOOTBALL GAME
using IC's

easy to build
DIGITAL CLOCKS
using modules

phase-locked-loop
SYNTHESIZERS

LEN FELDMAN REPORTS—
Binaural and Biphonetic Sound
Sitting in this new JVC experimental 4-channel
biphonetic chair, our Contributing High-Fidelity Editor
becomes one of the first to experience listening to
binaural sound without wearing headphones

ULTRAMETERS ⭐ Komputer Korner
1's Service Clinic
Solid State ⭐ Equipment Reports

Reports on
hi 610 Preamp and Garrard GT-55 Turntable
New! Equalization analyzer...

Balance a system...Balance a budget.

Quick and accurate adjustment of sound system frequency response is finally within the reach of most budgets. The Shure M615AS Equalization Analyzer System is a revolutionary breakthrough that lets you “see” room response trouble spots in sound reinforcement and hi-fi systems—without bulky equipment, and at a fraction of the cost of conventional analyzers.

The portable, 11-pound system (which includes the analyzer, special microphone, accessories, and carrying case) puts an equal-energy-per-octave “pink noise” test signal into your sound system. You place the microphone in the listening area and simply adjust the filters of an octave equalizer (such as the Shure SR107 or M610) until the M615 display indicates that each of 10 octaves are properly balanced. You can achieve accuracy within ±1 dB, without having to “play it by ear.”

Send for complete descriptive brochure AL558.

Shure Brothers Inc.
222 Hartrey Ave.
Evanston, IL 60204
In Canada:
A. C. Simmonds & Sons Limited

MANUFACTURERS OF HIGH FIDELITY COMPONENTS, MICROPHONES, SOUND SYSTEMS AND RELATED CIRCUITRY.

CIRCLE 23 ON FREE INFORMATION CARD

TECHNICORNER
The M615 Analyzer’s display contains 20 LEDs that indicate frequency response level in each of 10 octave bands from 32 Hz to 16,000 Hz. A rotary hi-lo envelope control adjusts the HI LED threshold relative to the LO LED threshold. At minimum setting, the resulting frequency response is correct within ±1 dB. Includes input and microphone preamplifier overload LEDs. A front panel switch selects either flat or “house curve” equalization.

The ES615 Omnidirectional Analyzer Microphone (also available separately) is designed specifically for equalization analyzer systems.
Suddenly, you're the most versatile shop in town.

With this little 25-pound test jig, you can adapt to over 10,000 color sets, 59 different brands. Delta 70° and 90° tube, hybrid, transistor, SCR sweep. Anode voltages to 30kV and more. Regular 4.5kV and 7.1kV focus voltages.

And our new optional In-Line Test Kit lets you handle more than 100 precision in-line chassis, including RCA, Magnavox, Admiral and Sears. (We're the first test-jig manufacturer to offer a kit like this.)

CK3000 comes to you fully assembled, pretested and ready to use. Just plug it in, and you're in business. See it now, at your Sylvania distributor.

GTE Sylvania, Electronic Components Group, 100 First Avenue, Waltham, Massachusetts 02154.

Simply the most versatile test jig you can buy.
The Control of Power by Sansui.

For the audiophile who wants the finest matched stereo amplifiers and stereo control preamplifiers, Sansui offers the answer — its Definition Series. Look at two of these outstanding components. The Sansui BA 3000 is designed with plenty of power to handle those bursts of percussion and those dynamic fortissimos that give you concert hall presence. The CA 3000 controls and features are a true joy for the creative pro and audiophile who wants the music to his own personal preferences.

This extraordinary pair is designed for the most demanding tasks: recording studios, sound reinforcement and audiophile home listening. The Definition Series offers the clearest, cleanest fidelity available anywhere. Top of the line Sansui BA 5000, called the "Monster," is one of the most powerful amplifiers available today: 300 watts per channel min. RMS into 2, 4 and 8 ohms from 20 to 20,000 Hz with no more than 0.1% THD.

For complete information on the entire Definition Series visit your local Sansui dealer soon or write directly to us.

The BA 3000 stereo amplifier 170 watts per channel, m.n. RMS, both channels driven into 8 ohms from 20 to 20,000 Hz with no more than 0.15% THD. Specially abounds: 4 jumbo-heatsink (Sansui patent pending), triple protection circuits for ample power protection; and front panel LED power/overload protection indicator on the front panel to show safe operation. Specially damped output power meter.

The CA 3000 phono preamplifier is within 0.2 db of RIAA equalization curve. Offers everything desirable in a preamplifier and more: Triple tone controls; Left and right input and output channel meters. Tape control for copy and playback; Sensitivity controls; Phonoinput capacitance selector.

Each Definition Series component comes with a test data sheet, complete with all performance characteristics. And Sansui offers a limited 5 year warranty.
Binaural and Biphonic Sound Today
Precise spatial effects are possible. Read about a new JVC system that makes it work. by Len Feldman

Tomorrow's Hi-Fi Gear
What happened at the Tokyo and New York Hi-Fi shows—Sennheiser infra-red headphone link and more. by Len Feldman

Get Rid of RFI
It can really destroy hi-fi reproduction but can usually be guarded. Discover what you can do to stop this kind of interference. by Len Feldman

R-E Lab Tests Garrard GT-55
A new multiple play turntable system rates high in our report.

R-E Lab Tests Nakamichi 610 Preamp
Outstanding quality in performance and construction.

Easy To Build Digital Clocks
Semi-kits speed assembly. Roundup of available modules. by Fred Biechman

Action Football Games
Plays like the real thing. IC circuit-board construction makes it easy to duplicate. by Rudy Graf & George Whalen

Tone Probe for IC Testing
Checks digital IC's. Audible tones tell you high or low. Costs under $16.00. by Larry Fort

R-E Reports on Data Precision 175
A digital multi-meter worth looking at.

All About Analog Multimeters
Part III—Concluding section of this comprehensive report. by Charles Gilmore

R-E reports on Heath IP-2718
New power supply works well. You build it from a kit.

R-E reports on Switchcraft 1002
Cable tester that really does a job.

Phase-Locked Loop
Part II—How Motorola's XC3390 PLL frequency synthesizer works. by Robert F. Scott

Looking Ahead
Tomorrow's news today. by David Lachenbruch

Komputer Korner
Stacking computer data. by Tim Barry

Auto Search Finds the Cassette Program
New circuit looks for and looks on to the music passage you want to hear. by Karl Savon

State-Of-Solid State
Music generating and synthesizing IC's. by Karl Savon

Service Clinic
Lightning protection. by Jack Darr

Reader Questions
R-E's Service Editor solves reader problems.

Advertising Index
6 New & Timely

Advertising Sales Offices
102 New Books

Free Information Card
88 New Products

Letters
103 Next Month

ON THE COVER
That's Len Feldman sitting in JVC's special biphonic chair. If you want to know what he is hearing, see our special story starting on page 40.

Infrared Signals link these headphones to the amplifier. For the story behind them and other new equipment ……see story on page 40


Subscription Service: Mail all subscription orders, changes, correspondence and Postmaster Notices of undelivered copies (Form 3579) to Radio-Electronics Subscription Service, Box 2520, Boulder, CO 80302.

A stamped self-addressed envelope must accompany all submitted manuscripts and/or artwork or photographs if their return is desired should they be rejected. We disclaim any responsibility for the loss or damage of manuscripts and/or artwork or photographs while in our possession or otherwise.
looking ahead

Video horserace is on: The Japanese government, prodded by parliament, has urged videocassette recorder manufacturers to establish a single standard system. Although four separate, and incompatible, systems have already been introduced on the Japan home market, the race seems to be narrowing down to two somewhat similar—but, once again, incompatible—systems. These are the Sony Betamax, which has a large lead in terms of number of machines produced, and the Japan Victor Corporation (JVC) VHS, or Video Home System. The VHS currently offers two-hour recording and playing time on a single cassette, compared with one hour for Betamax that will double the playing time of its standard cassette.

Japanese manufacturers are choosing up sides, and since no American manufacturers are known to be preparing their own entries in the field, this should set the pace for this country. In addition to JVC, the VHS system now has been chosen by Hitachi and Sharp. Matsushita, Japan’s No. 1 television set maker and JVC’s parent company, has its own system (VX-2000), but it has indicated that it may add VHS. Mitsubishi is also believed to be in the VHS camp. Toshiba and Sanyo are pushing another system (V-Cord II), but Toshiba is wavering and presumably will decide between VHS and Betamax. The question in many minds is whether Sony has enough momentum going for its Betamax to offset a massive challenge from VHS. How important are these Japanese maneuvers to us? Well, one major American manufacturer (which asks not to be identified) has told us that it will manufacture videocassette decks to the specifications of the format that wins in Japan.

VTR turn-off: Three home videocassette recorders are now on sale in the United States—Sony’s Betamax, Sanyo’s V-Cord II and Quasar’s “Time Machine” VR-1000. The strong success of Betamax, whose sales last year totaled 25,000 to 30,000 units and exhausted virtually all supplies, is worrying the movie makers, as evidenced by the suit filed by Universal Pictures and Walt Disney Studios against Sony (Radio-Electronics, February, 1977). Now the Motion Picture Association of America is looking into the situation, seeking a technological—rather than legal—solution to the problem. The MPAA has signed a contract with Bell & Howell for the development of a system that would make it impossible for consumers to tape certain copyrighted programs.

The idea would be to transmit along with the program (probably in the vertical interval between pictures) a signal which would prevent home videocassette machines from recording. This would be a lock-and-key situation, requiring special equipment at both the transmitting and receiving ends, and appears to pose some legal as well as technical problems. The electronics work may be the simplest part. After technical specs are developed, it would be necessary to get FCC approval for the transmission of the special anti-taping signal and Congressional legislation to require all VTR manufacturers to include in their products circuits which would automatically make it impossible to record programs which are transmitted with “no-no” signals. Or MPAA could try to get VTR manufacturers to agree to include such circuitry voluntarily. Fat chance.

Warwick becomes Sanyo: Sanyo Electric of Japan has purchased Warwick Electronics, which manufactures television sets, mainly for Sears Roebuck. This latest purchase of an American television manufacturer by foreign interests leaves only seven American-owned TV makers in a field which once had more than 100. The remaining U.S.-owned manufacturers are Admiral Group (part of Rockwell International), General Electric, Curtis Mathes, RCA, Sylvania, Wells-Gardner and Zenith. There are actually 10 if you include Andrea Radio Corp., which is principally a regional manufacturer in New York; Heath Co., which makes TV kits, and Advent, manufacturer of consumer projection TV.

Other acquisitions of American TV companies by foreign-controlled organizations in recent years have been Matsushita Electric’s purchase of Motorola’s TV business (now Quasar) and North American Philips’ acquisition of the Magnavox Co. The television-manufacturing portion of Warwick, which was controlled by Whirlpool Corp., has been re-named Sanyo Manufacturing Corp. What is left of Warwick, unaffected by the sale, is now Thomas International, manufacturer of Thomas electronic organs. Sanyo plans to continue the manufacture of color TV consoles in the former Warwick Forrest City, Ark. plant. The purchase puts Sanyo into contention for the title of third-largest supplier in the American television market (Sanyo also markets here under its own brandname and various private labels). Other contenders for the No. 3 spot are Magnavox, Sony and Matsushita (the latter selling under Panasonic, Quasar and private labels).

LCD TV projection: Television manufacturers are watching with interest a project by Hughes Aircraft, that could conquer one of the major problems of home projection TV—lack of brightness. Hughes’ Dr. Alex Jacobson heads a team which has developed a breadboarded color TV projector using a liquid-crystal light valve to modulate the beam of an external light source, such as a xenon arc lamp. (Existing home projectors use cathode-ray tubes as light sources.) The color projector has three LCD’s—one for each color—and uses dichroic mirrors to converge the picture into a single lens system. There are still some technical problems, but the Hughes engineers are confident they’ll have a pre-production prototype of a reasonably priced super-bright projector within a year.

continued on page 101
**FEATURES**

- A UHF Tuner with 70 channels which are detented and indicated just like VHF channels.
- A VHF Hi Gain Solid State Tuner.
- AC Powered.
- 90 Day Warranty.

Demonstrate the **SUBSTITUNER** to your customers and show improved reception with their TV sets.

You may place your order through any of the Centers listed below.

<table>
<thead>
<tr>
<th>HEADQUARTERS</th>
<th>ADDRESS</th>
<th>TELEPHONE</th>
<th>AREA CODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S.A.</td>
<td></td>
<td></td>
<td>800</td>
</tr>
<tr>
<td>BLOOMINGTON, INDIANA 47401</td>
<td>537 South Walnut Street</td>
<td>812/334-0411</td>
<td></td>
</tr>
<tr>
<td>ALABAMA</td>
<td>BRUNNCHAM, ALABAMA 35212</td>
<td>205/322-8129</td>
<td></td>
</tr>
<tr>
<td>NORTH HOLLYWOOD, CALIF. 90601</td>
<td>10654 Magnolia Boulevard</td>
<td>213/755-2720</td>
<td></td>
</tr>
<tr>
<td>SAN MATEO, CALIF. 94402</td>
<td>205 E. Amethyst Boulevard</td>
<td>415/368-3291</td>
<td></td>
</tr>
<tr>
<td>MODESTO, CALIF. 95351</td>
<td>123 Phoebe Avenue</td>
<td>209/829-8005</td>
<td></td>
</tr>
<tr>
<td>TAMPA, Florida 33606</td>
<td>1505 Cypress Street</td>
<td>813/359-6257</td>
<td></td>
</tr>
<tr>
<td>PT. AUDERDALE, FLORIDA 32069</td>
<td>3156 N W 15th Avenue</td>
<td>407/562-7395</td>
<td></td>
</tr>
<tr>
<td>ATLANTA, GEORGIA 30310</td>
<td>1646 Evans Street S W</td>
<td>704/775-2292</td>
<td></td>
</tr>
<tr>
<td>URBANA, ILLINOIS 61801</td>
<td>100 E Main Street</td>
<td>717/384-2002</td>
<td></td>
</tr>
<tr>
<td>SICKIE, ILLINOIS 60076</td>
<td>21900 S. 67th Avenue</td>
<td>773/479-0030</td>
<td></td>
</tr>
<tr>
<td>INDIANAPOLIS, INDIANA 46204</td>
<td>111 West St Clair Street</td>
<td>317/632-3037</td>
<td></td>
</tr>
<tr>
<td>KENTUCKY</td>
<td>LOISVILLE, KENTUCKY 40205</td>
<td>502/431-1191</td>
<td></td>
</tr>
<tr>
<td>LOUISIANA</td>
<td>SHreveport, LOUISIANA 71104</td>
<td>318/571-0286</td>
<td></td>
</tr>
<tr>
<td>MASSACHUSETTS</td>
<td>SPRINGFIELD, MASSACHUSETTS 01098</td>
<td>413/781-8208</td>
<td></td>
</tr>
<tr>
<td>MISSOURI</td>
<td>ST LOUIS, MISSOURI 63132</td>
<td>314/320-6553</td>
<td></td>
</tr>
<tr>
<td>NEVADA</td>
<td>LAS VEGAS, NEVADA 89102</td>
<td>702/624-4225</td>
<td></td>
</tr>
<tr>
<td>NEW JERSEY</td>
<td>TRENTON, NEW JERSEY 08625</td>
<td>609/682-0999</td>
<td></td>
</tr>
<tr>
<td>NEW YORK</td>
<td>ROCHESTER, NEW YORK 14618</td>
<td>716/432-9180</td>
<td></td>
</tr>
<tr>
<td>NEW ORLEANS</td>
<td>4547 Tunica Avenue</td>
<td>504/886-3720</td>
<td></td>
</tr>
<tr>
<td>NORTH CAROLINA</td>
<td>ROCHESTER, NEW YORK 14618</td>
<td>716/432-9180</td>
<td></td>
</tr>
<tr>
<td>OREGON</td>
<td>PORTLAND, OREGON 97210</td>
<td>503/222-9509</td>
<td></td>
</tr>
<tr>
<td>PENNSYLVANIA</td>
<td>PITTSBURGH, PENNSYLVANIA 15209</td>
<td>412/621-4004</td>
<td></td>
</tr>
<tr>
<td>TENNESSEE</td>
<td>MEMPHIS, TENNESSEE 38111</td>
<td>901/479-3955</td>
<td></td>
</tr>
<tr>
<td>TEXAS</td>
<td>11740 Old Gallatin Road</td>
<td>713/645-6577</td>
<td></td>
</tr>
<tr>
<td>CANADA</td>
<td>ST. LAURENT, QUEBEC H4N-2L7</td>
<td>514/748-8803</td>
<td></td>
</tr>
<tr>
<td>CALGARY, ALBERTA 72H-1Y5</td>
<td>1800 St. Laurent Avenue</td>
<td>506/243-0571</td>
<td></td>
</tr>
</tbody>
</table>

**REPAIR**

- VHF or UHF ANY TYPE (U.S.A. ONLY) $10.95
- UHF/VHF COMBINATION (U.S.A. ONLY) $17.95

**MAJOR PARTS AND SHIPPING CHARGED AT COST**

- Fast, efficient service at our conveniently located Service Centers.
- All tuners are ultrasonically cleaned, repaired, realigned, and air tested.

**REPLACE**

- Universal Replacement Tuner $13.95 (U.S.A. ONLY)
- This price buys you a complete new tuner built specifically for this purpose.
- **All shafts have a maximum length of 10½" which can be cut to 1½"**
- Specify heater type parallel and series 450 mA or 600 mA.

**CUSTOMIZE**

- Customized tuners are available at a cost of $14.95 and up (U.S.A. Only).
- Send in your original tuner for comparison purposes to any of the centers listed above.

**SERVICES OFFERED**

- The Bloomington Tuner Repair Service
- A UHF Tuner with 70 channels which are detented and indicated just like VHF channels.
- A VHF Hi Gain Solid State Tuner.
- AC Powered.
- 90 Day Warranty.

**FOR MORE INFORMATION**

WRITE TO THE BLOOMINGTON HEADQUARTERS ABOUT A FRANCHISE.
Sun’s magnetic field determined by Pioneer 11

Scientists studying data returned by Pioneer 11—now on its way to Saturn—have been able for the first time to determine the structure of the sun’s magnetic field. According to the data, it’s roughly spherical, envelops the entire solar system (probably as far out as the orbit of the planet Pluto), extends several billion miles above the sun’s north and south poles and is split into northern and southern hemispheres by a thin sheet of electric current.

Previous data, from spacecraft traveling in or near the earth’s orbit, had recorded confusing and apparently contradictory data. Pioneer 11 was able to make its discoveries because it traversed a hitherto unknown region of space high above the earth’s orbit. On its way to Saturn, the spacecraft had been thrown 100 million miles above the earth’s plane by Jupiter’s gravity while flying by that planet.

The northern and southern magnetic fields of the sun, explained Dr. Edward J. Smith of the Jet Propulsion Laboratory, Pasadena, CA, to a meeting of the American Geophysical Union, are separated by a warped sheet of electric current. The currents tend to circle the sun in the inner solar system, but gradually turn and flow outward in the outer part of the system. As the sun rotates, the warped sheet appears to move up and down, above and below the plane of the earth’s orbit. Thus, a spacecraft might at different times see a field in one direction, no field or one in the opposite direction depending on whether it was below, in, or above the sheet of current.

Mysterious source jams radios

Amateur and commercial radio stations have been troubled during the late summer and fall months of 1976, by a powerful pulse transmission. This appeared on several frequencies, and was heard in both the United States and Europe. It was not clear whether the source was one station operating on different frequencies, or several stations.

One educated guess is that three stations were involved.

One New Jersey amateur reported an unmodulated pulse signal on about 14.2 MHz. It spread out enough to be audible over about 300 kHz. Severe interference (as an amateur understands the word) was confined to a few kilohertz on each side of the peak. (He had also heard of the same type of interference on the 7-MHz band.)

Using a directional antenna and checking with a California friend who also had a directional antenna, the source was located roughly in the northern part of European Russia, possibly in the Leningrad area. Purpose of the transmission was not clear. “It sounded like an ionosphere sounder,” he said. Power was high and the signal was strong, though few other signals were heard from the same direction.

Commercial and maritime stations also reported the same type of transmission. One East Coast station measured the signals at different times on 12.393, 16.523, 22.080 and 22.032 MHz. Interference was strong on the peak frequencies, dropping off to each side. This type of thing, the informer pointed out, was not uncommon—signals were often encountered where they apparently had no business being. The usual procedure in such cases was to inform the FCC, who would track down the interference and take any necessary steps.

Inquiries made around the middle of November indicated that at that time the interference had not been heard for a week or two. It was suggested that the station or stations may have shut down or been shifted to a non-interfering frequency after the publication of articles on the subject by the Washington Star and the New York Times.

CB workshops begin operation in 1977

A series of training workshops in CB servicing (including the second class radiotelephone license) will be conducted by Forest Belt in various parts of the country during 1977. Mr. Belt is a leading teacher and writer on electronic subjects, and a former editor of Radio-Electronics. The workshops are divided into two parts:

Section A devotes three days to fundamentals of CB communication, AM and single-sideband transmitters and receivers, 40-channel phase-locked-loop circuits, frequency synthesizers, etc. Trouble-shooting techniques, performance measurements, alignment, and trans-
With the new, updated Mallory PTC Semiconductor Product Guide. Instead of looking all over for replacement semiconductors, just open the guide. There’s new indexing and cataloging for fast, easy access to the electrical and physical parameters of each PTC product. Plus, a listing of thousands of semiconductors, each cross-referenced to Mallory PTCs.

It’s the authoritative source-book and cross-reference for transistors, zener diodes, diodes, high-voltage rectifiers, color crystals, integrated circuits, field-effect transistors. Now it’s easier than ever to get Mallory performance and reliability in your semiconductor replacement parts. See your Mallory distributor or give him a call, today.
NRI BRINGS "POWER-ON" TRAINING TO YOUR HOME... FOR QUICKER, EASIER LEARNING AND FASTER EARNING

You get trouble-shooting experience from the chassis up . . . with NRI's unique training equipment.

The "firsts" described here are typical of NRI's over 63 years of leadership in electronics home training. When you enroll as an NRI student, you get the technical knowledge and the priceless confidence of "hands-on" experience sought by employers in communications, TV-audio servicing, computers, and industrial and military electronics. NRI training is designed for your education . . . from the educator-acclaimed Achievement Kit sent the day you enroll, to bite-size, well illustrated, easy-to-read lessons programmed with designed-for-learning training equipment.

NRI Firsts make learning at home fast and fascinating. More than a million have come to NRI for home training. Professional TV/Audio technicians who learned their profession through home training rate NRI as first choice by far, over any other school.

SEND FOR THE FREE FULL-COLOR CATALOG . . . for full details on NRI home training. There is no obligation . . . no salesman will call.

First and only school with designed-for-learning Quadraphonic Audio Center with four SP14 speaker systems. This solid state SQ" system is designed so that you perform meaningful experiments at every stage of assembly . . . for thorough training in audio technology.

Trademark of CBS, Inc.

First with an electronics Discovery Lab". This self-contained advanced solid-state lab gives you fast, hands-on access to fully-powered semiconductor circuitry. NRI is the only school with all these modern solid state component experiments in: bipolar and field effect transistors, Zener diodes, light-emitting diodes, SCR's and phototransistors.

"McGraw Hill CEC.

First and only school with new Optical Transmission System engineered to allow you to analyze digital and analog signal transmission via light beam. Systems you build use LED and phototransistor technology, simulating basic principles of laser communications as used in video disc home entertainment systems.
First and only school with designed-for-learning 25" diagonal solid state Color TV complete with cabinet. This solid state set was designed by NRI's own engineers from the chassis up so that students can perform over 25 in-set experiments during construction, including valuable "Power-On" trouble-shooting.

First and only training with an actual programmable digital computer to give you the only home training in machine-language programming essential to trouble shooting digital computers. Extra Memory Expansion Kit doubles memory size for practice in advanced programming techniques.

First and only school with a portable CMOS digital frequency counter engineered by NRI to give you experience in the newest types of digital systems coming into expanded use in consumer electronics.

First and only school with a solid state regulated power supply engineered by NRI to give you experience with modern power supply designs; to give you a premium power supply for your NRI Transceiver, or to use in trouble-shooting mobile equipment.

First and only school with an Antenna Applications Lab engineered to give you a thorough understanding of practical communications antenna requirements. You assemble and test several different types of antennas and matching sections, measuring gain and radiation patterns.

First and only school with designed-for-learning, 400-channel, digitally-synthesized VHF Transceiver to give you the only fully-up-to-date 2-meter equipment for complete training in commercial, amateur, and CB communications. The design incorporates circuitry and components representative of the latest state of the art. Circuitry is on five plug-in circuit cards to take full advantage of NRI "Power-On" training.

If card is missing, write to:
NRI Schools
McGraw Hill Continuing Education Center
3939 Wisconsin Ave.
Washington, D.C. 20016
sisor and integrated circuit testing will also be covered.

Section B, an advanced two-day workshop, covers FM communications and equipment as used in marine, police, taxi and other two-way mobile systems. A Second Class Radiotelephone option is offered. The radiotelephone license is necessary for any technician who services CB or other transmitting equipment. Workshops will be held in Indianapolis, IN, January 24–28; in Oakland, CA, February 28–March 4; San Diego, CA, March 7–11; Phoenix, AZ, April 4–8; Denver, CO, April 11–15, and San Antonio, TX, April 25–29.

For further details, schedule of locations, rates, enrollment applications, etc., write Forest Bell's Training Workshops, Box 69120, Indianapolis, IN 46268.

Sharon Penix, Samuel Ford are Gernsback Award winners

This month's first-prize winner of the Gernsback Award, a check for $150 sent to an outstanding student in each of eight leading electronics home study schools, is Samuel R. Ford. He enrolled in the National Technical Schools' Master Course in Color-TV Servicing in March 1975 and had finished three quarters of the course by the middle of 1976. Ms. Penix, this month's second-prize winner, and Mr. Ford, the school says, have "received excellent grades on all lessons completed."

Sharon Rose Penix is not professionally in the electronics field, but lives on an Indiana farm, occasionally engaging in the farm work by driving trucks for her father during the harvest season. Her husband works on construction as an operating engineer. She started the course in December, 1975, and had finished three-fourths of it by June, 1976.

A CB'er, her call is KPU 8579. She uses the CB equipment on the farm and when camping (the Penix's designed and built their own recreational vehicle, "which is difficult to distinguish from a factory model"). Other hobbies, furthered by the rural environment, are flower gardening and attracting wild life to the property. She also collects antique clocks.

Ms. Penix's object in studying radio and television is threefold: First, she is interested in learning more of the "magical world" of electronics. Her second object is to learn a skill that could be an aid to employment; and last—and more immediately important—she wants to keep her own TV and electronic equipment in working order.

Ms. Penix receives a model 280 digital multimeter donated for the purpose by B & K.
When you're serious about CB only the BEST will do!

All GC CB accessories are 40 channel approved!

SEE THE COMPLETE LINE OF GC CB ACCESSORIES AT YOUR FAVORITE CB DEALER TODAY!

IMPROVE THE PERFORMANCE OF YOUR RIG! COLORFUL CATALOG ILLUSTRATES AND DESCRIBES NEARLY 150 CB ACCESSORIES—ALL 40 CHANNEL APPROVED! FOR YOUR FREE COPY, SEE YOUR FAVORITE CB DEALER TODAY!

METERS...

CB MULTI-METER SWR/PWR & MODULATION METER
Measures R.F. Power in two scales: 0-12 watts, or 0-500 watts, as well as VSWR and relative modulation. Front panel switches.
Cat.No. 18-152

SWR/FS METER
Accurately measures SWR and FS for peak system performance. For mobile or base station applications.
Cat.No. 18-155

MIKES...

POWER-BASE MIKE
Built-in two stage amplifier increases range of any transceiver by boosting modulation up to 50 times. Excellent with AM and SSB systems. Designed for use with modern, solid-state transceivers, but will greatly increase modulation of older tube type transceivers as well.
Cat.No. 18-000

POWER HAND MIKE
Rugged, powerful, dependable! Power amplified modulation punches through "skip" and interference to increase range. Solid-state circuitry withstands temperature extremes.
Cat.No. 18-010

ANTENNA ACCESSORIES...

TWO POSITION COAX ANTENNA SWITCH
Easy switching of directional to omni-directional antennas! No changing of connectors from ground-plane to beam antenna. Accepts PL-259 coax connectors. May be used for 50 ohm CB or switching 72 ohm Ham antennas up to 1000 watts.
Cat.No. 18-710

CB ANTENNA MATCH
Improves reception range and permits you to match your system even in adverse weather conditions! Tunes your antenna system to perfect SWR to allow all transmission power to leave antenna. Accepts PL-259 coax connectors. Equipped with dual SWR adjustment controls.
Cat.No. 18-716

COLORFUL CATALOG ILLUSTRATES AND DESCRIBES NEARLY 150 CB ACCESSORIES—ALL 40 CHANNEL APPROVED!

FOR YOUR FREE COPY, SEE YOUR FAVORITE CB DEALER TODAY!

GC ELECTRONICS DIVISION OF HYDROMETALS, INC.
ROCKFORD, ILLINOIS 61101 U.S.A.
NEW BRAINWAVE APPLICATION

Brainwave detection ("Mindpower: Alpha"; July, August, September and October, 1976, issues) has one unexplored area of great usefulness. Alpha and certain other brainwaves tend to signal a lack of concentration on the senses. This can be dangerous when one is driving or operating complex machinery. Using such brainwave detectors in an opposite direction to sound a jolting alarm for possible lack of attention could be a great safety innovation.

Some readers may like to look into developing a simple, portable, lack-of-attention or sleep alarm based on brainwave techniques. This should be welcomed by long-distance truck drivers, guards and workers operating almost automatic (and thus boring) machinery—all of which represent danger due to a lack of attention or sleep.

PETER LEFFERTS
Electro-Audio Research Labs
San Martin, CA

Some other interesting functions are; "2nd", "11", summation; "2nd", "11", exchange; "2nd", "1", "tan". These all turn off the display for various amounts of time. The first for about one minute-ten seconds; the second, as far as I can tell, indefinitely; and the third for about four seconds. If the operator wishes to return his calculator back to normal operation, just turn the calculator off and then back on again.

The SR-51 may have limited memory, but for me it is an unlimited source of entertainment.

STEVEN L. BUCHHOLZ
Davis, CA

DIODE POLARITY WRONG?

When I built the Electronic Stopwatch (from the November 1975 and February 1976 issues) I found that all diodes (D1-D7) on the printed-circuit board layout have the wrong polarity indicated. The diodes must be reversed in order for the stopwatch to function properly. I completed the stopwatch and am very pleased with the way that it operates. Keep up the good work.

GABRIEL ROTTER
Roseville, MI

We are happy that you were able to troubleshoot the stopwatch and correct the problem. It appears that you are confused about the accepted method of marking diode elements on schematics and parts placement diagrams. On schematics and any other places where the symbol is used, the arrowhead indicates the anode and the bar indicates the cathode. In addition, the cathode terminal may be marked with a plus sign. This indicates the terminal of the diode that will show a positive voltage or polarity when an alternating voltage is applied to the other terminal.—Editor

COUNTDOWN TIMER QUERIES

(A number of readers questioned apparent discrepancies between the schematic diagrams and board layouts for the Digital Countdown Timer in the August and September 1976 issues. Most of the questions were among those included in letter below. Answers—supplied by author George R. Baumgras—appear in italics.—Editor)

The following errors were noted in the Digital Countdown Timer articles in the August and September issues.

1—IC8. Bottom layout shows pins 2 and 3 tied together but not on the schematic.

2—IC9 has the same function as IC8 but pins 2 and 3 are not tied together in the bottom layout. Is one of these wrong?

The 7490 and 7492 can be reset with either pin. Rather than leave an unused floating input to an active circuit, the two continued on page 16
A new stay-in-touch system for all outdoorsmen.

Hunters
More than doubles the hunting area.

Boaters
Stay in voice contact over water.

Now, Handic's new Outdoor Communicators take 2-way voice contact outdoors.

For hunters, Outdoor Communicators enlarge the game area in a single stroke. They allow the hunting party to spread out of sight-range while still keeping voice contact. And the bright, visible Handic orange is an added safety factor in the field.

For boaters, Outdoor Communicators are a great way to zero in on fish when you're out with friends in other boats. Or to chat away idle hours while waiting for a strike. And, because they carry their own power, they're ideal for sailboat purists.

Campers can keep the whole family in touch in the biggest park, zoo, or at the beach. Just push a button to talk and you know exactly where everyone is at any time.

You have four basic units to choose from, with up to 6 channels, 5 watts of power, and a range of 16 miles.

Outdoor Communicators start at $59 and accept a raft of accessories, including rechargeable ni-cad batteries, Universal Cassette for converting your Outdoor Communicator to a mobile unit or base station, plus numerous antennas for every task.

Outdoor Communicators
Handic

Handic USA, Inc.
14560 N.W. 60th Ave., Miami Lakes, FL 33014

Please send me more information:

NAME

ADDRESS

CITY

STATE

ZIP

THE ORANGE EQUIPMENT KNOWN FOR PROFESSIONAL QUALITY THE WORLD OVER

CIRCLE 77 ON FREE INFORMATION CARD

MARCH 1977
inputs should be tied together. This is done during the circuit-board layout.

3—IC9. Bottom layout shows a wire going from pin 4 to pin 13 of IC10. Actually pin 4 is not connected to anything inside the IC. So why the hookup?

"No-function" pins are often used to simplify board layout but are not shown on the schematic. In this case, IC9 pin 4 should go across to IC9 pin 12.

4—The terminal of IC2-b that connects to IC9 pin 1 is not numbered.

Should be pin 6.

5—IC5. On the bottom layout, pin 4 goes to pin 13 of IC10. Since pin 4 is not used internally in IC9, I believe that the whole connection is wrong and pin 12 of IC9 should have been used. Is this correct?

The connection is correct as noted in question 3.

6—IC5. Pin 3 goes to pin 2 of IC4 in the bottom layout. I think it should have been pin 2. Is this correct?

IC5 pins 2 and 3 go to IC4 pins 2 and 6. Also refer to question 1.

7—IC5. Pin 5 on the schematic is going to pin 13 of IC6. Pin 5 is the Vcc connection so this is not correct. I think it should have been pin 8, not pin 5.

Correct.

8—IC14 has pins 6 and 7 tied together on the bottom layout but not on the schematic.

9—IC16 has pins 2 and 3 tied together on the bottom layout but not on the schematic.

Refer to answer to questions 1 and 2.

10—IC 16, Pin 4 on the schematic goes to ground. Actually, it is not connected inside the IC. Is this necessary?

Should be IC16 pins 6 and 7.

11—IC17. Pins 6 and 7 tied together on bottom layout but not in the schematic?

Refer to answer to questions 1 and 2.

12—IC17. Pin 3 goes to ground on bottom layout but not in schematic?

Refer to answer to question 3. IC17 pin 3 connects to ground on the other side of the board.

13—IC15. R6 is marked 11K on the schematic and 1K in the parts list. Which is correct?

Should be 1K.

14—IC15. Pin 6 and 7 tied together to ground on bottom layout but not in the schematic. Which is correct?

IC15 pin 6 is not connected to pin 7. It goes to IC16 pins 1 and 14.

15—IC15. Pin 11 is tied to pins 1 and 2 on the schematic but pin 10 is tied to 1 and 2 on the bottom layout. Which is correct?

Is the resistor connected to pin 6 should be R27, not R20.

Correct. Should be R27, 3.3K.

19—Capacitor C4 is listed as 2.2 µF in the parts list and 22 µF on the schematic. Which is correct?

The correct value is 2.2 µF as in the parts list.

20—Top view of the control board. The EN and ACD labels are reversed on the left side of the board.

OK as shown.

21—On the alarm board we have three 1N4000 diodes. The outlines indicate axial-lead types. Actually, a 1N4000 is a 10-watt, stud-mount 7.5-volt Zener. Shouldn't these diodes be 1N4001's?

Yes. They should be 1N4001's or similar.

WILLIAM L. SCHREIBER
Fullerton, CA

Rural fire departments using scanning monitors

The fire department of Wicasset, ME, has recently purchased 11 scanning monitors, and a department in Whitefish, MT, bought 21 units, reports RCA's Distributor and Special Products Division, which makes the units in portable, base and mobile models. Scanners are also being used by fire departments in Markleville, IN; Lakewood, NJ; Auburn, VA and Kingston, PA.

The scanners tune continuously over several emergency frequencies and then lock in on any one that is transmitting. They are especially useful on mobile units, alerting the crew to an emergency immediately without having to wait for a message from headquarters.

Fire Chief Gordon Merry of Wicasset reports that members of his department are now able to keep in much better contact with all local fire, police and ambulance calls. In three recent emergencies, he says, the scanners were especially useful. Calls for an ambulance came in on the wrong frequency. Had it not been for the scanners, he said, the calls would have been missed.

240,000 telephone calls an hour switched in new central office

With its 1,000th local-service electronic switching system (ESS), the Bell System initiated its first large-capacity central office switching system, the 1A ESS. The new system went into action last October in Chicago.

The system operates around a new information-processing control unit, the 1A Processor, which operates at more than twice the speed of the earlier No. 1 ESS machines. With its maximum speed of 240,000 calls an hour, the No. 1 A ESS becomes the highest-capacity local

switching system in the world. The processor is also used in the No. 4 ESS for long-distance switching.

The new processor is so designed and constructed that it can easily replace the No. 1 processor used in No. 1 ESS exchanges, wherever the call-handling capacity needs to be increased. It can even be switched in without interruption to the telephone service.

Decimal computations abandoned by new sexagesimal calculator

A sexagesimal calculator (one that counts by sixties instead of by tens) has minutes, seconds and tenths of seconds without the cumbersome conversions required with a decimal calculator. In the numerous applications where time is calculated, the instrument reduces calculating time by 50 percent or more. It is, of course, equally useful in other applications requiring circular measurement by degrees, minutes and seconds.

The instrument has both manual and automatic modes, and also converts hours, minutes, etc., to decimal form and vice-versa. A calculator that handles sexagesimal computations as one of its functions has been announced previously (from Casio), but this is the first instrument to make such calculations its primary feature. It sells for about $50.

THE BABYLONIAN MATHEMATICIANS would have welcomed the new Canon calculator.

been introduced by Chafitz, Inc. of Rockville, MD. The instrument, called the Time Machine, was designed to automatically add, subtract, multiply and divide hours, minutes, seconds and tenths of seconds without the cumbersome conversions required with a decimal calculator. In the numerous applications where time is calculated, the instrument reduces calculating time by 50 percent or more. It is, of course, equally useful in other applications requiring circular measurement by degrees, minutes and seconds.

The instrument has both manual and automatic modes, and also converts hours, minutes, etc., to decimal form and vice-versa. A calculator that handles sexagesimal computations as one of its functions has been announced previously (from Casio), but this is the first instrument to make such calculations its primary feature. It sells for about $50.
But that's not the only reason for buying the Realistic® 452 at the nationwide CB supermarket.

Realistic CB's have been designed to meet challenging conditions, and the TRC-452 is no exception. Adjustable RF gain for best reception of strong and weak signals. Switchable automatic noise limiter and adjustable squelch. Illuminated S/RF meter and channel selector. LED modulation indicator. With plug-in dynamic mike, universal mounting bracket, power cable for any 12 VDC positive or negative ground vehicle. Only $139.95*. So when you go 40-channel — gc Realistic!

*Price may vary at individual stores and dealers.
Learn electronics easier... with HEATHKIT

MONEY-BACK GUARANTEE
We're so confident you will enjoy and benefit from these five courses, that if for any reason you are dissatisfied, we will refund the full purchase price of the course text material.

Unique Heathkit Electronics Courses are designed to provide you with a complete overview of basic and advanced electronics. You learn at your own pace, without pressure or deadlines, and all material is presented in a clear, logical, step-by-step fashion. It's the ideal, effective way to learn about electronics if you're a beginner, or to "brush up" on the latest techniques and theory.

Courses start as low as $39.95 (less trainer)

Thousands of people just like you have already learned electronics the easy Heathkit way — and you can, too. The secret is our efficient approach to self-learning with easy, step-by-step "programmed" instructions; audio records to introduce and reinforce key concepts; self-evaluation quizzes to test your understanding; and interesting experiments that let you learn the easy "hands-on" way. All you need is a record player, small tools and a VOM. The optional Heathkit experimenter/trainer is specifically designed to help you do the experiments in each course, and when you finish the course, you can use it to design and breadboard your own circuits. After completing each course, you can take the optional final exam (passing grade 70%) and receive both a Certificate of Achievement and Continuing Education Units, a nationally recognized way of acknowledging participation in non-credit adult education.

ORDER NOW and SAVE! Buy Any Single Course with Trainer and — SAVE $9.95

Buy Courses 1 thru 4 with Trainer and — SAVE $24.95

Heath Company, Dept. 20-271 Benton Harbor, Michigan 49022
IMPORTANT NOTE: These courses and trainers may qualify for a Federal Tax Deduction. Treasury Regulation 1.162-5 permits an income tax deduction for educational expenses undertaken to: (1) maintain or improve skills required in one's employment or other trade or business, or (2) meet express requirements of an employer or a law imposed as a condition to retention of employment, job status or rate of compensation. In many instances, your employer may re-imburse you in part or in total for taking these courses.

ORDER NOW – get this FREE WELDER SOLDERING IRON!

Comparable $7.95 VALUE!

Your BONUS for promptness—this FREE $7.95 comparable value Weller pencil-style 40-watt soldering iron—perfect for assembling your Experimenter/Trainer, other Heathkit projects and a thousand-and-one soldering jobs around the house!

FREE SOLDERING IRON OFFER EXPIRES APRIL 30, 1977

---

HEATH COMPANY
Dept. 20-271
Benton Harbor, Michigan 49022

Order Form/Agreement
HEATH COMPANY, Dept. 20-271, Benton Harbor, Michigan 49022

Please send me the items checked below and include my FREE $7.95-value Weller Soldering Iron (GDP-1105).

In addition, please send the following courses (less trainer):

☐ Send one course (checked below) with the Experimenter/Trainer (ET-3100) at the special price of only $89.95 plus $3.00 shipping and handling.

☐ Send me the Electronic Circuits Course (EE-3104) with the Experimenter/Trainer (ET-3100) at the special price of only $99.95 plus $3.00 shipping and handling.

☐ Send all four of the courses above (EE-3101, 3102, 3103, 3104) with the Experimenter/Trainer at the special price of just $199.95 plus $4.50 shipping and handling.

I enclose □ check □ money order for $______________

Michigan residents add 4% sales tax.

Charge to my: ☐ BankAmericard Acct. No. ______________ Exp. Date ______________

☐ Master Charge Acct. No. ______________ Exp. Date ______________

Signature: X

NAME (please print) __________________________________________

ADDRESS ________________________________________________

CITY ______ STATE ______ ZIP ________

Radio Electronics PC-121
ORDER TODAY-WE PAY POSTAGE!

Remove this label from card, dampen and use on your envelope instead of a stamp and YOU SAVE 13¢ IN POSTAGE!

Only Heathkit Electronics Courses give you all of these practical advantages

- Clear, step-by-step learning instructions
- Audio recordings to personalize text material
- Electronic parts and experimenter/trainer for “hands-on” experiments
- Up-to-date theories and applications on every subject
- Certificate of Achievement plus Continuing Education Units
- Possible qualification for tax exemption (see other side)
- Courses for everyone – from beginners to engineers

Start enjoying the advantages of knowing more about electronics today! Order now!
faster...at lower cost...Self-Learning Courses!

**COURSE 1: DC Electronics**
An ideal introduction to electronics. Covers current, voltage, resistance, magnetism, Ohm's law, electrical measurements, DC circuits, inductance and capacitance. Discusses matter, atoms, current, flow, voltage rises and drops, series and parallel connections, magnetic fields, voltage dividers, network theorems, more. Includes text, records and 56 parts for 20 different experiments. Average completion time, 20 hours. 2.0 Continuing Education Units and certificate for passing optional final exam.
Course EE-3101 .......................... 39.95

**COURSE 3: Semiconductor Devices**
Essential for understanding latest solid-state equipment. Covers fundamentals, diodes, zener diodes, special diodes, bipolar transistor operation and characteristics, FET's, thyristors, integrated circuits and optoelectronics. Discusses holes, current flow, N and P types, biasing, tunnels and varactors, PIN, IMPATT, gain, cutoff and leakage current, SCR's, bi-directional triodes, light sensitive and light emitting devices, more. Includes text, records and 27 parts for 11 different experiments. Average completion time, 30 hours. 3.0 Continuing Education Units and certificate for passing optional final exam.
Course EE-3103 .......................... 39.95

**COURSE 2: AC Electronics**
Provides an understanding of most commonly used circuits. Covers alternating current, AC measurements, capacitive and inductive circuits, transformers and tuned circuits. Discusses waveforms, period and frequency, meters, scopes, series and parallel circuits, RC filters, dividers, phase shifts, reactance, vectors, transformers and characteristics, series and parallel resonance, more. Includes text, records and 16 parts for 8 different experiments. Average completion time, 15 hours. 1.5 Continuing Education Units and certificate for passing optional final exam.
Course EE-3102 .......................... 39.95

**COURSE 4: Electronic Circuits**
Outstanding explanations of basic circuits. Covers basic amplifiers, special purpose amplifiers, operational amplifiers, power supplies, oscillators, pulse circuits, modulation and demodulation. Discusses amplifier functions and configurations, class of operation, audio characteristics, video amplifiers, buffers, FET's, rectifiers, voltage multipliers, voltage regulation, basic oscillators, RC waveshaping, clipping, AM, FM and SSB, modulation fundamentals and more. Assumes knowledge of courses 1 through 3 or equivalent and requires an oscilloscope for some experiments. Includes text, records and over 110 parts for 18 different experiments. Average completion time, 30 hours. 3.0 Continuing Education Units and certificate for passing optional final exam.
Course EE-3104 .......................... 49.95

**HEATHKIT EXPERIMENTER/TRAINER**
For use with Heathkit Electronics Courses 1 through 4 — helps you perform all the experiments quickly and easily. Has solderless breadboarding sockets, dual variable power supply for positive and negative voltages, sine and square wave signal source, center-tapped transformer. After you complete the course, the trainer is ideal for experimenting and breadboarding with your own circuit designs.
Kit ET-3100 .......................... 50.95

**HEATH**
Sinchulberger
Heath Company, Dept. 20-271
Benton Harbor, Michigan 49022

Please send me items checked below and include FREE $7.95-value Weller Soldering Iron (GD-1105). (See Order Card)
☐ Send one course (checked below) with the Experimenter/Trainer (ET-3100) at the special price of only $39.95 plus $3.00 shipping and handling.
☐ DC (EE-3101) ☐ AC (EE-3102) ☐ Semiconductors (EE-3103)
☐ Send me the Electronic Circuits Course (EE-3104) with the Experimenter/Trainer (ET-3100) at the special price of only $99.95 plus $3.00 shipping and handling.
☐ Send all four of the courses above (EE-3101, 3102, 3103, 3104) with the Experimenter/Trainer at the special price of just $199.95 plus $4.50 shipping and handling.

In addition, please send the following courses (less trainer):
☐ DC (EE-3101) ☐ AC (EE-3102) ☐ Semiconductors (EE-3103) for just $95.95 plus $1.50 shipping and handling each.
☐ Electronics Circuits (EE-3104) for just $49.95 plus $1.50 shipping and handling.
☐ Send me the Digital Techniques Course (EE-3201) with its Experimenter/Trainer (ET-3200) for only $109.95 plus $3.00 shipping and handling.
☐ Also send me that 1M-17 VOM Kit for just $32.95 plus $1.50 shipping and handling.

Michigan residents add 8% sales tax.
I enclose ☐ check ☐ money order for $_____________. or, Charge to my:
☐ BankAmericard Acct. No. __________ Exp. Date __________
☐ Master Charge Acct. No. __________ Exp. Date __________
☐ If Master Charge, include Code No. __________

Signature: ____________________________________________
Name (please print) ______________________________________
ADDRESS ______________________________________________
CITY_ STATE_ ZIP_ _______________________________________

Radio Electronics ED-105
MARCH 1977
Stacks—what they are and how they’re used

TIM BARRY

MICROCOMPUTER USERS THESE DAYS ARE CONSTANTLY BOMBARDED WITH A WILDERING SUPPLY OF NEW JARGON. IN ADDITION TO THE NORMAL PROLIFERATION OF NEW HARDWARE TERMS, WE NOW HAVE TO COPE WITH WORDS FROM SOFTWARE DESIGN, SYSTEMS ANALYSIS, AND A WHOLE HERD OF OTHER LESS WELL DEFINED DISCIPLINES. ONE OF THE MOST COMMONLY USED (AND ABUSED) TERMS THESE DAYS IS STACK. THE HARDWARE REPRESENTED BY THIS PICTURESQUE TERM IS OFTEN ENDOURED WITH RATHER MYSTERIOUS QUALITIES. VAGUE UTTERANCES ABOUT “PUSHING” AND “PULLING” BLEND TOGETHER WITH QUESTIONS ABOUT “BALANCING” AND “NESTING” TO CREATE AN AMBオス省 ATMOSPHERE OF CONFUSION. IN THIS ARTICLE WE WILL LOOK AT TWO PRINCIPAL TYPES OF STACKS AND HOW THEY OPERATE. IN DOING THIS WE WILL HOPefully dispel SOME OF THE MYTHS SURROUNDING THESE EXTREMELY VERSATILE DEVICES.

WHAT IS A STACK?

IN THE MOST GENERAL TERMS, A STACK CAN BE CONSIDERED TO BE ANY SERIAL STORAGE SYSTEM. A STACK WILL HAVE AN INPUT END AND AN OUTPUT END. ALL DATA PLACED INTO THE STACK MUST PASS ONE ELEMENT AT A TIME THROUGH THE INPUT END OF THE STACK. ONCE AN INDIVIDUAL DATA ELEMENT IS IN THE STACK, IT CAN ONLY BE ACCESSED BY REMOVING PRECEDING OR SUCCEEDING DATA ELEMENTS UNTIL IT REACHES THE OUTPUT END OF THE STACK. THE ORDER IN WHICH DATA IS PLACED INTO AND REMOVED FROM THE STACK DIFFERENTIATES BETWEEN TWO DIFFERENT TYPES. FIGURE 1 ILLUSTRATES THE TWO DIFFERENT TYPES.

FIG 1

THE FIRST TYPE WE WILL DISCUSS IS PROBABLY THE EASIEST TO UNDERSTAND. IN THESE DAYS OF CROWDED FACILITIES AND LONG LINES, WE, AS PEOPLE, ALL SPEND PLenty OF TIME IN FIFO (FIRST IN, FIRST OUT) STACKS. THE DATA ENTERED INTO THE INPUT END OF A FIFO EMERGES FROM THE OUTPUT END IN THE SAME ORDER IN WHICH IT WAS ENTERED. (SEE FIG. 1-A) THE PRINCIPAL USE OF FIFO’S IS TO STORE ARRIVING DATA FOR LATER USE. THE NEXT TIME YOU ARE WAITING IN LINE, YOU CAN REFLECT ON THE FACT THAT YOU ARE PARTICIPATING IN A GENUINE COMPUTER BUZZ WORD.

THE SECOND TYPE OF STACK IS LESS COMMONLY ENCOUNTERED IN OUR DAY TO DAY EXPERIENCES. A LIFO (LAST IN, FIRST OUT) STACK RETURNS DATA IN THE OPPOSITE ORDER FROM WHICH IT WAS ENTERED. (SEE FIG. 1-B) THIS MEANS THAT ALL THE DATA IN THE LIFO MUST BE REMOVED BEFORE THE FIRST DATA ELEMENT ENTERED CAN BE RECOVERED. FOR EXAMPLE, CONSIDER AN EMPTY BUS. ASSUME THAT EACH PASSENGER WHO GETS ON THE BUS GOES TO THE BACK AND NO ONE GETS OFF EN ROUTE. WHEN THE BUS UNLOADS, IT SHOULD BEHAVE LIKE A LIFO, WITH THE LAST PASSENGER THAT ENTERED BEING THE FIRST ONE OFF. LIFO’S ARE MOST COMMONLY USED IN COMPUTER PROGRAMMING TO SAVE PROGRAM DATA AND SUBROUTINE RETURN ADDRESSES.

CONTINUED ON PAGE 24

TREAT YOURSELF TO A NEW DIRECT READING DVM TODAY.

DVM35
POCKET PORTABLE ANALOG REPLACEMENT
3½-digit, 1% DCC, Battery or AC
Only $134

DVM36
LAB ACCURATE POCKET PORTABLE
3½-digit, 5% DCC, Battery or AC
Only $158

DVM32
BENCH & FIELD MASTER
3½-digit, 5% DCC, Battery or AC
Only $198

DVM38
"PRIME" STANDARD AT YOUR FINGERTIPS
3½-digit, .1% DCC, Auto-Ranging
Only $348

A COMPLETE LINE OF DVMS TO FILL YOUR EVERY NEED OR WANT.

YOU CAN BE SURE THAT SENCORE DVMS WOULD LIKE TO TELL YOU ABOUT THE SENCORE DVMS BY sending you a 24-page Sencore News, a six-page brochure, and the name of your nearest Sencore Distributor today... simply write or circle reader's service number.

3200 Sencore Drive, Sioux Falls, SD 57107

CIRCLE 19 ON FREE INFORMATION CARD
If you can see a difference, imagine what you’ll hear.

You’re looking at the solution to one of the oldest problems in audio—how to protect records from wear, while at the same time preserving full fidelity.

It’s called Sound Guard*, and it’s remarkable.

Independent tests show that discs treated with Sound Guard preservative played 100 times display the same full amplitude at all frequencies and the same absence of surface noise and harmonic distortion as “mint condition” discs played once.

A by-product of dry lubricants developed for aerospace applications, Sound Guard preservative is so smooth it reduces friction, yet so thin (less than 0.000003") it leaves even the most fragile groove modulations unaffected.

Len Feldman in Radio Electronics reports “At last! The long awaited record-care product has arrived. It preserves frequency response while reducing distortion and surface noise.” It’s effective and safe for all discs, from precious old 78’s to the newest LP’s.

Sound Guard preservative, in a kit complete with a non-aerosol pump sprayer and velvet buffing pad, is available in audio and record outlets.

*Sound Guard is Ball Corporation’s registered trademark for its record preservative. Copyright ©Ball Corporation, 1976.
EICO's 30 Years Experience Assures More Electronics Value For Your Money!

TEST INSTRUMENTS

EICO 396 COLOR BAR GENERATOR
Pocket-size, battery operated with LED Indicator. MOS LSI IC provides 9 digitally controlled, stable patterns. Crystal controlled color bars and timing oscillators. Simply connects to TV's VHF antenna terminals. Wired $89.95

EICO 390 FUNCTION/SWEEP GENERATOR
Outstanding features include: Sine, Square, Triangle Waveforms; Linear and Log Sweep; Calibrated attenuator; VCO for External Frequency Control; BNC Front Panel Output. Wired $169.95

EICOCRAFT® IC KITS

EC-5000
SCA ADAPTOR KIT
ONLY $12.95

Convert your FM radio or receiver to pick up the official FCC-licensed background music service (SCA). IC decoder/adapter permits hearing uninterrupted, commercial-free music broadcast by many FM stations (For personal, non-commercial use only).

IC PROJECT KITS NOW AVAILABLE
ED-5100 ESP Tester $10.95
EC-5200 “Decision Maker” $9.95
EC-5400 Stereo Power Amplifier $10.95
EC-5500 Stereo Pre-Amp $9.95
EC-5600 Electronic Lock $11.95
EC-5700 Universal Power Amp $8.95

BURGLAR/FIRE ALARMS

SS-500 BURGLAR/FIRE ALARM SYSTEM
Professional Security System designed for easy do-it-yourself installation. Features EICO FC-100 Control Center with AC/DC automatic transfer to battery operation. Complete system includes Installation Handbook. Add additional sensors, bells, to suit your own needs. $159.95

SD-75 BATTERY OPERATED FIRE/SMOKE ALARM
Ionization-type detector gives earliest possible fire warning. Mounts directly to ceiling with 2 screws. “Beeps” when battery needs replacement. U.L. listed. $39.95

CB ACCESSORIES

EICO 700 CB FREQUENCY COUNTER
Compact inline-type frequency counter for the serious CB'er/Hobbyist. Operates automatically on transmit. 10 Hz to 30 MHz. $99.95

EICO LR-3 “LONG RANGER” INLINE PREAMP
Bring in those distant/weak signals. Boosts receiver sensitivity up to 20 db. Automatic transmit/receive switching. $29.95

EICO CM-2 “CHANNEL MONITOR” AUTO-SWITCH
Automatically silences car radio when CB call is received/transmitted. $29.95

FREE EICO CATALOG

The more you know about electronics, the more you’ll appreciate EICO. Every EICO product is designed to provide you with the most pleasure and quality performance for your money. The fact that more than 3 million EICO products are in use attests to their quality and performance.

“BUILD-IT-YOURSELF” and save up to 50% with our famous electronic kits.

For the latest EICO Catalog and name of nearest EICO Distributor, check reader service card or send 50¢ for last first class mail service.

EICO-283 Mafia Street, Brooklyn, N.Y. 11207
Leadership in creative electronics since 1945.

ROBERT LEDERER, Pres.

KOMPUTER KORNER
continued from page 22

FIFO operation

FIFO stacks are most commonly encountered in computer I/O systems and data acquisition systems. They are used to match the data transfer rates between two systems. In this type of application they are often referred to as storage buffers. The need for these devices arises when data is transmitted in bursts which are too fast for the receiving device to process. The FIFO is used to store the data in the order in which it arrives during the entire burst. The receiver (usually a computer) can then process the data from the FIFO at its own rate. A common FIFO application of this type is found in computer disk systems. Data to be transferred to or from a disk must be transferred at a higher rate than most computers can manage. To solve this problem, a FIFO buffer is used. The disk transfers a block of data into the FIFO at high speed. The computer can then use the data at its own rate.

---

Add your own comments or questions here.
WIRE WRAPPING TOOL
For AWG 30, .025" (0.63mm) sq. post, "MODIFIED" wrap, positive indexing, anti-overwrapping device.

OK MACHINE & TOOL CORPORATION
3455 Conner St., Bronx, N.Y. 10475 / (212) 994-6600 / Telex 125091

NEW
HOBBY-WRAP
Model BW-630

Battery wire wrapping tool
$34.95
ONLY
COMPLETE WITH BIT AND SLEEVE

OK MACHINE & TOOL CORPORATION
3455 Conner St., Bronx, N.Y. 10475 / (212) 994-6600 / Telex 125091

CIRCLE 21 ON FREE INFORMATION CARD
from the FIFO, the first data element in the memory is pulled into the output buffer. All other data in the memory is then moved down one. If the FIFO becomes full or empty, it sets flags to indicate these conditions. A graphical illustration of a FIFO operation is shown in Figure 2-b.

A FIFO can be implemented using software instead of hardware. In this case subroutines are used to perform the push and pull operations. The flow chart for the push subroutine is shown in Fig. 3-a and the pull subroutine is shown in Fig. 3-b. In actual use, these two programs will both share a common block of the computer’s main memory for the FIFO stack. They will keep track of where the data in the FIFO is by using a stack pointer. A stack pointer always indicates the memory address of the most recent data element entered into the stack. (This is true of both FIFO’s and LIFO’s.)

When the push subroutine is executed, the stack pointer is incremented by one and the new value returned to the memory. The data passed to the subroutine is then transferred into the stack memory at the address now indicated by the stack pointer. For a pull operation, the stack pointer is first tested to see if the stack is empty. If it is, an error flag is set and the subroutine returns. If it is not empty, the data at the first memory address of the stack is obtained. The stack pointer is then decremented by one and re-stored in the memory. All the data in the FIFO is moved down one in the memory. The routine then returns to the calling program with the data.

LIFO operation

The LIFO stack is most commonly encountered in systems programming and microcomputer subroutine systems. In systems programming (particularly language processors), the LIFO is used to store data and operands during the evaluation of arithmetic and algebraic expressions. In microcomputer subroutine systems, the LIFO is used to hold program data and subroutine return addresses.

The hardware required to implement a LIFO consists of the same basic hardware we saw used in the FIFO. It is simply connected together in a different configuration. (See Fig. 4-a.) In operation, the data is received into the input buffer just as before. However, all the other data in the LIFO is now pushed down one to make room at the top for the new element. For an output operation, the top element of the stack is popped into the output register and all the other data is then moved up in the memory. These LIFO operations are illustrated in Fig. 4-b.

Implementing the LIFO can also be done in software. The flowchart for the push subroutine is shown in Fig. 5-a and the pop subroutine is shown in Fig. 5-b. As with our software FIFO, the software LIFO routines will share a common memory area and stack pointer. When the push subroutine is called,
Performance features at a price you can afford—and fully backed by Tektronix

Only Telequipment offers you:

TEKTRONIX GUARANTEE
The Telequipment family of oscilloscopes is fully guaranteed by Tektronix, the world's leading oscilloscope manufacturer. This guarantee means that during your first year of ownership, if there are any defects in Telequipment parts or workmanship, you can bring your oscilloscope to any of 35 Tektronix Service Centers across the United States for fast repair by experts—free of charge.

PERFORMANCE FEATURES YOU NEED AT A PRICE YOU CAN AFFORD
Model D61a—Designed for portability and easy operation, the D61a is a dual trace 10 MHz 'scope for only $595. For easy, accurate viewing, the D61a features automatic triggering and bright, stable waveforms on an 8 x 10 cm display.

Model S61—NEW from Telequipment, the S61 is a 5 MHz single trace oscilloscope featuring automatic triggering and 8 x 10 cm display for $375. This lightweight (14 lb.) instrument has a straightforward, easy to read front control panel—well suited for education applications.

Model D32—When you demand an extremely portable 'scope, the D32 is ideal. Battery or ac line operated, this 10 MHz dual trace 'scope weighs only 10 lbs. An optional shoulder strap or attaché carrying case can be used to take your 'scope into the field. The $750 price includes batteries and probes.

IDEAL FOR MANY APPLICATIONS
If you're servicing pocket calculators, TV, radio, microwave ovens, alarm systems or dozens of other consumer products, Telequipment 'scopes can do the job for you. Easy viewing and operating make Telequipment ideal for classroom use too.

TELEQUIPMENT...THE CHOICE FOR YOU
Performance features at a price you can afford, plus full backing by Tektronix make Telequipment a wise choice when you're looking for low-cost oscilloscopes.

For more information about Telequipment oscilloscopes, contact your nearest Tektronix Field Sales Office, or write Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97077. For immediate information, call Bill Glaze at Tektronix: (503) 644-0161, extension 7163.

Telequipment is a division of Tektronix U.K. Ltd., a wholly owned subsidiary of Tektronix, Inc.
U.S. Sales Price F.O.B. Beaverton, Oregon.

CIRCLE 35 ON FREE INFORMATION CARD
CIE has a terrific idea for a few people who know what they want.
If you want success in electronics...if you want the skills people are glad to pay for...find out about CIE training.
It's a terrific idea that can get you on your way to success in electronics troubleshooting.

Let's face it, learning valuable new skills isn't something you just breeze through. Especially in a modern technological field like electronics troubleshooting. You've got to really want success if you're going to build your skills properly.

But, oh boy, the rewards when you do! In today's world, the ones who really know electronics troubleshooting find that people...even industries...look for their help.

What about you? How much do you want the thrill of success...of being in demand? Enough to roll up your sleeves and work for it?

Why it pays to build troubleshooting skills.
Suppose the automated production controls on an assembly line break down. Imagine how much money the manufacturer can lose when help doesn't come fast! And it takes a skilled electronics troubleshooter to move in...locate the problem...solve it...and get the lines moving again.

Or take a TV station. Breakdowns are costly in broadcasting where time is money. Viewers won't sit forever waiting for sound or the picture to come back. Before they change channels, the station needs to get back on the air again—with the help of a skilled troubleshooter.

No question about it. Building new skills in electronics troubleshooting is an investment in your future. It's well worth the effort.

Why you should get CIE to help you do it.
Troubleshooting starts with ideas...principles. CIE's Auto-Programmed® Lessons help you get the idea—at your own most comfortable pace. Step by step at home, you explore each principle—each theory—until you understand it thoroughly and completely. Then you start to use it.

How CIE helps you turn ideas into reality.
If you're a beginner, you start with CIE's Experimental Electronics Laboratory. You actually perform over 200 experiments to help you grasp the basics. Plus you use a 3-in-1 Precision Multimeter to get your first taste of the testing, checking, analyzing steps you take in troubleshooting!

How 3 practical steps help you build troubleshooting skills.
You'll take your first practical step in professional troubleshooting when you build your own 5MHz triggered-sweep, solid-state oscilloscope.
As a trained troubleshooter, you'll use your oscilloscope the way a doctor uses his X-ray machine. As a student, you learn how to "read" waveform patterns on a big, 8cm. x 10cm. screen...how to "lock them in" for closer study...how to understand and interpret what they tell you.

Your second practical, skill-building step begins when you get your Zenith 19-inch diagonal, solid-state color TV—featuring nine removable modules!
Now's your chance to apply the new skills you learned with your oscilloscope!

With CIE's guidance, you perform actual service operations—the kind you'd handle on the job as a trained troubleshooter! Using the TV, you learn to trace signal flow...detect and locate malfunctions...restore perfect operating standards...just as you would with any sophisticated electronics equipment.

Finally, step three rounds out your experience as you work with a completely solid-state color bar generator—actually a TV signal transmitter that produces ten different display patterns on your TV screen!

You study a gated color bar rainbow...crosshatch lines...dot patterns... You explore digital logic circuits...observe the action of a crystal-controlled oscillator!

This practical, "hands on" training takes concentration and effort. But it's enjoyable and rewarding. And it's a great way to prepare for a troubleshooting career!

Why it's important to get your FCC License.
For some troubleshooting jobs, you must have your FCC License. For others, employers often consider it a mark in your favor. It's government-certified proof of specific knowledge and skills!
Almost 4 out of 5 CIE graduates who take the exam get their Licenses. More than half of CIE's courses can prepare you for it...and the broadest range of career opportunities!

Free catalog!
Mail the card. If it's gone, cut out and mail the coupon. If you prefer to write, mention the name of this magazine. We'll send you a copy of CIE's FREE school catalog—plus a complete package of independent home study information! For your convenience, we'll try to have a representative call to help you with course selection. Mail the card or coupon...or write: CIE, 1776 East 17th Street, Cleveland, Ohio 44114.

CIE Cleveland Institute of Electronics, Inc.
1776 East 17th Street, Cleveland, Ohio 44114
Acredited Member National Home Study Council

□ YES...I want to succeed in electronics. Mail me my FREE CIE school catalog— including details about troubleshooting courses plus my FREE package of home study information!

NAME (please print)
ADDRESS APT.
CITY
STATE ZIP
AGE PHONE (area code)
Check box for G, I, Bill information:
□ Veteran □ Active Duty
Mail today!
the stack pointer is incremented by one and the new value returned to the memory. The data passed to the subroutine is then transferred into memory at the address indicated by the stack pointer. For a pop operation, the stack pointer is first tested to see if the stack is empty. If it is, an error indicator flag is set and the routine returns. If the stack is not empty, the data at the address indicated by the stack pointer is obtained. The stack pointer is then decremented by one and the new value stored in the memory. The routine then returns to the calling program with the data.

Stacks and microcomputers

As mentioned earlier, many microcomputers use stacks to implement their subroutine systems. This arose because of the unsuitability of the normal minicomputer way of saving return addresses. When a subroutine is called, most minicomputers save the return address of the calling program in the top location of the subroutine called. A return can then be executed by performing an indirect jump to the first location in the subroutine. (See Fig. 6-a.) This works great in systems where the subroutines are located in read/write memory. It's not so hot when the subroutines are to be located in read only memory. Since most microcomputers make extensive use of ROM, something had to be done. Enter the LIFO.

When a LIFO is used for the subroutine structure every time a subroutine is called, its return address is pushed onto the stack. When a subroutine return is executed, the top address in the stack is popped into the program counter, thus transferring control to that location. (See Fig. 6-b.) Now this means that all subroutines must be returned in the opposite order in which they were called if proper program operation is to be maintained. The number of subroutine calls executed before a return is executed is called nesting. Thus the phrase, "My program is nested five deep," means that the program has called five subroutines before the first return has been executed.

Microcomputer designers took two basic approaches to implementing the LIFO stack for return addresses. The first way was to build the LIFO in as part of the CPU hardware. This method required no special

continued from page 26
Hobbyist or professional, there are probably a lot of circuits you build just for the fun of it. And a lot you'd like to build, but never get around to.

One reason is the cost of parts. Parts you buy for one project, but can't re-use... because you haven't time to take them carefully apart. Or because of heat and mechanical damage that occur when you do.

Now, there's an easier way that can save you big money on parts and hours on every project, as well: Proto-Board® Solderless Breadboards.

Now, assembling, testing and modifying circuits is as easy as pushing in—or pulling out—a lead IC's, LED's, transistors, resistors, capacitors... virtually every kind of component... connect and inter-connect instantly via long-life, nickel-silver contacts. No special patch cords or jumpers needed—just lengths of ordinary #22-30 AWG solid hook up wire.

Circuits go together as quickly as you can think them up. And parts are re-usable, so as your "junk box" builds, you build more and more projects for less and less money.

Before you invest in your next project, invest in a CSC breadboard. See your dealer or order by phone: 203-624-3103 (East Coast) or 415-421-8872 (West Coast) — major charge cards accepted. You've got nothing to lose... and a lot to gain.

CONTINENTAL SPECIALTIES CORPORATION

44 Kendall Street
Box 1942 New Haven, CT 06509
203-624-3103 TWX 710-465-1227

West Coast office: Box 7809 San Francisco, CA
94119 * 5-421-8872 TWX 910-372-7992

C976 Continental Specialties Corporation

CIRCLE 39 ON FREE INFORMATION CARD
Data Precision Model 175
Digital Multimeter

The Data Precision Corporation refers to their model 175 as a "miniature portable 3½ digit multimeter". They couldn't be more accurate. Miniature and portable are the only words to describe it. The model 175 is only 3.5 deep × 5.5 wide × 1.5-inches high. If you’ve already gone all metric, 9 × 13 × 4.5 mm. The case is the only little thing about it. The LED display is almost ½-inch high, and bright.

It has all of the functions and ranges needed for a full-sized digital multimeter. AC and DC volts can be read from a 100-millivolt full-scale range up to 1,000 volts. Due to the automatic overranging, this will let you read up to a 100% overrange. The display on the 100-mV scale will read up to 199.9. Only on the highest scale, 1,000 volts, is overrange capability inoperative. The limit on AC volts is 500.

For resistance and current ranges, the overrange works. On the 10-megohm resistance scale, resistance up to 19.99 megohms will be displayed. The AC and DC current ranges are calibrated in milliamperes, and can be read up to 199.9 mA. The lowest resistance range is 100 ohms full-scale, maximum reading 199.9 ohms. Low- and high-voltage ohms scales are used; maximum voltage of 2.5 volts on HI and 300 mV on LO. This can be set up by the function switch on any ohms range. Incidentally, for the accident-prone, the ohms ranges are able to withstand up to 250-volts RMS AC or DC without harm. As long as you stay out of the raw boost circuits, you’re OK.

There are only the two controls and the switch on the front panel. The rest is taken up by the LED readout. The test leads plug into miniature banana jacks at the right side of the case, near the back. The whole thing is so compact that you can easily hold the instrument and the common test-lead in one hand, and the hot test-lead in the other. They have thoughtfully provided a wrist strap with a pivoted ring, to slip over your arm so that you won’t drop it. This makes it very nice for getting readings in dark places. You don’t have to shine your penlight on the meter to read it! (Where do you get the third hand to continued on page 87)
invites you to take this
1624-page electronics library for only

Only $1.99 for all three!

Regular List Price $33.85.
Top-Quality Hardbinding
Features huge quick-find index
Over 2300 illustrations
Contains over 800,000 words
1624 data-packed pages

with a Trial Membership in the Book Club
that Saves you 25% to 75% on a wide selection of electronics books

with the literature published in your areas of interest and to save substantially while so doing. As part of your Trial Membership you need purchase as few as four books during the coming 12 months. You would probably buy at least this many anyway without the savings offered through Club Membership.

To start your Membership on these attractive terms, simply fill out and mail the coupon today. You will receive the 3-volume Electronics Library for 10-day inspection. YOU NEED SEND NO MONEY! If you are not delighted return them within 10 days and your Trial Membership will be cancelled without cost or obligation.

ELECTRONICS BOOK CLUB, P.O. Box 10, Blue Ridge Summit, Pa. 17214.

- 3 introductory books carry a publishers retail price of $33.85. They are yours for only $1.99 (plus postage and handling with your Trial Membership).
- You will serve the Club Membership by describing the current selection. Alternatives and other offerings, every 4 weeks (13 issues a year).
- If you want the Selection, do nothing; it will be sent to you automatically. If you do not wish to receive the Selection or wish to order one of the alternatives offered, simply give instructions on the reply form (mailed on the envelope provided), and return it to us by the date specified. The date allows you at least 10 days in which to return the book.
- If you do not want to receive the Selection or any alternatives, do not have 10 days to make a decision and so receive an unwanted Selection, you may return it for a full refund.
- Personal service for your account—no computers used!
- To complete your Trial Membership, you need buy only four additional monthly selections or alternatives during the next 12 months. You may cancel your Membership any time after you purchase these four books.
- All books—including the introductory offer—are fully returnable after 10 days if you're not completely satisfied.
- All books are shipped postpaid and handling charges prepaid. Reduced postage and handling charges. Prepaid orders shipped postpaid.
- Continuing Bonus: If you continue after this Trial Membership, you will earn a dividend Certificate for every book you purchase. These Certificates, plus payment of the nominal sum of 1$199 will entitle you to a valuable Book Dividend of your choice which you may choose from a list provided Members.

ELECTRONICS BOOK CLUB
P.O. Box 10
Blue Ridge Summit, Pa., 17214

Please open my Trial Membership in ELECTRONICS BOOK CLUB and send me your 3-volume Electronics Library, invoicing me for only $1.99 plus shipping. If it is not delighted, I may return the books within 10 days and owe nothing, and have my Trial Membership cancelled. I agree to purchase at least four additional books during the next 12 months, after which I may cancel my Membership at any time.

Name ____________________________ Phone ____________________________
Address ____________________________________________________________
City ____________________________ State ______ Zip __________

(The offer valid for new members only. Foreign and Canada add 10%.) RE:37

CIRCLE 1 ON FREE INFORMATION CARD

MARCH 1977

35
CB servicing is PROFITABLE
with the
B&K-PRECISION
40-channel CB Test Bench

When used with a scope and signal generator, you can:

- Measure signal-to-noise ratio of CB receiver
- Measure audio output power
- Measure audio distortion percentage
- Measure receiver sensitivity
- Check AGC
- Measure effectiveness of CB noise limiter or blanker (when used with an impulse noise generator)
- Measure squelch threshold
- Measure adjacent channel rejection on any channel
- Measure transmitter AM power output—even mobile!
- Measure SSB power output with TRUE peak-reading RF Wattmeter
- Check AM modulation
- Check SSB modulation with a two-tone test—the only accurate way!
- Measure antenna SWR—even mobile!
- Check the transceiver in the car to determine if the problem is in the antenna system or the transceiver

You can save $500—$1,500 in equipment costs because the CB Servicemaster eliminates many of the test instruments you would otherwise need for CB servicing. These instruments, or their functions, are built into the unit:

- Audio wattmeter
- Audio generator
- Distortion meter
- RF wattmeter/dummy load
- DB meter
- SWR bridge

These instruments—which you should have, if you don’t own them already, are all you need to get the maximum use from your CB Servicemaster. And the B&K-PRECISION CB Servicemaster is compatible with most oscilloscopes, frequency counters, signal generators and power supplies on the market today.

MODEL 1040—$250
The B&K-PRECISION CB servicemaster is designed for rapid programmed testing and trouble shooting of any CB transceiver—even 40-channel models!

MODEL 1403A—3", 5 MHz Recurrent Sweep Oscilloscope
Checks CB modulation and provides viewing of 27MHz CB envelope when used with the Model 1040. Small, compact and inexpensive, it frees other scopes for more effective use. $299

MODEL 1801—Digital Frequency Counter
To quickly determine the exact frequency of a CB channel, the 1801 automatically displays it for you in large, easy-to-read digits. You can tune oscillators precisely, conduct audio frequency analysis tests. Six digit display is updated five times per second. Accuracy guaranteed to 40MHz; 60MHz typical. $240

MODEL 1640—Regulated Power Supply
Designed especially for CB and other mobile equipment, the 1640 eliminates changes in supply voltage due to load variations. A stable power supply is essential to precise testing of the transceivers. Less than 0.8% variation from zero to full load, 3 amps continuous, 5 amps surge. Adjustable to any output from 11 to 15 VDC. Suppressed zero scale for greater accuracy. Overload protected. $100

MODEL 2040—40-Channel CB Signal Generator
Covers all 40 channels, AM and SSB with built-in capability. Ultra-stable crystal-controlled, phase-locked-loop frequency generation. Has 5 ppm accuracy. Output attenuator and vernier provide calibrated outputs from 100,000 µV to 0.1 µV for receiver sensitivity measurements. Includes EIA standard noise test signal generator to check receiver noise suppression. Internal 400, 1000 and 2500 Hz modulating frequencies—can also be externally modulated. Internal protection against 5W RF input. $475

For additional information, contact your B&K-PRECISION distributor for our comprehensive brochure describing the operation of the Model 1040 CB Servicemaster and the CB Service Center—or write us for your free copy.

CIRCLE 71 ON FREE INFORMATION CARD
ADD DIMENSION TO STEREO

Binaural/Biphononic Sound

A recent revival of an old technique that provides precise spatial localization of sound sources. JVC's recent introduction of a combination headphone/microphone brings this technique within easy grasp of the home recordist.

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

Back in the early 1930's, Bell Laboratories performed extensive research into the nature of human hearing and, more specifically, the "binaural" effect. As most readers are probably aware, the reason that we can localize or perceive the direction of sound is that we have two ears. Until recently, it was thought that two factors help us to determine angular directions from which sound reaches us— the difference in time of arrival of a sound to our two ears, and the difference in amplitude of the sound reaching our left and right ears. These factors are illustrated in Fig. 1. Sound waves approaching us from the left arrive at the left ear first, with sound reaching the right ear a small fraction of a second later. Since the sound has also travelled a greater distance to reach the right ear, it will be somewhat diminished in intensity as well.

More recent studies have shown that a third factor influences our ability to localize sounds. When the early Bell Lab studies were being performed, the question arose as to why we are able to detect the difference between a sound coming from directly in front of us and one coming from directly behind. It was at first supposed that since both kinds of sounds arrive at both ears simultaneously, and with equal intensity, that we must subconsciously be turning our heads ever so slightly to establish an angular difference (and hence a different time of arrival) that then gives us the final clue as to the source of the sound. More recently, studies have shown that there is another factor involved. Because of the construction of our outer-ear (the auricle, or pinna), the frequency response of our overall hearing is "poorer" for sounds reaching us from behind, compared with sounds reaching us from in front. The "baffle" formed by the outer ear attenuates "highs" reaching us from behind.

Dummy-head microphones

In those early Bell Lab experiments, a dummyhead was fitted with two microphones, each located where the ears would normally be. Sounds picked up by each microphone were amplified by a separate amplifier and reproduced over a pair of headphones, as shown in Fig. 2. The sensation was very much as though the listener wearing the headphones was "transported" to the position in space occupied by the dummy head. Not only were angular directions of sounds clearly discernible, but listeners were able to determine, quite accurately, the distances to the sound source. In other words, there was a total and complete sound field perceived by listeners wearing the headphones.

Years passed and, as we know, binaural sound reproduction was given little or no attention. In the early 1950's, attention was turned to stereophonic sound. The chief reason why binaural
sound was regarded as impractical as a home entertainment music system was its need for headphone listening. Most people preferred listening to music reproduced over free-standing loudspeakers. If a binaural recording (using a dummy-head microphone arrangement) were to be played back over a stereo system, one would lose almost all perception of sound localization. The reason for this is obvious. The sounds originally intended for only the left ear are heard in both ears when reproduced via speaker systems, and the same is true of those sounds intended for only the right ear.

In order to synthesize a feeling of spread or separation, stereo recordings intended for reproduction over two loudspeakers had to be made with microphones widely separated. In this way, the sounds picked up by the left-channel microphone would be substantially different from those picked up by the right microphone.

As stereo recording technology advanced, all attempts to recreate a true "sound field" have just about vanished. Most stereo recordings today contain a mixture of multi-channel monophonic recordings (often, combined from 16, 24 or even more microphone channels). Such recordings can "fool" the listener into visualizing a two-dimensional sound plane, with musical instruments or vocalists "positioned" across a wall of sound. But the typical stereo recording, reproduced over conventional stereo hi-fi equipment cannot offer sound in three dimensions. The sense of distance is lacking.

Recent interest in 4-channel sound reproduction arose because of this deficiency in conventional stereo reproduction. But even 4-channel recordings, however carefully engineered, fail to provide true 360-degree sound fields with total realism and with distances from the listener to the sound source that are still difficult to ascertain with any precision. The ability to perceive sound sources, even in a discrete 4-channel system, is limited. (See Fig. 3.)

Renewed Interest in binaural

Several factors have recently contributed to renewed interest in binaural sound recording and reproduction. For one thing, headphone listening has become quite popular and many audiophiles listen to stereo programming via headphones a good deal of the time. Also, compact high-performance microphones have been developed which facilitate the construction of "dummy head" dual-microphone systems that more nearly duplicate the physical dimensions and shape of the human head and ear. Finally, there has been a growing interest in live recording both in Japan and in the United States as more and more audiophiles take to the field with high-quality portable stereo cassette decks to record live events, musical or otherwise. As anyone who has tried to do a live stereo recording in the field is well aware, the problem of microphone placement, monitoring of the recording as it is being made, and the like, can discourage even the most enthusiastic of recordists.

After extensive research, JVC (Japan Victor Company) developed and is marketing an unusual headphone/microphone combination they call the model HM-200E. A close-up view of this product is shown in Fig. 4. In addition to housing a dynamic-type air-tight headphone, each earpiece is also fitted with an omni-directional electret microphone that is surrounded by a plastic molded "outer ear" or pinna designed to provide much the same frequency response and attenuating characteristics as the human ear. A tiny battery compartment houses a penlight battery for powering the microphone in each earpiece. The cable terminates in three phono-plugs—the usual stereo headphone plug and one single-circuit plug for each microphone.

The robot-looking "head" shown in...
Fig. 4 is actually the microphone stand supplied with each HM-200E. It is made of a plastic material coated with a felt-like substance that is intended to approximate the density of a human head. The underside of the head is equipped with a variety of tapped screw-holes to fit any standard microphone stand (including the ⅜-inch standard used in the U.S.). So, the phone/microphone combination can be used to record either while wearing the combination on your own head or by mounting them on the supplied dummy head and pointing it in the right direction.

Because the headphones are the sealed or air-tight type, it is even possible to monitor sounds that are to be recorded while recording is taking place without inducing acoustic feedback between the microphones and the dynamic headphone transducers.

While the product may seem rather obvious and simple, a great deal of study went into its development. Primarily considerations had to be given to the time difference between the arrival of sounds at each microphone for different incident angles, level-difference characteristics and frequency response. Comparisons had to be made between these characteristics observed on a scientifically accurate "dummy head", the same characteristics as observed when fitting the product on the listener's head, and those characteristics as observed when the product is fitted to the supplied "microphone stand" head. The frequency response at angles of 0 degrees and 180 degrees (the characteristic which enables us to distinguish between "front" and "rear" sounds) of the model HM-200E fitted on a human head is shown in Fig. 5.

Binaural sound from speakers

JVC's research into binaural sound has gone much beyond the development of the headphone/microphone system just described. Recognizing that it would be desirable if some of the spatial qualities of true binaural sound could be reproduced via a pair of stereo loudspeakers (or even a quadriphonic array of four speakers), they have developed an electronic processor that, under ideal listening conditions, can actually make it possible to enjoy the effects of binaural sound over a pair of loudspeakers.

As we stated earlier, the problem in listening to binaural sound over speakers is basically one of psychoacoustic crosstalk. Both ears end up hearing material intended for one ear alone, and in unprocessed form, binaural sound played over speakers sounds not much better than mono. If, however, precisely calculated amounts of out-of-phase, delayed and frequency-automized left-channel information could be cross-

![Diagram of Biphonic Processor](image)

**FIG. 7—BIPHONIC PROCESSOR** is comprised of equalization and delay circuits.

coupled to the right-speaker channel and vice versa, it might be possible to create the binaural effect even when listening through speakers.

The principle is shown in Fig. 6 and a simplified block diagram of the binaural-stereophonic processor is shown in Fig. 7. Although the processor does restrict listener position to a very small area in the listening room, we can attest to the fact that it really does work. For the first time in our own listening experience, we were actually conscious of distances from sounds heard, as well as of their angular relationship in space.

Another interesting effect of the binaural-stereophonic processor is the expanded sound field it gives to conventional stereophonically recorded program sources. As illustrated in Fig. 8, a listener actually feels that sounds are coming from beyond the speakers themselves—an effect that may someday be quite useful, especially in situations where physical distance between speakers in a listening room is less than adequate because of limitations imposed by the room or its decor.

Taking the idea a step further, JVC explored the possibility of processing quadriphonically recorded material to create a binaural-listening experience. They concluded that even when binaurally recorded material is played back via the processor over a pair of speakers, sound images that should be localized behind the listener are still localized in a rather vague manner and the listener senses sound images over little more than a 180-degree angle in front of him.

They proposed to solve this problem by what they call a quad-binaural-stereophonic system using dual artificial heads as shown in Fig. 9. Reproduced sounds "heard" by the microphones in the front head are reproduced from speakers placed in front of the listener, while those sounds picked up by the microphones in the rear head are reproduced over the speakers positioned at the rear of the listener. In this listening arrangement, they found that best results are obtained when the front speakers form an arc of 60 degrees with respect to the listener, while rear speakers are positioned at 90 degrees.

Neither of the two processors (the two-channel or four-channel version) is currently available to consumers, though that situation may, of course, change if the company feels that there is growing interest in such unique...
Tomorrow's HI-FI Gear

A look at future hi-fi equipment revealed at conventions in Tokyo and New York.

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

TRYING TO PREDICT WHAT TECHNOLOGICAL paths the high-fidelity industry will follow in the coming years is, at best, a risky business. An industry that has managed to triple its sales volume in less than half a decade is too dynamic and too diverse to lend itself to firm prophecies, as is evident if one examines the optimistic prognostications made for quadraphonic sound just a few years ago and compare them with the present state of apathy regarding 4-channel sound reproduction.

Nevertheless, two recent events took place within the audio industry that may serve as fairly good indicators of things to come in hi-fi. The first of these was a mammoth consumer high-fidelity show held at the giant Harumi convention center in Tokyo, Japan, that I was fortunate enough to attend, if only briefly. The second event was the annual Audio Engineering Society convention held in New York in the late autumn of 1976 that I also attended. These two events, as far apart geographically as any two happenings could be, had several things in common. Chiefly, they provided a glimpse of products and concepts that we are likely to see brought to commercial reality in the coming months and years. So, rather than devote this story to a single audio development, I would like to briefly discuss several innovative products and ideas that caught my fancy, either in Tokyo or in New York.

Headphones without wires

Popularity of stereo headphone listening has been growing ever since John Koss first introduced his somewhat crude looking stereophones in the late 1950's. One of the disadvantages of headphone listening has been the physical constraints that are imposed upon the listener who wears the phones. The long cable (neatly coiled as it may be) that connects the phones to the familiar front-panel phone jack confines the wearer to a limited area within the listening room (few cables are longer than 10 feet or so). Now, Sennheiser Electronics Corporation has developed a "wireless" set of stereophones that are shown in Fig. 1. While the company had earlier shown a monophonic version of the wireless phones, their introduction of a stereo version occurred at the AES convention mentioned earlier.

The phones work on a completely invisible infrared light with a wavelength of 930 nanometers that is frequency modulated by a carrier of 95 kHz for one channel, 250 kHz for the other channel. Pre-emphasis of 50 micro-seconds is used. The transmitter, model HDI-434, shown in Fig. 2, uses twelve light-emitting diodes to transform the audio signal into infrared light. These special GaAs diodes can be modulated up to several hundred kHz, but 50 kHz deviation has been standardized as the maximum frequency modulation swing for these units.

The audio signal to be transmitted is applied to the transmitter unit by connecting a plug to the normal stereo output jack of the amplifier or receiver. An audio output of 1.5 volts is required for a full 50-kHz deviation of the light carrier. The transmitter is powered by connection to a regular 120-VAC socket. An example of a working transmitter modulator circuit for an audio frequency modulated carrier set to 95 kHz is shown, schematically, in Fig. 3.

At the receiver (headphone) end of the system, two dynamic transducers are driven by the built-in infrared light receiver. A switch allows the user to select both phones to be activated by the left channel, the right channel or in the stereo mode. This feature makes it possible for the phones (model HDI-434) to be used for two different programs. For example, the original and the translated sound track of a foreign language film could be "received" simultaneously and selectively assigned to both earpieces. One of the two
earpieces is also equipped with separate fader/volume controls for left-right channel balancing. A block diagram of the receiver setup for one channel of the headphones is shown in Fig. 4. Tentative pricing for the phones is $209.00 while the infrared transmitter module is expected to sell for around $184.00.

In our visit to Sennheiser's exhibit at the AES show we donned the phones and walked about the rather large room in which the units were being demonstrated. There was no fading whatsoever and, even more significant, unlike RF transmissions that have been attempted in the past for similar applications, there is no audible interference or multipath distortion no matter where one is situated in the room. We were informed that in very large listening areas, additional transmitters can be used in one room without creating problems. The power of the radiated light simply adds together for greater area coverage. A synchronizing jack on each transmitter permits connection of a second transmitter for such cascading of infrared light-emitting units.

**Binaural and Bi-Phonic sound**

Long before quadraphonic sound was introduced to audiophiles, experimenters (such as Bell Laboratories) had done considerable work with binaural sound reproducing systems. For those not familiar with the term "binaural", Fig. 5 shows the technique.

An artificial or "dummy" head, equipped with a pair of microphones located where our ears normally would be is used to record a live musical or other audible event in the standard two-channel format. When the recording is played back and listened to via headphones, spacial positioning of sounds is extremely precise. (After all, in real life we have only two ears with which to localize the sources of sound we hear and we manage to do so with pin-point accuracy.)

The reason why binaural recordings have not been more popular in the past is because most people prefer to listen to music via speakers rather than headphones and, in order to provide reasonable spatial information using speakers, stereophonic recordings employ microphones that are placed much further apart than the distance between our two ears. This is done to compensate for the fact that the speakers will also be placed far apart during listening and the fact that both of the listener's ears will be subjected to sounds from both speakers (as opposed to the binaural technique in which the listener hears only left-channel information via a headphone placed on his or her left ear and right-channel information via the right earphone).

One of the persistent problems in conventional stereophonic playback has been the inability to recreate sounds that have perceivable front-to-back localization. Stereo, in effect, creates two-dimensional sound rather than three dimensional sound, as might be the case with classical binaural recording and reproduction. It is this failing of stereo that prompted experiments with quadraphonic sound. But even 4-channel sound, using the usual two-up-front, two-in-the-rear speaker placement suffers from an inability to create convincing side images and an inability to recreate accurately those sound images

![Diagram of block diagram of infrared receiver and headphone setup](image-url)
that were intended to be close-in to the listener.

At the Tokyo high-fidelity show, a major portion of JVC’s exhibit space was given over to demonstrations of two newly developed recording and reproducing systems. The first of these is known as Bi-Phonic (short for Binaural-Phonic) and involves the playing of tapes or discs that have been recorded in the classical binaural method (using dummy head equipped with microphones instead of ears). Interposed between the record or tape player and the amplifier which drives a pair of loudspeakers is a device called a “Bi-Phonic Processor”. This processor transforms binaural signals into stereophonic signals by means of a complex equalizing and time delay system. The effect produces a convincing sound field from only a single pair of loudspeakers that actually “wraps” sound around the listener over at least a 180 degree arc. A simple block diagram of this approach is shown in Fig. 6.

Taking the binaural-to-stereo approach a step further, JVC also demonstrated a system they call Q-Bi-Phonic. In this system, two artificial heads are used. They are placed in close proximity—12 to 15 inches apart. Both face forward (towards the performance) and there is a special baffle between them. The front head is clearly forward oriented, while the rear head is less so, because of the interposed baffle. Each head produces a pair of binaural signals. Rather than being played back in binaural fashion, each pair of signals is fed through a special processing unit that again incorporates equalizing and time delay circuits to produce two pairs of signals. These signals are then suitable for quadraphonic loudspeaker presentation. This processor effectively produces a “binaural-to-quadraphonic” transformation, thus enabling the artificial head signals to be played back over loudspeakers set up in a normal 4-channel array. A block diagram of the Q-Bi-Phonic arrangement is shown in Fig. 7.

Bi-Phonic and Q-Bi-Phonic both represent elaborations on stereo and quadraphonic technology. Based upon our own listening tests, both systems require that the listener be located within a fairly small area along the axis of left-right symmetry. This is essential because the spatial phasors produced by either the Bi-Phonic or Q-Bi-Phonic processors cannot be accurately recreated over a wide lateral range. Listeners who are not located close to the axis of symmetry will, however, hear the traditional stereo or quadraphonic sound as they would normally be perceived.

Our experience with these two new approaches to sound recording and reproduction suggest that both offer considerable challenge in the recording studio for innovative record producers. We were treated to some very specta-
IF YOU SUDDENLY HEAR A "GOOD BUDDY" warning of the imminent approach of Smokey over your expensive stereo hi-fi system while you are trying to audition a disc, don't get the idea that you are being singled out as a solitary victim by your neighborhood CB'er. You are just one of hundreds of thousands of victims of RFI (Radio Frequency Interference). In the last year alone, the FCC has received nearly 100,000 complaints regarding interference that degrades TV performance, intrudes upon the sounds of hi-fi and generally makes owners of home entertainment equipment miserable. In most cases, the FCC is powerless to do anything about the problem, especially since this sort of interference can and does take place even when the offending transmission equipment is operated within legal power limits. Even in cases where CB'ers use linear amplifiers to increase radiated power beyond authorized limits, the FCC is so understaffed (and CB usage has been proliferating at such a fast clip) that they would not be able to look into a specific complaint for months, if at all.

The Consumer Electronics Group of the Electronics Industry Association (EIA) has been considering this growing problem for some time and recently, they prepared a comprehensive booklet entitled Electronic Technician's Interference Handbook, Audio Rectification. Much of the material contained in this article is paraphrased from the final draft of that booklet, while some comes from personal experience with the problems of interference we have encountered over the past few years ourselves.

The most common type of audio interference encountered in hi-fi (and occasionally in TV) equipment found in the home is due to a phenomenon known as audio rectification. Audio rectification is the detection of modulated RF signals by an audio circuit of a radio, preamplifier, amplifier, or tape deck electronics that appear as unwanted or disturbing audio signals at the speaker output terminals. Since not all RF interference is created by RF transmitting equipment, the most common forms of interference can be divided into two groups: signals emanating from RF transmitting sources (radio or TV stations, amateur radio operators, CB operators, paging systems) and interference from electrical equipment or appliances (X-ray and diathermy equipment, neon signs, light dimmers, thermostats, commutators and switches).

The first category of equipment is usually not within direct reach of the "victim", and curing of interference problems from RF transmitting equipment is largely confined to working on the actual equipment experiencing the interference. The second category is more likely to be located within your house or apartment and, by turning off the suspected interfering source, it can at least be localized and identified.

Interference from the first group will prove more difficult to diagnose, because its point of entry into an audio device can be anywhere from the antenna to the speakers. Interference can be picked up by long connecting cables acting as antennas or a component acting as a detector, or it may be
transmitted through the AC power lines, especially if the source of interference is in the same building as yours. Detection will then take place in the power-supply circuit of the audio equipment with the same disturbing effect on the listener.

Since the majority of interference problems occur because of nearby interfering equipment, there is little point in taking your receiver, amplifier or other equipment to a factory or authorized warranty service station. The technician at such service centers will be completely frustrated in trying to solve the problem remotely, because it would be impossible to duplicate the problem. Audio rectification happens with the best of equipment, and its absence is no indication that one piece or brand of equipment is better than another. In fact, equipment with higher sensitivity and gain is a better prospect than some inexpensive, low-gain audio equipment.

Correcting external interference

Before digging inside your receiver, amplifier or tape deck, there are several simple remedies you should try first. Check connecting audio (shielded) cables and replace overly long ones with shorter ones, wherever possible. If the interference is noticed only when the pick-up arm or the turntable is touched, a ground wire between the pick-up arm and preamplifier chassis ground is called for. If the phonograph pick-up headshell is bakelite or plastic, a small piece of foil or metal between the cartridge and headshell that is grounded to the metal portion of the pick-up arm or to the metal base of the turntable, may help. (See Fig. 1.) If the metal or foil alters the tracking force, this should be readjusted to maintain proper cartridge performance.

If the interference occurs when holding a microphone (but not when you place it on a table), a ground wire between the microphone shell and the preamplifier or amplifier chassis is called for. A “buzz” recorded on tape when using a hand-held microphone can also be caused by a defective or poorly shielded microphone, but this can be verified by making a recording in a location where the identified RFI is not present.

Interference is often caused by long speaker cables that can act as an antenna. In some extreme cases of strong RFI, the interference persisted (and was heard over the speakers) even after the entire system was turned off! Replacing unshielded speaker cables with shielded cable or installing a small capacitor across the speaker will often cure this problem. The audio purist will, of course, object to altering the load seen by the amplifier in this manner, but most modern amplifiers can tolerate fairly large values of capacitance across speaker terminals before oscillation occurs. Even so, it would be a good idea to check with a scope connected across the speaker terminals for any evidence of oscillation before you run into a case of blown tweeter voice coils!

If you want to play things completely safe, you might try increasing the capacitance across the speaker terminals (while observing the scope trace) until evidence of high-frequency oscillation just begins. Final total capacitance should then be no more than half of the value required before oscillation takes place. Where speaker output terminals of the amplifier consist of a “hot” and a “ground” terminal, the capacitor should be connected as shown in Fig. 2-a. If both terminals at the output of the amplifier are “hot”, use the configuration shown in Fig. 2-b, recalling that each of the two capacitors involved must be double the required value previously determined as needed to stop the interference. Such arrangements where both terminals are “hot” occur in some amplifiers that have been “strapped” for higher power (as in the case of some quadraphonic units that can be switched to 2-channel operation for increased output power.

Internal equipment modifications

If the few corrective steps enumerated above fail to eliminate or sufficiently reduce audio rectification, it’s time to look inside your amplifier, receiver,

---

**FIG. 2—LONG SPEAKER WIRES can act as a receiving antenna for RFI. Capacitors mounted across speaker terminals will eliminate this problem. Normal connection is shown as Filter F, and Filter G shows connection for strapped amplifiers.**

---

**FIG. 3—FILTER LOCATIONS In AM/FM/phonograph equipment.**

---

of oscillation before you run into a case of blown tweeter voice coils!

If you want to play things completely safe, you might try increasing the capacitance across the speaker terminals (while observing the scope trace) until evidence of high-frequency oscillation just begins. Final total capacitance should then be no more than half of the value required before oscillation takes place. Where speaker output terminals of the amplifier consist of a “hot” and a “ground” terminal, the capacitor should be connected as shown in Fig. 2-a. If both terminals at the output of the amplifier are “hot”, use the configuration shown in Fig. 2-b, recalling that each of the two capacitors involved must be double the required value previously determined as needed to stop the interference. Such arrangements where both terminals are “hot” occur in some amplifiers that have been “strapped” for higher power (as in the case of some quadraphonic units that can be switched to 2-channel operation for increased output power.

Internal equipment modifications

If the few corrective steps enumerated above fail to eliminate or sufficiently reduce audio rectification, it’s time to look inside your amplifier, receiver,
point, it's time to consider adding one or more filter networks. Table I is a troubleshooting chart that will help you to isolate AM, FM and phono interference-problems logically. Associated with Table I is Fig. 3, which is a simplified block diagram of a typical home hi-fi installation. The circled numerals indicate points of insertion of various filter circuits as called out in Table I. Filters are designated by the letters A through H.

Table II is a troubleshooting chart designed to help you analyze and correct RFI problems that occur in connection with the use of tape equipment, and Fig. 4 shows the location of possible corrective filters. The filter identified as "A" should be used for correcting tape RFI problems.

**Filter networks**

The most effective RFI filter, from practical experience, is a "pi" filter-network consisting of a series RF-coil and two shunt capacitors. Suggested values for this filter, designated as Filter A in the troubleshooting chart of Table I, are shown in Fig. 5.

In mild cases of RFI, a single bypass capacitor between the base and emitter may be sufficient. This configuration is designated as Filter B in Fig. 6. Another fairly effective way to suppress RFI is through the installation of an L-type filter in the collector circuit, shown as Filter C in Fig. 6.

A coil inserted in series with the emitter leg of an audio input transistor, as shown in Fig. 7, may help in very mild cases of RFI. If such a remedy is used (Filter D), the coil should not be bypassed. This filter is the least desirable because of difficulty of installation in printed circuits and because of the possibility of oscillation that might take place in some circuits after it is installed.

Filters designated as E and H are generally used when it has been ascertained that RFI is coming in through AC power lines. Wiring diagrams for these two filters are shown in Fig. 8. In cases where the line cord is part of an indoor antenna system, there may already be a pair of coils wired in series with each side of the line cord. In that case, either Filter E or Filter F should be wired between these existing coils and the primary of the power transformer, as shown in Fig. 9.

Filters F and G have already been discussed and illustrated (see Fig. 2) in relation to speaker-cable pick up of RFI.

**Filter installation**

Several precautions should be observed whenever adding any of the filters illustrated. Install the filter network as close to the input of the audio stage that follows the so-called RFI...
pickup point (close to the base of the transistor or grid of a tube in the preamp of a receiver, for example). Use physically small components; small ceramic capacitors are preferable to paper capacitors. Keep all capacitor and coil leads (ground leads as well as “hot” leads) as short as possible. Long leads may compound the RFI problems instead of solving them. Install only as many filters as are found to be absolutely necessary. Too many filters may also do more harm than good.

It is advisable to run a frequency response check before and after filter installation to make sure that RFI filters have not changed gain or frequency response of the audio component significantly. A capacitor value that is suitable in a low-impedance circuit will not be a good choice in a high-impedance circuit.

IC's often pick up RF interference. Because of the feedback circuits incorporated in many IC applications, RFI filters should be installed both at the signal inputs and outputs of IC's, where they are suspect.

If RFI originates at the tape recorder source only, it must be determined whether it shows up only during playback of home recorded tapes or on commercially recorded tapes as well. In the former case, the RFI is actually recorded on the tape itself and will be heard whenever or wherever that tape is played back. A filter at the microphone preamp input will be necessary in such cases.

To avoid ground loops, shunt and bypass capacitors should be grounded to the emitter of the transistor when such filters are installed in the base circuit of a transistor stage.

Safety comes first

In your eagerness to solve your RFI problems, don’t overlook the importance of component safety. Use only U.L. approved components, especially when installing filters across the power-line input of the equipment. Capacitors rated at 400 VDC are not safe for 120 VAC. Capacitors must be rated specifically for line bypass applications and suitable for continuous operation at 125–150 VAC, RMS, 60 Hz. Mount components carefully to avoid possible shorts or arcing.

RF chokes are made by several continued on page 97
Radio-Electronics Tests Garrard GT-55 Turntable

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

IT IS NOW SOME SEVEN YEARS OR SO SINCE THE Garrard division of Plessey Incorporated first introduced their model Zero-100 multiple-play turntable. That unit had the distinction of being the first model that provided true tangential tracking of the pickup arm as the arm was pivoted across the surface of a record. Tracking error of a cartridge’s stylus had then been recognized as one of several distortion producing causes in record reproduction and Garrard sought to eliminate this source of distortion. The only other way to eliminate this form of distortion is by constructing a pickup arm that travels across the record while remaining parallel to the grooves, as was the case for the Rabco (Harmon-Kardon) model ST-7 and the Bang & Olufsen Beogram model 4002. Both of these models sell for considerably more than the new GT-55.

The new GT-55 is shown in Fig. 1. It features a newly designed magnesium lightweight pickup arm that rides on jewelled vertical-pivot bearings and horizontal ballbearings. While the headshell is a permanent part of this arm, a slide-in cartridge carrier, equipped with four slide-contacts, is removable and it is this carrier that retains the cartridge. A separate plastic stylus-alignment gauge is supplied for positioning the cartridge in the carrier to provide optimum stylus positioning and overhang.

Pickup arm balance is achieved by means of a counterweight that is screwed into the rear of the arm. When balance is achieved (with cartridge mounted), a rotatable indexing ring on the counterweight is set to zero. The entire counterweight is then screwed forward until the index reads desired downward tracking force, in grams.

A magnetic anti-skate control on the base of the turntable is completely free of mechanical linkage to any portion of the pickup arm and uses a magnet of varying diameter that is wrapped around the base of the arm. The anti-skate control has two calibration scales: one for use with elliptical stylus cartridges, the other for cartridges equipped with CD-4 (Shibata, etc.) stylus lips.

A cueing-speed control is located on the base, beneath the center of the arm, and permits the user to adjust the rate of descent or ascent of the pickup arm when the cueing lever is used. Further along the base is a lever that locks or releases the arm from its rest post.

Four lever operated controls are located at the front of the turntable base. A detailed view of these controls is shown in Fig. 2. The leftmost lever is the cue control. The second lever, labelled AUTO, is used to initiate the playing cycle and to reject a record at any time during play. The 2nd lever selects record sizes (7, 10 or 12 inches) so that the pickup arm is properly indexed. The rightmost MODE lever has an OFF position, as well as positions for MANUAL play, AUTOMATIC (multiple play) and RIPPLER play. When repeat play is selected, a single record will be replayed so long as the MODE switch is left in this position or, in the case of a stack of records, the last record in the stack will be repeated until some other mode is chosen.

At the lower left of the turntable base is a SPEED level that selects 33⅓ or 45 RPM, and a continuous control that varies the selected speed by ±3%. (See Fig. 3.) The speed and pitch controls are completely electronic. Unlike Garrard’s earlier "zero-tracking" models, the GT-55 is belt driven by a DC servo-controlled motor. The center front of the turntable base has a viewing window for strobe markings that can be seen for precise speed adjustment. Illumination of the strobe markings is provided for.

The underside view of the GT-55 shown in Fig. 4 reveals that the designers of this unit have been able to considerably simplify the mechanism over previous models. The DC motor, near the upper right in the photo, is connected to an electronic circuit board that provides speed regulation. A secondary belt may be observed running from the turntable center-spindle leftward to the cycling and pickup arm linkages.

The platter itself, viewed from the underside in Fig. 5, is a dynamically balanced diecast zinc-alloy unit. The two cutouts visible in

MANUFACTURER'S PUBLISHED SPECIFICATIONS:
It is difficult to ascribe the low distortion reproduction we heard to any one feature of the GT-55, and we must take the company's word for it that tangential tracking is an important factor here. But, whatever the contributing design factors, we must complement the designers of this "second generation" Garrard turntable system for having succeeded in a total redesign that seems trouble free and, in our opinion, is capable of providing years of reliable record playing service.

Our overall product evaluation will be found in Table II, together with summary comments regarding our reaction to the GT-55.

### Table I

<table>
<thead>
<tr>
<th>Manufacturer: GARRARD</th>
<th>Model: GT-55</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TURNTABLE SYSTEM MEASUREMENTS</strong></td>
<td>R-E</td>
</tr>
<tr>
<td><strong>PERFORMANCE CHARACTERISTICS</strong></td>
<td>Measurement</td>
</tr>
<tr>
<td>Wow-and-flutter (% WRMS)</td>
<td>0.04</td>
</tr>
<tr>
<td>Rumble, unweighted (dB)</td>
<td>50</td>
</tr>
<tr>
<td>Rumble, (DIN weighted &quot;B&quot;) (dB)</td>
<td>68</td>
</tr>
<tr>
<td>Speed adjustment range (± %)</td>
<td>+3.5, -4.0</td>
</tr>
<tr>
<td>Speed build-up time (rotations)</td>
<td>&lt;1.0</td>
</tr>
<tr>
<td><strong>COMPONENT MATCHING CHARACTERISTICS</strong></td>
<td></td>
</tr>
<tr>
<td>Tracking Force Range (___ to ___ grams)</td>
<td>0-3</td>
</tr>
<tr>
<td>Anti-tracking Force Range (___ to ___ grams)</td>
<td>0-3</td>
</tr>
<tr>
<td>Available speeds (RPM)</td>
<td>33⅓/6, 45</td>
</tr>
<tr>
<td>Drive System</td>
<td>Belt</td>
</tr>
<tr>
<td>Motor Type</td>
<td>DC servo</td>
</tr>
<tr>
<td>Power Requirements</td>
<td>&lt;10(watts)</td>
</tr>
<tr>
<td>Pick-up arm wiring capacitance (per channel) (pF)</td>
<td>23</td>
</tr>
<tr>
<td><strong>MISCELLANEOUS EVALUATIONS</strong></td>
<td></td>
</tr>
<tr>
<td>Adequacy of Controls</td>
<td>Excellent</td>
</tr>
<tr>
<td>Automatic features, performance</td>
<td>Very good</td>
</tr>
<tr>
<td>Speed stability</td>
<td>Superb</td>
</tr>
<tr>
<td>Vertical pickup arm friction</td>
<td>Good</td>
</tr>
<tr>
<td>Lateral pickup arm friction</td>
<td>Good</td>
</tr>
<tr>
<td>Quality of Construction</td>
<td>Excellent</td>
</tr>
<tr>
<td><strong>OVERALL TURNTABLE SYSTEM RATING</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Very good</td>
</tr>
</tbody>
</table>

### Table II

<table>
<thead>
<tr>
<th>Manufacturer: Garrard</th>
<th>Model: GT-55</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OVERALL PRODUCT ANALYSIS</strong></td>
<td></td>
</tr>
<tr>
<td>Retail price</td>
<td>$249.95</td>
</tr>
<tr>
<td>(Base and dust cover are extra.)</td>
<td></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>Excellent</td>
</tr>
</tbody>
</table>

Comments: Garrard's emphasis of their articulated pickup-arm head is, perhaps, unfortunate, for there is so much else going for this totally redesigned unit that readers of their literature may lose sight of its other virtues. The departure from a synchronous motor (however many poles it might have) to a DC servo motor that is electronically controlled is, to us, a more significant breakthrough. The low mass magnesium pickup-arm is another significant breakthrough that would be important even if it did not include the "true-tangential" feature. Belt drive for a multiple-play turntable system is no longer unique, but Garrard's excellent execution of this principle, plus their use of a second belt to actuate the pickup arm cycling and motion, is an improvement over earlier linkages and results in one of the smoothest changing cycles we have ever seen. Truly, their claim that the pickup arm is handled more gently than could be done by the steadiest of hands is well founded. The one thing we wish Garrard had been able to achieve with their new design is somewhat simpler installation. The typical purchaser of a multiple play turntable is, perhaps, not as sophisticated or mechanically inclined as is the purchaser of a single-play machine and confrontation with the many "loose parts" (including the platter, the C-ring that must be removed and replaced, the belt which must be properly installed and the center-spindle which must be pre-lubricated) may be discouraging to some. Once the installation has been accomplished, however, the GT-55 performs extremely well, has fewer parts that can go wrong than did its predecessor, and measures well in all the major areas that determine ultimate turntable performance.

The photo permit relatively simple installation of the flexible rubber drive-belt after the turntable has been mounted on the center spindle. Multiple-play as well as single-play spindles are supplied with the unit, as is a 45 RPM adaptor. A rear support post combines with the multiple-play center spindle to provide two-point support when stacking records.

**Laboratory measurements**

There are really only three measurements that are significant when measuring performance of a turntable. These are speed accuracy, signal-to-noise, and wow-and-flutter. Although Garrard does not specifically say so, we presume that their wow-and-flutter specification was measured on the basis of a WRMS (Weighted Root-Mean-Square) measurement, and our measurements were made accordingly. On that basis, we did a bit better than Garrard claimed, measuring 0.04% as opposed to the claimed 0.05%.

As for rumble, using the DIN "B" weighting curve, we read an excellent -68 dB as opposed to the -66 dB claimed. By way of comparison, we should note that the best readings we have ever obtained for rumble (with the most expensive, single-play direct-drive turntable systems around) were just above -70 dB.

Once the 33⅓/6 RPM speed was adjusted by means of the pitch control, we detected absolutely no drift in speed over a test period of one hour. Line-voltage variations of ±10% (from 120 volts) similarly had no effect on speed accuracy. The pitch control on our sample provided +3.5% and -4.0% variation, somewhat greater than that specified. A complete listing of our laboratory measurements appears in Table I.

**Use and listening tests**

We used the Garrard GT-55 with a variety of phono cartridges, ranging from a CD-4 type that required 2 grams of downward tracking force to a moving-coil type that normally is intended to track at less than 1.0 gram. Each of these cartridges was accommodated with no problem and tracked very well at recommended forces. The record changing cycle of the GT-55 is extremely smooth and noise free and we noted that there was considerably less "drag" on the drive mechanism during the cycling than we were accustomed to seeing with other multiple-play machines. Cueing-lever action is precise and we were able to interrupt play of records and resume playing with a maximum error of no more than one groove width.
Nakamichi 610 Preamplifier

MANUFACTURERS PUBLISHED SPECIFICATIONS:

Frequency Response: Mike: 30 Hz—100 kHz, +0, -1.5 dB; Phono: 30 Hz—15 kHz, +0.3 dB; High Level: 20 Hz—100 kHz, +0, -1.5 dB. Input Sensitivity: Mike: 0.2 mV. Phono: 1 mV. High Level: 75 mV. Maximum Input Level: Mike: 1 volt. Phono: 250 mV. High Level: 50 volts. Signal-To-Noise Ratio: (IHF A-weighting): Mike: Better than 53 dB, referenced to 0 dB, Phono: Better than 80 dB, referenced to 1 mV. Distortion: Mike: Less than 0.1% at all frequencies up to 10 kHz. Phono: less than 0.05% at all frequencies up to 10 kHz. High Level: Less than 0.005%. Dimensions: 15.75 wide x 6.70 high x 9.33-inches deep (400 x 170 x 237 mm). Weight: 15 1/2 pounds (7 kg).
Some idea of the variety of components that may be used with the model 610 is illustrated in Fig. 3.

Circuit configuration
As can be seen from the photo of the internal layout of the 610 (Fig. 4), Nakamichi has managed to incorporate a vast amount of circuitry into a relatively small space while retaining reasonable access to the many circuit boards involved in the assembly of the product.

![Image of Nakamichi 610]

A particularly interesting circuit section is the phono preamplifier/equalizer. First, its rated sensitivity is a low 1.0 mV, which means that there is enough gain so that it can be used with many of the moving coil cartridges that have been gaining in popularity in recent years. A basic schematic layout of the phono-preamp section is shown in Fig. 5. The first stage employs a unique "triple transistor" circuit. The three transistors are arranged in a parallel configuration that provides a signal-to-noise improvement of about 5 dB above that of conventional designs. Selected low-noise silicon units are used for these "first stage" transistors, which act as a single transistor with very low internal impedance in a common-emitter configuration. A second common-emitter stage, Q4, with current supplied by constant current source Q6, establishes a low distortion current drive for the final stage. The output stage of the phono section is a complimentary Class A circuit with bias set by the Q5 collector to emitter voltage. Proper RIAA equalization is provided via the negative feedback loop, which ties the output signal to the emitter of the first triple-transistor stage.

Laboratory measurements
Table 1 summarizes measurements and lists reference levels applicable to the Nakamichi 610. Microphone input sensitivity (without attenuation) was measured as 0.2 mV for a 0-dB meter reading, exactly as specified. It should be noted that the phono preamplifier signal-to-noise ratio recorded (~83 dB, IHF A-weighted) was measured with respect to a 1-mV input sensitivity. Most other preamplifiers have an input sensitivity of around 2.0 to 2.5 mV, so that if the S/N were specified with respect to that higher input level (typical of moving magnet cartridge nominal outputs), the figure would be between 89 and 91 dB! Carrying this still further, if a 10 mV input signal reference were used (many manufacturers quote S/N with respect to this high input figure), S/N would be an incredible 103 dB!

The few distortion figures listed in Table 1 are actually residual distortion contained in our source signal.

Use and listening tests
Since there are nineteen different inputs to the model 610, attempting to describe everything you can do with this preamp would require more space than a single test report warrants. Here are just a few of them. You can do live recording with up to five microphones on as many as three separate tape decks simultaneously with independent monitoring capability. You can combine live and prerecorded inputs, such as three mikes and a tape deck or a phono input source. You can mix two stereo sources, such as a pair of phono's, a tuner plus a tape deck, or any combination of these. A-B comparison of any source, such as tape versus disc, tape...
**TABLE II**

<table>
<thead>
<tr>
<th>Radio-electronics Product Test Report</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Manufacturer</strong>: Nakamichi</td>
</tr>
<tr>
<td><strong>Model</strong>: 610</td>
</tr>
</tbody>
</table>

**Overall Product Analysis**

<table>
<thead>
<tr>
<th>Feature</th>
<th>Test Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Retail price</td>
<td>$570 ($550 in silver finish)</td>
</tr>
<tr>
<td>Price category</td>
<td>Medium-high</td>
</tr>
<tr>
<td>Price/performance ratio</td>
<td>Excellent</td>
</tr>
<tr>
<td>Styling and appearance</td>
<td>Superb</td>
</tr>
<tr>
<td>Sound quality</td>
<td>Superb</td>
</tr>
<tr>
<td>Mechanical performance</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

**Comments**: As you might gather from glancing at our Evaluation column above and in Table I, we were tremendously impressed with the design, construction and performance of the Nakamichi 610. We hasten to point out, however, that the emphasis on this unit is understandably towards the serious tape recordist, rather than to the passive audiophile. If you crave elaborate tone controls, filters, loudness controls and the like, this is not the preamp/control unit for you. But if you normally play your music flat, own a tape deck or two, and like to do some live recording, the 610 can well serve not only as your basic preamp but as your mixing console as well. The incorporation of the test tones and the pink noise generator was truly an inspiration as far as we are concerned. Comparing the sound of “pink noise” in an A-B test is still one of the best methods we know for evaluating the response of a component system by ear and even the few frequencies from 1 kHz to 14.6 kHz supplied by the test-tone circuitry are enough to help you calibrate or align tape heads and the rest of your tape recording circuitry should that become necessary. The tones serve as a ready means of comparing different tape formulations and their performance on your given machine, too.

Considered strictly as a preamplifier, the performance of the 610 is as close to that of a “straight wire with gain” as anything we have ever measured. Our test equipment, as good as it is, was simply not able to indicate meaningful distortion figures, since its own signal distortion is known to be around 0.005% and that reading was obtained using any of the input terminals of the 610.

Controls are logically arranged on the sloped front panel, though a few minutes of familiarization are needed to operate the unit with assurance. Nakamichi recently introduced a matching power amplifier, model 620, and had previously introduced their model 600 stereo cassette deck. These three items, placed side by side or mounted in a special rack available from the company, represent a flexible home recording system that any serious recordist would be proud to own and use.

versus FM and so forth becomes simple and meaningful, with the aid of the independent level matching controls at the monitor outputs. All of these intricate interconnection schemes are accomplished by the push of a few buttons—no juggling of patch cords, cables and the like.

Used alone, with a pair of good quality headphones (in remote recording situations where the balance of a stereo monitoring system is not available), we were able to do on-location monitoring of a recording and, unlike the headphone outlets supplied on some lesser preamps, there was plenty of gain and power available to drive our 8-ohm phones so that we could hear the full dynamic range of the sound sources we were mixing during that session. While we did not have the optional RM-610 remote control box available for our tests, we can easily see that its addition (for around $75.00) would add even more versatility to this "dream" preamp.

As for sonic qualities of program sources fed through it strictly for musical listening purposes, we compared FM signals received from one of the few “clean signal” stations in our area by feeding them directly to our high quality power-amp and to that same power amp via the line inputs and outputs of the model 60 preamp. With levels adjusted carefully, we, as well as several other listeners subjected to the same test, could not detect any audible difference between the two setups. If a preamp control unit is intended to process signals with absolutely no coloration or alteration, this one comes as close to doing so as anything we have ever heard. If, on the other hand, you insist upon a variety of equalizing and tone controlling functions, you can always buy a separate graphic equalizer which could be outboard-connected to the model 610 via one of the tape monitor circuits. You would still have two such circuits available for two tape decks.

Our summary comments regarding the Nakamichi model 610 will be found, together with our overall product analysis, in Table II.

**Higher hi-fi recording group goes back to direct-on-disc**

A Canadian record company, Nimbus 9 Productions Ltd., has abandoned the tape-recording stage of disc production. The new direct-on-disc albums, bearing the Umbrella trademark, will be sold in the United States by Audio-Technica, the phone cartridge firm.

According to Jon Kelly, general manager of Audio-Technica, bypassing the tape recording stage eliminates problems of distortion, limited dynamic range, and of course, tape noise. Because engineers mix and record the studio performances direct onto a master disc, Kelly points out: “Musicians and engineers must display a high degree of professionalism. There is no room for error.

**Records were expected to be available early this winter. Discs will cost $12.95 at retail. Umbrella's first release through Audio-Technica will be a rock album by the Toronto group "Rough Trade," a six-piece ensemble. Later releases will include classical and percussion offerings.**

**Large-screen TV viewers now have stereo vision**

Three-dimensional wide-screen projection television was demonstrated to the Society of Motion Picture and Television Engineers at their conference in New York recently. The demonstration was accompanied by a technical paper by television consultant and video experimenter Bruce D. Stephens.

Mr. Stephens' technique combines two well known devices, the General Electric single-lens Light Valve color television projector and the Marks Polarized Corp. 3-D film projection Polarator, to produce a new effect.

The two slightly differing left-eye and right-eye images, positioned one above the other in a single film or video frame, are projected through the Light Valve projector and the Polarator, then redirected toward the screen so that they are superimposed.

One of the superimposed pictures is horizontally, the other vertically, polarized. The viewer wears a pair of inexpensive viewing spectacles of the type used in 3-D movies. These act as a decoder, allowing each eye to see only the picture intended for it.
GETTING CLOSE TO THE SELECTION YOU want is not too difficult using the footage indicator on a cassette tape. But then there is the annoying trial and error hunting to find the precise selection, and then to locate its opening bars. A turns-counter works providing you have the number of turns written down, that you remembered to reset it at the beginning of the tape and, of course, that your machine has one.

Sharp Electronics has an interesting alternative in their GF-6000 Cassette Recorder and MW/SW/FM Receiver combination. It incorporates the APSS (Automatic Program Search System) that is designed to quickly get you to the beginning of the next tape selection or back to the beginning of the one in progress.

What identifier can be found on most tapes that would serve as a beginning-of-selection marker? Sharp’s answer is the blank interval between recorded segments. APSS looks for these blank segments in either the fast forward or rewind modes and switches back to the normal playback mode when it finds one.

Pushing the FWD-APSS button starts a fast-forward operation in the conventional way by retracting the pinch roller from the capstan and engaging the fast-forward gear with the take-up reel. The only mechanical difference is that the function is latched by the APSS lock-plate that can be released by applying power to a solenoid-type plunger. The system runs at 10 to 30 times normal playback speed until the electronics senses a blank interval in the tape. When this occurs, the plunger is activated and the fast-forward gear is disengaged. The action is identical when the fast-rewind mode is selected.

How it works

The circuit details are shown in the schematic in Fig. 1 and the waveforms in Fig. 2. In the playback mode, equalizer amplifier IC2 is fed from the record/playback head. Part of its output signal drives the APSS preamp IC4. Power is applied to the preamp only during APSS operations. Amplified signals from the tape are coupled to the base of Q111 through C177. Both the base and emitter of the transistor are connected to the +12-volt (+B1) supply so that when the output of IC4 exceeds 1 Vpe (one base-to-emitter junction potential of approximately 0.6 volt), transistor Q111 turns on. Each time Q111 conducts, it supplies a relatively high-current pulse into its collector load—the R177-C179 network. In effect, C179 is charged through the 33-ohm emitter resistor R176, but discharges through the 8.2K resistor R177.

Very much like a diode peak detector rectifies a signal, transistor Q111 peak detects and amplifies the signal from the tape. Whenever a signal is present, the collector of Q111 is very close to 12 volts. The output of this transistor drives the base of Q112. Transistors Q112 and Q113 form a regeneratively-switched schmitt trigger. An input sufficient to start Q112 into conduction quickly causes it to go fully on while Q113 turns off. As the collector of Q112 is lowered, the emitter voltage of Q113 and Q112 is reduced. Transistor Q112 then conducts more heavily because of its increased base-to-emitter potential, and things spiral or rather regenerate so that the circuit latches.

Notice the way the collector of Q113 feeds the emitter of the following Q114 stage through capacitor C180. The emitter and base of this device are both referenced from the positive supply so it is biased off. Further, the positive pulse coupled to its emitter when Q113 goes off is in a direction to keep it off, so nothing happens here yet. As long as
Q114 is off, driver transistor Q115 is also off. Transistor Q115 drives the solenoid that disengages the fast-forward gear.

As the high-speed search continues, a drive current is sent to squelch transistor Q202 (not shown). The base current of transistor Q202 is derived simply by a resistor from the APSS +B supply. Signals are blocked from reaching the speaker by Q202 whenever an APSS search is in progress.

Assuming that a blank segment of tape has been reached, let's retrace the circuit operation: The signal from the playback head is amplified by IC4 and it now consists only of low-level noise of insufficient amplitude to overcome the base-to-emitter threshold of Q111. This transistor no longer provides current pulses to the R–C network in its collector circuit. The network discharges as shown in the waveforms of Fig. 2. Discrimination against temporary nulls in program material is provided by the time constant of the R–C network. A minimum of a one-to-three second blank interval at normal playback speed is necessary for the APSS circuit to detect. The range in time is because of the three-to-one variation in fast tape speed.

Base drive to transistor Q112 falls below its conduction level and Q112-Q113 switches to its opposite state with Q113 on. The negative pulse generated at the collector of Q113 turns on Q114 for a time interval determined by the coupling network. During the time it takes to charge C180, Q114 and Q115 remain on.

The circuit can be fooled by a prolonged soft music or blank passages. A second or third operation of the button may be required in such cases. Complete misses of the blank leader occur if the button is pressed when the tape happens to be less than 10 playing seconds away from the leader.

Two LED's indicate operation of the circuit, one for each tape direction. Switch contacts S301 are closed by the FWD/APSS button. Power to IC4 and the squelch transistor is supplied through the switch contacts and diode D301. Transistors Q301 and Q302 are an astable multivibrator that flashes the LED indicator. The bottom waveform in Fig. 2 represents the pulsing of the LED during the search time.
FIFTEEN YEARS AGO, IF YOU WANTED TO BUILD AN ELECTRONIC digital clock to display hours, minutes and seconds, it took hundreds of parts, a hopeless maze of wiring and would have cost at least $150 for parts. In the early '60's, when the first IC's became popular, you could build the same clock with 12 IC's and about 70 additional discrete parts—still a lot of wiring—at a cost of about $75. Then along came LSI (Large Scale Integration), and its application resulted in IC's designed specifically for clocks and watches.

From a large stable of contenders, a few thoroughbreds emerged, among them the National Semiconductor MM5314 and MM5316. These IC's contained various clock functions, but they still needed a variety of parts for signal and display conditioning to end up with a clock. Kits appeared on the market in abundance for $12 and up, with a wide spectrum of digit sizes and features—but most of them still required a lot of careful soldering and hours to assemble and troubleshoot. (See "Digital Clock Kit Roundup", Radio-Electronics, August and September 1976 issues.)

The latest advance in electronic digital clock design is the full-featured, pre-tested "clock module" with almost all the electronic parts preassembled on a common board. All you need to add is a transformer and switches for a complete clock!

The first three clock modules to appear on the market are the National Semiconductor MA1001 and MA1002 (both with 0.5-inch-high digits) and the Fairchild FCS8100 (with 0.8-inch-high digits). The MA1001 series, released in December 1975, is already obsolete and has been replaced by the slightly smaller MA1002 series. Some MA1001A's are still available at a reduced price (see parts list). Functionally, the MA1001A and the MA1002A are identical—the physical difference is that the large 40-pin MM5385 IC package has been removed from the display side of the board and now appears as a small circular black "blob" on the back. Figures 1 and 2 show the physical dimensions of these two modules. The Fairchild FCS8100, recently released, is roughly a half-inch wider and higher, since it has digits 60 percent higher. See Fig. 3 for its physical dimensions and pin connections.

Features and assembly
The MA1001A and MA1002A have the same features: 1. Bright 3½-digit 0.5 inch red LED 12-hour display showing
MA1002A DIGITAL CLOCK MODULE.

hours and minutes, but with seconds displayed on demand. 2. Alarm and 9-minute "snooze". 3. Alarm-on indicator. 4. PM indicator allows setting alarm for 24-hour repeat. 5. External radio can be controlled with 59-minute "sleep" function. 6. Direct drive of display—no radio interference. 7. Brightness control capability. 8. A 1-second flashing colon. 9. Power failure indication—the entire display flashes on and off.

Other versions of the MA1001 and MA1002 (identified by the suffix letters B,C,D,E,F,G & H) offer a variety of built-in options, such as 24-hour display, 50-Hz input, and alarm tone output (requiring a special earphone). For simplicity, only the MA1001A and the MA1002A full-feature clock-radio 12-hour 60-Hz modules are covered in this article.

Figure 4 shows the external wiring to the MA1001A or MA1002A, and the connection points on the modules are shown in Figs. 5 and 6. The HOLD function is not shown wired, since it is also available by closing the seconds display switch and holding down the SLOW SET switch until you want counting to resume. Wiring is shown for maximum brightness: a 50K potentiometer wired to vary the resistance from MA1001A pin-6 or MA1002A pin-4 to VDD will cause the...
brightness to vary from dark (high resistance) to bright (no resistance). This suggests the use of a photocell to automatically dim the display at night—but be careful! The photocell must have specific light response to give you the proper brightness variation. The photocell shown in the parts list has been selected for this use.

The transformer specified in the National Semiconductor data sheet for these modules is a special model. Two sources are given in the parts list. However, a standard 12.6-volt center-tapped transformer (less expensive, but larger than the specified special transformer) can be used if wired as shown in Fig. 4. By adding C1 (220 μF 16V) electrolytic capacitor as shown, the brightness is increased to the level obtained with the special transformer, and without any sacrifice in performance.

Unfortunately, some of the pin connections are scattered around on the board, so be very careful in using the drawings as a guide: some discrete components near the connection points have been shown to help you. Although only the front of these modules are shown, they have a printed circuit on both sides, with plated-through holes, so you can solder to either the front or back side of the connection holes.

The Fairchald FCS8100 12-hour clock radio module is built around the FCM 3817A digital clock IC. It features: 1. 3½-digit 0.8-inch LED red display showing hours and minutes, with seconds on command. 2. Operation from 50 or 60-Hz line using a standard 12.6-volt center-tapped transformer. 3. Built-in alarm tone. 4. Alarm on indicator. 5. AM and PM indicators that permits setting the alarm for 24-hour repeat operation. 6. 9-minute “snooze”. 7. External radio can be controlled with 59-minute “sleep” function. 8. Direct drive—no RFI. 9. Power failure protection for 10 seconds. 10. Power failure indication after 10 seconds—AM indicator blinks, and display reads 12:00. 11. 1-second flashing colon.

Figure 7 shows the external wiring to the FCS8100 module. A transistor driver is built into this module, and the jumper between pins 14 and 16 is necessary to operate the transistor for the alarm function (the sleep-output pin is internally connected to the driver-transistor input). Since this module has a built-in tone oscillator connected to the alarm circuitry, all you need to do is: hear the alarm is connect a small speaker and 33-ohm resistor in series between pins 9 and 22. Now, whenever the alarm switch S6 is placed in the on position and the alarm-set time and real time coincide, you’ll hear a 700-Hz (approximate) tone from the speaker.

The MA1001A or MA1002A modules have only direct current at their alarm outputs (E3). Therefore, a tone oscillator is required to drive a small speaker. Figure 8 shows such a circuit. Power for this oscillator is derived from the transformer (E8 and E9), using D1 and C2 as a rectifier and filter. This isolates the power supply of this circuit from the clock IC, which is a problem if power is taken directly from the alarm output pin. Instead, the alarm output (pin E3) only provides control voltage to the oscillator, with very little current drain (less than 0.5 mA). The speaker emits a loud, pleasant tone when the alarm is activated.

Although you can make an operating clock from one of these modules by wiring just the transformer and switches to the appropriate module points with a small-tip soldering iron in about 30 minutes (once you’ve identified the module terminals), the real “rub” is the packaging—mounting the various switches and the transformer and speaker in some kind of enclosure. Since this can take considerably more time than building the clock, the modular-style case offered in the parts list is highly recommended. It is made from anodized aluminum and walnut end-blocks, held together with one long screw. All necessary mounting and speaker grille holes are punched and tapped, and even a red plastic bezel is included.
PARTS LIST

CM1—National Semiconductor MA1001A Clock Module. (Jade Co., 2007 West Carson, Torrance, CA 90501. $9.95 each plus $1.00 shipping and handling per order. California residents add 60¢ tax for each module.)

CM2—National Semiconductor MA1002A Clock Module. (Interfab, 27963 Cabot Road, Laguna Niguel, CA 92677. $12.50 each, plus $1.00 handling and shipping charge per order. California residents add 75¢ tax for each module. Order DC-60 MA1002A Clock Module.)

CM3—Fairchild FCS 8100 Clock Module. (Interfab. Order DC-60 FCS 8100 Clock Module. $18.00 each, plus $1.00 shipping and handling per order. California residents add $1.08 tax for each module.)

T1—Special transformer, Universal 102P1 (Universal Transformer Co., 4211 W. Lawrence Ave., Chicago, IL 60630, $5.00) or Staco 203-1846 (Staco, Inc., 2240 E. Third St., Dayton, OH 4412, $8.75). 117V, 60 Hz input.

T2—Transformer, 12.6V CT output, 117V 60 Hz input (Radio Shack 273-1505 or equal.)

S1, S2, S3, S4—Pushbutton switches, normally open. (Radio Shack 275-1547 or equal.)

S5, S6—SPDT switch (subminiature toggle, Radio Shack 275-613, or slide switch, Radio Shack 275-402 or equal.)

C1—220-µF, 16V electrolytic (used only with T2). (Radio Shack 272-1006 or equal.)

OPTIONAL ALARM PARTS

R1—33 ohms, ½ watt
R2—6,800 ohms, ½ watt
R3—1000 ohms, ½ watt
R2—470-µF, 16V electrolytic
C3—0.047-µF, 16V disc
C4—1 µF, 16V electrolytic
D1—1N4001 silicon diode
IC—NE555 integrated circuit timer
SPKR—Minature 2-inch, 8-ohm speaker

COMPLETE KITS AND OPTIONS

Interfab Corp., 27963 Cabot Road, Laguna Niguel, CA 92677, offers the following: (California residents, add 6 percent sales tax on merchandise price. All orders, add $1.00 shipping and handling per total order.)

DC-60N—MA1002A Complete Kit. Including decorator extruded aluminum case (Specify, gold, silver or black) with all holes drilled; walnut end blocks, finished, drilled and tapped, clock module; all switches; all alarm parts; transformer; pre-cut switch wires; solder; red plastic bezel, line cord and grommet, mounting hardware and instructions. $28.00 complete

DC-60F—Fairchild FCS 8100 Complete Kit. $31.00.

DC-60C—Case and endblocks, pre-drilled, with case assembly hardware. Includes bezel. Specify case color. $6.95.

RAC—60—Remote control appliance option. Operates from Sleep or Alarm outputs to control AC appliance. Plugs into an 117 volt AC line. All parts, including box, line cord, plug, jack, relay, switch, diodes, transistor and cable. $7.00.

TB-60—Timebase option for car use. All parts and printed circuit board. $4.95.

DCD-60—Automatic dimmer option. Special photocell. $1.00.

option was mentioned previously.

If you want to "customize", feel free. Several clocks shown in the photos may give you some ideas. The clear plastic cube-shaped clock was built by Peter Hillen, National Semiconductor field applications engineer, using an MA1001A module, as a demonstrator unit. He used the special transformer specified by National in their literature, and used toggle and pushbutton switches for display functions and time-setting. Very modern in appearance, the clear case (it's actually tinted red) shows all the interior parts making it a unique decorator conversation piece.

Using the controls

The switch and display functions of all the modules are essentially the same. The FAST switch moves the minutes ahead rapidly, while the SLOW switch moves the minutes ahead—you guessed it—slowly. The SECONDS switch "shifts" the display to show the last digit of the minutes, and the

FIG. 7—THE FAIRCHILD FCS 8100 clock module. Wiring diagram and connections for speaker.

FIG. 8—AN ALARM TONE CIRCUIT for units using the MA1001A or the MA1002A.
Using PLL for CB Frequency Synthesizers

Part II. A single IC from Motorola, plus an external amplifier, filter and voltage-controlled oscillator, forms a complete phase-locked-loop frequency synthesizer for 40-channel CB rigs. Here's how it works.

ROBERT F. SCOTT  
TECHNICAL EDITOR

LAST MONTH, WE REVIEWED THE BASIC phase-locked loop as applied to frequency synthesis and saw how the Nitron NC6402 digital PLL IC can be applied to a 40-channel CB rig. Now, as we promised, we'll take a look at the Motorola XC3390 phase-locked loop frequency synthesizer for CB radios.

The device is in a 24-pin plastic package with a 724 case configuration. It requires only one crystal to generate all transmit and receive frequencies in a 40-channel transceiver using a double-conversion superhet receiver. Channel selection can be by means of voltages from a binary-coded switch or from a 7-segment digital display. Figure 1 shows how the XC3390 fits into a typical CB transceiver.

When the transceiver is in the transmit mode, the synthesizer generates the channel carrier-frequency and feeds it to the exciter—a low-level RF voltage or power amplifier. In the receive mode, the synthesizer develops the oscillator injection frequencies for a double-superheterodyne receiver with first and second IF's of 10.695 MHz and 455 kHz, respectively. The first and second mixer injection frequencies are on the low side of the channel carrier and the first IF, respectively.

Figure 2 shows the sections of the XC3390 and how they are used to generate the carrier frequencies for the transmitter. The reference signal is developed by a precise and highly stable crystal oscillator. This is the signal that is processed to provide the various precise signal frequencies needed in the transmit and receive processes. It is divided by 2 and by 3 to develop new precise signals on 15.36 and 10.24 MHz. The latter signal is divided by 2048 to develop the 5-kHz reference that, as we saw last month, is needed as the reference for the frequency synthesizer as it develops signals for the 10-kHz spaced CB-channels.

Now, let's look at the VCO. It operates in the range of 16.725 to 17.165 MHz—10.695 MHz below the channel carrier frequency—to prevent birds and spurious frequency modulation due to RF feedback when transmitting. The VCO output frequency $f_o$ is summed in a balanced modulator with the 10.24-MHz output of the divide-by-3 circuit to develop the exciter drive signal $f_x$—a signal that ranges from 26.965 MHz for Channel 1 to 27.405 MHz for Channel 40.

The 15.36-MHz output of the divide-by-2 circuit is mixed with $f_x$ to produce a difference frequency $f_d$ ranging from 1.365 to 1.805 MHz, depending on the channel selected. This signal frequency is fed to a divide-by-n circuit where it is divided by a number between 273 and 361 to develop an output at precisely 5 kHz when the loop system is in lock. (The divide-by-n circuit is a programmable divider whose operation is controlled by the binary number $n_{ph}$ appearing on the program lines.) It is this 5-kHz signal that is compared to the 5-kHz reference obtained by dividing the 30.720-MHz reference frequency by 3 and then by 2048. Any frequency or phase error develops a correcting current that, after being filtered and amplified—pulls the VCO back on frequency.

If the PLL system is out-of-lock, the phase detector develops an auxiliary signal that gates off the exciter drive signal. This prevents the transmitter from radiating an off-channel signal.
FIG. 2—MOTOROLA XC3390 phase-locked-loop IC requires external VCO, loop amplifier and filter. Frequencies are programmed via the \( n \) counter.

FIG. 3—RECEIVE FREQUENCIES generated by the phase-locked-loop synthesizer.

<table>
<thead>
<tr>
<th>Channel Number</th>
<th>Decimal Equivalent ( n_{PL} )</th>
<th>Program Line Data Entries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>D0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>24</td>
<td>52</td>
</tr>
<tr>
<td>13</td>
<td>24</td>
<td>54</td>
</tr>
<tr>
<td>14</td>
<td>25</td>
<td>56</td>
</tr>
<tr>
<td>15</td>
<td>23</td>
<td>58</td>
</tr>
<tr>
<td>16</td>
<td>26</td>
<td>60</td>
</tr>
<tr>
<td>17</td>
<td>27</td>
<td>62</td>
</tr>
<tr>
<td>18</td>
<td>30</td>
<td>68</td>
</tr>
<tr>
<td>19</td>
<td>35</td>
<td>78</td>
</tr>
<tr>
<td>20</td>
<td>40</td>
<td>88</td>
</tr>
</tbody>
</table>

**How the receiver works**

During the receive mode, the synthesizer generates the frequencies shown in Fig. 3. The 5-kHz reference input to the phase detector, which remains constant during the transmit and receive modes, is obtained by dividing 30.72 MHz by 3 and then by 2,048. The output of the divide-by-2 is 10.24 MHz–455 kHz below the first IF.

When in the receive mode, the VCO operates between 16.270 MHz and 16.710–10.965 MHz below the channel carrier fed to the first receiver mixer. A part of the VCO output is mixed with the 15.360 MHz output of the divide-by-2 to develop a mixer output frequency \( f_m \) ranging from 910 kHz to 1.350 MHz. The programmable divide-by-\( n \) operates over a range of 182 to 270 as determined by the binary-coded number on the program lines.

**Binary channel selection**

When in the transmit mode, the transmit-receive switch grounds the Tx/Rx terminal on the IC. The binary number on the synthesizer program lines equals the program-line number \( n_{PL} \), a digital number plus 273. Channel 1 requires a divide number of 273 so the binary number on the program line will be zero. Table 1 shows the relationship between channel numbers, \( n_{PL} \), and the binary equivalent as applied to the program lines.

When receiving, the Tx/Rx terminal is taken high and the divide-by-\( n \) number equals the program-line number plus 182. Thus \( n \) in the programmable divider varies from 182 for Channel 1 to 270 for Channel 40.

Figure 4 shows how the binary signals for the program lines can be developed.

**TABLE I**

<table>
<thead>
<tr>
<th>Channel Number</th>
<th>Decimal Equivalent ( n_{PL} )</th>
<th>Program Line Data Entries</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>10</td>
<td>0</td>
</tr>
<tr>
<td>6</td>
<td>12</td>
<td>0</td>
</tr>
<tr>
<td>7</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>8</td>
<td>18</td>
<td>0</td>
</tr>
<tr>
<td>9</td>
<td>20</td>
<td>0</td>
</tr>
<tr>
<td>10</td>
<td>22</td>
<td>0</td>
</tr>
<tr>
<td>11</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>24</td>
<td>52</td>
</tr>
<tr>
<td>13</td>
<td>24</td>
<td>54</td>
</tr>
<tr>
<td>14</td>
<td>25</td>
<td>56</td>
</tr>
<tr>
<td>15</td>
<td>23</td>
<td>58</td>
</tr>
<tr>
<td>16</td>
<td>26</td>
<td>60</td>
</tr>
<tr>
<td>17</td>
<td>27</td>
<td>62</td>
</tr>
<tr>
<td>18</td>
<td>30</td>
<td>68</td>
</tr>
<tr>
<td>19</td>
<td>35</td>
<td>78</td>
</tr>
<tr>
<td>20</td>
<td>40</td>
<td>88</td>
</tr>
</tbody>
</table>
TO A TRUE FOOTBALL FAN, ANY MONTH having more than 27 days is a great time to enjoy football! Unfortunately, the real thing is available for just a few short months—barely enough to satisfy the pigskin addict's craving. Before you can say "Statue-of-Liberty play", the bowl games come and go, the goalposts are torn down and discussions with friends turn to rehashing events of the past season's games.

If you're tired of stale verbal "reruns" of past gridiron glories, invite your football buddies to join you for an evening in playing a fast-paced game of electronic football that pits your skill against that of your opponent, while bringing in the element of chance that so often means success or failure on the playing field!

The game is built around a unique random-chance "chaser" circuit using sixteen specially matched neon lamps and two integrated circuits. When in operation, a "count" is circulated through the chaser circuit so rapidly that all lamps appear to be flickering on and off at the same time. However, only one of the sixteen lamps is really on at any given millisecond. This means that if the count is stopped, just one lamp will remain glowing: the others will be extinguished. This is important because the lamps serve as indicators for reading the results of plays that you and your opponent select and run.

You, as the offense, for example, pick a play. There are sixteen possible outcomes for that play. Now, your opponent picks a defense and there are sixteen possible outcomes for his choice! The plays and results are all contained on a printed chart that fits under the 16-

Lamp line-up of the game. For any given play, the chart gives a statistically weighted ratio of risk-to-reward. That is, for plays that usually succeed, the chart gives better odds for success, although yardage gains will be smaller than in riskier plays. Conversely, for plays that are harder to pull off, yardage gains are greater and there's a chance of a touchdown, but the possibilities of failure are greater, too.

In devising the play chart, we consulted several football authorities (and we are particularly indebted to coach Curtis Blake of Colgate University for his expert assistance in setting up the play-chart odds). Of course, as in the real thing, there are possibilities of blocked kicks, interceptions and fumbles. That's why the element of skill in picking the right offensive or defensive play strategy is so strong in this game. While the circuitry may appear simple, the game is to be played by shrewd competitors who know the right plays to pick and who can stand the consequences. It's hot action for people who really know football!

How it works

The random-chance "chaser" circuit shown in Fig. 1 uses sixteen neon lamps arranged so that they form a series of cascaded neon lamp astable multivibrators. Each astable has two lamps, two resistors and two coupling capacitors.

Figure 2 shows one such astable multivibrator stage. When the supply voltage is applied to the circuit, the voltage across lamps NE1 and NE2 begins to increase as the stray capacitance that is in parallel with the lamps charges up through R1 and R2. The firing voltage of one of the lamps will be reached first, since it is extremely unlikely that both will reach their trigger potentials at precisely the same time. Assuming that NE1 lights first, as that lamp goes into conduction, the voltage across it suddenly decreases to the maintaining voltage. Accordingly, a positive voltage pulse appears across R1, and this is coupled via capacitor C1 to the cathode of NE2. This pulse is approximately equal to the difference between the firing and maintaining voltages of lamp NE1. The pulse drives the cathode of NE2 positive, effectively reducing the potential difference across NE2 and preventing it from glowing. The voltage appearing across NE1, meanwhile, is approximately equal to its maintaining voltage so that it is glowing.

Shortly thereafter, however, capacitor C1 discharges permitting the voltage across NE2 to increase toward its firing potential. As this potential is reached, NE2 conducts and glows. When this happens, the voltage between its electrodes is reduced to the maintaining-voltage level. This causes a positive pulse to appear across R2, which is then coupled back to the junction of the NE1 cathode and R1. The pulse amplitude represents the difference between NE2's firing and maintaining voltages. However, since NE1 is only at its maintaining voltage, the sudden positive pulse at its cathode sharply decreases the potential difference between the lamp's electrodes, causing NE1 to extinguish. At this point, NE1 switches to the
high-resistance state and stops glowing, while NE2 is now at its maintaining voltage and is glowing. Note also that capacitor C2 has coupled the output pulse appearing across R2 to the next lamp in the chain. This means that this lamp will now go through the cycle of being inhibited from firing, then firing and extinguishing NE2 in the same sequence and manner as that just described.

As shown in Fig. 1, the identical stages of the circuit are connected as a "ring", with the output capacitor of the last stage feeding back into the first stage. This means that the "count" circulates rapidly through the ring causing the lamps to flicker in sequence, but giving the appearance that they're all flickering at the same rate.

PARTS LIST

All resistors are 1/4 watt, 10%, unless noted.
R1—330,000 ohms
R2-R17—1.5 megohms, 5%
R18—1000 ohms
C1—10 µF, 150-volt electrolytic
C2-17—0.05 µF, 50-volt radial-lead disc ceramic
D1—silicon rectifier, 200 PIV. 1 amp (International Rectifier 100D6; RCA SK3017A, or equal)
NE1-NE16—miniature neon lamp (G-E 5AB-B, or equal)
IC1, IC2—16-diode array (Fairchild FSA2510)
S1, S2—single-pole normally closed pushbutton switches.
Misc.—PC board, playchart, game board, playing pieces, vinyl case.
The following parts are available from:
National Mentor Corp.
Box 53
Wykagyl Station
New Rochelle, NY 10804
A basic parts kit consisting of the neon lamps, IC's, woodgrain case and playchart for $29.00 postpaid. Order No. FBL-1.
A complete parts kit that includes everything in the FBL-1 kit, plus all resistors, capacitors, diode, PC board for the main game circuit, pushbutton switches, line cord, etc., for $39.00 postpaid. Order No. FBL-2.
NE1-NE16—16 neon lamps for $10.00 IC1, IC2—two 16-diode arrays for $7.50
PC board for main game circuit, $5.50 Walnut woodgrain predrilled case for $10.00
Playchart, game board and playing pieces on a pressure sensitive adhesive-backed stock for $2.75.

FIG. 1—GAME CIRCUIT uses neon lamps in astable multivibrator configuration. Switches S1 and S2 should have been shown as normally closed.
As an NTS student you'll acquire the know-how that comes with first-hand training on NTS professional equipment. **Equipment you'll build and keep.** Our courses include equipment like the NTS/Heath GR-2001 computerized color TV (25” diagonal) with varactor diode tuning and digital read-out channel selection; (optional programming capability and digital clock avail.).

Also pictured above are other units — 5” solid state oscilloscope, vector monitor scope, solid-state stereo AM-FM receiver with twin speakers, digital multimeter, and more. It's the kind of better equipment that gets you better equipped for the electronics industry.

This electronic gear is not only designed for training; it's field-type — like you'll meet on the job, or when you're making service calls. And with NTS easy-to-read, profusely illustrated lessons you learn the theory behind these tools of the trade.

**Choose from 12 NTS courses** covering a wide range of fields in electronics, each complete with equipment, lessons, and manuals to make your training more practical and interesting.

**Compare our training; compare our lower tuition.** We employ no salesmen, pay no commissions. You receive all home-study information by mail only. All Kits, lessons, and experiments are described in full color. Most liberal refund policy and cancella-
and the equipment be equipped.

COMPARE OUR KITS AND LESSONS. COMPARE OUR TUITION.

TUBE & TRANSISTOR TESTER
FET-VOM
AM/FM/SW PORTABLE SOLID-STATE RECEIVER
5" OSCILLOSCOPE
DIGITAL MULTIMETER
SOLID-STATE 2-METER FM TRANSEIVER & POWER SUPPLY
SOLID-STATE STEREO AM/FM/MULTIPLEX RECEIVER
COLOR BAR/DOT GENERATOR
VECTOR MONITOR SCOPE
74 sq. in., Solid-State B&W TV
SIGNAL GENERATOR

comparison privileges spelled out. Make your own comparisons, your own decision. Mail card today, or clip coupon if card is missing.

NO OBLIGATION. NO SALESMAN WILL CALL
APPROVED FOR VETERAN TRAINING
Get facts on new 2-year extension

NATIONAL SCHOOLS
TECHNICAL-TRADE TRAINING SINCE 1905
Resident and Home-Study Schools
4000 So. Figueroa St., Los Angeles, Calif. 90037

Please send FREE Color Catalog and Sample Lesson.
NO OBLIGATION. NO SALESMAN WILL CALL

Color TV Servicing
B & W TV and Radio Servicing
Electronic Communications
FCC License Course
Electronics Technology
Computer Electronics
Basic Electronics
Audio Electronics Servicing

NAME
ADDRESS
CITY
STATE
PT

AGE

Please fill in Zip Code for fast service

Check if interested in G.I. Bill Information

Check if interested ONLY in classroom training in Los Angeles

MARCH 1977

65
This is only half the story, for now we must be able to stop the “count” at a random point so that only one lamp remains glowing while all the others are off. This is possible with the diode gating provided in the integrated circuits, IC1 and IC2.

There are a total of 16 series-connected diode-pairs with IC1 and IC2. Two diode-pairs are connected, as shown in Fig. 3, to each astable stage of the chaser. The anode-cathode junction of D1 and D2 is connected to the junction of the NE1 cathode, R1 and C1, while the anode-cathode junction of D3 and D4 connects to the junction of C1, R2 and the cathode of NE2. The common anodes and cathodes of the diodes respectively connect to the terminals of switch S1. When switch S1 is open, no current flows through the diodes because the anodes are connected only to other anodes, and cathodes are connected only to other cathodes. During this time, the chaser is in the free-running “chase” mode described earlier.

If switch S1 is closed, all capacitors in the circuit are suddenly shunted because diodes D1-D4 and D2-D3 respectively and immediately appear in series across C1 (as well as across all the other capacitors in the circuit). In effect, all of the stages are suddenly inhibited so that only the lamp that is on at the time switch S1 is closed remains on. The count cannot be transferred until switch S1 is opened.

Referring back to Fig. 1, IC1 and IC2 provide a total of 32 diodes to interconnect the 16 lamp-stages. Switch S1 is actually an AND function formed by the series connection of two normally-closed pushbutton switches, S1 and S2. This means that to get the chaser to run, either you or your opponent must press a button. However, to get the chaser to stop, both you and your opponent must release. This “added extra” contributes to the randomness of the circuit.

The power supply of the circuit uses a conventional halfwave rectifier, D1 and filter capacitor C1. Resistor R18 serves only as a protective current-limiter to buffer the supply against inadvertent short-circuiting. Resistor R1 is a bleeder resistor for the filter capacitor.

**Portable operation**

There’s no reason to stay indoors to play football, if the game is equipped with the accessory battery/inverter supply shown in Fig. 4. Using but a single transistor, a 9-volt alkaline battery, a transformer and a few other parts, this supply delivers a high-frequency non-sinusoidal voltage of approximately 100 volts RMS. This input is applied to rectifier diode D1 and filter capacitor C1, providing adequate DC for several hours of operation.

The inverter circuit operates as follows: When toggle switch S1 is closed, current is supplied to the emitter-base junction of Q1, through R1. Transistor Q1 conducts a current pulse through its collector, storing energy in T1 and also inducing a voltage in the output winding that momentarily turns off Q1. The collapse of the magnetic field in T1 induces a voltage pulse across the output winding that is stepped-up by the turns ratio of the transformer. Diode D1 prevents the base of Q1 from going excessively negative, and also serves as the return path for the current to flow back to the transformer output winding. When the output pulse has passed, Q1 again conducts because of the bias supplied through R1, and another cycle commences.

**Construction**

The Football Game circuit is contained on a 4 × 8-inch printed-circuit board that speeds and simplifies assembly. (See Fig. 5.) Importantly, the board also holds the sixteen indicator lamps in the correct physical alignment so that they will slip through holes in the case and be accurately aligned with the columns of the play chart that will later be affixed to the top of the case. Figure 6 shows the parts layout on the printed-circuit board. The 16 coupling/timing capacitors (C2 through C17), 16 resistors (R2 through R17), and the two IC diode arrays are mounted on the non-foil side of the board, as are the power-supply components (diode D1, filter capacitor C1 and resistors R1 and R18). The neon lamps are soldered to the foil side of the board, thus making it possible to install the board with the foil side facing the case. (This prevents accidental contact with components and conductors that operate at line voltage.) The two inte-
groated circuits (IC1 and IC2) are installed directly on the board, without sockets (although sockets may be used, if you prefer). A low-wattage soldering iron should be used to solder the components to the board.

To install the lamps, slide their lead wires through the board from the foil side, pressing gently but firmly until the point of maximum downward travel is reached. Board holes are spaced so that the lamps will be lead-supported about 3/16-inch above the foil side of the board. When the board is installed, only the topmost portion of each lamp will jut through the case holes. Switches S1 and S2 are installed on the case at either end and connected in series to the points 1 and 2 as shown in Fig. 6. The 117 VAC line-cord enters the case through a hole in the rear and soldiers directly to the board at points 2 and 3. The line is thus completely insulated from any components you touch. No on-off switch is included for AC-line operation, and so, the highest point of isolation from the line is maintained. The unit is turned on by plugging it into an AC outlet and shut off by removing the plug. If you choose the inverter, its leads connect to the points 2 and 3 on the board instead of the line cord. Switch for the inverter then mounts in the case hole for the line cord.

The assembled board is supported in the case on four ½-inch screws fitted with ½-inch insulated spacers. Flat-head screws are used, and holes in the case are counter-sunk so that no hardware protrudes above the case top surface. When the board has been mounted in the case and wiring has been completed, the play chart is installed on the case top. Next, prepare the playing field and game pieces. You can either cut these from a sheet of paper and use them as they are, or you can glue the sheet to a stiffening cardboard and cut the pieces out afterward. Be sure to cut out the center of the play selector and ball with a sharp knife or razor blade. The play chart, playing field and play pieces are shown in Fig. 7. A full-size pre-printed play chart, playing field and pieces with a self-adhesive backing is available (see parts list).

If portable operation is desired, assemble the optional battery inverter circuit. The foil pattern for this board is shown in Fig. 8, and the component placement diagram is shown in Fig. 9. The assembly procedure for this board is straightforward.

**Playing the game**

You start by flipping a coin to see who kicks off. The player winning the toss will receive. His opponent places the ball marker on his 40-yard line. The play selector is moved to the row labelled KICKOFF on the chart and the kicker's button is pressed. The light remaining on when the kicker releases his button indicates the kick's distance. If it went, say 48 yards, the ball marker is placed on the receiving team's 12-yard line. The play selector is now placed on KICK RET and the process is repeated to see how many yards the receiver, by pressing his button, makes on the runback. (If the kick goes into the end zone, the receiver takes the ball on his 20-yard line with no runback).

At this point, the offensive player has a first down with four tries to go 10-yards and make another first down. He
A player may either kick on the fourth down or try for yardage. If he gambles and fails to make the first down, his opponent takes over the ball at that point. If he kicks, the play selector is moved to PUNT on the chart and the buttons are operated to determine the kick's distance. The opposing player then takes over the ball and uses the kick return play to determine how far he runs back the punt.

To score a touchdown on any play, the yardage indicated must be enough for another first down and the line of scrimmage on each play.
Analog Voltmeters

THE FIRST TWO PARTS OF THIS ARTICLE discussed the different types of analog voltmeters and their features and specifications.

This concluding part of the article completes the discussion on specifications and introduces various applications.

Ohmmeter ranges

The TVM ohmmeter ranges are identical to those of the VTVM. They have a 10-ohm center scale and have ranges from $R \times 1$ ohms to $R \times 1$ Meg. The TVM adds additional specifications to the ohmmeter. First, the maximum open circuit voltage of the ohmmeter is specified. This is especially true if the TVM has selection of high and low ohms. A maximum open circuit voltage is then given for both high and low ohms operation. The ohmmeter specifications may also give the maximum source current. This specification is useful if there are critical components in the circuits that might be damaged by excessive currents. The common terminal of the TVM is usually negative, but if the manufacturer does not indicate this in the specifications or on the terminals of the meter itself, it is a good idea to check it out after purchase and note the information where it can easily be seen.

Input impedance

In the DC function the input impedance of the TVM is most commonly 10 megohms. A few still have an input impedance of 11 megohms.

The AC input impedance of the TVM is composed of the same DC resistance used on the DC input with a shunt capacitance specified. The shunt capacitance ranges from a low of 30 to 40 pF on the very best of TVM's to 100 pF on the more common units. It should be noted this input capacitance does not disappear when the DC mode is used. When measuring the DC component of a signal, this capacitance may cause some disruption to the AC characteristics of the circuit. Unfortunately, few if any manufacturers specify the input capacitance of the DC voltmeter.

The ammeter

Specifications for both the AC and DC ammeter are very much alike. Not all TVM's have the ammeter function, and the lack of ammeter specifications indicates a lack of the function. Ammeter specifications indicate the insertion loss when the meter is placed in the circuit. This may be given in two ways. First, the manufacturer may note that the ammeter has a certain maximum voltage drop. Second, the manufacturer may indicate the insertion resistance and give the information necessary to calculate the voltage drop. Some manufacturers give both. The insertion resistance may be greater than expected in the high-ampere ranges, as the lead and connector resistances become appreciable.

Accuracy of the ammeter closely follows the accuracy of the lowest voltage scales of the meter. An additional error figure is often given for the lowest value of shunt resistance (highest current range),

*Manager Design Engineering, Heath Co., Benton Harbor, MI.
as high-accuracy shunts at low resistance are very difficult to make.

Frequency response of the AC ammeter closely follows the frequency response of the lowest range of the AC voltmeter. There may, however, be an additional derating for the high values of shunt resistance (lowest current ranges), as the distributed capacitance and the high value of the shunt resistance cause additional loss of high frequencies.

Ammeter ranges for TVM's run from 10A to 1A full scale. A few TVM's offer wider ranges than this; however, they are not common. Up to 10-ampere ranges are offered on some TVOM's designed with appliance service in mind.

Probes
Normally the probes provided with the TVM are not as exotic as those supplied with the VTVM. The most common one is the simple test probe with a test lead terminated in a banana plug, or sometimes in a tip plug. Occasionally some TVM's offer the VTVM probe. An 11-megohm input impedance is often a clue to a special probe.

AC rejection
A few TVM manufacturers specify the AC rejection of the DC ranges. This specification indicates the number of full scale overloads of a certain frequency AC (usually 60 Hz) which may be applied without affecting the DC reading.

Protection
As the TVM, especially TVOM's, are often used in situations where accidental contact with high voltages can occur (most commonly either the 120 or the 240 VAC power line), protection of the DC voltmeter and other functions is important. Protection is accomplished and specified in a number of ways. The manufacturer may simply state that the meter is protected from momentary overloads of 220 volts AC or DC on any range. This protection takes the form of back-to-back diodes at appropriate places in the circuit. Additional intrinsic protection is given by a set of back-to-back diodes across the meter movement itself. These diodes prevent the movement from being destroyed by a continuous overload. Ohmmeters are protected by diodes, and a fuse may provide additional protection. Ammeter shunts are often fuse protected. These fuses may be difficult to obtain, and acquiring a few spares is wise.

Some of the TVM's, especially the TVOM's, have a ruggedized taut-band meter movement. Such an instrument will come through a fall onto a hard surface undamaged to at least with minor repairable damage, while conventional meters would be seriously damaged.

Scales
A typical TVM scale is shown in Fig. 12. Note the battery test position. The dB scale is calibrated in dBm. (Zero dBm is one milliwatt on 600 ohms, or 0.774 volts). A small center-zero scale is given for null measurements.

Controls
The number of controls and the selection of functions are highly dependent on the functions offered by the particular TVM. Function selection is by rotary switch and/or push buttons. Range selection on the TVM frequency includes a battery test position.

A zero control is common to TVM's. The range of this control is sufficient to prevent zero-centering the meter as well as left-hand zeroing. An ohmmeter adjustment may not be included on a meter that utilizes internal constant current generators in its ohmmeter function.

The meter movement
As noted in the section on meter protection, some TVM's employ the taut-band meter movement. Those not indicating this type of meter movement use the regular moving-coil or D'Arsonval meter. Most manufacturers specify the size of the meter. A four- to five-inch meter is common and adequate for most laboratory and field service applications. Meter displays smaller than that become difficult to read, especially when there are a number of scales clustered on the face. Meters larger than five inches are useful in some shop or laboratory applications. A mirror-backed meter aids in resolution, but rarely does the TVM offer accuracy requiring a mirror-backed meter.

Amplifier outputs
Good laboratory TVM's have two different forms of outputs. There may be a DC voltage directly proportional to the meter movement. Such an output may be 100 mV, or 1 volt for a full-scale meter deflection. This type of output is handy for driving a strip-chart recorder or perhaps some form of limit detecting circuit. The second form of output is a signal taken from the meter amplifier prior to being applied to the rectifier. Such an output may be used to drive a set of headphones, for example, to listen to a circuit as well as to measure it. Such outputs usually have a few kilohms source impedance.

Floating inputs
A floating input is one not connected to the earth side of the power line. Generally this indicates the impedance to ground (usually a very high resistance with a small shunt capacitance) from both the high and the low (common) terminals of the voltmeter input is the same. Such a feature allows the voltmeter to be operated without one side of the voltmeter attached to ground. This is particularly handy for measuring voltage drops across circuit elements which have both terminals above ground. A maximum limit is given to this floating capability when the instrument is line operated. Battery operation automatically provides floating operation.

Accessory probes
Many manufacturers offer high-voltage probes to extend the useful DC voltage range of the meter, and RF probes to extend the useful frequency range of the AC voltmeter. These probes are often not interchangeable from one manufacturer to another. Close attention to the specifications of the voltmeter with which they are intended to be used is wise.

Battery operation
As noted in the section on floating inputs, battery operation is a useful feature when the instrument is operated with both inputs above ground. This feature is also used to eliminate unwanted signals present on a common ground system. This is desirable when the common input to the TVM is common to earth ground. Battery operation is also essential to field operation and is therefore a part of every TVOM. Batteries do tend to spoil after a time and can damage the instrument when they do. This feature also adds to the price.

Special current measurement
As noted in the theoretical discussion on ammeters, a few special types are available. These special ammeters are generally dictated by some special application. However, the ammeter in the Weston model 670, which does not require opening the circuit to make the current measurement, is especially useful for service work. Ammeters with special high current ranges are available for special applications. Generally such special scales come at the expense of some other feature or ranges.

Automatic polarity indication
Some of the more sophisticated TVM's have polarity indicators instead of a DC polarity reversal switch. Polarity reversal is indicated by the change of the polarity indicators from + to — or vice versa. Polarity indicators are disabled when AC measurements are being made.
Ohmmeter features

As noted before, many TVM ohmmeters offer both high and low resistance measurements. In addition to the high and low measurements, some TVM’s offer an ohmmeter polarity reversal switch. The polarity reversal switch permits a quick check when forward biasing a semiconductor junction in a circuit, or when a semiconductor is being tested for shorts or opens.

The AC voltmeter

The ranges of the AC voltmeter cover a wider range than those of either the VTVM or the TVM. Ranges extend from the 0.1 to 10 mV area to the 300 to 1,000 volt area. The ranges of the AC voltmeter are also calibrated in decibels. Zero dB is 0.774 volt for zero dBm.

AC voltmeter accuracy is specified in one of two ways. First, the voltmeter may be given an accuracy specification at a single frequency and a frequency response specification to cover the operating band of frequencies for the instrument. The total operating range of the voltmeter may be subdivided into a number of ranges with a different response for each range. Second, the voltmeter may be given an accuracy specification for the entire range of operation. Usually this form of specification is reserved for the higher-priced meters. Accuracy may be specified as a percentage of reading plus a percentage of full scale for the AC voltmeter. Again the accuracy may be broken down by the frequency ranges of the meter.

The frequency response of the AC voltmeter is from the 10 to 20 Hz region to the 1 to 4 MHz area. The exact extent of response may vary with the voltage range being discussed. The frequency response of the AC voltmeter is better than that either the TVM or the VTVM.

A 10-megohm input impedance shunted by 10 to 40 pF is common for the AC voltmeter. A few AC meters offer a lower input impedance. The input capacitance changes with the voltage ranges selected on some meters. This feature can cause a change in the circuit impedance when the meter is switched through its ranges, due to a change in capacitive loading.

The response time of the AC voltmeter indicates the time for the meter to settle within its rated accuracy. This specification indicates the time associated with the rectifier circuit. The response time indicates that the voltmeter may, or may not, be used as a VU meter, which requires a 0.3 second maximum response time.

AC voltmeters frequently feature amplifier outputs; the meter may also be used as a high-gain test amplifier. The output impedance of these amplifiers is either 50 or 600 ohms. Other features include an output proportional to the meter deflection (either 100 mV or 1V); filtering that may be switched in to eliminate high-frequency response, battery operation for portability and elimination of ground currents, linear dB scales, mirror-backed meters for ease in making high resolution measurements, and a true RMS converter. Generally, such options are available only on higher-priced units, and some, such as the true RMS converter, are expensive.

Regular and special applications

The electronic analog multimeter is used where it is necessary to measure a voltage, current, or power, with an accuracy of two percent or less. This, in fact, is most of the time, especially for the home experimenter or the consumer products service shop. Some industrial service and laboratory situations require greater accuracy. The digital multimeter should be considered for those applications.

As noted previously, the analog meter is definitely the best display device when the desired information is trend. Numerous situations exist in the alignment of an FM receiver/transmitter, for example, where the procedure calls for peaking the output of a stage. An analog meter proves its worth here and should always be carried for this purpose if for no other. Other examples of trend measurement are found in the same FM receiver/transmitter alignment procedures. For example, many oscillator circuits and some output stages require their supply current to the stage be reduced to a minimum, or "dipped." This too is a measurement of trend.

The DC output of the receiver discriminator is zero when the discriminator transformer is tuned to the center frequency of the IF strip. The zero offset capability of the TVM or VTVM is especially handy for this measurement, as the discriminator output voltage is of one polarity for frequencies above the IF center-frequency and of opposite polarity for frequencies below it. An analog voltmeter is needed to set the output of the discriminator at zero. This same "nulling" procedure is used in a number of bridge circuits, where an analog voltmeter with zero range is also called for. A common problem is the need to make a floating measurement when the meter's common terminal is connected to earth ground. A solution to this requires making two measurements, one at each end of the circuit, and subtracting the readings. When this technique is used, the difference between two large numbers is a small number with the same error as the large numbers. For example, the voltage drop across R2 of Fig. 13 is needed. E1 is measured with 90 volts and E2 is measured as 85 volts. The voltage drop across R2 is determined to be 5 volts. Examining the errors involved in the measurements, the 150-volt range of a 3% VTVM gave each of the high voltage measurements a ± 4.5 volt error. This error shifts the floating voltage of R2 by ± 4.5 volts. The accuracy of the difference between E1 and E2 depends on the linearity of the meter. Linearity is not often specified, but 1% of full scale is a good figure to use. The 5-volt drop across R2 can therefore vary by as much as ± 1.5 volts.

Many alignment and test procedures call for a specific type of voltmeter, frequently the TVM. The 10-megohm TVM is a good substitute if the circuit is known not to need the isolation of the 1-megohm probe tip resistor of the VTVM. It is wise not to convert such measurements to digital multimeter measurements. Often the added resolution of the digital meter causes needless confusion. If a 10-megohm TVM is the only instrument available, a special probe can be made. This probe with the additional 1-megohm resistance at its tip reduces all measurements by 9%. However, the measurements are still valid with a known 9% error especially if these test points will be tolerated the capacitive loading of a 10-megohm 100-pF TVM. Fig. 14 depicts the construction of such a probe.

The in-circuit current meter is useful for troubleshooting. For example, presume one of ten integrated circuits soldered to a printed circuit board is shorted internally, enough to make the power supply enter current foldback. The normal method of servicing is to replace or disconnect each integrated circuit from the power rail until the power supply recovers. With the in-circuit current measurement, the current to each integrated circuit is measured. The shorted device is identified as the one drawing a large current. The defective component is replaced, saving considerable work. Needless to say, this technique is applicable to many other similar situations in both discrete and integrated designs.

Sources of error

The analog voltmeter, like any other instrument, is capable of introducing errors in the circuit being analyzed. These are fundamentally of two types, errors introduced by the operator and those caused by some characteristic of the instrument.

Errors in reading are the most common operator errors. Simple errors are often made from a misreading of scale continued on page 104
If you can’t go to college for your career in electronics — read this!

CREI brings college-level training to you with eight educational advantages, including special arrangements for engineering degrees.

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.

If your career in electronics is limited without college-level training, take a look at the advantages a CREI home study program can offer you.

1. Convenient Training
CREI brings the college to you. Through the convenience of home study, you receive exactly the same level of training you will find in any college or university offering programs in electronic engineering technology. With CREI, however, you can “go to college” whenever you have spare time at home or on the job.

2. Specialized Programs
With CREI, you enjoy the advantage of specialized training. That is, your program will include only those courses directly applicable to your career in electronics. We omit such courses as English, social studies and other subjects, which are usually required in resident schools. Therefore, with CREI, you move ahead faster to the more interesting and useful part of your training.

3. Practical Engineering
CREI programs give you a practical engineering knowledge of electronics. That is, each part of your training is planned for your “use on the job.” By using your training, you reinforce the learning process. And by demonstrating your increased knowledge to your employer, you may qualify for faster career advancement.

4. Engineering Degrees
CREI offers you a number of special arrangements for earning engineering degrees at recognized colleges and universities. You can earn college credit while you are taking your CREI program or apply later, whatever is best for your career plans.
Career Training at Home

5. Unique Laboratory
Only CREI offers you the unique Electronic Design Laboratory Program. This complete college laboratory makes learning advanced electronics easier and it gives you extensive practical experience in many areas of engineering, including design of electronic circuits. No other school offers this unique program. It is a better "Lab" than we have found in many colleges. And the professional equipment included in the program becomes yours to keep and use throughout your professional career.

6. Wide Program Choice
CREI gives you a choice of specialization in 14 areas of electronics. You can select exactly the area of electronics best for your career field. You can specialize in such areas as computer electronics, communications engineering, microwave, CATV, television (broadcast) engineering and many other areas of modern electronics.

7. Prepared by Experts
Experts in industry and technical organizations of government develop CREI programs. Each part of your training is developed by a recognized expert in that area of electronics. That means you get the most up-to-date and practical instruction for your career.

8. Industry Recognition
That CREI training is recognized by industry and government is evident from the fact CREI provides training to advanced technical personnel in over 1,700 technical organizations. Many subsidize the training of their employees with CREI. If there is any question about the advantages of CREI training for you, ask your employer or any engineer to evaluate the outline of a CREI program for you.

Other Advantages
Of course, there are many other advantages to CREI training. For example, throughout your training, CREI's staff gives you personal instruction for each step of your program. And in many industrial areas, both in the U.S. and abroad, CREI Field Service Representatives provide a number of important personal services for your training and your career.

FREE Book
There isn't room here to give you all of the facts about career opportunities in advanced electronics and how CREI prepares you for them. So we invite you to send for our free catalog (if you are qualified). This fully illustrated, 80 page catalog describes in detail the programs, equipment and services of CREI.

Qualifications
You may be eligible to take a CREI college-level program in electronics if you are a high school graduate (or the true equivalent) and have previous training or experience in electronics. Program arrangements are available depending upon whether you have extensive or minimum experience in electronics.

Send for this FREE Book describing your opportunities and CREI college-level programs in electronics

Mail card or write describing qualifications to

CREI - Capitol Radio Engineering Institute
McGraw-Hill Continuing Education Center
3939 Wisconsin Avenue Northwest
Washington, D.C. 20016

Accredited Member National Home Study Council

GI Bill
CREI programs are approved for training of veterans and servicemen under the G.I. Bill.

MARCH 1977
**BUILD**

**Tone Probe for Testing Digital IC's**

This easy-to-build test instrument costs less than $16 and emits an audible tone to denote low and high logic-levels

LARRY FORT

---

**HAVE YOU EVER COMPLETED A DIGITAL circuit project only to find that something is wrong? It's no problem if you have an oscilloscope, particularly one with a triggered sweep, but if your scope isn't too good, troubleshooting digital circuits will be difficult.**

What if all you have is a voltmeter? They're fine for low-speed circuits where a signal stays at a given level long enough for the meter to react and settle at a reading, but fast pulses and high repetition rates make meters almost useless.

A logic probe then, is almost indispensable if you're building projects that use digital circuits, because you must be able to tell whether inputs and outputs are high, low or floating. Many probes are available today, but most of them use some kind of visual indication to tell the signal level. If your hands are steady and you have your wits about you, it's possible to look away from what you're probing to determine the signal level, then immediately return your attention to the probe and start again at the next lead. If not, you're in trouble unless you have a tone probe.

The tone probe described here uses sound to tell the status of the signal being probed. That means you can probe difficult points rapidly and know each signal level without any distractions. It has the added advantage of detecting intermittent problems just by the sound "pattern" changes that occur as you manipulate other components of the circuit.

There are really only three voltage levels of interest. A voltage level of less than 0.8 is considered low for almost all TTL and DTL families of digital IC's. Voltages greater than 2 volts are considered high, and any voltages between 0.8 volts and 2 volts are not guaranteed to be either high or low and can cause noise problems. The tone probe has an input circuit that senses the condition of the signal and produces either a low-pitched tone for low-level signals, or a high-pitched tone for high-level signals.

Any signal between these two produces no tone.

An important consideration for all logic probes is that they must have a high input impedance so they will not load down the circuit under test. A low input-impedance can cause a good circuit to malfunction.

The tone probe is powered by the circuit-under-test rather than being self-powered, for two reasons: The supply voltage affects the switching points to some extent; and it is necessary to have a ground lead to all probes so the inconvenience of clipping one or more wires for B+ is insignificant.

**How it works**

Figure 1 shows the schematic diagram. Resistors R1 and R2 form a voltage divider that supplies about 1.5 V to resistors R3 and R4. Resistor R3 supplies some base drive to Q1, causing it to conduct. Transistor Q1's collector will be near ground and D1 is reverse-biased, thus no current flows through D1 to IC1.

Transistor Q1 is the low-level input detector. When the circuit-under-test forces the voltage at the junction of resistors R1 and R2 below approximately .5 V, Q1 stops conducting. Its collector rises toward +5 V through R7. This action forward-biases D1 and supplies current to IC1. IC1 is the popular 555 one-shot. It is connected to run in the astable mode. When R7 and D1 supply current to IC1 pin 7, IC1 oscillates at a low frequency.

Transistor Q2 is the high-level detector. Resistors R5 and R6 form a voltage divider that provides approximately 1.6...
V for the emitter of Q2. With the probe low or floating, the base-emitter junction of Q2 is reverse-biased and no collector current flows. If the circuit-under-test changes state and goes high, Q2 begins to conduct at about 2.3 V.

With Q2 conducting, R9 supplies base drive to Q3, causing it to conduct. The input signal causes Q1 to return to a conducting state and removes from IC1 the drive that causes it to oscillate at a low frequency. Transistor Q3 now supplies this drive current through R11 and D2. Resistor R11, being much smaller than R7, sends more current to IC1 and it oscillates at a much higher rate, producing a high-pitched tone.

Construction

The probe layout is not critical and may be built on perforated board or on a printed-circuit board made from the layout (Fig. 2) supplied.

All components, including the speaker, mount on the printed circuit board.

A small amount of epoxy glue or silicon rubber sealant secures the rear of the speaker magnet to the component side of the board. When installed in the case, the cover is compression fit to the speaker.

The three leads have a knot just inside the cover of the box to act as a strain relief. The probe can be either a commercially available replacement probe or it can be made from a ball-point pen.

Checkout

To check the tone probe, a 5-volt supply is needed as well as a 1,000-ohm potentiometer. Connect the supply to the + and – leads of the probe. Connect the outside terminals of the pot across the power supply and rotate the pot so the center terminal is at ground (–). Connect the probe to the center terminal on the pot and check for a low-frequency tone. Turn the pot, increasing the voltage until the tone just quits. Measure this voltage. It should be between 0.4 and 0.6 V. Increase the voltage further until a high-pitched tone just starts. Measure this voltage. It should be between 1.7 and 2.0 V.

If your probe triggers within these limits it is functioning correctly. If it does not test correct, check for proper value resistors in R1, R2, R3, and R6.

If the probe does not make any sound, check IC1, Q1 and Q3. Also make sure D1 and D2 are connected in the right direction.

Using the probe

After attaching the tone probe to a power source, touch the probe to each of the leads of the integrated circuit being checked. A high-pitched tone will be heard if there is a high-level signal (2 volts); a low-pitched tone will be heard if there is a low-level signal (0.8 volt). No tone will be heard if the signal is between these two voltages. To check the tone probe, touch the end of the probe to the B+ source—a high-pitched tone should be heard.
State of SOLID STATE

An in-depth look at two rhythm generators designed for electronic organs, new microcomputer boards and a programmable scientific calculator plug-in board are featured this month.

KARL SAVON
SEMICONDUCTOR EDITOR

SOME YEARS AGO I PURCHASED A FAIRLY DELUXE SOLID-STATE ELECTRONIC organ. Solid-state meant that all the active devices in the instrument were transistors. The IC was not yet a reality. There was still a good crop of tube jobs around at the time. Oh boy! This was the epitome of home music making; it even had a little box in its innards that put an alternating-note xylophone into the percussion lineup! Press enough tabs and even a simple single-note melody line played in some semblance of cadence impressed the uninitiated.

With a couple of weeks or months of developmental ground work, you (or better still an organ manufacturer) can now take a handful of IC's and put together a tone and percussion generator that gives the older units a run for their money. The performance output per dollar of parts is unprecedented, even with continuing inflation.

The rhythm generator has always been an exciting add-on or add-in to the organ. Inability to play in time is a common fault of many amateur musicians. If they want to stop for a few beats to figure out what to do and you're doing something wrong. The rhythm generator is a big help in this situation. It acts as a metronome and forces you to learn to keep an even tempo. The first time you try to play along with one of these gadgets you may be in for a rude awakening.

At the time I bought my instrument, rhythm generators were expensive discrete multiple stage shift-register gizmos with slews of decoding diodes, switches, and wire.

Well, the IC rhythm generator has arrived. Ever-expanding memory products and technology have brought prices down to where consumer product makers are using them. The products will do new tricks and the manufacturer's costs are usually reduced. Toss the rhythm generator in with other music and standard monolithic devices and you can build an amazingly versatile wonder in a deceptively small container. Frequency dividers, flip-flops, and oscillator chips are natural additions to the mix.

Integrated rhythm generators

American Microsystems Inc. and more recently SGS-ATES Semiconductor Corporation have announced rhythm generators designed specifically for organs and other electronic instruments. These are not conglomerations of standard digital circuits but one-chip devices with only one application in mind.

Both manufacturers' devices are largely read-only memories with the various rhythm patterns embedded in their cells. Supporting circuitry reacts to input controls and supplies the independent instrument outputs.

The AMI S9660 will drive seven rhythm instruments—that is, seven different, usually percussion simulation generators such as electronic versions of drums, cymbals, or bells. The rhythm pattern is 64 bits long—a unique nonrepeating 64-count sequence can be generated for each of seven selected rhythms, for each of the seven instrument outputs.

Figure 1 is the block diagram of the AMI S9660. One of the most fundamental things that must be done on the chip is to generate the 64 separately decoded beats for the maximum length rhythm pattern. That is done by a six-stage counter which is fed from a divide-by-two and an on-the-chip oscillator that is externally frequency controlled.

FIG. 1—AMI S9660 BLOCK DIAGRAM.
over a 3 to 30-Hz range. Terminal RC connects from the oscillator to the external resistor-capacitor frequency determining network. Base current to an external PNP transistor from terminal DC (dumps charge) discharges the capacitor during the oscillator cycle. The six-stage counter steps through 64 independent states. (This maximum number of states is simply calculated as two to the sixth power.) There will be 64 different combinations of ones and zeros showing up in the counter's six stages. It is the job of the decoder to use this to produce an independent output for each of these 64 counter states. The counter has 12 inputs, one for each complemented and uncomplemented stage of the counter, and 64 outputs. Each of the outputs activates one word in a 64-word read-only-memory. For this discussion, read-only-memory is synonymous with PROM. The memories are programmed during processing by using specially prepared masks.

Enough flexibility is built into the chip to generate all common rhythms. A 64-bit count is just not right for many of them, so the generator must be able to change the maximum sequence length. The S9660 has five mask programmable reset options. Normally the fifth one is reserved for the 64 unshortened count. These reset options are stored in a portion of the ROM. After programming, the five reset options are selected by the ABDK meter input terminals. \( V_c \) (ground) is connected to one of the four terminals to select the first four meters. If none of the leads are activated the default 64-bit count is implemented.

Typically the timing could be programmed as follows: A might be \( \frac{1}{4} \) time. A total of 36 bits can be broken into 9 bits for each of 4 modules. Each of three bits is assigned to each of the three bits in the measure. The idea is to provide the maximum possible bits-per-beat for each meter within the 64-bit limit, consistent with the intricacies of the final rhythm. If \( B \) were set for \( \frac{1}{4} \) time, 2 measures could be separated into 20 bits each. The number of bits in each measure must be a multiple of 5 in this case. This allows four bit divisions for each of the 5 beats, allowing timing outputs at %note intervals. \( B \), programmed for \( \frac{1}{4} \) time, could have a total 48-bit count with again 4 bits assigned to each beat, in this case 6 beats per measure. \( K \) could also be \( \frac{1}{4} \) time like \( A \) but with 4 bits/beat. A 48-bit sequence is required by 4 measures \( \times \) 3 beats/measure \( \times \) 4 bits/beat. And finally the full 64 count selected if all inputs are unconnected might be 4/4 time with 4 bits/beat. 4 measures. 4 bits/beat and 4 bits/beat: 4 \( \times \) 4 \( \times \) 4 \( = \) 64.

At this point the decoded sequences have been generated and the device must be able to select the particular rhythms and generate the seven outputs.

Each of the 64 programmed words in the voice-enable PROM contains in its ones and zeroes the binary information as to which of the seven instrument outputs is to be activated at which of the maximum of 64 counts. Each of the seven instruments may contain an entirely different and independent rhythm as desired.

The seven \( H \) inputs address the pattern-enable portion of the ROM. A pattern is selected by applying \( V_c \) to one of seven pins. The voice buffers are fed by the selected programmed ROM patterns. An interesting feature is that the rhythms may be combined by overlaying them by enabling more than one pin at a time. Overlaid outputs are logically OR'd so that an output occurs when at least one of the overlapped patterns is enabled during a particular interval. The output voice drivers interface with transistors and provide low-resistance paths to \( V_c \) when activated.

When held at \( V_{DD} \) the \( C \) reset input holds all outputs off. Applying the supply voltage starts the count at its beginning. This feature can be used as a synchronized trigger connected, say, to an organ-pedal sensing circuit.

The S9660 is built with AMI's ion-implant process. Starting out with the standard P-channel process, two ion implant steps are tacked on. Transistor thresholds are reduced to \(-1.5 \) volts by the first implant. Power consumption is reduced and TTL compatible input and outputs are the result. Constant-current load devices with \(+3.5 \) volt thresholds are selectively produced with the second implant. Higher speeds for the same current are possible with constant current loads. Accurately controlling threshold (the gate-to-source voltage at which the channel begins to turn on) increases the yield. Yield refers to how many of the pellets processed turn out to be good ones at the end of the line.

Internal pull-up resistors to \( V_{DD} \) are provided on all inputs except the oscillator input. The S9660 comes in a 28 pin dual-in-line package. The \( V_{DD} \) supply is operated between \(-8 \) and \(-13 \) volts.

A particular set of IC rhythm sequences is programmed by punching 54 IBM cards. Five cards are punched for the five reset short count inputs (N,K,D,B,A). Seven cards are punched for each \( H \) rhythm select input. Each of the seven cards for each \( H \) input contains the sequence (64 bits or less) for each instrument plus identification recognized by the programming machine. So these last cards total \( 7 \times 7 \) plus the other five for the total of 54.

Besides the S9660, AMI makes a number of other music-oriented products. The S2555 Music Frequency Synthesizer generates seven notes of the equally tempered scale, dividing down a 2.1 MHz input clock. The S2556 used with the S2555 supplies the other six notes of the scale. The equally tempered scale is the widely adopted harmonic compromise system. The same thirteen frequencies per octave can be used whatever the key.

American Microsystems Inc. is located at 3800 Homestead Road, Santa Clara, CA 95051.

**An offering from SGS-ATES**

The SGS-ATES M252 and M253 are similar monolithic circuits. The M252 has a 3840-bit PROM, which will store 15 rhythm patterns for eight instruments. Since the patterns may be up to 32 beats each, this calculates to \( 15 \times 32 \times 8 = 3840 \) bits. The M252 will store 12 rhythm patterns for the same 8 instruments and 32 beats, and so uses a smaller 3072-bit memory.

The interesting thing is that the smaller memory device is packaged in the bigger DIP! The M252 comes in a 16-pin DIP but the M253 is mounted in a 24-pin package. The reason is that the M252 has its 12 patterns selected by connecting the input pin for the pattern to \( V_{SS} \). Only one terminal is enabled at a time so 12 terminals are tied up in the process. This is simple for the user because all he does is provide an uncoded series of SPDT pushbuttons. Double-throw switches are needed to return the unused inputs to \( V_{SS} \). The M252 with 15 rhythms uses binary coded 1-2-4-8 weighted select inputs. Four terminals then select the full 15 combinations. The difference between the 12 and 4-pin input terminal count is 8, precisely the difference in pins between the 16 and 24 pin packages.

Both devices are either purchased with standard patterns programmed in or are specially mask programmed to a user's preference. The standard version of the M252 includes the following rhythms: Waltz, Tango, March, Swing, Slow Rock, Rock Pop, Shuffle, Beguine, Cha Cha, Samba, Bossa Nova, Jazz Waltz, Foxtrot, Mambo, and Bajon. The 253 in its standard version leaves off the last four and adds the Rumba \( \times \) 4 \( \times \) 64.

![Fig. 2-SGS-ATES MODEL M2525 rhythm generator.](image)

Figure 2 shows a typical setup of the standard content M252 device with the suggested external instruments. If space separation for stereo effects is desired, the instruments can be split and summed differently into two or more amplifiers rather than the hookup shown. By combining two chips, the number of rhythms, the number of instruments, or the total number of beats can be extended.

Figure 3 shows the rhythm extension scheme. The 1-2-4-8 encoded inputs feed the corresponding terminals on the two chips in parallel. A coded 16-weight input is added to give the extended control. Thirty rhythms require five bits to control them since \( 2^5 \) is only 16. The added input simply selects which of the chips is to be activated. Both
reset inputs are fed through diodes but chip-1 has an inverter in its reset path. This way one device is held at reset and the other allowed to operate, depending on whether the 16 input is high or low. To increase the number of rhythms with the M253, which is not binary coded, the two chips are operated with their outputs paralleled. The inputs are renumbered from 1 to 24 and no further select logic is needed.

The number of instruments can be increased by operating the two devices’ clock inputs in parallel, resetting them at the same time and clocking them with the same generator, keeping them phase-locked. Rhythm programming is different for the two circuits so there are eight different instrument patterns from each chip for a total of 16 in all.

Figure 4 details the count lengthening scheme. A maximum of 64 beats is possible. The idea here is to let the two generators work sequentially. One-half of a 4027A dual J-K master-slave flip-flop is used to hold one generator reset while the other goes through its 32 counts. The flip-flop then changes state and the other rhythm generator takes over with its 32-bit sequence. Isolation diodes (D2 & D3) are connected to the flip-flop clock input from the reset terminals of each generator. It is the reset signal at the end of the 32nd pulse that signals the termination of one sequence and toggles the flip-flop. Since the output devices are open-drain and normally off, the eight instrument outputs on chip-1 can be wired directly in parallel with those on chip-2.

Mask programming information for the SGS-ATES circuits are written into a truth-table form. A table is filled out for each instrument, with 8 columns, one for each instrument.

Standard +5 and -12-volt supplies are used and maximum current drain is 15 mA. On output resistance is less than 500 ohms. Downbeat trigger signals are available on the external reset/down-beat terminal. Driving a lamp from this signal gives visual indication at the start of each sequence.

P-channel silicon gate processing is used and both ceramic and plastic packages are available. Small-quantity prices for the M252 and M253 are $15 and $19.50 respectively. The prices drop by a third for quantities between 100 and 999. Further information is available from SGS-ATES Semiconductor Corp., 435 Newtonville Avenue, Newtonville, Mass. 02160.

Microprocessor news

Martin Research, authors of the book Microcomputer Design, offer a set of PC boards which form a bus-oriented system so that any board may be plugged into any position on the bus. If you want to expand the system you add the board at the next empty slot. This is the same sound philosophy used by some well-known minicomputer companies.

They have a Mike 2-1 CPU Board, which holds the 8008 chip, a crystal-controlled oscillator, and the timing generation circuits. The Mike 2-20 Console Board has six seven-segment displays and a twenty-key calculator-type keyboard. The output display can be read in octal, decimal, or hexadecimal (base 16). The Mike 2-3 PROM/RAM board holds 1K of RAM and 2K of PROM.

MR's basic system uses 256 words of RAM and 256 words of PROM. It is preprogrammed with the Mike 2 monitor that is used to write instructions into and read instructions from any location in memory using the keyboard.

The Mike 203A, which includes the 8008 microprocessor sells for $269.95 in kit form and $319.95 assembled (and tested). For details write to Martin Research, 1825 S. Halsted Street, Chicago, IL 60608.

Scorpio Laboratories SC-440

This is an externally programmable scientific calculator plug-in circuit board that interfaces with TTL. It works with ASCII inputs and has multiplexed BCD outputs. It can be used tied to instrumentation for data-reduction tasks that do not need the complexity of a microcomputer and the necessary software. In effect the software is built into the calculator chip. Or it can be a microcomputer satellite as a hard-wired data-reduction peripheral. Keyboards, accessory RAM/ROM memory cards, a low-cost cassette, a 3½-digit DVM/DMM and a 40-MHz frequency counter are being developed.

Scorpio's SC-441 is a 42-pin module designed to interface instruments with BCD outputs, such as digital voltmeters or clocks with microprocessors on 4, 8, or 16-bit data busses. It also allows retrofitting BCD instruments to become remotely controlled transmitters, using the recently standardized Universal Interface Bus.

It is useful in reading and storing in memory the time of the measurement as well as the readings of temperature, pressure, flow, liquid level or pH. The SC-440 is also useful in security alarm and payroll computing systems.

The SC-440 costs $300 in single units and drops a third over 50. The single unit price of the SC-441 is $100. Scorpio Laboratories Inc., 46 Liberty Street, Brandy Boro Station, Metuchen, N.J. 08840.

Calculator display drivers

National's DS8864 has nine independent LED digit drivers that will sink up to 50 ma from a common cathode display operating in a multiplexed mode. Drive current is typically 0.9 to 1.2 ma, which will interface with most MOS calculator chips. The LED to MOS interface chip also includes a battery-condition sense circuit that lights up the leftmost decimal point when the battery is low.
R-E's Service Clinic

Lightning protection

Be safe rather than sorry

JACK DARR
SERVICE EDITOR

There's an old saying that goes: "Lightning never strikes twice in the same place; because when it hits the second time, the place isn't there any more". Unfortunately, in solid-state circuitry, this isn't true. We're running into more repeated failures of the same parts due to lightning transients than ever before. This is the bane of designers' and technicians' lives. One harried technician wrote us a pitiful story of having replaced the same IC in a well-known make six times under warranty, and twice after the warranty ran out!

Unfortunately, there isn't any such thing as a true "lightning arrester". The only thing these gadgets can do is shunt the current off to ground through a small arc-gap, destroying themselves in the process. In the case of a direct hit, it's just too bad. The current is so tremendous that the place literally isn't there. I've seen a 6-inch square heavy ceramic fuse block, two big fuses, the brass holders, and everything except the ends of the wires completely disintegrated after a lick like this. (This occurred in a radio transmitter atop a mountain.) The cabinet looked as if someone had thrown about 5 pounds of flour in it!

However, for the smaller hits that cause sharp line-transients, we can help things a little. We can't stop them but we can hold the damage down quite a lot. There are devices that will help.

Chassis modifications

One of these is the super-fast action varistor, such as the GE-750 from General Electric, that is connected directly across the AC line where it comes into the chassis. These are specially designed metal-oxide devices and are called GE-MOV varistors. In normal operation, they have a very high resistance so that they have no effect on the circuit. When a transient spike comes along, they break down very quickly and become a short circuit across the line ("crowbar" effect). G-E's Application Note on these gives a response-time of less than 50 nanoseconds for the type V130LA1.

That's one; another method recommended by set-makers is the installation of chokes in the AC line. The idea of these is to offer a high resistance to very sudden changes of current, such as a transient spike. Bypass capacitors to ground are also used for the same reason; they provide a low-impedance path to ground for the spikes.

Zenith has a set of recommendations for problems like this. In their 19DC12 and 23DC14 chasses, they tell you to replace the original line chokes (95-2920) with one of higher inductance, 95-2964. In Issue 72-73 of Tech-Topics, they also recommend moving some of the low-level leads going to the 9-97 color module—one of the parts that have suffered repeated damage in areas where thunderstorms are frequent. It looks to me as if they are figuring on reducing the chance of the spikes being coupled into the module circuit by interlead capacitance.

Paraphrasing the instruction for this, several leads of the control plug and socket are changed. This requires the use of an 868-2 (Molex HT-1010-2B) pin-extraction tool. For the 19DC12 chassis, here are the changes (Fig. 1) that should be made:

1. Remove the orange wire from pin 4 and place it in the empty pin-10 position.
2. Remove the black wire from pin 13 and place it in pin 4.
3. Remove the green wire from pin 5 and place it in pin 12.
4. Remove the blue wire from pin 6 and place it in pin 13.

(1 and 2 in the original layout are the leads to the AC switch. The leads on 5 and 6 go to the color circuits, and for goodness sake don't forget to change the leads in both plug and socket! It would also be a good idea to stick a note on the chassis saying that this modification had been made!)

In the 23DC14 control plug (Fig. 2) these changes should be made:
1. Remove the white-green wire from
pin 4 and place it in the empty pin 7 position.
2. Remove the black wire from pin 10 and place it in pin 4.
3. Remove the green wire from pin 5 and place it in pin 10.
4. Remove the white/black wire from pin 11 and place it in pin 5.
5. Remove the violet wire from pin 6 and place it in pin 11.
Be sure to get the right plug in the 23DC14. This is P203, which is the 12-pin connector and not the 15-pin "Secondary Control Plug" P204.
Other manufacturers have similar "fixes" for these problems, for they've all run into them. If you have trouble, check with the nearest distributor for the brand and ask them what the factory recommends. If you can't get anything, you might go ahead and add the GE-MOV varistor and the bypass capacitors, as well as the chokes in the AC line. I've always been a "belt-plus-suspenders" man; a bit extra can't hurt.

Antennas
Cable systems are usually pretty well protected against lightning. The spikes have to travel through so many things that they dissipate before they get to you. However, if the set is used with an outside antenna, there are several things that must be done to make it as safe as possible from damage.
For the most important, the mast or tower must be well grounded. Drive at least a 4-foot ground rod and tie or bolt this to the mast. There is a very handy thing available that I wish I had when I was putting up antennas. This is a combined base and ground-rod. It's driven into the ground up to the flange, and the mast simply dropped over the stud on top. Since practically all antennas are well-grounded by the mounting bolts, a properly installed mast makes a very good lightning rod!
The other essential is a good UL approved lightning arrester, which should be mounted on the wall as close as possible to the place where the lead-in enters the house. If this is close to the bottom of the mast, you can use this ground. If it's more than a few feet away, drive another ground rod directly below the arrester and run a short heavy ground wire to it.
One more precaution. If a certain location seems to get more than its share of lightning damage, check the grounding of the AC line at the point where it enters the house. There should be an 8-foot ground-rod directly under the "service entrance" box. These ground rods are sometimes hard to drive all the way. Some careless workmen have been known to drive them only about 24-inches and hit a rock. Then they cut off the top of the rod and go away! This is not sufficient grounding for protection. (Ask me how I know. I did this, and lightning promptly hit the place and scattered the motor of my water-pump all over the basement! The well-casing made a good ground! There is now a full 8 feet of ground rod at my place; I had to drive three of them before I got one all the way in through the rocks but it's there and we haven't had any more of this kind of trouble.)
There is only one really effective way of eliminating lightning damage: pull the line plug and disconnect the antenna! This is quite safe, unless you take a direct hit on the house. If this happens, you will have so many other worries, you'll forget the TV set!

reader questions

LOSS OF VERTICAL SWEEP
I've got a black-and-white portable with no vertical sweep at all. I want to make a quick-check of the vertical output transformer and yoke. Can I use a separate 6.3-volt filament transformer to feed a signal into the output tube? This set has a series heater string.—J.G., Arlington, VA.
BETTS
THERE'S ALTERNATOR, ripple loaded the dash. It seems the eo 0.5 disconnect of tubes and filters others. made now: J.W. alternator output. This boxes some it before?-J.H., Orangeburg, SC.

I've run into this a long time ago in two-way radio receivers. We just called it "alternator whine", and it is pretty hard to get out. We finally made up some L-C filters enclosed in metal boxes connected in the line from the alternator output. This killed it. You can get these filters all ready made now: J.W. Miller C-503-E, and others. I'm pretty sure these are L-C filters and not difficult to install.

LOSS OF WIDTH
The picture is perfect on this Zenith 16H27, but it isn't wide enough. I've checked all of the regular things: new tubes and so on. No go. The drive voltage

1 out of 2 who have it don't know it...

now... 97% ACTIVE INGREDIENTS
Plus WARMER SPRAY FOR MORE CLEANING POWER

TUN-O-WASH has long been the industry standard in tuner degreasers. Now, it's better and more economical than ever.

We haven't tampered with the famous TUN-O-WASH formula. That's too good to change. What we have changed is the propellant. We now use carbon dioxide (CO2) as a propellant. This permits us to fill the can with 97% active ingredients, compared with only 65% active ingredients before this development. The can is the same size, but you get more cleaning power for your money.

There are other advantages to using CO2 as a propellant. FIRST, the spray comes out 10° warmer. Everyone knows that heat increases solvent action. SEC-OND, the particles of solvent come out in larger drops, making the wetter spray. And, finally, CO2 enables us to maintain a uniform 70 pound pressure until the can is completely empty.

This is another first from the electronics industry's leading chemical manufacturer.

CIRCLE 78 ON FREE INFORMATION CARD

THERE'S A BETTER WAY TO GO.

Energy shortages tell us we have to change our driving style. Now! It doesn't mean we have to go back to horse and buggy days. But it does mean we have to make every drop of gas give us the most go for our money. Anyone with horse sense knows that a well-tuned car gets better mileage, and in times of fuel shortages, better mileage means a lot. The Mark Ten B Capacitive Discharge System keeps your car in better tune so it burns less gas. Using Mark Ten B is more than horse sense. It's the smart move under the hood, helping a nation survive an energy crisis and keeping you on the road. Delta Mark Ten. The best way to go.

CIRCLE 46 ON FREE INFORMATION CARD

DELTA PRODUCTS, INC.
One Delta Way, Dept. RE
Grand Junction, Colo. 81501
(303) 242-9000

I want to know more about Mark Ten CDI's. Send me complete no-nonsense information on how they can improve the performance of my car.

Name ____________________________

Address __________________________

City __________________ State ______ Zip ______

MARCH 1977
from the horizontal oscillator is low, and the oscillator plate voltage is too. B+ seems to be OK. In fact, the +265-volt source that feeds the horizontal oscillator reads +300 volts. This should be easy, but it isn’t!—J.M., Marina del Rey, CA.

Old Saying: “Ought to be ain’t is!”. Sometimes I think there’s no such thing as an easy one. Let’s see.

Your grid drive to the 6DQ6 is low and this could cause it; low plate voltage on horizontal oscillator may be the cause. This stage is not fed from the B+ 265-volt source; it’s fed from the boost, which should be +700 volts. Check the damper stage, particularly the boost capacitor. Also: there is a tricky one in this chassis. Check that 40-µF electrolytic capacitor on the cathode of the 6DQ6. If this is open, you’ll get a degenerative feedback that will reduce the output. Scope it to make sure.

TOO MUCH RIPPLE IN PICTURE

I wrote you before about checking the excessive ripple in the picture of a Gamble’s TV2-3701 black-and-white TV. You suggested checking ripple on the power-supply filters. That was it! I had to add 80 µF of extra capacitance to get rid of it! Works now. Thanks.—J.W., Hastings, MI.

EXCESSIVE WIDTH

The raster in this Sylvania D05-14 is so wide that I can see only 8 vertical lines of a crosshatch pattern! All of the DC voltages seem to check out all right. I tried reducing the screen grid voltage of the horizontal output tube. That didn’t work!—C.M., Diamond Bar, CA.

Well, there went one of my favorite ways of reducing excess width! So now what? In several cases this chassis has shown excessive width if that VDR from the pin-3 cathode of the 6C38 high-voltage regulator tube to ground goes bad. This is part No. 38-15257-9. Replace with exact factory duplicate; couldn’t find a listing on it.

120-HZ HUM BARS

If you see two hum-bars in the picture, you have a bad filter capacitor—right? Not Always! I had them in an old tube-type Sears color TV set. Checked all electrolytic capacitors by substitution revealed nothing. Scope showed the typical “writhing” ripple with one hump crawling up the other. The peak-to-peak amplitude of this ripple wasn’t too bad, either.

So: what is it? The filter choke is shorted. Not to ground, but the windings were shorted. After finding this, I remembered that I had found the same thing in an RCA about a year ago! Watch for this.

Thanks to Leon Caldwell, Caldwell TV, Mena, AR.

HIGH-VOLTAGE FLUCTUATION

This RCA CTC-22 chassis has a 12CT3 damper tube instead of the solid-state device used in others. The high-voltage fluctuates oddly; it will be going good, then for no apparent reason it’ll bloom and then go black. The high-voltage drops to about 4kV. Cathode current of output tube holds steady at about 180 mA. I suspect the pulse regulator. New tubes no help. Any ideas?—W.L., Fairmont, WV.

I believe I’ll go with you. Check that little capacitor from the plate of the 17KV6 regulator to the screen. I don’t know exactly what it’s for but I suspect it somehow.

(Feedback: That was it! I took it out, checked it and it was bad. Seemed to have gone up in capacitance from 15 pF to about 28-30 pF. Replaced it and the thing works. How did you know?)

(I guessed!)

GREEN RASTER

This G-E CA chassis has all kinds of intermittent! Horizontal bars on the screen, the raster turns green and finally you lose focus, high-voltage and everything. If I pull the high-voltage lead to the picture tube, the high-voltage comes back. Found that when the problem shows up, the picture tube grid voltages
all jump up to about +400 volts. Checked the blanker and other stages, no luck. I'm learning, and any help will be appreciated.—L.M., Hopatcong, NJ.

You'll learn, all right! This is kind of a tough one to start on. Though: you have found the cause of the symptom: now look for the cause of the cause. This will probably be one of two things. The basic cause is something that kills the plate current of the color-difference amplifier stages.

Check these: one: the 270-ohm cathode resistor of the difference-amplifier stages. This is common to all three and if one end has a bad solder joint, it opens the cathode circuits. Two: in this chassis, the heater supply for both difference-amplifier tubes goes through a wire jumper on top of the PC board. Check this for a bad solder joint.

WIDE SCANNING LINES

There are 5 or 6 horizontal lines in the center of the raster in this ED-2 Sylvania that are much wider-spaced than the rest. Vertical adjustments do nothing. Oddly: rolling the picture downward, the wide-spaced lines stay where they are! Could this be the deflection yoke?—G.D., San Juan Capistrano, CA.

Try turning the horizontal hold control on a blank raster. If this affects the position of these lines, suspect something in the pin-cushion circuitry. There is a resistor, R377, shunted across the pin-transformer that may be bad.

HALF A PICTURE

Here's a confusing one! I have the right half of the picture on the screen in this Magnavox T-940 chassis. The trouble is that the right half is on the left side of the screen and the right half is blank! Not blank, but black; no raster! Any suggestions?—H.S., Universal City, TX.

I have a silly cartoon over my desk on exactly the same problem! While the Professor is trying to figure out what's causing it, his wife pushes the cabinet to the left, this centers the picture! I don't think this is what's wrong here. (Did you try it, though? Never can tell!)

OK: Seriously. This chassis uses a pair of diodes in the horizontal centering circuit, with the centering control across them. This is in the horizontal deflection yoke circuitry. It sounds as if the raster is being deflected far too much to the left. Check the diodes, the bypass capacitors and the control itself for an open circuit. One of these has gone, I'd say.

MULTIPLE PROBLEMS

I changed the picture tube in this RCA CTC-16; now I've got several problems!

Picture is dim when first turned on, but comes up to normal brightness after a few minutes. Contrast is poor; AGC has very little effect; color is odd, and for a last one, the horizontal hold is very touchy. It falls out of sync, but it can be restored by just touching the hold control. Give me some hints as to what's doing this!—J.C., Ft. Worth, TX.

You've got problems, and the problems have got problems! For openers, I believe I'd ignore the others and fix the horizontal hold problem. You just might clear up a whole lot of them when you do. All of the rest could be due to incorrect phase of the horizontal oscillator!

Suspect the AFC diode unit first. Replacement is the fastest way. If this doesn't get it, check the PC board conductors and that little 51-pF coupling capacitor from the sync separator to the AFC diode unit.

VERTICAL OUTPUT TRANSISTOR

I need a replacement for the vertical output transistor in a G-E UA-4104 WD. There was another type in it. Can't find a substitute. What will do this?—J.L., High Point, NC.

The original is a G-E ES15X91. An RCA SK-3104 or Motorola HEP SS015 should replace it. Same spec's and plenty of voltage rating.——R.E.
user operations and solved most problems associated with the subroutine system. The main drawback of this method was imposed by the semiconductor processing technology. With the stack on the same chip as the processor, there wasn’t a lot of room left. This meant that the number of elements in the LIFO had to be limited. The result was a limit on the amount of program nesting that could be performed without filling the stack and losing return addresses. On most processors the user was limited to seven unrelated subroutine calls. This limitation also meant that stack usage had to be limited to subroutine return addresses alone. This denied the user access to many of the other features a stack can provide.

To solve these two problems, some manufacturers decided to implement the LIFO as part of the system main memory. They provided the stack pointer and the automatic increment-decrement hardware. The user then supplied the address of the memory block to be used as the LIFO. This is accomplished by loading the top address of the selected memory block into the stack pointer. From then on the stack functions automatically.

This certainly solved the nesting problem. Most systems have far more memory than a properly functioning program will ever need for subroutine nesting. It also makes the stack available for other uses. This allows you to use the stack to save registers, pass data to and from subroutines, and lots of other useful functions. However, there is no such thing as a free lunch. If you are going to manipulate data in the stack you have to balance the stack pointer.

Balancing the stack pointer simply means that it must be pointing to the correct return address when a subroutine return is executed. Failure to do this can result in your program accidentally using the data you meant to pass back in the stack as the return address. This type of error can result in some really interesting program execution. Balancing the stack requires that you pay close attention to the order in which data is entered and removed from the stack. Under normal operations, the data must always be removed in the opposite order in which it was entered.

You must also be certain that no programs accidentally write data into the area you have reserved as the stack. It is also a good idea to make sure the stack doesn’t grow too large and encroach on other program storage. The easiest way to avoid most of these problems is to assign the stack to the top 100 bytes of your system memory and leave it alone. This will probably be far more stack than you ever need and it will save you a lot of time you would otherwise have to spend computing exact stack usage.

Summary

Stacks provide you with a convenient way to solve many design problems. The FIFO and LIFO offer different characteristics for use in different applications. They can both save you much time and make it easier to implement a variety of system functions. If your computer uses a memory LIFO stack for subroutine return addresses, with a little practice you will discover ways to use it to make your programs more efficient. Whether hardware or software, the stack is a useful new tool for the designer.

1977 CB sales will exceed all previous years combined

More CB radios will be bought in the United States in 1977 than in all of CB’s previous 28 years added together, says John Sodolski, vice president of the communications division of the Electronic Industries Association (EIA). He expects sales to approach the ten million mark for 1977, and estimates that retail sales of CB radios, antennas and accessories should top $2 billion for the year.

Only about three million CB radios were sold between 1958—when the FCC allocated 23 channels for Citizens radio—and 1973, when the sudden upsurge began. Sales exceeded a million in 1973, then doubled each succeeding year, hitting nearly five million in 1975.

Unlike some industry predictors, Mr. Sodolski believes that 23-channel radios will continue to be popular, especially during the earlier part of 1977, before the supply of 40-channel sets catches up with the demand. Favorable pricing and the realization that the 23-channel radio satisfies the needs of a majority of the people in many parts of the country are the important factors that will keep the 23-channel sets moving, he says.

R-E
EQUIPMENT REPORTS
continued from page 34

hold the penlight? You don’t: you hold it between your teeth just as you always did.)

The model 175 is powered by self-contained rechargeable batteries. All of the very complex “works” are on only two boards, one for the logic, and the other for the display. A proprietary LSI/MOS IC performs all of the logic functions required by the A/D converter. Due to the extensive use of MOS circuitry, the total power consumption is less than 1.0 watt when used with the AC powered battery charger, and 0.6 watt on battery alone. The battery is good for up to 6 hours of normal operation with a full charge, and it can be recharged overnight: 12 hours. When the battery needs charging, the decimal point of the display blinks continuously.

The inherent high accuracy of the digital multimeter is taken full advantage of here. On DC volts, the accuracy is 0.1%. On AC volts between 50 Hz and 500 Hz, the accuracy 0.4%. To verify this, a complete set of the final test calibration readings is packed with every instrument. Specification limits are given and the actual test reading logged. On the 1,000 volt range of the one we reviewed, for example, the spec was +998 to +1002 volts. Anywhere between these limits, OK. The actual reading was 1,000 volts. Each instrument is given a burn-in test for 8 hours, and the calibration is then rechecked.

Everything else is automatic. The decimal point is automatically positioned correctly. On all DC measurements the polarity indicator is automatic. As is customary in DMM’s, the resistance is read out in 1000 ohms, except for the very lowest range, 100 ohms. Overrange greater than 100% is indicated by a blanked display, leaving only the decimal point and polarity indicator lit.

Overload protection is provided as mentioned. If you accidentally go too far while reading AC or DC currents, they have provided a 2.0-amphere fuse located inside the handle of the red test prod! Just unscrew the black tip and the fuse pops out. Be sure to use only fast-blow type fuses for replacement. A spare fuse and push-on clips are also provided. The whole thing—meter, charger, test leads and all—can be stowed in a handy zipper carrying case.

There is a small pull-out stand on the underside of the case, to raise the front panel to an easier viewing angle. This folds for storage. A very detailed instruction manual comes with each instrument. This gives not only the correct method of operation, but a circuit description, parts lists, calibration data and a schematic with parts layout.

A very useful little instrument, and very reasonably priced for one with this kind of accuracy and reliability.

Heath IP2718 Tri-Power Supply

THE HEATH COMPANY HAS INTRODUCED QUITE a range of power supplies for bench and experimental use. A typical example of these is their new IP-2718 “Tri-Power” supply. This supply is intended for general experimental work in either analogue or digital circuitry. TTL and similar devices use a 5-volt DC power supply. The IP-2718 has one:

CIRCLE 50 ON FREE INFORMATION CARD

For analogue circuits requiring a positive and negative DC voltage, there are two completely isolated 20-volt DC supplies. Each of these has a maximum output of 500 mA and can be continuously varied from 0 to 20 volts by the front-panel controls. Current or voltage in each supply can be read on the meter. These, too, are tightly regulated by transistor voltage regulators. The regulation is specified as less than 0.1% variation from full load to no load. Filtering is good: the maximum ripple level is only .005 V (5.0 millivolts RMS.)

All three of the DC supplies (one 5-volt and two 20-volt supplies) are completely isolated from each other and from the instrument ground. They can be tied together in

continued on page 94

external speakers save lost CB sound

Notice what happens to the high frequencies? You lose them mounting the average CB under the dash. The speaker points down into the floor insulation. Sound is lost. With the addition of an acoustically designed “KRIKET!” external speaker, also mounted under the dash but pointing at the driver, the high frequencies come through.

In a KRIKET all AFS®/KRIKET® speakers are manufactured in the U.S.A.
using American materials and craftsmen.

Copyright 1976 Acoustic Fiber Sound Systems, Inc.
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 108.

INSTRUCTION DETECTOR, model T-10 buried-line unit protects an area up to 400 feet long and 10 feet wide. It is intended for direct burial in the ground of parking lots, driveways, sidewalks, or any other surface for total concealment. It can be adjusted so it is not triggered by any weight of less than 50 pounds—Mountain West Alarm Co., 4215 North 16th Street, Phoenix, AZ 85016

CIRCLE 84 ON FREE INFORMATION CARD

WIRE-WRAP TOOL, Hobby Wrap model BW-630, is a battery-powered tool for wire wrapping 30 AWG wire onto standard DIP socket terminals. The tool comes complete with a built-in bit and sleeve for producing the preferred "modified" style wrap. Weighs 11 ounces and runs on any size "C" batteries. Price—$34.95—OK Machine And Tool Corp., 3455 Conner St., Bronx, NY 10475

CIRCLE 85 ON FREE INFORMATION CARD

CB SERVICE MONITOR, Measurements model CB-27E is a low-cost instrument for trouble shooting and aligning CB transceivers. Used to check transceiver frequencies and offset from mid-channel frequencies measured by the front panel meter and calibrated against internal frequency standard by zero-beating with the built-in speaker. Additional channels in the 27-MHz spectrum can be added if assigned. When powered with optional NiCad battery, the CB-27E can check the transceiver without removing it from the vehicle. An incremental tuning range of ± 5 kHz is provided for simulated SSB receiver tests. Features include 455-kHz crystal IF output with modulation and output level control, and provision for two additional intermediate frequencies. Monitor and transmitter are both protected against overloading if transmitter is accidently keyed; 1-kHz sinewave AM internal modulation and jack for external modulation covering speech frequencies; built-in transmitter meter. Price—$495.00—Edison Electronics Div., Dept. 27E, Grenier Field, Manchester, NH 03103

CIRCLE 86 ON FREE INFORMATION CARD

TVI FILTERS. Trapper 45 is a compact low-pass TVI filter designed for average situations, eliminates CB-caused TVI on channels 2 and 5. Attenuation is 45 dB at 54 MHz, and 40 dB at 81 MHz. Trapper 100, super strength, low-pass TVI filter is intended for severe interference prob-

lems. Attenuates 100 dB at 54 MHz, and 75 dB at 81 MHz—Channel Master, Div. of Avnet, Inc., Ellenville, NY 12428

CIRCLE 87 ON FREE INFORMATION CARD

SLIDE MOUNT, Universal key-lock unit, model CBLM-520, safe guards CB radios against theft. It is designed for use with all automobile CB transceivers, and mounts easily under the dash-board or on the floor. Both the mount and radio can be easily unlocked and removed when not in use. The unit comes complete with male and
Female coaxial cable connectors, 3-wires, mounting hardware, screws, and key. $14.50—RMS Electronics, Inc., 50 Antin Place, Bronx, NY 10462

CIRCLE 88 ON FREE INFORMATION CARD

CB TRANSEIVER. Bobcat 23, features a ceramic filter, a dual-conversion receiver, an S/RF meter, a front-panel switch to control the public address system, automatic noise limiter with manual override, solid-state circuitry and crystals for all 23 CB channels.

Specifications include a power output of 4 watts, 100% modulation, sensitivity of 0.5-mV for a 10 dB signal-to-noise ratio, frequency tolerance within 0.005% and input voltage of 13.8 VDC positive or negative ground. The unit measures 2.5 x 5/8 x 8 1/4-inches and weighs 3 1/2 lbs.—Pearce Radio Corp., Dept. of Gladding Corp. P.O. Box 50800, Biscayne Annex, Miami, FL 33152.

CIRCLE 89 ON FREE INFORMATION CARD

CB BEAM ANTENNA. The fiberglass Mega-Beam style #704, resists the harshest environmental conditions, provides a low VSWR over the entire bandwidth. The fiberglass elements exceed metal in reducing precipitation static.—The Shakespeare Co.—Antenna Group, 2805 Mt. woodland Ave., Columbia, SC 29250

CIRCLE 90 ON FREE INFORMATION CARD

**THE PROGRAMMABLE CLOCK KIT!** $29.95

**SYSTEM 5000** is the first full-feature timepiece available in programmable form. After the circuit has been assembled and tested, all that is necessary is to add the appropriate switches and jumpers to easily program the system for the desired functions. The system may be expanded or reprogrammed at any time.

This represents a revolutionary concept in adaptability and flexibility. Build an Alarm/Clock/Calendar or a full feature Desk or Radio Station clock. Use the DUPLICATE TIME REGISTER to monitor GMT, another time zone, or as an elapsed timer. Add the optional relay to control AC or DC accessories. The possibilities are limited only by your imagination.

**CIRCUIT 57 ON FREE INFORMATION CARD**

**PROGRAM**

1. Turn on the power switch. The display will show the time.
Don't Get Caught With Your Modules Down

Increase Your Profits By Utilizing Our Module Rebuilding Program

Consider these features!

- **Original Parts.** We use ONLY original parts. Brands we rebuild include Magnavox, Admiral, GE, Montgomery Ward, Quasar, RCA, Zenith and others.
- **Quality.** Only professionally trained technicians will handle your modules. All modules are tested, temperature cycled, retested and reoiled.
- **Protective Packaging.** Rebuilt modules are returned to you in polyethylene skin packaging for protection during shipping and storage.
- **Free Service.** Quick, reliable service is our tradition.
- **One Year Warranty.** One year limited warranty on workmanship and parts.

PTS ELECTRONICS, INC.

P.O. Box 272 Bloomington, IN 47401 812-824-9331

OR, check the white pages for the location of the PTS branch nearest you.

CIRCLE 55 ON FREE INFORMATION CARD

---

Car Starting Problems?

... Won't Start Because of WEAK BATTERY?
... Won't Start Because of COLD WEATHER?
... Won't Start Because of WET WEATHER?

Coil Foil®

AUTOMATIC STARTING BOOSTER

... is the ANSWER to these Problems!

*GIVES YOU "Sure-Fire" STARTS EVERY TIME*

If your Cold or Weak Battery can turn the Engine over just ONCE... COIL/FOIL will START your Car, even under the worst weather conditions, by Automatically providing a STRONG Spark from its OWN Power Source.

*No one in your Family need ever be STRANDED with a Car that WON'T START! No more running the Car Battery DEAD trying to start the Car! COIL/FOIL uses its own Power (2-Dry Cell Batteries, not included) ONLY in Starting and Batteries usually last a year.

**TESTED and APPROVED** by Leading Automotive Magazines and Authorities!
- Comes with FACTORY WARRANTY
- Easy-to-install (only 4-Wires & 2-Relays) Fits ALL Vehicles with Battery/Coil Systems
- COIL/FOIL Prolongs Car Battery Life and reduces wear and tear on Starter-Motor and Ring-Gear

ADVANCED ELECTRONICS, N.V.

P.O. Box 1579--RA, 2, Washington, D.C. 20013

Please Rush COIL/FOIL Units to:

NAME ____________________________

ADDRESS ____________________________

CITY STATE ZIP ____________________________

MAKE/YEAR of Vehicle __________

Add $2 for Postage, Insurance & Handling. Canadian & Foreign Add $3.

Enclosed: [ ] Check. [ ] M.O. in amount $ ________

30-Day "NO-RISK" TRIAL... SATISFACTION GUARANTEED or Return Unit in 30 Days for Full Return.

SPECIAL Introductory Offer

ONLY $19.95

---

CIRCLE 17 ON FREE INFORMATION CARD

---

ANTENNA TUNER, Model "Back Talk" is said to tune up to four antennas and provide up to four times the talk power. Eliminates transceiver damage caused by excess power feedback, shorts or mismatched antennas. The tuner tunes the antennas, not the coax. Thus, coax signal radiation is eliminated. The antenna is easily installed and recommended for multi-antenna installations. Trucks, mobile homes, base stations. Measures 2 1/4" x 4 3/4" x 3 1/4" inches, weighs 12 ounces and comes with two PL-258 plugs, 9-inch coax and one PL-259 connector. Suggested retail $49.95--Norcom Electronics Inc., P.O. Box 332, Northfield, OH 44067

CIRCLE 94 ON FREE INFORMATION CARD

PREAMPLIFIER, Model PT-2 is a versatile, base station receiving preamplifier that tunes all ham and CB frequencies from 1.8 MHz through 54 MHz. It is meant to be used with a transceiver and provides full station control. Improves reception of weak signals by boosting sensitivity and signal-to-noise ratio while receiving.

Bypasses itself automatically, when the transceiver is transmitting. FET amplifier gives superior cross-modulation protection. Provides master power control for station equipment. $69.95--Ameco Equipment Co., 275 Hillsdale Ave., Williston Park, NY 11596

CIRCLE 95 ON FREE INFORMATION CARD

---

CIRCLE 100 ON FREE INFORMATION CARD

---
FREE HEATHKIT CATALOG!

The world's largest selection of superior quality electronic products in money-saving easy-to-build kit form.

YOU CAN BUILD some of the finest electronic products available today...and get great satisfaction doing it.

Please rush me my FREE copy of the new Heathkit Catalog
I am not on your mailing list.

Name
Address
City
State
Dept.
Zip
Radio Electronics

I'd like to do a favor for a friend—send another catalog to:

Name
Address
City
State
Dept.
Zip

Heath Company, Benton Harbor, Michigan 49022

FREE HEATHKIT CATALOG
Featuring nearly 400 top quality, easy-to-build electronic kits. Stereo hi-fi, color TV, automotive and marine accessories, security systems, short-wave radio and more. PLUS special buys on fully assembled, famous-brand CB radios!

INSTRUMENTS
R/C MODELING
AUTOMOTIVE
COLOR TELEVISION
WEATHER
STEREO HI-FI
AMATEUR RADIO
Send for the largest catalog of electronic kits available today.

Discover for yourself the enjoyment that can be experienced when you build one of our many quality kits—all are easy to build with our famous step-by-step assembly manuals.

Kitbuilding is a rewarding pastime that is both creative and satisfying. We have nearly 400 kits for you to choose from in our new FREE catalog.

**Stereo Hi-Fi.** 2 and 4 channel components, digital and analog tuners, speaker systems, everything for the casual listener or the serious audiophile.

**Color TV.** From small cart-size portables to a futuristic "computerized" console model with a programmable memory.

**Amateur and Shortwave Radio.** From Code Practice Oscillators to a Digital Broadbanded SSB Transceiver... everything for beginner or Pro!

**Digital Clocks and Weather Instruments.** Fun to build kits tell you what's going on...by the numbers!

**Radio Control Gear.** 3, 4, 5 and 8-channel systems, all with instant plug-in frequency change.

**Auto Test Equipment.** Keep your car in top shape all year 'round.

**Outdoor Fun Kits.** Programmable digital stopwatch. Deluxe metal locator/treasure finder.

**Test Equipment.** Scopes, VTVM's, DMM's, Counters, Generators and Power Supplies for all your test and service needs.

**WE WON'T LET YOU FAIL**
The world famous Heathkit assembly manual (included with every kit) makes kit assembly easy regardless of whether you're building a color TV or a tabletop lamp dimmer. And technical help, if you need it, is just a phone call away.

Send For Your Copy Today!

HEATH COMPANY
BENTON HARBOR, MI 49022
WE DON'T PROMISE. WE DELIVER.

AS A DEALER, YOU PROBABLY KNOW THAT MOST DISTRIBUTORS CLAIM TO BE "THE BEST". AND YOU'RE PROBABLY GETTING A LITTLE TIRED OF PROMISES THAT REMAIN JUST THAT, PROMISES.

AT BENNIES WE'VE BUILT A NATIONAL REPUTATION AS A DISTRIBUTOR YOU CAN COUNT ON. AND WE'VE DONE IT WITH HARD WORK. NOT WITH PROMISES.

WE DELIVER WITH FAST, COURTEOUS SERVICE, A MULTI-MILLION DOLLAR INVENTORY OF THE CB INDUSTRIES TOP BRAND PRODUCTS, AND WEEKLY PROFIT BUILDING SPECIALS YOU HAVE TO SEE TO BELIEVE.

JUST SEND $5.00 (DEDUCTIBLE FROM YOUR FIRST ORDER IF MADE WITHIN 90 DAYS) AND YOUR TAX NUMBER FOR OUR GIANT NEW 248 PAGE CATALOG, AND LET US GO TO WORK FOR YOU. SORRY, CATALOG OFFER IS AVAILABLE TO DEALERS ONLY.

FOR THE COMPLETE LINE OF PACE
40 CHANNEL CITIZENS BAND RADIOS CONTACT
Serving Quality Conscious Dealers and Distributors Coast to Coast

BENNIES
WAREHOUSE DISTRIBUTION CENTER
R.D.1 BERWICK, PA. 18603  717-759-2201
series for higher voltage, or in parallel for a higher current rating. So, for the 20-volt supplies, you could have a +40-volt supply at 500 mA, a 20 volt supply at 1.0 amp or, by connecting in series and using the center tap as common, a +20 volt supply for CMOS and similar equipment. Voltage and current can be read in each "channel" with the selector switch for the meter.

All three supplies are current-limited at a point slightly above the maximum rated output. For protection against accidental shorts in the load.

A novel circuit is used with the two 20 volt supplies that allows the two supplies to operate either independently or to track each other. A selector switch is used for this purpose. In the independent position, the controls can be used to adjust the A or B supplies to any voltage between 0 and 20 volts. There is no interaction—each one is isolated from the other. If you want to make one supply "track" the other at a preset difference, move the switch to the tracking position. The control for the B supply is a dual concentric-type with a small red inner knob. To get a preset difference, say the B supply 5 volts greater than the A supply, set the switch to tracking and move the meter switch to read the voltage of A. Set the red knob to make this read say 10 volts. You must hold the black outer knob to do this; this is intentional. Now move the meter switch to read the voltage of the B supply and adjust the black control knob for the B supply to make the volt read 15 volts. From this point on, both voltages will increase or decrease in step; the tracking error is claimed to be only 1%.

In the tracking position, the A control is disconnected; the red inner knob of the dual control sets A voltage. In the independent position, the red knob is disconnected and only the A control adjusts the A voltage. This is not as convenient as it sounds; in operation it's very easy.

The JP-2718 is available in kit form, with the customary excellently-detailed Heathkit construction manual that tells you in detail just what to put where. It can also be purchased in fully assembled and tested form. For the serious experimenter, the versatility of this power supply will make things a lot easier. It has all of the necessary protective circuits to save the day in case of problems. It's easy to use: the terminals will accept banana plugs, terminal lugs or even old fashioned pieces of bare wire in emergencies. A very handy little instrument, that occupies only a little space on the bench.

**EQUIPMENT REPORTS continued from page 87**

---

**ALLISON XR-700**

with the Exclusive…Solid-State Voltage Regulator.

The ONLY Ignition System that has COMPLETELY overcome the Problems that have baffled the Auto Industry for Years!

**MODERNIZE and Bring Your Car "UP-TO-DATE" with the MOST EFFICIENT Ignition ever invented!**

End "Tune-Up" Problems FOREVER caused by Points and Condenser...

**THAT'S EVERYTHING…INCLUDING No CIRCLE that the 911 DISTRIBUTOR...**

**ALLISON Rated #1 by Official Testing Laboratory at the BEST Fuel Saving Ignition System of ALL the Different Ignition Systems Tested!**

**The "XR-700" is a COMPLETELY NEW Ignition System employing the Most Advanced Technology, that replaces the inefficient Points and Condenser with an infrared Light Beam to Trigger the Latest type of Solid-State Power Components.**

Once installed... "XR-700" has NO moving Parts to wear out or break, It works in any rain, No Friction to wear, No affected by Dirt, Oil, Moisture, Vibration or extreme Engine Temperatures! RUGGED and RELIABLE **The "XR-700" is engineered to OUTLAST YOUR CAR!**

**The "XR-700" produces the MAXIMUM "High Energy" Long Duration Spark… from your present car's Ignition Coil.**

This permits the Positive Firing of Spark plugs, even under the most Adverse conditions. Also, Eliminates "Engine Misfire," resulting in more COMPLETE COMBUSTION, thus you get IMPROVED Fuel Mileage, a HIGH PERFORMANCE Level. keeps Plugs from Fouling and gives LONGER Plug Life!

Customers Report:

**"IT MORE THAN PAYS FOR ITSELF!"**

**INCREASES Gas Mileage up to 30%!**

**Saves Money on Costly "Tune-Ups"**

**Gives D-I-Y Performance!**

**QUICKER Starting in Any Weather!**

**Smother Running… Faster Acceleration!**

**Plugs Last Up to 4-Times LONGER!**

**Reliability PROVEN in Millions of Customer Miles to be exceptionally GUARANTEED, that every "XR-700" has a LIFETIME WARRANTY! FREE Repair or Replacement for as long as you own the unit!**

Even if you CHANGE Cars, Allison will supply you the necessary PARTS to fit any Point-Type Distributor. …FREE! (Include $2 for Postage & Handling)

**FITS ALL CARS. Domestic & Foreign. 4, 6, or 8 Cylinder.**

**DO-IT-YOURSELF…EASY INSTALLATION!**


**Thousands sold at $59.95**

**NOW! Allison's Production Technology offers you the same Premium Quality XR-700 at this SPECIAL LOW Price…39.95**

**ORDER WITH CONFIDENCE** install the "XR-700", and prove to your own SATISFACTION that it is after all, a reward or return in 30 days for a FULL Refund at the Purchase Price.

**SAVE ORDER DIRECT FACTORY DIRECT** Send Checks, Money Orders, No. Cylinders.

**MASTER CHARGE at BANKAMERICARD Card Holders** ORDER by TOLL FREE PHONE: (609) 423-8032, Ext. 2 or Send us in (1) Your Number, (2) In Bank No., (3) Exp. Date.

**SEND FOR FREE BROCHURE AND Comparison Sheet.**

**"CB" USERS: The "XR-700" completely ELIMINATES the Major Cause of Electrical Ignition Noise. Interference.**

If you have already installed a "Capacitive Discharge" Ignition **Convert your "C.D." Unit to BREAKERLESS!** INCREASE its EFFICIENCY with "XR-700"... only $29.95

**America's Oldest and Largest Manufacturer of Opto-Electronic Ignition Systems.**

ALLISON AUTOMOTIVE CO.
1287 - Ra. East Enda Pl., COVINA, CAL. 91722

---

**CIRCLE 82 ON FREE INFORMATION CARD**

**P urpose:** A portable unit that will quickly check out practically all types of cables and plugs used in audio work. The unit is very compact, and battery-powered so that it can be used anywhere.

The QC-1002 will check any kind of audio cable with up to 5 conductors plus a shield, for opens, shorts or even mis-wiring. The panel of the Q-Chek has eleven sets of jacks, divided into two sections and coded for fast identification. These are all numbered in pairs. The connectors range all the way from the miniature phone jacks up to the 5-pin DIN plugs used on many tape recorders, etc.

Testing is pretty simple; even I can do it. You plug one end of the cable into a matching jack in the PL-1 section on the left, and the other end into the matching jack on the OR-1 section. There are six pushbuttons across the bottom of the panel. All you do is push one button for each conductor in the cable. Start with the one marked red; this checks the shield for continuity. If it's good, the pushbutton lights up. If cable one has three conductors, depress the pushbuttons marked 1, 2 and 3. If they all light, the cable is good.

For finding an intermittent connection, just hold the pushbutton down and bend the cable back and forth. If the light blinks, you've found it. If you have a job that calls for making up a number of multi-conductor cables, testing them is a breeze. It will catch any mis-wired plugs. If you push button 2 and button 2 lights up, something is wrong. If pushing 2 makes both 2 and 3 light, you have a short between these two leads of a jumper in the plug, which they warn you about in the instructions.

If you run into a cable with a plug not included on the panel, the company has adapters available that will convert them to types which can be tested. If the cable has a male plug on one end and a female on the other, conversion adapters for this are also on hand. The Switchcraft catalogue No. A-4043 lists a great many of these adapters. In the lid of the Q-Chek's case, spring clips are provided for holding up to 18 adapters.

If you do audio work, this unit can save a great deal of time and trouble. In specialized work such as language labs, that are now showing up in high schools as well as colleges, you may have to check a great number of cables. This unit will do it. The model QC-1002 comes complete with carrying case, instructions, 9-volt battery and seven separate audio adapters; and is priced at $160.00.

---

**Switchcraft Q-Chek QC-1002 Cable Tester**

**P urpose:** The Switchcraft Company has long been known for their comprehensive line of plugs, jacks, switches and many more useful things. Now they have brought out a very handy piece of specialized test equipment. This is the Q-Chek model QC-1002 audio cable tester. (One suspects that this is a refinement of a production-line quality control test unit! It would be admirably suited for this.) It's a
Electronic-communications contributors honored

The Radio Club of America, at its annual meeting and banquet in New York City last November, awarded its Armstrong Medal to Captain Wm. G.H. Finch, USN, retired, "for significant contributions to radio art and science." Captain Finch is the holder of more than 180 patents on facsimile, teletyping and kindred subjects.

The Club's Sarnoff Citation, "for important contributions in electronic communications," was awarded to Fred Link, pioneer in mobile two-way radio communication and founder of Link Radio. A special Pioneer Award was presented to Harold Beverage for his early developments of the Beverage antenna and diversity reception; and Morgan McMahon, publisher of the Vintage Radio books, received the Ralph Batchler Memorial Award for his and his wife's work in preserving the history of radio.

Twenty-five members were elevated to the grade of Fellow in the Club. These included such well known figures as Lewis A. Bonden, founder and president of Prodelin, Inc.; Thomas A. Campobasso, vice president of the international sales division, Collins Radio; Francis T. Cassidy, Jr., general manager of ITT domestic communications operations; Richard E. Horner, president of E.F. Johnson Co.; Samuel McConoughy, chief of the mobile services division, FCC; R.D. Mignault, president of Pye Electronics, Canada; Charles E. Summers, manager, IBM private radio services; and William J. Weisz, president, Motorola, Inc.

The Radio Club of America, the world's oldest radio communications society, was founded in 1909, and has about 670 active members.

National Service Managers elect O'Shanna president

Robert J. O'Shanna, director of service of the Alemite Instrument Div., Stewart-Warner Corp., was elected president of the National Association of Service Managers at their annual conference last October. Mr. O'Shanna has held several offices in the Association, and as a member of the Education Committee, has been instrumental in having service management seminars set up at the University of Wisconsin and at Syracuse University in New York.

Edwin L. Penar, national service manager of Dole Refrigerating Co., Lewisburg, TN, was elected vice president. James Britton, service manager, Hartford Div., Stanadney, Inc., of Hartford, CN, was named second vice president. Charles K. Lins, director of area service for Bell and Howell in Dallas, was named secretary, and William P. Zabler, Sears, Roebuck national service manager, was named treasurer.

Five-year warranty for new Sylvania picture tubes

GTE-Sylvania Color Bright 85 picture tubes are now being sold with a five-year limited warranty. Sylvania is said to be the first manufacturer to offer a limited warranty of this extent on any grade of TV tube.
channel of audio power at approximately 0.1% total harmonic distortion while remaining comfortably cool to the touch. Figure 10 illustrates the output stage dissipation of the PWM amplifier.

These are but a few of the innovative product ideas and circuit developments that I saw on opposite sides of the world and they suggest that the state of the audio art is hardly dormant. At that, we have only been able to skim the surface of the technology involved in each of these devices or products. As each reaches commercial reality in the marketplace, we hope to explore them in greater depth—either by devoting a full article to each, or by testing and reporting upon the resulting products themselves in future test reports.
GET RID OF RFI
continued from page 46

manufacturers and are available from most electronic supply houses, especially those dealing in industrial electronic components. Because physical size is important, miniature or subminiature coils should be used. Capacitors should be disc ceramic types, of the HiK or TC type, and their size must be small, too.

Some final suggestions

If interference is known to originate from CB equipment, it might be a good idea to borrow a CB rig (unless you already own one) and operate it near the audio equipment while trying to cure the problem. By so doing, you won't have to wait for the interfering signal to come "on the air" to ascertain whether your attempts at a cure have been successful. If you are successful, record what parts you added to your equipment by adding them to the schematic diagram of your hi-fi component.

Remember, it is not always possible to cure RFI problems completely. In many cases only a reduction of interference may be possible, despite your best efforts, but reducing the problem is better than no solution at all. We know of at least one case in which just about all of the solutions we have outlined were attempted with no success. The listener was located directly across the street from a local FM transmitter tower. This frustrated audiophile had just about given up, and loved his hi-fi music enough to move to another location. Having disassembled his hi-fi in preparation for the move, he had stored all the components in his bedroom, which faced another exposure, away from the transmitter tower. Before packing the gear in shipping cartons, he decided to hook the units up for one last listen and, you guessed, the RFI was gone!  

In any hi-fi system, the one component most likely to wear out is the phono cartridge. Or more specifically, the phono stylus.

While you're relaxing to your favorite music, the stylus is riding miles of groove, withstanding accelerations that would black out an astronaut.

Which is why the Shibata stylus, used on the top models of Audio-Technica cartridges, is so important. Its shape reduces tracking pressure at any given tracking force. Even with a setting as high as 2 grams it will outlast an elliptical stylus tracking at a fraction of a gram. Which means the good sound of Audio-Technica lasts longer. And so do your records.

Audio-Technica with a Shibata stylus: lower cost per record/mile and better sound in the bargain!

When you shop for better sound ask about good mileage!

AUDIO-TECHNICA U.S., INC., Dept. 37E, 33 Shiwasee Ave., Fairlawn, Ohio 44313
Available in Canada from Superior Electronics, Inc.

Use Quick-Wedge to install a bus, connect a motor, mount a p.c. board, cinch up a connector

They do all that ordinary screwdrivers do, PLUS they hold and start the screw

QUICK-WEDGE - 17 sizes
Screw-holding screwdrivers
Unconditionally guaranteed.
BUY A SET TODAY
See your dealer or write to:
Kedman Company, P.O. Box 25667,
Salt Lake City, Utah 84125

“My father built this Schober Organ for me!”

You'd be proud to buy her an organ this good - but how would you feel if you'd also built it? It's a special kind of satisfaction. The gift of a lifetime of magnificent music, crafted with your own hands!

And you can do it! You need no prior electronic or mechanical abilities. Just the capacity to follow instructions. Every step is clearly detailed. Every component is supplied. You'll find the assembly process as enjoyable as the music which follows!

And what music? For this is a truly fine instrument you will build. For superior to most 'ready-made' organs, easily comparable to others at twice the price. Kit costs range from $650 to $2650 for all basic components, and you can purchase it in sections to spread costs out...or have two-year time payments.

Just send the coupon for the fascinating Schober color catalog (or enclose $1 for a record that lets you hear as well as see the quality of Schober).

The Schober Organ Corp., Dept. RE-180
43 West 61st Street, New York, N.Y. 10023

D Please send me Schober Organ Catalog.
D Enclosed please find $1 for 12-inch LP record of Schober Organ music.

NAME
ADDRESS
CITY STATE ZIP

CIRCLE 80 ON FREE INFORMATION CARD

MARCH 1977

CIRCLE 32 ON FREE INFORMATION CARD

"Now that you've built your TV Typewriter, your minicomputer, your digital clock, and your CB transmitter, do you think you're ready to tackle a broken toaster?"
Nothing is Faster and Easier than ACE for circuit breadboarding.

Used to be you'd get a circuit idea, lay out a pc board, print it, solder everything together, troubleshoot, change your layout, try a new board, and spend absolutely too much time breadboarding. Now A P ACE All Circuit Evaluators let you breadboard in a fraction of the time. Make your changes immediately. Keep full leads on your components. Avoid the heat damage possible with repeated soldering and desoldering. And have a pattern for your board—if you need a board—sitting in front of you. In about as long as it takes to sketch a schematic. Get cooking with ACE. ACE. The All Circuit Evaluator from A P Products.

<table>
<thead>
<tr>
<th>Part No</th>
<th>Model No</th>
<th>Tie Points</th>
<th>DIP Points</th>
<th>No. Buses</th>
<th>No. Posts</th>
<th>Board Size (inches)</th>
<th>Price Each</th>
</tr>
</thead>
<tbody>
<tr>
<td>923333</td>
<td>200-K (bl)</td>
<td>228</td>
<td>9 (15's)</td>
<td>2</td>
<td>2</td>
<td>4-3/16x 1/2</td>
<td>$18.95</td>
</tr>
<tr>
<td>923132</td>
<td>200-K (bl)</td>
<td>208</td>
<td>8 (16's)</td>
<td>2</td>
<td>2</td>
<td>4-9/16x 5/16</td>
<td>28.95</td>
</tr>
<tr>
<td>923331</td>
<td>201-K (bl)</td>
<td>2012</td>
<td>12 (14's)</td>
<td>2</td>
<td>2</td>
<td>4-9/16x 5/16</td>
<td>28.95</td>
</tr>
<tr>
<td>923331</td>
<td>201-K (bl)</td>
<td>212</td>
<td>12 (14's)</td>
<td>2</td>
<td>2</td>
<td>4-9/16x 5/16</td>
<td>28.95</td>
</tr>
<tr>
<td>923122</td>
<td>200-K (bl)</td>
<td>210</td>
<td>12 (14's)</td>
<td>2</td>
<td>2</td>
<td>4-9/16x 5/16</td>
<td>28.95</td>
</tr>
<tr>
<td>923122</td>
<td>200-K (bl)</td>
<td>227</td>
<td>27 (14's)</td>
<td>29</td>
<td>4</td>
<td>8-9/16x 7/8</td>
<td>79.95</td>
</tr>
<tr>
<td>922324</td>
<td>236</td>
<td>3648</td>
<td>35 (14's)</td>
<td>36</td>
<td>4</td>
<td>10-1/4x 9/16</td>
<td>79.95</td>
</tr>
</tbody>
</table>

Order from your A P distributor today. Our distributor list is growing daily. For the name of the distributor nearest you call Toll-Free 800-321-9666.

Send for our complete A P catalog. The Faster and Easier Book.

A P PRODUCTS INCORPORATED
Box 110-R Painesville, OH 44077 (216) 354-2101 TWX: 810-425-2250

FREE!

NEW CATALOG OF HARD-TO-FIND PRECISION TOOLS

Jensen's new 128-page catalog is jam-packed with more than 2800 quality items. Your single source for hard-to-find precision tools used by electronic technicians, scientists, engineers, instrument mechanics, schools, laborato-
tories and government agencies. This wanted catalog also contains Jensen's world-famous line of more than 40 tool kits. Plus 10 pages of useful "Tool Tips" to aid in tool selection. Send for your free copy today!

JENSEN TOOLS AND ALLOYS
4117 W. 44th Street, Phoenix, Arizona 85018

CIRCLE 12 ON FREE INFORMATION CARD

FREE!

Over 24 years of service to the world's finest craftsmen and technicians.

A carefully selected and tested assortment of unique, hard-to-find tools, clever gadgets, precision instruments, bargain kits. One-stop shopping for the technician, craftsman, hobbyist, lab specialist, production supervisor. Many tools and measuring instruments available nowhere else. One of the most unusual and complete tool catalogs anywhere. Get your copy of the NC FLASHER today.

National Camera
2000 West Union Ave., Dept.GBA
Englewood, Colorado 80110
(303) 789-1091

CIRCLE 2 ON FREE INFORMATION CARD

ACTION FOOTBALL
continued from page 68

to reach, or go beyond, the goal line. The same holds true for a field goal attempt. If a field goal fails short, the ball is taken by the opposing player at his 20-yard line. If either a field goal or a punt is blocked, the opposing player takes possession at the line of scrimmage.

If the ball is fumbled, the play selector is moved to FUMBLE on the chart and the buttons are activated to see if the offensive team retains possession or not. If the result is NOT, the opposing player takes over at the line of scrimmage. If it is KEEP, the offensive player loses the down but continues to play.

A pass can be complete with the yardage indicated, incomplete with no yardage or intercepted. If it is intercepted, the ball is first advanced to the point of interception according to the yardage shown in the chart. Then, the play selector is moved to INT RUNBACK and the buttons are actuated to determine how many yards the opposing player runs back the interception. If the intercepting player fumbles the runback, the fumble play is used to tell whether he keeps possession at the point of interception, or loses the ball. If there is pass interference, the offensive team gets a first down at the point of interference, which is indicated by the yardage shown on the chart.

As in actual football scoring, touchdowns count six points, field goals three and extra points one. Conversion attempts are determined by using the extra-point play to see if the kick is good or no good. You can, of course, vary the rules as you wish. You might decide, for instance, to permit two-point conversions.

Quarters can be determined by setting a kitchen timer to an agreed-on period or by limiting each player to a certain number of plays, say 16 or 20. In this case, only actual plays from scrimmage count. Kickoffs, kick returns, interception runbacks and conversion attempts are not included. At the start of the second half, the player who kicked off at the beginning of the game now receives the ball.

R-E

Your contribution helps make tomorrow better than today for the handicapped.

Give to

Easter Seals
for crippled children and adults

Easter Seals
DIGITAL CLOCKS
continued from page 57

seconds. When this switch is closed, the FAST switch becomes
zero seconds AND hold and the SLOW switch becomes hold
count. If all three of these switches are closed at the same
time, the display changes to 12:00 AM. This peculiar
"programming" allows you to make any of these modules into
a 24-hour "stopclock" that will count and display by the
second, and can even be controlled and reset remotely! To do
this, use toggle or slide switches instead of pushbutton
switches. Hint: Small toggle switches will mount in the same
¼-inch diameter hole as miniature pushbutton switches.

The ALARM display switch is also used as the SNOOZE switch.
When this switch is closed, the alarm time is displayed, and is
advanced by the fast AND slow switches to the desired time.
(Be careful that you don’t overlook AM or PM designation, or
your alarm will be 12 hours off!) With the ALARM ON switch
closed, when the real time matches the alarm-set time, the
alarm will sound. By pressing the ALARM display/SNOOZE
switch, the alarm will stop for 9 minutes, then go on again.
This can be repeated for up to one hour from the original
alarm time. Of course, the alarm OFF switch disables the
alarm at any time. If this switch is turned off when the alarm
sounds, and then turned right back on again, the alarm will
automatically go on again in 24 hours! In other words, you
can set the alarm for the next day when you get up, instead of
before going to sleep . . . when you might forget.

Although all these modules are able to turn a radio on and
off automatically, this requires a SLEEP SPINNER display switch
(shown in the wiring diagram, and included in the kit offered
in the parts list), a MODE selector switch, and, in the case of the
National modules, external driving circuitry. Also, because of
the power requirements, this could mean a different power
transformer, and you would need specific information on the
radio circuit requirements. Therefore, these applications are
not covered in this article. Although each of these modules is a
versatile “brain” about which a lot more could be written, the
main features and uses are covered. If you want more specific
information, contact National Semiconductor Corp. (2900
Semiconductor Drive, Santa Clara, CA 95051), Fairchild
Semiconductor Consumer Products Group (4001 Miranda
Ave., Palo Alto, CA 94304) or Interfah Corp. (See parts
list).

THE UNFINISHED JOB
I asked you for some ideas on why I had several odd
symptoms in an RCA CTC-38. You said “Check the electrolytic
filter capacitors for any sign of signal.” I did, and found that it
was the one you said, on the +140 volt line! However, the filter
capacitor itself wasn’t bad. It had been replaced but whoever did
it just forgot to solder the lugs of the can to the chassis! Fixing
this up stopped all the trouble. Thanks very much.—H.Y.,
Martinez, CA.

The moral of this is “Don’t stop working on the job until
you’re through!”

HALF A PICTURE MISSING!
I’ve got a real screwball in this Zenith 18EC45. The top half
of the picture is perfect; no compression, no stretch. The whole
bottom half is gone. It’s just black! What the heck is this?—J.G.,
Crystal Springs, AR.

Real simple after you find out what it is! This set has an
OTL (Output Transformer Less) two-transistor vertical output
stage with dual-polarity DC power supply. (Just like the OTL,
circuits you find in transistor stereo amps, and so on.) So,
there are two output transistors. Each one scans one half of
the screen. If one should open or develop a bad contact in the
socket, this is the reaction you’ll see. If you lost the bottom
half, go and check Q708. This is the transistor in the middle of
the heat sink. That’s it.
FOR FAST TROUBLE-SHOOTING . . . .

"FERRET"

TV MINI-ANALYZER

$99.95
SG-785

- VHF/UHF Subber
- I.F. - Video Trouble Shooter
- Convergence Generator
- Dots and Cross-Hatch Patterns

The "FERRET" is a multi-functional instrument for fast, efficient trouble-shooting and adjustment of all Color and B&W tvs. It is ideal for both shop and field work. (Cables included.)

Telematic
2849 Fulton St., Brooklyn, N.Y. 11207

Please send more information. R3

NAME __________________________
ADDRESS _______________________
CITY ____________________________
STATE ________ ZIP ___________

SOLD THROUGH DISTRIBUTORS ONLY
CIRCLE 52 ON FREE INFORMATION CARD

DISTORTION
The right channel sounds awful in this Truetone 4DC6325. Left channel OK. The scope shows a funny waveform in the right channel with a sinewave on the input. (See diagram.) I pulled both transistors in that channel, checked them out of circuit and they were good! Help—MDO, Ink., AR.

The output stages in this amplifier use small thermistors in the bias networks. It’s very likely that one of these has been shorted out by a solder bridge! This has happened to me. Check the resistance across the terminals of each; should be a about 22 ohms. The waveform you drew shows a very bad case of crossover distortion and bad transistors are one cause of this; so, your test was correct.

VERTICAL RETRACE
I wrote you some time ago about a vertical retrace problem in a Sears TV set. I checked everything you suggested. Still had ’em. Finally, in desperation, I moved the vertical centering control. This raised the raster so that the retrace was hidden! I figured that I’d lose too much of the picture, so I ran the setup adjustment on the vertical size, linearity, and shape controls. Much to my surprise, I found that I had a perfect raster—full, linear, and no retrace lines!

Do you think that the set came from the factory this way, or was it one of the Sears service technicians who had previously worked on it?—R.K., Middleburg Heights, OH.

Well, you’ve got one of two choices. Take your pick! R-E

Why use the ATC-10 General Television Servicer?

Because for an investment of $299.95, the ATC-10 provides most of the combined features of a conventional color bar pattern generator, an Analyst and a substitute tuner. You get time savings, bonus features too, like the RED RASTER, 3.58 MONITOR, GRAY QUAD, and multi-purpose HATCHDOTS patterns.

Al Flynn, proprietor of Al Flynn Radio TV Repair Service, Inglewood, California says . . .

"Versatility makes the ATC-10 generator a money maker. The ATC-10 is what TV repairmen have needed for ten years."

Write for more information on the ATC-10 General Television Servicer, or try it at our risk — 30 day shop trial — if not 100% satisfied in every way, return for instant refund in full.

American Technology Corporation
225 Main Street, Dept. 3C, Canon City, CO 81212

For your convenience, we accept Master Charge, BankAmericard and COD phone orders.
Same day shipment! (303) 275-8991, Ext. 3

CIRCLE 59 ON FREE INFORMATION CARD

GO DIGITAL,
GO DANAMETER®
(The New VOM For Today’s Needs.)

- 0.25% Accuracy
- Full Overload Protection
- Really Drop-Proof
- Full One Year Battery Life

Dana Laboratories, Inc.
2401 Campus Dr, Irvine, CA 92715, (714) 833-1234
CIRCLE 63 ON FREE INFORMATION CARD

PATENTS PENDING COVERING 13 UNIQUE FEATURES

CIRCLE 62 ON FREE INFORMATION CARD
AM stereo soon? The FCC could act to establish an AM stereo radio service as soon as the end of this year, in the opinion of Washington observers. An industry-wide National AM Stereo Radio Committee (NASRC) has studied a number of proposed systems and was scheduled to start field-testing them over radio stations in February.

**Game problems:** The hottest new electronic product since CB may be running into an unexpected problem: Are video games injurious to television sets? The first rumbles were heard from television dealers who found that after leaving games on the screen all day for many days, the outlines of the game perimeters were "burned" into the picture tube screen. They reported these problems to the set manufacturers, who immediately began to envision thousands of picture-tube warranty replacements due to the use of games, and got their engineers and lawyers working to figure out what to do about it.

The Federal Trade Commission got wind of the potential problem and quietly started an investigation, questioning TV set, game, and picture tube manufacturers. The investigation has been inconclusive so far, but the Canadian government's Consumer and Corporate Affairs Department issued a public warning that "prolonged use of the games may cause the game pattern to remain as a ghost during regular TV viewing," explaining that this was the result of "phosphor exhaustion" caused by fixed lines on the screen. An American catalog house, Service Merchandise Corporation, is sending its game customers a letter telling them that the extent of the problem isn't known, but suggesting that games be turned off when play is completed and that normal viewing habits be maintained, to give the set a "rest."

Sounds like a regular epidemic of trouble—except that so far as we can determine there have been no complaints from consumers. The Electronic Industries Association (EIA), which is conducting its own investigation, has heard of none. The Council of Better Business Bureaus says it is aware of the potential for trouble but hasn't received any complaints, and game and TV makers say they've heard only scattered complaints, but these were from stores which leave the games on for protracted periods, and not from consumers.

*(Radio-Electronics* is interested in this problem too. If you have had some personal experience with any instance of a TV game display damaging a picture tube, tell us about it. Send us full details, including manufacturer, model number, screen size, hours of use per day and room lighting. Send your data to Radio-Electronics Magazine, TV Games Data, 200 Park Avenue South, New York, NY 10003. Letters can not be acknowledged. We will publish the collected data in a future issue.—Editor)

The biggest worry, of course, is that the big game sales started just last year and there hasn't been enough experience yet to determine the long-term effects, if any. Television set makers, increasingly nervous about thousands of potential claims, are preparing to put disclaimers in their warranties to indicate that the terms cover only the use of the sets to view programs. Until the problem is better defined, there's a simple precaution which probably will prevent any potential damage: Turn down the brightness and contrast.

**LOOKING AHEAD**

*continued from page 4*

**Put Professional Knowledge and a COLLEGE DEGREE**

*in your Electronics Career through HOME STUDY*

**Earn Your DEGREE**

by correspondence, while continuing your present job. No commuting to class. Study at your own pace. Learn from complete and explicit lesson materials, with additional assistance from our home study instructors. Advance as fast as you wish, but take all the time you need to master each topic. Profit from, and enjoy, the advantages of independent study.

The Grantham correspondence degree program in electronics is comprehensive. It begins with basics, written in very simple language, and continues through the B.S.E.E. degree level. Throughout the entire program, heavy emphasis is placed on clear explanations written in great detail, progressing from the simple to the complex, in easy steps.

Our free bulletin gives complete details on the curriculum, the degrees awarded, the requirements for each degree, and how to enroll.

**GRANTHAM SCHOOL OF ENGINEERING**

2000 Stoner Ave., Los Angeles CA 90025

- Telephone (213) 477-1901 -

Worldwide Career Training thru Home Study

Mail the coupon below for free bulletin.

**Grantham School of Engineering**

2000 Stoner Ave., Los Angeles, CA 90025

I have been in electronics for ___________ years. Please mail me your free bulletin which gives details concerning your electronics degree programs.

Name ______________________ Age ________

Address ___________________

City __________________ State ______ Zip ______

CIRCLE 13 ON FREE INFORMATION CARD

MARCH 1977

101
CIRCLE B ON FREE INFORMATION CARD

mountain west alarm
4215 n. 16th st.
phoenix, az. 85016
(602) 263-8831

CIRCLE 25 ON FREE INFORMATION CARD

Clever Kleps

Test probes designed by your needs — Push to seize, push to release (all Kleps spring loaded).

Kleps 10. Boathook clamp grips wires, lugs, terminals. $1.39

Kleps 20. Same, but 7" long. $1.49

Kleps 30. Completely flexible. Forked-tongue gripper. Accepts banana plug or bare lead. $1.79

Kleps 40. Completely flexible. 3-segment automatic collet firmly grips wire ends, PC-board terminals, connector pins. $2.59

Kleps 1. Economy Kleps for light line work (not lab quality). Meshing claws, 4½" long. $.89


All in red or black, specify. (Add 50¢ postage and handling). Write for complete catalog of test probes, plugs, sockets, connectors, earphones, headphones, miniature components.

Available through your local distributor, or write to:

RYE INDUSTRIES INC.
129 Spencer Place, Mamaroneck, N.Y. 10543
In Canada: Rye Industries (Canada) Ltd.

new books


Good Buddies and would be Good Buddies alike will find this up-to-now look at the hottest hobby in America intriguing. It contains valuable information for both longtime CB'r's and those with newly acquired ears. The author begins with a brief history of CB radio explaining how the Arab oil boycott and the double-nickels speed limit precipitated the CB mania. Once used only by a handful of businessmen and backroad coyote hunters, CB radios today are the truckers' best friend and a handy tool for thousands of motorists.

The book covers the ABC's of CB as well as the more technical aspects. The author explains AM and SSB operations, gives advice on operating etiquette, provides details of proper antenna mounts and the variety of useful tips. He also tells how to operate a unit from a home base, even in an apartment. Of particular interest will be the glossary of CB terms in the back of the book. Other helpful appendices include a guide to the 10-code and a copy of the FCC Rule and Regulations, Part 95.

CB RADIO, Tab Editorial staff. Tab Books, Blue Ridge Summit, PA 17214. 7 x 10-in., 210 pp, $5.95 softcover.

This is volume 4 in a series of CB Radio Schematic/Servicing Manuals. This one covers Pace, Fanon/Courier and Dynascan (Cobra). It's a complete rundown on servicing data on more than 30 CB transceivers. A valuable reference for any technician looking at the service and repair of CB radio equipment.


Like the fifty-two previous editions, the ARRL Handbook is destined to be one of the most sought-after publications in the electronics field. It is chock full of material for beginners, advanced amateurs and electronics engineers alike. Readers of the Handbook will be pleasantly surprised at the number of new construction projects in this edition. Among them are a two-band solid-state transmitter, a 2-kW 2-meter amplifier and a communications receiver with digital readout. Hundreds of drawings, charts and photographs are used to present the material.


This is a basic introduction to the fascinating world of CB updated and revised with all the latest rules, "lingo," and equipment. The following topics are covered fully: getting started; selecting equipment; cost of equipment; power sources for the house, vehicle, boat and walkie-talkie; antennas; installation; maintenance and repair; and efficient use of air time.

Special features include a complete application form, official 10-code, CB operator lingo, trucker's CB lingo, abbreviations, and protecting yourself with CB radio.


This book contains 142 easy-to-build performance boosters for every CB'er including mobile and base station antennas, direction finders, modulation boosters, RF preamplifiers and converters, noise limiters, clippers, squelch switches, audio compressors and limiters plus 101 other useful and novel operating aids. Most of the projects can be built for under $5.00 using new parts. A soldering iron and normal hand tools are all that are needed to build any of these projects.
next month

APRIL 1977

■ Build A Computer
   It's all on one circuit board: 2650 IC, 1024 bytes of PROM expandable to 4K, 2048 bytes of RAM, cassette interface at 300 baud, video display interface and more.

■ Experiment With EXAR Function Generator IC
   Build almost any kind of generator you can think of—sine, square, triangle, FM, AM, and PSK.

■ IC Data Sheet For Reticon SAD-1024
   See how it works and what you can do with this "Bucket Brigade Delay" device.

■ Build Teleswitch
   First of series of telephone associated projects. This one lets you turn electrical devices on and off when you're away from home, by using the nearest telephone.

PLUS
Komputer Korner
Phase-Locked Loop For CB
Jack Darr's Service Clinic
Dynamic Range Enhancement
Hi-Fi Lab Test Reports

The world of electronics is becoming both larger and smaller. As its essential hardware is rapidly decreasing in size, the demand for competent technicians is rapidly increasing, especially in communications and marine technology.

The Jensen Beach Campus of Florida Institute of Technology offers an Associate of Science degree in Electronic Technology concentrating on the specialized skills needed in modern marine and communications applications. Students in this program receive broad academic training in electronics as well as diverse practical experience qualifying them for various career opportunities in industry.

To learn more about F.I.T.'s Associate of Science degree in Electronic Technology, return the coupon below today.

Florida Institute of Technology
720 S. Indian River Drive
Jensen Beach, Florida 33457

Name ____________________________
Address __________________________
City ____________________________ State ______
Zip _______ Phone __________
Age ______ Veteran □ Area Code ________

CIRCLE 14 ON FREE INFORMATION CARD
FROM KIT TO CAR IN 80 MINUTES!

Electronic ignition is "in." It is easy to install the TIGER ST capacitor discharge ignition in the car. The TIGER delivers increased power, increased efficiency, and increased reliability—more economic and friendly to the environment. The TIGER comes with a switch for TIGER or standard ignition for 12V negative ground only.

Simpli-Kit $21.95
POST PAID U.S.A.
WE ACCEPT:
Mastercharge or BankAmericard.
Send check or money order with order to:

Tri-Star Corporation
DEPT. FF, P.O. Box 1727
Grand Junction, Colorado 81501

CIRCLE 4 ON FREE INFORMATION CARD

MODEL 100A AUDIO RESPONSE PLOTTING SYSTEM
and general purpose sweep/tone burst/pulse generator consists of two sine/square/triangle function generators, pulse generator, frequency counter and peak amplitude measurement sections. It is primarily intended to generate a frequency response plot on an X-Y recorder or scope.

Time base generator offers symmetrical or independent control of the positive and negative pulses of the ramp providing a duty cycle of 7% to 99.3%. Frequency range is 0.005Hz to 100kHz. Amplitude is 15 Vpp into 500 Ω with a 5 VDC offset. The time base output drives the X axis of an X-Y recorder. Manual mode provides for setup.

Audio sweep generator provides manual frequency adjustment or log/linear sweep of 0Hz to 20kHz, with range switching and blanking mode produces zero reference line on X-Y recorder or tone burst. Amplitude is 15 Vpp into 500 Ω or 10 Vpp into 81Ω.

Pulse generator frequency range is 0.005Hz to 625kHz. Pulse width is adjustable independent of frequency from 4 seconds to 40 nanoseconds. Outputs are complimentary TTL.

Peak amplitude measurement section measures internal or external signals from mV to power amp level, amplitude range is 50 mv to 5kV at 20kHz.

Dimensions: 8 x 14 x 3. Shipping Weight 9lbs.
5500 stock to 30 days. Warranty: 1 year.

Adelity Sound
1988 Commeracent M-105
San Bernardino, Ca 92408 (714) 899-7623

CIRCLE 61 ON FREE INFORMATION CARD

ANALOG VOLTMETERS continued from page 71

or range. This is quite common, especially with the crowded scales of a versatile multifunction meter. For example, it is easy to have the voltmeter set on the 15-volt range and take the reading from the 50-volt scale. A more subtle version of this problem is to take a 15-volt AC reading from the 15-volt scale rather than the special scale provided for the 1.5 VAC range.

Errors in reading can be generated from parallax. Parallax is the difference in readings obtained by viewing the meter from different angles. Generally, errors due to parallax are important only when high-precision measurements are being made. Where parallax is a severe problem, a mirror-backed meter scale helps maintain all readings from a single point.

Another operator error is to make measurements with the probe tip switched in the wrong position. Either the switch is in the DC position, which places one megohm in series with the probe, or the measurement is made with the probe tip touching the case of the meter. Here the problem is that the measurement is made with the probe tip touching the case of the meter.

Resistance measurements made with current still flowing in the circuit are invalid. The ohmmeter, in the final analysis, measures voltage. Any extra current in the resistance being measured sets up a voltage, which is a source of error. If the meter is not protected, there may also be damage to the ohmmeter.

Resistance measurements made on transformer windings (or other highly inductive components) are susceptible to two problems. The first is caused by a lack of transformer knowledge. The operator discards a good transformer because the resistance of a winding appears to be low. What has been forgotten is the reflected impedance from the other windings.

The second problem is caused by the high inductance itself, and is normally a problem only with power transformers. The primary of the transformer saturates when the ohmmeter is disconnected from the winding, the magnetic field collapses. This collapse causes a high voltage to appear at the winding terminals. The high voltage can cause electrical shock; damage to the ohmmeter or both.

Polarity errors are common and come in two forms. First, the user may only have the meter set for one polarity and assume another. The second polarity error is associated with ohmmeter measurements: The operator fails to consider the effects ohmmeter polarity may have on the circuit containing semiconductor junctions. If the presence of semiconductor junctions in the measurement is suspected, a simple check is reversal of the test leads. Significant different resistance readings indicate the presence of semiconductor junctions.

Improper interpretation of the decibel scales often leads to error.

In the area of errors introduced by the meter itself, circuit loading is probably the most common. Often a simplistic view of the VTVM or the TVM is taken, and the conclusion is that the electronic voltmeter does not load the circuit at all. Although the electronic voltmeter may be substantially better than the VOM, it still loads the circuit. Looking at the simple DC case, it is apparent that a 10-megohm voltmeter loads a one-megohm source enough to produce a 10 percent error in the reading. This is if DC only is taken into consideration.

If the AC component of the signal is also considered, capacitive loading must also be considered. The meter input capacitance presents a low-impedance resistive load of the divider. As noted earlier, this must be taken into consideration when making DC as well as AC measurements. This is especially true when dealing with a circuit where the loss of AC shifts the DC values of the circuit. The self-biasing stages of a transmitter are an example of such a case. The isolating resistance of the VTVM is most necessary in these cases.

There are times when the VOM is actually better than the TVOM or the VTVM. For example, the TVVM has an 11-megohm input impedance when used on the 1.5V voltage range; however, a VOM with 20,000 ohms per volt input impedance has 20,000 X 1500, or 30 megohms input impedance. When measuring a high-voltage supply, this may be of considerable advantage. The VOM may have the further advantage of having an even higher voltage range (4 to 5 kV for example), and the circuit loading caused by these ranges is even less than that of the TVOM or TVVM.

The analog voltmeter is truly not dead nor dying. Although many of its functions are being replaced by the digital multi-meter, there are still many places where the analog instrument is adequate.

BIPHONIC SOUND continued from page 39

products in the future. In a recent visit to JVC's headquarters in New York City, we were treated to yet another experience in sound reproduction. To best illustrate the effects of their binaural-stereophonic and quadriphonic-binaural-stereophonic processors and program material, they devised a special listening chair (see cover photo), equipped with four small speakers in front of and behind the chair's occupant. Despite the obvious fidelity limitations of the small speakers constructed into the framework of the experimental chair, the sound images created by these carefully positioned speakers were beyond description.

At the moment, there are only a few records recorded binaurally in this country; though in Japan it is reported that some twenty such discs are already available. If interest in binaural sound increases, we may well see additional offerings of such discs in this country and may, perhaps, even witness the resurrection of an old form of sound recording and reproduction that has been dormant for more than forty years.
FREE KIT Catalog
STOP! Take a moment & let us send our latest kit catalog. If you like, send us the name & address of a friend who may also be interested & we'll include it to our booklist. "How to Build Electronic Equipment"
DAGE SCIENTIFIC INSTRUMENTS
1054R LIVERTON CLEVELAND OH 44120

SAVE 50%. Build your own speaker systems. Write: MChee, RADIO ELECTRONICS, 1901 McGee Street, Kansas City, MO 64108

FASCINATING microcomputer kits! Build inexpensive ASCII keyboard, paper tape reader, teletype printer interface, trivoltage PS. Construction manuals 2 each, 1702A Programming-Set. Free Catalogue: MICROTRONICS, P.O. Box 7454, D101, Menlo Park, CA 94025

TV JAMMER
Amaze your friends! Makes TV's go into distortion. Max. range 20'. IN EASY KIT FORM!...2.65...SEND FOR FREE CATALOG...ELECTRONICS COMPANY
6827 Tobias Ave Van Nuys Ca 91405

KITS, semiconductors, components. Free flyer
CHIPS ELECTRONICS, Box 1030, Oakville, Ont., Canada L6J5E9. U.S. inquiries invited.

TV JAMMER
Amaze your friends! Makes TV's go into distortion. Max. range 20'. IN EASY KIT FORM!...2.65...SEND FOR FREE CATALOG...ELECTRONICS COMPANY
6827 Tobias Ave Van Nuys Ca 91405

KITS, semiconductors, components. Free flyer
CHIPS ELECTRONICS, Box 1030, Oakville, Ont., Canada L6J5E9. U.S. inquiries invited.

ORGAN KITS KEYBOARDS
THE ULTIMATE IN DESIGN AND SOUND
DEMO RECORD AND BROCHURE $1.00
DEVTRONIX ORGAN PRODUCTS, Dept. 4B
5872 Amapola Dr. • San Jose, CA 95129
Poly Pak's EXCLUSIVE
Barrel Kits 100% of Barrels Purchased!
For the first time anywhere, Poly Pak merchandisers introduce a new way to save and buy the best components of stock from the "Barrel." Remember what they're talking about. There's been a new way manufacturers have been selling for years. It's been a new way to buy...the barrel way!

Every kit carries a money-back guarantee!
INCREASES "100%" MATERIAL TOO!!!

Barrel Kit 2286 Mini Block 10 Barrels
100 for $1.98
Recall: Worth $35.00

Barrel Kit 2287 100% Resistor Special
100 for $1.98
As tested. Includes a wide range of values, Power lab Cat. No. 323853

Barrel Kits 2288 Diode Block 10 Barrels
100 for $1.98
Recall: Worth $35.00

Barrel Kit 2289 TRANSFORMERS 10 Barrels
25 for $1.98
Uses 60, 120, 240 volt, 5% grade asst., for all types of applications. Insured test report included. Cat. No. 303616

Barrel Kit 2290 Throw Switches 10 Barrels
100 for $1.98
Recall: Worth $35.00

Barrel Kit 2291 500 Parts
100 for $1.98
Recall: Worth $35.00

Barrel Kit 2292 2000 Resistors
200 for $1.98
Recall: Worth $35.00

Poly Pak's CRACKS:
TTS Prices

BUY ANY 10 TAKE 15%
BUY 100 TAKE 25%

Poly Pak's Inc. Wakefield, Mass., U.S.A. 01801

CIRCLE 26 ON FREE INFORMATION CARD

Poly Pak's EXCLUSIVE
Barrel Kits 100% of Barrels Purchased!
For the first time anywhere, Poly Pak merchandisers introduce a new way to save and buy the best components of stock from the "Barrel." Remember what they're talking about. There's been a new way manufacturers have been selling for years. It's been a new way to buy...the barrel way!

Every kit carries a money-back guarantee!
INCREASES "100%" MATERIAL TOO!!!

Barrel Kit 2286 Mini Block 10 Barrels
100 for $1.98
Recall: Worth $35.00

Barrel Kit 2287 100% Resistor Special
100 for $1.98
As tested. Includes a wide range of values, Power lab Cat. No. 323853

Barrel Kits 2288 Diode Block 10 Barrels
100 for $1.98
Recall: Worth $35.00

Barrel Kit 2289 TRANSFORMERS 10 Barrels
25 for $1.98
Uses 60, 120, 240 volt, 5% grade asst., for all types of applications. Insured test report included. Cat. No. 303616

Barrel Kit 2290 Throw Switches 10 Barrels
100 for $1.98
Recall: Worth $35.00

Poly Pak's CRACKS:
TTS Prices

BUY ANY 10 TAKE 15%
BUY 100 TAKE 25%

 Poly Pak's Inc. Wakefield, Mass., U.S.A. 01801

CIRCLE 26 ON FREE INFORMATION CARD
Sencore TF40 Pocket Cricket Portable Transistor & FET Tester

One simplified, safe test for all transistors and FETs. 99.9% reliable with complete leakage test on meter. And the Pocket Portable is the only one that has it. No set-up information is needed. Total test takes seconds. Identifies transistor polarity, FET or bipolar transistor. Identifies all 3 leads everytime. Includes test tone indicator.

CB41
Portable CB Performance Tester
Tests SWR, RF power and % modulation. Tells if a CB rig is getting out as far as possible . . . if it needs servicing.

CB42
Total CB Automatic Analyzer
The complete CB service bench, simplified for quick troubleshooting and performance testing. Performs 12 receiver tests; 12 transmitter tests. Single digital readout for all tests. Combines five units in one: 1) Frequency Counter; 2) RF-IF Generator; 3) Audio Generator; 4) Digital RF Wattmeter; and 5) special CB Tester.

PS43
Port-A-Pak Power Supply/Battery Eliminator
Combines advantages of rechargeable batteries with an AC operated supply for any 12 volt service need.

FOR PRICING AND TO PLACE YOUR ORDER:
Call collect for Mr. Louis (516) 752-0050
Master Charge, BankAmericard and C.O.D.'s accepted

FORDHAM
YOUR ONE STOP DISCOUNT CENTER

FREE
148 page catalog of over 3000 items, test equipment, CB, tools, tubes, components and a full line of electronic supplies
ADVERTISING INDEX

RADIO-ELECTRONICS does not assume any responsibility for errors that may appear in the index below.

Free Information Number Page
17 Acoustic Fiber Sound Systems
22 Advanced Electronics
49 American Audioport
59 American Technology
7 AP Products
71 Audio-Technica
72 B & K Divs. of Dynascan
92 Bernie's Warehouse Distribution Center
78 Chemtronics
145 Special Test Equipment
31 CIE-Cleveland Institute of Electronics
26 Cobra Divs. of Dynascan Cover IV
33 Continental Specialties
31 CREL-5, Divs. of McGraw-Hill Continuing Education
63 Dayton Labs
83 Delta Products
57 Digital Concepts
18 Edmund Scientific
70 EICO
64 E & I Instruments
111 Electronics Book Club
55 E FM-Electronics Measurement
160 Fidelity Supply
14 Florida Institute of Technology
72 GC Electronics
113 Grantham School of Electronics
111 GTE Sylvania Consumer Renewal
131 Handle of USA
169 Heath
91 Hickok Electrical Instruments
131 Indiana Home Study Institute
75 International Crystal
43 JB Electronics
12 Jensen Tools and Alloys
80 John Shop
27 Leader
95 Mallory
7 Mountain West Alarm Supply
2 National Camera Supply
101 National Radio Institute (NRI)- Divs. of McGraw-Hill Continuing Education Center
81 National Technical Schools
83 Nesda
21 OR Machine & Tool
3 PAIA Electronics
55 PTS Electronics
90 Radio Shack
125 Rye Industries
12 Sanuvi
22 Sencore
23 Schober Organ
23 Shakespeare
23 Share Brothers
44 Soundguard
69 Southwest Technical Products
35 Tektronix
37, 54, 53, 52 Telematic Divs. of UX1
104 Tri-Star
51 Tuner Service
36 V.I.Z., Mfg.
83 Vector Electronics
...

Free Information Number Page
45 Babylon Electronics
116 Karel Barta
112 Brooks
108 Burdes Security
114 CFR Associates
114 Cornell Electronics
105 Command Productions
105 Dave Scientific Instruments
114 Delta Electronics
116 Detronix Other Products
105 Digi-Key
117 EDI
105 Fordham Radio Supply
107 385, 124, 125 Formula International
105 Financial Management Associates
112 Godbout Electronics
118 Information Unlimited
112 International Electronics
115 11, 24 James Electronics
122, 123 Johnson-Smith
112 Lab Science
112 Lakeside Industries
118 Marusha
120 Morrow's Micro-Stuff
100 New Tone
114 Optoelectronics
113 Ohm Electronics
112 P.P.G. Electronics
105 Poly Pak
114 Quest
116 Radio Hot
119 Ruple-Songer Electronics
112 SD Sales
111 Solid State Sales
116 Surplus Center
112 Tray Design
118 Trumbull
...

MOVING?

Don't miss a single copy of Radio-Electronics. Give us:
Six weeks' notice
Your old address and zip code
Your new address and zip code

name (please print)
city state zip code

ATTACH LABEL TO HERE

Mail to: Radio-Electronics
SUBSCRIPTION DEPT., P.O. BOX 2520,
BOULDER, COLO. 80302

RADIO-ELECTRONICS

CIRCLE 41 ON FREE INFORMATION CARD

108
S.D. SALES CO.
Z–80 CPU CARD KIT FOR IMSAI/ALTAIR

$149. KIT

Kit shipped with 2 MHZ crystals for existing 500NS memory. Easily modified for faster RAM chips when the prices come down.

You requested it! Our first DC operated clock kit. Professionally engineered from scratch to be a DC operated clock. Not a makeshift kludge as sold by others.

Features: Bowmar 4 digit .5 inch LED array, Mostek 50252 super clock chip, on board precision time base, 12 or 24 hour real time format, perfect for cars, boats, vans, etc. Kit contains PC Board and all other parts needed (except case). 50,000 satisfied clock kit customers cannot be wrong!

FOR ALARM OPTION ADD $1.50
FOR XFRM FOR AC OPERATION ADD $1.50

60 HZ CRYSTAL TIME BASE FOR DIGITAL CLOCKS
S.D. SALES EXCLUSIVE!

KIT FEATURES:
A. 60HZ output with accuracy comparable to a digital watch.
B. Directly interfaces with all Mostek clock chips.
C. Super low power consumption, (1.5 ma typ.)
D. Uses latest MOS 17 stage divider IC.
E. Eliminates forever the problem of AC line glitches.
F. Perfect for cars, boats, campers, or even for portable clocks at home field days.
G. Small Size, can be used in existing enclosures.

KIT INCLUDES CRYSTAL, DIVIDER IC, PC BOARD
PLUS ALL OTHER NECESSARY PARTS & SPECS

50HZ CRYSTAL TIME BASE KIT – $6.95

All the features of our 60HZ kit but has 50HZ output. For use with clock chips like the 50252 that require 50HZ to give 24 hour time format.

THIS MONTH'S SPECIALS!
300.00 HZ CRYSTAL – $1.50
8008A – CPU chip by AMD – $19.95
82512 – 256 x 4 PROM – $2.50
N.S. 8865 OCTAL DARLINGTON DRIVERS
3 for $1.00
Z-80 – CPU by ZILog – $69.95
MM2504 – 4 K EPROM – $7.95

Prices in effect this month ONLY!

4K LOW POWER RAM BOARD KIT
THE WHOLE WORKS – $89.95

Imsai and Altair 8080 plug in compatible. Uses low power static 21102–1 500ns. RAM’s, which are included. Fully buffered, drastically reduced power consumption, on board regulated, all sockets and parts included. Premium quality plated thru PC Board.

TERMS:
Money Back Guarantee. No COD. Texas Residents add 5% tax. Add 5% of order for postage and handling. Orders under $10.00 add 75c. Foreign orders: US Funds ONLY!

For orders over $15.00 Choose $1.00 FREE mdse.

CIRCLE 73 ON FREE INFORMATION CARD

S.D. SALES CO.
P.O. BOX 28810 C
DALLAS, TEXAS 75228

P.O. BOX 28810 C
DALLAS, TEXAS 75228

MARCH 1977

TERMS:
Money Back Guarantee. No COD. Texas Residents add 5% tax. Add 5% of order for postage and handling. Orders under $10.00 add 75c. Foreign orders: US Funds ONLY!

For orders over $15.00 Choose $1.00 FREE mdse.

CIRCLE 73 ON FREE INFORMATION CARD

S.D. SALES CO.
P.O. BOX 28810 C
DALLAS, TEXAS 75228

P.O. BOX 28810 C
DALLAS, TEXAS 75228

MARCH 1977

TERMS:
Money Back Guarantee. No COD. Texas Residents add 5% tax. Add 5% of order for postage and handling. Orders under $10.00 add 75c. Foreign orders: US Funds ONLY!

For orders over $15.00 Choose $1.00 FREE mdse.

CIRCLE 73 ON FREE INFORMATION CARD

S.D. SALES CO.
P.O. BOX 28810 C
DALLAS, TEXAS 75228

P.O. BOX 28810 C
DALLAS, TEXAS 75228

MARCH 1977

TERMS:
Money Back Guarantee. No COD. Texas Residents add 5% tax. Add 5% of order for postage and handling. Orders under $10.00 add 75c. Foreign orders: US Funds ONLY!

For orders over $15.00 Choose $1.00 FREE mdse.

CIRCLE 73 ON FREE INFORMATION CARD

S.D. SALES CO.
P.O. BOX 28810 C
DALLAS, TEXAS 75228

P.O. BOX 28810 C
DALLAS, TEXAS 75228

MARCH 1977

TERMS:
Money Back Guarantee. No COD. Texas Residents add 5% tax. Add 5% of order for postage and handling. Orders under $10.00 add 75c. Foreign orders: US Funds ONLY!

For orders over $15.00 Choose $1.00 FREE mdse.

CIRCLE 73 ON FREE INFORMATION CARD

S.D. SALES CO.
P.O. BOX 28810 C
DALLAS, TEXAS 75228

P.O. BOX 28810 C
DALLAS, TEXAS 75228

MARCH 1977

TERMS:
Money Back Guarantee. No COD. Texas Residents add 5% tax. Add 5% of order for postage and handling. Orders under $10.00 add 75c. Foreign orders: US Funds ONLY!

For orders over $15.00 Choose $1.00 FREE mdse.

CIRCLE 73 ON FREE INFORMATION CARD

S.D. SALES CO.
P.O. BOX 28810 C
DALLAS, TEXAS 75228

P.O. BOX 28810 C
DALLAS, TEXAS 75228

MARCH 1977

TERMS:
Money Back Guarantee. No COD. Texas Residents add 5% tax. Add 5% of order for postage and handling. Orders under $10.00 add 75c. Foreign orders: US Funds ONLY!

For orders over $15.00 Choose $1.00 FREE mdse.

CIRCLE 73 ON FREE INFORMATION CARD

S.D. SALES CO.
P.O. BOX 28810 C
DALLAS, TEXAS 75228

P.O. BOX 28810 C
DALLAS, TEXAS 75228

MARCH 1977

TERMS:
Money Back Guarantee. No COD. Texas Residents add 5% tax. Add 5% of order for postage and handling. Orders under $10.00 add 75c. Foreign orders: US Funds ONLY!

For orders over $15.00 Choose $1.00 FREE mdse.

CIRCLE 73 ON FREE INFORMATION CARD

S.D. SALES CO.
P.O. BOX 28810 C
DALLAS, TEXAS 75228

P.O. BOX 28810 C
DALLAS, TEXAS 75228

MARCH 1977

TERMS:
Money Back Guarantee. No COD. Texas Residents add 5% tax. Add 5% of order for postage and handling. Orders under $10.00 add 75c. Foreign orders: US Funds ONLY!

For orders over $15.00 Choose $1.00 FREE mdse.

CIRCLE 73 ON FREE INFORMATION CARD

S.D. SALES CO.
P.O. BOX 28810 C
DALLAS, TEXAS 75228

P.O. BOX 28810 C
DALLAS, TEXAS 75228

MARCH 1977

TERMS:
Money Back Guarantee. No COD. Texas Residents add 5% tax. Add 5% of order for postage and handling. Orders under $10.00 add 75c. Foreign orders: US Funds ONLY!

For orders over $15.00 Choose $1.00 FREE mdse.

CIRCLE 73 ON FREE INFORMATION CARD

S.D. SALES CO.
P.O. BOX 28810 C
DALLAS, TEXAS 75228

P.O. BOX 28810 C
DALLAS, TEXAS 75228

MARCH 1977

TERMS:
Money Back Guarantee. No COD. Texas Residents add 5% tax. Add 5% of order for postage and handling. Orders under $10.00 add 75c. Foreign orders: US Funds ONLY!

For orders over $15.00 Choose $1.00 FREE mdse.

CIRCLE 73 ON FREE INFORMATION CARD

S.D. SALES CO.
P.O. BOX 28810 C
DALLAS, TEXAS 75228

P.O. BOX 28810 C
DALLAS, TEXAS 75228

MARCH 1977

TERMS:
Money Back Guarantee. No COD. Texas Residents add 5% tax. Add 5% of order for postage and handling. Orders under $10.00 add 75c. Foreign orders: US Funds ONLY!

For orders over $15.00 Choose $1.00 FREE mdse.

CIRCLE 73 ON FREE INFORMATION CARD

S.D. SALES CO.
P.O. BOX 28810 C
DALLAS, TEXAS 75228

P.O. BOX 28810 C
DALLAS, TEXAS 75228

MARCH 1977

TERMS:
Money Back Guarantee. No COD. Texas Residents add 5% tax. Add 5% of order for postage and handling. Orders under $10.00 add 75c. Foreign orders: US Funds ONLY!

For orders over $15.00 Choose $1.00 FREE mdse.

CIRCLE 73 ON FREE INFORMATION CARD

S.D. SALES CO.
P.O. BOX 28810 C
DALLAS, TEXAS 75228

P.O. BOX 28810 C
DALLAS, TEXAS 75228

MARCH 1977

TERMS:
Money Back Guarantee. No COD. Texas Residents add 5% tax. Add 5% of order for postage and handling. Orders under $10.00 add 75c. Foreign orders: US Funds ONLY!

For orders over $15.00 Choose $1.00 FREE mdse.

CIRCLE 73 ON FREE INFORMATION CARD


FREE CATALOG

O'ISON electronics
260 SO FORGE ST.
DEPT. LV, AKRON, OHIO 44327

FREE POSTAGE AND SALES TAX

CIRCLE 68 ON FREE INFORMATION CARD

Micro Mini Mike Wireless Microphone

Send for your information packet today — which also includes circuit functions, component line-up and inexpensive component sales. Packet $1.00 refundable.

Micro Mini Mike

Visux.

P.O. Box 4204R, Mountain View, CA 94040

ECONOMY kits. TVT-III (4 page) $114.75. screen read $11.65. manual switch $9.60. cassette interface $28.50. S ¥ 50 min. detector (ultrasonic) assembled $16.95. Free catalog. ELECTRONIC DISCOUNT SALES, 138 N. 81st Street, Mesa, AZ 85209.

Oscilloscope kit. Assemble your own 5" scope. Combined simple instructions and operating manual Included. Special price $89.95. Send check or M.O. ELECTRONIC TECHNICAL INSTITUTE, Little Falls, NJ 07424, Dept. 2739.

Circuit boards made to order from your drawings and photos. Johnson Dual-Scan Monitor. Complete instruction booklets. Catalog, $5.00. Kit price $39.00. Send check or money order to R.F.O. P.O. Box 31433, Dallas, TX 75231. Department K1.

LIGHT pen controller for TV-IT works with or without controller system. Complete kit $12.50. Micro-Lite, RFD 1, Box 30. North Stonington, CT 06359.

BUSINESS OPPORTUNITIES

HIGHLY PROFITABLE

ONE-MAN ELECTRONIC FACTORY

Investment unnecessary, knowledge not required. Free type handling by professionals. Ideal home business. Write today for facts!

Postcard will do. V. A. Box 248, Walnut Creek, CA 94597.

FOR SALE

SEMICONDUCTORS and parts literature, J. & J. ELECTRONICS, Box 1437R, Winnipeg, Manitoba, Canada. U.S. inquiries invited.

AMAZING ELECTRONIC PRODUCTS AND PROJECTS:

Lasers. Super Powered, Burning, Cutting, Rifle, Pistol. Pocket. See in Dark—Shutgun Directional Mike—Unscarable Wires Test—Stunproof—TV Disrupter—Emergency Producing, Surveillance, Deception, Electrofying, Ultrasonic, CB, Auto and Merch. Present Price to Pay 50% to 60% Only. Send 5.50 for CATALOG 161-957. ALL IN USA. Apply NOW. Full instructions. Send for Free Catalog.

U.S. GOVERNMENT ELECTRONIC SURPLUS

• Nationally Enclosed — World Famous SURPLUS CENTER offers finest, most extensive, Government Surplus electronic units and components at a fraction of their original acquisition cost.

AUTOMATIC BATT. CHARGER

(ITEM 91-188) — Charges 12-volt batteries in 8 amperes rate. Turns off when battery reaches full charge. Turns on automatically. Can be mounted permanently in engine. (20 lbs. 3 oz. 3 compartments 5 3/4 x 9 1/2 x 7 1/2)

$12.95

SNAP-AROUND VOLT-AMMETER

(ITEM 71-1015) — Non-invasive clamp-on AC and DC ammeter. Fits in pocket. Will measure AC or DC. up to 2,500 volts, furnished with test leads. Overall size 4 1/2 x 1 3/4 x 2 1/2. 1 lbs.

$22.95

STANDARD DIAL TELEPHONE

(ITEM 93-151) — Same as used on commercial circuits in U.S. Use as extension to private system. Connect several together for local intercom system. Instruments furnished. Original Cost $12.50.

$8.79

RUNNING TIME METER

ITEM 27186 — Record number of operating hours of electric lights, electrical devices such as refrigerators, furnaces, etc. Records total hours, tenths and hundredths to 99999.99 hours. For 1/2"-inch bimetal strip. 2 1/2" x 2 1/2" x 1/2". 1 lbs.

$4.39

SPECIAL SALE

Correspondence Course In ELECTRICAL ENGINEERING

Prepared in U.S.A. 11779.

$8.79

ITEM 101-115 — Technical training at low cost! Lincoln Engineering School suspended Correspondence Course because of limited space. Limited number of Electrical Engineering Courses are available without exams and grading services. Consists of fifteen lesson books, each with sample exams and standard answers. Book showing how to build automobile Home Experimental Laboratory Box included at no extra cost.

$29.99

ALL ITEMS SHIPPED FREE. Order Directly Or Send For Free Catalog.

SURPLUS CENTER

DEPT. RE-037

LINCOLN, NEBR., 68507

CIRCLE 20 ON FREE INFORMATION CARD


Burglar, Smoke Fire Alarm Catalog

FREE CATALOG

• Billions of dollars lost annually due to lack of protective warning alarms.

FREE CATALOG

shows you how to protect your home, business and person. Wholesale prices. Do-it-yourself. Free engineering service.
6 DIGIT LED CLOCK KIT - 12/24 hr.

**$95 ea.**

**$105 ea.**

**$115 ea.**

**KIT INCLUDES:**

- **INSTRUCTIONS**
- **QUALITY COMPONENTS**
- **50 or 60 Hertz Operation**
- **12 or 24 Hr. Operation**
- **LARGE .4" DIGITS!**
- **ORDER KIT #850-4**
- **AN INCREDIBLE VALUE!**
- **24 Molex pins for IC socket**

**KIT #850-4 will furnish a complete set of clock components as listed. The only additional items required are a 7-12 VAC transformer, a circuit board and a cabinet, if desired.**

Printed Circuit Board for kit # 850-4 (etched & drilled fiberglass) ................................... 92.95
Mini-Brite Red LED's (for use in clock display) pkg. of 5 .................................................... 1.95
Molded Plug Transformer 115/10 VAC (with cord) ............................................................... 2.50
NOTE: Entire clock may be assembled on one PC Board or Board may be cut to remote display.
Kit #850-4 will fit Plexiglas Cabinet III.

6 DIGIT-LED CLOCK Calendar-Alarm Kit

This is a complete, top of the line, Kit for the person that wants the best. Some of the many features and options are: 12/24 time, 28-30-31 day calendar, alternates time (8 sec) and date (2 sec) or can display time only and date on day, 24 hr alarm - 10 minute snooze, alarm set indicator, 50/60 Hz line operation or use with XTal time base (#TB-1), built in OSC for battery back-up / AC failure, Aux timer, CHOICE OF DIGITS.

**KIT #7001B**

- **6 - .4" Digits**
- **4 - .6" Digits**
- **2 - " Seconds"**

$39.95

**KIT #7001C**

- **6 - .6" Digits**
- **4 - .6" Digits**
- **2 - " Seconds"**

$45.95

Kits are complete (less cabinet) including PC boards, power supply, IC socket, 9 switches, 16 transistors and all parts required for above features and options (all #7001's Will Fit Cabinet I)

6 DIGIT LED RED'S 12/$1.00 $5/3.95

**PRINTED CIRCUIT BOARD**

CT 7001 kits sold separately with assembly info. PC boards are drilled Fiberglass, solder plated and screened with component layout. Specify for # 70018 or # 7001C (Set of 2) 7.95

JUMBO DIGIT CLOCK KIT

A complete kit (less cabinet) featuring six digit LED's, MULplex, PC Board, Line Cord, Switches, and all Parts.

**IDEAL** Fit in Cabinet II

$19.95 2/38.

JUMBO DIGIT CONVERSION KIT

Convert small digit LED clock to large .5" displays. Kit includes 6-.5" LED's, MULplex PC Board & easy hook-up info.

**KIT #70-1CC** For Common Cathode

$9.95 2/19.

Fairchild Super Digit FND 359

**FND 359**

4 - .75 HDHP .95

FND 503 RED 5 - .75 HDHP .95

DL 750 RED 6 - .75 HDHP .95

XAN 864 GREEN 6 - NDP .95

XAN 864 RED 6 - NDP .95

**COMMON ANODE**

DL 747 RED 3 - NDP .95

MAN 72 RED 3 - NDP .95

XAN 81 YELLOW 3 - NDP .95

XAN 351 GREEN 3 - NDP .95

XAN 841 RED 3 - NDP .95

XAN 832 RED 3 - NDP .95

XAN 862 RED 6 - NDP .95

From Inexpensive Sockets.

**MOLEX PINS**

100 11¢ 25¢

Reel of 1000 $8.50

60 Hz.

XTAL TIME BASE KIT

Will enable Digital Clock or Clock Kit to operate from 120V. Uses MULplex 5156, 5156X, XTAL, Req. 5156VDC/2.5A MA. 1"x PC Board. Easy 3 wire hookup. Accuracy 2 PPM.

**#TB-1** Adjustable

Complete kit $4.95 ea.

**Wired & Cal.** $9.95 ea.

**OPTO-ELECTRONICS, INC.**

**SAVE UP TO 50% OFF**

**MOBILE LED CLOCK**

12 VOLT AC or DC POWERED FOR FIXED OR MOBILE OPERATION.

SIX LARGE .4" DIGITS!

**MODEL 2001**

Approx. Size: 1 1/8" X 4 1/4" X 4 1/4" **D**

**BATTERY BACK UP** FOR POWER FAILURE TRANSMITTER TO MOBILE. FROM HOUSE TO CAR ETC

- **JUMBO 4 RED LED's RED REAR FILTER REDS USING CHROME BEZEL**
- **SET TIME FROM FRONT VIA HOIDEN SWITCHES + 12/24 TIME FORMAT**
- **SLYSTYLIC CHARCOAL GRAY CASE OF MODIFIED MOLLEST PLASTIC**
- **BIDGE POWER INPUT CIRCUITRY**
- **TWO WIRE NO POLARITY HOOKUP**
- **OPTIONAL CONNECTION TO BLANK DISPLAY (Use When Key On In Car, Etc.)**

**TOP QUALITY PC BOARDS & COMPONENTS**

EXCELLENT INSTRUCTIONS

**MOUNTING BRACKET INCLUDED**

**$299.00**

**$279.00**

**$229.00**

**$199.00**

**$189.00**

**$179.00**

**$169.00**

**$159.00**

**$149.00**

**$139.00**

**$129.00**

**$119.00**

**$109.00**

**$99.00**

**$89.00**

**$79.00**

**$69.00**

**$59.00**

**$49.00**

**$39.00**

**$29.00**

**$19.00**

**$9.00**

**$7.00**

**$5.00**

**$3.00**

**$1.00**

**$0.50**

**$0.25**

**$0.05**

**$0.01**

**$0.00**

**CPU**

- **$19.95 ea.**

- **$17.95 ea.**

- **$15.95 ea.**

**NH8080AD**

- **$45.00 ea.**

- **$40.00 ea.**

- **$35.00 ea.**

- **$30.00 ea.**

**Micro Processor Chips**

Prime National Labs.

40 Pin socket

**$50** with each 8080A!

- **$50.00**

- **$45.00**

- **$40.00**

- **$35.00**

- **$30.00**

- **$25.00**

- **$20.00**

- **$15.00**

- **$10.00**

- **$5.00**

- **$1.00**

**Plexiglas Cabinets**

- **Black, White or Clear Cover**

Great for Clocks

- **CABINET I**

3" H, 6" W, 5" D

**CABINET II**

2 1/8" H, 5" W, 4" D

- **$5.00 ea.**

- **$4.50 ea.**

- **$4.00 ea.**

**MARCH 1977**

- **$6.50 ea.**

- **$2/12.**

- **ANY SIZE!**

- **$45.00 ea.**

**Plexiglas for Digital Bezels**

- **$56.00 ea.**

- **$51.95 ea.**

- **$45.95 ea.**

- **$40.95 ea.**

**MARCH 1977**

**OPTOELECTRONICS, INC.**

**$19.00 ea.**

**$16.00 ea.**

**$12.00 ea.**

**$8.00 ea.**

**$5.00 ea.**

**$3.00 ea.**

**$1.00 ea.**

**$0.50 ea.**

**$0.25 ea.**

**$0.05 ea.**

**$0.01 ea.**

**$0.00 ea.**

**CIRCLE 48 ON FREE INFORMATION CARD**
NEW adjustable three-output regulated power supply, plus 900 part worths $400.00 list, contained in a solid-state Carfivision television recorder electronic unit. Schematics, parts cross-reference furnished. Uses Heatkith television transistor subassemblies, power CB radios and microprocessors, build electronic projects. $17.95 plus $3.50 S&H, USA. Free brochure. Master Charge, Bank Americard, Satisfaction guaranteed. MADISON ELECTRONICS COMPANY, Box 369, D101, Madison, AL 35785

CASES—High quality walnut, cherry, plexiglass. Great for clocks, home stereo, or other small components. Send for free flyer. E.F. COPE ELECTRONICS, 1406 Lenape Rd., West Chester, PA 19380

CIRCLE 58 ON FREE INFORMATION CARD


<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2SC481</td>
<td>1.5V 2SC787 1S572</td>
<td>$3.00</td>
</tr>
<tr>
<td>2SC482</td>
<td>2.5V 2SC774 1S572</td>
<td>$3.00</td>
</tr>
<tr>
<td>2SC483</td>
<td>3.5V 2SC774 1S572</td>
<td>$3.00</td>
</tr>
<tr>
<td>2SC484</td>
<td>4.5V 2SC774 1S572</td>
<td>$3.00</td>
</tr>
<tr>
<td>2SC485</td>
<td>5.5V 2SC774 1S572</td>
<td>$3.00</td>
</tr>
<tr>
<td>2SC502</td>
<td>1.5V 2SC775 1S572</td>
<td>$3.00</td>
</tr>
<tr>
<td>2SC503</td>
<td>2.5V 2SC775 1S572</td>
<td>$3.00</td>
</tr>
<tr>
<td>2SC504</td>
<td>3.5V 2SC775 1S572</td>
<td>$3.00</td>
</tr>
<tr>
<td>2SC505</td>
<td>4.5V 2SC775 1S572</td>
<td>$3.00</td>
</tr>
<tr>
<td>2SC506</td>
<td>5.5V 2SC775 1S572</td>
<td>$3.00</td>
</tr>
</tbody>
</table>

JAPANESE TRANSISTORS

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2SA752</td>
<td>0.5V 2SC836 1S572</td>
<td>$1.50</td>
</tr>
<tr>
<td>2SA753</td>
<td>1.5V 2SC846 1S572</td>
<td>$1.50</td>
</tr>
<tr>
<td>2SA754</td>
<td>2.5V 2SC847 1S572</td>
<td>$1.50</td>
</tr>
<tr>
<td>2SA755</td>
<td>3.5V 2SC848 1S572</td>
<td>$1.50</td>
</tr>
<tr>
<td>2SA756</td>
<td>4.5V 2SC849 1S572</td>
<td>$1.50</td>
</tr>
<tr>
<td>2SA757</td>
<td>5.5V 2SC850 1S572</td>
<td>$1.50</td>
</tr>
</tbody>
</table>

SILICON UNIJUNCTIONS

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2N2496</td>
<td>1.0V 2N414 1S572</td>
<td>$1.00</td>
</tr>
<tr>
<td>2N2497</td>
<td>2.0V 2N415 1S572</td>
<td>$1.00</td>
</tr>
<tr>
<td>2N2498</td>
<td>3.0V 2N416 1S572</td>
<td>$1.00</td>
</tr>
<tr>
<td>2N2499</td>
<td>4.0V 2N417 1S572</td>
<td>$1.00</td>
</tr>
</tbody>
</table>

INTEGRATED CIRCUITS

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2N702</td>
<td>1000V 2N702 1S572</td>
<td>$2.00</td>
</tr>
<tr>
<td>2N703</td>
<td>1500V 2N703 1S572</td>
<td>$2.00</td>
</tr>
<tr>
<td>2N704</td>
<td>2000V 2N704 1S572</td>
<td>$2.00</td>
</tr>
</tbody>
</table>

OEM SPECIALS

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>2N705</td>
<td>3000V 2N705 1S572</td>
<td>$2.00</td>
</tr>
<tr>
<td>2N706</td>
<td>4000V 2N706 1S572</td>
<td>$2.00</td>
</tr>
<tr>
<td>2N707</td>
<td>5000V 2N707 1S572</td>
<td>$2.00</td>
</tr>
</tbody>
</table>

POWER-TRANSISTORS: HIGH-VOLT. TV. TYPE

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>BU204</td>
<td>1300V 3.90 2SC1170</td>
<td>$4.00</td>
</tr>
<tr>
<td>BU205</td>
<td>1700V 5.90 2SC1170</td>
<td>$4.00</td>
</tr>
</tbody>
</table>

CIRCLE 29 ON FREE INFORMATION CARD
<table>
<thead>
<tr>
<th>Part Number</th>
<th>Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>20496</td>
<td>1k Resistors</td>
<td>$6.95</td>
</tr>
<tr>
<td>20494</td>
<td>4k Resistors</td>
<td>$1.49</td>
</tr>
</tbody>
</table>

**MARCH SPECIALS**

- **RED LED**
  - 5.6V Green LED $0.25
  - 3.6V Red LED $0.30
  - 2.5V Yellow LED $0.35

**LINEAR CIRCUITS**

- **7400**
  - 40-pin DIP $3.49
  - 40-pin SOIC $3.49

**MULTIPLE DISPLAYS**

- **74HC**
  - 74HC00 DIP $1.79
  - 74HC02 DIP $1.79

**KEYBOARD**

- **20 Keys**
  - 2x5 3.5x3 $0.99

**5 VOLT REGULATOR**

- **741**
  - MIN 12V $0.50

**CALCULATOR DISPLAY**

- **744**
  - MIN 6-pin $0.50

**EDGECONECTOR**

- **6/99**
  - ECO MODULAR UNIT $0.39

**CLOCK CHIPS**

- **M4S312**
  - 12-bit 20-pin $1.99

**DISCRETE L.E.D.**

- **DISPL 0**
  - MIN $0.10

**SPECIAL DEVICES**

- **U74**
  - 4-bit 20-pin $1.99

**TANTALUM CAPACITORS**

- **500μF**
  - 10V $0.25
  - 15V $0.30

**OPTICAL ISOLATORS**

- **5V Optoisolator diode**
  - Op $1.99

**AUTO CLOCK KIT**

- **300-hour, 30-day, 12V, 5W**
  - Kit $6.95

**IC SOCKETS**

- **Solder Tag Low Profile**
  - 14-pin $0.19

**MARCH SPECIALS**

- **IC SOCKETS**
  - **Solder Tag Low Profile**
  - 14-pin $0.19

**LOW POWER**

- **74S06**
  - $0.49

**HIGH SPEED**

- **74HCT32**
  - $0.79

**SCHOTTKY**

- **74SCH32**
  - $0.89

**ROGUE (NATIONAL)**

- **74HC08**
  - $0.79

**ROGUE (BIG-/NEGOTIENT)**

- **74HC32**
  - $0.49

**DVM CHIP**

- **4-digit DVM chip**
  - **4-digit DVM chip**
  - **4-digit DVM chip**

**IC BREADBOARD**

- **100 pin**
  - **50 pin**

**UNIVERSAL BREADBOARD**

- **100 pin**
  - **50 pin**

**FREIGHT CATALOG AVAILABLE ON REQUEST**

- **Special Orders**
  - **Special Orders**
  - **Special Orders**

**INTERNATIONAL ELECTRONICS UNLIMITED**

P.O. BOX 306 / MONTEREY, CA. 93940 USA

PHONE (408) 659-3117

CIRCLE 47 ON FREE INFORMATION CARD

MARCH, 1972
Babylon-Pac super SALE! Each pac only $1.98

All parts are first quality (no tests), tested and guaranteed.

linear pac 10...
Flip-Flop pac 10...
Comparator pac 10...
Linear pac 10...
Transistor pac 10...

500 $ 1.50
1000 $ 1.00
2000 $ 0.75
5000 $ 0.50
10,000 $ 0.25

MOLEX TRIACS
500 $ 1.50
1000 $ 1.00
2000 $ 0.75
5000 $ 0.50
10,000 $ 0.25

Send a sample for our flyer "Flyer to save money saving bargains!" including microprocessors! P.O. Box 42788 Sacramento, CA 95841

BANKAMERICAN

$20.00
$10.00
$5.00
$1.00
$0.50
$0.25

SPACE AGE CLOCK KIT

Basic kit $ 8.50 - 12 or more $ 7.50
Four digit clock kit includes all parts for complete clock. 3V 3? 2N7052

BABYLON ELECTRONICS

$16.95

PRINTED CIRCUIT BOARD

SINGLE SIDED

480 x 480 - $ 1.95
450 x 450 - $ 1.60
425 x 425 - $ 1.35

TANTALUM CAPACITORS

1500 $ 1.25
2000 $ 1.00
5000 $ 0.75
10,000 $ 0.50
50,000 $ 0.25

SOI LAR SOLAR CELLS

30 in diameter $ 4.00 at 500 ma. $ 4.422.50

SOLID STATE SALES

P.O. BOX 74D

WE SHIP OVER 95% OF OUR ORDERS THE SAME DAY WE RECEIVE THEM

CIRCLE 40 ON FREE INFORMATION CARD

CIRCLE 45 ON FREE INFORMATION CARD

CIRCLE 49 ON FREE INFORMATION CARD
Digi-Key Corporation
Quality Electronic Components
Double-Digit Discounts
Save You Even More!

NATIONAL SEMICONDUCTOR CLOCK MODULES

MA1010A 12 Hour (AM-PM) Version . . . . $13.00
MA1010C 24 Hour Version . . . . . . . . . $13.00

0.84" High LED Digits

Special transformer and 6 switches when ordered with module add $3.45

Hobby-Wrap-30 $5.95

Double Digit Discounts Save You Even More!

In-Stock Products can be ordered online at:

DIGI-KEY CORPORATION
www.digikey.com

MARCH 1977

CIRCLE 70 ON FREE INFORMATION CARD
AM/FM RADIO $10
Plugs into wall, add your 2 speakers and you're ready to go. Calibrated alio motion am/fm tuning dial. Has stereo amps for use with phone or tape inputs to give stereo output. Solid state new.

H.H. SCOTT Misc Etched & Drilled P.C.
Boards Asst. ........................ 15—$1.00

GOULD NICADS NEW
"AA" Cells .................................. 10—$10.00
Sub "C" Cells .................................. 5—$7.00

GREEN LED .................................. 4—$1.00
YELLOW LED
w/MOUNT COLLAR ...................... 3—$1.00

GALLIUM ARSENIDE
IRLED Emitter ............................. $1 or 6/$5.00

40 PIN SOCKET FOR MM5314-5318-
UART—Etc. .......................... 2/$1.00

MAGNETIC RECORDING TAPE
Audio 1/4" ................................
3600 ft. ................................ $1.50 or 10 $12.00
1800 ft. ................................ $1.15 or 10 $10.00

MESHNA, PO BOX 62, E. Lynn Ma 01904

CIRCLE 30 ON FREE INFORMATION CARD

SPRING SALE

100 Ass'd Resistors (Cut Leads) .......... $1.00
20 Ass'd Wire Wound Resistors ........... $1.00
20 Assorted Controls. ..................... $1.00
2 Ass't Filter Cond. (Trans. Work) ...... $1.00
10 HV Anode Leads—Small Cup .......... $1.00
2 HV Anode Leads—Large Cup .......... $1.00
2 HOOF RECTIFIERS. ..................... $1.00
2-4 KY FOCUS RECTIFIERS. .......... $1.00
10-133A CRYSTAL DIODES .......... $1.00
5-15UH LOOP ANT. 18" Lead .......... $1.00
2-SHUNT REG. HODS (BRX4 Etc.) ....... $1.00
3 Audio Output Xlms. ................. $1.00
4 CRT Harness Color 19"/23" CRT. ...... $1.00
1-21" CRT Conver. Assembly ............ $1.00
1-25" CRT Conver. Assembly ............ $1.00
1000 Ohm Controls TAB Mount ......... $1.00
10-1000 Ohm Controls TAB Mount ....... $1.00
2-500 Mil—500 Volts Axial ............. $1.00
4-40 Mil—150 Volts (P.C.) .............. $1.00
25 Ass'd Plate Caps ..................... $1.00
1-ISR BTOC Cart. With Needles. ....... $1.00
1-F5300 Ant. Match. Xlrms. .......... $1.00
2-UHF TUNERS DETENT .......... $1.00
3-Ass't UHF TUNERS .................... $1.00
1-3.58 MHZ COLOR CRYSTAL ......... $1.00
2-PL 259 CB CONNECTORS .................. $1.00
1-56 MHZ RESISTOR .......... $1.00
5-ANT. CLOTHESPINS .................... $1.00
10-RCA PHONO PLUGS .................... $1.00
20 ASS'T SLIDE SWITCHES .......... $1.00
1-UNDER PILLOW SPE 6 FT. LEAD-PLUG $1.00

ZENITH
COLOR YOKKE-589750. ....... $7.95
VIDEO IF STRIP-150115 .......... $7.95
COLOR FLYBACK 566453 0-2 .......... $6.95
ZENITH B/W YODE-7857-2874 (OTHERS) $6.95
VOLTAGE TRIPLER-722-1200 .......... $7.95
VOLTAGE TRIPLER-712-120. .......... $7.95
2-15-250 MAG FOCUS CONTROL ........ $1.00
1 CONV. DIODE PAK ........ $1.00
1-45 KY HV STICK .................. $1.00

COLOR FLYBACK XFMRs.
MAGNADIX 361374-I ................ $5.95
PHILCO 32-10122-1 ................ $2.95 Each
RCA 136640 ........................ $2.95
RCA 137545 ........................ $2.95
GRAB BAG JL FLYBACKS .... 2 for $1.00

COLOR YOKES
REPL. DJ 95AC-109 (LESS COVER) .... $6.95
GEN. ECO, 70-91-111 . .......... $6.95
70-"CIR. MID") RND 3-11 . .......... $6.95
SYLVANIA S1-38509-2 ........................ $6.95
SYLVANIA S1-29966-2 ........................ $6.95
SYLVANIA S1-38553-2 ........................ $6.95
SYLVANIA S1-33657-4 ........................ $6.95
PACK BELL 290545-2E ................ $6.95
FLETCHW 720181 ........................ $6.95

ANTENNA EQUIPMENT
1000 FT. 300 Ohm FOAM 7 Str. 100 Mil ........ $6.95
1000 FT. COAX CABLE (BLACK) .... $3.95
2-7 CT. COUPLERS—300 Ohm ........ $3.95
2-4 CT. COUPLERS—300 Ohm ........ $3.95
2-BEHIND SET ANT. (UNIV.) .... $3.95
UHF-VHF SPLITTER ................ $1.49
UHF-VHF-300 Ohm SPLITTER. .... $1.49

DIST. FOR B/K TEST EQUIPMENT
DST FOR SBE-CONRAD CENTERS
SEND FOR FREE CATALOG
TUBES UP TO 80% OFF
MINIMUM ORDER $50.00
Orders over $50.00 include shipping & handling
SEND CHECK OR M.O.

TV TECH SPECIALS
P.O. BOX 603
KINGS PARK, L.I., NEW YORK 11754
PHONE 516-269-0805

CIRCLE 37 ON FREE INFORMATION CARD

CIRCLE 62 ON FREE INFORMATION CARD
### FAIRCHILD TECHNOLOGY KITS

- Complete Specifications on back of each kit
- Packaged for WALL DISPLAY APPEARANCE
- Dealer’s Inquiries Invited — Price List Available

**7205 - Stop Watch Chip** $19.95

<table>
<thead>
<tr>
<th>KIT</th>
<th>PARTS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>7205</td>
<td>143406.12</td>
<td>LM311N</td>
</tr>
<tr>
<td>7205</td>
<td>193207.15</td>
<td>LM310CN</td>
</tr>
</tbody>
</table>

**7400N TTL**

<table>
<thead>
<tr>
<th>KIT</th>
<th>PARTS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>7400N</td>
<td>143406.12</td>
<td>LM311N</td>
</tr>
<tr>
<td>7400N</td>
<td>193207.15</td>
<td>LM310CN</td>
</tr>
</tbody>
</table>

### CMOS

<table>
<thead>
<tr>
<th>KIT</th>
<th>PARTS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>74CM01</td>
<td>1143204.5</td>
<td>CD4p28</td>
</tr>
<tr>
<td>74CM02</td>
<td>1143204.5</td>
<td>CD4075</td>
</tr>
<tr>
<td>74CM03</td>
<td>1143204.5</td>
<td>CD4073</td>
</tr>
<tr>
<td>74CM04</td>
<td>1143204.5</td>
<td>CDW19</td>
</tr>
<tr>
<td>74CM05</td>
<td>1143204.5</td>
<td>C04U16</td>
</tr>
</tbody>
</table>

### DISCRETE LEDS

<table>
<thead>
<tr>
<th>KIT</th>
<th>PARTS</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>7400N</td>
<td>1143204.5</td>
<td>CD4p28</td>
</tr>
<tr>
<td>7400N</td>
<td>1143204.5</td>
<td>CD4075</td>
</tr>
<tr>
<td>7400N</td>
<td>1143204.5</td>
<td>CD4073</td>
</tr>
<tr>
<td>7400N</td>
<td>1143204.5</td>
<td>CDW19</td>
</tr>
<tr>
<td>7400N</td>
<td>1143204.5</td>
<td>C04U16</td>
</tr>
</tbody>
</table>

### WIRE WRAP CENTER

**HOBBY-WRAP TOOL** BW-630
- Battery Operated (15 hr)
- Weighs ONLY 11 Ounces
- Wraps 30 AWG wire only

**Tool for 30 AWG Wire**
- Roll of 50 ft. Wraps 30 AWG Wire
- 50 ft. wire with 2 / 6 / 2 lengths

### THUMBWHEEL SWITCHES

- 25 mm $1.25 - 50 AWG Wire
- $1.95 for 100 / $5.95 for 250
- Specify Color: White - Yellow - Red - Green - Black

### WIRE WRAP WIRE

- 30 AWG Wire

- Strip & Unwrap

- Per 1000 $15.95

**WIRE WRAP WIRE**

- $34.95 per box

**CIRCLE 11 ON FREE INFORMATION CARD**
**MICROPROCESSOR COMPONENTS**

<table>
<thead>
<tr>
<th>Component</th>
<th>Price</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>8080A CPU</td>
<td>$19.95</td>
<td>58600 MHz 8 bit MPU</td>
</tr>
<tr>
<td>8212 8 bit Input/Output</td>
<td>$4.95</td>
<td>58600 MHz 8 bit MPU</td>
</tr>
<tr>
<td>8216 8 bit Directional Bus Driver</td>
<td>$6.50</td>
<td>58600 MHz 8 bit MPU</td>
</tr>
<tr>
<td>8224 Clock Generator (Driver)</td>
<td>$10.50</td>
<td>58600 MHz 8 bit MPU</td>
</tr>
<tr>
<td>8226 System Controller: Bus Driver</td>
<td>$10.95</td>
<td>58600 MHz 8 bit MPU</td>
</tr>
</tbody>
</table>

**CONNECTORS**

PRINTED CIRCUIT CARD

- 156 Spacing: Tray-Double Read-Out
- Bifurcated Contacts — .050 to .090 Pin Cards

**PRINTED CIRCUIT BOARD**

- 25 PIN D-SUB MINIATURE

**WIRE WIRING**

**REPLACEMENT WIRE — BOBBINS FOR WIRING**

- W36-3 Pin, 12 AWG RED, $2.40
- W36-3 Pin, 12 AWG BLUE, $2.40

**HEAT SINKS**

- KM-5 105°C, $0.35
- KM-5 115°C, $0.35

**HEXDECIMAL ENCODER 18-KET KEY PAD**

- ADD/DIFF: Key Return Key

**JOYSTICK**

- 5 K Pot C.95 | 100 K Pots $7.95

**DIGITAL ALARM CLOCK**

- $16.95

**DIGITAL WATCHES**

- EXELAR Men’s Watch
- $25.00

**DIGITAL STOPWATCH**

- $8.95

**DIGITAL QUARTZ-COMPUTER**

- $39.95

**J500 KIT**

- $34.95 WIDE & ASSEMBLED

**DIGITAL CLOCK**

- $24.95

**JE803 PROBE**

- $9.95 Per Kit

**JE803 Probe**

- New probe is used which is one of the most popular probes used today. It has all the features of a JE800 probe plus an additional feature of a P1000 probe head and is compatible with all probe test fixtures.**
Smallest and lightest duplex radio for paramedics.

A new Emergency Medical Service (EMS) full duplex/multiplex portable radio now aids the paramedic in lifesaving operations. The new Motorola APCOR is the smallest and lightest of its type now available. Weighing only 13 pounds, it can be carried easily to the scene of almost any emergency.

THE APCOR EMS RADIO in a simulated emergency situation.

Duplex/multiplex operation makes possible simultaneous transmission of ECG (electrocardiogram) and voice information from the patient to the hospital. Other features of the APCOR radio are: two watts of audio power, extended range via vehicular repeaters, a full hour of continuous operation, 1-hour rechargeable battery, private-line squelch encode/decode capability and reliable plug-in modules.

New patents improve test instrument

Two new patents of interest to electronic service technicians have been granted to engineers of Sencore, Inc., Sioux Falls, SD.

Patent No. 3,990,002, proudly displayed by Robert Baum, Sencore Engineering Director, is on a simplified yoke and flyback tester. With it, a TV technician can check flyback transformer and deflection yokes in-circuit and out-of-circuit by simple ringing counts from full excitation to 25 percent decay. The rings are converted into voltage steps and applied to a simple analog meter, making it possible to design a tester with a GOOD-BAD scale.

SENCORE ENGINEERS Marvin Westra and Robert Baum, with their patents and the devices in which they are embodied.

Patent No. 3,990,008 is used in the Sencore DVM32 digital portable multimeter, to preserve battery life. A circuit installed in the test lead input and excited by a very small fraction of a volt turns on the digital display. Since the display draws 100 milliamperes as against only 10 for the operating circuit, battery life is roughly ten times as long as that of digital multimeters that are not turned off when no testing voltages are applied.

New device eliminates converter on 20-channel CATV systems

Magnavox has announced a new device, an isolation amplifier, that makes a 20-channel converter unnecessary when used with a Magnavox 25-inch varactor-tuned color-TV set. It is designed for Cable TV (CATV) channels that carry more than the normal 12-VHF channels and use the eight midband CATV channels B through I. The converter had been necessary to prevent possible electronic tuner interference to other cable-system users, a possibility the isolation amplifier eliminates.

If users are subscribers to a Home Box Office (HBO) system transmitting a scrambled signal, a converter will still be necessary to unscramble the signal and receive the channels, unless the HBO uses an electronic filtering system.

Isolation amplifier kits (which must be installed by a service technician) for the Magnavox STAR system and the Videomatic Touch-Tune units are available at Magnavox dealers, with a suggested retail price of $14.95.

R-E

---

COMPLETE UNIT... NOT A KIT!

HARDEN

12 DIGITS DESK TOP CALCULATORS BY ROCKWELL

reg. $69.50

Special Only $29.50

* Uses LCD with backup light.
* 5 functions +, -, x, ÷, %
* With accumulating true memories.
* Full floating decimal points, or fixed.
* 12 digits, silver color LCD display.
* Leading zero suppression.
* Overflow indicator.

Model DT/12 A Uses 110V AC.
Model DT/12 B Uses 220V AC.
Add $2.50 postage for this item.

TV Games

Direct Sales Only $58.50

USES 6 C SIZE BATTERIES (Not Included)

JUST SIMPLY HOOK THE OUTPUT LEAD OF THE UNIT TO THE ANTENNA INPUT OF YOUR TV SET AND YOU'RE READY TO PLAY!

FEATURES:

* 4 Games—Tennis, Hockey, Racquet Handball and Single Handball.
* Adjustable bat size.
* Automatic or manual serve.
* 20° or 40° ball angles.
* Pair of extension control units optional (3.00 each)
* Auto counter display on the screen.

* 3 different beeps:
  Ball against bat-high beep
  Ball against boundary-low beep
  Ball out of play-2 low beeps.

For Postage Add $2.50 For Each Set

FORMULA INTERNATIONAL INC.
12603 Crenshaw Boulevard • Hawthorne, California 90250
For more information phone (213) 679-5167
STOCH 404 REG 10-7 Monday - Saturday

SEND CHECK OR MONEY ORDER TO
CIRCLE 38 ON FREE INFORMATION CARD

RADIO-ELECTRONICS 124
**RCA STEREO SALE**

**AM-FM MONO TUNER AMP**
- 3 WATT OUTPUT
- All Solid State
- And Power Supply
- ONLY $12.00 EACH
- ADD $1.00 POSTAGE FOR THIS ITEM

**AM-FM STEREO TUNER**
- 20 WATT PER CHANNEL AMP
- 2NO5X4
- All Solid State
- With Dial Indicator
- 110V AC INPUT
- ONLY $55.00 EACH
- ADD $4.00 POSTAGE FOR THIS ITEM

**STEREO AM-FM MUX TUNER AMP**
- Included with Built In
- 8 TRACK PLAYER
- USES HITACHI
- I.C. POWER AMP
- 4W PER CHANNEL OUTPUT
- All Solid State with a Beautiful Panel.
- ONLY $55.00 EACH
- ADD $3.00 POSTAGE FOR THIS ITEM

**STEREO AM-FM MUX TUNER AMP**
- 4 WATT PER CHANNEL
- All Solid State
- With a Vertical Panel
- All Brand New with Power Supply
- ONLY $45.00 EACH
- 110V AC $57.00 HE INPUT
- ADD $3.00 POSTAGE FOR THIS ITEM

**STEREO AM-FM MUX TUNER AMP**
- 5 Watt Per Channel Output
- Uses Sanyo STK011
- Hybrid Power Amp and RCA Hybrid Dis.
- vers.
- Two separate dials
- 10 AM and FM with slide vol.
- ume control and signal Indicator.
- ONLY $40.00 EACH
- ADD $3.00 POSTAGE FOR THIS ITEM

**RCA 12 WATT PER CHANNEL AMP**
- FM AM MUX TUNER AMP
- All brand new but no case.
- ADD $4.00 POSTAGE FOR THIS ITEM
- Special Price $35.00 each

**COMPLETE ALARM CLOCK**
- *4 Digits 0.5" LED with brightness control*
- *12 Hour display with AM/FM Indication*
- *True 24 hour alarm with repeatable snooze*
- *Power failure indication for power interrupt*

MODEL EC 400
(Not A Kit)
Only $22.60
ON SALE
$17.50 ea.

**CLOCK KIT**
**MOST POPULAR MMM314 KIT**
**WITH A NEW CASE!**
- Features: 12/24 Hour Display
- 50/60 HZ Input: 6 Digits Readout
- Kit Includes: Gray Color Plastic Case
- MMM314 Clock Chip PC Boards and Trans
- former, 6 Green Color 0.3" Tube Readouts
- All other Transistors and other Com.
- ponents.

Special Only $19.95 ea.

**5U AUDIO AMP KIT**
- USE 2 LM380
- with Volume Control
- POWER SUPPLY 6VDC
- only $5.00 ea.

**TRUE DIGITAL CASSETTE RECORDER**
For use in Control of Both Start/End/Start write operation. Signed Technicians
- DETROIT 12V DC Power Only
- Built-in Test and Output
- Direct compatible with 2 Pcs. Metal and Hard Shells
- 125 Gyrations, using standard
- Philips MINI-CASSETTE. Made by
- Technicians. New w/ manual:
- LIMITED STOCK $79.50
- (nothing contains available at $4.60 ea.

**SPECIAL THIS MONTH**
- CPU $80.00
- UART TR1402A $7.50
- ROMS $25.00
- RAMS $110.00
- $3.50 ea.

**19 KEY ALPHANUMERIC KEYBOARD**
- STANDARD SIZE
- KEY TOPS
- WITH UNENCODED
- SPT KEYS
- ONLY $9.95 EACH

**AUTO ALARM KIT**
- Complete Auto Alarm in an assembly, useful to install exclusively in the ground box of an automobile. Two seconds after turning off the ignition, the alarm automatically turns itself "on". When the auto is re-lighted, the horn will sound for a 1045 second delay. The automobile owner, in changing the ignition key, will not activate the alarm. Once armed, the alarm will sound for a short time and then it will go off. It can be programmed by numbers to protect the vehicle, then un-programmed by numbers to disarm.

**FEATURES**
- Simple installation in one minute.
- Automatically turns off when auto is parked.
- Adjustable delay time. It can be used in combination with other alarm systems; protection of information, protection of barns, campers, recreational vehicles, boats. Cannot be disabled by "not wiring" an auto. Can be turned off without opening key, Any key-ground only.

**ONLY $16.00 per kit Complete Unit $18.00**

**QUAD VOLUME CONTROL**
- VOLUME CONTROL
- Six-way Volume Control
- Used with National 5300 make a perfect time base for clock.

1500A METER
- only
- $1.50 ea.

**ELECTRONIC SWITCH KIT**
**CONDENSER TYPE**
- Touch on Touch Off
- price: $743 I.C.
- and 12V relay
- $5.50 each

**FM WIRELESS MIC KIT**
- Transmit range up to 500 ft.
- Easy to assemble
- $4.50 each

**ASCII KEYBOARD ENCODER CHIP**
- 815 $3.600
- 40 pin DIP package, 4 level, 10 BITS per level, encoding for up to 90 keys. Latched data outputs and control sig.
- nals output. TTL compat.
- ibility for all control.

**WITH DATA ONLY $15.00 EACH**

**COMPUTER KEYBOARDS**
- Standard Teletype Keyboards with gold plated contact switches. All switches are inde.
- pendent and allow you to connect into any form.
- of output.
- 63 Keys - 19.50
- 60 Keys - 14.50

**SOLAR CELL**
- Large Size $6.00 each
- Smaller Size, $3.00 each
- Model A Solar Panel
- $24.00 each
- Model B Solar Panel
- $32.00 each

**SAE DIP SWITCHES**
- 8 positions, 1 $1.25 ea.
- 10 positions, 1 $1.50 ea.
- 12 positions, 1 $2.50 ea.

**SUBMINIATURES TOGGLE SWITCHES**
- Miniature Push-Pull Type
- 1596, $2.40 each
- 1600, $2.60 each

**EECO BCD Thumbwheel SWITCHES**
- 8 positions, 1 $2.50 ea.
- 10 positions, 1 $2.75 ea.
- 12 positions, 1 $3.50 ea.

**PUSH-BUTTON SWITCH**
- RED LED OPEN
- 4.5/10
- BLACK COLOR OPEN
- $1.80
- LARGE STOCK AVAILABLE

**SOLID STATE ELECTRONIC BUZZER**
- Model 1 1-1/2"-V2". Supply voltage 5 VAC
- $2.50 each

**FORMULA INTERNATIONAL INC.**
- 12603 CRENSHAW BOULEVARD • HARTSDORF CALIFORNIA 90245
- For more information please call (213) 679-5162
- CIRCLE 5 ON FREE INFORMATION CARD

MARCH 1977

**CIRCLE 5 ON FREE INFORMATION CARD**
AMAZING & HARD-TO-FIND SCIENCE BUYS! ALTERNATE ENERGY SPACE AGE • HOBBIES

SUPER POWER FOR ANY AM RADIO
Antenna assist has pulled in stations up to 1000 miles+ with no wires, clips, grounding. Solid state—monoch., bivolt. tubes. No. 72,095EH $19.95 Ppd.
ULTRA SELECT-A-TENNA (OVER 1000 MILES) No. 72,147EH $24.95 SUBJ. TO LOCAL CONS.

SAVE 50%! 8x20 MONOCULAR
Top quality Scope, $30 value, now $14.95. Special
--chase saves you 50% off price. 100% coated optics, 333 ft. field of view. Only 2 oz.—stores in pocket, purse, glove box. No. 1588EH $14.95 Ppd.

SEE MUSIC IN PULSATING COLOR
3-Channel Color Organ lets you modulate 3 independent strings of colored lamps or intensify your music. "Audible light show" flashes, responds to rhythm, pitch!
No. 42,309EH (ASSEMBLED) $18.50 Ppd. No. 42,336EH (UNASSEMBLED) $15.95 Ppd.

NASA-CHOOSEN FOR APOLLO/SOYUZ
The Astronauts used this super
2030C binocular (modified) to view Earth's 60 mm objective lenses, 173-ft. field of view at 1000 yds. Relative brightness, 9.8. Fully coated optics, more!
No. 1585EH $99.95 Ppd.

110V FUEL MISER RECLAIMS HEAT
Save your 40% wasted heat to
warm a basement, garage, rec. rm at no extra cost! Do-it-your way instead of up the chimney. Fan-forced clean hot air via easy ducting!
No. 19,194EH (6" DIA) Shpg. 17 lb... $121.50 FOB No. 19,195EH (6 DIA);

KNOW YOUR ALPHA FROM THETA!
for greater relaxation & concentra-
tion, monitor your Alpha/Theta brainwaves w/ or w/o visual, on Bossine II Feast. of 200-up units inc. 3 feedback models.
No. 1668EH (9x35mm4") $149.95 Ppd. No. 71,809EH (FOR BEGINNERS) $59.95 Ppd.

PRO ELECTRONIC SOUND CATCHER
Parabolic mike w/ 18" trans-
parent reflecting shield & 2 F. C.'s in amplifier magnifies signals 100X over omni-
directional micro. Catch sounds never heard before. Highest signal to noise ratio. 9 lb. No. 1649EH (REG. 39 V Batt.) $299.00 Ppd.

AN ULTRA-MINIATURE AM RADIO!
About the size of a small match-
box. Amazing volume & clarity (depends on locale). Insert earing (incl.) & directional AM mini marvel plays! Runs ab. 100 hrs. on 2 hear. and Batt. incl. (LESS THAN 1" in.) No. 1976EH $14.95 Ppd.

CAN'T SLEEP, RELAX? TRY THIS!
Electronic sound conditioner simulates 4 kinds of soothing sounds of ocean surf & rain, "white" sound helps mask unwanted noise. Medical tests proved analgesic effects.
No. 71,907EH $89.95 Ppd.

GIANT FREE 164 PG. CATALOG
1450 UNUSUAL BARGAINS FOR HOBBYISTS, SCHOOLS, INDUSTRY

EDMUND SCIENTIFIC CO.
300 Edsorop Blvd., Barrington, N. J.08007 (609) 547-3488 America's Greatest Science • Optics • Hobby Center
CIRCLE 18 ON FREE INFORMATION CARD

THERE IS NO OTHER TELESCOPE LIKE IT!
THE NEW EDMUND 4 1/4", f/4 NEWTONIAN WIDE FIELD REFLECTOR TELESCOPE
Clear, bright, spectacular wide angle views of stars, moons, comets... easy to use... portable!

IN SECONDS YOU'RE SCANNING THE ASTOUNDING UNIVERSE, able to see and study the breath-taking cosmos as perhaps you never have before: awesome vastness, unbeliavably orderliness, stark silent beauty. All the fascinating heavenly mysteries are yours to enter and explore. This new reflector telescope makes it easy for everyone to share the thrill of space-age enjoyment of the heavens and outdoors. No complicated set-up! Just insert the eyepiece focus, and view the big 3" field of view gives you more stars in a single view than any other type of telescope. Bright crisp, freely received images to capture your interest and imagination! It's probably the easiest to use telescope ever to cross your shoulder. In your lap, on a tripod or just on the spherical base on its own mount for use on a table, car hood. Take it anywhere (only 17 lb.) Top quality optical system. 4" f/4 parabolic primary mirror (3" wave). F.T.I. unaligned, a wave diagram on a coaxial optical window bona fides from moisture and dust. 24mm Kellner eyepiece gives (10") higher than without eyepiece or Barlow. Fast focusing (25" to infinity). Bright Scharlachian red (does impair night vision) adju. carrying strap A first scope must be an ideal second scope!

No. 2001EH $149.95 Ppd.

FOR GREATER RELAXATION, CONCENTRATION, listen to your Alpha and Theta brainwaves!
Do it with an amazing biofeedback monitor. This ultra-sensitive sensor detects brain sig-
nals, lets you monitor (hear and see!) your Alpha and Theta brainwaves. Great aid to re-
 laxation, concentration. This portable (8 x 3 x 4") lightweight (24 oz.) metal unit has a unique electrode headband to slip on or off in seconds without messy creams or solutions. Hooked to amplifier, it filters brainwaves, and signals an audible beep for each Alpha or Theta wave passed. You get both audio and visual (LED) feedback with this reliable, com-
pletely safe unit. It operates on two 9V trans-
sistor batteries, offers features comparable to many costlier models. A comprehensive in-
struction booklet is included.

No. 1659EH JUST $99 95 Ppd.

LOW COST, HIGH QUALITY INFRA-RED EYE
Binocular Style, $299.95; Standard, Only $299.95
A must for infra-red crime detection surveillance, security system alignment, I.R. detection, laser checking, night-time wildlife study—any work requiring I.R. detection and conversion to the visible spectrum. Self-contained scope (1 x 14 x 4 x 3") includes I.R. light source for up to 90" sight at night. 3002 I.R. converter tube, f/3.5 telephoto lens, adjustable tripie eyepiece, an adapter for use with your car's cigarette lighter—more! Bright 1.6X image (Binocular style gives super-bright 2.5X). Focuses from 10' to infinity, runs on 6 or 12V DC.
Not for sale to Cal. residents other than authorized by U.S. Armed Forces, law enforcement agencies or solely for scientific research and education purposes.

STANDARD STYLE, STOCK NO. 1683EH ..... ONLY $299.95 Ppd.
BINOCULAR STYLE, STOCK NO. 1685EH ..... JUST $299.95 Ppd.

COMPLETE AND MAIL COUPON NOW
EDMUND SCIENTIFIC CO. 300 Edsorop Blvd., Barrington, N. J. 08007 Send me the following: Stock No. Quantity Price Ea.

SEND FREE
164 PG CATALOG "EH"
Charge my American Exp
□ VisaAmerican Exp □ Master Charge
□ BankAmericard □ Master Charge
Interbank No. ___________ ___________ ___________
Add handling charge $_________ ___________ 1.00
Enclosed is ___________ ___________ ___________
M.O. in amount of $_________ ___________ ___________

Expiration Date. ___________ ___________ ___________
Signature ______________________________________
Address _______________________________________

30-DAY MONEY-BACK GUAR.
ANTIE. You must be satisfied or return any purchase in 30 days for full refund.

City, State, Zip.
Shakespeare's White Knight. The best antenna going. And coming.

Shakespeare comes on strong for the new 40 channel era. With high performance CB antennas that turn on the power on all 23 or 40 channel CB transceivers.

Shakespeare's new White Knight Antenna combines the rugged, mechanical strength of gleaming white fiberglass with precision engineered electronic components. Components like the high quality loading coil permanently fused in a solid polycarbonate thermoplastic base. Totally impervious to the environment. And pre-tuned to an SWR of 1.9 to 1 or less over the 40 channel band (1.3 to 1 or less at the center). To assure maximum range and peak performance every time you key the mike. That's what sets the White Knight antenna apart from all the others.

Ride full tilt into the 40 channel era with the new White Knight CB Antenna. And take the Shakespeare performance route home.

The White Knight Antenna, Style 4125 available in a variety of pre-assembled mounting styles. Complete with cables and connectors. Under $25.

Shakespeare

Coming on strong for the Knights of the Road.

Shakespeare Company/ Antenna Group, P.O. Box 246, Columbia, S.C. 29202
In Canada: Len Finkler Ltd., Ontario

CIRCLE 33 ON FREE INFORMATION CARD
The 40-channel Cobra 29XLR. From the sleek brushed chrome face to the matte black housing, it's a beauty. But its beauty is more than skin deep. Because inside, this CB has the guts to pack a powerful punch.

The illuminated 3-in-1 meter tells you exactly how much power you're pushing out. And pulling in. It also measures the system's efficiency with an SWR check. In short, this Cobra's meter lets you keep an eye on your ears.

The Digital Channel Selector shows you the channel you're on in large LED numerals that can be read clearly in any light. There's also switchable noise blanking to reject short-pulse noise other systems can't block. The built-in power of DynaMike Plus. Automatic noise limiting and Delta Tuning for clearer reception.

And the added protection of Cobra's nationwide network of Authorized Service Centers with factory-trained technicians to help you with installation, service and advice.

The Cobra 29XLR. It has 40 channels. And it has what it takes to improve communications by punching through loud and clear on every one of them. That's the beauty of it.

Cobra
Punches through loud and clear.
Cobra Communications Products
DYNASCAN CORPORATION
6460 W. Cortland St., Chicago, Illinois 60635
Write for color brochure
EXPORTERS: Empire • Plainview, N.Y. • CANADA: Atlas Electronics • Toronto

PUNCH
AND BEAUTY