Popular Electronics
WORLD'S LARGEST SELLING ELECTRONICS MAGAZINE AUGUST 1977 / $1.25

- HOW TO AVOID STATIC DAMAGE TO MOS DEVICES
- BUILD A CAMERA SHUTTER-SPEED TESTER
- NEW COMMUNICATION BAND FOR "KIDDIE-TALKIES"
- ADD DIGITAL CLOCK/TIMER FUNCTION TO SIMPLE CALCULATORS
- SOFTWARE FOR THE TYT-6 VIDEO DISPLAY
- TESTED IN THIS ISSUE: Heath AR-1515 Digital Readout Stereo FM/AM Receiver ■ Thorens TD-126C Turntable ■ President "Washington" 40-Channel Base Station

BUILD THE "CABONGA" ELECTRONIC PERCUSSION SYNTHESIZER
Simulates percussive instruments from bass drum to wood block
Introducing the mobile that can move you out of the world of the ordinary and into the world of the serious CB'er. The Cobra 138XLR Single Sideband.

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2. Integral heater/tips.

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WHEN YOU'RE NOT IN A RUSH TO CATCH UP, YOU'VE GOT THE TIME TO BUILD THINGS RIGHT.

When Pioneer first introduced the 160 watt SX 1250 last year, it prompted our competitors to hastily introduce a bevy of high powered receivers.

Unlike the others, however, the SX 1250 wasn't a rush job. And the time and care that went into it can both be seen and heard.

Inside the SX 1250, for example, you'll find that we took the time to shield every critical section. So spurious signals from one section can't leak into another. And dirt and dust can't get in to affect performance. So the SX 1250 not only produces crisp, interference-free sound when it's new, but still sounds great as it grows old.

In our power supply, instead of finding a conventional transformer, you'll find a heavier, more advanced toroidal-core transformer. It's less susceptible to voltage variations. And less likely to leak noise. Which means you get a cleaner, clearer sound.

And where most high powered receivers come with a three, or four gang variable capacitor for FM tuning, the SX 1250 features a five gang zinc plated variable capacitor that cleans up FM reception much better. And helps to pull in stations that some three or four gang capacitors can't even touch.

Obviously, these are only a few of the refinements that went into the SX 1250. But given just these few things, it should come as no surprise that the SX 1250 even weighs more than most of our competitors' high powered offerings.

So before you run out and buy just any high powered receiver, consider all the time and engineering that went into the SX 1250. And weigh your decision carefully.

*160 watts per channel minimum RMS continuous power output at 8 ohms, from 20 to 20,000 Hz, with no more than 0.1% total harmonic distortion.
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AUGUST 1977
ELITISM FINELY DRAWN

The results of the mythical quiz on electronics sent to our 400,000 or so primary readers as a prelude to accepting their subscriptions have finally been tallied (by computer, of course).

The first part of the test was simple enough. It concerned d.c. theory; I=E/R and all that. Only 5% failed, leaving us with 380,000 potential readers. The second test covered a.c. theory, which included vector algebra and some trigonometric functions. (We graciously supplied formulas.) An impressive-enough number handled polar coordinates, the j factor and the Pythagorean theorem to earn our respect. We only lost 15% of the remaining subscribers on this one, leaving us 323,000 electronics buffs.

In the third section, circuit analysis techniques, we decided to forgive those who missed solving multiple-source networks with the superposition theorem. After all, this could be picked up quite easily. Employing this tactic, 258,400 determined people were left. (Females did better on this one, though they account for only 0.1% of the testees.)

I must be candid and say that I did not fully agree with the questions posed in the fourth part. They covered too much ground, I believe, ranging from transistor theory to operational amplifier operation with feedback, inverting, etc., as well as radio and TV circuits. After all, how many of us can draw a synchroguide circuit from memory? So we marked everyone right on this one problem. Nevertheless, a hefty 30% dropped by the wayside, with 180,880 left.

The fifth part really separated the men from the boys. It concerned digital electronics. Most did rather well on gates and such, but when it came to Karnaugh- Veitch maps . . . Would you believe only about 18,000 made it? It was the n variables that did it.

The final test was composed of a potpourri of special interests, designed to check the broad base of electronics knowledge that our potential readers had. It included an analysis of SQ and QS matrix systems, designing a proportional control system for radio-control purposes, interpreting a host of logic timing scope traces, Brillouin scattering (everyone should know something about quantum electronics, right?), and an essay on how the Intel 8080 MPU works, among others.

To our surprise, only one person came through with flying colors—Marcia Swampfeller. This single subscription was processed. After publishing our next issue for one subscriber, we instituted a PE reader attitude study (to keep a finger on the pulse, so to speak). The only subscriber left responded: "I'm too qualified to fully enjoy it."

The moral of this parable is clear. Elitism can be carried too far. That's why POPULAR ELECTRONICS touches all bases in electronics—high level and lower level, from audio to microcomputers, from news to new-development details, tutorials and construction projects. Through PE, there's always the joy and stimulation of being exposed to some facet of electronics that is new to a reader. The excitement is in unfamiliarity, whether it's a PE "breakthrough" project, a refreshing different description of a device to give one new insight, or an explanation of how a particular circuit works. Happily, too, age is not a disqualifier, as attested by two sixth-grade girls who recently won the Crest Hill Science Fair in Wyoming with a Kirlian photography project. They said, "What we learned came mostly from POPULAR ELECTRONICS magazine."
EVERY PROJECT IN THIS BOOK IS ANOTHER REASON TO OWN CSC’S QT SOCKETS AND BUS STRIPS.

With QT solderless breadboarding sockets and bus strips, you can build twice the projects in half the time. Because making connections or circuit changes is as fast as pushing in—or pulling out—component leads. No special clips or jumpers required, either.

When you’re building circuits just for the fun of it, you can take them apart in minutes—not hours. So you save money by re-using parts, while eliminating heat damage to expensive components. Interlocking QT Sockets and Bus Strips are infinitely expandable, too: start small and “grow” breadboards as large as you wish.

For as little as $3.00, you can get a lot more out of your time in electronics—so why not treat yourself to a QT Socket today?

<table>
<thead>
<tr>
<th>Length</th>
<th>Hole-to-Hole</th>
<th>Terminals</th>
<th>Unit Price per Unit</th>
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<tr>
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<tr>
<td>QT-47S</td>
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<td>3.8</td>
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<td>1.4</td>
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<td>QT-7S</td>
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<td>14</td>
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All QT units are .33” thick

Variety — 10 models from 70 to 590 solderless tie-points feature snap/lock design to expand or contract your breadboard to fit every circuit and budget requirement.

Versatility — Use with virtually all types of parts, including resistors, capacitors, transistors, DIPs, TO-5 s, LED’s, transformers, relays, pots, etc. Most plug-in directly and instantly in seconds. No special jumpers required—just lengths of #22-30 AWG solid hookup wire. Molded-in holes let you mount QT units securely on any flat surface with 4-40 flat head screws or 6-32 self-tapping screws from behind panel.

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Speed — For last circuit layouts. QT Sockets have 5 interconnecting tie-points per terminal. Bus Strips feature 2 separate rows of interconnecting terminals. Both connect and disconnect easily, without damage to socket or parts.

Visibility — All parts are instantly and easily visible and accessible, for quick signal tracing, circuit analysis and diagramming.

Durability — Higher-temperature sockets with abrasion-resistant, glass-filled plastic, rated better than 100°C. Screw-down-and-interlocked design provides high mechanical strength.

Reliability — Ruggedly designed to professional engineering standards, for heavy-duty, day-out use. Non-corrosive prestressed nickel-silver contacts insure more secure mechanical and electrical connections. Vinyl backing prevents shorting when mounted on conductive surfaces.

See your CSC dealer or call
203-624-3103 (East Coast) or 415-421-8872 (West Coast) major credit cards accepted.

*Manufacturer’s suggested list Prices and specifications subject to change without notice
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AUGUST 1977
A BIT OF NOSTALGIA

"The Morse-A-Letter" in the January 1977 issue was particularly interesting to me because it brought to mind the tinkering I did in the late 1930's and early 1940's. At that time, I put together a "siphon" telegraph recorder that recorded code as a wiggly line on "ticker" tape at speeds up to 100 wpm. This copy could then be decoded by eye at speeds faster than I could copy by ear.

One of the peculiarities I found was that manual keying was much more difficult to read by eye than by ear due to the great variation in keying characteristics among the operators. I wonder if your digital system might have a similar problem.—George L. Rogers, WB9LV, Waynesboro, VA.

In on-the-air tests, we found very few instances where the Morse-A-Letter could not decipher code. In those rare cases where the converter "went wild," the operator of the received transmission had a very sloppy "fist."

UPPING THE COUNT RANGE

The "Photoelectric Sensor's" (January 1977) maximum count can be increased from 9 to 15 simply by replacing the 74192 (IC4) with a 74193 IC. Since these two IC's have exactly the same pinout, no other change in the basic circuit is needed. If a second 74193 is connected as shown in Fig. 2 of the article, the maximum count would be 255. —Charlie D. Hefley, Pasadena, TX.

VIDEO GAMES AND PIX TUBE ETCHING

I note that POPULAR ELECTRONICS has recently presented a number of construction articles for inexpensive video games. While it is true that such games do provide many hours of entertainment, nowhere in any of the articles is it mentioned that court boundaries, paddles, etc., displayed on-screen can etch the expensive receiver picture tube. Believe me, this is a very real problem. I should know because I work for a vending service.—B.M. Michaud, Lake Placid, NY.

Though it is true that some commercial "arcade" types of video games have exhibited this "etching" process, there does not appear to be a similar problem in a home-entertainment system. Commercial vending games (and retail video game demonstrators) are generally operated 12 or more hours every day, which, over a long period of time can affect the CRT's phosphor. A video game used in a home, is not likely to be operated over prolonged periods of time.

GETTING PIN NUMBERS STRAIGHT

I was unable to obtain the recommended Hewlett-Packard 5062-7340 hex displays for my "COSMAC EI" microcomputer (August 1976). So, I had to substitute Texas Instruments TIL311 displays. Unfortunately, the pinout table supplied with the TI displays contained several errors that other POPULAR ELECTRONICS readers might want to know about. The TI displays will work fine if the following pin substitutions are made:

<table>
<thead>
<tr>
<th>H-P DISPLAY</th>
<th>TI DISPLAY</th>
</tr>
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<tbody>
<tr>
<td>PIN NO.</td>
<td>PIN NO.</td>
</tr>
<tr>
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<td>2</td>
</tr>
<tr>
<td>2</td>
<td>13</td>
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<td>7</td>
<td>1,14</td>
</tr>
<tr>
<td>8</td>
<td>3</td>
</tr>
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</table>

Do not connect pins 4, 6, 9, 10, and 11 of the TI displays.—Clayton Hallmark, Shelby, OH.

TESTING SEQUENTIAL IC'S

The "Digital IC Tester" (June 1977) may operate satisfactorily when combinational logic such as AND gates and BCD-to-decimal devices are tested, but it will not do a good job when testing sequential circuits like latches and counters. As an example, the 7490 decade counter shown in the article is made up of three JK flip-flops and one SR flip-flop. The set input of the last flip-flop will never be tested. Because the reset to zero and gate are conditioned before every fourth clock pulse at pin 1, inputs S1 and S2 will never both be high when the clock is applied to the toggle inputs of the SR flip-flop. Since the set input is never tested, it may be defective, but the IC would still pass the test.—Richard Bipes, Rochester, MN.

Your statements would be basically correct—if the 7490 were connected only as shown in the example in the article. However, the jumpers on the setup matrix can be arranged to test any part of a digital IC.

MAKING IT WORK

When I built the "Digital Electronic Westminster Clock" (November 1976), I had problems getting it to operate properly. I found that pin 23 of IC19 must be connected to VDD when fluorescent displays are used. Also, H at the junction of C3 and R9 should be connected to pin 13 of IC19 for a one-hour pulse. Now my Westminster clock operates fine.—Larry Baxter, New Rochelle, NY.

FILTERING OUT THE NOISE

I am very happy with the performance of my "Digital Bicycle Speedometer" (March 1977). However, I would like to pass on to other readers a slight addition I had to make to the circuit to obtain proper operation. The 556 IC I used for IC3 was so noisy that the power supply had to be filtered. I solved this problem by installing a 2000-µF electrolytic capacitor between pins 4 of IC3 and the ground, or common, bus.—Rob Breffleih, Shreveport, LA.
At last, a constant readout (no buttons to push) precision quartz electronic watch with a built-in 24 hour alarm system.

A quiet revolution has been taking place in the electronic watch industry during the last few years. Push-button LED's are being replaced with continuous-display LCD watches; 4-digit displays are being replaced by 6-digit readouts. This year there will be many such LCD watches available.

However, Winthrop-Rogers prides itself on offering not only the most technologically-perfect products available, but also on introducing the most technologically-advanced products on the electronic market before they are readily available. Therefore, we are pleased to announce the most remarkable achievement in electronic watch technology to-date.

By combining the quartz-accuracy precision of the LCD watch with miniaturized alarm technology, we proudly introduce the first CONTINUOUS DISPLAY ALARM WATCH. A watch that may not be available from other sources for years can now be yours at a price hundreds of dollars less than you would imagine.

And now consider the incredible convenience of a portable alarm clock handsomely adorning your wrist at all times!!!

- Never again missing an appointment because you lost track of time.
- Never again missing a plane or a train because you didn't realize how late it had become.
- Never again forgetting to make that all-important phone call.
- Never having to worry about forgetting to take important medication on time.
- Never worrying about waking up from that snore, or at a hotel if your wake-up call isn't on time.
- Always being aware of when you should be coming or going or doing all that your hectic schedule demands — without devoting your valuable time to trying to remember it all.

THE ALARM

The MICRO-ALARMS have a 24 hour Alarm System, allowing you to set your watch to signal at any minute of the day or night (1,440 settings per day are possible). Once set, you need not be concerned about your next appointment or train, plane or phone call. The MICRO-ALARMS will remember for you and remind you when you need to be reminded.

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For your convenience the MICRO-ALARMS will give one short beep prior to its full alarm cycle, allowing you to turn it off without disturbing others. If not deactivated after the first short beep, the alarm will then beep for 15 continuous seconds. Push the deactivate button twice and the alarm is off. However, should you want a further reminder, then push the deactivate button only once and the alarm will go through its cycle again in exactly 5 minutes, allowing you to continue your current activity whether it be a snooze or phone call without fear of forgetting your next commitment.

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Each MICRO-ALARMS comes with a 2-year limited warranty. You may order in your choice of gold-tone or silvertone case. Each for only $69.95 plus $1.99 for shipping and handling. Each MICRO-ALARMS comes with a matching, elegant, thin mesh bracelet, more handsome and much more practical than those "pull-over-snap" type bracelets. This band adjusts comfortably and easily, eliminating cumbersome link adjustments.

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Wear the MICRO-ALARMS for 15 days to assure yourself that this is no ordinary watch. If at the end of that time you are dissatisfied for any reason you may return it for a prompt refund, no questions asked.

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To expedite shipping by UPS, please provide street address rather than P.O. Box number.

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New Products

Additional information on new products covered in this section is available from the manufacturers. Either circle the item’s code number on the Reader Service Card inside the back cover or write to the manufacturer at the address given.

TRIPLETT HAND-SIZED VOM

The new Model 100-T from Triplett is a hand-sized VOM featuring temperature ranges from -50 to +300 degrees F. A handy leather carrying case includes temperature probes, VOM leads, clamp-on ac ammeter, plus a plug-in line separator for current readings on standard line cords. The 100-T consists of the company’s basic Model 390 “shirt pocket” VOM with five ac/dc voltage ranges (0-1200 volts), four dc millamp ranges (0.6-600 mA), and four ohm ranges (10 k to 10 M). Dc sensitivity is 20 kilohms/volt; ac is 5 kilohms/volt. $120.

ONKYO "QUARTZ-LOCKED" FM TUNER

Onkyo's Model T-9 AM/Stereo FM "quartz-locked" tuner uses a front-end dual-gate MOSFET. Mono FM sensitivity is rated at 3 µV (16.1 dB) at 50 dB quieting; image rejection, 83 dB; and stereo S/N ratio, 73-dB PLL multiplex circuitry provides 40-dB stereo separation at 1000 Hz. A touch-sensitive FM tuning knob unlocks the frequency comparator and automatically activates a muting circuit when tuning in a station. Also featured are separate signal and center-channel tuning meters. Front-panel pushbutton switches are provided for POWER on/off, injecting a 400-Hz recording signal for tape recording, MUTE/LOCKED function, stereo noise filter, and AM/FM selection.

TARBELL MICROPROCESSOR PROTOTYPING

The Model 1010 prototyping board from Tarbell Electronics can be used with the 8080-microprocessor based microcomputers made by MITS and IMSAI. The board accepts up to 33 14-pin IC's or a mixture of 40-, 24-, 18-, 16-, and 14-pin DIP IC’s. Mainly oriented toward point-to-point soldering, the board can also be used for Wire Wrap. There are three rows for IC's. The IC's or their sockets are inserted from the top of the board and then wires are soldered to the adjacent tabs. Even with 40-pin IC's, there are two holes left over on each pin for hooking up wires. A place for a 5-volt regulator is provided on the board, and edge-connector pads are gold plated. $29.95.

ELECTRA PROGRAMMABLE SCANNER

The Bearcat 210 scanning monitor receiver gives the user pushbutton access to more than 6000 public-service frequencies. The five-band crystalless receiver employs completely synthesized circuitry. Any 10 frequencies can be programmed into the receiver in a matter of seconds. The scanning rate is 20 channels/second. A large digital numeric display allows the operator to see the frequencies he has selected as well as those being received. Bearcat's exclusive rolling zeroes indicate when the scanning function is active. A 2-second scan delay allows the listener to hear both parts of a two-way broadcast. A pushbutton lock-out feature permits selective skipping of those channels the user does not wish to monitor. The receiver can be operated on either ac or battery power.

TEAC CASSETTE DECK

Model A-103 front-loading, all black design cassette deck from Teac features Dolby noise reduction, two-step bias and equalization switches, Permalux heads for record/playback and erase, separate left and right level controls, and a mic or line input switch. Wow and flutter is rated at 0.10%; frequency response 30-14,000 Hz with chromium dioxide tape; signal-to-noise ratio 50 dB, improved to 10 dB at 5000 Hz with Dolby. Dimensions: 17 5/16" x 9 5/8" x 7 11/16" (40 x 24 x 20 cm). $180.
Revolutionary breakthrough in CB antenna design

AVANTI Invents the Saturn™ Base

The reason the "Saturn" is so revolutionary is that it is absolutely the only combination vertical and horizontal omni-directional antenna. That's right, it needs no rotor! You can pick up mobiles (which are vertical) or horizontal and vertical beams.

The "Saturn", invented after years of research by Avanti engineers, is the latest development using AVANTI's unique CO-INDUCTIVE principle to give you the performance of two antennas combined into one.

The "Saturn" not only works on both polarities, but pounds out signals like an air hammer and picks them up like a magnet. Both polarities offer high gain figures.

Those of you who are worried about sun spots and "skip" can relax too. This antenna really helps. When the sun spots cause a signal shift, you can often change polarity (just like our P.D.L. or Moonraker) and still pick up the desired channel with no loss of transmission.

The P.D.L. and Moonraker made dual polarity famous as the only antennas to have during the last sun spot cycle, and this time around any serious C.B.'er will want to have the "Saturn."

In fact, having a "Saturn" and a "P.D.L." or "Moonraker" will put you in the elite group of C.B.'ers who "always seem to get out better."

Avanti makes a complete line of high performance base and mobile CB antennas from $11.95 to $404.00. Write for free Avanti catalog.
The "Click and Pop" machine

by SAE

Ever since the invention of the recorded disc annoying "clicks" and "pops" caused by scratches, static and imperfections have consistently disturbed the listening pleasure of music lovers.

Now, SAE introduces the unique model 5000, an Impulse Noise Reduction System which eliminates those unwanted sounds with no adverse effect on the quality of the recorded material.

This breakthrough in electronic circuitry is so demonstrably effective that the SAE 5000 is destined to become an essential part of any sound system.

The SAE 5000 is compact and sleek, built to SAE's exacting standards, and ready to enhance the performance of any system, from the standard receiver/turtable combination, to the most sophisticated audiophile components.

SAE is proud to add the 5000 to their broad line of Components for the Connoisseur.

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P.O. Box 60271, Terminal Annex
Los Angeles, Cal. 90060

Please send more information on the 5000.

Name ____________________________
Address ____________________________
City ____________________________ State Zip ____________

CIRCLE NO. 49 ON FREE INFORMATION CARD

HUNT IGNITION NOISE SUPPRESSOR

"Phantom Damper" is what Hunt CB Accessories is calling its noise filter which, it claims, eliminates from 75% to 100% of all vehicle engine noise from CB radios. Housed in a small black box, approximately 1\(\frac{1}{2}\) inches square, the unit is installed in the vehicle between the alternator and CB unit. Equipped with self-adhesive backing, installation is said to take only 15 minutes. It may be attached directly to the CB unit or any convenient location within 12 inches of the set. A power cable runs from the Damper through the vehicle's firewall to the battery and shielded coax runs from the Damper to the CB unit. A red LED lamp, located on the Damper, glows when all connections are tight and unit is correctly grounded. $39.95. Address: Hunt CB Accessories, Box 489, Eaglepoint, OR 97524.

JOHNSON CB RADIO WITH FLASHING METER

E.F. Johnson's new 40-channel, mobile CB AM transceiver, the Messenger 4145, is equipped with a "Power Bar" LED meter which indicates red when signal strength and relative power output with red LED segments. It can also function as an attention-getting "silent alert" light when operating the radio with the volume control off. Other features are a PA function, built-in electronic speech compression, a tapered switchable automatic noise limiter, PLL circuitry on a single IC chip, a dimmer switch, and positive/negative ground power capability. Accessories available include an external speaker and ac power supply for base operations. $179.95.

CIRCLE NO. 97 ON FREE INFORMATION CARD

B&K-PRECISION INSTRUMENT PROBE

A new deluxe wideband instrument probe, designated the Model PR-37, has been announced by B&K-Precision. It is designed to be used with frequency counters and oscilloscopes at frequencies up to 100 MHz. The lightweight, slim-bodied probe has a three position switch that allows selection of 10:1 or direct modes or a reference position that grounds the tip through a 9-megohm resistor. A complete set of accessories is supplied with the probe, including a spring-loaded retractable tip cover, insulating tip, BNC tip adapter, IC tip, and an insulated compensation capacitor adjustment tool. The insulating tip is designed for probing dense solid-state circuitry with no danger of shorting to nearby components. The BNC adapter converts the probe tip into a push-on BNC connector. The IC tip guides the probe contact onto any pin of a DIP, making it almost impossible to short two pins of an IC. $40.00.

CIRCLE NO. 98 ON FREE INFORMATION CARD

HITACHI STEREO RECEIVER

Hitachi has expanded its Series "E" line of audio components with the Model SR-2004 AM/stereo FM receiver, rated at 200 watts/channel, 0.8% THD (20 Hz to 20 kHz at 8 ohms). It incorporates the company's Class "G" amplifier circuit design and is said to be capable of delivering up to 400 watts/channel of transient music power with rated distortion. Features include dual power-output meters, separate signal and tuning meters, microphone mixing, turnover tone controls, audio mute lever switch, FM muting/auto-lock switch, MPX noise-filter, i-f wide/narrow switch, three front-panel speaker system selector switches, and tape copy and monitor switches. In addition, performance specifications include 1.5 \(\mu\)V FM sensitivity, 85 dB selectivity and 50 dB stereo separation. $1000.

CIRCLE NO. 99 ON FREE INFORMATION CARD

MITS AUDIO CASSETTE INTERFACE

The MITS Model 680b-KCACR is designed to interface the Altair 680b microcomputer's bus with an audio cassette recorder/player to provide a mass data storage/retrieval medium. The circuitry is based on the Kansas City Standard. Other design features include a digital demodulator, CMOS logic for low power consumption, a motor control circuit for starting and stopping tape motion, and test points at key locations in the circuit. All IC's are socketed. A complete set of documentation containing diagnostic software, test-point waveforms, theory of operation, and a detailed operator's section is provided. Altair 680b BASIC, Version 1.2, has been developed for use with the system and includes the standard functions and operations of 680b BASIC as well as the capability to store and load software through the interface system.

CIRCLE NO. 100 ON FREE INFORMATION CARD

POPULAR ELECTRONICS
ANOTHER UNIQUE PRODUCT
DESIGNED, MANUFACTURED
AND MARKETED WORLDWIDE
BY
OK MACHINE & TOOL CORPORATION

BATTERY WIRE-WRAPPING TOOL MODEL BW-630

$34.95*

ANOTHER UNIQUE PRODUCT
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AND MARKETED WORLDWIDE
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OK MACHINE & TOOL CORPORATION

STRIP/WRAP/UNWRAP TOOL MODEL WSU-30

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ANOTHER UNIQUE PRODUCT
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WIRE DISPENSER MODEL WD-30-B

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ANOTHER UNIQUE PRODUCT
DESIGNED, MANUFACTURED
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DIP IC INSERTION TOOL WITH PIN STRAIGHTENER
MODEL INS-1416

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$3.45*
**HUSTLER CB ANTENNA CATALOG**

The Hustler 1977 revised 26-page CB and Monitor antenna catalog is offered by New-Tronics. Mobile and base station antennas are illustrated with special designs including the "Homing Pigeon," the "Hustloff" and "Super Hustler." A selection of 40-channel antennas and hardware is also described plus a new series for recreational vehicles.

Address: New-Tronics Corp., 15800 Commerce Park Dr., Brookpark, OH 44142.

**LOUDSPEAKER CATALOG**

"Quam '77, The Sound Decision" is the title of the new, 12-page catalog from Quam-Nichols. Listed are 127 models, including mobile 2-way radio replacement speakers and updated listings of general-purpose, automotive, high-fidelity, music-instrument and sound-system loudspeakers and matching line transformers. Specifications for each speaker provide information on dimensions, frequency response, power handling capability, voice coil impedance and diameter, and magnet material and weight. Line drawings illustrate configurations and mounting dimensions.

Address: Quam-Nichols Co., 234 E. Marquette Rd., Chicago, IL 60637.

**MOTOROLA EXCLUSIVE-RADIO-CHANNEL GUIDE**

"Introducing a New Dimension In Radio Communications" is a guide offered by Motorola for land mobile business radio operators interested in interference-free, FM 2-way radio communication. The booklet provides information on the FCC's decision to assign an exclusive channel to any user who can meet the 800-MHz loading requirements.

Address: Motorola Communications Group, Literature Distribution Center, 1301 E. Algonquin Rd., Schaumburg, IL 60196.

**BREADBOARDING & TEST EQUIPMENT**

The 24-page, Spring 1977 Breadboarding and Test Equipment Catalog is available from Continental Specialties. The company's line of solderless breadboards (including the Experimentor series which snap-together suit circuit design) are described, along with protoboard kits; logic monitors; logic probes; and equipment for design troubleshooting and testing. A section describing components is also included.

Address: Continental Specialties Corp., 44 Kendall St., Box 142, New Haven, CT 06509.

**RCA BIMOS OP AMP BULLETIN**

Data Bulletin, File No. 976, describing the CA3160 series of BIMOS operational amplifiers, is available from the RCA Solid State Division. The CA3160 series are frequency-compensated versions of the popular CA3130 COS/MOS operational amplifiers. Features include high input impedance and low input current, wide bandwidth (15 MHz), high slew rate, and strobing capability to reduce standby power consumption. Applications include voltage followers and regulators, and voltage-controlled oscillators.

Address: RCA Solid State Div., Box 3200, Somerville, NJ 08876.

**VOR RECORD CLEANER BROCHURE**

VOR Industries offers a 4-color brochure describing the benefits and operation of its Vac-O-Rec "dry" vacuum record cleaner. Address: Sales Dept., VOR Industries, 1440 S. State College Blvd., Unit 5H, Anaheim, CA 92806.

**STACO POWER SUPPLIES SPEC SHEET**

A spec sheet from Staco, Inc. describes its line of regulated and filtered power supplies for "home base" operation of mobile CB radios, stereos, and tape decks. Technical data, features and application information are provided. Address: Staco, Inc., 2240 E. 3rd St., Dayton, OH 45403.
SWTPC announces first dual minifloppy kit under $1,000

Now SWTPC offers complete best-buy computer system with $995 dual minifloppy, $500 video terminal/monitor, $395 4K computer.

$995 MF-68 Dual Minifloppy
You need dual drives to get full benefits from a minifloppy. So we waited to offer a floppy until we could give you a dependable dual system at the right price.

The MF-68 is a complete top-quality minifloppy for your SWTPC Computer. The kit has controller, chassis, cover, power supply, cables, assembly instructions, two highly reliable Shugart drives, and a diskette with the Floppy Disk Operating System (FDOS) and disk BASIC. (A floppy is no better than its operating system, and the MF-68 has one of the best available.) An optional $850 MF-6X kit expands the system to four drives.

$500 Terminal/Monitor
The CT-64 terminal kit offers these premium features: 64-character lines, upper/lower case letters, switchable control character printing, word highlighting, full cursor control, 110-1200 Baud serial interface, and many others. Separately the CT-64 is $325, the 12 MHz CT-VM monitor $175.

$395 4K 6800 Computer
The SWTPC 6800 comes complete with 4K memory, serial interface, power supply, chassis, famous Motorola MIKBUG® mini-operating system in read-only memory (ROM), and the most complete documentation with any computer kit. Our growing software library includes 4K and 8K BASIC (cassettes $4.95 and $9.95; paper tape $10.00 and $20.00). Extra memory, $100/4K or $250/8K.

Other SWTPC peripherals include $250 PR-40 Alphanumeric Line Printer (40 characters/line, 5 x 7 dot matrix, 75 line/minute speed, compatible with our 6800 computer and MITS/IMSAI); $79.50 AC-30 Cassette Interface System (writes/reads Kansas City standard tapes, controls two recorders, usable with other computers); and other peripherals now and to come.

Enclosed is:

- $1,990 for the full system shown above (MF-68 Minifloppy, CT-64 Terminal with CT-VM Monitor)
- $995 for the Dual Minifloppy
- $325 for the CT-64 Terminal
- $175 for the CT-VM Monitor
- $395 for the 4K 6800 Computer
- $250 for the PR-40 Line Printer
- $79.50 for AC-30 Cassette Interface
- Additional 4K memory boards at $100
- Additional 8K memory boards at $250
- Or BAC # Exp Date
- Or MC # Exp Date

Name Address City State Zip

Southwest Technical Products Corp.

219 W. Rhapsody, San Antonio, Texas 78216
London: Southwest Technical Products Co., Ltd.
Tokyo: Southwest Technical Products Corp./Japan
CONSEQUENTIAL things are suddenly happening in the consumer tape industry. I don’t mean to refer to the Elcaset and similar evolutionary developments. Rather, the overall potential of consumer tape recording in any format is on the brink of giant steps forward in at least three and possibly four areas of research. The first step is probably only months away. The second involves a technology that is virtually perfected, but poses compatibility problems with almost all existing tape machines. The third will insinuate itself subtly over a period of some years. And the fourth is a total departure from anything that has gone before.

Let’s take them as they (probably) will occur.

The Hall Head. The Hall effect, named after its discoverer, was happened upon late in the nineteenth century. It involves the ability of a suitably biased piece of semiconductor material (metallic compounds of antimony, arsenic, and other exotic metals being among those favored) to develop an “output” voltage proportional to any magnetic flux impinging on it. This is precisely what we want from the playback head of a tape recorder. But there is an important distinction! A conventional coil-wound playback head can only respond to the rate of change in magnetic flux (the crossings of magnetic lines of force), and hence it cannot respond to a tape that is not moving. A Hall device can, however (with a steady and triumphant dc output). This opens a delightful Pandora’s Box of possibilities.

The possibilities are all based on the virtual elimination of playback equalization in tape machines. Conventional playback heads, being rate-of-change dependent, exhibit a rising output with rising frequency, and hence must be compensated by “lossy” equalization circuits to restore flat frequency response. Additional gain stages must then be used to repair the losses, and the noise contribution from the electronics becomes a significant problem.

A Hall-effect device could care less about rate of change. Instantaneous flux determines its output, which is therefore independent of frequency and essentially “flat” from any properly recorded tape. Of course, gap losses at high frequencies are still a factor (present Hall-effect heads use conventional head “yokes” of laminated iron with carefully defined gaps), but the amount of equalization necessary to compensate for them is comparatively (and audibly) trivial.

At a press conference in late April, Hitachi announced the intention of installing Hall-effect playback heads into three-head cassette machines within the year. (At present no application for the Hall effect in record heads is foreseen, so any Hall tape recorders will necessarily have to be three-head devices.) The Hitachi people allowed that development, requiring an exceedingly thin slab of material, was frustratingly difficult. (A vapor-deposited film of indium antimonide on a ferrite substrate is used, amounting to a total thickness of about 1 micron.) The resulting playback head, lacking bulky coils, is quite compact, permitting it to nestle that much closer to the record head in a cassette deck. It thus further reduces the possibility of tape skew between record and playback gaps.

Another benefit legitimately claimed for the Hall head is a drastic reduction in phase shift (academic when you consider that the record head has already introduced copious phase shift, but of interest all the same). The Hitachi spokesman, Dr. Miyazaki, also claimed that the Hall head developed by his company is intrinsically less noisy than a coil-wound playback head. If true, this (and all the rest of the benefits) should put a good ferric tape recorded without Dolby noise reduction (and played on a Hall-head machine) within easy reach of a chromium-dioxide tape recorded with noise reduction.

Fe “Yes,” Fe₂O₃ “No!” But who cares about ferric-oxide tape if a pure-iron tape can do much better? I first heard about tape coatings containing pure metal particles (not oxides) several years ago. At that time, Philips was talking about some remarkable results achieved with pure-iron tapes. The major fly in the ointment was that these tapes tended to corrode rapidly and even burn into flame spontaneously when used in an atmosphere containing oxygen. Now 3M, in a recent announcement, claims to have found a way—presumably an alloying process—to keep a very “hot” tape from literally burning itself up. And “hot” is an understatement. The tape, which 3M has dubbed Metafine, is reported to provide an increase in recording headroom (or signal-to-noise ratio, if you prefer) of between 6 to 12 dB over anything now available, at all audio frequencies. The potential here is a little unsettling, to say the least.

The company originally viewed Metafine as a video-tape product; but when its phenomenal retentivity characteristics became apparent, the temptation to really rock the audio-tape market was a strong one.
NOW, SCANNING
OVER 6000 FREQUENCIES
IS AS EASY AS
USING A PUSHBUTTON
PHONE.

Introducing the incredible new Bearcat 210.

The exciting new Scanner Radio with the
space-age, computer control center that brings in
every available public service frequency with
pushbutton ease.

Bearcat's new 210 is as easy to program as
a pushbutton phone. You can select any of the
public service bands (all the available local
frequencies) simply by pushing buttons.

Simply punch in the frequency numbers on the
computer control center keyboard. Hit the Enter
button. And you're programmed.

A large, flashing, digital readout panel shows
you each frequency you've selected.

The Bearcat 210 patented search capacity lets
you explore the endless world of every available
public frequency out there, too.

Best of all, you're no longer limited to a given
band or set of frequencies. The new Bearcat 210
is synthesized. Space-age circuitry lets you forget
crystals forever.

Let's look at some Bearcat 210 features and
clicks.

5 BAND COVERAGE - Includes Low, High, UHF
and UHF 'T' public service bands; the 2-meter
amateur (Ham) band; plus other UHF frequencies.

SCANS 20 CHANNELS PER SECOND - In half
a second, the Bearcat 210 scans all 10 channels.

CRYSTAL-LESS - Space-age circuitry with 5
custom designed chips. You never have to buy a
crystal.

TRACK-TUNING - Patented track tuning provides
full-band coverage on every band.

AUTOMATIC LOCK-OUT - Locks out channels and
'skips' frequencies not of current interest.

AC/DC - Mobile mounting bracket included.

SELECTIVE SCAN DELAY - Adds a two-second
delay to prevent missing transmissions when
calls and 'answers' are on the same frequency.

AUTOMATIC SEARCH - New, patented feature
searches out any active local public service
frequency automatically. For more police, fire,
marine, emergency calls. And much more.

THE NEW
BEARCAT 210
THE MOST EXCITING THING THAT'S HAPPENED
TO SCANNING SINCE SCANNERS.

Electra Company
300 East County Line Road, South, Cumberland, Indiana 46229
Copyright 1977 Masco Corporation of Indiana
No other school gives you a choice of five ways to learn TV/Audio servicing, with complete courses starting as low as $445 and convenient, inexpensive time payment plans. No other school includes both an engineered-for-training 25" diagonal color TV and a four-speaker Quadraphonic stereo in its best course. In fact, to even match this kind of thorough training at another school, you'd have to take an extra course costing hundreds of dollars more. We're proud to quote our prices because we believe you get top educational value from NRI.

You pay less because NRI passes its savings on to its students.

NRI pays no salesmen. We buy no outside "hobby kits" for our experiments or training kits. We design our own equipment with special Power-On features that allow you to experiment as you build. You get low tuition rates without the penalty of exorbitant interest charges for time payments. We pass the savings on to you.

More than 1 million students have come to NRI for home training.

Home study isn't a sideline with NRI. We've been its innovating leader for over 62 years. More than one million students have enrolled in our many career courses. NRI is one of the few home study schools with a full-time staff of engineers, authors and editors to help you with any problem. NRI graduates will tell you: you can pay more, but you can't buy better training.

Widest choice of courses with digital computer, CB, and complete communications.

Send for the free NRI electronics catalog and check out the full spectrum of courses available, including Color TV, FCC License, Complete Communications Electronics—with Citizens Band radio, Computer Electronics, Marine and Aircraft Electronics, Mobile Communications, etc.

Mail the card for your free NRI catalog.

No salesman will call.

Available for career study under GI Bill
Check the GI Bill Box on the card for information.
7 kits: Quadraphonic Stereo...
$445 or low monthly terms
A basic TV/Audio Servicing Course including 7 training kits for your experiments. You build your own 4-speaker Quadraphonic System, solid-state volt-ohmmeter, CMOS digital frequency counter, and electronics Discovery Lab. Includes 48 bite-size lessons (18 on color TV), 10 special reference texts with hundreds of servicing shortcuts, tips on setting up your own business, etc. This completely up-to-date course covers black & white and color TV, FM multiplex receivers, public address systems, antennas, radios, tube, transistor and solid-state circuits.

11 kits: Quadraphonic Stereo and B/W TV...$550 or low monthly terms
A complete course in B&W and Color TV Servicing, including 48 lessons (18 on color TV) 10 special reference texts and 11 training kits. Kits you build include 4-speaker Quadraphonic System, solid-state volt-ohmmeter, CMOS digital frequency counter, electronics Discovery Lab, plus a 12” diagonal solid-state black & white portable TV to build and use. At each assembly stage, you learn theory and “Power On” application of that theory in typical solid-state TV sets.

11 kits: 19” diagonal Color TV...
$880 or low monthly terms
The course includes 42 lessons and 4 reference texts plus kits and experiments to build a superb solid-state 19” diagonal color TV receiver... complete with cabinet, and engineered specifically for training by NRI’s own engineers and instructors. This handsome set was designed from the chassis up to give you a thorough understanding of circuitry and professional troubleshooting techniques. You build your own solid state volt-ohmmeter, CMOS digital frequency counter, and experimental electronics Discovery Lab.

14 kits: 25” diagonal color TV and Quadraphonic Stereo...$1195.00 or low monthly terms
The ultimate home training in Color TV/Audio servicing with 48 bite-sized lessons, 10 reference texts, and 14 training kits... including kits to build a 25” diagonal color TV, complete with console cabinet; a 4-speaker Quadraphonic Center; a wide band, solid-state, triggered sweep, service type 5” oscilloscope, digital integrated circuit color TV pattern generator; a CMOS digital frequency counter, and an electronics Discovery Lab. This gives you thorough TV and Audio training for hundreds of dollars less than the separate courses you’d have to take elsewhere.
This Master Course combines theory with practice, using the “Power On” stages for experimentation and learning. Building NRI’s equipment will give you the confidence and ability to service any color TV or Audio unit on the market. And you’ll have a magnificent TV and quad unit for years of trouble-free performance.

Pro Color: 19” diagonal color TV...
$665 or low monthly terms
An advanced Color TV Servicing Course for experienced technicians, 18 lessons, 5 new “Shop Manuals”, and NRI 19” diagonal Color TV receiver with cabinet.
bit too hard to resist. Consequently there now exists—in prototype form—a Metafine cassette tape. Of late it has been made available to tape-machine manufacturers for their confidential evaluation and feedback, and rumor has it that similar tapes from Maxell and TDK are undergoing the same process.

Of course, there are a few things about Metafine that will take some getting used to. For example, its coercivity is on the high side of 1,000 oersteds, or roughly twice that of chromium dioxide.

This will call for a bias current approaching the strength of the erase current used in some consumer tape decks. 3M estimates there might perhaps be one tape machine presently on the market (whether professional or consumer was not specified) capable of delivering that kind of bias through to its record head. As for the rest of the machine population, the anticipated problems with tape-head saturation and even excessive head temperatures are obvious. Evidently we'll all need new tape machines to cope with recording Metafine and other tapes of its kind. In the meantime, wouldn't Metafine make a really superb prerecorded tape?

Transports. Chances are that the tape-transport mechanism on your open-reel tape machine looks pretty much like mine: supply reel to port, take-up reel to starboard, heads in the middle (with the capstan and pinch roller just to the right), and tape guides or tension arms here and there. Not all audio tape recorders look like this. The 3M Iso-loop transport, invented years ago by tape pioneer John Mulinn and still enjoying immense popularity in professional recording studios, is a marvel of simplicity by comparison.

A large central capstan and two pinch rollers are used. The left-hand pinch roller seizes the tape and propels it downward around a roughly rectangular head nest. As the tape comes up again, the right-hand pinch roller takes hold and sends the tape out in the direction of the take-up reel. Both pinch rollers contact the same capstan, and hence there's not the battle over which capstan will “win” that you find in some dual-capstan designs. The capstan and the left pinch roller are gently “stepped” in profile, providing two effective diameters. The left pinch roller contacts the inner diameter of the capstan, while the right pinch roller rides on the outer capstan diameter. The resulting differential in surface velocity controls tape tension across the heads quite precisely, and the whole concept makes for an absolute minimum of unsupported tape in the head region. I never expect to hear a user of an Iso-loop transport complain of scrape flutter or other unsupported-tape problems.

It nearly brought tears to my eyes to visit 3M some weeks ago and find numerous Iso-loop transports designed for ¼-inch tape in constant use, and none of them available to the consumer. But there's a bit of consolation to be had in the fact that, last year, Technics/Panasonic introduced the RS-1500US, a machine whose transport is the Iso-loop
Some guys rely on their 2-way radios more than others.

Fighting a fire takes tough men. And tough equipment. Equipment like the Motorola® 2-way radios carried by so many fire fighters.

Today you can own a 2-way radio with many of the engineering principles that go into Motorola professional radios.

You can own a Motorola CB.

Features like gain control, audio compression, and noise limiting are built in, fully automatic.

So a Motorola CB is exceptionally simple to operate. Yet offers outstanding talk/listen performance.

A top-fire 3½-inch professional-quality speaker produces an audio fidelity that must be heard to be fully appreciated.

A power mic that doesn’t require batteries, that doesn’t cost extra, is standard equipment.

When you’ve made 2-way radios as long as Motorola, the result is a radio with a difference you can hear.

Whether you’re fighting a fire. Or fighting the traffic home.

Motorola CB

From the voice of experience in 2-way radio.
You gotta shop around.

When you do, you'll probably pick CIE. You can't afford to settle for less when it comes to something like electronics training that could affect your whole life.
When you shop around for tires, you look for a bargain. After all, if it's the same brand, better price—why not save money?

Education's different. There's no such thing as "same brand." No two schools are alike. And, once you've made your choice, the training you get stays with you for the rest of your life.

So, shop around for your training. Not for the bargain. For the best. Thorough, professional training to help you pride and confidence.

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If your cartridge is more than three years old, don’t replace your stylus!

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(aside that pinch rollers of different hardness composition are used instead of the stepped pin roller and capstan arrangement). As far as I can tell from my brief experience with the Technic deck, the trick of creating tape tension across the heads with hard and soft pin roller works reliably, but I regret that I have no firm numbers to report.

The trend of the moment, of course, is to eliminate pin roller entirely, a goal being pursued in the professional field by Ampex (the ATR-100) and in the consumer area by Uher with its recently introduced Omega drive. The benefits of pin rollerless drive are difficult to describe in a few sentences, so the subject is best put aside until the time when the trend is more fully established. However, be aware that it seems to be the coming thing.

PCM. But once again, who cares about sophisticated tape transports if he can have a nonanalog recording system that pays no attention to speed irregularities? Pulse-code modulation (PCM), although not a digital recording technique in any strict sense, is independent of recorded signal strength (and hence tape noise). It is also potentially independent of tape-speed irregularities.

It consists of a series of uniform-amplitude pulses (on tape or any other recording medium) that define the analog signal originally picked up by the microphones. They are “metered” by an electronic clock in the playback system to eliminate any time errors. So far as I know, there is no standard “code” to which audio PCM systems adhere. Duration and spacing of the pulses are the data that the recording generally provides, and these variables are “interpreted” as the designer of the overall system sees fit.

Don’t look now, but consumer PCM recorders are virtually right on top of us. Sony has announced an adapter for the Betamax video-cartridge deck that will convert it into an audio PCM recorder. Another highly esteemed tape-machine manufacturer (I’m not free to name names just now) has halted all work on its latest open-reel creation to convert it to PCM. The conviction here is that PCM is the only possible (immediate) future for tape, and that a properly designed conventional audio recorder can do the job quite nicely, thank you.

It’s apparent from the foregoing that tape recording, after these four immanent developments have materialized, will never be the same again. So let’s gird our loins for the onslaught.  

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In recent years, several FM tuners and receivers have been acclaimed as being "digital" components. In this context, "digital" is a catch-word that (with apologies to Lewis Carroll) usually means just what its writer intends it to mean; no more, and no less.

The most obvious external feature of a digital tuner is its frequency display, which is usually the only digital feature it has. Instead of a tuning dial calibrated with an accuracy that may range from the barely acceptable to the unusable, the tuner frequency is displayed via glowing digits to the nearest 0.1 MHz (or 10 kHz on AM, if that feature is included). In its simplest form, a digital FM tuner uses a frequency counter to measure its local oscillator frequency, subtract 10.7 MHz, and display the difference. Such a tuner (the Heath Model AR-1515 receiver, reviewed in this issue, is a good example) still requires a tuning meter as an aid to finding the exact center of the channel, since the digital display cannot resolve closer than 100 kHz. Normally the display blanks out "even" numbered channels (for example, it will go directly from 96.1 to 96.3 MHz) since all channel assignments in this country are on "odd" frequencies.

The advantages of the counter-type frequency display to the user are its improved accuracy and visibility at a distance. The designer's job is easier because he does not need a linear tuning characteristic, or even any sort of reproducible tuning characteristic. However, the same stability and overall tuning ease are required as for any ordinary tuner.

Another type of digital tuning system uses a frequency synthesizer instead of a free-running oscillator. As a rule, a phase-lock loop (PLL) locks the local oscillator to a stable crystal oscillator. The PLL is an analog circuit, but considerable digital circuitry is required in the frequency dividers that reduce the frequency of the local oscillator to where it can be compared with the reference signal. And, of course, this type of tuner has digital counter and display circuits as well (although this function could be handled easily by several selector switches like those used to select channels on 144-MHz Amateur FM transceivers).

A synthesized tuner behaves quite differently from one that has a free-running oscillator with a frequency counter display. The synthesized signal moves in discrete steps, usually 200 kHz in this country. (Some European synthesized tuners use 50-kHz steps to accommodate the channel assignments used there.) A tuning meter is not required, since the oscillator frequency is generated— and known—with far more accuracy than could be achieved by any manual tuning means.

A synthesizer can be programmed to generate any frequency within its range. The most striking example of this (and still the only unit of its kind) is the Heath Model AJ-1510A FM tuner. Any frequency in the FM band can be selected by sequentially pressing the calculator-type keys on its panel. This tuner and some others made in past years also can be programmed with punched cards to go immediately to the selected frequency when a card is inserted in a slot in the panel. (Heath's tuner can hold three cards, which can be selected by push buttons.) For scanning a band of frequencies, synthesized oscillators can be swept electronically (in discrete steps, although this is not obvious to the user), or tuned electrically by a conventional knob. The Revox tuner covers the FM band in 50-kHz steps as its knob is rotated, as an example.

The next step up in digital complexity is the use of a microprocessor in a tuner. So far, the only such application we know of is in a new "super tuner" announced by Sherwood but not yet available for sale at this writing. Not only the frequencies, but the call letters, of selected stations can be made to appear on its alphanumeric display. We will undoubtedly see other, even more imaginative, applications of digital circuitry to tuner displays in the near future.

Of course, none of these novel and intriguing applications of digital electronics to FM tuners affects its sound. And since they all add to the cost, one is spending a portion of the product's cost for cosmetic appeal in many cases, and for repeatable tuning accuracy in other instances.

Are there any actual digital circuits used in the functional portions of the tuner? There are a few easily overlooked ones because they are within a single circuit block or IC chip whose function is basically analog. In a multiplex demodulator, for example, there are frequency dividers to produce 38- and 19-kHz signals from a 76-kHz voltage-controlled oscillator (vco). For that matter, digital techniques have been used for decades in FM detection to give the greatest linearity. The discriminator, or ratio detector, is one of the sources of distortion in an FM tuner. It should be perfectly linear, with a voltage output proportional to signal frequency. Any nonlinearity
creates distortion in the audio signal from the tuner. Most discriminators depend on a resonant circuit for their operation. This circuit can be linear over only a limited band of frequencies and never perfectly linear from a theoretical standpoint.

For many years, the counter-type detector has been recognized as the most linear form of FM demodulator. In the ideal case, it would generate a single very-short pulse of constant width and amplitude every time the incoming signal waveform crosses the zero-voltage axis. The average value of these pulses, emerging in a train from the detector, is proportional only to the number of pulses occurring in a unit of time (that is, to the frequency of the incoming signal). Since the pulse amplitude is also independent of the signal amplitude, this type of detector is also an effective limiter.

In practice, a true counter detector is too expensive to use in a consumer-type FM tuner, although it is found in some laboratory instruments. Less expensive versions have been developed, some of which are found in recent products from Sherwood and Heath (the Heath AR-1515 has such a detector).

Another digital circuit in an FM tuner is in its interstation noise muting system. This is literally a "go/no-go" circuit that responds to one or more of the internal tuner parameters that depend on the presence, frequency, or strength of a signal. These include the discriminator output and limiter voltages and high-frequency random noise in the detector output. In the more sophisticated muting systems, a logic circuit monitors all these voltages and passes the audio signals only when they indicate that a signal of receivable quality is in the tuner's pass band. The "digital" character of the final muting action may range from none at all (a gradual reduction of signal level with strength) to total (a reed relay that opens or shorts the audio).

Aside from these idealized examples, the very nature of FM reception is analog rather than digital. So when you read about a "digital" tuner, remember that this applies, at most, only to the generation of its local oscillator signal or, more probably, only to the display of its frequency. It is still less expensive to make an accurately calibrated tuning dial that's readable to 100 kHz than to incorporate a frequency counter into an FM tuner. Nevertheless, so few companies have ever made a serious effort to achieve "slide-rule" dial tuning accuracy (this is one tuner parameter that has absolutely no relationship to the selling price of the product) that we assume digital numeric displays will eventually take over this function. As dropping prices of digital IC's and display components eliminate the economic advantage of a tuning dial, we can expect digital tuner displays to become common at all price levels in a few years.

HEATH MODEL AR-1515 AM STEREO FM RECEIVER

Complete integrated tuner/control center/amplifier has digital display.

The Model AR-1515 AM/stereo FM receiver that tops Heath's hi-fi receiver lineup is derived, at least in part, from the highly versatile Modulus introduced a couple of years ago. For example, both have digital numeric AM/FM frequency displays instead of a tuning "dial" and most circuits are built on swing-up, plug-in pc boards. (In fact, the optional FM Dolby decoder in both cases is identical.) Where the two differ is in the fact that the Model AR-1515 is a complete integrated tuner/control center/amplifier, while the Modulus is basically a tuner/control center to which external power amplifiers must be added. The new digital receiver is rated to deliver a minimum of 70 watts/channel into 8 ohms with less than 0.08% THD from 20 to 20,000 Hz.

The Model AR-1515 receiver measures 21½"W x 15"D x 6¼"H (54.6 x 38.1 x 15.9 cm) and weighs 35.8 lb (16.3 kg). Available only in kit form, it is catalog priced at $549.95. The optional Model AD-1504 FM Dolby decoder kit is $39.95.

General Description. The numeric display is really what makes this a "digital" receiver. The ½" (12.7-mm) red LED seven-segment display indicates FM frequencies to the nearest 0.1-MHz, displaying only the odd-numbered channels used in the U.S., and to the nearest 10-kHz on AM. The display and its decoder/driver circuits are located behind a rectangular "dial" area at the left of the front panel. The dial area is covered with a window that appears as a dead black area when the receiver is turned off.

Also behind the window are two meters that indicate relative signal strength on AM and FM and center-channel tuning on FM. The meters are lit in soft blue-green when the tuners are in use. Other illuminated legends that appear on the window identify the program source selected (AUX, TAPE, AM, FM, PHONO 1, and PHONO 2), the mode (MONO or 2CH), and the presence of a stereo FM PILOT during reception.

To the left of the dial window is the pushbutton POWER switch. When the power is on, no discrete power indicator comes on. Instead the numeric display lights up when the receiver is set to either tuner or at least one of the other legends is illuminated when the tuners are not selected to indicate the power-on status.

To the right of the dial window area

Hirsch-Houck Laboratories

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To the right of the dial window area

Popular Electronics
are all the primary controls, arranged in a horizontal row. These include the tuning control, mode and source selector switches, and the volume control. All less-frequently used controls are located along the lower portion of the front panel and hidden behind a narrow panel that hinges down to allow access to them. At the left is a headphone jack for private listening. This is followed by separate pushbuttons that switch in and out two sets of speaker systems. The next two buttons allow switching in and out low and hi audio filters. Next come three small controls, with knobs that are the same size and shape as those on the pushbutton switches. These are for adjusting the bass, treble, and balance.

After the rotary controls come seven pushbutton switches: tone flat bypasses the tone controls; loud compensates the response at reduced volume levels; squelch defeat; blend reduces noise on weak stereo FM signals; Dolby for decoding Dolby-encoded FM broadcasts when the optional Dolby module is included; tape mon (monitor); and tape dubbing. The tape dubbing switch is used with the two tape dubbing jacks located to its right. The jacks are labelled in and out. They can be used to patch a second tape deck into the system (in addition to a deck connected to the terminals on the rear of the receiver). Programs can be dubbed from either deck to the other or copied on either or both decks from a selected program source.

The speaker outputs on the rear apron use Heath's proprietary polarized connectors that are designed to simplify installation and eliminate phasing errors. Since there are no markings on the plugs themselves, the "hot" and ground terminals can be identified only by examining the rear panel of the receiver, on which the polarities are plainly marked. (The plugs can go into the connector blocks in only one direction).

Among the input and output connectors provided are separate preamplifier output and power amplifier input jacks that are normally linked together by external jumpers. Vertical and horizontal outputs are also provided for using an oscilloscope as a mulithread indicator. A 300- or a 75-ohm FM antenna can be hooked up to the receiver via screw-type terminals, while a phono jack is used for the shielded coaxial AM loop antenna used with the receiver. (Materials are provided in the kit for making the antenna.)

The power transistors and their large heat sinks are mounted on the sides of the receiver, flush with the rear apron. Wooden walnut-finished side panels decorate the sides between the heat sinks and front panel.

The FM tuner has a preassembled and tested front end containing two MOSFET r-f amplifiers and four tuned circuits. The oscillator frequency is divided by eight before being counted for display on the numeric frequency display. The FM i-f amplifier has two shielded LC filters, IC stages for gain and limiting, and an IC digital detector. The multiplex decoder uses a phase-locked-loop (PLL) IC.

**Laboratory Measurements.** Our test receiver was built from a kit and aligned in accordance with instructions without the use of external test equipment. Since we found that the measured performance of the receiver after assembly and alignment without instruments generally matched or surpassed its ratings, we did not attempt to make any improvements by instrument alignment.

After the one-hour preconditioning period at one-third rated power, the heat sinks were fairly warm but not uncomfortable to the touch. The rest of the receiver was quite cool. (In normal service, the hottest part of the cabinet is directly over the numeric display and its three IC drivers.) The outputs clipped at 78 watts/channel with both channels driving 8-ohm loads at 1000 Hz. The 4-ohm output was 122 watts, and the 16-ohm power was 59 watts.

The 1000 Hz THD was between 0.006% and 0.01% from 0.1 to 30 watts output. It increased to 0.014% at the rated 70 watts and to 0.017% at 75 watts. The intermodulation (IM) distortion was between 0.02% and 0.1% for all outputs from 20 mW to 75 watts output.

At the rated output into 8 ohms, the THD was about 0.015% in the midrange and less than 0.05% from 20 to 20,000 Hz. At half power and less, the characteristic was similar and the distortion remained below those limits. The input required for a 10-watt reference output was 55 mV through the aux inputs and 0.63 mV through the phono inputs. The respective S/N measurements were 85 and 77 dB (unweighted), both of which are exceptional figures. The phono input overloaded at a very safe 125 mV.

The tone control characteristics were excellent, with the bass control turnover frequency shifting from well below 100 Hz to about 300 Hz as the control was moved from center and the treble response hinging at about 5000 Hz. Except at the extreme settings of the controls, the midrange response was hardly affected. The filters had the desirable (and rarely found) 12 dB/octave cutoff slopes, with their -3-dB response frequencies being 5000 and 22 Hz. The loudness compensation boosted both low and high frequencies to such a moderate degree that the feature was actually useful.

The RIAA phono equalization was as
accurate as our test instruments could measure, with ±0.5 dB from 25 to 20,000 Hz. It was immune to cartridge inductance, which changed the frequency response by less than 0.5 dB in the 10,000-to-20,000-Hz range. This is a result of the use of op-amps for the phono preamplifiers, which maintain good isolation between the signal input and the feedback components that determine the frequency response.

The FM tuner was as "hot" as any we have tested. The mono IHF sensitivity and 50-dB quieting sensitivity both measured 10.8 dB (1.9 μV). In stereo, the IHF sensitivity was 17 dB (4.0 μV), and the 50-dB quieting sensitivity was 35 dB (30 μV) with 0.45% THD. The ultimate THD at a 65-dB (1000 μV) input was 0.24% in mono and 0.34% in stereo. The respective S/N measurements were 70.5 and 63 dB. The stereo THD, with L – R modulation, was 1.1% at 100 Hz, 0.63% at 1000 Hz, and 0.07% at 6000 Hz.

The FM capture ratio of 1.7 dB was fair by current standards, though the 72-dB AM rejection figure was well above average. Image rejection was a very good 100 dB, and was barely within the range of our test equipment. Alternate-channel selectivity was also very good at 83.7 dB, and adjacent-channel selectivity was 11.8 dB. The muting threshold, as set by the kit builder, was at 21 dB (6 μV), which was a suitable setting for most purposes (the threshold is adjustable during the alignment of the receiver). Unlike most FM receivers, the AR-1515 does not automatically switch from stereo to mono when the signal strength drops below a certain level. If a stereo signal is heard with too much noise, the user has merely to set the MODE switch to MONO. This does not affect the FM PILOT indicator on the panel, so that one is always aware that a transmission is in stereo, even if it is being heard in mono.

The FM frequency response was almost perfectly flat from 30 to 10,000 Hz and was down 1.4 dB at 15,000 Hz. The 19-kHz pilot carrier in the audio outputs was suppressed to –62 dB. FM tuner hum was –70 dB. Stereo crosstalk was about –47 dB at 400 Hz, increasing smoothly to –28 dB at 30 Hz and to –23.5 dB at 15,000 Hz. Both channels were identical in this respect, and the adjustment of the separation control on the multiplex board (its only alignment adjustment) was completely noncritical. When it is set so that the FM PILOT light comes on, the separation is automatically optimum. The only measurement made on the AM tuner was for frequency response, which (like that of the Heath Modulus) was excellent. It was within ±1 dB from 20 to 4000 Hz, and down 6 dB at about 6800 Hz, after which it dropped off steeply to –30 dB at 10,000 Hz and beyond. (The usual AM "whistles" are effectively eliminated in this tuner.)

User Comment. Assembling the receiver was a time-consuming but by no means a difficult job. The kit builder spent some 41 hours assembling, checking out, and adjusting the receiver. An additional two hours were spent on assembling the tester that comes with the receiver and the optional Dolby noise-reduction module.

As usual, a great deal of credit must be given to Heath's excellent assembly manual and the use of wiring harnesses with prepared wire ends (including sockets for the pc modules) for the ease with which this kit went together. Each sub-assembly that makes up the receiver was packaged in its own box, which made the kit-building job appear more like an exercise in assembling a number of mini-kits. Too, the mechanical portions of the receiver seemed to fall into place, so easily did they line up and fasten together.

In many respects this receiver's performance is in keeping with the better manufactured receivers on the market today in its price range. In almost all other respects, the receiver would rank from good to excellent. Only in a couple of measurements did it fall short of what we have come to expect from an expensive, deluxe receiver. Judged by its actual off-the-air performance and sound quality, the receiver can hardly be faulted. Moreover, we know of no other stereo receiver that can match its AM quality.

The concept of an uncluttered front panel, with only the principal controls exposed to view, is an admirable one. Heath has come very close to achieving this goal in the AR-1515. It missed its full realization, however, by putting the MONO/STEREO switch on the main panel with a knob equal in size to the TUNING, VOLUME, and INPUT SELECTOR controls.

The tuning rate is unusually fast. Only about five turns of the tuning knob are needed to cover the entire FM band. The actual "feel" of the tuning is very different from the freely-moving flywheel mechanisms of other tuners and receivers, but it is very smooth, positive, and

With hinged front panel open, minor controls and jacks are shown.
noncritical. The digital "dial" leaves no doubt as to which channel the receiver is tuned to, of course, and there is no detectable frequency drift, even from a cold start. The tuning is non-critical for optimum noise, distortion, and stereo separation characteristics, so that centering the tuning meter assures that the receiver is doing its best job. Interstation FM muting is positive and noise-free, except for a slight "click" as it goes in and out of action. Also, this receiver is one of the very few to have really effective audio filters.

The AR-1515 receiver is certainly flexible enough for any reasonable listening situation and will easily hold its own with any receiver in sheer listening quality. If the pleasure of building your own receiver is a factor, (it requires considerable time to assemble, but it goes together without a snag), this receiver represents a fine choice since the end result from both a performance and aesthetic view would make any builder proud to claim it as his handiwork.

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THORENS MODEL TD-126C RECORD PLAYER

Has low-mass tonearm and electronic belt-driven turntable.

The new Model TD-126C high-performance record player from Thorens features the company's very-low-mass "Isotrack" tonearm and an electronic belt-driven turntable. It is also one of the very few modern turntables to offer the 78-rpm speed as well as the more commonly available 33 1/3- and 45-rpm speeds. The platter and tonearm are isolated from the base on which the motor controls are mounted by a highly compliant spring suspension.

The record player is supplied on a black base with silver accents and comes with a hinged plastic dust cover. It measures 19 9/16"W x 15 1/2"D x 6 3/4"H (50.5 x 39.4 x 17.1 cm) and weighs 34 lb (15.5 kg). Price is $625. Additional plug-in tonearms are $15.00 each.

General Description. The gimbal pivots support a 9" (23-cm) straight tubular lightweight aluminum tonearm. Anti-skating compensation is applied by opposing magnetic fields and can be adjusted by turning a knob on the side of the pivot housing. Four antisquating scales cover the use of conical and elliptical stylus on dry and wet (lubricated) record surfaces.

A large part of the effective mass of a tonearm is in the plug-in cartridge shell and its locking hardware found in most record-player systems. Thorens has eliminated the usual cartridge shell with the result that the end of the tonearm contains only a plastic T that is just large enough to permit mounting a cartridge through its 3/4" (12.7-mm) spaced holes and a light metal finger lift.

For cartridge installation and interchanging, the entire tonearm plugs into and unplugs from a socket that resembles the four-pin type used in most conventional tonearms at the cartridge shell end. The socket is located, according to the height (6.35 cm) from the pivot, where its mass is much more tolerable than it would be if it were on the end of the tonearm. The removable tonearm (additional arms are available for installing other cartridges) is furnished in a plastic storage container that also serves as a jig for aligning and orienting the phono cartridge.

The 7-lb (3.2-kg) cast nonferrous platter is driven by a 16-pole synchronous motor. The speed of the motor is controlled by a stable Wein-bridge oscillator. A vernier control is provided for adjusting the speeds over a nominal ±6% range.

The controls for the turntable are located in a row across the top front of the base. The suspended portion of the rec-
storage container/setup jig, we found that the apparent tracking error was larger than we had expected it to be. Investigating further, we discovered that it was difficult to measure the tracking error with our stylus protractor because of the shape of the tonearm. (No cartridge shell surfaces are tangent to the record groove.) On the reasonable assumption that the almost constant 2° error that we found was a measurement problem rather than a true tracking error, we determined that the tonearm has a near zero error over most of the record surface and a maximum of 0.5°/in. near the outside of the record.

When we balanced the tonearm so that the stylus was just above the surface (this according to instructions), the tracking force was high by 0.25 gram at all settings of the pressure dial. We readjusted the balance for a correct reading with the force dial set to 1 gram and found that the calibration was accurate over the entire 0.5-to-3-gram range of the dial. However, the tonearm balanced with the stylus about 1/2” above the surface of the record.

When we measured the mass of the tonearm with a calibrated spring driven by a small loudspeaker motor, it was 9.8 grams (after subtracting the 6-gram mass of the cartridge). Although this is somewhat more than the claimed 7.5-gram mass, it was substantially lower than the mass of a typical record player tonearm.

The low-frequency resonance of the M95ED cartridge in the Isotrack tonearm fell at 10 Hz instead of the 8 Hz or so that is typical of other tonearms. The capacitance of the tonearm’s wiring and the integral signal cables was 190 pF/ channel, which is suitable for stereo cartridges but obviously not intended for use with CD-4 cartridges.

The turntable rumble was a very low -42 dB in a lateral unweighted measurement and -64 dB with ARLL weighting. Spectrum analysis revealed that the rumble was predominantly at 6 Hz. Although flutter was a low 0.035%, the wow varied at a slow rate, with a period of several seconds, between 0.02% and 0.08%, averaging about 0.06%. The principal flutter component was at 50 Hz.

The speeds of the turntable were exact and did not change with line voltage or with extended use. The vernier control had a measured range of ±9%.

The antiskating calibration was correct, giving equal distortion in both channels of the cartridge’s output when the control was set to match the tracking force. However, when the antiskating was set to its minimum, there was sufficient residual force to swing the tonearm outward when it was floated in a balanced condition. The descent of the tonearm during cueing was slightly influenced by the antiskating force, causing it to drift outward enough to repeat a couple of seconds of the record.

The isolation of the record player from base-conducted vibrations was extremely effective. There was only one resonant transmission peak, between 40 and 50 Hz, and at this frequency, the sensitivity of the player to external vibration was 10 to 30 dB lower than any other record player we have tested. At other frequencies, the isolation was as much as 50 dB better than on other players. The self-resonant frequency of the player on its springs was about 3 Hz.

User Comment. The Model TD-126C record player represents an appreciable advance in player performance, even
though most of its basic design features are conventional. Most important is that its tonearm mass is the lowest by far that we have measured on a conventional record player (with a pivoted offset arm). The antiskating is correct, which is most unusual in our experience. Turntable flutter is low, though not unusually so, but the rumble is on a par with some of the best direct-drive turntables and is lower than we have previously measured on a belt-driven turntable. And as we mentioned before, this is also one of the very few modern turntables to offer a 78-rpm speed.

The operation of the player is simple and logical, providing a choice of partial automation or none at all. For all practical purposes, the player is immune to acoustic feedback conducted through its base. However, the player was somewhat sensitive to jarring under rough handling.

To counterbalance its virtues, the player is large, heavy, and quite expensive. It is obviously not suited to CD-4 cartridges, and it does not have a perfectly drift-free cueing system (though it is no worse in this respect than most other players).

Cartridge installation was an incredibly exasperating procedure, we observed. Fortunately, this is not a recurring process. Perhaps our reaction is colored by having read the manufacturer’s instruction manual before starting. The importer’s manual is relatively clear on the cartridge installation procedure.

In sum, even at its rather high price, the Model TD-126C record player is certain to appeal to discriminating phonophiles, especially those who have collections of 78-rpm discs.

**ORTHOFON MODEL MC20 PHONO CARTRIDGE AND MODEL MCA-76 PREAMPLIFIER**

*Top-grade stereo cartridge uses moving-coil design.*

Ortofon has recently produced some moving-iron cartridges, but its newest and finest model, the MC20, uses the moving-coil principle, which they had previously employed exclusively. As is the case with most moving-coil cartridges, this one does not allow user replacement of the stylus. Instead, the entire cartridge can be exchanged for a new one at a considerable price saving when it comes time to replace the stylus.

Since the moving-coil type of cartridge has a very low output level, it usually requires a signal “booster” to allow it to adequately drive the phono input circuits of most amplifiers and receivers. This booster can be a step-up transformer or a separate preamplifier, both of which are available from Ortofon. For our tests on the Model MC20 cartridge, we selected the new Model MCA-76 preamplifier.

The Model MC20 cartridge is priced at $120 ($65 on exchange for stylus replacement); the Model MCA-76 preamplifier is $170.

**General Details.** A modified elliptical “Fine-Line” stylus is used on this cartridge. The shape of the stylus allows contact with the groove walls along thin edges in a manner similar to that of the special styli developed for CD-4 cartridges to give better high-frequency tracking and lower record wear. The compliance of the cartridge is rated 25 horizontally and 15 vertically, and the equivalent tip mass is 1.5 mg. The range of tracking forces is rated at 1.6 to 3.0 grams, with 1.7 grams being the force recommended by Ortofon. The vertical tracking angle is 20°. Total cartridge mass is 7 grams.

The stylus drives the signal-generating coils through a cantilever whose diameter is stepped to provide stiffness with low mass. The fixed end of the cantilever is supported and damped by a rubber suspension, and the motion of the stylus “wiggles” the dual coil assembly in a powerful magnetic field. Each coil has only 28 turns of very fine wire. Hence, the output signal voltage at a 5-cm/s recorded velocity is a mere 70 µV. The dc resistance of the coils is 2.5 ohms/channel, and the inductance is negligible.

The Model MCA-76 preamplifier used with the cartridge has a voltage gain of 50, which increases the minute output level of the cartridge to about 3.6 mV. The input impedance of the preamplifier is 75 ohms, which is a suitable load for the cartridge. The output impedance of...
less than 140 ohms allows the preamplifier to drive long cable lengths or to be terminated by almost any preamplifier input circuit without modifying the response of either the cartridge or the amplifier.

The maximum input rating of the preamplifier is 6 mV to provide a 300-mV output, providing the assurance that it will never limit the system's dynamic range. The preamplifier's distortion is negligible, rated at less than 0.04% THD and 0.01% IM at the maximum input levels. Hum is rated to be 120 dB below the maximum operating level. Since this is almost 40 dB above the nominal output of the cartridge, the net S/N ratio is on the order of 80 dB, which is highly noteworthy and surpasses the S/N of any preamplifier that is likely to be used with this cartridge preamplifier.

The preamplifier is housed in a small black box and has its own integral ac power supply. A pushbutton switch at one end of the box shuts off the power and simultaneously bypasses the amplifier circuits when in the out position. This allows the preamplifier to be left connected to a record player in which other types of cartridges will also be used. A second button on the case allows insertion of a built-in CD-4 low-pass filter to roll off the response sharply beyond 50,000 Hz. This prevents interference with the demodulator circuits from r-f noise pickup. There is a fixed subsonic filter that cuts off the response very sharply below 7 Hz.

**Laboratory Measurements.** We tested the cartridge both directly at its outputs and through its companion preamplifier. For most of our tests, the cartridge was installed in the tonearm of a Thorens Model TD-126C player.

Experimenting with different tracking forces, we found that a 2-gram force was required to track the highest velocities on our test records. That force was subsequently used throughout our tests. Playing the CBS STR100 test record, the frequency response of the cartridge stopped gently downward with increasing frequency, to about –2.5 dB between 5000 and 10,000 Hz, before rising to between +1 and +2.5 dB at 20,000 Hz. (The two channels responded slightly differently.) The rise was obviously the lower skirt of a relatively undamped stylus resonance, but we did not extend our measurements beyond 20,000 Hz.

Channel separation measured 20 to 25 dB up to 10,000 Hz and beyond. It decreased to 12 to 18 dB at 20,000 Hz. The square-wave response of the cartridge with the CBS STR112 test record revealed fairly low-level sustained ringing over the entire duration of the square wave at a frequency we estimate to be about 40,000 Hz. The measured vertical tracking angle was 20° (as rated).

The output of the cartridge at 3.54 cm/s was about 5.1 mV when using the Model MCA-76 preamplifier, with the two channels matched to within 0.4 dB.

In our tracking tests, the cartridge was able to play all levels of the Shure TTR-110 record at 2 grams, although there was a hint of mistracking at the highest level of the bass drum. The 60-micron level of the German Hi-Fi Institute test record was barely tracked at 2 grams. Using the Shure TTR-103 record, the 10,800-Hz tone-burst distortion was low at less than 1% at all velocities up to 30 cm/s maximum.

The IM test, using the Shure TTR-102 record, revealed that the distortion increased gradually from about 1.6% at velocities slower than 15 cm/s to 4% at 27.1 cm/s. There was no evidence of the severe mistracking that occurs with some cartridges at the higher levels of this record.

The Model MCA-76 preamplifier had a gain of 34 dB (equivalent to a voltage gain of 50) ±0.3 dB from below 10 Hz to well beyond 50,000 Hz. The 1000-Hz distortion was less than 0.04% for outputs up to 100 mV and only 0.1% at the maximum rated output of 300 mV. The output clipped at 430 mV, which required just slightly greater than 8 mV at the input.

We could not measure the noise level of the preamplifier. It was below the minimum levels readable on our instruments.

**User Comment.** An extended listening experience with the cartridge/preamplifier system did nothing to resolve our doubts about whether or not moving-coil cartridges have special qualities. We never heard anything in the sound of this cartridge that we did not hear more or less when playing the same records with other good cartridges. Unfortunately, we were not able to make true A-B comparisons with this and other cartridges in identical tonearms playing the same record.

In the same vein, the measured performance of the Ortofon cartridge reveals that it is good to excellent in practically every respect. After "living" with the new Ortofon cartridge for an extended period, we eventually came to realize that its sound was impressively devoid of harshness and identifiable coloration, measurements aside. We got the personal sense that this cartridge has a clarity and definition that place it somewhat apart from other cartridges, although we would not be able to support this statement objectively.

To our hearing, the preamplifier contributes no noise when in operation. At the highest listening levels we could use, lifting the pickup resulted in dead silence from the speaker systems. (At higher gain settings, which we do not consider to be normal for listening, some slight amount of hiss could be heard.) We did find, however, that there was enough power-line hum pickup in the cartridge circuit, apparently from ground loops, to be audible at high gain settings when the cartridge was installed in the Thorens tonearm. The magnitude of the hum varied with our choice of amplifier and was much less when we installed the cartridge in other tonearms. It appears that this hum problem was a peculiarity of our installation and cannot be chargeable to the record player or cartridge.

This is one of the best as well as one of the most expensive phonograph cartridges we have used. (We include the cost of the cartridge preamplifier in our assessment; the cartridge alone is not unusually expensive.) In combination with a suitable audio system, it will provide as great a sense of reality as any other top-quality cartridge.

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AUTOMATIC percussion synthesizers are popular musical accompaniment accessories. The "Cabonga" described here is a percussion synthesizer that is designed to be played by hand like a conventional bongo drum. All electronic, it is battery powered and produces an output that can drive just about any instrument amplifier/speaker system.

The Cabonga electronically generates a damped sine wave whose frequency is continuously variable to provide sounds that range from a bass drum to a wood block. Its exponential decay time can be varied from a fraction of a second to more than two seconds to simulate sounds that range from a click to a timpani.

Provisions are included for both local and remote triggering. In addition, a multivibrator (such as the automatic trigger accessory to be described next month) can be used to continuously trigger the Cabonga at a preset rate. By interconnecting the external-trigger jacks of two or more Cabongas, you can simulate a wide range of percussion instruments at one time.

In this first part of a two-part article, we discuss the operation and construction of the basic Cabonga. Next month, we cover the accessories that can be used with it. These include snare-drum, automatic triggering, special-effects sound modifier, and a combination ac power supply and active audio mixer.

**About the Circuit.** The circuit of the Cabonga is shown schematically in Fig. 1. When the drum head is struck, S1 closes and applies a positive-going pulse to C1 and R2. This pulse is passed by C2 and 02 to the tone generator. When S1 opens and C1 discharges, the negative-going pulse produced is shunted to ground by D1.

The tone generator is a twin-T active filter made up of IC1B, R4, R5, R10, and C3 through C6. An additional feedback loop is made up of R8 and R9. With the component values shown, applying a trigger pulse produces an exponentially damped sine-wave output. Potentiometer R10 determines the operating frequency of the sine wave, while R8 and R9 in the feedback loop determine the decay time of the damping. The output signal from the tone generator is attenuated by volume control R11 and is buffered by IC1A and fed to J3 for subsequent processing.

**Construction.** The Cabonga's circuit can be assembled on perforated board or a printed circuit board, the etching...
and drilling and component-placement guides for which are shown in Fig. 2. In either case, it is recommended that you use a socket or two rows of Molex soldercons for the IC. Also, be sure you observe the proper polarities and orientation of the components.

The circuit board, batteries and holder, jacks, etc. can be mounted in any convenient size box that will accommodate them and the momentary-action pushbutton switch used for triggering the Cabonga.

The box can be made from four pieces of $\frac{3}{4}$" (19.1-mm) thick plywood for the sides and two pieces of $\frac{1}{4}$" (6.4-mm) thick Masonite or tempered hardboard. The overall dimensions of the box should be roughly $9\frac{1}{2}" \times 7" \times 2"$ (24 x 17.8 x 5.1 cm). The top and bottom of each wall should be rabbed to provide $\frac{3}{8}$" (9.5-mm) deep by $\frac{1}{4}$" wide "shelves" so that the top and bottom plates are flush with the top and bottom of the walls. (Note: If you do not have a router to make the rabbets, you can make each wall from separate pieces of $\frac{1}{2}$" and $\frac{1}{4}$" plywood, cutting the latter $\frac{1}{2}$" narrower and fastening the pieces together with glue and $\frac{3}{8}$" finishing nails.) Round all top and bottom edges of the walls with sandpaper.

The top plate must be finished to permit mounting of the controls, switches, jacks, and the drum head assembly, as shown in the lead photo. If you use a metal control plate as shown, be sure that jack J2 is isolated from it. The calculator switch used under the drum head as the trigger switch is not mounted on the top plate. Hence a $\frac{1}{4}$" (3.8-cm) hole must be drilled for it. Fix the center of this hole at the mid-point of the shorter side and $3"$ (7.6-cm) up from the end opposite the location of the jacks and controls. Drill the hole where the two measurements coincide.

Next, referring to detail A in Fig. 3, fabricate the drum head switch retainer assembly from white pine lumber. Note the grooves in which the hardboard on which the switch is mounted fits. You do not need a router to make these grooves; a sharp wood chisel will do satisfactorily because of the softness of the pine. The No. 8 x 1" sheet metal screw used for adjusting the sensitivity of the drum head should have its point filed off.

Once the retainer assembly is fabricated, fasten it to the bottom surface of the top plate with glue and flathead wood screws. Coat the top surface of
the top plate with contact cement except for a 5½" diameter circular area centered at the keyswitch hole. Neatly cover the plate with black vinyl, overlapping it on all sides. Cut away the vinyl from around the holes already drilled but not from around the keyswitch hole.

The collar over which the drum’s diaphragm is stretched is made from a 6" square by ¾" thick (15.2 x 15.2 x 2 cm) piece of plywood. When the wood ring has been cut out, round the top outer mastic surfaces must close up on each other. This tape is the decorative band that goes around the drum head and covers the staples holding the diaphragm. To hold it in place, use 10 chrome-finished upholstery tacks around the circumference of the ring collar. (See details B and C in Fig. 3.)

Use four ¾" flathead wood screws to fasten the drum head assembly to the top plate, centering it over the calculator key switch. Then glue a block of described above for locating the center of the calculator key hole, locate the center of the access hole for the sensitivity-adjust screw on the key switch retainer assembly. Drill a 5/16" (8-mm) hole at this point. Strike a line passing through the center of this hole and parallel to the bottom edge of the plate. At points approximately 1" (2.54 cm) on both sides of the access hole, drill a ½" (3.2-mm) hole.

Smoothly sand and clean the bottom plate. Then coat a sheet of black vinyl with contact cement and neatly attach it to the outer surface of the bottom plate. Again, overlap the vinyl around all edges and onto the inner surface. (If you wish, you can fasten a sheet of ribbed rubber

and inner edges so that the top forms almost a semicircle. Smoothly sand all surfaces. Then stretch a single layer of fabric-backed white vinyl over the top of the ring collar, fastening it in place with wire staples. Allow the vinyl to overlap the bottom edge and staple it to the side of the ring. Cut the vinyl flush with the bottom edge of the ring. Now, fold an 18" (46-cm) length of black Mystik cloth tape along its entire length ¼" in from both edges so that the tape has a seam down its center. When you fold the tape, the ¾" square by 5¼" long pine to the top plate as shown in Fig. 4 to provide a means for mounting the circuit board assembly and batteries. When the glue has set, fasten the battery holder and the circuit board assembly side by side on the top of the block with woodscrews. Interconnect the board with the various controls, switches, and jacks with insulated hookup wire. Temporarily set aside the top plate assembly.

The bottom plate can be prepared as follows. First, using the same procedure

**Fig. 4. Bottom view of the finished top plate shows the locations of the switch retainer assembly, pc board, controls and jacks.**

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**BILL OF MATERIALS**

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<tr>
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<td>1—piece ¼&quot; tempered hardboard (Masonite or equivalent) 8-3½&quot; x 5-3½&quot;</td>
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<td>1—piece black vinyl 9¼&quot; x 6-3¼&quot;</td>
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<td>1—piece ¼&quot; tempered hardboard 8-7½&quot; x 5-3¼&quot;</td>
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<tr>
<td>1—piece rubber matting 8-3¼&quot; x 5-7½&quot; or 1 piece black vinyl 9¼&quot; x 6¼&quot; (see text)</td>
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<tr>
<td>1—piece cloth-backed white vinyl 7½&quot; x 7½&quot;</td>
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<td>10—chromed upholstery tacks</td>
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<tr>
<td>1—5&quot; x 3½&quot; x 3½&quot; pine block</td>
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<tr>
<td>4—No. 8 x 3¼&quot; wood screws</td>
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<tr>
<td>1—No. 8 x 1½&quot; sheet metal screw</td>
</tr>
<tr>
<td>2—No. 8 x 1½&quot; sheet metal screws</td>
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<tr>
<td>Nails, glue, etc.</td>
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Note: The following are available from JAL Associates, Box 107, Etontown, NJ 07724: Complete kit including all components (M1), $32.50; parts kit (M1-E) including all electronic components, jacks, switches, pc board, $19.50; etched and drilled pc board (M1-PC), $33.50. All prices include postage. New Jersey residents add 5% sales tax.
runner to the outer surface of the bottom plate with contact cement instead of the vinyl. The runner will provide an antiskid grip when the Cabonga is placed on a table as it is being played.) Clear away the vinyl (or rubber runner) from around the three holes. If you are using the rubber runner, clear away enough of it to allow the two screws that go into the holes on both sides of the access hole to go far enough in so that their heads sit flat against the bottom plate. Temporarily set aside the bottom plate assembly.

Smoothly sand and clean all exterior surfaces of the box wall assembly and then coat all surfaces with flat black paint. When the paint has dried, coat the rear surface of a 35" x 4½" (90 x 11.4 cm) sheet of black vinyl with contact cement and wrap it around the wall assembly. Start about 1" from one corner and finish up at the same corner; trim off any excess vinyl to make a neat seam. At each corner, slit the vinyl and trim it as necessary. Carefully fold the vinyl over the top and bottom edges and into the rabbets. Try to avoid having any of the wood show through as you trim.

Before final assembly, check that the air seal between the drum head and the vinyl covering the key switch on the top plate is sufficient for proper triggering. To do this, first adjust the sensitivity screw on the key switch retainer assembly so that it is slightly depressed by the vinyl on the top plate. Press down on the drum head and note whether or not the key switch moves. If it does, the seal is sufficient; if not, you will have to tighten the screws that secure the drum head to the top plate until you get sufficient air sealing. If all else fails, you might have to remove the drum head assembly and place gasketing material between it and the top plate.

Final assembly consists of placing the top and bottom plate assemblies in the box wall assembly and securing the whole unit together with two No. 8 x 1½" sheet metal screws passed through the bottom plate's holes and driven into the crossbar on the switch retainer assembly.

Checkout. To check out the operation of the Cabonga, it is necessary to take it out of its case. Once this is done, feed the output of the Cabonga from J3 to an instrument amplifier. Turn on the power via S2. Now, set PITCH control R10 to about its 9 o'clock position and DEcAY control R9 and VOLUME control R11 fully clockwise. Then turn the sensitivity-adjust screw for the key switch until the switch closes and you hear a sound. Back off on the adjusting screw until the sound drops out and you can hear it only when the drum head is struck.

If the Cabonga breaks into oscillation, adjust trimmer potentiometer R8 until the oscillations just cease. If you hear no oscillations on initial checkout, adjust R8 until you do and then back off until the oscillations just drop out. Replace R4 with a 68,000-ohm resistor if you cannot obtain oscillations no matter where R8 is set.

After the initial adjustment is made, vary the PITCH control over its entire range to determine whether or not oscillations still occur. The circuit might continue to oscillate at higher frequencies, such as at the fully clockwise position of the PITCH control. If these oscillations do occur at high frequencies, break the connection between R10 and the C5/C6 network and insert a 10-ohm resistor between the potentiometer and capacitors.

Experiment with the settings of the PITCH, DEcAY, and VOLUME controls while striking the drum head to determine whether or not the project is operating properly. When you are satisfied with the operation of the Cabonga, reassemble it in its case.

Bottom with rabbeting, tension adjust hole and retaining screw.

Use Ideas. You will probably want to use several Cabongas, each tuned to produce a different sound, at the same time to simulate different musical effects. To interconnect all Cabongas you might wish to use, you can do so with the passive summer shown in Fig. 5. Some attenuation of the signal will occur when the summer is used, but the output level will still be adequate to drive most instrument amplifiers.

When interconnecting Cabongas via the external trigger jacks, you must adjust the individual volume controls so that all sounds can easily be heard.

Next month's discussion of a number of accessories will enable you to add to the Cabonga's versatility. Until then, you have an instrument that should provide many hours of entertainment.

Fig. 5. Mixer combines several signals for use with one amplifier.
CHOOSING PORTABLE & MOBILE TAPE RECORDERS

BY JAMES R. HORSTMANN

Tape enthusiasts need not be tied to a wall socket.

The cassette and 8-track cartridge tape formats for portable and mobile applications have grown and prospered side by side, each boasting its own unique advantages.

The standard compact cassette is actually a small, reel-to-reel tape housed in a self-contained plastic shell that measures only 4" long by 21/2" high by 7/16" thick. Like open-reel tapes, with separate supply and feed reels, it may be rewound or turned over to play other tracks. When the loaded cassette machine is activated, a small pinch roller moves the tape smoothly at 13 ips. Tape measures about 1/2" wide and is available in 20-minute to 120-minute play-or-record-time formats.

Now, there are also sub-compact cassettes. They're designed primarily for voice-dictation and note-taking purposes. Moreover, there are at least four sub-compact systems that are not interchangeable.

The tape cartridge, on the other hand, is much different. Its tape is wound in a continuous loop that's fed from the center of a single reel and rewound on the outside of that same reel, permitting continuous play. When it reaches the end of one revolution, the playback head moves over a notch (manually or automatically) to play the next track. In stereo, this head-moving process occurs four times, while in 4-channel it's done twice. Compared to a cassette, a cartridge is bulky, being four times its size. Tape speed is 31/2 ips and tape width is 7/8", which, theoretically should make the cartridge superior to the cassette in terms of potential hi-fi reproduction.

Further, each tape cartridge contains its own pinch roller (which most experts feel is not an advantage).

Theory aside, however, the standard cassette system generally provides better fidelity. This is due, in part, to the special tape formulations available for cassettes. Additionally, the 8-track cartridge drive and head alignment systems are inherently less precise than a cassette's. But these differences are less noticeable in portables and auto units since Dolby noise-reduction circuitry, dual capstans, etc. are rarely used.

As a result, choice of format generally involves considerations other than high-fidelity sound. For example, if one were to choose a battery-powered portable, it's likely that the choice would be a cassette. Due to its much smaller size and lighter weight, it has essentially eliminated cartridges from this market. Further, cassettes can be rewound and have a fast-forward speed, making it much easier (and faster) to locate specific recorded sections on the tape. Also, most 8-track machines do not offer record facilities, while most cartridge machines do.

Selecting a car tape format, however, is an entirely different story. Here, 8-track cartridges got the jump on cassettes when Lear Jet teamed up with RCA and Ford before Philips got up...
Aside from the auto tape lead initially enjoyed by 8-track, the no-fumble convenience of simply pushing a cartridge into a slot while driving and listening to commercial-free music played without ending attracted many people. It still does, thanks to the availability of a large library of prerecorded tapes and the easy transition from stereo to 4-channel sound made possible by the 8-track cartridge system. The latter is something cassette manufacturers are still struggling with.

Cassettes are challenging the 8-track machine in automobiles, though. Compact size is one reason. Another is the ability to locate portions of a recording very quickly. And, equally important, if a person owns a home cassette deck, the recording facility and interchangeability permit a cassette to do double duty. Also, there are automatic-reversing cassette systems now available for continuous listening.

Costlier cassette models offer a host of extra features you might want to check out. Here are some examples:

- Ac and dc operation to extend battery life.
- Built-in battery charger for automatic charging when plugged in an ac outlet.
- Automatic shutoff with mechanism disengage when tape play is ended.
- Automatic level control to maintain relatively constant sound recording level, so that the recordist need not continually monitor a volume control.
- Large VU/battery indicator for easy viewing.
- Tone control to adjust playback to your liking.
- Tape counter to permit quick location of a recorded portion of your tape.
- Tape select switch to give you the flexibility of using premium tapes.
- Speedier fast-forward and rewind time for impatient users.

These tape recorders illustrate the types available to “on-the-move” tape enthusiasts. Clockwise from upper left: an in-dash AM/stereo FM multiplex radio with cassette player; portable AM/FM radio cassette recorder with weather band; cassette deck for a car with under-dash mounting bracket; portable stereo cassette deck with ANRS and other features.
Dual flywheels for reduced wow and flutter.
Servo-control motor to maintain accurate speed when batteries weaken.
Interlocking pause control for stable recording speed when starting and stopping.
Remote microphone provisions to free you from the machine.
Variable pitch control for the critical music lover.
Peak limiter to automatically prevent distortion from overloading.
Subminiature size for handy carrying.
Stereo provisions.
More powerful amplifier(s).
Automatic voice activator so you don't miss a thing.

Clearly, there will have to be tradeoffs. Each "extra" chosen adds to the cost, weight, and/or size. The latter is sometimes offset by superb miniaturization with rugged construction, but the trade-off here is higher cost.

How does one "test" a portable? There are a number of guidelines: 
1. First, handle it to judge weight and size.
2. Play cassette tapes that you've heard on a high-quality cassette deck (preferably a tape with plenty of highs and lows, and one with a solo piano recording).
3. Record a tape for playback at home.
4. Record a few minutes on a C-120 (two-hour) tape, which is ultra thin, to judge tape-handling quality.
5. If you have a cassette deck at home, you can get more from your mobile unit by making your own recordings. You can save money, too, since prerecorded tapes are costlier than discs by one or two dollars. Furthermore, with a high-quality cassette deck and good source equipment and material, you can make better tapes than you can buy. (Exceptions, here, are the premium prerecorded cassettes made on chromium-dioxide tapes by Advent of classical music.)

An increasingly popular option in car cassette units is a built-in stereo FM radio, which gives the driver more program options. Many of these models have a clever "custom" look in which the radio tuning dial also serves as the cassette slot. Some are wired to record directly off the air (usually in mono, although the unit will play back in stereo), while others even have a hand-held microphone so you can dictate while you drive. If you have only an AM radio in the car, as many of us do, this combination can be most rewarding.

Other features to look for in an auto cassette machine (remembering that they add to the cost) are: automatic reverse, multiband radio, automatic stop and/or reject, and signal-seeking on the radio.

8-Track Players. Features you may want to consider in 8-track machines are track indicators, bass boost, and automatic track switching. Models with automatic play-through often feature a manual override switch so you can select channels if you wish. Cartridge players, too, have been mated with AM/stereo FM radios.

Speaker Installation. Installing speakers and positioning them properly generally presents a severe challenge to the do-it-yourselfer. Probably most people should turn the job over to a specialist, such as an auto dealer or auto radio/tape player installation outfit.

A popular speaker-mounting location is in the front door. There are also kick-panel installations in case the thought of cutting into doors upsets you. The latter technique is less expensive too. Underdash installation of speakers is another possibility, but the overall stereo or quadraphonic effect is reduced considerably. As for rear speakers, you have a choice of rear doors, trunk ledge, or external speakers. You'll have to find the combination that pleases you, based on the interior configuration of your car.

Conclusion. Before finalizing your buying decision—whether a portable or mobile tape machine in the cassette or 8-track format—listen to a unit a "price point" higher and lower to determine if you can hear the difference. Consider, too, whether or not your choice is a well-known brand, the reputation of the deal- er, and what you have to do to obtain in-warranty and out-of-warranty repair. The latter is especially important with auto players since there is a removal-installation chore involved.

Don't expect to match the high-quality sound of your home hi-fi system in portables or mobile equipment—they rarely exceed 10,000 Hz response and are often well under that. If you want truly good sound, do consider adding a "booster" amplifier to increase output power so that some of the fine, compact, low-efficiency speaker systems can be satisfactorily driven. There are also some high-power audio systems designed for car use (including ADS, sold as a package with Nakamichi's 250 cassette player or 350 record/player.) In any case, experienced travelers feel that fairly good mobile sound is every bit as rewarding as great sound that just sits there.
THE DAY of the 27-MHz band unlicensed walkie-talkie is coming to an end. Production of such units has been halted, but the millions of unsold walkie-talkies can still be sold until March 1978. After this time, unsold units must be junked or rebuilt for the new 49.9-MHz band to which personal-communication walkie-talkie operation has been moved. Existing 27-MHz band w-t’s can still be used until March 1983.

The FCC established the 49.9-MHz personal-communication band for two good reasons. The first is that users of the 100-mW walkie-talkies operating on the 27-MHz Citizens Band are being clobbered by the standard 4-watt CB transceivers that must be operated with a license from the FCC. The other reason is that CB’ers are being interfered with by the unregulated users of w-t’s on the CB channels.

Technical Details. Under Part 15 of the FCC Rules and Regulations, no license is required to operate low-power (up to 100 mW) communication devices in the 26.97-to-27.27-MHz band and the 49.82-to-49.90-MHz band if the equipment meets applicable technical standards.

The power of the 27-MHz w-t’s is limited to 100 mW input to the final r-f stage of the transmitter. The w-t’s can be operated on any frequency within the band ranging from 26.97 to 27.27 MHz. This does not necessarily mean that operation must be on an exact frequency assigned to the normal CB channels.

The input power of the 49.9-MHz band w-t’s is not specified, but radiation is limited to 10,000 µV/meter, measured at a distance of 3 meters. These w-t’s must be operated only on any of five channels whose specified frequencies are: 49.830, 49.845, 49.860, 49.875, and 49.890 MHz. The frequency tolerance must be within ±0.01% of the channel carrier frequency. Either amplitude modulation (AM) or frequency modulation (FM) can be used as long as the
emission is confined within a 20,000-Hz band centered at the carrier frequency.

The rules require that the microphone be built into the case of the w-t's and that the antenna be permanently attached to the box containing the transmitter. Factory-built w-t's must also be certified by the manufacturer and FCC as being in compliance with the applicable technical standards.

W-t's already in production use either a superregenerative or a superheterodyne design in the receiver section. All have crystal-controlled transmitters to assure on-frequency operation.

**Home Design Rules.** You can design your own w-t and build up to five 49.9-MHz band transmitters and/or transceivers for your own use. Here are some of the rules you must follow:

1. The antenna must be a single element that is not more than 1 meter in length. It must be permanently mounted on the case that houses the transmitter/transceiver circuitry. You can operate a home-made low-power communication device on any of the five 49.9-MHz band channels set aside by the FCC or on any frequency between these channels, provided the carrier and modulation products are contained within the 49.82- to 49.90-MHz range.

2. The total input power of the transmitter/transceiver, the latter in the transmit mode, must not exceed 100 mW under any modulation condition. Input power is measured at the battery or at the power line terminals if the w-t is ac operated. This means that if a 9-volt battery is the power source, total input current of all transmitter stages may not exceed 11.11 mA. If the power source is the ac line, the total current drawn must not exceed 860 μA.

3. The rules applicable to home-built 49.9-MHz band w-t's require that the microphone be an integral part of the unit. The rules also require that harmonic emissions must be at least 20 dB below the level of the unmodulated carrier. (These harmonics are at exact multiples of the carrier frequency—100 MHz, 150 MHz, 200 MHz, etc.) The 100-MHz second harmonic could interfere with FM broadcast band reception, while the 200-MHz fourth harmonic could cause TVI (television interference) to TV channel 11 and/or channel 12. The other harmonics could cause interference to nearby radio communication stations. Needless to say, it is extremely important to maintain harmonic radiation at the absolute minimum possible.

4. **Some Design Ideas.** The simplest transceiver you can design would employ a superregenerative detector, crystal-controlled oscillator, and an audio amplifier that doubles as the modulator when transmitting, as illustrated by the block diagram in Fig. 1. A more elaborate transceiver would employ a superheterodyne receiver, as shown in the block diagram of Fig. 2. Alternatively, you could design a five-channel w-t with a crystal for each of the five channels and a switch.

   - For optimum radiation, the antenna should be a quarter wavelength long, or 1.5 meters (4.93') long, when an adequate ground plane is provided. Since antenna length is limited to 1 meter (3.28'), a loading coil in series with the output of the transmitter and input of the antenna is required. In the case of a hand-held transceiver, the ground plane is inadequate for good antenna system efficiency. If you build the transceiver into a metal case, your body will effectively serve as the ground plane when you hold the w-t in your hand. If you build a base station, you can use a metal enclosure and ground it to the power line through a pair of capacitors, as shown in Fig. 3.

   - When you build your own 49.9-MHz band low-power communication device, it is a good idea to have the transmitter checked out by a professional unless you have the instruments and know-how to do it yourself. No matter who checks out the device, the following should be on the list: transmitting frequency; modulation level; occupied bandwidth; harmonic radiation; and input power. Occupied bandwidth and harmonic radiation can most easily be checked with a spectrum analyzer.

**Fig. 1. This simple walkie-talkie uses a superregenerative detector.**

**Fig. 2. Block diagram of superheterodyne receiver.**

**Fig. 3. Base station grounding.**

**Fig. 4. Tunable converter for use with a CB transceiver.**

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**Operating Hints.** Factory-made w-t’s are usually equipped for single-channel operation on 49.860 MHz so that various users will be able to communicate with each other, regardless of which manufacturer made the transceivers. Since a lot of users can be expected to be operating on this channel, those who want more privacy and less interference will probably prefer another channel.

A hand-held w-t uses the same whip antenna for transmitting and receiving.

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**Six transistor “walkie talkie” from Interworld Enterprises.**

When operating at a fixed location, receiving range can be increased by using a separate receiver connected to an external antenna. When communicating with a base station using such a receiving setup, your flea-power transmitter will be more effective.

The receiver can be one designed for hams and tunable through the 6-meter band (you might have to trim it to tune down to 49.82 MHz). You can also use a 6-meter converter with a standard shortwave receiver or a home-built converter with a CB transceiver (see Fig. 4).

If you use a separate receiver with an external antenna, you can improve the receiving range by increasing the height of the antenna. If the effective radiated power is +13 dBm (20 mW) and the signal delivered to an antenna 10’ (about 3 m) above ground is −107 dBm (1 µV), raising the antenna to a height of 30’ (9 m) will increase the received signal level 10 dB to −97 dBm, or about 3 µV.

When communicating with hand-held w-t’s, the antennas of all units should be vertical or at the same angle. Otherwise, there will be a significant transmission loss due to conflicting polarization of the antennas involved.

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**SHUT-OFF TIMER**

*For Battery-Powered Appliances*

**BY JEFFREY SANDLER**

It is easy to attach a timer to a line-powered radio so that the power will be shut off after a certain time, should the listener fall asleep. It is not so easy with a battery-powered radio unless you build the simple circuit described here. With this simple add-on, you can fall asleep on the beach or in a hammock, secure in the knowledge that the radio will automatically shut down later to conserve the battery.

**Circuit Operation.** A schematic of the circuit is shown in Fig. 1. Resistor R1 and capacitor C1 provide a very long time constant. When S1 is closed, C1 is discharged and its low voltage is applied to the parallel high-impedance inputs of IC1. In this case the outputs of the NAND gates are high and the battery voltage is available at output 1.

When S1 is opened, capacitor C1 starts to charge slowly through R1. When the voltage across C1 reaches about half that of the battery, the outputs of the NAND gates drop essentially to zero, effectively turning off output 1.

Transistor Q1 is added to handle higher current loads. When output 1 is high, Q1 is on and it supplies a higher current to output 2. The amount of current depends on the transistor used. Changing R1 and C1 changes the timing.

**Construction.** The circuit can be assembled on a small perforated board or a small pc board such as that shown in Fig. 2. You can make the board small enough to fit inside many transistor radios. The battery battery also supplies power to the timing circuit. However, the circuit draws so little current that it will not run the battery down when the radio is not in use. This low current demand is due to the use of CMOS logic and the high value of R1. Note that C1 should have a very low leakage to maintain the charging interval.

The construction of S1 is left up to the user. It can be a miniaturized pushbutton switch, a pair of small bare leads that can be bridged with a fingertip or even a small mercury switch. If using the latter, simply momentarily tilt the radio on its side to "toggle" the timing circuit. If you elect to use your fingertip, you can vary the playing time by the length of time you keep your finger on the two leads. One to five seconds of contact time is usually enough to produce between five and 35 minutes of playing time.

The shut-down timer can be used to control almost any appliance if a separate battery is used for the timer and with output 2 driving a relay. The relay can then apply power through its own contacts to the appliance.

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**Fig. 1. Four parallel gates supply added power.**

**PARTS LIST**

<table>
<thead>
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<th>Part</th>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
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<td>220-µF low-leakage capacitor</td>
<td></td>
</tr>
<tr>
<td>IC1</td>
<td>4014 quad NAND gate (CMOS)</td>
<td></td>
</tr>
<tr>
<td>Q1</td>
<td>2N2222 or any low-leakage npn silicon transistor</td>
<td></td>
</tr>
<tr>
<td>R1</td>
<td>10-megohm, 1/4 or 1/4-watt resistor</td>
<td></td>
</tr>
<tr>
<td>R2</td>
<td>5200-ohm, 1/4 or 1/4-watt resistor</td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>See text</td>
<td></td>
</tr>
</tbody>
</table>

**Fig. 2. Small pc board and component layout are shown.**
BUILD THE TVT-6 Part II

System debugging, software, and how to interface to other processors.

BY DON LANCASTER

LAST MONTH, we discussed construction of the TVT-6 TV typewriter and explained how it works and how it is connected to a KIM-1 microcomputer. We also started a discussion of the operating secrets of the TVT-6. Here, we complete the "secrets" discussion and go on to system debugging, some useful programs, and tell you how to interface the TVT-6 with other microprocessors.

Software. Four examples of tested, annotated, and workable KIM-1 software are given in the tables in this article. Table II contains a 16 × 32 scan program with full interface. It automatically generates almost all the timing required by the TVT-6 and its companion TV monitor for this display format. The program is run by jumping to memory location 17Ad. The display is stopped by interrupting with the operating system, the cursor, or other program.

Table III is an optional full-performance cursor for the 16 × 32 system and includes scrolling, full cursor motion, and erase-to-end-of-screen capabilities. It is run by allowing the keypress signal from the keyboard to interrupt the scan program (any of the three Tables) via the IRQ interrupt line. Note that the cursor program is totally independent of the SCAN program. The only thing the programs share in common are the same pages of display memory. The screen-read-to-cassette can be performed using the existing KIM-1 operating system programs. You can also load from cassette to display, using the automatic search firmware.

Table IV is a 16-line/64-character scan program that requires only 64 words to be written into memory for the entire program. This program can be used to display the entire 1k of minimum KIM-1 memory for use as a super front-panel display if desired. For display-only applications, 1k of contiguous memory

Fig. 7. TVT-6 waveforms with Table II program: (A) video rate; (B) horizontal rate; (C) horizontal sync; (D) character rate; (E) vertical rate; (F) outputs.
### Table II

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<th>μP</th>
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<th>Start - JNP 17Ad</th>
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<td>0200-037F</td>
<td>17Ad</td>
<td>17E2</td>
<td>17dF 80 BMI 30 A4*</td>
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<th>μP - 6502</th>
<th>Displayed</th>
<th>Start - JNP 17Ad</th>
<th>ℒ-Interrupt</th>
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<td>0200-037F</td>
<td>17Ad</td>
<td>17E2</td>
<td>17dF 80 BMI 30 A4*</td>
</tr>
</tbody>
</table>

### Notes:

- TVT6 must be connected and scan microprogram from (IC1) must be in circuit for program to run.
- Both 17B4 and 17C1 require that page 17 be enabled when page 57 is addressed. This is done automatically with KIM-1 circuitry.
- Step 1788 goes to where the upper address stored in 178A and the lower address stored in 1780 tells it to. Values in these slots continuously change throughout the program.
- For a 525-line system, use 17B8 64 and 17C5 65 and a KIM-1 crystal of 992.250 kHz. This is only needed for video superposition and titling applications.
- Normal program horizontal frequency 15,873.015 kHz; vertical frequency 60.014 Hz; 63 us per line; 264.5 lines.
- Denotes a relative branch that is program length sensitive.
- ( ) Denotes an absolute address that is program location sensitive.
- TVT6 length jumper must be in "32" position.

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is required. Keep in mind that the KIM-1 has some operating system slots in the top of page zero and the stack at the top of page one. Unless you actually want to display the stack and operating system parameters, do not use these slots.

The 64-character line makes the TV receiver's horizontal frequency run considerably lower than normal. This will require a readjustment of the horizontal hold control or some extra capacitance across the existing horizontal hold capacitor. The width of the raster may also have to be reduced; this is most easily accomplished by adding a low-value inductor in series with the yoke. These changes are best made in a small-screen, transformer-powered monochrome TV receiver. The tradeoff of a lowered horizontal frequency produces a longer character line but still allows 1 μs/character. This will not tax the bandwidth restrictions of TV receivers or t-f modulators. (Editor's Note: The small-screen Sears TV receiver we used required adjustment of horizontal size and linearity, a 0.033-μF Mylar capacitor in parallel with the 0.069-μF capacitor used for C408 in the receiver, and an inductor consisting of 60 turns of No. 24 enameled wire on a 1/2" Nylon form in series with the red yoke lead in the receiver. In addition, it was necessary to disconnect one side of C201 in the receiver.
to defeat the sound trap. Never attempt to modify a TV receiver that is powered directly from the ac line without an isolating transformer.)

Table V contains a program that we call "Cruncher the Bear." This program produces 64 fully interlaced characters in each of 32 rows, for a total of 2048 sharp ASCII characters on-screen at one time within the 3-MHz bandwidth. You can add a hex-to-ASCII converter that slowly sequences high- and low-order machine code characters in the same slot and end up with 4096 hex characters displayed in only 3 MHz of bandwidth.

Table V requires a contiguous 2k of memory with a common upstream tap and separate chip enables. However, it is easily incorporated if you really want or need to display as many characters as the program allows.

Other software is easily written and developed for the TVT-6. For example, you may wish to have a 32 x 44 or a 32 x 48 character display and still use normal, or nearly normal, horizontal scanning rates. This allows for video titling and superimposition, oversized characters, color graphics, lower-case characters, and game displays. There is no lower limit to the number of character rows or characters per line you can use. If you have limited memory available,
you can run $8 \times 32$, $4 \times 64$, $1 \times 64$, or even $1 \times 8$ character formats. All this takes is software changes, and the circuitry of the TVT-6 remains the same.

**Initial Debugging.** At this point, there should be no IC's in the sockets of the TVT-6 board assembly. Start by connecting the LENGTH jumper to 32 and the CURSOR jumper to YES on the TVT-6 board. (Note: These points are pads located at the center of the circuit board, not the edge-connector contacts.) Temporarily insert a jumper wire between pins 3 and 14 on the IC5 socket. Center the two position control potentiometers and install IC1, IC2, and IC6 in their respective sockets.

Connect your video monitor to the TVT-6 board and power up the system. Check for the presence of the SCAN instructions (see PROM Truth Table in Fig. 1 of Part 1) at hex locations 8000 through 8020. Write a simple program that jumps to a subroutine at location 8000 and then loops. Single-step through this program to verify proper operation of the SCAN instruction. Do not

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**Using the TVT-6 with Other Popular Microprocessors**

Both parts of this article have used the TVT-6 with the 6502 microprocessor-based KIM-1 microcomputer. Here is how to use the TVT-6 in µC's that use other popular microprocessors.

**6800.** The 6800 µP is very similar to the 6502 and, therefore, is easiest to convert. The SCAN microprogram can be LDAB(C6) for words 0 through 30 and RTS(BD) for word 31. A literal translation of the tightest part of the SCAN program (1D;1782 through 178C) is: STA(B7); JSR(BD); ADDA(8B); CMFA(81); BCC(24). This routine requires 25 µs to cycle through as compared to the 21 µs required for the 6502.
A stock 8080 µP can normally change its program counter once every 2 µs, but it can be "tricked" into doubling its speed during a SCAN microprogram by driving the usual address line A9 of the display memory from SYNC. The SCAN microprogram is then NOP(00) for words 0 through 30 and RET(A9) for word 31. A tighter than literal translation of the SCAN program (1D;1782 through 178C) is: STAXB(02); CALL(AD); ADD(82); CMP(BB); JNC(DB), which requires 24 µs to cycle through. Here, the TVT-6 address lines A5 through A1 must be relabelled A4 through A8, respectively.

The Z80 µP can use 8080-developed software with speed-doubling scans, or it can simply be run faster, allowing the program counter to change once every microsecond. Use a literal translation of the program for the 6502.

12 Address Line µP's. The four upper address lines of 12 address line µP's can be decoded to allow normal operation, 8 to 12 lines of scan, a vertical sync pulse, an operating return system, and an optional "page-change" command. This leaves a 256-character page on the bottom eight bits, and the "page-change" command can be latched to change to any number of additional pages, as required.

General Hints. Horizontal scan should last at least 62, 63.5, or 64 µs for conventional horizontal-frequency operation. The microprogram scan must end exactly this number of microseconds later for each horizontal line in the total scan program. The total number of lines must produce a vertical frequency between 59.9 and 60.1 Hz per field. Note that a portion of the RTS time will be spent during the active (microprogram) scan time. Horizontal scans that last longer than 85 µs may make it difficult to obtain TV interface.

You can shorten a blank microprogram active scan by an even number simply by jumping ahead when you call your subroutine. For example, a JSR 8000 may produce a 32-character scan, while a JSR 8002 can produce a 30-character scan. This approach can come in handy when there is a need for equalizing scan lengths between character rows and during vertical retrace.
TABLE IV
16 line X 64 character per line TVTS Raster Scan:

<table>
<thead>
<tr>
<th>Upper Address</th>
<th>Lower Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>1780 LDA 49 80</td>
<td>Initialize Upper Address</td>
</tr>
<tr>
<td>1782 STA 94 (87) (17)</td>
<td>Store Upper Address</td>
</tr>
<tr>
<td>1785 JSR 20 00 80</td>
<td>Store Upper Address</td>
</tr>
<tr>
<td>1788 ADD 69 00</td>
<td>Increment character scan counter</td>
</tr>
<tr>
<td>178A CMP C9 00</td>
<td>Is VS = 1?</td>
</tr>
<tr>
<td>178C BCC 90 F4*</td>
<td>No, Do next character scan</td>
</tr>
<tr>
<td>178E TAX AA</td>
<td>Save Upper Address</td>
</tr>
<tr>
<td>178F LDA A4 (86) (17)</td>
<td>Get lower address</td>
</tr>
<tr>
<td>1792 BCS b0 00</td>
<td>Equalize 3 cycles</td>
</tr>
<tr>
<td>1794 JSR 20 04 80</td>
<td>Character Scan 9/11/</td>
</tr>
<tr>
<td>1797 BCS b0 00</td>
<td>Equalize 3 cycles</td>
</tr>
<tr>
<td>1799 ADD 69 3F</td>
<td>Increment Lower; Set C on V2 overflow</td>
</tr>
<tr>
<td>179B STA 84 (86) (17)</td>
<td>Restore Lower Address; save carry</td>
</tr>
<tr>
<td>179E STA A8</td>
<td>Get upper address</td>
</tr>
<tr>
<td>179F JSR 20 00 80</td>
<td>Character Scan 10/11/</td>
</tr>
<tr>
<td>17A2 ADD 69 00</td>
<td>Add Carry; Reset VS</td>
</tr>
<tr>
<td>17A4 CMP C9 84</td>
<td>It is “Line 17”?</td>
</tr>
<tr>
<td>17A6 BCC 90 d4*</td>
<td>No, Continue character scans</td>
</tr>
<tr>
<td>17A8 BCS b0 00</td>
<td>Yes, Go to vertical blanking scans</td>
</tr>
<tr>
<td>17A4 CLI 48</td>
<td>Equalize 2 cycles</td>
</tr>
<tr>
<td>17A5 JSR 20 00 00</td>
<td>Vertical Sync Scan/</td>
</tr>
<tr>
<td>17A7 IDX 22</td>
<td>Load V Blank Scans -2</td>
</tr>
<tr>
<td>17B0 LDA A9 00</td>
<td>Initialize Lower Address</td>
</tr>
<tr>
<td>17B2 STA 84 (86) (17)</td>
<td>Continued</td>
</tr>
<tr>
<td>17B5 CLI 18</td>
<td>Equalize 2 cycles</td>
</tr>
<tr>
<td>17B6 BCS b0 00</td>
<td>Equalize 2 cycles again</td>
</tr>
<tr>
<td>17B6 JSR 20 00 80</td>
<td>Vertical Blanking Scans/</td>
</tr>
<tr>
<td>17BE DEX CA</td>
<td>One less scan</td>
</tr>
<tr>
<td>178E BPL 00 00</td>
<td>Start Character Scan</td>
</tr>
<tr>
<td>178E BPL 00 00</td>
<td>Repeat Vertical Blanking scans</td>
</tr>
</tbody>
</table>

NOTES:
- TVTS must be connected and scan microprogram PROM (IC1) must be in circuit for program to run.
- Step 1785 goes to where the upper address stored in 1787 and the lower address stored in 1786 tells it to. Values in these slots continuously change throughout the program.
- Normal program horizontal frequency is 11,756,705 Hz.
- Vertical Frequency is 60,024 Hz. 85 um per line:
- 50 active lines. Character time 1 ms. 160 active lines, 36 retrace. Needs TV set adjustment and possible modification (hold and width).
- * Denotes a relative branch that is program length sensitive.
- ( ) Denotes an absolute address that is program location sensitive.

TVTS length jumper must be in ‘64’ position.

proceed beyond this point until you are certain that the SCAN subroutine is operating properly. (Critical waveforms to be observed with an oscilloscope are illustrated in Fig. 7 using the program listed in Table II.)

Insert IC3 into its socket and load the program given in Table II. (Never install an IC in a powered circuit; always turn off the power, install the IC, and power up again.) Set the address to 17A4 and depress GO. Using an oscilloscope, check at test point VR for the presence of a 60-Hz pulse. Switch the scope to line-sync and observe that the pulse remains fixed or drifts very slowly across the screen. Again, do not proceed until you are certain that the SCAN program is operating properly.

Install all remaining IC's, except IC5, in their respective sockets on the TVT-6 board. At this point, the screen should be filled with a stable display of 512 cursor boxes. Viewed up close, the boxes should appear to be "hiding" characters. Do not proceed until you have the indicated display.

Checking with Fig. 7, particularly with respect to the LOAD and CLOCK on IC6 (Fig. 7A) verify whether or not the appropriate waveforms are present. If they are, remove the jumper wire from the IC5 socket and install IC5. Now, the screen of the monitor should have displayed on it a full array of characters with about half of them winking cursor blocks. Load the following hex numbers into memory, starting at location 0200:
20, 20, 20, 50, 4F, 50, 55, 4C, 41, 52, 20, 20, 45, 4C, 45, 43, 54, 52, 4F, 4E, 49, 43, 53, 20, 20, 54, 56, 54, 2D, 36, 20, 20. Return to address 17Ad and depress GO. The top display line should now read "POPULAR ELECTRONICS TVT-6" and be indented three spaces. If all is well to this point, you can begin feeding in your cursor programs, add external keyboard and/or cassette loads and dumps, etc.

Should you encounter problems with your TVT-6, always begin debugging by using the 16 x 32 format on a KIM-1, even if you plan on using longer line lengths or plan to translate the code into another coding system. Note that the translation must be at the machine-language level because the SCAN program must provide the exact number of machine cycles as well as the proper sequencing. The 64-character lines will require some adjustments to be made in the monitor TV receiver's horizontal circuit as detailed earlier.

Closing Remarks. We have presented here full construction and operating details for a very versatile and inexpensive TV typewriter for use with the KIM-1 microcomputer. If you have a computer that uses a microprocessor other than the 6502 used in the KIM-1, we refer you to the box for use details.

---

**TABLE V**

CRUNCHER THE BEAR Program for a 32 line X 64 character per line TV76 raster scan:

<table>
<thead>
<tr>
<th>µP</th>
<th>6502 Start - JMF 1700</th>
<th>Displayed 0000-07FF</th>
</tr>
</thead>
<tbody>
<tr>
<td>System</td>
<td>KIM-1 End - Interrupt</td>
<td></td>
</tr>
<tr>
<td>Program Space</td>
<td>1780-176A</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>V1</th>
<th>V2</th>
<th>V3</th>
<th>V4</th>
<th>V5</th>
<th>V6</th>
<th>V7</th>
<th>V8</th>
</tr>
</thead>
<tbody>
<tr>
<td>1768</td>
<td>1763</td>
<td>1762</td>
<td>1761</td>
<td>1760</td>
<td>1759</td>
<td>1758</td>
<td>1757</td>
</tr>
<tr>
<td>LDA</td>
<td>A9</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STA</td>
<td>84</td>
<td>(67)</td>
<td>(17)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JSR</td>
<td>20</td>
<td>00</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JSR</td>
<td>00</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1745</th>
<th>1744</th>
<th>1743</th>
<th>1742</th>
<th>1741</th>
<th>1740</th>
<th>1739</th>
<th>1738</th>
</tr>
</thead>
<tbody>
<tr>
<td>STA</td>
<td>A9</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>STA</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STA</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>STA</td>
<td>80</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTES:** TV76 must be connected and scan microprogram FROM TC1 must be in circuit for program to run. TV76 length jumper must be in ‘64’ position.

Step 1705 goes to where the upper address stored in 1787 and the lower address stored in 1789 tells it to. Values in these slots continuously change throughout the program.

Step 1781 is 80 for even fields and 88 for odd fields. Step 1792 is 88 for even fields and 90 for odd fields.

Both 17AC and 17C2 require that page 17 be enabled when page 57 is addressed. This is done automatically with KIM-1 circuitry.

Note that 2k worth of contiguous memory from 0000 to 07FF is needed. This takes a KIM-1 modification. Both sets of 1k words must share a common upstream tap but be separately enabled.

Normal program horizontal frequency is 11,764.705 Hz. Vertical frequency is 59.8712 Hz. For 60 Hz vertical use 1,002.150 Mhz crystal. 65 us per line; 156.3 interlaced lines per field; two fields per frame. One character time, 160 active lines per field. Needs TV set adjustment and possible modification (hold and width).

* Denotes a relative branch that is program length sensitive.

( ) Denotes an absolute address that is program location sensitive.
M ost low-cost "four-banger" calculators can be converted to provide a stopwatch function with 0.1-second resolution by adding the inexpensive three-IC circuit described here. The circuit in no way alters the normal operation of the calculator. It provides crystal-controlled accuracy of 0.005% or better and has a drain of 3 mA or less.

The timer circuit can be added to any calculator that has an automatic-constant feature on the addition (+) function. Once installed, it can be used to time virtually any event from a race to developing a photograph to baking a cake. In addition, you can even convert directly to miles or kilometers/hour, feet/minute or second, etc. For example, you can check the accuracy of your car's speedometer by clocking a measured mile and dividing the time in seconds into 3600 to find the average miles/hour.

About the Circuit. Many low-cost calculators can be converted to provide the timing function—including some calculators with memory and other high-level functions. The only requirement is the automatic-constant feature on the + function. To check whether or not your calculator has this feature, key in . + . = . . = . . = . . = . . . If your calculator has the automatic-constant feature, 0.3 should appear in the display. If the reading remains at 0.1, the calculator cannot be used.

The circuit shown in Fig. 1 consists of a 5369 CMOS programmable counter-divider IC (IC1) with a 5.79545-MHz crystal to deliver a 60-Hz output; a divide-by-six counter (IC2); and a CMOS analog switch (IC3). Pushbutton switch S1 enables IC3 and effectively closes the = key in the calculator 10 times a second. CMOS circuitry provides a very low battery drain and allows use of any battery that can deliver 3 to 16 volts.

Integrated circuit IC1 contains a crystal oscillator amplifier that causes the crystal to resonate, a 16-stage divider, and a fractional divider to provide the 60-Hz output. Presettable divide-by-N counter IC2 is set to divide by 6 by connecting pin 6 to pin 1. The output of this IC, taken at pin 13, is a 10-Hz square wave. Quad bilateral switch IC3 transmits an input signal to the output only when it is triggered. With the 10-Hz signal from IC2 connected to the toggle pin of IC3, and the = key in the calculator connected to the switch contacts, the = function is initiated 10 times/second.

The timer function takes control of the calculator only when S1 is closed. With S1 open, the calculator operates in its normal manner.

Construction. The timer circuit is best assembled on a small printed circuit board, the etching and drilling guide/ component-placement diagram for which is shown in Fig. 2. It is important to use care when mounting the crystal so that it can be bent back to lie flat against R1. Alternatively, R1 can be mounted on the bottom side of the board and the crystal bent back to lie flat on the board itself.

Install the IC's last, and practice safe MOS-handling procedures when handling and soldering the IC's in place. (See MOS-handling article in this issue.) When interconnecting the timer board and calculator circuitry, make absolutely certain that the power leads are connected in proper polarity. If you reverse the power leads, the integrated circuits can be destroyed.

Switch S1 can be installed anywhere sufficient space is available. (It fits nicely directly opposite the power switch on the Texas Instruments Model TI-1200 calculator this author used, requiring only accurate drilling of a mounting hole in the case. Check the fit of the switch and pc board assembly before drilling any

**Fig. 1. Timer updates count 10 times/second when constant is activated.**

**PARTS LIST**

<table>
<thead>
<tr>
<th>Part</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1—5- to-40-pF trimmer capacitor</td>
<td>1</td>
</tr>
<tr>
<td>C2—27-pF ceramic capacitor</td>
<td>1</td>
</tr>
<tr>
<td>IC1—MM5369 programmable oscillator/divider (National)</td>
<td>1</td>
</tr>
<tr>
<td>IC2—4018 CMOS presettable divide-by-N counter</td>
<td>1</td>
</tr>
<tr>
<td>IC3—4016 CMOS quad bilateral switch</td>
<td>1</td>
</tr>
<tr>
<td>R1—22-megohm, 1/4-watt resistor</td>
<td>1</td>
</tr>
<tr>
<td>S1—Miniature push-push switch</td>
<td>1</td>
</tr>
<tr>
<td>XTL—3.579545-MHz (color TV) crystal</td>
<td>1</td>
</tr>
<tr>
<td>Misc—Printed circuit board; red, black, yellow, green stranded hookup wire; insulating tape or fish paper; solder; etc.</td>
<td>1</td>
</tr>
</tbody>
</table>
holes to make sure switch and board will fit in your calculator.

It is best to leave the interconnecting leads a bit long to facilitate easy installation and calibration of the timer circuit. The red (+) lead from the timer goes to any point on the calculator's bus after the power switch. The black (−) lead then goes to any point on the calculator's negative bus.

The green and yellow leads connect across the = key in the calculator. The hookup points for the = key can be found by trial and error with the aid of a jumper wire. Simply jumper from one contact to another, after feeding into the calculator (via the keyboard) 1, +, =. When you hit on the right combination, the display will read 2. On calculators with an X-Y matrix keyboard, each lead from a vertical key row initiates a function with each lead from a horizontal row. In the TI-1200, for example, there are nine leads coming from the keyboard, four vertical and five horizontal; the = function is controlled by the first and eighth leads, counting from the left.

After you have identified the appropriate leads for the = key, determine their polarity by using a small diode (a 1N914, for example) in series with the test lead. The function will initiate only when the cathode (banded) end of the diode points toward the negative contact. Connect the green lead from the timer circuit to the negative contact. The yellow lead then goes to the positive contact on the keyboard. (Note: a very few calculators cannot be keyed at the 300-ohm "on" resistance of IC3; with such calculators, you must connect a 500-to-1000-ohm resistor between pins 8 and 9 of IC3.)

Calibration. The timer can be calibrated quickly and easily with the aid of a frequency counter. If a counter is not available, you can use an electric clock with a large sweep second hand and obtain reasonable accuracy, trimming as necessary.

Start calibration with the trimmer capacitor (C1) centered and rotate it about 10° at a time. Ten minutes of timing (600.0 seconds) will provide better than 0.05% accuracy if 10 trials provide results that are within 0.5 second.

Before final assembly, completely insulate the timer board to avoid short circuits between leads or components. Usually, all that is required is to place a layer or two of masking or vinyl tape or a single layer of fish paper on the foil side of the board.

Using the Timer. Each time the calculator is turned on for use as a timer, key in the following sequence: ., 1, +. Then, when you depress S1, 0.1 will automatically be added to the display at 0.1-second intervals until S1 is again pressed. For successive timings, pressing the 0 key will clear the display while retaining the + constant. You can also count down from any number by entering the number via the calculator's keyboard, followed by −, .., 1. If you press the C (clear) key, you must reenter the constant before timing another event.

Another section of IC3 can be used in the 10-Hz line to provide remote actuation of the timer by a gate switch or photocell. This will require the addition of a jack to your calculator, assuming there is room to accommodate it.

The addition of the timing function to an existing calculator is one way of updating a very versatile instrument. The timer actually doubles the usefulness of your calculator by providing a function that is available commercially in only very expensive calculators.

THE HP-25 AS A DIGITAL CLOCK & TIMER

BY WILLIAM T. PETERS

The PRECEDING article showed you how to convert an inexpensive four-function calculator to a stopwatch by adding a three-IC circuit. This article describes how to program an HP-25 calculator to make it serve as a clock/timer. The display is in hours, minutes, and seconds, and resolution is to the nearest second.

The Program. To set up the HP-25 calculator as a timer, first put the display format into the FIX 4 mode. The display will read 0.0000. Now, switch to the program (PRGM) mode and key in the following sequence:

<table>
<thead>
<tr>
<th>STEP</th>
<th>KEYSTROKES</th>
</tr>
</thead>
<tbody>
<tr>
<td>01</td>
<td>RCL, 1</td>
</tr>
<tr>
<td>02</td>
<td>f, H.MS</td>
</tr>
<tr>
<td>03</td>
<td>f, PAUSE</td>
</tr>
<tr>
<td>04</td>
<td>RCL, 2</td>
</tr>
<tr>
<td>05</td>
<td>STO, +, 1</td>
</tr>
<tr>
<td>06</td>
<td>GTO, 01</td>
</tr>
</tbody>
</table>

Next, switch to the run mode and key in: 3600, g, 1/x, STO, 2. Now, when you press the run/stop (R/S) key, the calculator will begin counting in hours, minutes, and seconds (approximately). The two digits preceding the decimal point in the display are the hours; the two digits immediately following the decimal point are the minutes; and the two digits following the space are the seconds. You will note that the display updates every second as long as the calculator is in the RUN mode.

After a few minutes, you will probably find that your calculator is gaining time. To remedy this, you can add one or more steps to the program by pressing g and then NOP for each step you wish to add. These extra steps can be added anywhere in the program before the final step. Under no circumstances should you attempt to adjust the calculator's internal oscillator, which would void the manufacturer's warrantee.

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Now your timer will probably be accurate enough for most photographic or kitchen timing. However, with a little tinkering with the program, you can improve the accuracy to within seconds per day.

**Better Accuracy.** If your calculator is running slow, an increase in the number stored in Register 2 will compensate. If the calculator is running fast, the number in Register 2 will have to be decreased somewhat. For example, assume the timer is running 7 seconds slow after 16 minutes (960 seconds). You can compensate for this by increasing the number in Register 2 by 7/960. Alternatively, if the timer is running fast by 7 seconds, you can decrease the number in register 2 by 7/960.

**Using the Program.** You can use the HP-25 calculator as a stopclock by pressing the R/s key at the beginning of the event you wish to time. Then, at the end of the event, hit the R/s key again to stop the clock. The calculator will display the elapsed time, unless you stopped the clock while it was updating. To read the elapsed time, key in RCL, 1, f, H>M.S.

To use the calculator as a digital clock, simply store the hour, minute, and second from which you wish the calculator to start running in register 1. Before storing this number, convert it to a decimal-hour format by pressing g, H>M. While the HP-25 displays hours, minutes, and seconds, the timing program "thinks" in decimal fractions of an hour.

A simple program change turns the calculator into a countdown timer. Store the starting time in Register 1 and change step 5 in the program to STO, -1. Now, when the timing program is started, the calculator will count down from the time stored in Register 1, a second at a time.

Several of these countdown timer programs can be stored in the calculator simultaneously. They can be used as required by instructing the calculator to go to (GTO) the first step of the desired program and then pressing R/s to begin timing. In fact, the conditional-function keys make it possible to program the calculator to go from one countdown program to the next automatically, although a small loss in timing precision will be encountered because of increased program length. This is very handy in a darkroom, where several processes of different duration must often be timed in sequence.

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**TTL LOGIC QUIZ**

BY W.J. FISHER

Although the circuits shown here can not be put to any practical use, they can provide a test of your TTL IQ. For each circuit, determine the resulting outputs at B for the two possible logic inputs ("1" or "0") at A.
BUILD A DIGITAL CAMERA SHUTTER TIMER

Low cost digital timer provides accurate check of camera shutter speeds from 1/1000th of a second to 1 second.

HAVE YOU ever wondered why a camera whose diaphragm opening and shutter-speed setting are adjusted perfectly according to an exposure meter should regularly produce overexposed or underexposed negatives or prints? Too often, the cause is a shutter speed that deviates too much from the camera’s speed markings.

Now you can check your camera’s actual shutter speed by building the electronic shutter tester presented here. If the camera displays a gross speed inaccuracy, you’ll know that you must compensate for it by modifying the camera’s control adjustments (say, an f stop greater or smaller than the exposure meter’s indication) or having the camera serviced professionally.

With your own shutter tester, you can test your camera at any time you feel it needs adjustment. The shutter tester described here uses digital circuits and has six decades of display to give a high order of accuracy.

About the Circuit. The sensor/control circuit for the tester is shown in Fig. 1, while the counting circuit is shown in Fig. 2. The two circuits are coupled together via the +V and GND buses and the points marked K going to each other.

When light strikes phototransistor Q2 and not LDR1 in Fig. 1, the Darlington circuit made up of Q2 and ordinary transistor Q1 triggers on and supplies current to timer IC6. This causes the timer IC to generate pulses at a frequency of 10,000 Hz. (Potentiometer R1 is provided for adjusting the operating frequency of the oscillator to exactly 10,000 Hz.)

If at any time light strikes LDR1, the
Most people think there are only two levels of careers in electronics: the technician level and that of the degree engineer.

There is, however, a third and very important level. It is that of the engineering technician or practical engineer. The growing importance of this career level has created what might well be called the "New Professional" in electronics.

If you look at the various levels of employment in electronics, you will understand why this "New Professional" is so important.

The average technician is a person who has had vocational training in electronics. He understands the basic principles of electronics so he can troubleshoot, repair and maintain equipment. He usually works under close supervision in performing his duties.

The engineer has college training in electronics. He usually supervises technician personnel and is responsible for planning and developing of electronic equipment and systems. Frequently, however, engineers are more heavily trained in the scientific principles of electronics and less in their practical application.

The engineering technician, by contrast, is a specialist in the practical application of electronics. His training usually consists of a two-year college program in electronic engineering technology. In many organizations, the engineering technician handles several of the responsibilities of the degree engineer. He often has the title of engineer.

CREI programs are designed to give you at home the same level and depth of training you receive in a two-year college program in electronic engineering technology. CREI programs are, in fact, more extensive than you will find in many colleges. And CREI gives you the opportunity to specialize in your choice of the major fields of electronics.

**Unique Design Lab**

CREI gives you both theory and practical experience in circuit design with its Electronic Design Laboratory Program. The professional equipment included in this program allows you to construct, test out and correct the circuits you design until you have an effective circuit.

This Lab Program helps you understand advanced electronics. It also gives you practical experience in many other important areas of electronics, as in pro-
totype construction, breadboarding, test and measurement procedures, circuit operation and behavior, characteristics of electronic components and how to apply integrated circuits.

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resistance in the base circuit of Q2 drops to a low enough value to cause the Darlington circuit to cut off. This, in turn, turns off the timer circuit. Under normal operating conditions, no light will fall on either Q2 or LDR1 initially. After pressing reset switch S1 (Fig. 2), light is allowed to reach only Q2. This allows the timer circuit to generate a 10,000-Hz pulse output that is counted by the totalizer circuit shown in Fig. 2. The displays continue to count upward until the light to Q2 is interrupted or light falls on LDR1. At this time, the displays "freeze" to indicate the total number of pulses counted. When the tester is used with a camera, the camera's body covers LDR1 to exclude all light and the shutter/lens mechanism is positioned directly above Q2, in line with a high-intensity light source. Switch S1 is momentarily depressed to reset the counters to zero. Then, when the shutter is tripped, the system counts the number of pulses generated between the opening and closing of the shutter.

The counting circuit shown in Fig. 2 consists of five decade-counter IC's (IC1 through IC5) and their companion seven-segment displays (DIS1 through DIS5). Note that DIS2 is the only display whose decimal point is active. This decimal point comes on whenever the tester is powered. Note also that the decade counters are wired to suppress the zeroes to the left of the decimal point. Since the display indicates the number of pulses counted during a discrete interval of time, it does not indicate time. To obtain the time indicated by the number in the display, you must divide that number by 1000. Hence, displays of 1.0, 8.0, 16.6, and 33.3 translate to 0.001, 0.008, 0.0166, and 0.0333 second or, in photography terminology, 1/1000, 1/125, 1/60, and 1/30 second, respectively. (It is a good idea to make up a table of conversions that can be affixed to the completed project, as shown in the lead photo.)

The power supply for the tester is line operated. DC power for the system is obtained from a conventional rectifier-diode/filter-capacitor (D1/C1) setup that is driven from the center tap of transformer T1. This circuit assumes that high-intensity lamp I1 is an integral part of the system. If you prefer, you can use a separate line-powered high-intensity lamp and substitute a 6.3-volt transformer for T1.

Construction. The entire circuit, except T1 and the two switches and Q2

**Fig. 2. The five decade counters are formed from IC's that also include 7-segment decoded outputs. Note that DIS2 has the decimal point.**
and LDR1, can be assembled on a single printed circuit board, the etching and drilling and component-placement guides for which are shown in Fig. 3. Alternatively, you can assemble the circuit on perforated board, using appropriate solder hardware. In either case, the use of sockets for the IC's and displays is recommended.

Install the components on the circuit board as shown in the component-placement guide, taking care to properly orient them. Note here that the four jumper wires labelled J and R5 mount on the foil side of the board. To avoid the possibility of short-circuiting the board,

**CONVERSION TABLE**

<table>
<thead>
<tr>
<th>NUMBER</th>
<th>SHUTTER SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>1/1000 sec</td>
</tr>
<tr>
<td>2.0</td>
<td>1/500 sec</td>
</tr>
<tr>
<td>4.0</td>
<td>1/250 sec</td>
</tr>
<tr>
<td>8.0</td>
<td>1/125 sec</td>
</tr>
<tr>
<td>10.0</td>
<td>1/100 sec</td>
</tr>
<tr>
<td>16.6</td>
<td>1/60 sec</td>
</tr>
<tr>
<td>20.0</td>
<td>1/50 sec</td>
</tr>
<tr>
<td>33.3</td>
<td>1/30 sec</td>
</tr>
<tr>
<td>40.0</td>
<td>1/25 sec</td>
</tr>
<tr>
<td>100.0</td>
<td>1/10 sec</td>
</tr>
<tr>
<td>125.0</td>
<td>1/8 sec</td>
</tr>
<tr>
<td>250.0</td>
<td>1/4 sec</td>
</tr>
<tr>
<td>500.0</td>
<td>1/2 sec</td>
</tr>
<tr>
<td>1000.0</td>
<td>1.0 sec</td>
</tr>
</tbody>
</table>

Before you mount Q2 and LDR1 in the block of wood, apply a coat or two of flat black paint to all exterior surfaces of the block. Allow the paint to completely dry, and then mount the components in their respective holes, fixing them in place by force fitting. (If the fit is too snug, very carefully ream out the holes; if it is too loose, sparingly apply a drop or two of clear plastic cement to the component edges. Both components mount flush with the top surface of the block. When
this is done, use contact cement to fasten a thin sheet of soft matte black vinyl to the top of the block after first punching holes in it for Q2 and LDR1.

A 9"D x 5"W x 2½"H (22.9 x 12.7 x 6.4 cm) metal box comfortably accommodates the circuit board assembly, power transformer and its line cord, and switches. The case must be machined to provide a 2½" x ½" (6.7 x 1.3 cm) window for the displays; mounting holes for the switches, transformer, and wood block; and access holes for the line cord and leads from Q2 and LDR1. Once the case has been machined, spray two or three coats of matte black paint over all exterior surfaces. When the paint has dried, cement a red filter over the window from the inside. Then mount the wood block with screws, followed by T1, S1, and S2. Next, interconnect the switches, transformer, line cord (passed through the case via a rubber grommet), LDR, and phototransistor. Finally, mount the circuit board assembly in place with machine hardware and spacers, making sure its displays are properly oriented behind the filter.

Checkout and Use. Place a piece of black plastic tape over LDR1, plug the line cord into a convenient ac outlet, and turn on the tester's power. Now, using an oscilloscope or a frequency counter, adjust potentiometer R1 for an exact 10,000-Hz output from timer IC6. This completes calibration. Remove the tape from LDR1.

Open the back of the camera you wish to test and place it on the wood block so that the lens opening is directly over Q2. Make sure that the camera body covers LDR1. Then set the camera's lens diaphragm for maximum opening, set the shutter speed, and cock the shutter. Depress reset switch S1 so that all displays read zero. Trip the camera shutter. The displays should rapidly count up and freeze at a number that is the shutter speed in thousandths of a second.

Check each shutter speed at least three times, resetting the display at the start of each test. The most accurate reading is with the lens on the camera because the light is somewhat collimated. Without a lens on the camera, the light can diffract around the shutter curtain and indicate a longer than actual shutter speed time. This is important at fast shutter speeds when the curtain opening is narrow. This does not pertain to between-the-lens leaf shutters.

Do not be disappointed if your shutter speed is not close to its camera setting. Up to 1/500 of a second, the allowable error may be as great as ±25%; at higher settings, the allowable error might be ±35%. These figures would depend on the tolerance of the film used, of course.

With the aid of the camera shutter timer described here, you can eliminate some of the uncertainties you have about the accuracy of your camera's mechanism. Additionally, it can tell you why your latest batch of photos did not turn out as they should have.

Underside of timer reveals pc board and transformer mounting.
MOS TECHNOLOGY has brought tremendous advances to modern electronics. However, MOS devices suffer from one fatal shortcoming: they can easily be destroyed by static electricity when they are handled or being installed in a circuit. Even so-called "protected" MOS devices are not immune from being ruined by static electricity if proper precautions are not taken.

In this article, we will discuss the physical makeup of the typical MOS device and see how and why the MOS device is so easily destroyed. Then we will detail some of the steps you can take to prevent destruction of the device.

MOS Device Construction. In a circuit, a MOS device "looks" like a voltage-controlled resistor in which the equivalent MOS resistance between the drain and source is varied by a voltage applied to the gate electrode. (See Fig. 1.) Physically, the gate electrode is a thin layer of metal deposited on a very thin (about 1000 Angstroms) layer of silicon dioxide (glass). This layer of glass effectively insulates the gate from the substrate, in essence, forming a capacitor whose plates are the gate and substrate and whose dielectric is the layer of SiO₂ between the gate and substrate.

The strength of the electrical field that can rupture the SiO₂ layer is about 100 volts, at which point, a "punchthrough" can occur (Fig. 2.) Such a punchthrough catastrophically destroys the MOS device permanently.

Most MOS devices have an input resistance on the order of 10¹⁴ ohms. Using this figure, it can be seen that a current of about 10⁻¹² ampere (10 pA) can generate a 100-volt potential that can break through the layer of glass and destroy the device. Some semiconductor manufacturers protect their MOS devices with a variety of circuits, the built-in zener-diode-resistance method being the most common.

The schematic representation of a typical "protected" MOS device is shown in Fig. 3. Note the built-in zener diode that identifies this as a protected device. The "source," "gate," and "drain" electrodes are the equivalent of the "emitter," "base," and "collector" electrodes of the typical bipolar transistor. (The "substrate" lead of the device is usually connected to the source lead.) In most cases, the zener diode that protects the MOS device conducts at about 50 volts. However, selection of the "substrate resistance" can present a problem. This resistance must be great enough to limit current flow to prevent destruction of the zener diode, but it must not be so high that the sum of the voltage drop across the zener-resistance combination exceeds the breakdown voltage of the SiO₂ layer. Manufacturers are making improvements in their protective schemes, but as of this writing, there is still no such thing as complete protection.

HOW TO HANDLE MOS DEVICES WITHOUT DESTROYING THEM

The life span of many MOS devices depends on what happens between the time of purchase and installation.

BY LESLIE SOLOMON, Technical Editor

AUGUST 1977
Static Charges. High-voltage static charges are generated whenever there is motion between certain types of materials. A partial listing of typical generators of this "triboelectricity" is given in the table.

**ELECTROSTATIC CHARGE GENERATORS**

**Workbench Covering**
- Any plastic (except conducting)
- Finished wood
- Most synthetics
- Ungrounded metal
- Glass

**Floors**
- Any plastic (except conducting)
- Waxed surfaces
- Most carpeting

**Chairs**
- Fiberglass
- Plastic (except conducting)
- Fabric covered
- Ungrounded metal
- Finished wood

**Tools**
- Plastic nonconductive solder suckers

**Clothing**
- Wool, silk, synthetics, furs

**Packaging Materials**
- Everything nonconducting

We are all familiar with the considerable spark that can be generated as we reach for a doorknob or light switch after walking across the carpeted floor. Walking on a carpeted floor, sliding into or out of a chair or car seat, or even brushing across the surface of a workbench or table can build up a high static potential. Even the seemingly innocent acts of combing our hair and opening the wrapper on a pack of cigarettes or candy can generate a tremendously high static potential.

To understand how this happens, you must visualize yourself as part of a capacitor. You are one plate of the capacitor, the insulating soles of your shoes are the dielectric, and the ground or floor is the other electrode. Typical human capacitance values can range from 80 to 140 pF. Because the spark generated when this "capacitor" is discharged is a function of the energy stored in the capacitor (CV^2/2), body capacitance plays an important role when it comes to handling MOS devices. Measurements have revealed that the electrostatic potential can reach between 2000 and 4000 volts.

Note clothing, floor coverings, and furniture are not the only static-electricity generators. So are many of the usual materials used in packaging and transporting static-sensitive semiconductors and, in many cases, fully populated printed circuit board assemblies.

You can demonstrate the generation of a high static potential generator by using a simple desk tape dispenser and an NE-2 neon lamp. Hold the lamp close to the tape as you rapidly peel about 18" (45.7 cm) of tape from the roll. In dim lighting, you will note that the lamp flashes as the tape rapidly peels off. Now, drop the lamp into a polyethylene bag and rub the bag against a sweater in a darkened room. Again, the lamp will flash. Peel the tape off about an inch or so above a loaded ashtray and note the results. Keep in mind that it takes about 4kV to lift the ashes one inch.

One would expect that the tools we normally use in electronics are "safe" to use on MOS devices. This is far from true. One dangerous tool to use around MOS devices is the plastic solder sucker. The sudden rapid movement of the plastic piston in the housing sleeve of the sucker can generate a very high static potential. Another tool is the soldering iron. Unless it is grounded at the tip, the iron can be a dangerous static carrier.

After looking over the list given in the table, you may be wondering if there is anything you can do to assure safe handling and installation of MOS devices. Rest assured that there is and that we will be dealing with this particular subject later in this article.

The destruction of a MOS device results from the rapid discharge of static electricity across the elements within the device, usually with sufficient energy to rupture the SiO2 layer. Carefully note that this is not the voltage to ground; it is the potential difference between the device's pins that does the damage. Eliminate the potential difference and you eliminate the damaging charge. Note also that no matter how high the static potential you build up by shuffling your feet on a dry carpet, you cannot "zap" one hand with the other—because there is no potential difference.

The problem with MOS devices occurs when the device's pins are placed between two points that have a high potential—usually static—difference. This is why many construction articles advise you to place one hand on the copper traces of the printed circuit board when...
installing MOS IC's. This equalizes the potential difference. Such articles also tell you to handle the IC's only by their cases—not by their pins.

By touching the copper traces on the pc board when you install MOS devices in a circuit, you bridge conductors with a resistance that eliminates possible potential differences and discharges the human capacitor. It is even better to bridge pc board copper traces with a conductor that is better than human skin because skin resistance can be rather high in many cases.

Avoiding the Problem. If you plan to work with MOS devices, here are some things YOU SHOULD NOT DO:

- Insert MOS devices into any plastic containers or carriers unless they are of the conducting types.
- Place MOS devices or pc board assemblies on which they are installed in ordinary plastic bags.
- Hand a MOS device to another person who is not antistatic protected.
- Attempt to test a MOS device with a multimeter, even those with "low-power-ohms" functions.
- Wear nylon or other synthetic clothing. Wear clothing made from cotton or cotton blend fabrics.
- Remove jackets, sweaters, etc., near a MOS device. (Remember the experiment with the tape dispenser.)
- Handle MOS devices by their pins.

GROUN丁NG AND SHOCK HAZARD

Faulty electronic equipment that is not properly grounded can kill! This is the reason most modern electrically powered appliances and equipment are fitted with three-conductor power cords. One pair of conductors in the cord supplies the actual working power from the ac outlet, while the third conductor (usually color-coded green) should be connected between the metal chassis of the appliance or equipment and a good earth ground.

When installing IC's and other components in a circuit, many professionals recommend that you connect your body and the tip of your soldering iron to earth ground through a minimum resistance of 200,000 ohms. The resistor value is selected so that, in the event of an accidental short circuit, the current flow that does the actual damage is limited to 0.2 mA or less, which is considered to be a safe level. A current flow of this magnitude can barely be discerned. Listed below are the effects of electrical current passing through the body from arm to arm. The measurements were made at 60 Hz.

<table>
<thead>
<tr>
<th>Current</th>
<th>Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 0.5 mA</td>
<td>Little or no sensation</td>
</tr>
<tr>
<td>0.5 to 1 mA</td>
<td>Tingling sensation</td>
</tr>
<tr>
<td>1 to 5 mA</td>
<td>Mild pain</td>
</tr>
<tr>
<td>5 to 10 mA</td>
<td>Severe pain</td>
</tr>
<tr>
<td>Over 10 mA</td>
<td>Muscles contract</td>
</tr>
<tr>
<td>Over 100 mA</td>
<td>Ventricular fibrillation; lethal</td>
</tr>
<tr>
<td>Over 2 A</td>
<td>Lethal if sustained; momentary contact produces burns and physiological shock but good chance of recovery.</td>
</tr>
</tbody>
</table>

The above currents and effects are for a typical human being in good health. Except for the last, all effects given are for sustained contact with the current.

- Slide MOS devices across a surface.
- Handle Styrofoam or other plastic hot- or cold-drink cups, open cigarettes or candy packages with "cellophane" wrappers, or use plastic combs or any other item that is either plastic or wrapped in plastic.
- Use plastic solder suckers on or near the pins of MOS devices.
- One thing that most people never consider when working with MOS devices is the humidity of the working environment. The air in a very low-humidity environment is dry and has a very high resistance. Arid air will not discharge the static electricity as fast as moister air. Be particularly on your guard during the low-humidity winter months. Try to work in an environment where the relative humidity is between 30% and 50%.

Now here are some things you should do. MOS devices generally recommend that you wear some type of conductive wrist strap that is connected through a relatively high resistance to earth ground. This is usually followed with the instruction to similarly ground the tip of your soldering iron, tools, and test instruments that might come into contact with MOS devices both before and after they are installed in a circuit. If you heed these precautions and are working at a metal workbench or table, protect yourself from accidental shock (the protection of the MOS device is secondary here). Never connect your metal work station directly to ground; there should always be a minimum of 200,000 ohms between your skin and actual ground in case a faulty appliance power line or chassis has leakage to ground in excess of 0.5 mA.

Although the above precautions are one way in which you can protect your MOS devices from being zapped, it is important that you bear in mind that it is not the potential to ground that presents the hazard to the devices but the voltage difference that is the culprit. Therefore, all that must be done is to find some way to equalize the possible potential imbalance and thus eliminate the hazard.

Fortunately, there is another solution to the problem. This involves the use of antistatic (conductive) plastics. The RC-AS1200 conductive "pink" plastic from Richmond Division of Pak-Well and "Kimcel" from Kimberly-Clark are impregnated with a special noncorrosive organic antistatic liquid that migrates to all surfaces of the material. "Velostat" from 3M Company is a conductive plastic that has a medium resistance per square inch. Of course, we are all familiar with the black conductive plastic

Fig. 4. This is a fully protected work station that includes an ionizing air blower. (Photo courtesy 3M Co.)
Needle in the hi-fi haystack

Even we were astounded at how difficult it is to find an adequate other-brand replacement stylus for a Shure cartridge. We recently purchased 241 random styli that were not manufactured by Shure, but were being sold as replacements for our cartridges. Only ONE of these 241 styli could pass the same basic production line performance tests that ALL genuine Shure styli must pass. But don't simply accept what we say here. Send for the documented test results we've compiled for you in data booklet # ALS48. Insist on a genuine Shure stylus so that your cartridge will retain its original performance capability--and at the same time protect your records.

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In Canada: A.C. Simmonds & Sons Limited

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foam blocks used as carriers for MOS devices during shipping.

These antistatic plastics, with the exception of the last item, come in all forms—from film bags to heavy sheets to semirigid tubing. They can be used in sheet form for workbench tops, as a floor mat around the work station, and with a wrist strap and soldering-iron attachment.

The antistatic bags can be used to store static-sensitive semiconductors. You should have some distinctly labelled antistatic bags for storing semiconductors and completed MOS board assemblies.

Protected Workbench. A typical commercial work station that is fully protected is shown in the lead photo. Here, the technician is wearing a conductive plastic apron, is sitting on a conductive seat cover, and has her feet on a conductive floor mat. The top of the workbench is covered with a sheet of conductive plastic, and a conductive-strap plastic is attached to her bare wrist. A somewhat similarly protected work station is shown in Fig. 4. Here, the station is equipped with an optional ionizing air blower. In both cases, the entire work area, including the technicians, are at the same potential. And since there are no voltage differences, there can be no damaging static discharges that can destroy MOS devices.

If you wish to protect your work station as described here, you can obtain conductive plastic by contacting your local representative of 3M Nuclear Products (3M Center, St. Paul, MN 55101); Richmond Division of Pak-Well (P.O. Box 1129, Redlands, CA 92373); or Kimberly-Clark Corp. (Interior Packaging Dept., Neenah, WI 54956). As an aid to Popular Electronics readers, a hobby workbench setup consisting of a 20" x 12" (50 x 30 cm) Velostat working surface, wrist band with connecting strap, and an assortment of antistatic storage bags (including some large enough to accommodate large hobby-type computer boards) is available for $14.95 from Associated Electronics, 1885 W. Commonwealth, Unit G, Fullerton, CA 92663.

In Conclusion. Though MOS devices are very sensitive to destructive discharges, you can take positive steps to greatly reduce or completely eliminate the problem at its source. By thoroughly protecting your workstation against static hazards, you can work in complete safety with any MOS device.
A CIRCUIT MEDLEY

Rich rewards await the circuit prospector who does his digging in the literature published by various semiconductor manufacturers. Experimenters, hobbyists, teachers, students, practical engineers and professional technicians can all find a wealth of useful circuit information in such publications.

Suggested circuits are frequently included in new device data sheets. Some are offered in separately released application notes and bulletins, and still more will be discovered in manufacturers' bimonthly and quarterly periodicals. Sometimes, the seeker will find the precise circuit needed to solve a particular problem and to complete a pet project. In other cases, he may find that a suggested design can be adapted quite easily to current needs. Just as often, he may find that a proposed circuit sparks his imagination and suggests a number of completely new projects. An instrumentation op amp, for example, may be just the ticket for a control interface. A basic temperature sensing system may be ideal for adaptation as a fire alarm, or a wideband oscillator might be just the circuit needed to complete the design for a new electronic musical instrument.

Representative circuits abstracted from semiconductor manufacturers' publications are illustrated in Figures 1 through 5. Running the gamut from an unusual automotive application to a relatively sophisticated test instrument, the designs utilize both integrated circuits and discrete devices. In general, they are not overly critical as far as either layout or lead dress are concerned, although, of course, good wiring practice should be followed.

A potential life-saver when winter once again rears its frost-covered head, the circuit illustrated in Fig. 1 is one of some ten application circuits suggested by Texas Instruments, Inc. (P.O. Box 5012, Dallas, TX 75222) in a 20-page publication covering the firm's BIFET operational amplifiers, Bulletin CB-248. Dubbed an "Icy Road Warning Indicator," the unit is essentially a special-purpose electronic sensor designed to warn a driver when temperatures drop below a preset value. In operation, op amp IC1A serves as a combination voltage comparator, buffer amplifier and LED driver.

This device receives its inputs from oscillator IC1C and a second voltage comparator, IC1B, which, in turn, acts to compare the voltage applied through series combination R1-R2 with that derived through thermistor TDR1. When the thermometer's temperature drops, its resistance changes, causing a corresponding change in the inverting voltage signal applied to IC1B and developing a control voltage which is applied to IC1A through isolating series resistor R4. With an increased voltage applied to its noninverting input, IC1A supplies a drive current to the LED indicator through current-limiting resistor R10 at a rate determined by oscillator IC1C, causing a flashing light to warn the driver of potentially hazardous road conditions.

A single DIP quad op amp integrated circuit, type TL084, is used in the warning indicator, with three of its sections serving as IC1A, IC1B and IC1C. The fourth section is unused, although some clever experimenters may decide to employ it as an audio oscillator driving a small loudspeaker, thus providing an aural as well as a visual alarm. Except for potentiometer R1 and the thermistor, all resistors are standard half-watt units, while C1 is a conventional 15-volt electrolytic. The thermistor is rated at 15,000 ohms.

During installation, the thermistor should be positioned where it will sense outside temperatures but will not be affected by engine, exhaust, or passenger compartment heat. Naturally, the LED indicator should be placed where it will be clearly visible to the driver. After checkout and installation, R1

Fig. 1. This "Icy Road Warning Indicator," suggested by Texas Instruments, is essentially a special-purpose electronic sensor using an op amp as a combination voltage comparator, buffer amplifier and LED driver.
should be adjusted so that the LED is illuminated when the thermistor temperature drops to 32° F (0° C); during warm weather, an ice cube can be held against TDR1 to achieve the proper temperature for the adjustment.

Featured in Volume 4, Number 2 of the bimonthly periodical Progress, published by the Fairchild Camera and Instrument Corporation (Semiconductor Operations, 464 Ellis St., Mountain View, CA 94042), the bidirectional intercom circuit given in Fig. 2 permits two-way "hands-free" conversations. It is ideal for use, typically, as a door answerer by a housewife busy in a kitchen or laundry as well as in commercial and industrial applications where it may not be convenient for either party to operate a Push-to-Talk switch. Each of the two virtually identical units making up the system features a "privacy" switch (S1 and S2) in addition to individual volume (P2 and P5) and tone (P3 and P6) controls. The system requires a dual ±12-volt dc source, which may consist of either batteries or a well-filtered and regulated power supply.

In operation, a unique arrangement prevents intra-unit acoustic feedback. In Unit A, audio signals developed by the crystal microphone are applied to npn transistor Q1, which serves simultaneously as a preamplifier and phase-splitter, producing both in-phase and 180° out-of-phase signals. The in-phase and out-of-phase signals are combined in balance control P1, where the in-phase signal is cancelled and only a portion of the output phase signal is coupled on to the next stage. At the same time, however, the amplified out-of-phase signal is applied to Unit B through the connecting link, where it is coupled through a 10-µF dc blocking capacitor, balance control P4, and volume control P5 to a medium power operational amplifier. The op amp then drives a standard 16-ohm PM loud-speaker. Unit B operates in a similar fashion, with its out-of-phase signal coupled back to Unit A over the same connecting link. Thus, in-phase signals within each amplifier unit which might otherwise cause acoustic feedback are cancelled internally, and continuous two-way conversations are practical.

Standard commercial components are used in the intercom's design. Except for the balance, volume and tone control potentiometers (P1, P2, P3, P4, P5 and P6), all resistors are familiar half- or quarter-watt units. The larger capacitors are 25-volt electrolytics while the 0.005-µF capacitors used in the tone-control networks may be low-voltage ceramics, tubular paper or plastic film types. Only four active devices are used: transistors Q1 and Q2 (2N3695 and 2N3693, respectively) and two µA759 op amps. Privacy switches, S1 and S2, are spst and may be any type. Conventional assembly and wiring techniques can be used for circuit construction. After installation, the balance controls (P1 and P4) are adjusted to minimize acoustic feedback within each unit with the respective volume controls set at near maximum. Afterwards the volume and tone controls are operated as in any regular intercom system.

Intended primarily for use by photographers, the sensitive light meter circuit shown in Fig. 3 provides an analog readout proportional to the log value of light intensity and, therefore, can be calibrated directly in EV (Exposure Value) units. With ASA ratings of 100, the instrument's range is EV -3 to EV +18 on the 500-µA meter. The design is one of several for the 8007 FET-input operational amplifier described in Application Bulletin A005, published by Intersil, Inc. (10900 N. Tantau Ave., Cupertino, CA 95014). In addition to the 8007, the circuit uses a SBC 2020 silicon photodiode, an IT120 dual npn transistor, and a conventional 741 op amp. In operation, temperature compensation is provided by voltage divider R1-R2, which forms a gain block in conjunction with half of the dual transistor and the 741. Diode leakage errors are minimized by operating the photodiode at essentially zero voltage, while a log-gain characteristic is achieved by means of the transistor feedback element. The instrument requires a standard ±15-volt dual dc power source, with power supply connections to IC pins 7(+) and 4(−).

Featuring discrete devices and conventional IC's, the wide-range function generator in Fig. 4 offers serious experimenters more of a challenge than do simplified designs using special-purpose devices, such as the XR-2206. It is described by Robert C. Dobkin in Application Note AN-115, published by the National Semiconductor Corporation (2900 Semiconductor Drive, Santa Clara, CA 95051). The instrument is capable of supplying sine, square and triangular waveforms at ampli-

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**Fig. 2.** Fairchild's bidirectional intercom system permits two-way "hands-free" conversations. Each of the two units has a privacy switch in addition to individual volume and tone controls.

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tudes up to ±10 V from 10 Hz to 1 MHz without band switching. Usable outputs are available to as high as 2 MHz, but of reduced amplitude and waveform quality. It requires three IC's, a dual pnp transistor, two dual npn transistors, two conventional npn transistors, and seven standard diodes. With both trigger and signal outputs, the instrument has two semifixed adjustments and three operating controls in addition to its power switch: a three-position FUNCTION switch, a FREQUENCY control, and an AMPLITUDE control.

The basic generator comprises an LM319 dual voltage comparator, current-source switching transistors Q1-Q2 and Q3-Q4, timing capacitor C1, and an LH-0033C FET-input voltage follower buffer amplifier. A triangular signal waveform is generated by alternately charging and discharging timing capacitor C1 through switching current-source transistors Q1-Q2 and Q3-Q4 and diodes D1 and D2. The resulting signal is amplified by the LH0033C voltage follower and coupled back through voltage-divider R8-R9-R10 as inputs to the LM319 dual voltage comparator which forms part of the feedback network. The triangular signal also is applied to function switch S1 through series isolating resistor R18. Control dc voltages obtained from voltage-dividers R20-R32 and R23-R31 set the threshold at the other inputs of the voltage comparators, thus establishing the peak-to-peak amplitudes of the comparator outputs. Connected in parallel, the comparator output signals are applied to emitter follower Q5, which serves both to supply a square-wave output signal to function switch S1 through series isolating resistor R24 and to provide a drive signal to the current-source switching transistors, Q1-Q2 and Q3-Q4.

The generator's frequency of operation depends on C1's charge and discharge currents. Ranging from 5 nA to 5 mA, these are controlled by the emitter bias applied to the switch-

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Fig. 4. National Semiconductor's wide-range function generator circuit.

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carry a 1% tolerance. Good quality ceramic or plastic film capacitors should be used in the generator circuit, 25-volt electrolytics as power supply filters C7 and C8, and solid tantalum types for the power supply bypass units (C9, C10, C11 and C12). Function switch S1 is a 3-position, single-pole, non-shorting rotary switch.

If a separate power supply is used, bypass capacitors C9 through C12 should be wired within the function generator. However, with careful planning the entire circuit, including the power supply (except for the power transformer and ac line components), can be assembled on a single pc board. A common heat sink should be used to couple switching transistors Q1-Q2 and Q3-Q4 to insure thermal tracking. After assembly and check-out, two simple adjustments are required. With the function switch in mid-position (triangular wave output), R11 is set for a 1-MHz signal and R16 is adjusted for perfect waveform symmetry. Next, R11 is set for a 10-Hz output and R14 is adjusted for perfect symmetry.

**Fig. 5.** This power supply will provide plus-and-minus 5- and 12-volt supplies for the function generator of Fig. 4.

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VOX POPULI

Q. Could you please explain how a voice-operated switch in an SSB transmitter works?—R. Lloyd, Goldsboro, NC.

Q. Can you suggest a circuit for a VOX switch for use with my transmitter?—Dan Brown, New Albany, IN.

A. A VOX circuit samples the microphone signal, usually after amplification by a mike preamp. The signal is further amplified by a VOX amp, then rectified and smoothed into a positive dc level by an RC filter with a fairly long time constant. The receiver's audio output is also sampled, conditioned by an anti-VOX amp, then rectified and filtered by a diode and RC filter into a negative dc level. The VOX and anti-VOX signals are summed and applied to a comparator.

When the operator is not speaking, the microphone picks up the audio. But the anti-VOX signal prevents the receiver audio from tripping the VOX circuit. When the microphone detects speech, a positive input is applied to the comparator. When the VOX input exceeds a reference voltage (applied to the comparator to limit VOX sensitivity), a relay driver such as a transistor conducts, energizing the VOX relay. This relay in turn activates the transmitter's T/R relay. Also included in most VOX circuits is a delay circuit. This holds the VOX relay closed for an adjustable interval of time, thus preventing relay drop-out and chatter between syllables and closely spaced words.

A really nifty VOX circuit appeared in an article called, "A VOX for a Very Small Box," in QST for March 1976. It uses just two IC's and is powered by +12 volts dc. Back issues of QST are available for $1.50 from the American Radio Relay League, 225 Main Street, Newington, CT 06111.

ANTENNA DESIGNS

Q. I own a Bearcat IV scanner and would rather make an antenna than buy one. Can you show me a few simple and effective designs for external antennas which will work in the low and high vhf bands?—Chris Del Plato, Whippany, NJ.

A. There are many things to be considered here. You'll have to decide whether you want one antenna for each band, or say a broadband antenna to cover more than one. Also, are you interested in a low-gain, omni-directional antenna or a high-gain directional one? It's best to consult one of the many books on the subject, such as The Radio Amateur's Handbook, The ARRL Antenna Book, The Radio Amateur's VHF Manual (published by the American Radio Relay League, 225 Main Street, Newington, CT 06111), or the VHF Handbook for Radio Amateurs (Radio Publications, Box 149, Wilton, CT 06897), or the Radio Handbook (Editors and Engineers Division, Howard W. Sams & Co., Indianapolis, IN 46268).

Have a problem or question on circuitry, components, parts availability, etc? Send it to the Hobby Scene Editor, POPULAR ELECTRONICS, One Park Ave., New York, N.Y. 10016. Though all letters can't be answered individually, those with wide interest will be published.

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THE FOUR-LAYER DIODE

THE FOUR-LAYER diode is a npnp negative-resistance, two-terminal device with switching properties similar to those of the neon glow lamp (see December 1976 "Experimenter's Corner"). Below a certain voltage level, variously called the trigger, threshold, avalanche or firing voltage, the diode has a very high electrical resistance and is said to be in the "off" state. When the applied voltage reaches the trigger level, the resistance of the diode abruptly drops to a few ohms or less and the diode enters the "on" state. Sometimes called the Shockley diode after its inventor, the four-layer diode is virtually unknown to most electronics experimenters. Many of them, however, have used a four-layer diode with a third electrode, the well-known SCR (silicon controlled rectifier). While the four-layer diode will only trigger at a specific firing voltage, the SCR can be made to switch over a wide voltage range by simply applying a trigger pulse to its gate electrode. And, as some experimenters have accidentally learned, the SCR will self-trigger just like a four-layer diode if the anode-cathode voltage exceeds a certain "forward breakdown voltage."

It's true that the gate terminal makes the SCR a more versatile electronic switch than the basic four-layer diode. Nevertheless, since the four-layer diode is capable of self-switching, it is ideal for use in ultra-simple relaxation oscillator circuits. Considerable operating flexibility is available since four-layer diodes are available with trigger voltages ranging from 10 to more than 100 volts.

A basic four-layer diode relaxation oscillator is shown in Fig. 1. In operation, C1 is charged through R1 until the switching voltage of four-layer diode D1 is reached. The diode then turns on and the charge on C1 is suddenly shorted across D1 and the load, RL. When the current from C1 falls below a certain minimum level, D1 switches off and R1 again charges C1 to D1's switching voltage.

This oscillator circuit is so simple that important details of its operation are easy to ascertain before a test version is built. For example, since the charge on C1 determines when D1 switches on, the RC time constant of R1 and C1 determines the firing frequency of D1. The firing rate is limited to a certain maximum frequency since D1 will stay on if the current flowing through it exceeds a certain minimum level (Ih). Accordingly, R1 must be large enough to keep the current level from the power supply below Ih.

Finally, we know that since D1 has a very low "on" resistance, very high currents can be present during the circuit's discharge cycle. For example, if both RL and D1 (in the "on" state) each have a resistance of one ohm, the total resistance across C1 is only two ohms. Ohm's law says the current in a circuit equals the voltage divided by the resistance (I = E/R). Therefore, if D1 fires at 50 volts, an impressive 25 amperes will flow through D1 and RL during the discharge cycle of C1!

Of course, 25 amperes will rapidly destroy a relatively puny four-layer diode if applied continuously. But by limiting C1 to about 0.1 µF the width of the current pulse will be a very brief microsecond or so. This keeps unwanted heat build-up to a minimum and protects the diode from thermal destruction.

The ultra-fast switching speeds of the four-layer diode (less than 50 nanoseconds) mean that the inductance of the wire leads in the discharge path can slow the discharge pulse and induce ringing (negative undershoot). This isn't serious in some applications, but it can cause problems in others.

Practical Circuits. The super-simple circuitry of a four-layer diode relaxation oscillator lends itself to many practical applications. For example, Fig. 2 shows a simple, yet versatile, audio oscillator which can be used to produce audio frequencies ranging from the "pock . . . pock . . . pock" of a metronome to the ear-piercing sound of a 10,000-Hz tone. Switch S1 permits various values of capacitance to be selected. Potentiometer R2 varies the frequency of the circuit by altering the charging rate of the discharge capacitor. Diode D1 can be any common four-layer diode such as the 1N3831 through 1N3846, the 4E series or the M4L series.

Diodes with low firing voltages work well and simplify firing requirements. (See the specs for individual diodes.) For example, power for a diode with a 20-volt firing voltage such as the 1N3821 can be supplied by a series string of three fresh 9-volt transistor radio batteries.

The circuit in Fig. 2 can easily be adapted for use as a pulse generator by substituting the simple network in Fig. 3...
for the speaker. The 500-ohm potentiometer permits the amplitude of the output pulses to be varied between zero and the firing voltage of the four-layer diode. The small resistor (3.3-10 ohms) limits the output current and protects D1 from being damaged by excessive current flow in the event the output is shorted directly to ground.

My favorite application for the four-layer diode relaxation oscillator is as a subminiature, high-current driver for infrared LED's and semiconductor injection lasers. Figure 4 shows a circuit using only three components which easily delivers 10-ampere pulses with a width of about 100 nanoseconds and a rate of about a kilohertz to a diode laser. A typical experimenter-grade laser diode will deliver up to several watts of invisible infrared at a wavelength of about 900 nanometers when driven by this circuit. Laser, pulser, and batteries can be easily built into a small pocket-size package. A simple lens can be added to squeeze the broad beam from the laser into the pencil-thin beam produced by the much more costly gas lasers.

Be sure to keep the leads between the laser and the pulser short and direct if you try this circuit. Excess lead length can induce negative overshoot currents of several amperes, enough to damage or destroy the laser. It's very important to keep the pulse current below the maximum allowable for a particular laser. If you have access to a fast (25 MHz or so) scope, you can see the pulses delivered to the laser. Insert a 1-ohm resistor (fixed carbon; not wirewound) between the laser and ground and connect the scope across it. Since the resistance is one ohm, the voltage seen on the scope equals current in amperes through the laser.

You can also try building a four-layer diode audio oscillator to become familiar with the operating simplicity of this often overlooked parts saver.
**Product Test Reports**

**PRESIDENT "WASHINGTON" AM/SSB CB BASE STATION**

40-channel transceiver can be powered by ac line or 13.8-volt dc.

The "WASHINGTON" from President electronics is a sophisticated 40-channel AM/SSB CB base station transceiver. It is designed for operation from an 117-volt ac line source, but also may be powered from a nominal 13.8-volt dc supply with negative or positive ground.

Digital frequency synthesis and numeric LED channel indicators are used in the transceiver. Among its other features are: PHONE jack; VOLUME control; RF GAIN and SQUELCH controls; MIKE GAIN control; AM/USB/LSB mode selector; CLARIFIER control; PA/CB and NB (noise blanker) pushbutton switches, the latter with a noise limiter; illuminated s/RF PWR meter; LED mode indicators; front-facing speaker; transmitter-on LED; external-speaker jack; low-level clipper with filter; automatic modulation control (amc); automatic level control (aic) for SSB operation; electronic voltage regulation; reverse-polarity protection; and a line filter for dc sources.

The transceiver measured 13½" W x 11"D x 5¾"H (34.3 x 28 x 12.7 cm) and weighs 13.8 lb (6.3 kg). Supplied with microphone and mobile mounting hardware, it retails for $429.95.

**Technical Details.** Frequency control of the transceiver is provided by a PLL (phase-locked loop) synthesis system. A single-conversion receiver is employed, with the PLL’s voltage-controlled oscillator (vco) operating in the area of 35 MHz to produce a 7.8-MHz i-f. A diode-protected r-f stage precedes the FET mixer.

A simple crystal bandpass filter following the mixer minimizes unwanted-signal responses, while a multisection crystal-lattice filter provides AM adjacent-channel rejection and sideband selection on SSB. Three i-f stages, the second and third of which are dc coupled, provide high gain with good stability. Separate voltage-doubling diodes are used for the S meter, for which there is an additional i-f amplifier, AM detection, and the agc. The last is amplified along with the r-f gain and controls a transistor that functions as a variable attenuator at the input to the r-f amplifier. A product detector is provided for SSB.

The anl for AM is the usual type and is followed by an audio amplifier and an IC power-output stage that also provides the modulating signal on AM. An amplified squelch is agc activated. The noise blanker employs the usual setup. It functions at 23 MHz to prevent triggering by CB signals and is switched in along with the anl.

A 10,240-kHz crystal-controlled signal is divided down to 10,000 Hz to provide the standard PLL reference. Then an 11,285-kHz crystal signal is tripled, difference-mixed with the output of the vco, and divided (according to the channel selector position). This provides the vco comparison signal at the phase comparator that furnishes the control voltage for the vco. All dividing and phase comparison are accomplished in a single integrated circuit.

On transmit, the 11,825-kHz crystal signal is replaced by a ±800-Hz signal (depending on whether AM, USB, or LSB is selected). When tripled, this signal generates a total change of ±2400 Hz. This signal is then mixed with one of two carrier-oscillator signals, again depending on the mode of operation, that are also shifted ±2400 Hz from 7800 kHz.

The output of the vco is sum-combined at a transmitter mixer with the nominal 7800-kHz signal to provide the on-channel frequency. However, on SSB, the 7800-kHz signal is first modulated and the carrier suppressed at a balanced modulator. After this, the desired sideband is selected by the crystal-lattice filter.

The mixer is followed by an r-f amplifier, predriver, driver, and the r-f power amplifier stages. The power amplifier includes a three-section output network with a TVI trap. On SSB, the power amplifier functions as a linear amplifier, as do the preceding stages. On AM, the power amplifier and driver are collector modulated.

A bootstrap setup around an IC microphone amplifier provides compression with this amc augmented by a low-level clipper. This is followed by a dual-section low-pass audio filter that minimizes frequencies above about 2500 Hz. This scheme eliminates out-of-band distortion that might otherwise produce splatter due to the internal clipping action. The overall result is extremely effective in preventing overmodulation while still allowing high average modulation without out splatter. Similar results are obtained on SSB, where the low-level clipper is engaged along with an aic setup.

Transmit/receive transfer is accomplished with a relay, along with electronic switching.

**Laboratory Measurements.** In our laboratory measurements, we obtained the following results. The sensitivity of the receiver measured 0.55 µV on AM with 30% modulation at 1000 Hz and less than 0.2 µV on SSB for 10 dB (S + N)/N. Image, i-f, and other unwanted-signal rejection all measured greater than 75 dB. Adjacent-channel rejection, desensitization, and crossmodulation were in the range of 55 to 60 dB. The squelch threshold range was 0.4 to 1000 µV. The agc figure of merit was 13 dB of audio change with a 20-dB r-f input change at 1 to 10 µV, 16 dB of audio...
obtained change above SSB. The audio output measured AM and greater than 3.5 watts at 3% THD with a 1000-Hz test signal on receive and 3.75 watts on PA.

The noise blanker allowed 0.5-to-1-μV signals to be readable with only a trace of background noise in the presence of impulse noise 100 dB above 1 μV/MHz bandwidth. Pulses 70 dB above 1 μV were all subdued.

The AM carrier output was 4 watts when the transceiver was operated from the ac line. On SSB, the output was 12 watts pep with a test tone and 14 to 16 watts with voice modulation. Maximum AM modulation at input levels 25 dB above that required for 50% modulation were 90% on the positive peak and 85% on the negative peak at 6% THD with a 1000-Hz signal. The THD increased to 20% during maximum clipping at 400 Hz. Adjacent-channel splatter with voice or steady 1000-Hz modulation was a minimum of 60 dB down. It was in the range of 55 to 60 dB at 2500 Hz. The peaks occasionally hit 100% with voice modulation.

Third-order distortion products on SSB were 26 dB below two test tones, or 32 dB below the pep output, using maximum microphone gain and alc, which allowed high average modulation without distortion-causing flat-topping. Unwanted-sideband suppression at 1000 Hz was greater than 50 dB and carrier suppression was 60 dB.

**User Comment.** This is an impressive looking transceiver, matching its fine performance. The channel-selector knob is large and easy to handle. Much to our delight, there are no concentric controls to confuse the CB'er. The controls are arranged in logical order along the bottom of the front panel. The mode-indicating LED's are ideally located above the mode switch, and the channel displays are large and easy to read.

Another nicey is that the lighted meter is large and round for easy reading. The power scale's calibration at the point labelled "4" coincides closely with the actual AM r-f output power. Should the user switch to PA, however, he will learn that the meter is not illuminated, nor are there any other indicators that the transceiver is "on."

One of the fine performance features of this transceiver is its modulation. As noted by our tests, the transceiver provides a high average modulation level for a good punch, with the modulation peaks held to just short of 100%. This produces a clean signal without splatter, even with the MIC GAIN control fully turned up. However, it must be recognized that although the clipper's lowpass filter minimizes distortion products outside of the channel being used, distortion from heavy clipping can appear in the transmitter's audio passband. (The passband was nominally 260 to 2700 Hz on AM and 400 to 2500 Hz on SSB.) In this respect, the response varied somewhat with different microphone levels due to variations in the clipping levels at various frequencies. The Washington's front-facing speaker enhances voice intelligibility and the phone jack permits private monitoring.

With the exception of an SWR indicator, the Washington CB transceiver from President Electronics has everything you will need for convenient base-station use on both AM and SSB.

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**FLUKE MODEL 8020A DIGITAL MULTIMETER**

3½ digits, 6 functions, 28 ranges.

**FLUKE'S** new Model 8020A digital multimeter has a number of innovative features wrapped up in a rather small package for portable use. It features a 3½-digit liquid crystal display (LCD) and low-current IC's to permit up to 200 hours of continuous operation from a single replaceable 9-volt alkaline battery. In addition to the usual voltage, current, and resistance measuring capabilities, the new DMM has a novel "conductance" function that offers the user the capability of measuring transistor beta and high-resolution resistance up to 10,000 megohms.

The DMM measures 7½"L x 3½"W x 1½"D (18.1 x 8.6 x 3.8 cm) and weighs 13 oz (560 g). $169.

**General Details.** The DMM offers six functions and 26 ranges, all selectable by pushing in the appropriate switches located along the left side of the case. The functions include ac and dc current and voltage, resistance, and conductance. The accuracy on all functions and ranges is specified at 0.25%. Transient protection for up to 6000 volts is provided, as are automatic zeroing and automatic polarity indication.

Ac and dc voltages can be measured on five ranges that go up in decade steps from 200 mV to 1000 volts full-scale on dc and 750 volts on ac. Input resistance/impedance in both cases is 10 megohms (paralleled by less than 100 pF on the ac ranges). On dc, the input is protected up to 1000 volts on all ranges, while on ac, protection is provided for up to 300 volts rms on the 200-mV range and up to 750 volts rms on the higher ranges. Accuracy on dc is 0.25% + 1 count and on ac is a function of frequency, going from a low of 0.75% +2 counts up to 1000 Hz to a high of 5% + 5 counts at 5000 Hz. The normal-mode rejection is 60 dB at 50/60 Hz, while common-mode rejection is 100 dB at dc and 50/60 Hz.

Six ranges are provided for the resistance-measuring function, each going up in decade steps from 200 ohms to 20 megohms full-scale. Accuracy is stated as ranging from 0.2% on the lower ranges to 2% on the 20-megohm range. Full-scale test voltages on the 200-ohm, 20k, and 2-megohm ranges is 0.25 volt; greater than 0.7 volt on the 200k and 20-megohm ranges; and less than 1 volt on the 2k range. The open-circuit voltage is rated at less than 3.5 volts on the 2k range and less than 1.5 volts on all other ranges. Note that the test voltages are arranged so that on the 200-ohm, 2k, and 2-megohm ranges silicon diodes will not conduct when taking a resistance measurement in a circuit across a semiconductor junction. Overvoltage protection up to 300 volts dc and ac rms is provided on all ranges.

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The conductance function allows high-resistance measurements to be made to an equivalent of 10,000 megohms. This allows the user to test for capacitor leakage and check the condition of diodes, cables, etc. In addition, by using an external socket and a single resistor, transistor beta can be measured directly. This handy function makes transistor matching a snap.

Two conductance ranges are provided: 2 mS and 2 nS (S stands for Siemens, which replaces the formerly used mho). Accuracy is rated at 0.3% +1 count on the 2-mS and 2% +10 counts on the 2-nS ranges. The open-circuit test potential is less than 1.5 volts dc on both ranges, and both ranges will forward bias a typical transistor junction.

Four decade ranges are provided for making current measurements on ac and dc, starting with 2 mA and ending with 2000 mA (2 A) full-scale. Accuracy on dc is rated at 0.75% +1 count on all ranges. On ac, the accuracy is stated at 2% +2 counts between 45 and 450 Hz on the 2-mA range and 1.5% +2 counts on all other ranges between 45 and 1000 Hz. In both modes, the insertion drop is specified at 0.7 volt on the 2000-mA range and 0.25 volt on all other ranges. Overcurrent protection is provided for up to 2 A on all ranges in both modes, and the inputs are fuse-protected when measuring current in circuits where the open-circuit potential is 250 volts or less.

User Report. We tested the DMM in our usual manner, using a laboratory voltage reference standard and a variety of 1% and 0.1% precision resistors of known values. Our results verified that the meter was within the published specifications—in most cases, well within the spec—on the resistance and ac and dc voltage functions and ranges.

We used our voltage reference and 0.1% tolerance resistors to then check the accuracy of the current-measuring functions. Though we did not attempt to make current measurements greater than 250 mA, the results obtained leave no doubt that here, too, the instrument performed well within its published specifications.

The DMM is housed in a high-impact plastic case, on which we performed our usual drop test from a height of 1 meter onto a hardwood floor. Needless to say, the instrument survived the test. We performed the laboratory tests again and discovered that our results were no different from those we had obtained before the drop test.

We like the location of all the operating switches along the left side of the instrument's case. This makes for convenient one-hand operation of the DMM. Another plus is that the test-lead input jacks are deeply recessed into the case, which makes it virtually impossible for a user to accidentally bridge the inputs with his hand when making high-voltage measurements.

The large 7/16" (11.1-mm) high numerals in the display are dead black against the light metallic background, which makes them easy to read under almost all lighting conditions. Being a liquid crystal display, it requires very low current to operate, which is the primary reason an ordinary 9-volt alkaline battery delivers such a long operating life. In fact, during our field tests of the DMM we rarely ever turned off the power when we were on a job. And replacement of the battery is a simple operation. A cover at the bottom rear of the case slides out to allow the battery (and the fuse, which is mounted in a block atop the battery clip) to be replaced at a moment's notice.

We performed some transistor beta tests according to the instructions given in the manual supplied with the DMM. To our surprise, the Model 8020A DMM came up with almost identical readings as those obtained on our laboratory-grade transistor tester.

Although the conductance mode was new to us, it did not take us long to gain familiarity with it. The operating manual illustrates a conductance-to-resistance conversion table that can be used for exacting measurements. Essentially, the conductance function allows the DMM to make measurements out to 10,000 megohms, which is not possible with ordinary multimeters, even DMM's. This capability is ideal for checking capacitors and cables for leakage and semiconductors for forward/reverse ratios.

When the potential from the battery drops below 7.2 volts, the display indicates BT to inform the user that only 20% of the battery's life remains.

After using the Model 8020A digital multimeter on our workbench and in the field for some time, we conclude that it is an excellent instrument for the engineer, technician, and hobbyist. It is rugged, easy to use, and provides more than enough accuracy for most any measuring task. Moreover, its conductance function expands the meter's versatility. It is also quite reasonably priced for what it offers in the way of test and measurement capabilities.
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REMOTE CONTROL

There has been lots of talking in various computer circles about the possibility of using a computer and a special program to control appliances around the house. However, there has been very little doing on the subject after the expense of the necessary rewiring was calculated.

While considering this problem at one club meeting, I was reminded of an article published in this magazine some time ago that just might be of some help. The article was "Wireless Audio System for Remote Speakers" (January 1976) and it described the concept of using a wide-band (30 Hz to 17 kHz) FM carrier-current transmitting system operating at approximately 200 kHz, to pipe hi-fi music around the house using the ac power lines already existing in the structure. Wherever you wanted a loudspeaker, you merely installed a matched FM carrier-current receiver and used the audio output from this device to operate the remote speaker system.

Now, why couldn't the same idea be applied to a computer system since just about every structure where a computer is installed is already wired and the existing power lines could be used? The only requirement is to substitute discrete tone signals for the hi-fi music. Since the wireless system has excellent specifications (S/N is −65 dB, frequency response is 30 Hz to 17 kHz ±0.2 dB, and audio distortion is less than 2%), good results could be expected.

Although I am still in the process of building what I am about to describe, I want to pass the idea along so that any one who is interested can make his own modifications or redesign the system for better operation.

Modulating With a Program. The first requirement is a program that will turn on an audio tone generator at a frequency determined by a given command. This tone is then used to modulate the wireless intercom system. A separate decoder can be installed in each room where there are appliances to be controlled and each decoder supplies a number of output signals.

The decoded output could be used to turn on an SCR or triac, which, in turn, would supply power to a conventional appliance socket. If each socket is color-coded, or otherwise identified as to which tone turns it on, the computer can control power to any socket in the system. To avoid having to keep a tone on-line while each socket is powered, the decoded output pulse can be used to turn on a flip-flop that operates the SCR or triac. Thus, the first transmitted tone turns on a socket. Then, because of the flip-flop action, the socket remains powered even when the tone is removed. The second time the tone occurs, the power is removed from the socket.

Because of the 30-Hz-to-17-kHz bandwidth of the system, quite a number of discrete tones can be transmitted. The use of high-Q filters can increase even that number.

The Circuits. Transmitter and receiver circuits that can be used are shown here. Note that both are connected directly to the ac power line, so great care must be taken when working with the circuit to avoid electrical shock.

In the transmitter, which will be located at the computer, the selection of R1 and C1 will determine the oscillation frequency. In the circuit shown, C1 can be about 0.001 µF, while R1 is in the range of 1500 to 4700 ohms for a transmitting frequency of about 300 kHz. Other values may be used to set the desired operating frequency. Although you can use a single resistor for R1, switches may be used to select other values for other frequencies. In the circuit shown, transmission gates (TG) such as the CMOS 4016 can be operated by a computer signal. If desired, simple pushbutton switches can be used.

The output of the transmitter's 567 drives a transistor emitter follower (any good silicon type can be used) with the output passing through a high-pass filter to the ac line.

The receiver section to control only one socket is shown. Its input is coupled to the power line through a high-pass filter which also includes diode signal clipping (optional). The R1-C1 combination in the receiver is selected to mate with that used in the transmitter. The decoded tone output, which occurs when the 567 receives the correct frequency, is
used to operate the flip-flop. This stage, in turn, drives the SCR or triac. This controls the ac line supply to the power socket.

When the correct frequency is received, the flip-flop turns on the SCR or triac. The latter then remains on even when the tone is removed. When the correct frequency is detected the second time, the flip-flop changes states. Then, at the next zero crossing of the power supply, the triac is turned off, removing power from the controlled appliance. As previously mentioned, this system has not been built, but it looks workable. The reader can select his own frequencies, method of keying the tones, type of flip-flop, etc.

Suggestions. It is also possible to use a conventional wireless intercom system, available from most electronics parts distributors and catalogs. They can be modified to use tone generators at the transmitter end and phase-locked loops (like the 567) at the receiver end.

No matter what kind of system you use, the important thing is to remember that any home, farm, or factory wired for power is automatically wired for remote control. All you have to do is generate the correct activating signals.

Newsbreak. There have been rumors in the wind for more than a year now that Heath, among other well-known companies, was planning to introduce a hobbyist computer. Well, it has happened! Heath has entered the hobby computer field. Here is a brief description of what was shown to us at a Heath press conference in Benton Harbor, Mich. Based on the 8080A microprocessor, the new Heath H8 Digital Computer (kit price $375) features a 1k ROM operating system, a 9-digit, 7-segment LED octal display and a 16-key keypad. The readouts are used to display register and memory contents, even when the machine is running. Four discrete LED's are used as system status indicators, while a built-in loudspeaker can be used for a variety of audio effects.

The bus design features two 25-pin connectors, and the bus has provisions for 10 plug-ins. The plug-in boards are tilted at the same angle as the sloping front panel. The "edge" connectors are on one side, and the other side of each board is supported by a metal bracket. The chassis is convection-cooled by a series of louvres on the top and bottom surfaces.

The kit contains everything but RAM memory. A 4k static RAM board kit is available for $140, and a 4k chip set to expand the board to 8k costs $95. There is also a serial I/O board that contains a 1200-baud audio cassette (modified Manchester code, KC standard) for $110, and a three-port parallel I/O for $150.

The Heath H9 CRT terminal (kit price $350) features a 67-key board, and an 80-character by 12-line display on its built-in 12" glare-free monitor. Other features include a format option of four columns of 20 characters by 12 lines, full cursor control, batch transmit, and a plot mode. Standard serial I/O includes EIA (RS-232), 20-mA current loop, and TTL levels. The baud rate is selectable between 110 and 9600.

There are several other items in the Heath computer line, including the H11, a 16-bit machine for $1295. Based on the Digital Equipment Corp. LSI-11 microcomputer module (KD11-F), and featuring the PDP-11 software, this new computer comes with a wired and tested CPU board, and 4k x 16-bit RAM memory. The memory is expandable to 20k. The system includes a built-in backplane, power supply with switching regulators and full circuit protection, and I/O accessories. A complete DEC software package that includes an editor, PAL-11 assembler, linker, on-line debug package, I/O executive, BASIC and FOCAL, is also included. Accessories include a 4k x 16-bit RAM board at $275, a serial and a parallel interface at $95 each. Purchasers of the H11 are eligible to join DECUS (Digital Equipment Computer Users Society), whose library contains over 800 programs for the PDP-11 which can be run on the H11.

Another new item is the Heath H10 paper tape reader-punch for $350. Although intended for the Heath H8 and H11 computers, the H10 can be used with any other computers. This peripheral employs standard 1"-wide paper tape (roll or fan fold), and the reader operates at 50 characters per second and is silent. The tape punch operates at 10 characters per second and either function is independent of the other and may be operated simultaneously. The device also features a copy mode for tape duplication, a built-in power supply, and a stepper motor for the reader tape drive. The interface is standard parallel TTL.

Heath will also make available the LA36 DEC Writer II for use with their computer systems. This hard copy device features variable-width forms from 3" to 14½" wide, 128-character ASCII upper/lower case set with 95 printable characters, 132-column print format with 10 characters per inch horizontal and 6 lines per inch vertical spacing. It can handle up to 6 part forms with 0.020" maximum pack thickness. Other features include half- or full-duplex, parity check on output ANSI-standard multi-key rollover, and a keyboard similar to that on a typewriter. The LA36 uses a 20-mA current loop interface.
CB DEVELOPMENT NEWS AND VIEWS

MUCH HAS BEEN written in this column and others about the future of personal use radio, but soon many of these futuristic dreams may come true as CB technology moves into the realm of computer electronics.

As CB has taken the public fancy, FCC license holders have increased from fewer than a million in January, 1974 to a reported 12 million in 1977. It has been estimated that more than 20,000,000 rigs are now in active use in the U.S.

CB Radio has not only caused shifts in sociological habits of the American public, but it has also created new problems. There are noticeable increases in r-f radiation levels in all parts of the country as the public use of radiotelephone has increased, which includes more users in the business, marine, and the amateur services.

No one has yet suggested a health hazard, to the best of our knowledge, but the r-f background levels are very evident to TV viewers and audiophiles.

TVI (television interference) and audio rectification have become commonplace, and the FCC is under tremendous pressure from the public and from Congress to resolve the problem.

At the same time, with better than one in ten Americans using CB, the FCC is also being pressured to make more of the radio spectrum available for personal use. It was this pressure from both camps that precipitated the sudden 40-channel rule-making in July, 1976. In one quick decision, the FCC increased the number of channels from 23 to 40 and clamped down drastically on harmonic emissions and chassis radiation standards for new transceivers, all effective January 1, 1977.

The 40-channel rule-making was very nearly disastrous for CB manufacturers, all of which had built up huge inventories in anticipation of a banner sales year. Stock was introduced to the market at prices at or below cost in an attempt to reduce inventories. But at these bargain prices, the public just bought 23-channel transceivers, even though new 40-channel models were introduced. Profit margins had disappeared at the same time manufacturers were required to invest heavily in new research to meet the 1977 technical standards for type acceptance. Even so, several large appliance and electronic component manufacturers became newly committed to the CB market.

Now, a year later, the upheaval has not subsided entirely. In early spring there were still about a million new 23-channel rigs on dealers' shelves. Again, manufacturers were forced to reduce prices, this time on 40-channel units to make them more competitive; only top-of-the-line equipment was able to resist this price erosion. Of course, surviving manufacturers began looking for ways to make their expensive rigs look more attractive to the CB public. Their new ideas are beginning to appear in the

CB Scene
By Ray Newhall, KW6O10

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1978 models, which were on display at a trade show early this year.

On the whole, the CB boom has brought about significant improvement in design and production of high quality, low cost CB rigs, and should improve the status of all radiotelephone equipment. Type-accepted transceivers on the market in 1977 are greatly improved over the units sold only a couple of years ago. Major improvements have been made in less interference- and distortion-causing operation and improved reliability, as well as 17 additional channels. Speech-processing circuits have been redesigned to meet stricter modulation requirements, and adjacent channel interference reduced. To be more competitive, nearly all rigs operate close to maximum permissible power, with high modulation.

With the advent of the expansion to 40 channels, digital logic has become commonplace. PLL frequency synthesis is the most economic route to go to achieve 17 more channels, of course. And this design permits channels to be displayed digitally.

**A Shift Of Emphasis.** As mentioned earlier, many CB manufacturers (including surprising new entries to the industry, such as Texas Instruments) are planning to extend their use of digital logic into functions that had never occurred to most of us only a couple of years ago. Some, including Hy-Gain, and T1, are planning to introduce CB rigs in 1978 which incorporate microprocessor logic into the control units of their top-of-the-line sets. Hy-Gain has demonstrated a controller much like a telephone handset, which incorporates push-button control and digital display of channel number, signal strength and an LED digital clock, as well as a separate mike and earphone. Texas Instrument's offering will be similar to Hy-Gain's, but will include SWR readout on its digital display. Features such as channel recall memory and instantaneous channel 9 switching will be included on some transceivers.

**Proposals For The Future.** Robert Beeman of Berkley, Illinois, has formally presented the FCC with a plan to expand personal radio service into a 2-MHz band between 48 to 50 MHz, just below the six meter amateur band. His proposal, labeled RM-2849 by the FCC, recommends the assignment of 99 narrow-band FM channels for personal use.

The proposal analytically examines the usable radio spectrum and concludes that any new allocations must be above 40 MHz in order to eliminate ionospheric propagation (skip), and below 300 MHz because he judges that technical sophistication, high cost and high propagation losses make uhf unsuitable for a personal use radio service.

Mr. Beeman's proposal places major emphasis on problems associated with TVI (television interference), and recommends that any CB frequency allocation should be removed from the closest TV channel by at least four MHz, and that if...
beat characteristics be carefully analyzed. He eliminates the 220 MHz band (proposed by the EIA in 1968 for Class "E" CB) because it has just such an i-f beat relationship to TV channel 7.

Although Mr. Beeman concludes that the only suitable allocation would be from 48 to 50 MHz, he is quick to add that even this band has drawbacks (but no major ones which cannot be overcome by modern technology):

* The band is too close to TV channel 2, and also to the TV i-f frequency band between 41 to 47 MHz.
* Ionospheric "skip" still exists at 48 MHz, but it is infrequent and of short duration.

The advantages he lists for the recommended band are:

* It is presently little used, as compared with the other options available below 400 MHz. These frequencies are now assigned primarily to industry and miscellaneous governmental agencies.
* Six-meter antennas would be convenient for mobile use, yet antenna systems and propagation would be far more efficient than frequencies above 200 MHz.
* There is room in this band for 99 narrow-band FM channels, separated by 16 kHz spacing (transmitter frequency tolerances would be limited to ±1 kHz, or .002%).

The 99 channels would be allocated as follows:

* 70 channels for 5 watt simplex voice transmission
* 18 channels (9 pairs) for duplex wireless telephone
* 5 R/C channels using digital coding
* 5 low power walkie-talkie channels
* 1 channel reserved for digitally-encoded automatic selective calling.

The automatic digital calling channel would be used by transceivers equipped for selective calling. A calling unit might select any unused channel and dial in the identification of the unit he wishes to contact. At the push of a button, a digitally-encoded tone-burst message would be transmitted on the reserved channel (channel zero). When received by the addressed unit, the transceiver would be automatically switched to the channel specified in the message format, the selective squelch disabled, the calling unit identified by a digital display and the receiving operator alerted to receive the incoming call. Such equipment could be programmed to respond automatically to calls on the designated emergency channel.

Mr. Beeman's suggestion for a channel reserved for digital selective calling shows excellent foresight that's well within present day digital logic capability. It would provide high-grade, private personal communications, especially if repeaters, privacy scramblers and automatic patches were one day permitted as they are on the Class A band.

Another ATIS Proposal. There has been another automatic transmitter identification signal (ATIS) proposal submitted to the FCC by the chairman of the PURAC User Rules Task Group, Stu Lippoff, in a report of Minutes of a January 29th meeting. It is a detailed plan for mandatory ATIS applied to the present CBRS band. Although it appears to be a minority report of his own concepts rather than a consensus report by Task Group members, it does reflect some of the concern felt about CBers who refuse to identify themselves routinely by use of a call sign.

This columnist would welcome the inclusion of ATIS devices as a required part of any newly authorized band in the Personal Use Radio Service, but would resist any attempt to retrofit current CB equipment with ATIS devices.
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MICROPROCESSOR COMPONENTS

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- Temperature
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- Time at 1/100 of a Second
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