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 TVT-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.

Sidebanding puts you in your own private world. A world where there's less congestion. More privacy. More time to talk.

It's all possible because instead of 40 channels you get your choice of 120 channels. Both AM and SSB. And instead of 4 watts of legal power you get 12 watts of legal power. So you get almost double the range of AM.

With the 138XLR Single Sideband there's less background noise and less interference. So there's cleaner, clearer reception. Because like all Cobras, the 138XLR SSB is engineered to punch through loud and clear. Even in crowded metropolitan areas.

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You'll find the 138XLR SSB wherever Cobras are sold. Which is almost everywhere. Because Cobra's got a nationwide network of dealers and Authorized Service Centers offering sales, installation, service and advice. So come on in. And move on up.

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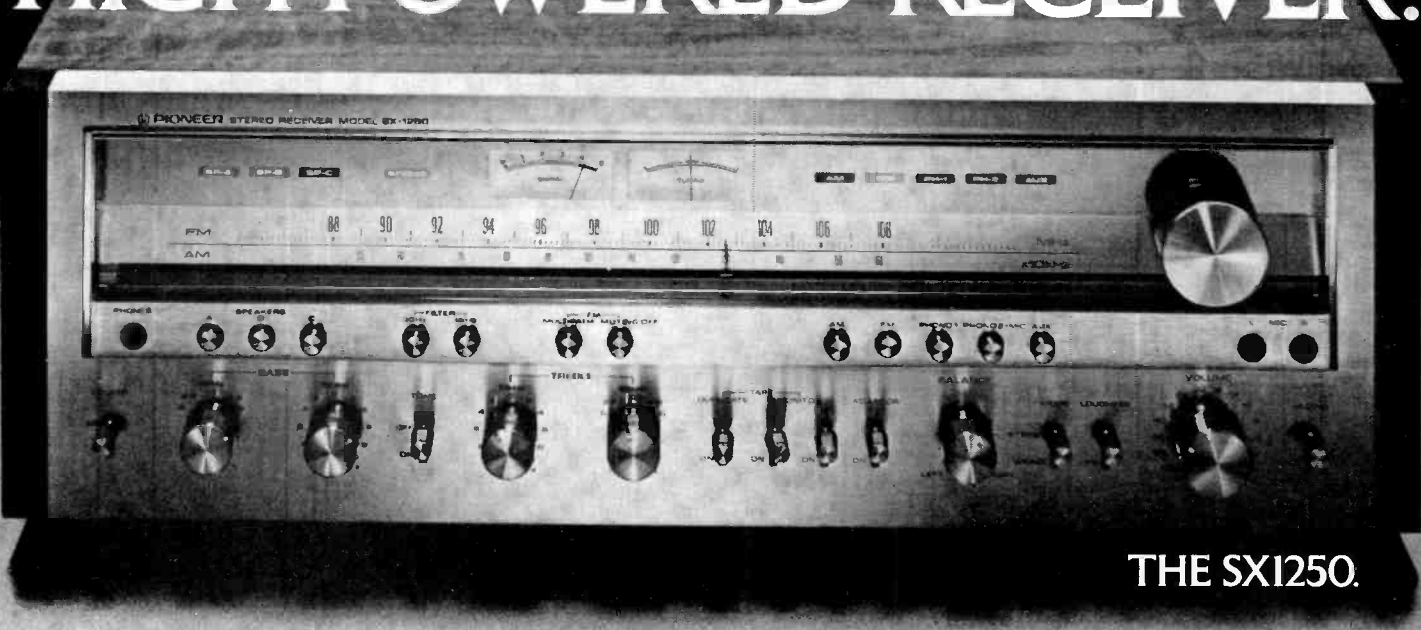
UPWARD MOBILITY.

CIRCLE NO. 59 ON FREE INFORMATION CARD

WHY THE FIRST HIGH POWERED RECEIVER IS STILL THE BEST HIGH POWERED RECEIVER.



THE SX1250.

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.

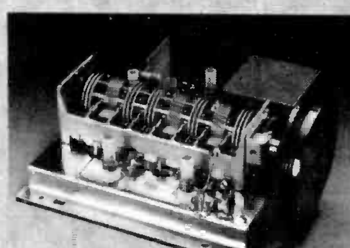
Unlike the others, however, the SX 1250 wasn't a rush job. And the time and care that went into it can both be seen and heard.

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.

An extraordinary power supply, for an extraordinary amount of power.

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.



A five gang variable capacitor for FM reception that never varies.

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.

High Fidelity Components
PIONEER
WE BRING IT BACK ALIVE.

*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 VOLUME 12, NUMBER 2

Popular Electronics®

WORLD'S LARGEST-SELLING ELECTRONICS MAGAZINE

FEATURE ARTICLES

CONSTRUCTION ARTICLES

COLUMNS

JULIAN HIRSCH AUDIO REPORTS

ELECTRONIC PRODUCT TEST REPORTS

DEPARTMENTS

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Editorial

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 dc theory; I=E/R and all that. Only 5% failed, leaving us with 380,000 potential readers. The second test covered ac 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, cricuit 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.

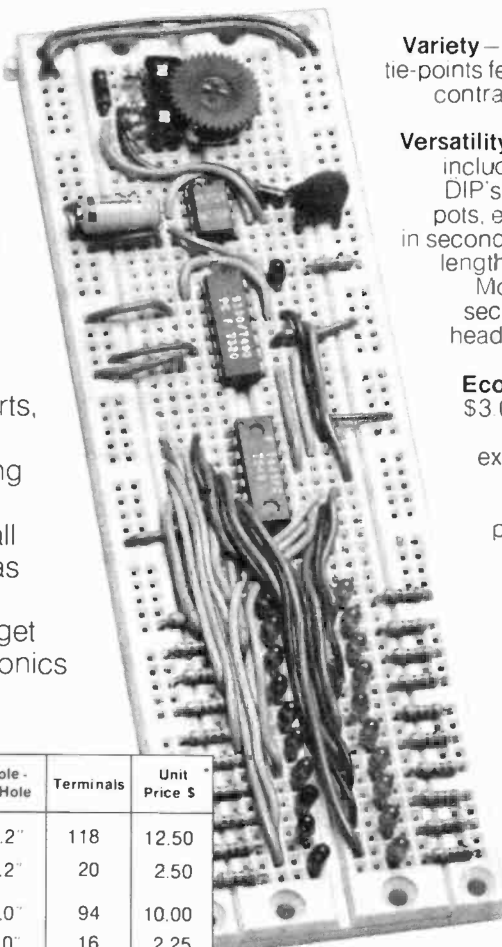
To our surprise, only one person came through with flying colors—Marcia Swampfelder. This single subscription was processed.

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 refreshingly 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."

Art Salsberg

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?

← Length → ← Hole-to-Hole →		Length	Hole-to-Hole	Terminals	Unit Price $
	QT-59S	6.5"	6.2"	118	12.50
	QT-59B	6.5"	6.2"	20	2.50
	QT-47S	5.3"	5.0"	94	10.00
	QT-47B	5.3"	5.0"	16	2.25
1.32"	QT-35S	4.1"	3.8"	70	8.50
	QT-35B	4.1"	3.8"	12	2.00
.7"	QT-18S	2.4"	2.1"	36	4.75
	QT-12S	1.8"	1.5"	24	3.75
	QT-8S	1.4"	1.1"	16	3.25
All QT units are .33" thick	QT-7S	1.3"	1.0"	14	3.00

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, DIP's, 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.

Economy—Sockets are priced as low as $3.00* Save more money by eliminating heat and mechanical damage to expensive parts, re-using components.

Speed—For fast 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 day-in, 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.

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*Manufacturer's suggested list • Prices and specifications subject to change without notice.

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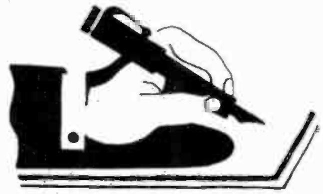


Letters

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, WB9LVI, 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 5082-7340 hex displays for my "COSMAC Elf" 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:

H-P DISPLAY PIN NO.	TI DISPLAY PIN NO.
1	2
2	13
3	12
4	8
5	5
6	7
7	1,14
8	3

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*

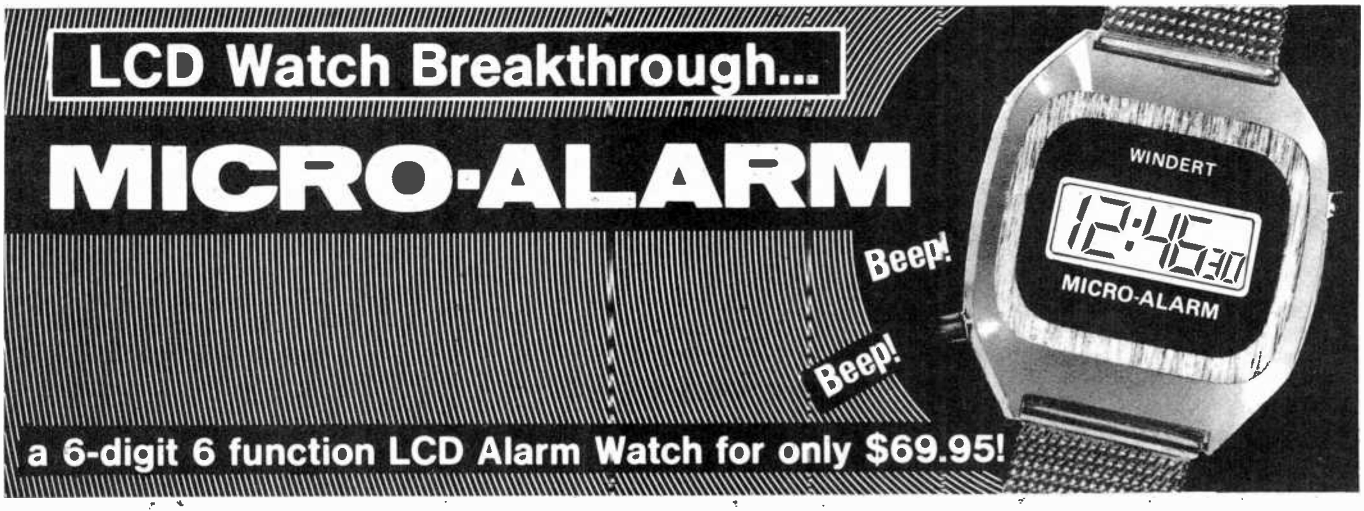
Your statements would be basically correct—if the 7490 were connected only as shown in the example in the article. However, the jumpers on the setup matrix can be arranged to test of any part of a digital IC.

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 V_{DD} 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 pin 4 of *IC3* and the ground, or common, bus. —*Rob Breffeilh, 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 relize 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 catnap, 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.*

7:55 AM

SET TO RING AT 7:55 A.M.

THE ALARM

The MICRO-ALARM has 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-ALARM will remember for you and remind you when you need to be reminded.

SNOOZE/REMIND CONTROL

For your convenience the MICRO-ALARM 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.

12:34 AND 56 SECONDS

12:34 56

6-DIGIT LCD DISPLAY

The MICRO-ALARM has a 6-digit readout showing hours, minutes and seconds at a glance. Since the readout is by Liquid Crystal Display (LCD) and not by Light Emitting Diode (LED), no button has to be pushed; the time is continuously displayed! A built in night-light functions at the push of a button for reading in darkness.

AUGUST 15th FRIDAY

8: 15 FR

CALENDAR DISPLAY

Just one push of the control button converts the display into a 3-function calendar; displaying the month, date of the month, and day of the week. The remarkable memory built into the module knows each month and the number of days in that month and resets automatically on the first day of the new month.

QUARTZ ACCURACY

The MICRO-ALARM is extraordinarily accurate. Its module is manufactured by Hughes Aircraft Company, one of the world's foremost manufacturers of microelectronics, and is guaranteed accurate to within 3 minutes a year (averaging less than 15 seconds per month). You can depend on the accuracy year after year. There are no moving parts, so there is nothing to wear out or even require servicing. The result of this accuracy is that you can set your watch to the second.

THINK ABOUT IT!

Even if you have no consistant need for a watch with a built-in electronic alarm, the MICRO-ALARM is a valuable investment for its watch features alone:

1. It is the most up-to-date fully-functioning electronic watch available today.

2. It is accurate to +/- 15 seconds per month, and never has to be wound — put it on, and the time and date are correct even if it has been in a drawer for a month!

3. Its elegant styling will compliment any attire — and elicit compliments from your associates and friends.

4. At this price you can not find a better buy.

5. One day you will have a critical need to be reminded of a vital appointment — and then, having used the alarm function once, you will never again return to any other reminder system.

6. Why buy an ordinary watch when you can own a MICRO-ALARM?

ELEGANT MESH BRACELET

Each MICRO-ALARM comes with a 1 year limited warranty. You may order in your choice of goldtone or silvertone case. Each for only $69.95 plus $1.99 for shipping and handling. Each MICRO-ALARM 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.

15 DAY TRIAL

Wear the MICRO-ALARM 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.

To order by credit card please phone our 24-hour toll-free number:

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Please send___MICRO-ALARMS @ $69.95 each plus $1.99 for shipping and handling.

_____Silvertone MICRO-ALARM

_____Goldtone MICRO-ALARM

If I am not completely satisfied I may return it for a full refund. Total amount enclosed $_____, check or money order. (Illinois residents please add 5% sales tax.) No C.O.D.s please.

Charge: ☐ Amer. Exp. ☐ Bank Amer./Visa ☐ Master Charge MCBK # __ __ __ __

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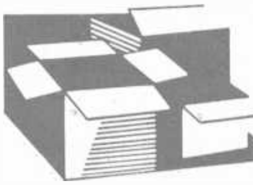


New Products

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 milliamp 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.

CIRCLE NO. 88 ON FREE INFORMATION CARD

AUTOMATIC RADIO STEREO POWER BOOSTER

Featuring dual amplifiers in a compact case for underdash mounting, the Automatic Radio PWR-2125 stereo power booster attaches to the output of any stereo radio or tape player. It boosts the power up to four times, to a total of 30 watts rms. A pushbutton allows switching from normal- to boost-power mode. $34.95.

CIRCLE NO. 89 ON FREE INFORMATION CARD

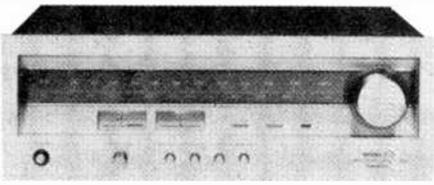
NEOSONIC CB SPEAKER

A CB speaker with a hinge that permits mounting virtually anywhere in cars, trucks, recreation vehicles, vans, tractors, base stations and boats, the Neosonic FS-10 measures 3¾" in diameter and 4" deep. It is said to provide high-quality sound over the 300-to-4000-Hz voice range because of a built-in sharp cutoff LC filter, with a response curve tailored for maximum intelligibility of CB signals. The FS-10 has an 8-ohm impedance and weighs just over 5 ounces. $14.95.

CIRCLE NO. 91 ON FREE INFORMATION CARD

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 dBf) 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.

CIRCLE NO. 92 ON FREE INFORMATION CARD

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. $28.00.

CIRCLE NO. 93 ON FREE INFORMATION CARD

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 frequen-

cies 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.

CIRCLE NO. 94 ON FREE INFORMATION CARD

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, Permaflux 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" × 9⅝" × 7 11/16" (40 × 24 × 20 cm). $180.

CIRCLE NO. 95 ON FREE INFORMATION CARD

VECTOR WIRE-WRAPPING TOOL

Vector's P160-9 is a double-ended tool with a wrapping bit on one end and an unwrapping bit on the other. Designed for use either with Vector's battery-powered P160-4R power

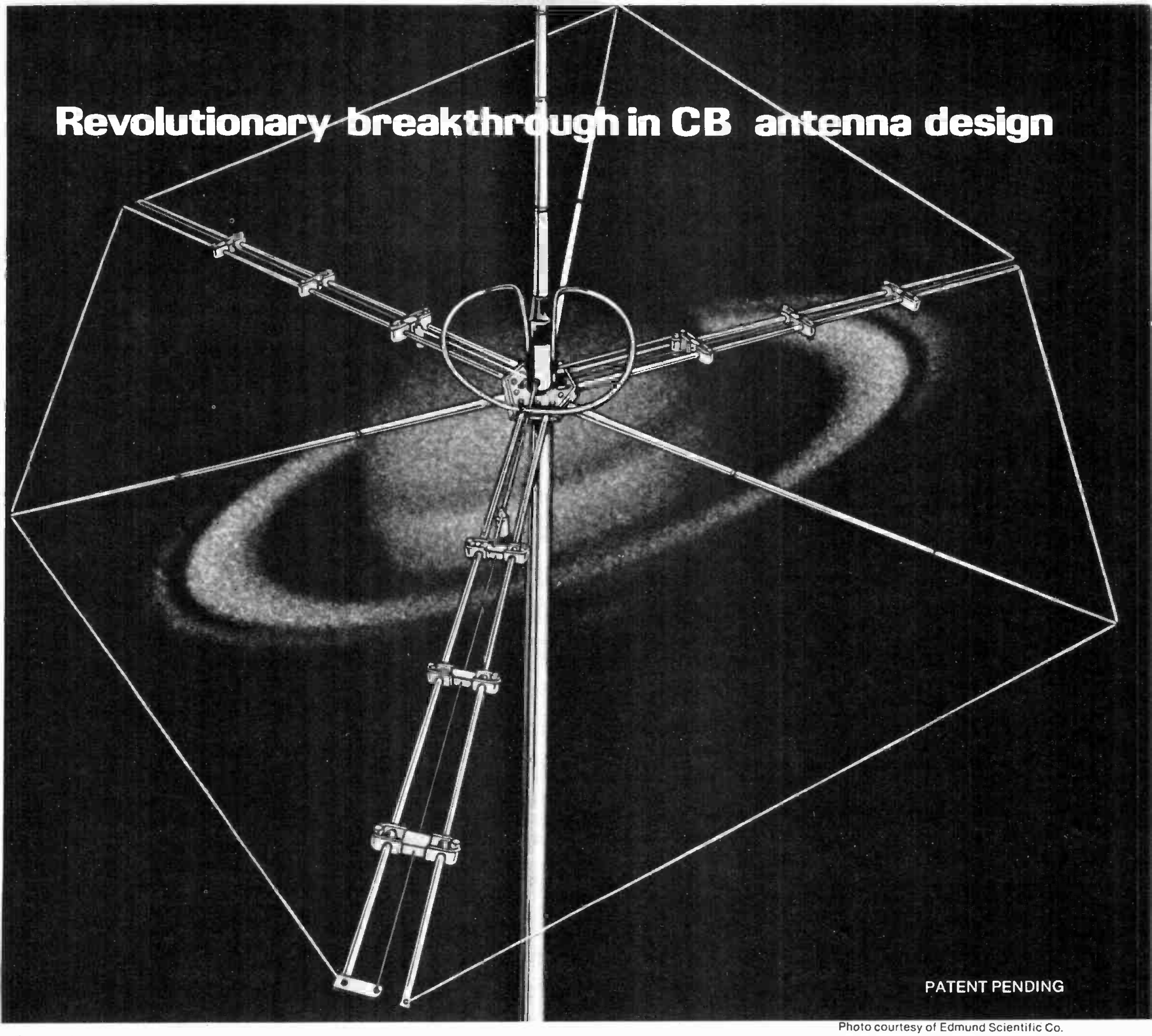


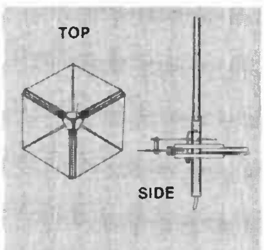
Photo courtesy of Edmund Scientific Co.

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.



Height 22′
Radials 9′
Weight 25 lbs.
Omni-directional — No rotor
AV-501 Switchbox Included

PATENT PENDING

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.

avanti®

AVANTI RESEARCH AND DEVELOPMENT, INC.,
340 Stewart Avenue, Addison, IL 60101

CIRCLE NO. 7 ON FREE INFORMATION CARD

Creators of the famous **MOONRAKER®**

tool, or for manual wrapping, the tool makes gas-tight terminations on 0.025-inch square posts, using 26 to 30 AWG wire. The wrapping bit's 0.07-inch radius allows terminations on posts on 0.1-inch centers. A bit depth of 0.56 inch permits three wrap levels. The P160-9 Wrap-N-Unwrap tool is $18.40, and the P160-4R power tool is $45.68.

CIRCLE NO. 96 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 1½ 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 received 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

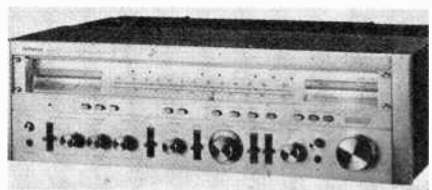
B&K-PRECISION INSTRUMENT PROBE

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 within rated distortion. Features include dual power-output meters, separate signal and tuning meters, mi-



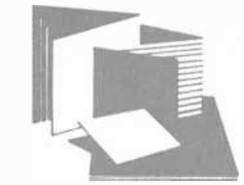
crophone mixing, turnover tone controls, audio mute lever switch, FM muting/auto-lock switch, MPX noise-filter, i-f wide/narrow switch, three front-panel speaker system selector switches, and tape copy and monitor switches. In addition, performance specifications include 1.5 μV FM sensitivity, 85 dB 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



New Literature

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., Schamburg, 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 to 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 1942, 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 90806.

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.

CIRCLE NO. 35 ON FREE INFORMATION CARD

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 ______

CIRCLE NO. 54 ON FREE INFORMATION CARD

SWTPC Southwest Technical Products Corp.
219 W. Rhapsody, San Antonio, Texas 78216
London: Southwest Technical Products Co., Ltd.
Tokyo: Southwest Technical Products Corp./Japan

Stereo Scene

By Ralph Hodges

TAPE TOPICS

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.

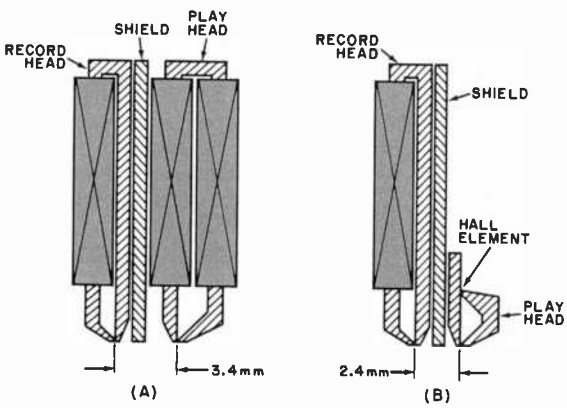
The Hall Head. The Hall effect, named after its discoverer, was happened upon late in the nineteenth century. It involves the ability of a suitably biased piece of semiconductor material (metallic compounds of antimony, arsenic, and other exotic metals being among those favored) to develop an "output" 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 play 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.

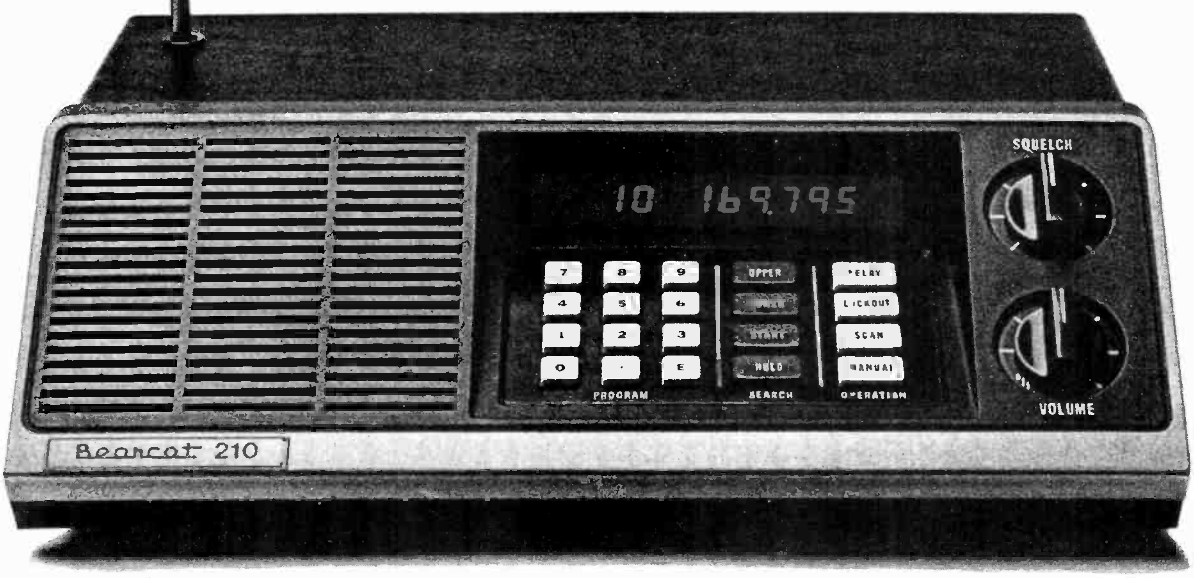


Comparison of a Hall-head assembly for a three-head cassette deck (B) with the conventional heads (A) presently used by Hitachi.

Fe "Yes," Fe_2O_3 "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 burst 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

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 facts.

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

CIRCLE NO. 64 ON FREE INFORMATION CARD

No other TV/Audio home study school puts prices in its ads. Why?

Maybe it's because they can't match these values.

1 2 3 4 5

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.

NRI SCHOOLS
McGraw-Hill Continuing Education Center
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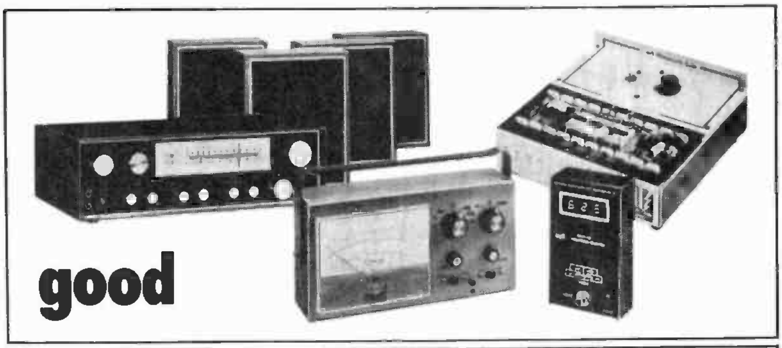
Washington, D.C. 20016

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 trouble-shooting 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

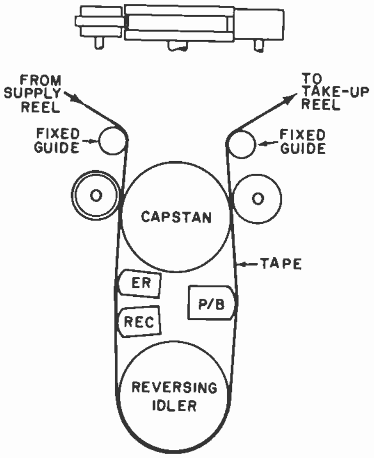
The ultimate home training in Color TV/Audio servicing with 48 bite-sized lessons, 10 reference texts, and 14 training kits . . . including kits to build a 25″ diagonal color TV, complete with console cabinet; a 4-speaker Quadraphonic Center; a wide band, solid-state, triggered sweep, service type 5″ 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.



The 3M Iso-loop with tape's view of capstan and pinch-roller configuration at the top.

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 Mullin 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

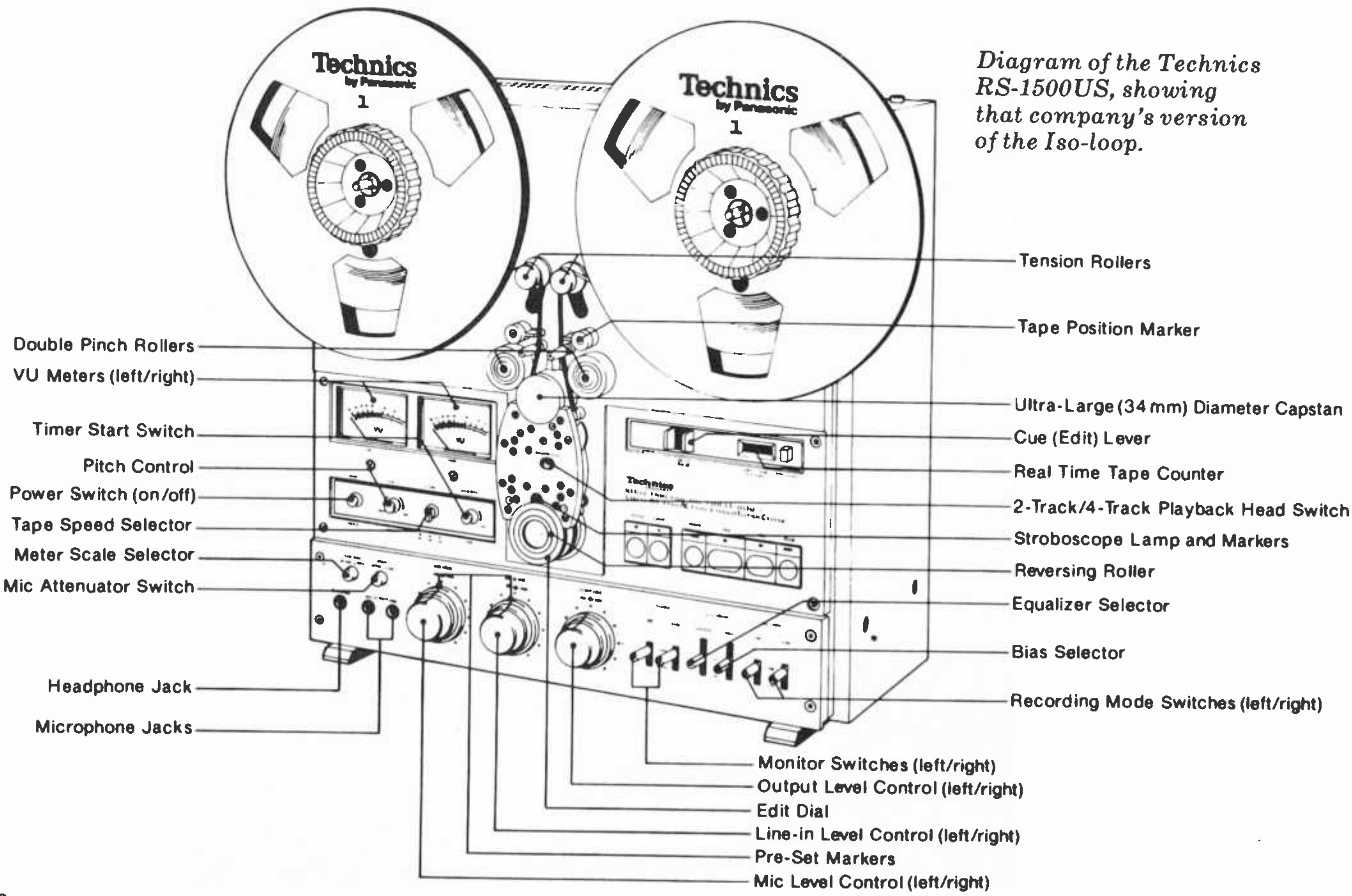
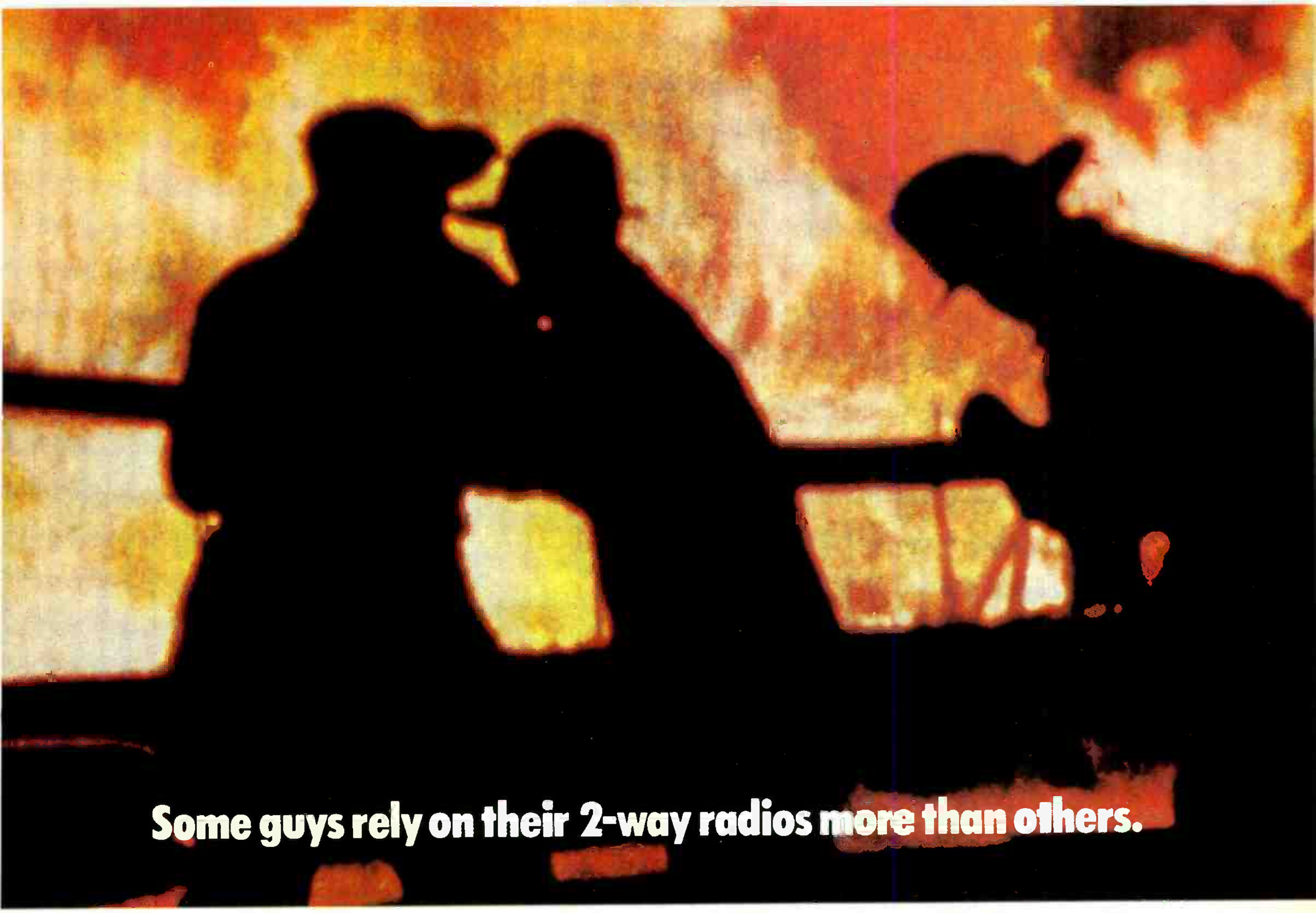


Diagram of the Technics RS-1500US, showing that company's version of the Iso-loop.



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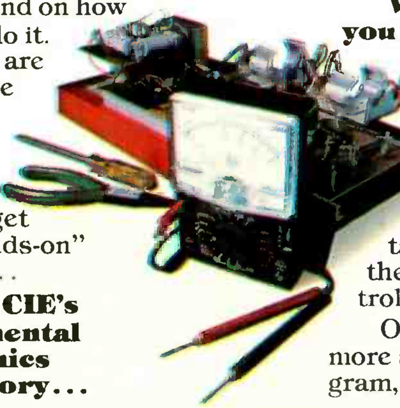

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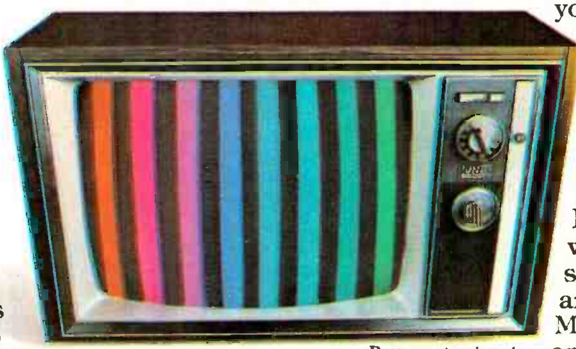

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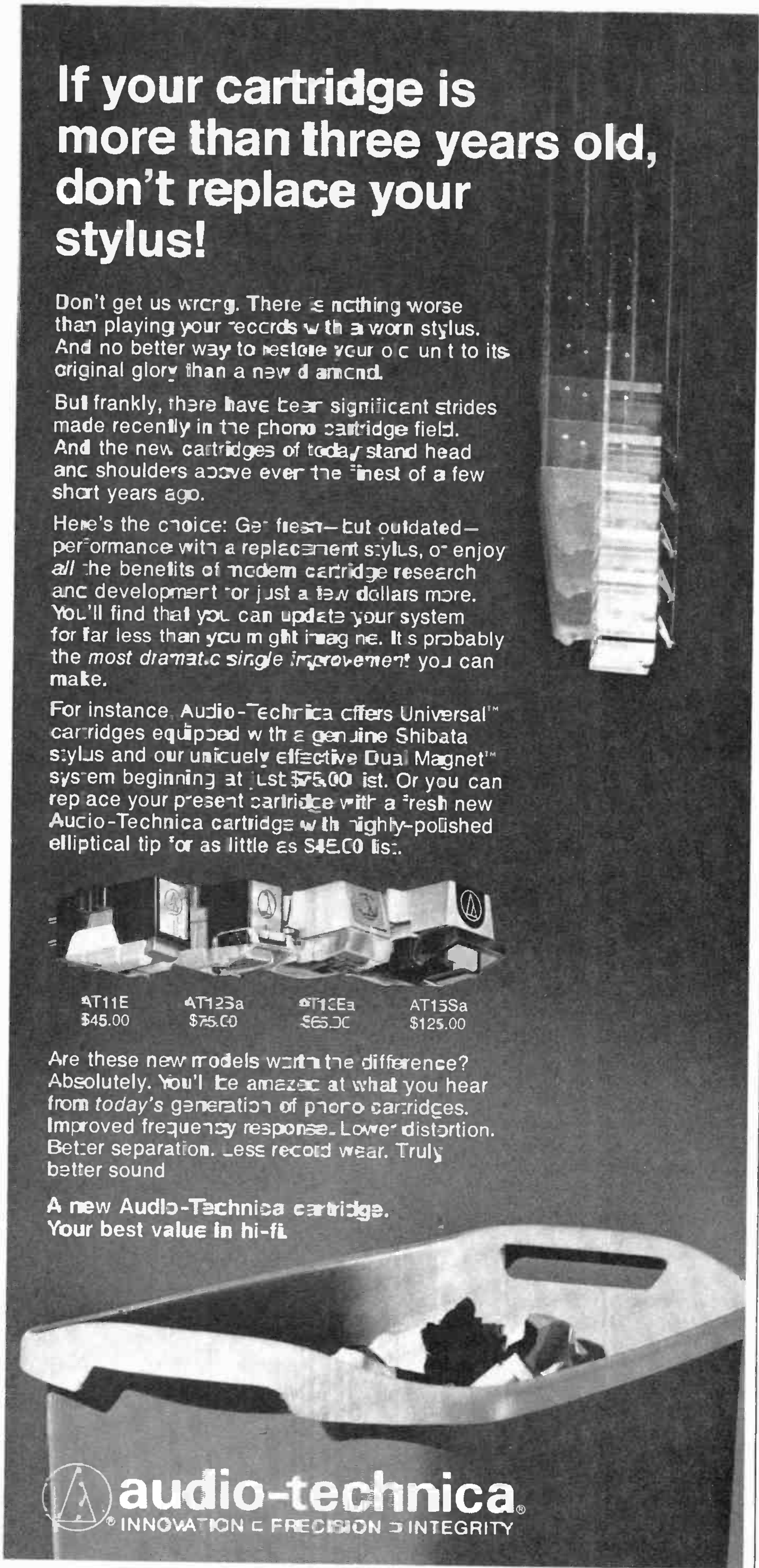

(except that pinch rollers of different hardness composition are used instead of the stepped pinch roller and capstan arrangement). As far as I can tell from my brief experience with the Technics deck, the trick of creating tape tension across the heads with hard and soft pinch rollers works reliably,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

The trend of the moment, of course, is to eliminate pinch rollers 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 pinch-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 imminent developments have materialized, will never be the same again. So let's gird our loins for the onslaught. ◇

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CIRCLE NO. 65 ON FREE INFORMATION CARD

Julian Hirsch Audio Reports

IS THERE A DIGITAL FM TUNER?

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 reproduceable 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 affect 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.

HIRSCH-HOUCK LABS REPORT

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.

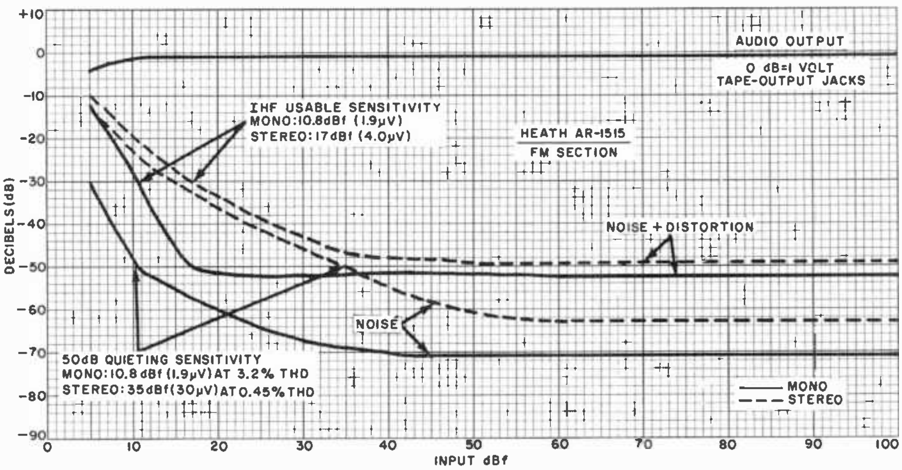
The Model AR-1515 receiver measures 21½"W × 15"D × 6¼"H (54.6 × 38.1 × 15.9 cm) and weighs 35.8 lb (16.3 kg). Available only in kit form, it is catalog priced at $549.95. The optional Model AD-1504 FM Dolby decoder kit is $39.95.

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



Noise and sensitivity curves for FM section of receiver.

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.

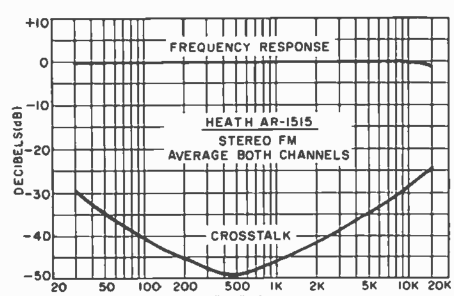
After the rotary controls come seven pushbutton switches: TONE FLAT bypasses the tone controls; LOUD compensates the response at reduced volume levels; SQUELCH DEFEAT; BLEND reduces noise on weak stereo FM signals; DOLBY for decoding Dolby-encoded FM broadcasts when the optional Dolby module is included; 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 multipath 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.



Frequency and crosstalk averaged for both channels.

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.

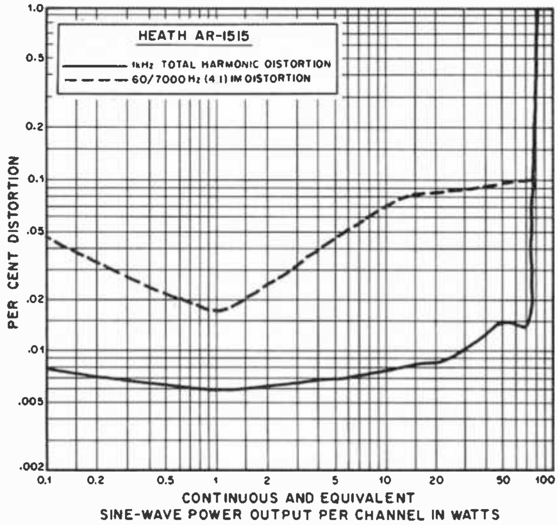
After the one-hour preconditioning period at one-third rated power, the heat sinks were fairly warm but not uncomfortable to the touch. The rest of the receiver was quite cool. (In normal service, the hottest part of the cabinet is directly over the numeric display and its three IC drivers.) The outputs 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.

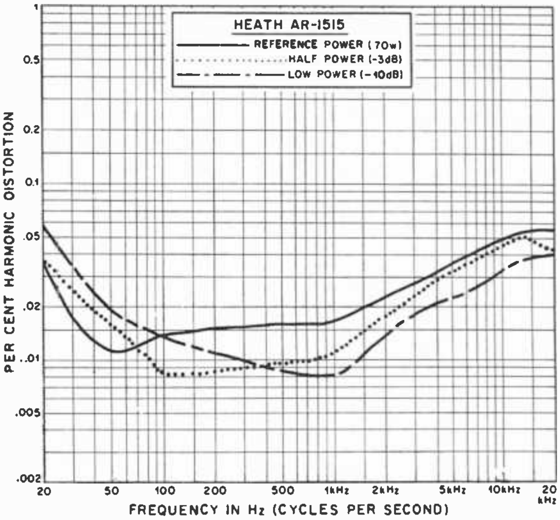
At the rated output into 8 ohms, the THD was about 0.015% in the midrange and less than 0.05% from 20 to 20,000 Hz. At half power and less, the characteristic was similar and the distortion remained between those limits. The input required for a 10-watt reference output was 55 mV through the AUX inputs 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



Total harmonic distortion and 60/7000-Hz distortion.



Harmonic distortion at three power levels.

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 dBf (1.9 μV). In stereo, the IHF sensitivity was 17 dBf (4.0 μV), and the 50-dB quieting sensitivity was 35 dBf (30 μV) with 0.45% THD. The ultimate THD at a 65-dBf (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 dBf (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 6600 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.)

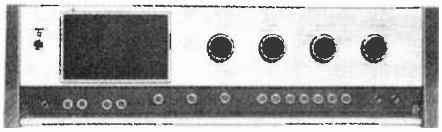
User Comment. Assembling the receiver was a time-consuming but by no means a difficult job. The kit builder spent some 41 hours assembling, checking out, and adjusting the receiver. An additional two hours were spent on assembling the tester that comes with the receiver and the optional Dolby noise-reduction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

THORENS MODEL TD-126C RECORD PLAYER

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

HIRSCH-HOUCK LABS REPORT

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 19⅞"W × 15½"D × 6¾"H (50.5 × 39.4 × 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. Antiskating compensation is applied by opposing magnetic fields and can be adjusted by turning a knob on the side of the pivot housing. Four antiskating scales cover the use of conical and elliptical styli 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 ½" (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 only about 2½" (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 record player lies behind the controls so that operation of the controls does not jar the pickup. A knob at the left is for turning on and off the power to the turntable. The speed is selected by pressing lightly one of three flat rectangular plates. The outer edge of the selected speed plate lights up. (When the turntable is initially turned on, the 33⅓-rpm speed is automatically selected.)

To the right of the speed-selector plates is the stroboscope window that provides a view of the illuminated markings on the bottom of the platter. A speed vernier control near the window can be used to adjust each speed, referred to its own set of stroboscope markings. Although a single Vernier speed control is provided, when one speed is accurately set, the others are also correctly set. To the right of the vernier control is the mode selector that provides the user with a choice of fully manual operation, automatic tonearm lift at the end of play, or automatic tonearm lift and motor shutoff at end of play.

Next come three flat plates, similar to those used for speed selection. The first plate, whose edge lights up when power is first applied, is a shutoff control that, when activated, lifts the tonearm and removes power from the motor. The next plate turns on the motor but does not lower the tonearm; it can be used as a cueing arm lift when a record is being played. The last plate turns on the motor and lowers the pickup; it is the cueing descent control when a record is on the turntable. Very little force and almost no travel are required to activate any of the plate controls. For the automatic end-of-play tonearm lift, an electric velocity sensor detects the rapid movement of the tonearm in the eccentric groove and triggers the lift circuit. It does so without imposing any additional load on the tonearm or cartridge.

Laboratory Measurements. We tested the record player with a Shure Model M95ED cartridge installed in its tonearm. After adjusting the cartridge as accurately as possible with the plastic 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 contant 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 ½" 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.

CIRCLE NO 102 ON FREE INFORMATION CARD

ORTOFON MODEL MC20 PHONO CARTRIDGE AND MODEL MCA-76 PREAMPLIFIER

Top-grade stereo cartridge uses moving-coil design.

HIRSCH-HOUCK LABS REPORT

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.

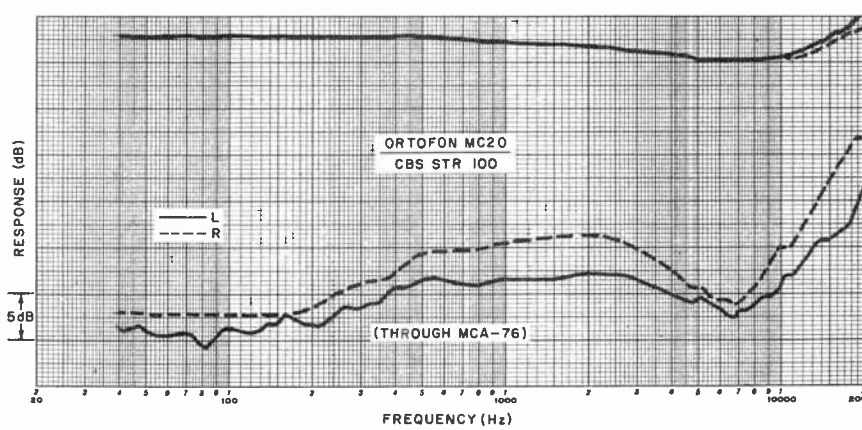
Since the moving-coil type of cartridge has a very low output level, it usually requires a signal "booster" to allow it to adequately drive the phono input circuits of most amplifiers and receivers. This booster can be a step-up transformer or a separate preamplifier, both of which are available from 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 0.5 mg. The range of tracking forces is rated at 1.5 to 2.0 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 3.5 mV. The input impedance of the preamplifier is 75 ohms, which is a suitable load for the cartridge. The output impedance of



Frequency response (top) and channel separation of both channels.

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.

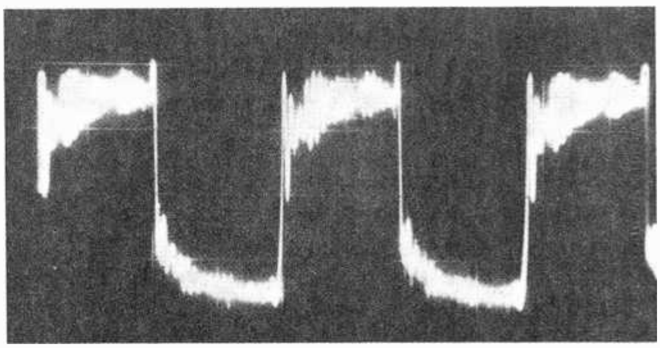
Laboratory Measurements. We tested the cartridge both directly at its outputs and through its companion preamplifier. For most of our tests, the cartridge was installed in the tonearm of a Thorens Model TD-126C player.

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 sloped 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.



Square-wave response revealed low-level ringing.

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 phono 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.

CIRCLE NO. 103 ON FREE INFORMATION CARD

Why you should buy a digital multimeter from the leader in digital multimeters.

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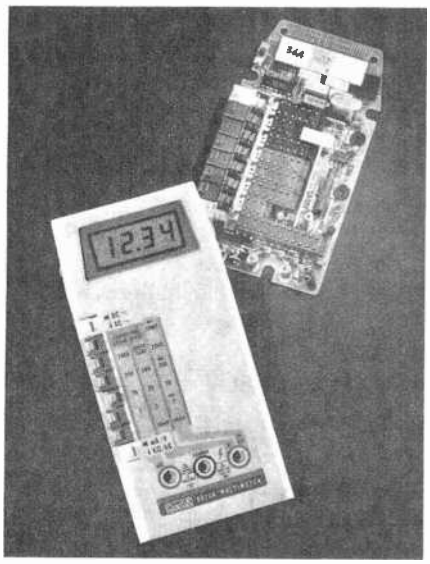

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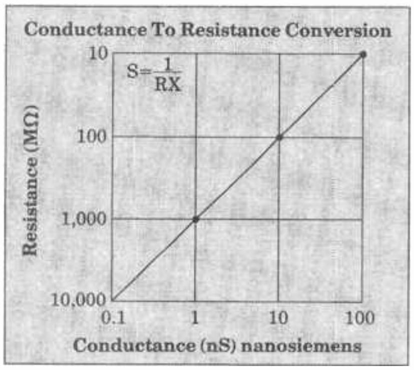
Nanosiemens?



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CIRCLE NO. 21 ON FREE INFORMATION CARD

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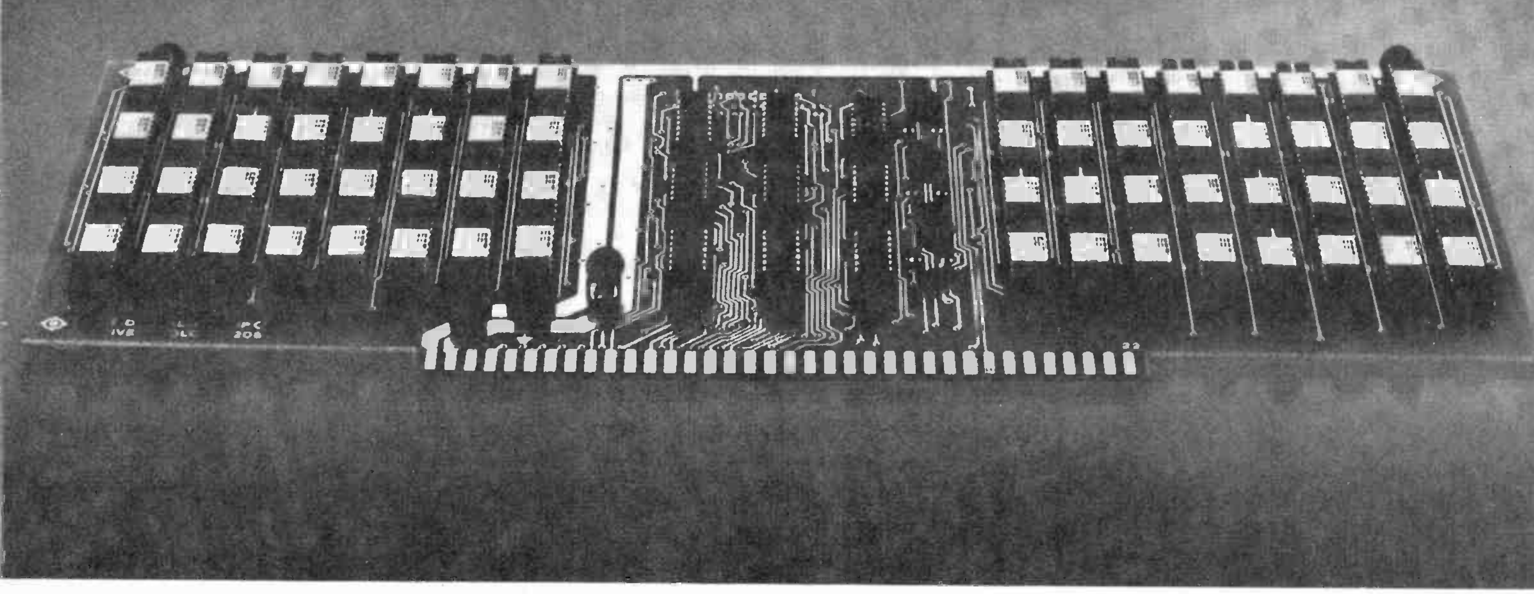

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CIRCLE NO. 15 ON FREE INFORMATION CARD

Popular Electronics®
AUGUST, 1977

BUILD "cabonga"

AN ELECTRONIC PERCUSSION SYNTHESIZER

BY JAMES BARBARELLO

Played like a bongo drum, the Cabonga produces waveforms that simulate sounds of percussive instruments from bass drum to wood block.

PART 1

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 *D2* 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

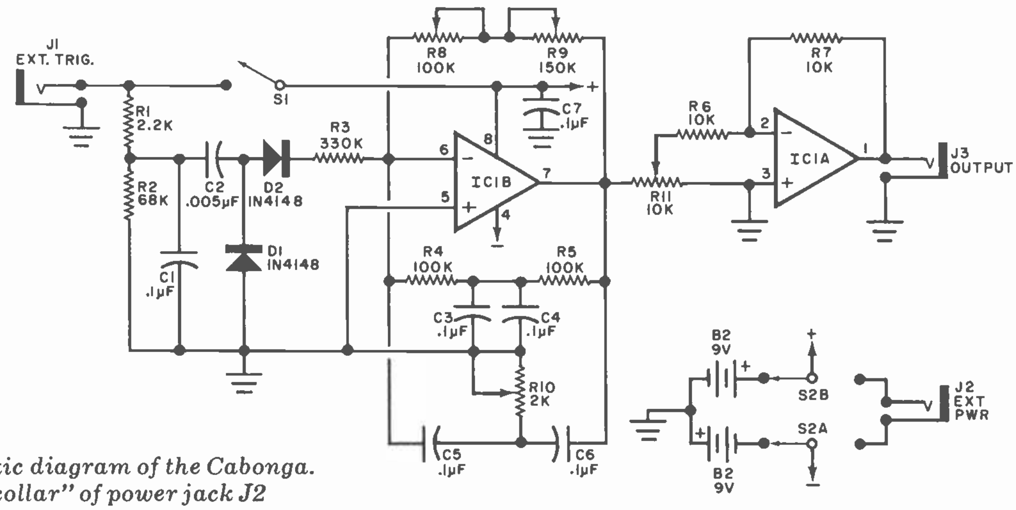


Fig. 1. Schematic diagram of the Cabonga. Note that the "collar" of power jack J2 is at −9 volts, not ground potential.

PARTS LIST

B1,B2—9-volt transistor batteries
C1,C3 through C7—0.1-µF disc ceramic capacitor
C2—0.005-µF disc ceramic capacitor
D1,D2—1N4148 silicon diode
IC1—5558 dual operational amplifier IC
J1—Subminiature phone jack
J2—Miniature phone jack (insulated)
J3—Standard phone jack
The following resistors are ¼-watt, 10% tolerance, carbon composition:
R1—2200 ohms
R2—68,000 ohms
R3—330,000 ohms
R4,R5—100,000 ohms
R6,R7—10,000 ohms
R8—100,000-ohm, linear-taper pc trimmer potentiometer
R9—150,000-ohm, linear-taper potentiometer
R10—2,000-ohm, linear-taper potentiometer
R11—10,000-ohm, linear-taper potentiometer
S1—Oak feather-touch calculator keyboard NO switch (Poly Paks 92CU1749 or equivalent).
S2—Subminiature dpdt switch
Misc.—Printed circuit board; battery clips; hookup wire; hardware; solder; etc.

Note: See Bill of Materials (next page) for availability of kits.

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 ¾" (19.1-mm) thick plywood for the sides and two pieces of ¼" (6.4-mm) thick Masonite or tempered hardboard. The overall dimensions of the box should be roughly 9½" × 7" × 2" (24 × 17.8 × 5.1 cm). The top and bottom of each wall should be rabbeted to provide ⅜" (9.5-mm) deep by ¼" 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 ½" and ¼" plywood, cutting the latter ½" narrower and fastening the pieces together with glue and ⅝" finishing nails.) Round all top and bottom edges of the walls with sandpaper.

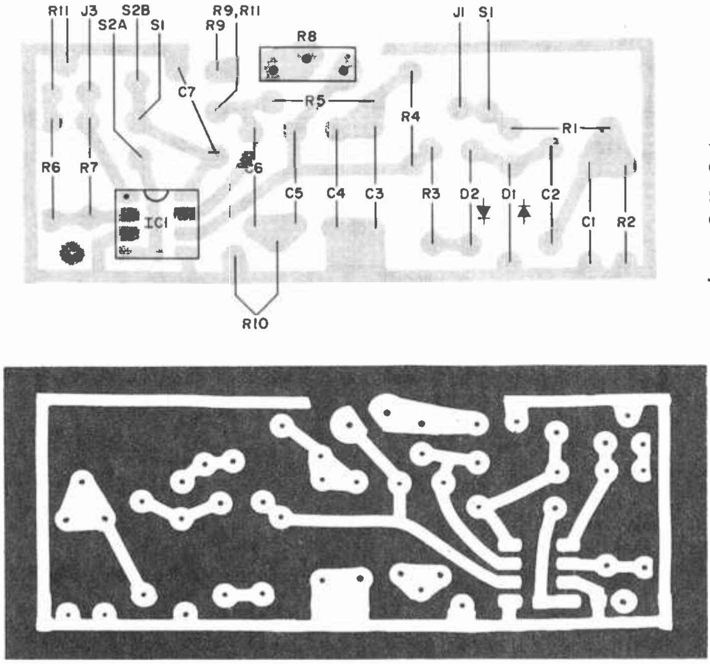


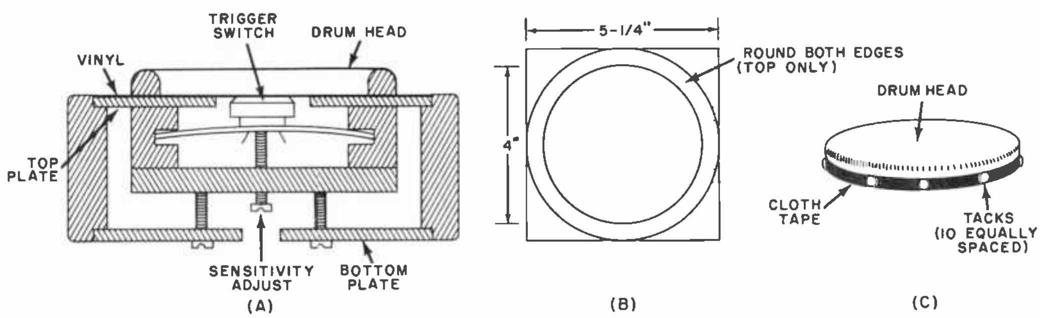
Fig. 2. Etching and drilling guide (below) and component layout (left) for the Cabonga pc board.

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 1½" (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 × 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

Fig. 3. Details for construction of switch retainer assembly (A), plywood head ring (B). Finished drum head is shown at (C).



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 × 15.2 × 2 cm) piece of plywood. When the wood ring has been cut out, round the top outer 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 Mystic cloth tape along its entire length ⅛" in from both edges so that the tape has a seam down its center. When you fold the tape, the 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 trigger switch. Then glue a block of 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.

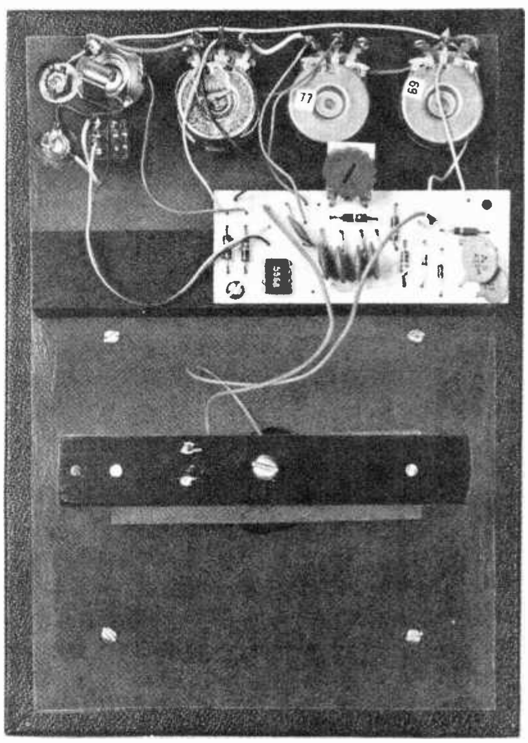


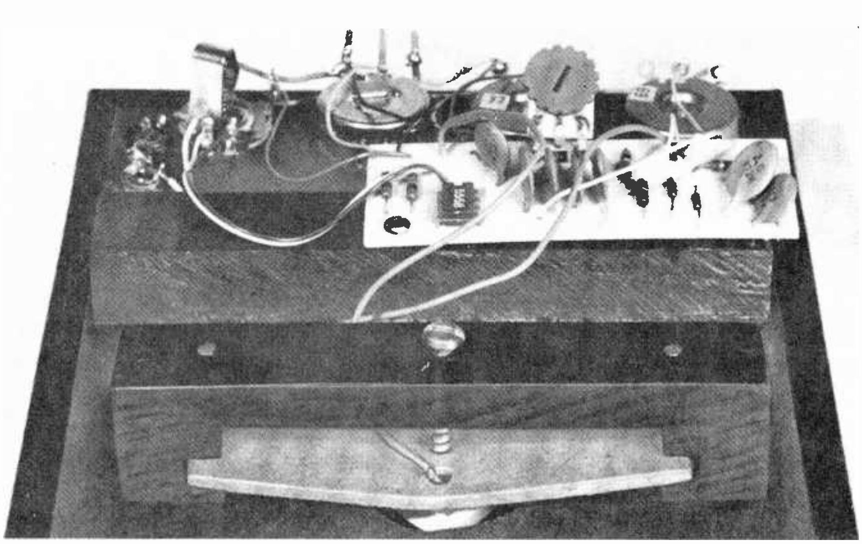
Fig. 4. Bottom view of the finished top plate shows the locations of the switch retainer assembly, pc board, controls and jacks.

The bottom plate can be prepared as follows. First, using the same procedure 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 ⅛" (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

BILL OF MATERIALS

Case
2—pieces ¾" plywood 9½" × 2"
2—pieces ¾" plywood 6" × 2"
1—piece unsupported black vinyl 35" × 4½"
Top Plate
1—piece ¼" tempered hardboard (Masonite or equivalent) 8-⅜" × 5-⅞"
1—piece black vinyl 9¼" × 6-¾"
Bottom Plate
1—piece ¼" tempered hardboard 8-⅜" × 5-⅞"
1—piece rubber matting 8-⅜" × 5-⅞" or 1 piece black vinyl 9¼" × 6¾" (see text)
Head
1—piece ¾" plywood 6" × 6"
1—piece cloth-backed white vinyl 7½" × 7½"
1—piece black cloth tape 18" × ¾"
10—chromed upholstery tacks
Control Plate
1—piece 1/32" aluminum stock 5-⅞" × 2"
Switch Assembly
1—piece ⅜" pine 4½" × ¾"
2—pieces ⅝" pine 1" ×
1—piece ⅛" hardboard 3½" × 1"
Miscellaneous
1—5" × ¾" × ¾" pine block
4—No. 8 × ¾" wood screws
1—No. 8 × 1¼" sheet metal screw
2—No. 8 × 1" sheet metal screws
Nails, glue, etc.
Note: The following are available from JAL Associates, Box 107, Eatontown, 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), $3.50. All prices include postage. New Jersey residents add 5% sales tax.



Side view of top plate reveals mounting details of switch retainer assembly, tension adjust screw and pc board.

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″ × 4½″ (90 × 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 × 1¼″ 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.

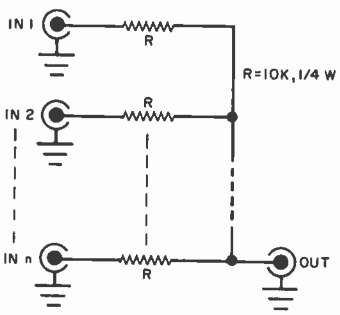
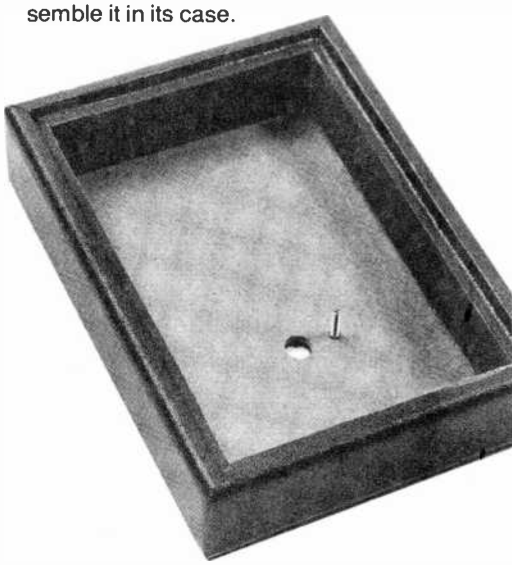


Fig. 5. Mixer combines several signals for use with one amplifier.

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. ◇

CHOOSING PORTABLE & MOBILE TAPE RECORDERS

BY JAMES R. HORSTMAN

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 2½" 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 1⅞ ips. Tape measures about ⅛" 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 3¾ ips and tape width is ¼", 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 Phillips got up steam with its cassette format.

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.

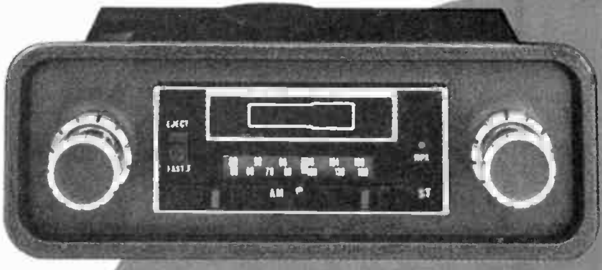
Shopping for Portables. The way to start shopping for tape portables is to sit down with paper and pencil and assess the quantity and quality of portability you will require. Very often, these two go together, as extra dollars add desirable features you'll find you cannot do without. Once you have seen some deluxe unit, it's difficult to go back "down."

Chances are that you'll choose a battery-powered cassette unit, since there aren't many cartridge machines around. Most portable cassette machines are monophonic, which is just as well since you wouldn't want to pack an extra speaker wherever you go. However, if you're willing to sacrifice small size and light weight, there are a handful of ac-dc portable cassette machines that record and play back in mono or stereo. Some do feature two built-in speakers and two microphones for stereo use. (Sub-compact cassettes exhibit poor fidelity for reproducing music as compared to the conventional cassettes.)

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 into an ac outlet.
- ☐ Larger speaker(s) for more robust sound.
- ☐ 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.



J.I.L. Model 604

General Electric Model 3-5212

JVC Model KD-2

Nakamichi Model 250

□ 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 tradeoff here is higher cost.

How does one "test" a portable? There are a number of guidelines. • First, handle it to judge weight and size. • 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). • Record a tape for playback at home. • Record a few minutes on a C-120 (two-hour) tape, which is ultra thin, to judge tape-handling quality. • Jingle keys so you can determine recording and playback realism. • Speak at the same level at different distances and with your back turned to evaluate how much the voice is obscured by the machine's noise. (You'll be surprised at the substantial differences among machines.) • Try the pushbuttons to be sure they're conveniently located and don't stick. • Attach an external, high-efficiency speaker system to the portable's external speaker jack.

Above all, don't lose sight of your quest for *portability*. After all, you don't want to be a furniture mover every time you wish to take along your portable.

Shopping for Auto Tape Players. A major reason for the popularity of the automobile tape player is that even a relatively inexpensive system sounds better in the car than at home. The closed environment and masking of fidelity limitations by external noise (engine, wind, tires, etc.) makes listening a rewarding experience. The choice of music is yours, not the disc jockey's nor the broadcast station's commercials. Equally important, there isn't much to distract you in the car.

You'll have to make a choice between 8-track cartridge and cassette machines. As discussed earlier, 8-track offers many more prerecorded selections, largely nonclassical. The cartridges are bulkier, though, and it's difficult to locate portions of a recording with dispatch. However, they play continuously, so a cartridge doesn't stop when the recording ends, but continues 'round and 'round. When driving; this no-handling facility is advantageous. Consider, too, that 8-track offers 4-channel sound, which provides a unique sound sensation, especially in an auto environment.

The favorable attributes of cassette machines can be recapitulated as: smaller machine, which makes for easier car installation; smaller tape package so you can store more cassettes in a small space; fast-forward and rewind facility; and a convenient recording facility (at home). So take your choice.

Cassette Players. Cassette car players are small enough to be mounted in the dashboard where the car radio goes or in the glove compartment—both major deterrents to theft—although many are still mounted under the dash. Whichever position you choose, practice loading the unit a few times before you try it on the road. With a glove-compartment mount, of course, you'll have to pull over to the side of the road to change tapes.

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 dealer, 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. ◇

NEW BAND FOR "KIDDIE-TALKIES"

100-mW portable two-way radios are moving out of the CB band.

BY LEO SANDS

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

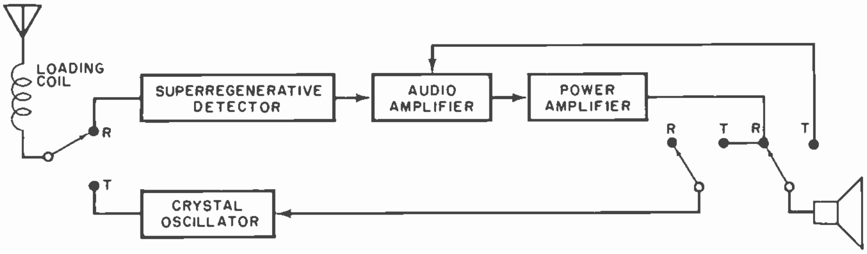


Fig. 1. This simple walkie-talkie uses a superregenerative detector.

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:

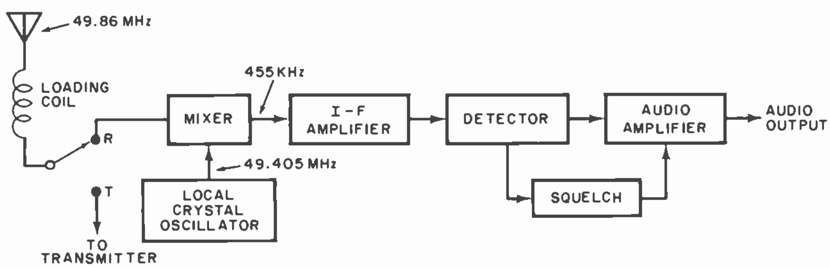


Fig. 2. Block diagram of superheterodyne receiver.

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.

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.

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.

Although the rules for home-built devices do not state that the transmitter must be crystal controlled, it should be. Since the band is only 80,000 Hz (80 kHz) wide, a self-excited oscillator could drift enough to put the signal (even one of the sidebands) beyond the band limits into the 30-to-50-MHz land mobile band or the 50-to-54-MHz (6-meter) amateur radio band. By using a crystal, you can be fairly certain that its frequency is close to the frequency indicated on the case. If you do not use a crystal, you will need a frequency counter.

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

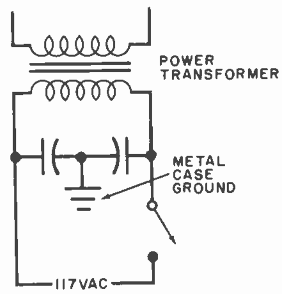


Fig 3. Base station grounding.

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.

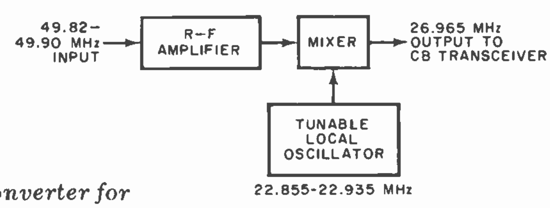
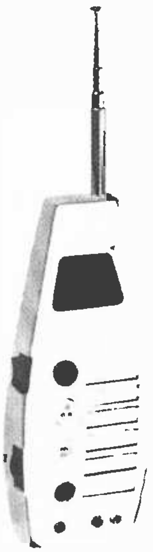


Fig. 4. Tunable converter for use with a CB transceiver.

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.



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. ◇

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 radio 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 subminiature 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. ◇

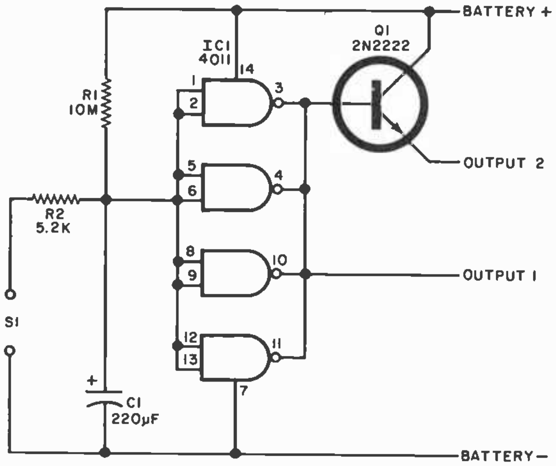


Fig. 1. Four parallel gates supply added power.

PARTS LIST

C1—220-μF low-leakage capacitor
IC1—4011 quad NAND gate (CMOS)
Q1—2N2222 or any low-leakage npn silicon transistor
R1—10-megohm, ⅛- or ¼-watt resistor
R2—5200-ohm, ⅛- or ¼-watt resistor
S1—See text

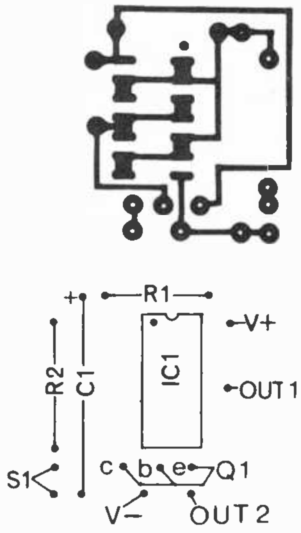
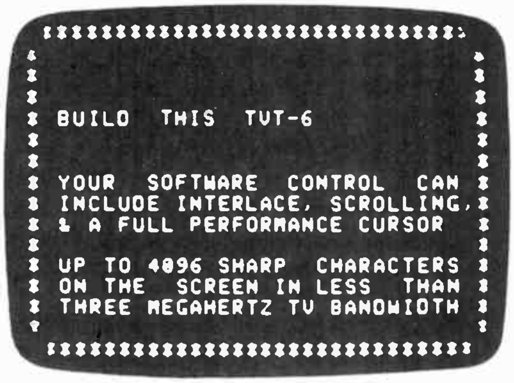


Fig. 2. Small pc board and component layout are shown.



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 interlace. 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 $\overline{IRQ}$ interrupt line. Note that the cursor program is totally independent of the SCAN program. The only things the two 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

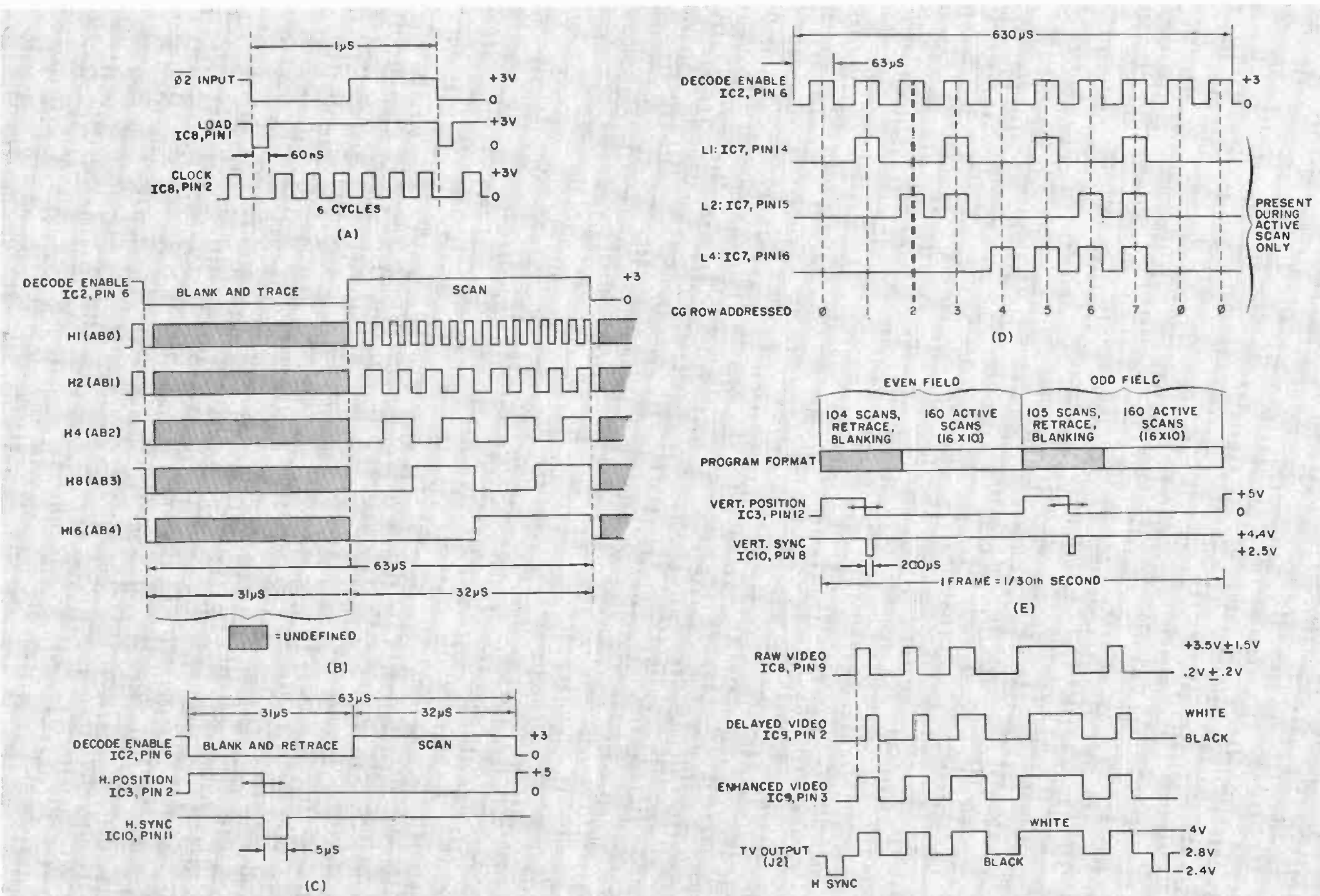


Fig. 7. TVT-6 waveforms with Table II program: (A) video rate; (B) horizontal rate; (C) horizontal sync; (D) character rate; (E) vertical rate; (F) outputs.

TABLE II

<u>16 line X 32 character per line Interlaced</u>
<u>TVT6 Raster Scan:</u>

```
µP - 6502          Start - JMP 17Ad     Displayed 0200-03FF
System - KIM-1     End - Interrupt      Program Space 1780-17E2

HS | VS | L4 | L2 | L1 | 0 | 1 | V8     V4 | V2 | V1 | H16 | H8 | H4 | H2 | H1

        Upper Address                         Lower Address

        1780  NOP  EA                  Equalize 2 cycles
        1781  STA  8d (8A)   (17)      Store upper address
        1784  PHA  48                  Equalize 10 cycles
        1785  PLA  68                  Continued

        1786  BNE  d0  00              Continued
        1788  JSR  20  00    80        ////Character Scans 1-8////
        178b  ADC  69  08              Increment Character Scan Counter
        178d  CMP  C9  C0              Is VS = 1?

        178F  BCC  90  F0*             No, do next character scan
        1791  JSR  20 (E0)   (17)      Equalize 15 cycles via sub
        1794  JSR  20  00    80        ////Character Scan 9////
        1797  TAX  AA                  Save Upper Address

        1798  LDA  Ad (89)   (17)      Get Lower Address
        179b  ADC  69  1F              Increment L; Set C on V4 overflow
        179d  STA  8d (89)   (17)      Restore lower word; save carry
        17A0  TXA  8A                  Get Lower Word

        17A1  BNE  d0  00              Equalize 5 cycles
        17A3  NOP  EA                  continued
        17A4  ADC  69  C0              Add carry; Reset VS
        17A6  JSR  20  00    80        ////Character Scan 10////

        17A9  CMP  C9  84              Is it line "17"?
        17Ab  BCC  90  d3*             No, continue character scans
-START- 17Ad  LDA  Ad (dF)   (17)      Get Interlace word
        17b0  EOR  49  80              Change field

        17b2  BMI  30  05*             Jump if even field
        17b4  STA  8d (dF)   (57)      Odd Field V Sync; Restore Interlace word
        17b7  LDX  A2  66              Load short number of VB scans
        17b9  JSR  20 (E0)   (17)      Equalize 15 cycles via sub

        17bC  JSR  20 (E0)   (17)      Equalize 15 cycles via sub again
        17bF  BPL  10  05*             Jump if odd field
        17C1  STA  8d (dF)   (57)      Even Field V Sync; restore interlace
        17C4  LDX  A2  67              Load long number of V Blank scans

        17C6  JSR  20  1E    80        ////1st V blanking scan ////
        17C9  CLD  d8                  Equalize 9 cycles
        17CA  PHA  48                  Continued
        17Cb  PLA  68                  Continued

        17CC  LDA  A9  00              Initialize lower address
        17CE  STA  8d (89)   (17)      Continued
        17d1  LDA  A9  82              Initialize upper address
        17d3  STA  8d (8A)   (17)      Continued

        17d6  JSR  20  00    80        ///Remaining V Blanking scans////
        17d9  CLC  18                  Initialize carry
        17dA  DEX  CA                  One less scan

        17db  BMI  30  A4*             Start Character scan
        17dd  BPL  10  Ed*             Repeat Vertical blanking scan
        17dF       80                  Interlace word storage
        17E0  BCS  b0  00              ///Equalize 15 SUBROUTINE ////

        17E2  RTS  60                  Continued.
```

NOTES: TVT6 must be connected and scan microprogram PROM (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 1789 tells it to. Values in these slots continuously change throughout the program.

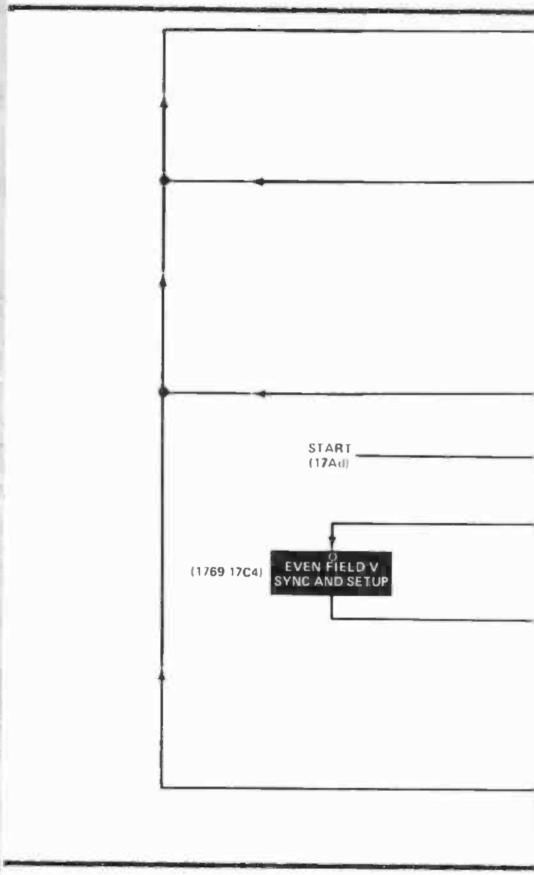
For a 525-line system, use 17b8 64 and 17C5 65 and a KIM-1 crystal of 992.250 kHz. This is only needed for video superposition and titling applications.

Normal program horizontal frequency 15,873.015 Hz; Vertical frequency 60.0114 Hz. 63 us per line; 264.5 lines.

* Denotes a relative branch that is program length sensitive.

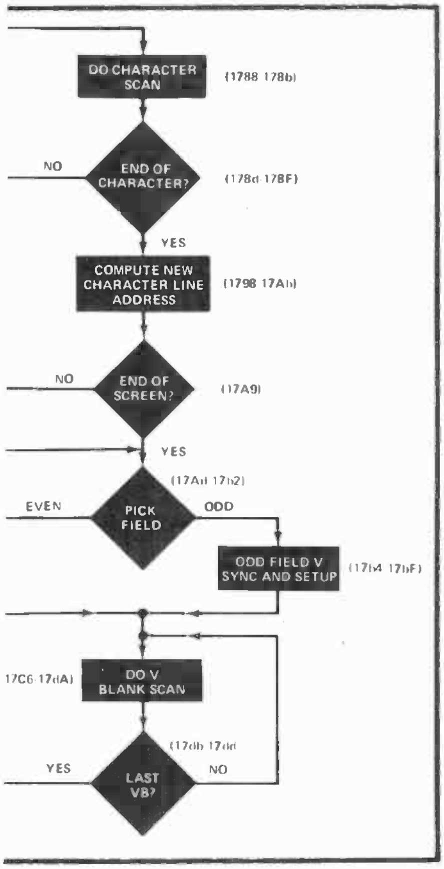
( ) Denotes an absolute address that is program location sensitive.

TVT6 length jumper must be in "32" position.



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 long character line but still allows 1 µs/character. This will not tax the bandwidth restrictions of TV receivers or r-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 0.068-µF capacitor used for *C408* in the receiver, and an inductor consisting of 60 turns of No. 24 enameled wire on a ½" 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 × 44 or a 32 × 48 character display and still use normal, or nearly normal, horizontal scanning rates. This allows for video titling and superimposition, oversize 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,

Table III

16 X 32 Full-performance Cursor:

```
µP -- 6502          Start -- IRQ   Displayed 0200-03FF
System -- KIM-1 End  --- RTI       Program Space 0100-01dF

Input to Parallel Word A  | Ø | A7 | A6 | A5 | A4 | A3 | A2 | A1 |  KP  IRQ
                                                           10 µs

Clear - CAN (18)                  Cursor Home - SOH (ØA)
Carriage Return - CR (Ød)         Scroll Up - DC1 (11)
Cursor Up - VT (Øb)               Erase to End - DC2 (12)
Cursor Down - LF (ØA)             Spare Hook - DC3 (13)

Cursor Left - BS (Ø8)             Enter -- All characters
Cursor Right - HT (Ø9)            Ignore -- All other CTRL

Enter via
  IRQ
      0100  PHA  48                   Save A
      0101  LDY  A0  00               Reset Y Index
      0103  LDA  A5  (EE)             Get Cursor and test for range
      0105  CMP  C9  03               Is cursor on page 3?

      0107  BEQ  F0  04*              Yes, OK to continue
      0109  CMP  C9  02               Is cursor on page 2?
      010b  BNE  d0  3A*              No, Home cursor
      010d  LDA  b1  (Ed)             Get old cursored character
0147
      010F  AND  29  7F               Erase old cursor
      0111  STA  91  (Ed)             Replace character without cursor
      0113  LDA  Ad  00     17        Get new character from A parallel Int.
      0116  CMP  C9  20               Is it a character to be entered?

0142--0118  BCS  b0  28*              Yes, go and enter character
      011A  CMP  C9  18               Clear Screen?
015E--011C  BEQ  F0  40*              Yes, clear screen
      011E  CMP  C9  0d               Return Carriage?

0152--0120  BEQ  F0  30*              Yes, Return carriage
      0122  CMP  C9  0b               Cursor Up?
0194--0124  BEQ  F0  6E*              Yes, Up Cursor
      0126  CMP  C9  0A               Cursor Down?

0166--0128  BEQ  F0  3C*              Yes, Down Cursor
      012A  CMP  C9  09               Cursor Right?
0158--012C  BEQ  F0  2A*              Yes, Right Cursor
      012E  CMP  C9  08               Cursor Left?

01A7--0130  BEQ  F0  75*              Yes, Left Cursor
      0132  CMP  C9  01               Cursor Home?
0147--0134  BEQ  F0  11*              Yes, Home Cursor
      0136  CMP  C9  11               Scroll Up?

0175--0138  BEQ  F0  3b*              Yes, Scroll Up
      013A  CMP  C9  12               Spare Hook?
014A--013C  BEQ  F0  0C*              Ignore--Restore Cursor
      013E  CMP  C9  13               Erase to EOS?

01b1--0140  BEQ  F0  6F*              Yes, Erase to EOS
      0142  JSR  20  (D3)  (01)       /////Enter Character/////
      0145  BNE  d0  03*              End of Screen?
      0147  JSR  20  (C2)  (01)       Yes, Home Cursor

      014A  LDA  b1  (Ed)             ////Restore Cursor/////
      014C  ORA  09  80               Add cursor to cursored character
      014E  STA  91  (Ed)             Replace cursored character
      0150  PLA  68                   Get A

--Out-0151  RTI  40                   Return to Scan
      0152  LDA  A5  (Ed)             ////Carriage Return/////
      0154  ORA  09  1F               Move Cursor to Right End
      0156  STA  85  (Ed)             Restore Cursor

      0158  JSR  20  (d5)  (01)       Increment Cursor
      015b  JMP  4C  (45)  (01)       Finish
      015E  JSR  20  (C2)  (01)       ////Clear////Home Cursor
      0161  JSR  20  (Cb)  (01)       Clear Screen

0147--0164  BEQ  F0  E1*              Finish
      0166  LDA  A5  (Ed)             ////Cursor Down//// Get Cursor
      0168  CLC  18                   Clear Carry
      0169  ADC  69  20               Move Cursor Down

      016b  STA  85  (Ed)             Restore Cursor
      016d  BCC  90  03*              Overflow of page?
      016F  JSR  20  (d9)  (01)       Yes, increment upper page
      0172  JMP  4C  (45)  (01)       Finish

      0175  JSR  20  (C2)  (01)       ////Scroll Up//// Home Cursor
      0178  LDY  A0  20               Add Offset to Index
      017A  LDA  b1  (Ed)             Get Offset Indexed Character
      017C  LDY  A0  00               Remove Offset from Index

      017E  JSR  20  (d3)  (01)       Enter Moved Character and Increment
      0181  BNE  d0  F5*              Repeat?
      0183  CLC  18                   Clear Carry
      0184  LDA  A9  01               Set A to page 3

      0186  STA  85  (EE)             Set Cursor to Page 3
      0188  LDA  A9  E0               Set A to start of last line
      018A  STA  85  (Ed)             Set Cursor to Start of last line
014A--018C  BCS  b0  bC*              Finish if carry set
```

(Continued on next page.)

Table III (Continued)

```
              018E  JSR  20 (Cb)  (01)  Clear last line
              0191  SEC  38             Set Carry
              0192  BCS  b0  F0*        Restore Cursor to start of last line
              0194  LDA  A5 (Ed)        ////Cursor Up/////Get Cursor

              0196  SEC  38             Set Carry
              0197  SBC  E9  20         Move up one line
              0199  STA  85 (Ed)        Restore Cursor
014A <------- 019b  BCS  b0  Ad*        Underflow of page?

              019d  DEC  C6 (EE)        Yes, decrement page
              019F  LDA  A9  01         Set A to Page 1
              01A1  CMP  C5 (EE)        Did screen underflow?
014A <------- 01A3  BNE  d0  A5*        No, Finish

0147 <------- 01A5  BEQ  F0  A0*        Yes, Home Cursor
              01A7  DEC  C6 (Ed)        ///Cursor Left////Decrement Cursor
              01A9  LDA  A9  FF         Set A to page underflow
              01Ab  CMP  C5 (Ed)        Test for page underflow

019d <------- 01Ad  BEQ  F0  EE*        Change Page if off Page
014A <------- 01Af  BNE  d0  99*        Finish if on page
              01b1  LDA  A5 (EE)        ////Erase to EOS///Get Cursor
              01b3  PHA  48             Save Upper cursor location

              01b4  LDA  A5 (Ed)        Get lower cursor location
              01b6  PHA  48             Save lower cursor location
              01b7  JSR  20 (Cb)  (01)  Clear to End of Screen
              01bA  PLA  68             Get lower cursor location

              01bb  STA  85 (Ed)        Restore lower cursor
              01bd  PLA  68             Get upper cursor location
              01bE  STA  85 (EE)        Restore upper cursor
014A <------- 01C0  BNE  d0  88*        Finish

              01C2  LDA  A9  00         ///SUB//Home Cursor///
              01C4  STA  85 (Ed)        Set lower cursor to zero
              01C6  LDA  A9  02         Put page 2 in A
              01C8  STA  85 (EE)        Set upper cursor to 0200

              01CA  RTS  60             Return to main program
          --> 01Cb  LDA  A9  20         ///SUB//Enter Space///
          |   01Cd  JSR  20 (d3)  (01)  Enter space via Sub
          --- 01d0  BNE  d0  F9*        Repeat if not to end

              01d2  RTS  60             Return to main program
              01d3  STA  91 (Ed)        ////SUB//Enter,Increment// store
              01d5  INC  E6 (Ed)        Increment Cursor
              01d7  BNE  d0  06*        Overflow?

          --- 01d9  INC  E6 (EE)        Yes, Increment cursor page to 03
          |   01db  LDA  A9  04         Load A with page 4
          |   01dd  CMP  C5 (EE)        Test for Overflow
          --> 01df  RTS  60             Return to main program
```

NOTES: $\overline{\text{IRQ}}$ vector must be stored in 17FE 00 and 17FF 01.

Total available stack length is 32 words. Approximately 16 are used by operating system, cursor, and scan program. Stack must be initialized to 01FF as is done in KIM-1 operating system. For 30 additional stack locations, relocate subroutines starting at 01C2 elsewhere.

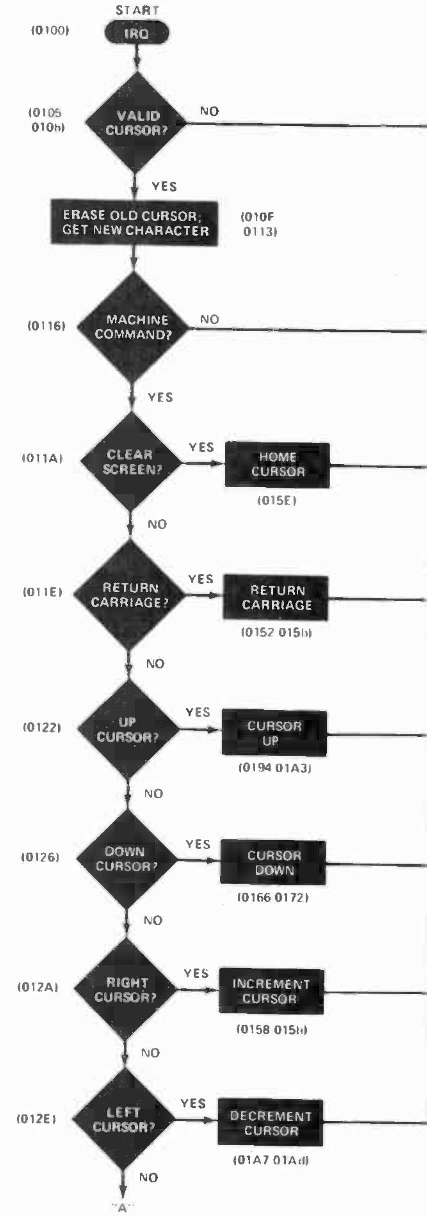
To protect page, load 00F3 04. To enable entry load 00F3 00.

Cursor address is stored at 00Ed low and 00EE high on page zero.

To display cursor load 014d 80. To not display cursor load 014d 00.

* Denotes a relative branch that is program length sensitive.

( ) Denotes an absolute address that is program location sensitive.



you can run 8 × 32, 4 × 64, 1 × 64, or even 1 × 8 character formats. All this takes is software changes, and the circuitry of the TVT-6 remains the same.

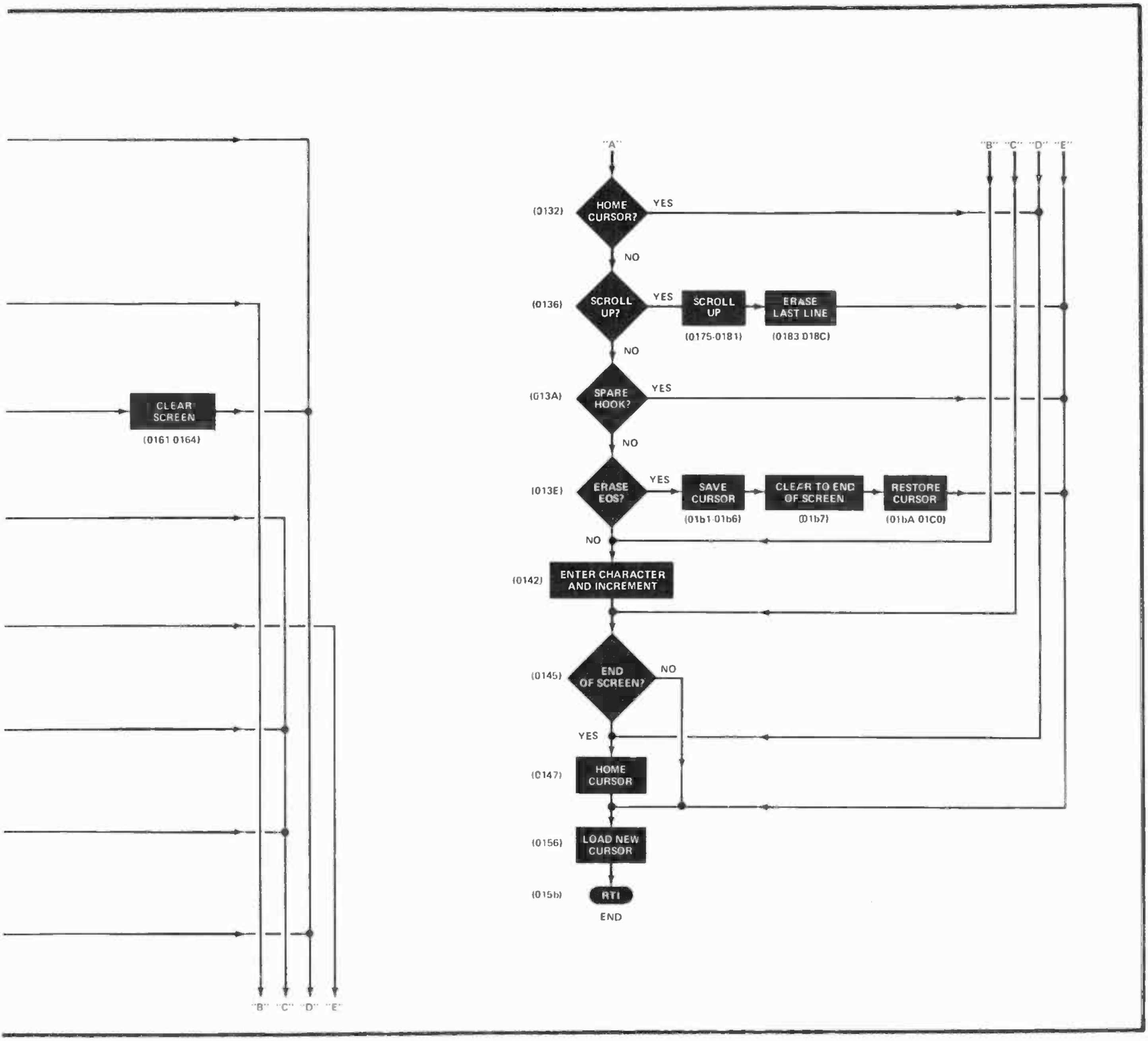
Initial Debugging. At this point, there should be no IC's in the sockets of the TVT-6 board assembly. Start by connecting the LENGTH jumper to 32 and the CURSOR jumper to YES on the TVT-6 board. (Note: These points are pads located at the center of the circuit board, not the edge-connector contacts.) 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

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(39) 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); CMPA(81); BCC(24). This routine requires 25 μs to cycle through as compared to the 21 μs required for the 6502.



8080. 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 AØ, respectively.

Z80. 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 TVT6 Raster Scan:

```
µP - 6502           Start - JMP 17AA      Displayed 0000 - 03FF
System - KIM-1      End - Interrupt       Program Space 1780-17bE

HS | VS | L4 | L2 | L1 | 0 | V8 | V4      V2 | V1 | H32 | H16 | H8 | H4 | H2 | H1

        Upper Address                           Lower Address

         1780  LDA  A9  80              Initialize Upper Address
         1782  STA  8d  (87)  (17)      Store Upper Address
         1785  JSR  20  00     80       ////Character Scans 1-8////
         1788  ADC  69  08              Increment character scan counter

         178A  CMP  C9  C0              Is VS = 1?
         178C  BCC  90  F4*             No, Do next character scan
         178E  TAX  AA                  Save Upper Address
         178F  LDA  Ad  (86)  (17)      Get lower address

         1792  BCS  b0  00              Equalize 3 cycles
         1794  JSR  20  04     80       ////Character Scan 9////
         1797  BCS  b0  00              Equalize 3 cycles
         1799  ADC  69  3F              Increment Lower; Set C on V2 overflow

         179b  STA  8d  (86)  (17)      Restore Lower Address; save carry
         179E  TXA  8A                  Get upper address
         179F  JSR  20  00     80       ////Character Scan 10////
         17A2  ADC  69  C0              Add Carry; Reset VS

         17A4  CMP  C9  84              It is "Line 17"?
         17A6  BCC  90  dA*             No, continue character scans
         17A8  BCS  b0  00              Yes, Go to vertical blanking scans
— START→ 17AA  CLD  d8                  Equalize 2 cycles

         17Ab  JSR  20  00     C0       ////Vertical Sync Scan////
         17AE  LDX  A2  22              Load #V Blank Scans -2
         17b0  LDA  A9  00              Initialize Lower Address
         17b2  STA  8d  (86)  (17)      Continued

         17b5  CLC  18                  Equalize 2 cycles
         17b6  BCS  b0  00              Equalize 2 cycles again
         17b8  JSR  20  00     80       ////Vertical Blanking Scans////
         17bb  DEX  CA                  One less scan

         17bC  BMI  30  C2*             Start Character Scan
         17bE  BPL  10  F5*             Repeat Vertical Blanking scans
```

NOTES: TVT6 must be connected and scan microprogram PROM (IC1) must be in circuit for program to run

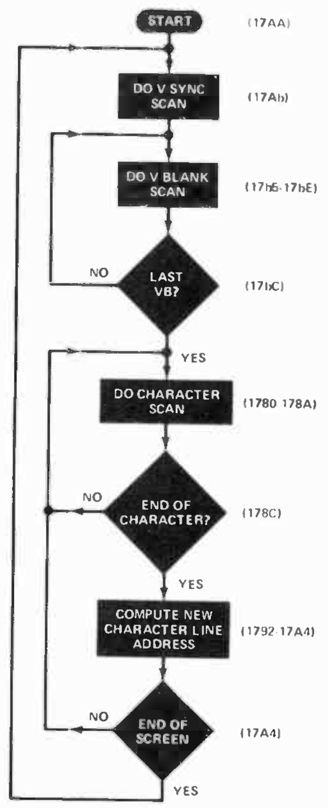
Step 1785 goes to where the upper address stored in 1787 and the lower address stored in 1786 tells it to. Values in these slots continuously change throughout the program.

Normal program horizontal frequency is 11,764.705 Hz. Vertical Frequency is 60,024 Hz. 85 us per line; 196 lines. Character time 1 us. 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.

TVT6 length jumper must be in "64" position.



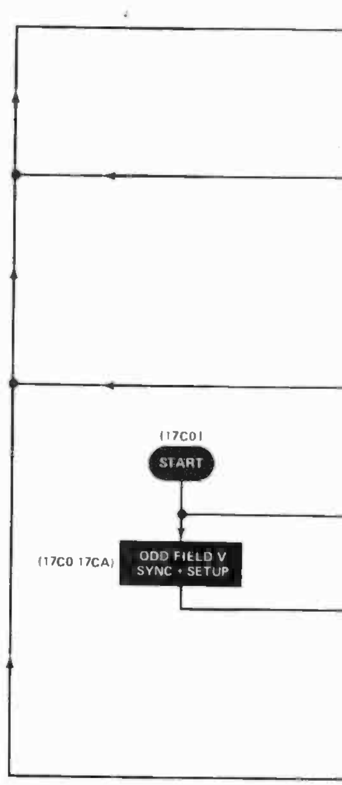
16 x 64 RASTER SCAN

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 17Ad 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 *IC8* (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 × 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. ◇

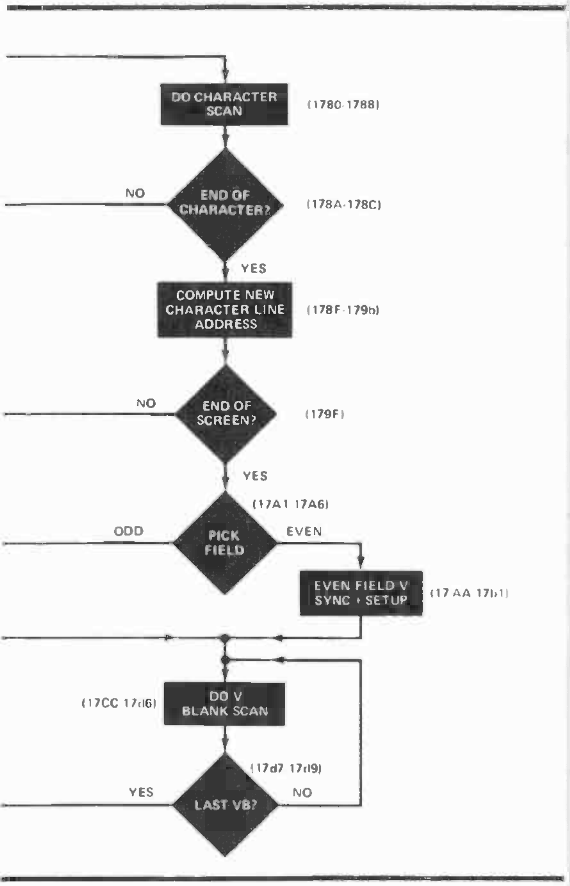


TABLE V

CRUNCHER THE BEAR Program for a 32 line X 64 character per line TVT6 raster scan:

```
µP - 6502          Start - JMP 17C0        Displayed 0000-07FF
System - KIM-1     End - Interrupt         Program Space 1780-17dA

HS VS L4 L2 L1 V16 V8 V4          V2 V1 H32 H16 H8 H4 H2 H1
      Upper Address                      Lower Address

        1780  LDA  A9  80              Initialize Upper Address
        1782  STA  8d  (87)  (17)      Store Upper Address
        1785  JSR  20  00    80        ////Character Scans 0-7////
        1788  ADC  69  10              Increment Character Gen by 2

        178A  CMP  C9  C0              Is VS = 1?
        178C  BCC  90  F4*             No, Do next character scan
        178E  PHA  48                  Save Upper Address
        178F  LDA  Ad  (86)  (17)      Get Lower address

        1792  ADC  69  3F              Increment L; Set Carry on V2 overflow
        1794  STA  8d  (86)  (17)      Restore L; Save carry
        1797  PLA  68                  Get Upper Word
        1798  JSR  20  0C    80        ////Character Scans 8,9 ////

        179b  ADC  69  C0              Add Carry; Reset Upper Address
        179d  CMP  C9  88              Is it "Line 33"?
        179F  BCC  90  E1*             No, repeat Character Scans
        17A1  LDA  Ad  (81)  (17)      Get Interlace word

        17A4  ADC  69  78              Set Carry if Odd Field finished
        17A6  BCC  90  0C*             Start Even Field if Carry Clear
        17A8  LDX  A2  22              Load Even number of V Scans -2
        17AA  LDA  A9  80              Load Even Field Upper Start

        17AC  STA  8d  (81)  (57)      Even Field V Sync + Restore Interlace
        17AF  LDA  A9  88              Even Field Line 33 CMP Value
        17b1  STA  8d  (9E)  (17)      Store Even 33 CMP Value
        17b4  LDA  A9  00              Clear Accumulator

        17b6  STA  8d  (86)  (17)      Initialize Lower Address
        17b9  LDY  A0  06              Equalize 31 cycles
        17bb  DEY  88                  continued
        17bC  BPL  10  Fd              continued

        17bE  BCS  b0  0C*             Jump if even field
-START- 17C0  LDA  A9  88              Load Odd Field Upper Start
        17C2  STA  8d  (81)  (57)      Odd Field V Sync + Restore Interlace
        17C5  LDA  A9  90              Odd Field line 33 CMP Value

        17C7  STA  8d  (9E)  (17)      Store Odd 33 CMP Value
        17CA  LDX  A2  23              Load Odd number of V Scans
        17CC  JSR  20  3F    80        ////  1st V Blanking Scan ////
        17Cf  PHA  48                  Equalize 7

        17d0  PLA  68                  continued
        17d1  CLD  d8                  Equalize 4
        17d2  CLC  18                  continued
        17d3  JSR  20  00    80        //// Other V Blanking Scans ////

        17d6  DEX  CA                  One Less scan
        17d7  BMI  30  A7*             Start Character Scans
        17d9  BPL  10  F6*             Repeat V Blanking Scan
```

NOTES: TVT6 must be connected and scan microprogram FROM IC1 must be in circuit for program to run. TVT6 length jumper must be in "64" position.

Step 1785 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 179E 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 1.002150 MHz crystal. 85 us per line; 196.5 interlaced lines per field; two fields per frame. One us 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.

MORE ON USING CALCULATORS AS STOPCLOCKS

HOW TO CONVERT A "FOUR BANGER" FOR STOPWATCH FUNCTIONS

BY CHARLES STANFORD

MOST 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 0.05% 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 ., 1, +, =, =, =. 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 3.579545-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 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.

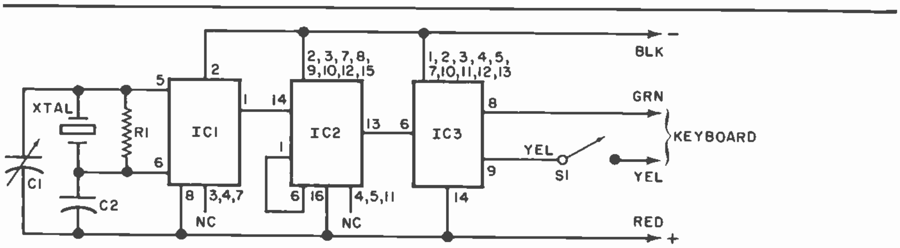


Fig. 1. Timer updates count 10 times/second when constant is activated.

PARTS LIST

C1—5-to-40-pF trimmer capacitor
C2—27-pF ceramic capacitor
IC1—MM5369 programmable oscillator/divider (National)
IC2—4018 CMOS presettable divide-by-N counter
IC3—4016 CMOS quad bilateral switch
R1—22-megohm, ¼-watt resistor
S1—Miniature push-push spst switch
XTAL—3.579545-MHz (color TV) crystal
Misc.—Printed circuit board; red, black, yellow, green stranded hookup wire; insulating tape or fish paper; solder; etc.

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 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

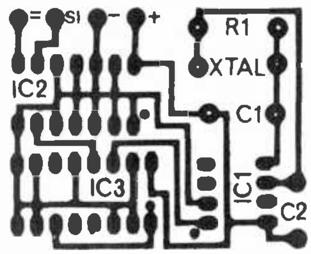


Fig. 2. Foil side, components mount on other side of board. Dots denote pin 1 of IC's.

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:

STEP	KEYSTROKES
01	RCL, 1
02	f, →H.MS
03	f, PAUSE
04	RCL, 2
05	STO, +, 1
06	GTO, 01

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.

Now your timer will probably be accurate enough for most photographic or kitchen timing. However, with a little further 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.MS.

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

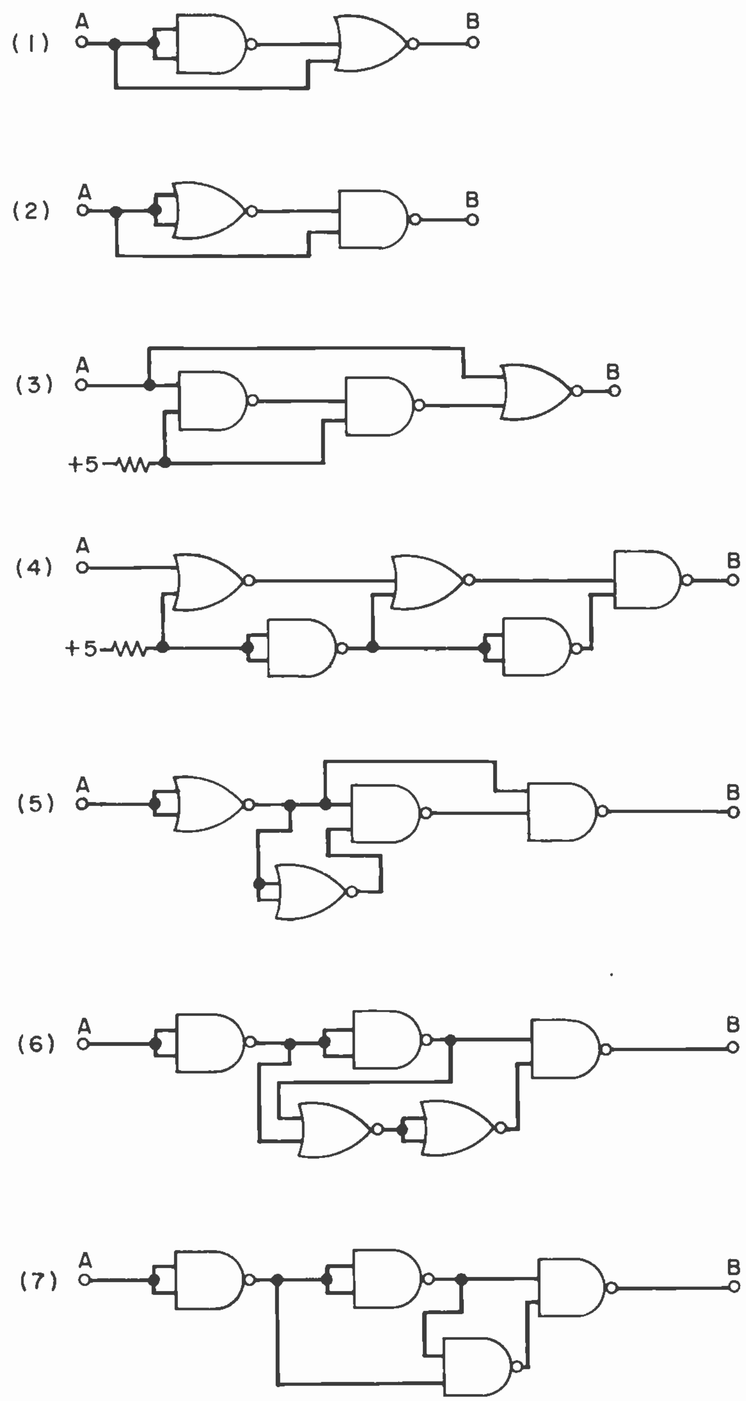
A simple program change turns the calculator into a countdown timer. Store the starting time in Register 1 and change step 5 in the program to STO, −1. Now, when the timing program is started, the calculator will count down from the time stored in Register 1, a second at a time.

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. ◇

TTL LOGIC QUIZ

BY W.J. FISHER

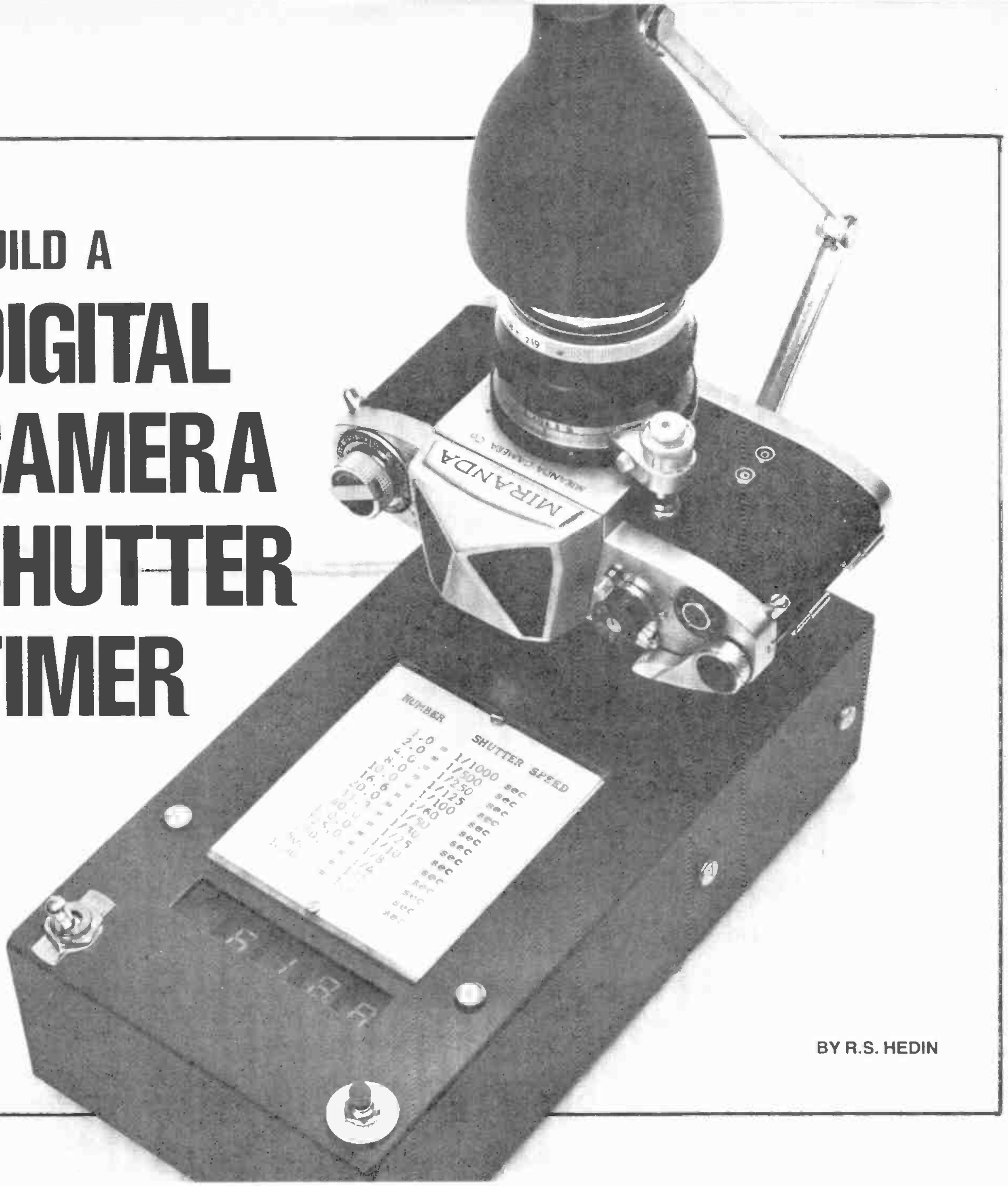
Although the circuits shown here can not be put to any practical use, they can provide a test of your TTL IQ. For each circuit, determine the resulting outputs at B for the two possible logic inputs ("1" or "0") at A.



ANSWERS: (1) A=1; B=0 A=0; B=0 (2) A=1; B=1 A=0; B=1 (3) A=1; B=0 A=0; B=1 (4) A=1; B=0 A=0; B=0 (5) A=1; B=1 A=0; B=0 (6) A=1; B=0 A=0; B=1 (7) A=1; B=0 A=0; B=1

BUILD A

DIGITAL CAMERA SHUTTER TIMER



BY R.S. HEDIN

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

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Most people think there are only two levels of careers in electronics: the technician level and that of the degree engineer.

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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.

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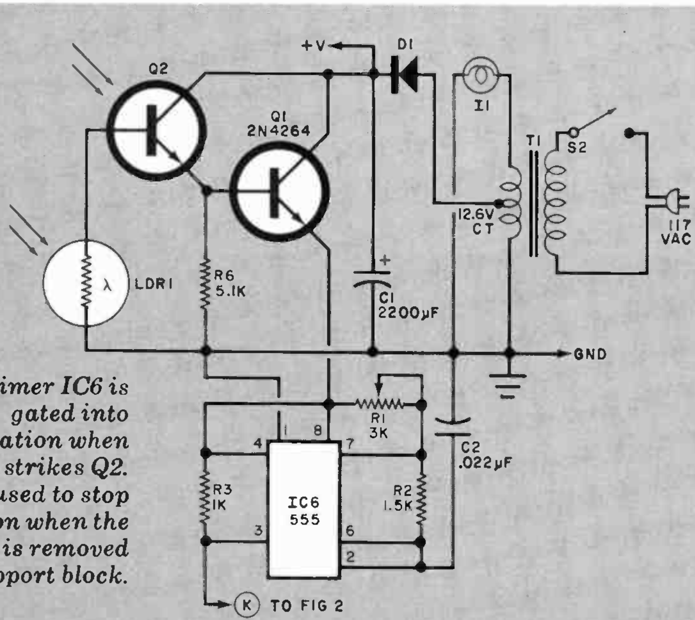


Fig. 1. Timer IC6 is gated into oscillation when light strikes Q2. LDR1 is used to stop operation when the camera is removed from support block.

PARTS LIST

C1—2200-µF, 16-volt electrolytic capacitor
C2—0.022-µF Mylar capacitor
DIS1 through DIS5—½" common-anode, seven-segment LED display (DL-704 or similar)
D1—100-volt, 1-ampere silicon rectifier diode
I1—12-volt high-intensity lamp with arm and reflector (see text)
IC1 through IC5—4033A CMOS decade counter
IC6—555 timer
LDR1—Light-dependent resistor (Vactec No. VT-214 or Clairex CL-903)
Q1—2N4264 transistor
Q2—FPT-100 phototransistor
R1—3000-ohm trimmer potentiometer
The following resistors ¼ watt, 10% tolerance:
R2—1500 ohms
R3,R4,R5—1000 ohms
R6—5100 ohms
S1—Normally open, momentrary-action spst pushbutton switch
S2—Spst toggle switch
T1—12-volt, 1.2-ampere transformer (see text)
Misc.—Printed circuit or perforated board; 16-pin DIP sockets (5); 14-pin DIP sockets (5); 8-pin DIP socket; chassis with cover (9" × 5" × 2½"); line cord; pine block (3½" × 1¾" × 1¾"); soft vinyl sheet; rubber feet (4); contact cement; machine hardware and spacers; hookup wire; solder; etc.

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*

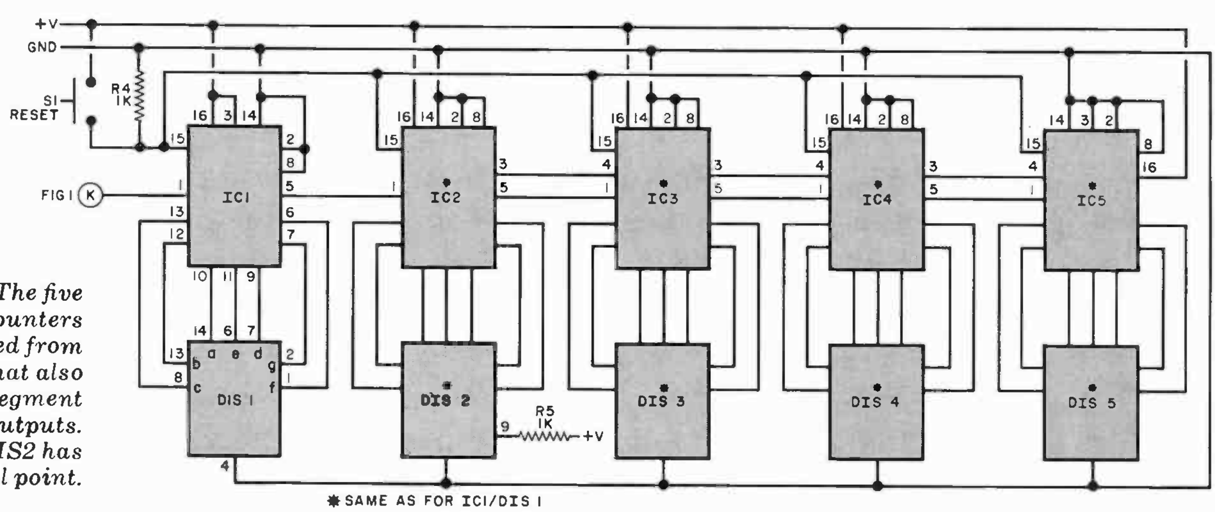


Fig. 2. The five decade counters are formed from IC's that also include 7-segment decoded outputs. Note that DIS2 has the decimal point.

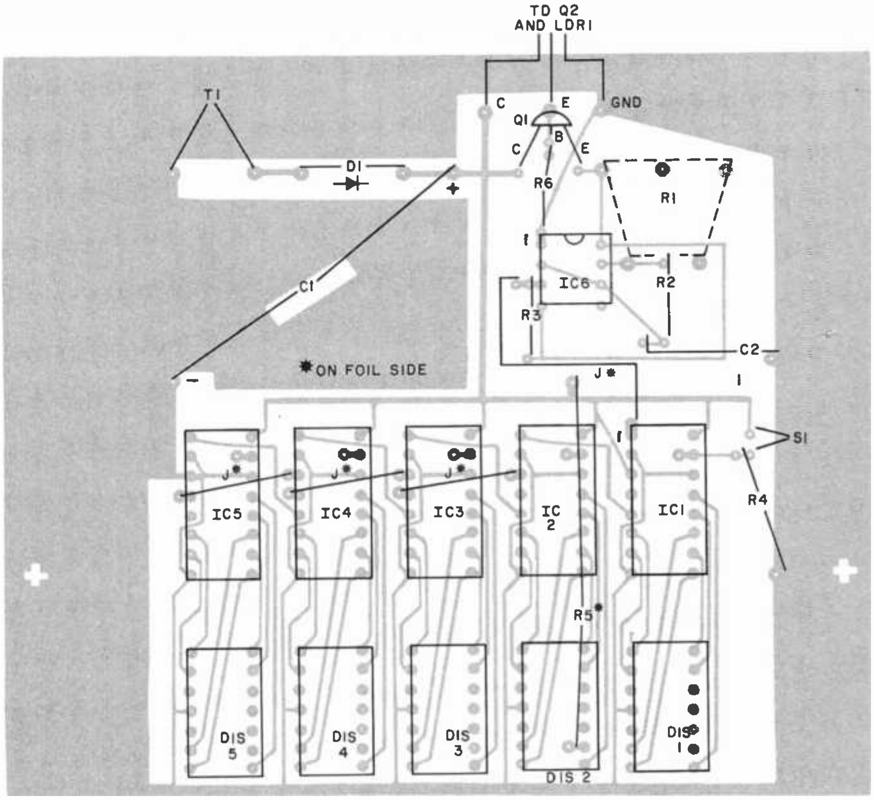
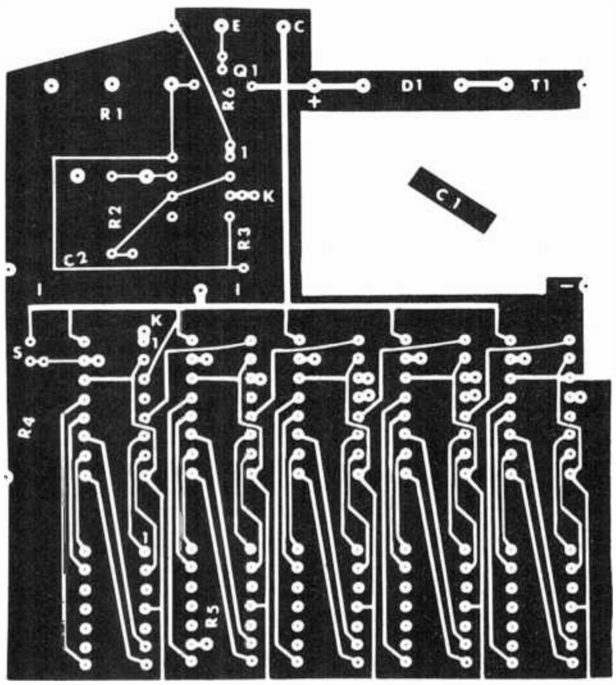


Fig. 3. Foil pattern and component installation. Pin 15 of IC1 through IC5 are connected together by a common jumper on the foil side of the board. Note that R5 and the other jumpers are also located on the foil side.

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,



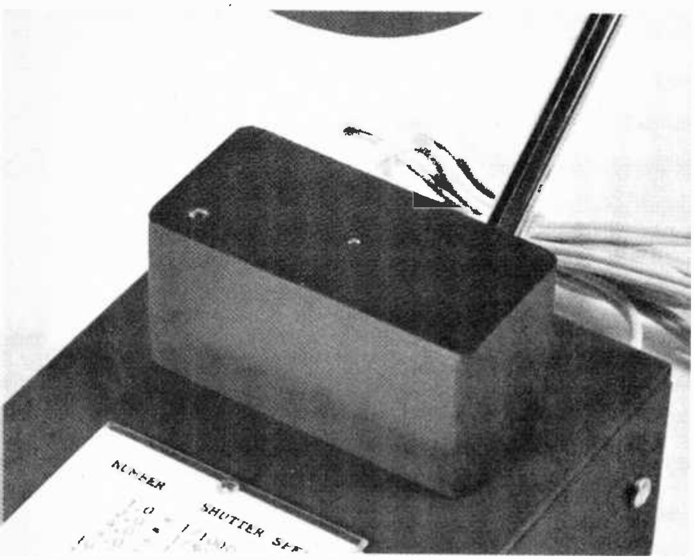
be sure to use insulated sleeving on the resistor leads and wire jumpers.

Phototransistor *Q2* and light-dependent resistor *LDR1* mount in a block of pine as shown in Fig. 4. The holes in which these two components mount must be stepped as indicated to permit easy routing of the hookup wires that interconnect them with the rest of the circuit. Note that *LDR1* mounts in the hole at the lower left corner and *Q2* mounts in the hole in the center of the block.

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

CONVERSION TABLE

NUMBER		SHUTTER SPEED
1.0	=	1/1000 sec
2.0	=	1/500 sec
4.0	=	1/250 sec
8.0	=	1/125 sec
10.0	=	1/100 sec
16.6	=	1/60 sec
20.0	=	1/50 sec
33.3	=	1/30 sec
40.0	=	1/25 sec
100.0	=	1/10 sec
125.0	=	1/8 sec
250.0	=	1/4 sec
500.0	=	1/2 sec
1000.0	=	1.0 sec



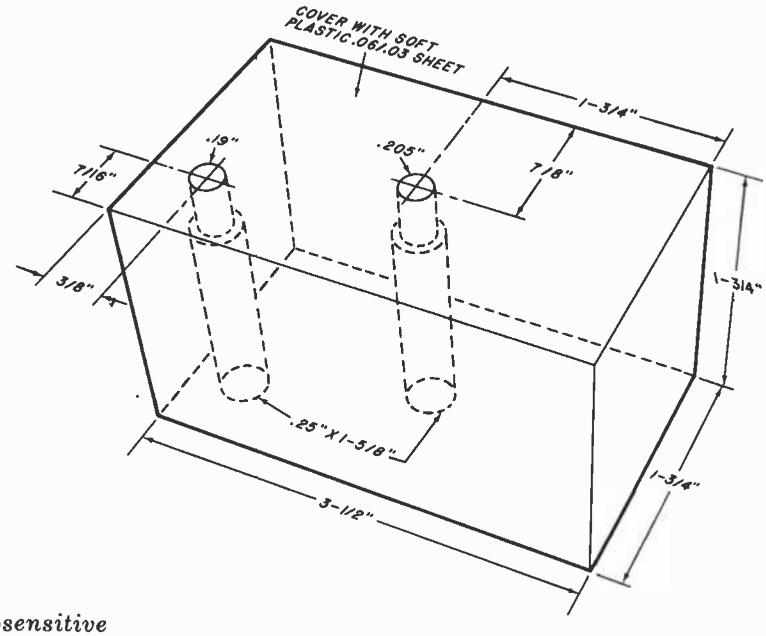


Fig. 4. Details of the camera mounting block. The two photosensitive devices (Q2 and LDR1) are mounted close to the upper surface of the block.

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 × 5"W × 2½"H (22.9 × 12.7 × 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 2⅝" × ½" (6.7 × 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.

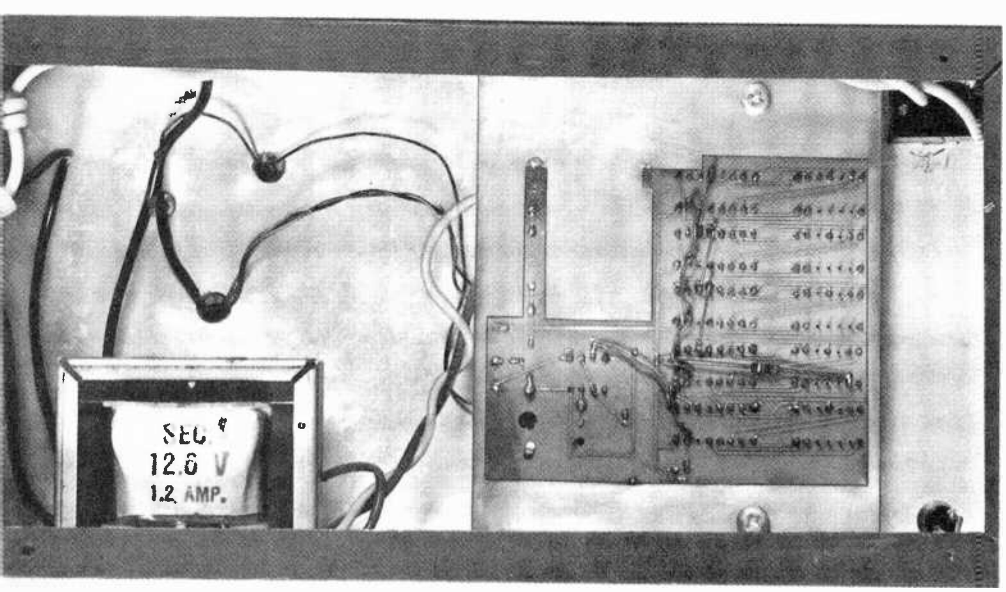
Checkout and Use. Place a piece of black plastic tape over *LDR1*, plug the line cord into a convenient ac outlet, and turn on the tester's power. Now, using an oscilloscope or a frequency counter, adjust potentiometer *R1* for an exact 10,000-Hz output from timer *IC6*. This completes calibration. Remove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

Photo courtesy 3M Co.

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

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 SiO_2 between the gate and substrate.

The strength of the electrical field that can rupture the SiO_2 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 10^{14} 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.

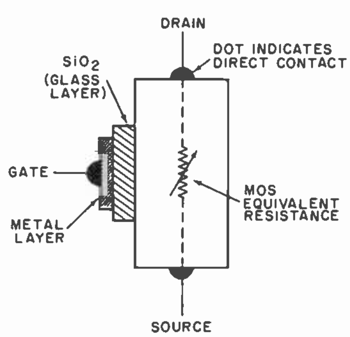


Fig. 1. Typical MOS device showing the insulated gate.

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 SiO_2 layer. Manufacturers are making improvements in their protective schemes, but as of this writing, there is still no such thing as complete protection.

Fig. 2. Magnified (4300X) view of a cell-destroying punchthrough that has catastrophically destroyed the semiconductor device.

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.

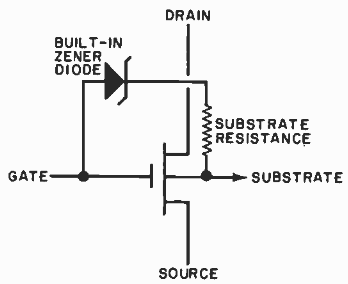


Fig. 3. The protection of a MOS device is usually 100 volts.

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 SiO_2 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

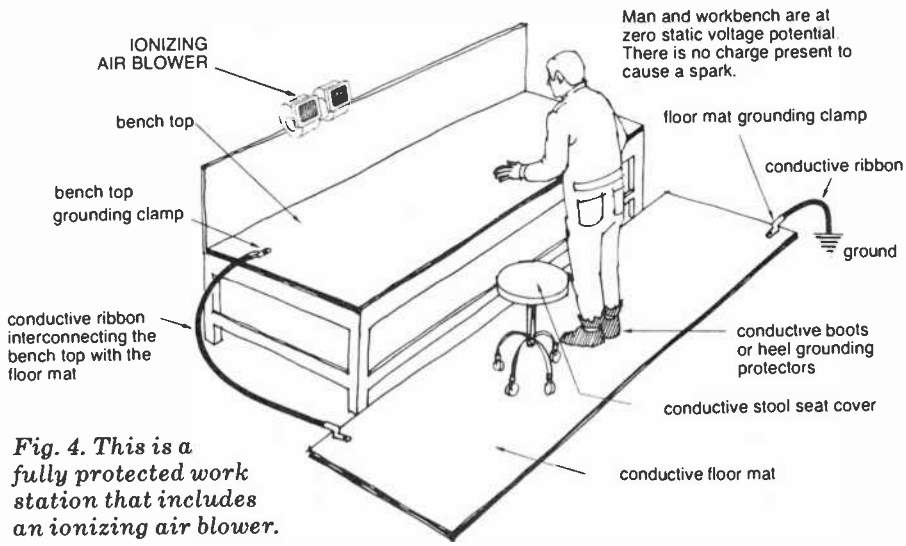


Fig. 4. This is a fully protected work station that includes an ionizing air blower. *(Photo courtesy 3M Co.)*

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.
- 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

GROUNDING 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.

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

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.

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-plastic strap 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" × 12" (50 × 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. ◇

Solid State

BY LOU GARNER

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 thermistor'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*

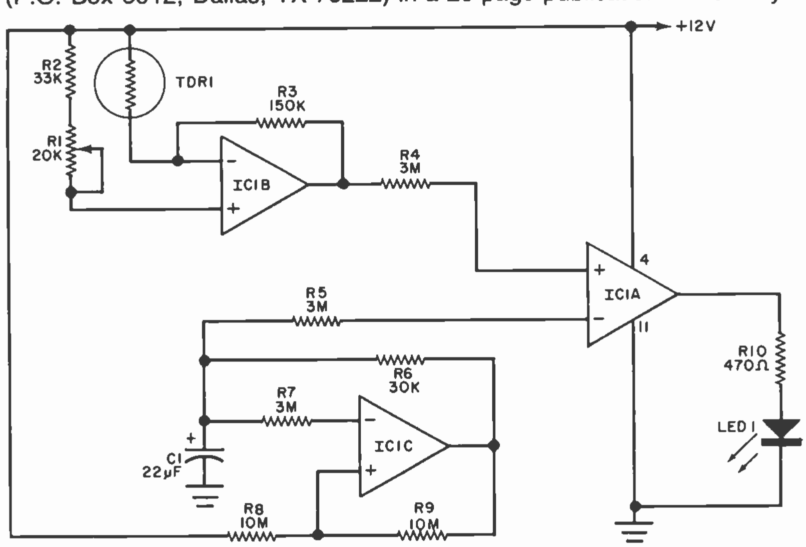


Fig. 1. This "Icy Road Warning Indicator," suggested by Texas Instruments, is essentially a special-purpose electronic sensor using an op amp as a combination voltage comparator, buffer amplifier and LED driver.

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 out-of-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-

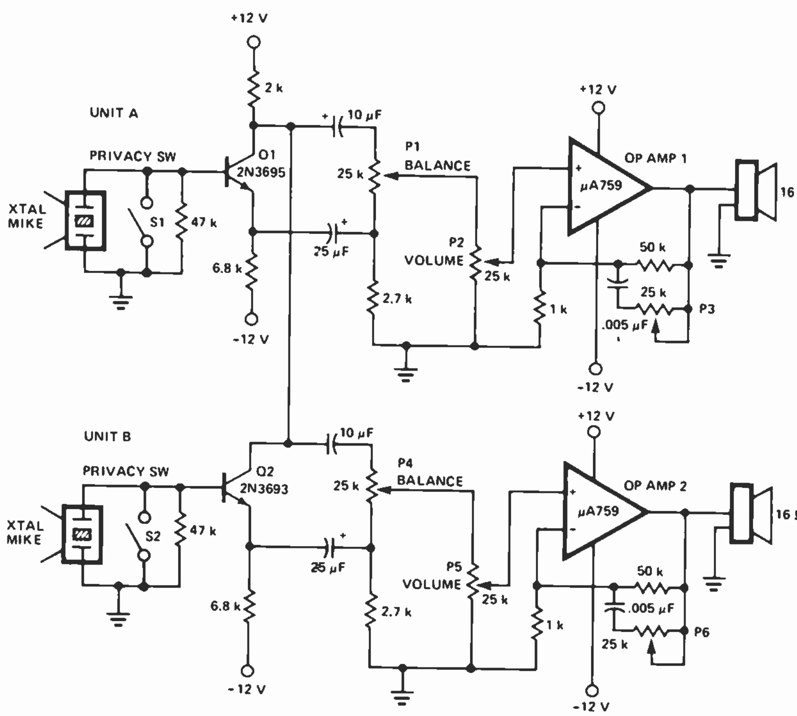


Fig. 2. Fairchild's bidirectional intercom system permits two-way "hands-free" conversations. Each of the two units has a privacy switch in addition to individual volume and tone controls.

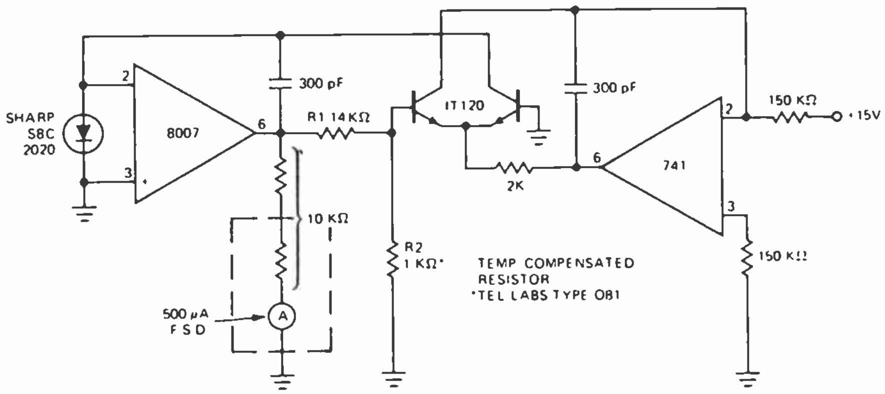


Fig.3. From a bulletin published by Intersil, this light meter circuit for photographers provides an analog readout proportional to the log value of light intensity. It uses an 8007 FET-input op amp.

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 semi-fixed 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-

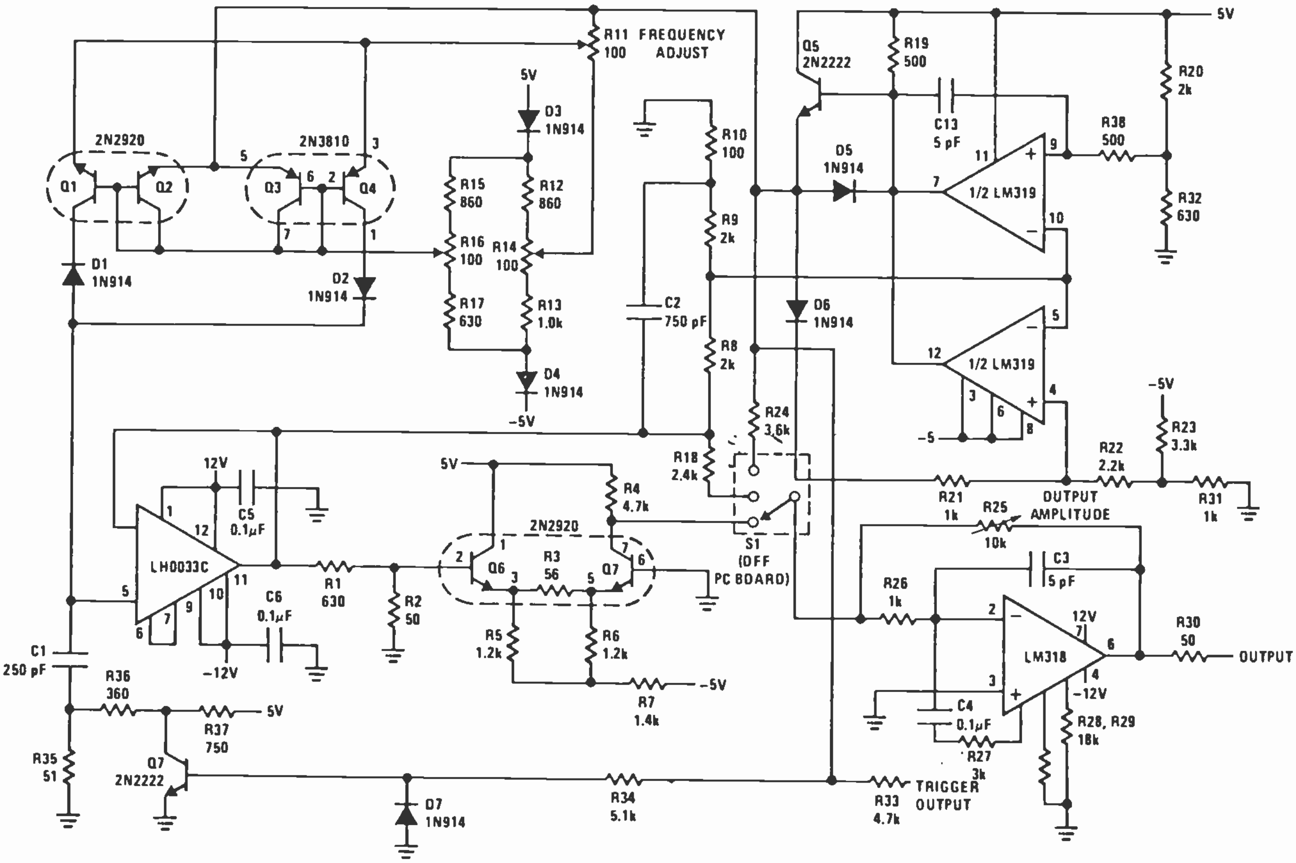


Fig. 4. National Semiconductor's wide-range function generator circuit.

ing transistors through frequency control *R11*. Differential amplifier *Q6-Q7*, operated with degenerative emitter feedback, serves to modify the triangular signal delivered by the buffer amplifier through voltage-divider *R1-R2*. This develops a close approximation to a sine wave across output load *R4* which is applied directly to function switch *S1*. From *S1*, the selected signal waveform is coupled through series resistor *R26* to the LM318 serving as the output amplifier. The output amplitude is controlled by *R25*, which provides inverse feedback across the op amp.

The function generator requires regulated dual ±5- and ±12-volt dc sources for proper operation. Suggested by National Semiconductor in its Application Note, the ac line operated power supply in Fig. 5 will provide the correct voltages. A conventional design, it comprises a spst ON-OFF switch, fuse, 24-volt step-down transformer, bridge rectifier, two filter capacitors (*C7* and *C8*), positive and negative 5- and 12-volt regulator IC's, and four bypass capacitors (*C9*, *C10*, *C11* and *C12*). All of the regulators are standard 3-terminal devices.

Though standard parts are specified in the instrument's design, some care must be exercised in the choice of components to insure optimum performance. A standard potentiometer may be used for frequency control *R11*, for example, but a vernier type or 10-turn pot is preferred due to the unit's six-decade frequency coverage. The output level control, *R25*, can be a standard potentiometer, with trimmer types used for semi-fixed adjustments *R14* and *R16*. All fixed resistors may be either quarter- or half-watt types, but should have a 5% tolerance rating except for *R1*, *R2*, *R5*, *R6* and *R7*, which should 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, nonshorting 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. ◇

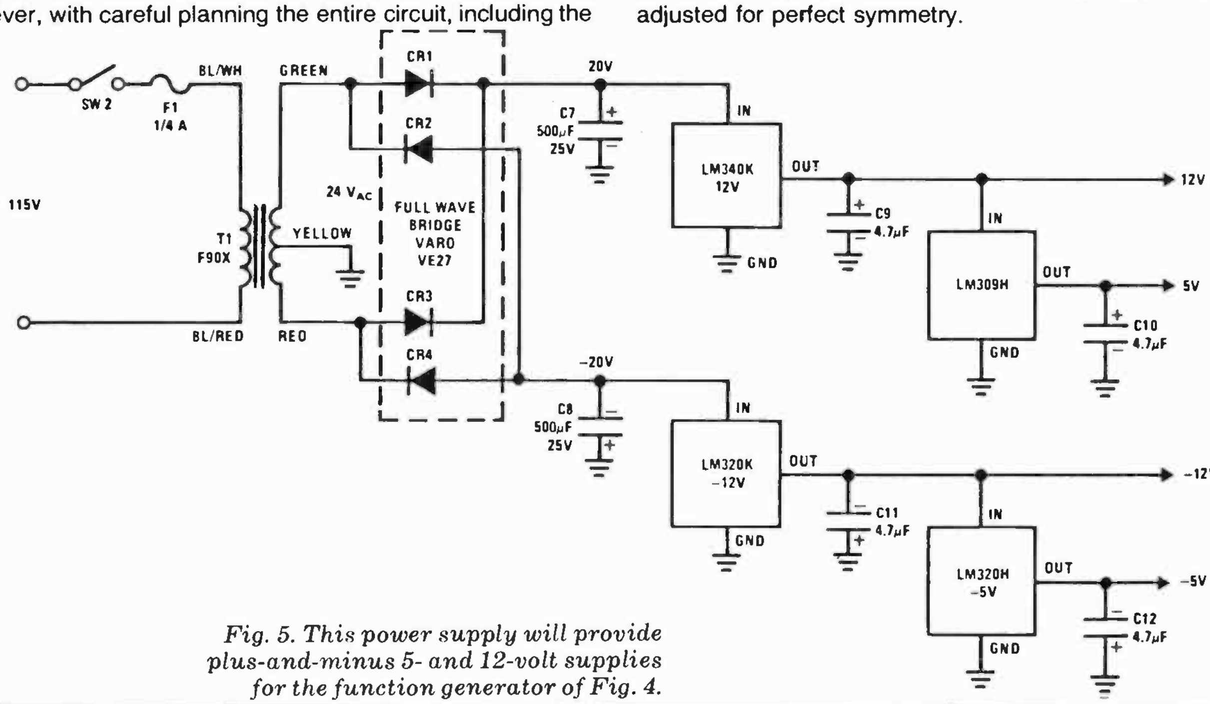


Fig. 5. This power supply will provide plus-and-minus 5- and 12-volt supplies for the function generator of Fig. 4.

Hobby Scene Q&A

By John McVeigh

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 scanner antennas which will work in the low and high vhf bands?—Chris Del Plato, Whippany, NJ.***

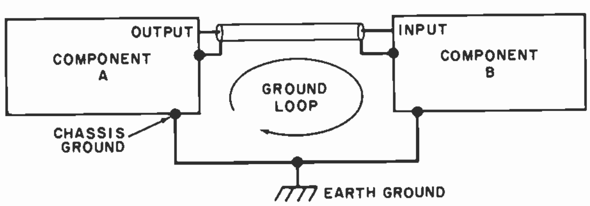
A. There are many things to be considered here. You'll have to decide whether you want one antenna for each band, or say a broadbanded antenna to cover more than one. Also, are you interested in a low-gain, omni-directional antenna or a high-gain directional one? It's best to consult one of the many 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).

GROUND LOOPS

Q. ***I would like to know how to avoid ground loops. Also, should the coils in a power line filter both be wound in one direction, or one clockwise and the other one counterclockwise?—Charles Gulino, Brooklyn, N.Y.***

A. The fundamental rule for avoiding ground loops is to make sure that only one grounded lead is connected to the chassis of a particular component. The figure shows an example of a ground loop. Note that the shielded cable between component A (say, a preamp) and component B (a power amp) is tied to both chassis. Also, separate grounding straps are run from each chassis to ground. If there is a potential difference between the two chassis, a current can flow around the ground loop. This can lead to hum problems. The easiest way to open the loop is to remove the grounding strap at either component A or component B. The chassis will still be grounded through the braid of the shielded lead—but only at one point.

It doesn't really make a difference which way you wind the coils for a line filter. Just be sure that wire with adequate insulation and capacitors rated for line bypassing (such as 1000-volt ac disc ceramic types) are used. Observe good construction practices and keep *safety* in mind. When in doubt, use a commerical UL-approved line filter.



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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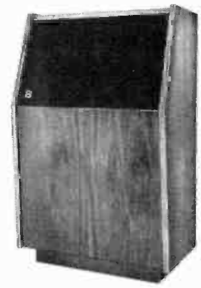

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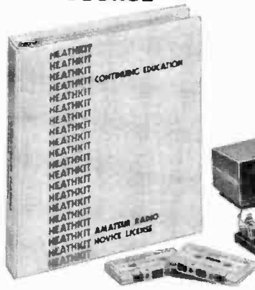

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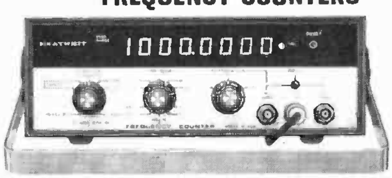

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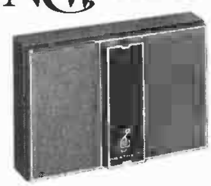

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Experimenter's Corner

By Forrest M. Mims

THE FOUR-LAYER DIODE

THE FOUR-LAYER diode is a pnpn 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.

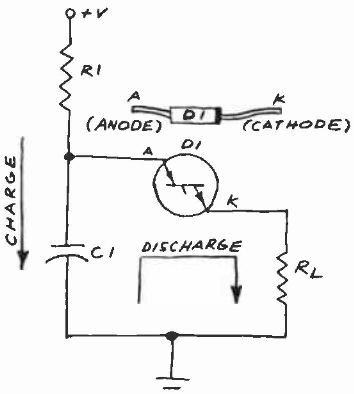


Fig. 1. Basic four-layer diode relaxation oscillator.

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, R_L. 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 (I_h). Accordingly, *R1* must be large enough to keep the current level from the power supply below I_h.

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 R_L 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.

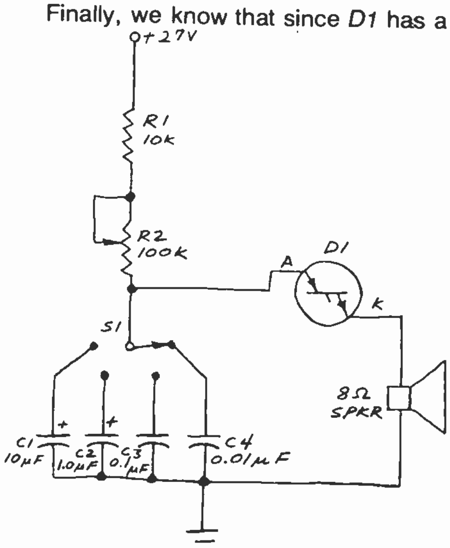


Fig. 2. Audio oscillator.

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

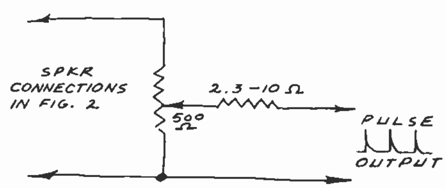


Fig. 3. Pulse generator output.

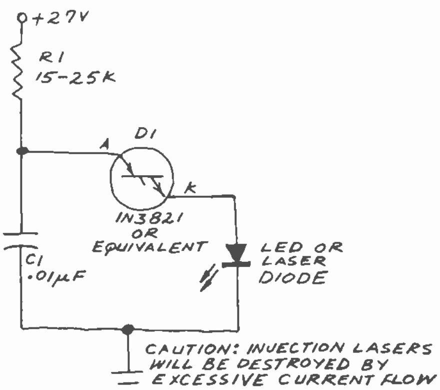


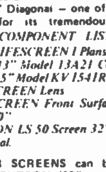
Fig. 4. Four-layer diode LED and injection laser driver.

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 a 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 (alc) for SSB operation; electronic voltage regulation; reverse-polarity protection; and a line filter for dc sources.

The transceiver measured 13½" W × 11"D × 5"H (34.3× 28 × 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 splatter. Similar results are obtained on SSB, where the low-level clipper is engaged along with an alc 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 change with an 80-dB r-f change at 1 to 10,000 μV.

An S9 indication on the S meter was obtained with a 50-μV signal. Unwanted-sideband suppression measured greater than 60 dB at 1000 Hz. The overall response was 200 to 2000 Hz on AM and nominally 50 to 2700 Hz on SSB. The audio output measured 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 nicety 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 low-pass 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.

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 7⅛"L × 3⅜"W × 1½"D (18.1 × 8.6 × 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.

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 specs—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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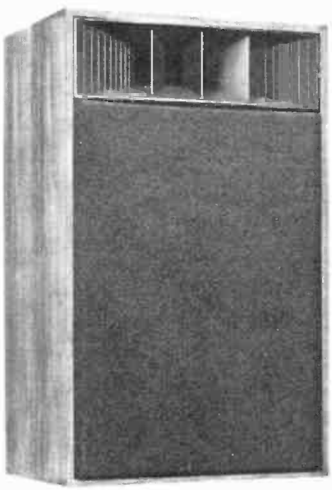

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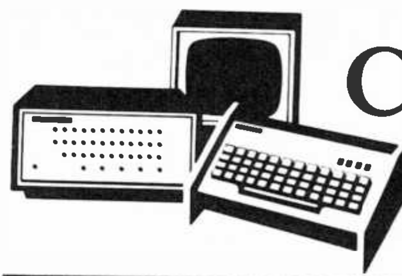


Computer Bits

By Leslie Solomon, Technical Editor

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 outputs 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.

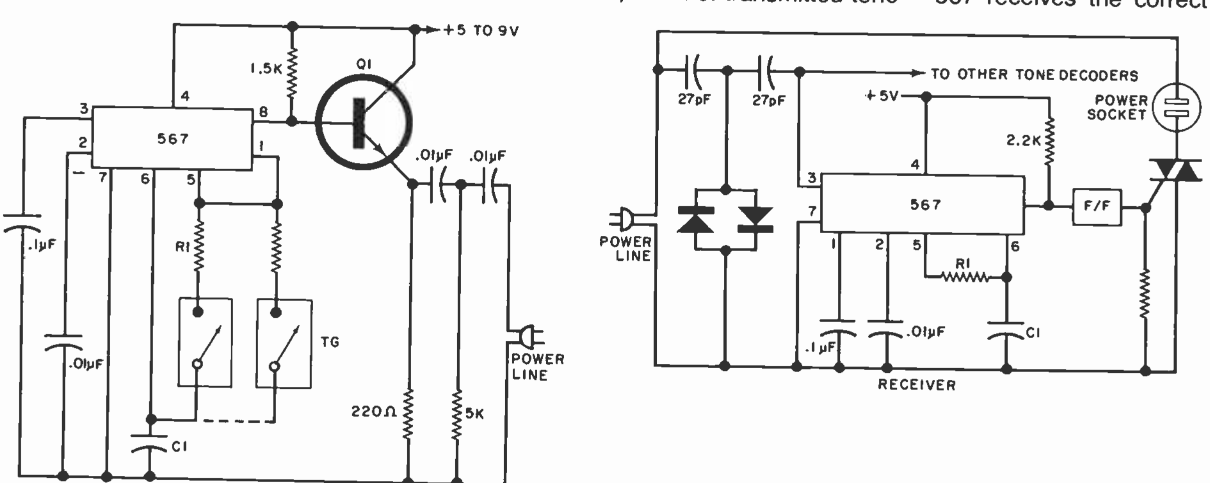
Because of the 30-Hz-to-17-kHz bandwidth of the system, quite a number of discrete tones can be transmitted. The use of high-Q filters can increase even that number.

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



Transmitter (left) and receiver (above) circuits for a wireless system of remote control by computer.

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

Heathkit H8 digital computer.

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 back-

Heathkit H9 CRT terminal.

plane, 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 14⅞" 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 Scene

By Ray Newhall, KWI6010

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.

Hy-Gain's Model 2716 40-channel Remote CB Mobile Transceiver.

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 transeivers, 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 kept buying 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

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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 TI, 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

Texas Instruments' hand-held unit includes digital SWR readout.

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 i-f 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 auto 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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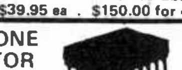

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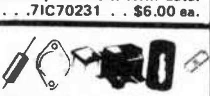

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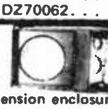

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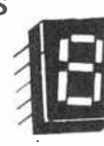

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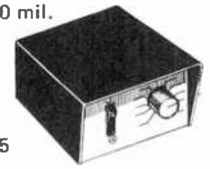

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CY1A	1.000 MHz	HC33/U	$5.95
CY2A	2.000 MHz	HC33/U	$5.95
CY2.01	2.010 MHz	HC33/U	$1.95
CY3A	4.000 MHz	HC18/U	$4.95
CY7A	5.000 MHz	HC18/U	$4.95
CY12A	10.000 MHz	HC18/U	$4.95
CY14A	14.31818 MHz	HC18U	$4.95
CY19A	18.000 MHz	HC18/U	$4.95
CY22A	20.000 MHz	HC18/U	$4.95
CY30B	32.000 MHz	HC18/U	$4.95

EXAR

XR-2206KB Kit $29.95 Special XR-2206KA Kit $19.95

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XR-205	$8.40
XR-2206CP	4.49
XR-2207CP	3.85

STEREO DECODERS	
XR-1310CP	$3.20
XR-1310EP	3.20
XR-1800P	3.20
XR-2567	2.99

MISCELLANEOUS	
XR-2211CP	$6.70
XR-4136	99
XR-1468	3.85
XR-1488	5.80
XR-1489	4.80
XR-2208	5.20

TIMERS	
XR-555CP	$ .39
XR-320P	1.55
XR-556CP	1.85
XR-2556CP	3.20
XR-2240CP	3.25

PHASE LOCKED LOOPS	
XR-210	5.20
XR-215	6.60
XR-567CP	1.95
XR-567CT	1.70

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PRINTED CIRCUIT EDGE-CARD

.156 Spacing-Tin-Double Read-Out

Bifurcated Contacts — Fits .054 to .070 P.C. Cards

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25 PIN-D SUBMINATURE

DB25P	PLUG	$3.25
DB25S	SOCKET	$4.95

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8080A	CPU	$19.95
8212	8 Bit Input/Output	4.95
8214	Priority Interrupt Control	15.95
8216	Bi-Directional Bus Driver	6.95
8224	Clock Generator/Driver	10.95
CDP1802	with user manual	39.95
8228	System Controller - Bus Driver	$10.95
MC6800L	8 Bit MPU	35.00
MC6820L	Periph. Interface Adapter	15.00
MC6810AP1	128 x 8 Static RAM	6.00
MC6830L8	1024 x 8 Bit ROM	18.00
Z80	CPU	49.95

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8080	Super 8008	24.95
8080A	Super 8008	19.95
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2519	Hex 40 BIT	4.00
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2525	1024 Dynamic	6.00
2527	Dual 256 BIT	3.95
2529	Dual 512 BIT	4.00
2532	Quad 80 BIT	3.95
2533	1024 Static	Special 5.95
3341	Fifo	6.95
74LS670	16 x 4 Reg	3.95

UART'S

AY-5-1013	30K Baud	$5.95

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2513(3021)	Char. Gen.-lower case	9.95
2516	Char. Gen.	10.95

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2101	256 x 4	Static	5.95
2102	1024 x 1	Static	1.75
2107/5280	4096 x 1	Dynamic	4.95
2111	256 x 4	Static	6.95
7489	16 x 4	Static	2.49
8101	256 x 4	Static	6.95
8111	256 x 4	Static	6.95
8599	16 x 4	Static	3.49
91L02	1024 x 1	Static	2.25
74200	256 x 1	Static	6.95
93421	256 x 1	Static	2.95
MM5262	2K x 1	Dynamic	2 for 1.00

PROMS

1702A	2048	Famos	$ 9.95
5203	2048	Famos	14.95
82S23	32 x 8	Open C	5.00
82S123	32 x 8	Tristate	5.00
74S287	1024	Static	7.95
3601	256 x 4	Fast	3.95
2708	8K	Eprom	29.95
6301-1	1024	Tri-State Bipolar	3.49
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MC14583	3.50	MCM6574	17.50	DS0026CH	3.75	LO11C/LO111	25.00/set
MC14562	14.50	MCM6575	17.50	TIL308	10.50	AY-5-9100	17.50 ea
CD4059	9.95	MC14419	14.95	ICM7208	22.00	95H90	13.95
CD4070	.95	ICM7045	24.95	ICM7207	7.50	ICM7209	7.50
MC14409	14.95					HD0165	7.95
MC14410	14.95						

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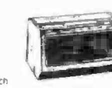
Digital Alarm Clocks

- 24-hour alarm
- Doze Button
- 100% Solid State
- Large Red Led Display (.8" high)
- AM/PM Indicator
- Seconds display at touch of button
- Power failure indicator
- One year factory warranty



C-500 - Ivory Case
C-500B - Ebony Case
$16.95

C-8211
Woodgrain Case
$19.95

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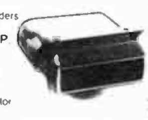
SEVEN DIFFERENT INSTRUMENTS!
MEETS OR EXCEEDS ORIGINAL AUTOMOTIVE SPECS

Please specify which one of the seven models you want when ordering — these do not all come in one unit. Each model must be bought separately.



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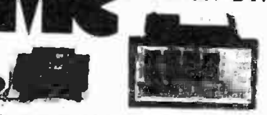
2 WATER TEMP 100-250° F
3 FUEL LEVEL Percentage Low Fuel Indicator
4 SPEEDOMETER* 0-99 MPH
5 OIL PRESSURE 0-80 PSI
6 OIL TEMP 200-350° F
7 BATTERY MONITOR ±1 Volts From 11-15 VDC

BRIGHT YELLOW ORANGE
3" LED DISPLAY!

Kit includes case, bracket and all components — complete. Nothing else to buy! 12 Volt NEG GRD.
DIMENSIONS 4½ x 4 x 2 — KIT: $49.95
* Add $10.00 for required speed transducer. ASSEMBLED: $59.95

iMC 3½ DIGIT DVM KIT



This 0-2 VDC .05 per cent digital voltmeter features the Motorola 3½ digit DVM chip set. It has a .4" LED display and operates from a single +5V power supply. The unit is provided complete with an injection molded black plastic case complete with Bezel. An optional power supply is available which fits into the same case as the 0-2V DVM allowing 117 VAC operation.

A. 0-2V DVM with Case	$49.95
B. 5V Power Supply	$14.95

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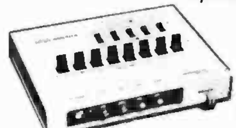
Logic Analyzer Kit



MODEL 100A
$189.00/Kit

- Analyzes any type of digital system
- Checks data rates in excess of 8 million words per second
- Trouble shoot TTL, CMOS, DTL, RTL, Schottky and MOS families
- Displays 16 logic states up to 8 digits wide
- See ones and zeros displayed on your CRT, octal or hexadecimal format
- Tests circuits under actual operating conditions
- Easy to assemble — comes with step-by-step construction manual which includes 80 pages on logic analyzer operation
- Some applications are:
  - Troubleshooting microprocessor address, instruction, and data flow
  - Examine contents of ROMS
  - Tracing operation of control logic
  - Checking counter and shift register operation
  - Monitoring I/O sequences
  - Verifying proper system operations during testing

DIGITAL STOPWATCH

- Bright 6 Digit LED Display
- Times to 59 minutes 59.59 seconds
- Crystal Controlled Time Base
- Three Stopwatches in One: Times Single Event — Split & Taylor
- Size 4.5" x 2.15" x .90" (4½ ounces)
- Uses 3 Penlite Cells

Kit —	$39.95
Assembled —	$49.95
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Stop Watch Chip Only (7205)	$19.95

AUTOTEL — an audible alarm kit indicating potential engine damage. An audible signal (70 db pulsing) immediately forewarns a malfunction or failure. There is no sound during normal operation. Features CMOS circuitry, 2½" x 2½" x ⅜" case. Complete kit with all components, hardware and case.

SPECIAL — $6.95/Kit

Vector

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0.1" Hole Spacing

	Part No.	P-Pattern L	P-Pattern W	Price 1	Price 2-Up
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	169P44 02XXXP	4.50	17.00	3.69	3.32
EPOXY GLASS	64P44 062	4.50	6.50	2.07	1.86
	84P44 062	4.50	8.50	2.56	2.31
	169P44 062	4.50	17.00	5.04	4.53
	169P84 062	8.50	17.00	9.23	8.26
EPOXY GLASS COPPER CLAD	169P44 062C1	4.50	17.00	6.80	6.12

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205CB — 680-.75A

205-CB	Beryllium Copper Heat Sink with Black Finish for TO-5	$ .25
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Elapsed Timer: Hrs, Mins and Secs
12 or 24 Hr Capacity
Simple Reset - Start Pushbutton Control

Complete kit includes mounting bracket, case and all components, nothing else to buy. Features MM5314 chip; Large .4" LED's. Accuracy better than ± min. per mo. internal battery backup. 12 volt non-polar operation.

DIMENSIONS 4½" x 4" x 2"
12 or 24 HOUR MODE

Kit: $29.95
Assembled: $39.95

CASE ONLY (includes hardware, mounting bracket and bezel) $6.50

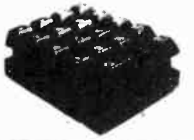
JE700 CLOCK

The JE700 is a low cost digital clock, but is a very high quality unit. The unit features a simulated walnut case with dimensions of 6" x 2½" x 1". It utilizes a MAN72 high brightness readout, and the MM5314 clock chip.

12/24 Hour
115 VAC

$17.95

HEXADECIMAL ENCODER 19-KEY PAD



- 1 - 0
- ABCDEF
- Return Key
- Optional Key (Period)
- — Key

$10.95 each

60 KEY KEYBOARD

This keyboard features 60 unencoded SPST keys, unattached to any kind of P.C.B. A very solid molded plastic 13" x 4" base suits most applications.

$19.95

HD0165 16 LINE TO FOUR BIT PARALLEL KEYBOARD ENCODER $7.95

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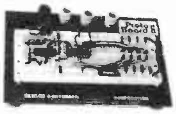
A97MS	— Diagonal Cutter - 4" semi-flush cut	$8.50 ea.
A11DMS	— Chain Nose Pliers - 4¾" long	7.50 ea.
T-6	— Wire Stripper - #16 to #26 gauge	3.75 ea.
55B	— Wire Stripper - #10 to #20 gauge	2.50 ea.
CS-8	— Cutter-Crimper Tool - 8¼" long	8.50 ea.
Nippling Tool — Cuts, Trims or Notches Metal up to #18 gauge		6.95 ea.
Nibbling Tool Replacement Punch		3.75 ea.

PERMACEL® P-29 PLUS Electrical Tape - All Weather
• ¾" wide x 66 ft. • Black vinyl
1-9 Rolls $.79 each — 10-up Rolls $7.95/10 roll package

CONTINENTAL SPECIALTIES

PROTO BOARD 6

$15.95
(6" long X 4" wide)



Other CS Proto Boards

PB100 - 4.5" x 6"	$ 19.95
PB101 - 5.8" x 4.5"	29.95
PB102 - 7" x 4.5"	39.95
PB103 - 9" x 6"	59.95
PB104 - 9.5" x 8"	79.95
PB203 - 9.75 x 6½ x 2¾	75.00
PB203A - 9.75 x 6½ x 2¾ (includes power supply)	120.00

Logic Monitor $84.95
for DTL, HTL, TTL or CMOS Devices

PROTO CLIPS

14 PIN	$4.50
16 PIN	4.75
24 PIN	8.50

DESIGN MATES

DM1 - Circuit Designer	54.95
DM2 - Function Generator	69.95
DM3 - RC Bridge	59.95

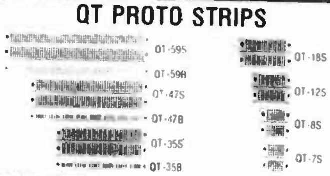
DIGITAL CLOCK KIT — 3½ INCH DIGITS

4 DIGIT KIT $49.95	4 DIGIT ASSEMBLED $59.95
6 DIGIT KIT $69.95	6 DIGIT ASSEMBLED $79.95

This clock features big 3½" high digits for viewing in offices, auditoriums, etc. Each digit is formed by 31 bright 0.2" LED's. The clock operates from 117 VAC, has either 12 or 24 hr. operation. The 6 digit version is 27" x 3½" x 1½" and the 4 digit is 18" x 3½" x 1½". Kits come complete with all components, case and transformer.

Specify 12 or 24 Hour When Ordering

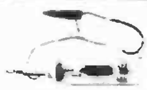
QT PROTO STRIPS



QT type	# holes	price
QT-59S	590	12.50
QT-59B	bus strip	2.50
QT-47S	470	10.00
QT-47B	bus strip	2.25
QT-35S	350	8.50
QT-35B	bus strip	2.00
QT-18S	180	4.75
QT-12S	120	3.75
QT-8S	80	3.25
QT-7S	70	3.00

Experimentor 300	$ 9.95
Experimentor 600	$10.95

JE803 PROBE



The Logic Probe is a unit which is for the most part indespensible in trouble shooting logic families TTL, DTL, RTL, CMOS. It derives the power it needs to operate directly off of the circuit under test, drawing a scant 10 mA max. It uses a MAN3 readout to indicate any of the following states by these symbols: (HI) - 1 (LOW) - 0 (PULSE) - P. The Probe can detect high frequency pulses to 45 MHz. It can't be used at MOS levels or circuit damage will result.

$9.95 Per Kit

printed circuit board

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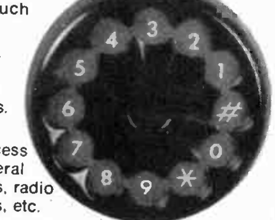

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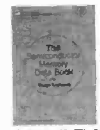

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74LS04	.29	74LS40	.28	74LS109	.39	74LS162	1.02	74LS258	.75
74LS05	.29	74LS42	.67	74LS112	.39	74LS163	1.02	74LS266	.39
74LS08	.29	74LS47	.79	74LS113	.39	74LS164	1.02	74LS283	.79
74LS09	.29	74LS48	.77	74LS114	.39	74LS168	1.14	74LS290	.65
74LS10	.28	74LS51	.28	74LS125	.49	74LS169	1.14	74LS293	.65
74LS11	.28	74LS54	.28	74LS126	.49	74LS170	1.73	74LS365	.67
74LS12	.28	75LS55	.28	74LS132	.81	74LS173	1.34	74LS366	.67
74LS13	.47	74LS73	.39	74LS136	.39	74LS174	1.06	74LS367	.67
74LS14	1.02	74LS74	.39	74LS138	.73	74LS175	.84	74LS368	.67
74LS15	.28	74LS75	.53	74LS139	.73	74LS190	1.18	74LS386	.39
74LS20	.28	74LS76	.39	74LS151	.75	74LS191	1.18	74LS670	2.34
74LS21	.28	74LS78	.39	74LS153	.75	74LS196	.86	71LS95	.77
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7409	.21	7492	.44	74193	.88	4021	1.14	LM324A	1.28
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7411	.21	7494	.70	74195	.88	4023	.23	LM340T-6	1.25
7412	.21	7495	.70	74196	.88	4024	.84	LM340T-8	1.25
7413	.25	7496	.70	74197	.88	4025	.23	LM340T-12	1.25
7414	.89	74100	1.28	74198	1.49	4026	1.68	LM340T-15	1.25
7416	.25	74107	.30	74199	1.49	4027	.40	LM340T-18	1.25
7417	.25	74109	.33	74251	1.09	4028	.89	LM340T-24	1.25
7420	.21	74121	.35	74279	.55	4029	1.14	LM3900N	.88
7421	.25	74122	.44	74365	.67	4030	.23	LM3909N	.69
7423	.35	74123	.61	74366	.67	4033	1.51	MC1456V	1.00
7425	.35	74125	.40	74367	.67	4034	3.50	MC1458V	.53
7426	.25	74126	.40	74368	.67	4035	1.14	MC3302P	1.15
7427	.33	74132	.70	8093	.40	4040	1.14	NE536T	3.24
7428	.28	74141	.88	8094	.40	4041	.79	NE540L	2.04
7430	.21	74145	.70	9095	.67	4042	.79	NE555V	.48
7432	.25	74147	1.63	8096	.67	4043	.70	NE556A	.88
7433	.30	74148	1.30	8097	.67	4044	.70	NE560B	3.83
7437	.25	74150	1.16	8098	.67	4046	1.86	NE561B	3.83
7438	.25	74151	.70	75150	1.16	4049	.40	NE562B	3.83
7440	.21	74153	.65	75450	.88	4050	.40	NE565A	1.25
7442	.53	74154	1.03	75451	.61	4051	1.26	NE566V	1.28
7443	.63	74155	.70	75452	.61	4052	1.26	NE567V	1.36
7445	.70	74156	.70	75453	.61	4053	1.26	uA709CV	.44
7446	.70	74157	.70	75454	.61	4060	1.58	uA710CA	.44
7447	.70	74160	.88	75491	.81	4066	.79	uA711CA	.53
7448	.70	74161	.88	75492	.84	4071	.23	uA723CA	.60
7450	.21	74162	.88	75493	1.09	4072	.23	uA733CA	.75
7451	.21	74163	.88	75494	1.19	4073	.23	uA741CV	.44
7453	.21	74164	.96	82525	2.19	4075	.23	uA747CA	.70
7454	.21	74165	1.15	4000	.23	4081	.23	uA748CV	.49
7459	.21	74166	1.26	4001	.23	4082	.23	uA7805CU	1.25
7460	.21	74170	2.64	4002	.23	4502	.79	uA7806CU	1.25
7470	.30	74173	1.42	4006	1.23	4510	1.14	uA7808CU	1.25
7472	.30	74174	.98	4007	.23	4511	1.05	uA7812CU	1.25
7473	.30	74175	.93	4008	.79	4514	2.80	uA7815CU	1.25
7474	.30	74176	.79	4009	.44	4515	2.80	uA7818CU	1.25
7475	.49	74177	.79	4010	.44	4516	1.23	uA7824CU	1.25
		74180	.70	4011	.23	4518	1.14		

WIRE WRAPPING WIRE IN BULK

Red or Black 30 ga. Kynar

100' $2.00 500' $8.50 1000' $15.00

SILICON DIODES

1N4001	.64/10	5.50/C	$49/M
1N4002	.66/10	5.60/C	$51/M
1N4003	.68/10	5.80/C	$52/M
1N4004	.70/10	5.95/C	$54/M
1N4005	.82/10	7.05/C	$63/M
1N4006	.90/10	7.75/C	$69/M
1N4007	.99/10	8.60/C	$77/M
1N4148	.40/10	3.50/C	$29/M

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1N5226B 3.3v	.15 $11/C	1N5236B 7.5v	.15 $11/C
1N5227B 3.6v	.15 $11/C	1N5237B 8.2v	.15 $11/C
1N5228B 3.9v	.15 $11/C	1N5238B 8.7v	.15 $11/C
1N5229B 4.3v	.15 $11/C	1N5239B 9.1v	.15 $11/C
1N5230B 4.7v	.15 $11/C	1N5240B 10v	.15 $11/C
1N5231B 5.1v	.15 $11/C	1N5241B 11v	.15 $11/C
1N5232B 5.6v	.15 $11/C	1N5242B 12v	.15 $11/C
1N5233B 6.0v	.15 $11/C	1N5243B 13v	.15 $11/C
1N5234B 6.2v	.15 $11/C	1N5244B 14v	.15 $11/C
1N5235V 6.8v	.15 $11/C	1N5245B 15v	.15 $11/C

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- NSN584 0.5" CA . . . . . $2.60/dual digit display
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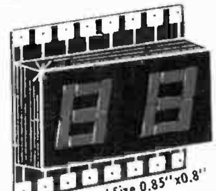
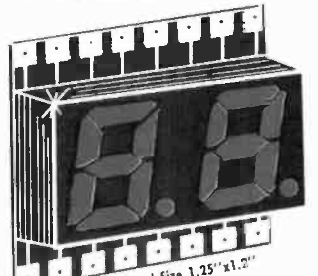
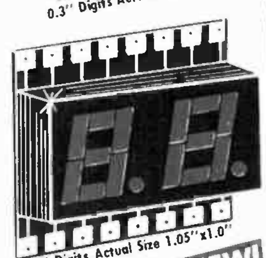
ALL LEADS BROUGHT OUT FOR EASE OF APPLICATION



0.3" Digits Actual Size 0.85"x0.8"



0.7" Digits Actual Size 1.25"x1.2"



0.5" Digits Actual Size 1.05"x1.0"

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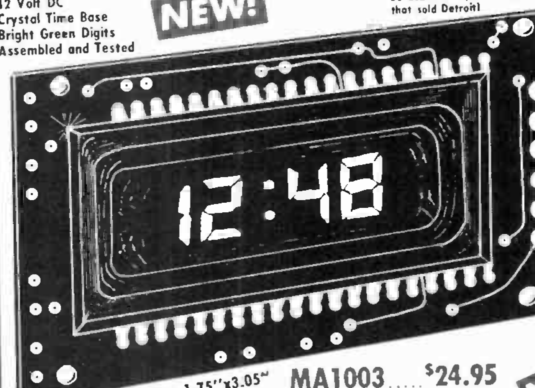
MA1003 CAR CLOCK

12 Hour Only
12 Volt DC
Crystal Time Base
Bright Green Digits
Assembled and Tested

NEW!

NEW — FOR CAR OR BOAT!

The MA1003 bright green flourescent display offers a brilliance that cannot be achieved by LED displays, a feature that sold Detroit!



0.3" Digits Actual Size 1.75"x3.05" MA1003 . . . . $24.95

NEW!

MA1002 0.5" High Digits

Actual Size: 1.375"x3.05"

MA1002A 12 Hour AM-PM	$10.50
MA1002C 24 Hour	$10.50
SPECIAL TRANSFORMER & SWITCHES	$3.45

ABOUT OUR CLOCKS

The MA1002 and MA1010 series clock modules by National Semiconductor are fully assembled and tested clocks using a 4 digit LED display and an MOS integrated circuit on the same board. Simply connect switches and our special transformer and you have a fully functioning clock.

The MA1003 clock module is a fully assembled and tested 12 hour clock using a high brilliance green flourescent display and crystal time base making it perfect for car, boat or other portable use. It operates directly from 12 volts DC so no transformer is needed. Our price includes three push button switches for setting the time.

MA1002A	.5" LED 12 Hour AM-PM Clock Module . . .	$10.50
MA1002A SET	Module with Transformer & Switches	$13.95
MA1002C	.5" LED 24 Hour Clock Module	$10.50
MA1002C SET	Module with Transformer & Switches .	$13.95
MA1003	12 Volt Car Clock with Switches . . .	$24.95
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MA1010A SET	Module with Transformer & Switches .	$16.45
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MA1010C SET	Module with Transformer & Switches	$16.45

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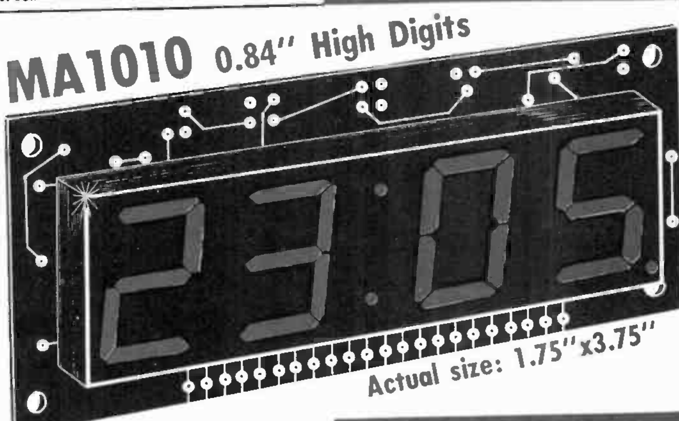
MA1010 0.84" High Digits



Actual size: 1.75"x3.75"

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MA1010C 24 Hour	$13.00
SPECIAL TRANSFORMER & SWITCHES	$3.45

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Interface IC's 464 p	$4.00
Volt. Regs. 126 p.	$3.00
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Audio 196 p	$3.00
MOS/LSI IC's 713 p	$4.00
CMOS 4000 278 p	$3.25
Analog Manual 637 p	$5.95

SLIDE SWITCHES

SPST	.15	1.20/10	10.00/C
SPDT	.19	1.70/10	13.00/C
DPDT	.23	2.00/10	19.00/C

STRANDED HOOK UP WIRE

20 ga PVC . .	2.50/100'	10.00/500'
22 ga PVC . .	2.80/100'	11.25/500'
24 ga PVC . .	2.10/100'	8.50/500'
26 ga PVC . .	2.10/100'	8.50/500'

50 VOLT DISCS

100 pf	.40/10	3.50/C
220 pf	.40/10	3.50/C
470 pf	.40/10	3.50/C
.001 uf	.40/10	3.50/C
.0022 uf	.40/10	3.50/C
.0047 uf	.40/10	3.50/C
.01 uf	.45/10	3.65/C
.022 uf	.50/10	4.00/C
.047 uf	.70/10	5.60/C
.1 uf	1.35/10	11.50/C

RADIAL ELECTROLYTICS

.47/50V	.08	.65/10	22/50V	.12	1.00/10	330/25V	.23	1.86/10
1/50V	.08	.65/10	100/6.3V	.09	.75/10	470/10R	.21	1.71/10
2.2/50V	.08	.65/10	100/10V	.10	.77/10	470/16V	.23	1.81/10
3.3/50V	.08	.65/10	100/16V	.11	.85/10	470/25V	.29	[illegible]
4.7/35V	.08	.65/10	100/25V	.13	1.10/10	1000/10V	.24	1.96/10
4.7/50V	.08	.68/10	100/50V	.21	1.71/10	1000/16V	.29	[illegible]
10/16V	.08	.65/10	220/10V	.13	1.08/10	1000/25V	.42	3.33/10
10/25V	.08	.65/10	220/16V	.15	1.16/10	2200/10V	.42	3.33/10
10/50V	.10	.75/10	220/25V	.21	1.71/10	2200/16V	.54	[illegible]
22/16V	.08	.67/10	220/50V	.29	2.35/10	2200/25V	.58	4.67/10
22/25V	.09	.70/10	330/10V	.15	1.16/10	3300/16V	.89	7.14/10
			330/16V	.21	1.66/10			

AXIAL ELECTROLYTICS

.47/10V	.11	.90/10	33/25V	.14	1.15/10	330/16V	.29	[illegible]
1/30V	.11	.90/10	33/50V	.19	1.52/10	330/25V	.32	2.54/10
3.3/35V	.12	.95/10	47/16V	.14	1.15/10	470/16V	.32	2.55/10
3.3/50V	.12	1.00/10	47/25V	.17	1.30/10	470/25V	.37	3.00/10
4.7/25V	.11	.90/10	47/50V	.21	1.17/10	1000/10V	.33	2.65/10
4.7/35V	.12	.95/10	100/10V	.14	1.13/10	1000/16V	.39	3.15/10
4.7/50V	.12	1.00/10	100/16V	.17	1.30/10	1000/25V	.56	4.50/10
10/25V	.12	1.00/10	100/25V	.20	1.55/10	2200/10V	.50	[illegible]
10/50V	.14	1.15/10	100/50V	.29	2.30/10	2200/16V	.62	4.95/10
22/16V	.12	1.00/10	220/10V	.18	1.42/10	2200/25V	.79	6.36/10
22/25V	.13	1.05/10	220/16V	.20	1.55/10	3300/16V	.95	7.63/10
22/50V	.17	1.32/10	220/25V	.29	2.35/10	4700/16V	1.09	8.70/10
33/16V	.12	1.00/10	220/50V	.40	3.23/10	10000/10V	1.15	9.19/10
			330/10V	.14	1.16/10			

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Wraps, Unwraps & Strips 30 ga. Wire

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8 Pin Solder	.17	1.60/10
14 Pin Solder	.20	1.90/10
16 Pin Solder	.22	2.10/10
18 Pin Solder	.29	2.75/10
24 Pin Solder	.38	3.60/10
28 Pin Solder	.45	4.25/10
40 Pin Solder	.63	6.00/10
8 Pin W-W	.24	2.30/10
14 Pin W-W	.26	2.50/10
16 Pin W-W	.30	2.85/10
18 Pin W-W	.60	[illegible]
24 Pin W-W	.96	[illegible]
28 Pin W-W	1.12	[illegible]
40 Pin W-W	.92	[illegible]

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4-40 1/2 Screw	.60/C	4.05/M
6-32 1/4 Screw	.65/C	4.40/M
6-32 1/2 Screw	.75/C	4.85/M
8-32 3/8 Screw	.90/C	5.85/M
8-32 5/8 Screw	.99/C	7.00/M
2-56 Hex Nut	.55/C	3.60/M
4-40 Hex Nut	.55/C	3.75/M
6-32 Hex Nut	.60/C	4.00/M
8-32 Hex Nut	.60/C	4.15/M
No. 2 Lockwasher	.85/C	5.75/M
No. 4 Lockwasher	.45/C	3.00/M
No. 6 Lockwasher	.45/C	3.00/M
No. 8 Lockwasher	.45/C	3.00/M

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7401	21	7448	1 15	74122	49
7402	21	7450	26	74123	1 05
7404	21	7451	27	74125	60
7405	24	7453	27	74126	81
7406	45	7454	41	74132	3 00
7407	45	7460	22	74141	1 15
7408	25	7472	39	74150	1 10
7409	25	7473	45	74151	1 25
7410	20	7474	45	74153	1 35
7411	30	7475	80	74154	1 25
7413	85	7482	1 75	74155	1 21
7416	43	7483	1 15	74157	1 30
7417	43	7485	1 12	74161	1 45
7420	21	7486	45	74164	1 65
7422	1 50	7489	2 49	74165	1 65
7425	43	7490	69	74166	1 70
7427	37	7491	1 20	74174	1 95
7428	33	7492	82	74175	1 95
7430	26	7493	82	74180	1 05
7432	31	7494	91	74181	3 55
7437	47	7495	91	74191	1 50
7438	40	7496	91	74195	1 00
7440	21	74100	1 25	74197	1 00
7441	1 10	74107	49	74298	1 30

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5410	1 00	5493	2 00
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4001AE	29	4022AE	1 20
4002AE	29	4023AE	29
4007AE	29	4024AE	1 50
4009AE	58	4025AE	35
4010AE	58	4026AE	1 49
4011AE	29	4028AE	1 60
4012AE	29	4029AE	2 90
4013AE	52	4030AE	65
4015AE	1 25	4037AE	4 50
4016AE	65	4040AE	2 40
4018AE	1 10	4044AE	1 50
4019AE	65	4047AE	2 75
4020AE	1 75	4049AE	75
4021AE	1 50	4050AE	75

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MC1004L	1 25	MC3004L	1 32
MC1008L	1 25	MC3006P	1 44
MC1010L	1 25	MC3007P	1 32
MC1011L	1 25	MC3021L	2 15
MC1036L	12 50	MC3021P	2 15
MC1037L	12 50	MC3060L	2 65
MC1352P	1 05	MC3062L	3 00
MC1406CP	3 95	MC4024P	2 20
MC1468L	2 90	MC14501CP	31
MC1469R	2 50	MC14502CP	18
MC1510G	8 00	MC14507CP	82
MC1514L	4 50	MC14510CP	2 40
MC1550G	1 50	MC14511CP	2 76
MC1558	4 37	MC14512CP	92
MC1595L	6 25	MC14519CG	94
MC1596G	3 31	MC14528CP	1 74
MC1723CG	1 25	MC4044P	4 80

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AN210	3 10	LA1201	4 25	TA7054P	3.05	TA7205P	6 50
AN211	3 30	LA1364	4 70	TA7055P	5 50	TA78005M	2 50
AN214	4 90	LA1366	6 00	TA7060P	1 85	TA78005P	1 95
AN217	3 30	LA1367	5 90	TA7061P	2 25	TA78012M	2 50
AN229	6 35	LA3301	4 85	TA7149P	4 00	TA78012P	1 95
AN234	5 75	LA4030	4 85	TA7063P	2 25	TA78015M	2 50
AN239	6 50	LA4031P	3 50	TA7074P	4 90	TA78015P	1 95
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AN288	4 80	LD3141	2 40	TA7106P	3 25	UPC48C	3 95
AN328	4 05	M5112	5 40	TA7120P	2 20	UPC554C	3 90
AN343	3 90	M5115PR	4 80	TA7120P-C	2 20	UPC563H2	8 00
BA511	3 50	M5155	2 85	TA7122AP	2 30	UPC566H	2 25
BA521	3 95	SG613	5 40	TA7124P	1 85	UPC575C	4 10
HA1158	6 30	STK011	10 50	TA7146P	4 10	UPC1001H2	5 15
HA1159	6 60	STK015	6 50	TA7150P	4 55	UPC1020H	5 50
HA1202	3 10	STK025	12 50	TA7153P	6.90	UPC1025	5 50
HA1306W	5 20	STK032	14 20	TA7200P	6 25		

74L SERIES TTL

74L00	33	74LS04	45	74LS113	98
74L10	33	74LS10	39	74LS138	1 89
74L30	33	74LS20	39	74LS174	2 50
74L42	1 50	74LS51	39	74LS386	5 50
74L86	69	74LS74	65	74S153	2 25
74LS00	39	74LS112	65	74S387	1 95

74H00 TTL

74H00	33	74H11	33	74H53	39
74H01	33	74H20	33	74H55	39
74H04	33	74H21	33	74H73	59
74H05	35	74H30	33	74H74	59
74H10	33	74H40	33	74H76	60

MISC CIRCUITS

BC184L	60	LM309K	1 95	SN15844N	55
CA3001	75	LM351AN	70	SN15946	55
CA3005	80	LM741CP	40	SN158097N	60
CA3006	1 10	LM1458M	65	SN72560P	4 50
CA3018	1 60	MFC9020	1.15	SN727410N	.85
CA3018A	1 60	MR995A	1 05	SN72741C	45
CA3026	2 15	MSC9967P	1 50	SN72748P	49
CA3035	2 45	N5558	55	UA703C	95
CA3039	1 35	N8598B	5 00	UA709C	40
CA3058	1 90	NE555V	45	USF7733393	2 40
CK707P	45	PA771131	45	995879	6 50
C5134J	1 15	PL994551	45	996079	12 50
C5135J	1 20	RC14370B	35	998979	9 00
C5136	1 25	SC9962P	70	936-5D	1 10
IC3(GE)	1 50	SC9966P	1 25	9313DC	1 20
LM301AN	35	SN15830N	50	93L28DC	2 75

POSITIVE VOLTAGE REGULATORS

LM340K-5	1 95
LM340K-6	1 95
LM340K-8	1 95
LM340K-12	1 95
LM340K-15	1 95
LM340K-18	1 95
LM340K-24	1 95
LM340T0-5	1 75
LM340T0-6	1 75
LM340T0-8	1 75
LM340T0-12	1 75
LM340T0-15	1 75
LM340T0-18	1 75
LM340T0-24	1 75

NEGATIVE REGULATORS AVAILABLE

IC's ON THE MOVE

BBD BUCKET BRIGADE DEVICE
MM3001 19 50 MN3002 11 70 MM3003 9.45
HALL IC DN834 1 25 DN837 1.50
DN835 1 35 DN838(NEW)
SN76001 1 75 SN76002 1 95
PLL02A MIDLAND PHASE LOCK LOOP 12 00

MICROPROCESSOR CHIPS

1404A	3 25	2102	2 50	MM5013	3 25
C1702A	19 95	C2708	95 00	8008	19.95
2101	6 95	C4702A	19 95	8080A	29.95

MK4200 P-11 4096x1 Bit Dymanic Ram 9.95
C5101-3 1024 Bit (256x4) Static C-Mos Ram 4.50
MC14514 4 Bit Latch 4 to 16 Line Decoder 4.25

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SPEC'S AVAILABLE

ELECTROLYTIC CAPACITORS

2 2MF50	AXIAL LEADS	15
3 3MF10	AXIAL LEADS	.15
3 3MF10	NO POLARITY	15
10MF25	AXIAL LEADS	15
10MF50	AXIAL LEADS	15
10MF150	AXIAL LEADS	20
25MF35	AXIAL LEADS	15
30MF25	AXIAL LEADS	15
47MF25	RADIAL LEADS	15
47MF50	RADIAL LEADS	20
100MF16	RADIAL LEADS	15
100MF25	RADIAL LEADS	20
500MF50	AXIAL LEADS	.60
1000MF35	AXIAL LEADS	65

CARBON RESISTORS

Minimum 5 Pcs Per Value

QUANTITY PRICING	5-25	30-95	100-495
¼w5%	06	05	04
½w5%	.08	07	06

STANDARD RESISTANCE VALUES
OHMS

10	270	820	4 7K	27K
22	300	910	5 1K	33K
47	330	1 0K	6 8K	47K
51	470	1 5K	7 5K	100K
100	510	2 2K	8 2K	330K
150	560	2 7K	10K	1 0M
220	680	3 3K	15K	
240	750	3 9K	22K	

HOBBY SPECIALS

YOU TEST 'EM $AVE BIG MONEY

Power Pac	100 Asst (includes Case T03. T066 T0220. T0202)	$2 99
Transistor/ Diode Pac	100 Asst (includes Case T05. T039. T018. D07. 0041)	$1.99
I C Pac	100 Asst (includes 14 & 16 Pin)	$3 50
Resistor Pac	50 Asst (Assorted values)	$1.50
Mos Fet Pac	10 Asst (many top #'s Case T072)	$0 99
SCR Pac	100 Asst (similar to C103 Series) Case to 92. VR 10-100V. I 400MA IGT 200MA	$4.00

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GREATER THAN 33V CALL FOR PRICING

PACE/PATHCOM PART #'S

130079	4 00	IP20-0123	2 75
1300821	.65	IP20-0131	2 50
13-0122	1 75	IP20-0141	3 00
83-0005	2 00	IP20-0142	3.00
83-0007	2 50	IP20-0139	.43
83-0008	2 00	IP20-0154	6 00
83-0015	3 00	IP20-0155	2.50
IP20-0005	3 00	IP20-0161	4.00
IP20-0016	40	IP20-0177	2 75
IP20-0034	.85	IP20-0176	2.85
IP20-0037	.85	IP20-0191	.72
IP20-0045	2.00		
IP20-0073	2.75		
IP20-0093	2.50		

JAPANESE TRANSISTORS ★ CB. AUDIO. INDUSTRIAL

2SA52	60	2SC206	1 00	2SC774	1 75	2SC1173	95	2SD77	1 00
2SA316	75	2SC240	1 10	2SC775	2 75	2SC1175	65	2SD81	3 25
2SA473	75	2SC291	65	2SC776	3 00	2SC1209	55	2SD88	1 50
2SA483	1 95	2SC292	3.00	2SC777	4 00	2SC1213	75	2SD118	3 25
2SA489	80	2SC320	75	2SC778	4 00	2SC1226A	1 25	2SD130	1 25
2SA490	70	2SC352	75	2SC781	3 00	2SC1237	4 50	2SD141	2 25
2SA505	70	2SC353	75	2SC783	1 00	2SC1239	4 00	2SD151	2 25
2SA564	50	2SC371	70	2SC784	70	2SC1243	1 50	2SD170	2 00
2SA628	65	2SC372	70	2SC785	1.00	2SC1293	.85	2SD180	2 75
2SA643	85	2SC394	70	2SC789	1.00	2SC1306	4.75	2SD201	1 95
2SA647	2 75	2SC458	70	2SC793	2 50	2SC1307	5 75	2SD218	4 75
2SA673	85	2SC460	70	2SC796	3.15	2SC1308	4.75	2SD235	1 00
2SA679	3 75	2SC478	80	2SC797	2 50	2SC1317	60	2SD300	2 50
2SA682	85	2SC481	1 85	2SC798	3 10	2SC1318	.70	2SD313	1 10
2SA699	1 30	2SC482	1 75	2SC799	4 25	2SC1325	4 95	2SD315	75
2SA699A	1 45	2SC491	2 50	2SC802	3 75	2SC1327	70	2SD316	2 50
2SA705	55	2SC495	1 10	2SC803	4 00	2SC1338	1 75	2SD317	1 25
2SA815	85	2SC497	1 60	2SC815	75	2SC1346	80	2SD318	95
2SA816	.85	2SC502	1 50	2SC828	75	2SC1347	80	2SD325	1.25
		2SC515	80	2SC829	75	2SC1364	1 50	2SD341	95
2SB22	.65	2SC517	4 25	2SC830	1 60	2SC1377	5.50	2SD350	3 25
2SB54	70	2SC535	.75	2SC838	70	2SC1383	75	2SD352	80
2SB56	70	2SC536	.65	2SC839	.85	2SC1384	.85	2SD380	5 70
2SB77	70	2SC537	.70	2SC922	55	2SC1409	1 25	2SD389	75
2SB128	2.25	2SC563	2.50	2SC929	70	2SC1410	1.25	2SD390	75
2SB152	4 50	2SC607	1.25	2SC930	.65	2SC1447	1.25		
2SB173	55	2SC614	3.80	2SC938	.65	2SC1448	1 25	2SF8	3.00
2SB175	55	2SC615	3 90	2SC943	1.50	2SC1449	1.30	2SCF8	3 50
2SB178	1 00	2SC616	4.15	2SC945	.65	2SC1475	1.50	2SCF6	1.25
2SB186	60	2SC617	4.25	2SC959	3.15	2SC1507	1.25	HEPS3001	3.25
2SB187	60	2SC620	.80	2SC960	2.75	2SC1509	1.25	JSP7001	75
2SB235	7.00	2SC627	1.75	2SC984	1 50	2SC1569	1.25	MRF8004	3.00
2SB303	.65	2SC642	3.50	2SC996	4.90	2SC1674	1.75	MPS8000	1.25
2SB324	1 00	2SC643	3.75	2SC1010	.80	2SC1675	1.75	MPS8001	1.25
2SB337	2 10	2SC644	70	2SC1012	.80	2SC1678	5.50	MPSU02	50
2SB367	1.60	2SC681	2.50	2SC1013	1 50	2SC1679	4.75	MPSU31	4.00
2SB370	.65	2SC684	2.10	2SC1014	1.50	2SC1756	1.25	SK3047	3.75
2SB405	.85	2SC687	2.50	2SC1017	1.50	2SC1760	2.15	SK3048	3.25
2SB407	1.65	2SC696	3.00	2SC1018	1.50	2SC1816	4.50	SK3049	4.75
2SB415	.85	2SC699	4.75	2SC1030	4.75	2SC1908	.70	SK3054	1.25
2SB461	1.25	2SC710	.70	2SC1051	2.50	2SC1909	4.75	2SK19	1 75
2SB463	1.65	2SC711	.70	2SC1060	.75	2SC1957	1.50	2SK30	1.00
2SB471	1.75	2SC712	.70	2SC1061	1.65	2SC1973	1.50	2SK33	1.20
2SB474	1 50	2SC713	.70	2SC1069	3.50	2SC1974	4.90	2SK41	1.75
2SB476	1.25	2SC731	3.00	2SC1079	3.75	2SC1975	4.90	3SK22Y	2.75
2SB481	2.10	2SC732	.70	2SC1080	3.75	2SC2028	1.10	3SK40	2.75
2SB492	1.25	2SC733	.70	2SC1096	1.20	2SC2029	4.75	3SK45	2.75
2SB495	.95	2SC735	.70	2SC1098	1.15	2SC2074	3.00	3SK49	2.75
2SB507	90	2SC739	.70	2SC1115	2.75			4004	3.00
2SB511	.70	2SC715	.70	2SC1166	.70	2SD45	2.00	4005	3.00
2SB531	3.00	2SC756	3.00	2SC1167	4.25	2SD65	.75	40080	1.25
2SB556	3.50	2SC762	1.90	2SC1170	4.00	2SD68	.90	40081	1.50
2SB135	.95	2SC773	.85	2SC1172B	4.25	2SD72	1.00	40082	3.00

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POPULAR JEDEC SEMICONDUCTORS

1N34	25	2N918	60	2N2218	.25	2N2906A	.30	2N3646	.14	2N4220A	.45
1N60	25	2N930	25	2N2218A	30	2N2907	.25	2N3730	2.50	2N4234	.95
1N270	40	2N956	30	2N2219	.25	2N2907A	.30	2N3731	3 75	2N4400	.18
1N914	10	2N960	.90	2N2219A	30	2N2913	75	2N3740	1.00	2N4401	.16
		2N962	95	2N2221	.25	2N2914	1 20	2N3771	1.75	2N4402	.16
2N173	1.75	2N967	95	2N2221A	.30	2N2916A	3.65	2N3772	1.90	2N4403	.20
2N174	3 50	2N1136	1.75	2N2222	.25	2N3019	50	2N3773	3.00	2N4409	.18
2N178	.90	2N1142	2 25	2N2222A	.30	2N3053	.30	2N3819	40	2N4410	.16
2N327A	1.15	2N1300	1 00	2N2223	1.00	2N3054	.70	2N3823	.70	2N4416	.75
2N334	1.20	2N1301	1 10	2N2270	.40	2N3055	.75	2N3856	.20	2N5061	.30
2N336	90	2N1302	1.25	2N2323	1.00	2N3227	1.00	2N3866	.85	2N5064	.50
2N338A	1.05	2N1303	70	2N2324	1.35	2N3247	3.40	2N3903	.16	2N5130	.20
2N398B	1.50	2N1304	1.25	2N2325	2.00	2N3250	.50	2N3904	.16	2N5133	.15
2N404	75	2N1305	75	2N2326	2.85	2N3375	6.50	2N3905	.16	2N5138	.15
2N443	2.50	2N1306	1 35	2N2327	3.80	2N3393	.20	2N3906	.16	2N5198	3.75
2N456	1 30	2N1307	75	2N2328	4.25	2N3394	.17	2N3925	3.75	2N5294	.50
2N501A	3.00	2N1308	1.50	2N2329	4.75	2N3414	.17	2N3954	3.50	2N5296	.50
2N508A	45	2N1309	.90	2N2368	.25	2N3415	.18	2N3954A	3.75	2N5306	.20
2N555	.75	2N1552	3 25	2N2369	.25	2N3416	.19	2N3955	2.45	2N5354	.20
2N652A	1.25	2N1554	1 25	2N2484	.32	2N3417	.20	2N3957	1.25	2N5369	.20
2N677	6.00	2N1557	1 15	2N2712	.18	2N3442	1.85	2N4036	.75	2N5400	.40
2N706	.25	2N1560	2 80	2N2894	.40	2N3553	1.50	2N4037	.80	2N5401	.50
2N706B	.75	2N1605	.35	2N2903	3.30	2N3563	.20	2N4093	.85	2N5457	.35
2N711	.90	2N1613	.30	2N2904	.25	2N3565	.20	2N4124	.16	2N5458	.30
2N711B	1 10	2N1711	.30	2N2904A	.30	2N3638	.20	2N4126	.16	CIO3Y	.25
2N718	.25	2N1907	4.10	2N2905	.25	2N3642	.20	2N4141	.20	C106B1	.50
2N718A	.30	2N2060	1.85	2N2905A	.30	2N3643	.20	2N4142	.20		
2N720A	50	2N2102	.40	2N2906	.25	2N3645	.20	2N4143	.20		

SILICON UNIJUNCTIONS

2N2160	.65	MU4892	.50
2N2646	.45	MU4893	.50
2N2647	.55	MU4894	50
2N4851	.75	2N6027	55
2N4852	.75	2N6028	.70
2N4870	.50	D5E37	.35
2N4871	.50	MU10	35
MU4891	.50	MU20	.40

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Four stage, 720° shifter. Wide-range speed control, plus depth and volume. Voltage regulator aids battery life.

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Plugs between guitar and amp to give concert hall effects. Springs not included but are readily available.

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The best looking, most complete kit on the market! Features include, time set pushbuttons, jumbo .4" readouts, Polaroid lens filter, line cord transformer, super quality PC boards and durable extruded aluminum case available in five different colors. All parts are included, there are no extras needed! Super instructions reduce assembly time to 1-2 hours. Fully guaranteed. Colors available: gold, silver, bronze, blue and black (specify).

Clock Kit, DC-5	$22.95
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Assembled & tested version add $10 to kit price.

VIDEO TERMINAL KIT $149.95

A compact 5 x 10-inch PC card that requires only an ASCII keyboard and a TV set to become a complete interactive terminal for connection to your microprocessor asynchronous interface. Its many features are: single 5-volt supply, crystal controlled sync and baud rates (up to 9600 baud), 2 pages of 32 characters by 16 lines, read to and from memory, computer and keyboard-operated cursor and page control, parity error display and control, power-on initialization, full 64-character ASCII display, block-type see-thru cursor. Keyboard/computer control backspaces, forward spaces, line feeds, rev. line feeds, home, returns cursor. Also clears page, clears to end of line, selects page 1 or 2, reads from or to memory. The card requires 5 volts at approx. 900 ma and outputs standard 75 ohm composite video.

TH3216 Kit	$149.95
TH3216, Assembled and Tested	$239.95
VD-1, Video to RF Modulator Kit	$ 6.95

CAR CLOCK KIT 6-Digit 12/24 HR.

- High Accuracy (1 Min./Month)
- Big .4" high readout
- Special circuit suppresses all spikes and transients
- Same case as DC-5 above
- Displays blanks with ignition

Complete Kit, DC-7 $25.95

Assembled & tested version add $10 to kit price.

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Has every feature one could ever ask for. Kit includes all parts except case, build it into wall, station or even car! Uses the incredible 7001 chip. Features:

- 6-digit .5" high
- Calendar shows mo./day
- 24-Hour alarm with snooze
- 12- or 24-Hr. Format
- Battery backup with on-chip time base

Complete Kit, less case, DC-9 $34.95

CAR CLOCK KIT $27.95

12/24-Hour 12-Volt AC or DC

- High Accuracy (1 minute/month)
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- Easy, no-polarity hookup
- Display blanks with ignition
- Case, mounting bracket included
- Super instructions

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Complete Kit, TD-1 $4.95

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Complete Kit, BL-1 $2.95

SUPER-SNOOP AMPLIFIER

A super-sensitive amplifier which will pick up a pin drop at 15 feet! Great for monitoring baby's room or as a general purpose test amplifier. Full 2 watts of output, runs on 6 to 12 volts, uses any type of mike. Requires 8-45 ohm speaker.

Complete Kit, BN-9 $4.95

MUSIC LIGHTS KIT

See music come alive! 3 different lights flicker with music or voice. One light for lows, one for the mid-range and one for the highs. Each channel individually adjustable, and drives up to 300 watts. Great for parties, band music, nite clubs and more.

Complete Kit, ML-1 $7.95

SIREN KIT

Produces upward and downward wail characteristic of police siren. 200mw audio output, runs on 3-9 volts, uses 8-45 ohm speaker.

Complete Kit, SM-3 $2.95

CODE OSCILLATOR KIT

Powerful 1 watt audio oscillator of approx. 1 kHz, good for many uses. Great for warning alarm, battery checker, voltage indicator and code oscillator.

Complete Kit, CPO-1 $2.50

POWER SUPPLY KIT

Complete triple regulated power supply provides variable ±15 volts at 200ma and +5 volts at 1 amp. 50mv load regulation good filtering and small size. Kit less transformers. Requires 6-8V at 1 amp and 18 to 30VCT.

Complete Kit, PS-3LT $6.95

DECADE COUNTER PARTS KIT

Includes: 7490A 33 MHz counter, 7475 latch, 7447 LED driver, LED readout, current limit resistors, hook up details and instructions on how to build an easy low cost freq. counter.

Kit of Parts, DCU-1 $3.50

600 mHz Prescaler $59.95

Fully assembled and tested.
Extend the range of your counter to 10 times higher in frequency. Works with any counter. High sensitivity input with built-in on-chip pre-amp.

PS-1B, 10 $59.95

741 OP-AMP
Factory prime mini-dip. House marked
10 for $2.00

NATIONAL

MA-1003A CAR CLOCK MODULE	$23.95
MA-1002A ALARM CLOCK MODULE	$12.95
Includes transformer and switches	
Auto dimmer photocell for use with 1002	$ .75

LINEAR		REGULATOR		TRANSISTORS	
555	.50	309K	.99	NPN 2N3904 type	10/$1.00
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567	1.75	340K-12	.99	NPN Power Tab 40W	3/$1.00
1458	.65	7805	.99	PNP Power Tab 40W	3/$1.00
LED DRIVER		7812	.99	FET MPF-102 type	3/$2.00
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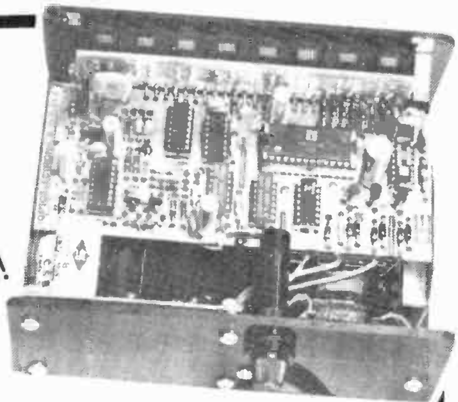
CIRCLE NO. 48 ON FREE INFORMATION CARD

NEW LSI TECHNOLOGY

FREQUENCY COUNTER



TAKE ADVANTAGE OF THIS NEW STATE-OF-THE-ART COUNTER FEATURING THE MANY BENEFITS OF CUSTOM LSI CIRCUITRY. THIS NEW TECHNOLOGY APPROACH TO INSTRUMENTATION YIELDS ENHANCED PERFORMANCE, SMALLER PHYSICAL SIZE, DRASTICALLY REDUCED POWER CONSUMPTION [PORTABLE BATTERY OPERATION IS NOW PRACTICAL], DEPENDABILITY, EASY ASSEMBLY AND REVOLUTIONARY LOWER PRICING!

.4" DIGITS!

SIZE:
3" High
6" Wide
5½" Deep

1¾ LBS.
COLOR: BLACK

FACTORY DIRECT PRICES

KIT #FC-50C	60 MHZ	COUNTER WITH CABINET & P.S.	$99.85
KIT #PSL-350	350 MHZ	PRESCALER [NOT SHOWN]	23.95
KIT #PSL-650	650 MHZ	PRESCALER [NOT SHOWN]	29.95
MODEL #FC-50WT	60 MHZ	COUNTER WIRED, TESTED & CAL.	165.95
MODEL #FC-50/600 WT	600 MHZ	COUNTER WIRED, TESTED & CAL.	199.95

KIT #FC-50C IS COMPLETE WITH PREDRILLED CHASSIS ALL HARDWARE AND STEP-BY-STEP INSTRUCTIONS. WIRED & TESTED UNITS ARE CALIBRATED AND GUARANTEED. PRESCALERS WILL FIT INSIDE COUNTER CABINET.

FEATURES AND SPECIFICATIONS:

DISPLAY: 8 RED LED DIGITS .4" CHARACTER HEIGHT
GATE TIMES: 1 SECOND AND 1/10 SECOND [AUTO DEC. PT. PLACEMENT]
RESOLUTION: 1 HZ AT 1 SECOND, 10 HZ AT 1/10 SECOND.
FREQUENCY RANGE: 10 HZ TO 60 MHZ [65 MHZ TYPICAL]
SENSITIVITY: 10 MV RMS TO 50 MHZ, 20 MV RMS TO 60 MHZ TYP
INPUT IMPEDANCE: 1 MEGOHM AND 20 PF [DIODE PROTECTED INPUT FOR OVER VOLTAGE PROTECTION]
ACCURACY: ± 1 PPM [± .0001%] AFTER CALIBRATION TYPICAL
STABILITY: WITHIN 1 PPM PER HOUR AFTER WARM UP [.001% XTAL
IC PACKAGE COUNT: 8 [ALL SOCKETED]
INTERNAL POWER SUPPLY: 5.2 V DC AT 800 MA REGULATED
INPUT POWER REQUIRED: 8-12 VDC OR 115 VAC AT 50/60 HZ.
POWER CONSUMPTION: 4 WATTS
INPUT CONNECTOR: BNC TYPE

PLEXIGLAS CABINETS

Great for Clocks or any LED Digital project. Clear-Red Chassis serves as Bezel to increase contrast of digital displays.

CABINET I 3"H, 6¼"W, 5½"D
CABINET II 2½"H, 5"W, 4"D

Black, White or Clear Cover
$6.50 ea

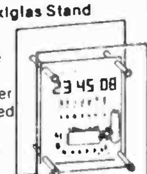
RED OR GREY PLEXIGLAS FOR DIGITAL BEZELS 3"x6"x1/8" 95¢ ea 4/$3

SEE THE WORKS Clock Kit
Clear Plexiglas Stand

- 6 Big .4" digits
- 12 or 24 hr. time
- 3 set switches
- Plug transformer
- all parts included

Plexiglas is Pre-cut & drilled

Kit #850-4 CP



Size: 6"H, 4⅓"W, 3"D

$23.50 ea 2/$45. A SUPER CLOCK!

60 HZ. XTAL TIME BASE

Will enable Digital Clock Kits or Clock-Calendar Kits to operate from 12V DC. 1"x2" PC Board. Power Req. 5-15V (2.5 MA TYP.) Easy 3 wire hookup. Accuracy ± 2PPM

#TB-1 (Adjustable)
Complete Kit $4.95
Wir & Cal $9.95

SPECIAL PRICING!

PRIME - HIGH SPEED RAM

21L02-3 400 NS

LOW POWER - FACTORY FRESH

1-24	$1.95 ea	100-199	$1.60 ea
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OVER 500 PCS. $1.39 ea.

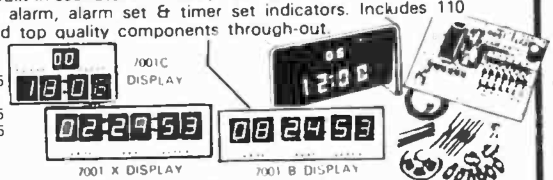
6-DIGIT LED CLOCK CALENDAR KIT

DATE-TIME-SNOOZE ALARM & MORE... KIT 7001

FOR THE BUILDER THAT WANTS THE BEST. FEATURING 12 OR 24 HOUR TIME — 29-30-31 DAY CALENDAR. ALARM, SNOOZE AND AUX. TIMER CIRCUITS

Will alternate time (8 seconds) and date (2 seconds) or may be wired for time or date display only, with other functions on demand. Has built-in oscillator for battery back-up. A loud 24 hour alarm with a repeatable 10 minute snooze alarm, alarm set & timer set indicators. Includes 110 VAC/60Hz power pack with cord and top quality components through-out.

KIT 7001B WITH 6 .5" DIGITS	$39.95
KIT 7001C WITH 4 .6" DIGITS & 2 .3" DIGITS FOR SECONDS	$42.95
KIT 7001X WITH 6 .6" DIGITS	$45.95



KITS ARE COMPLETE (LESS CABINET)
ALL 7001 KITS FIT CABINET I AND ACCEPT QUARTZ CRYSTAL TIME BASE KIT # TB-1

JUMBO DIGIT CLOCK

A complete Kit (less Cabinet) featuring six .5" digits. MM5314 IC 12/24 Hr time. PC Boards. Transformer. Line Cord. Switches and all Parts. Ideal Fit in Cabinet II

Kit #5314-5 $19.95 2/$38.

JUMBO DIGIT CONVERSTION KIT $9.95 ea

Convert small digit LED clock to large .5" displays. Kit includes 6 - LED's. Multiplex PC Board & Hook up info.
Kit #JD-1CC For Common Cathode
Kit #JD-1CA For Common Anode

PRINTED CIRCUIT BOARDS for CT 7001 Kits sold separately with assembly info. PC Boards are drilled Fiberglass, solder plated and screened with component layout.
Specify for 7001 B, C or X - $7.95

MOBILE LED CLOCK

12/24 HR .4" DIGITS!

MODEL #2001

12 VOLT AC or DC POWERED

- 6 JUMBO .4" RED LED'S BEHIND RED FILTER LENS WITH CHROME RIM
- SET TIME FROM FRONT VIA HIDDEN SWITCHES • 12/24-Hr. TIME FORMAT
- STYLISH CHARCOAL GRAY CASE OF MOLDED HIGH TEMP. PLASTIC
- BRIDGE POWER INPUT CIRCUITRY — TWO WIRE NO POLARITY HOOK-UP
- OPTIONAL CONNECTION TO BLANK DISPLAY [Use When Key Off in Car, Etc
- TOP QUALITY PC BOARDS & COMPONENTS - INSTRUCTIONS.
- MOUNTING BRACKET INCLUDED

KIT #2001 COMPLETE KIT [Less 9V. Battery] $29.95 EA. 3 OR MORE $27.95 EA. 115 VAC Power Pack #AC-1 $2.50 EA

ASSEMBLED UNITS WIRED & TESTED ORDER #2001 WT [LESS 9V. BATTERY] $39.95 EA. 3 OR MORE $37.95 EA
Wired for 12-Hr. Op. if not otherwise specified

AUTO BURGLAR ALARM KIT

AN EASY TO ASSEMBLE AND EASY TO INSTALL ALARM PROVIDING MANY FEATURES NOT NORMALLY FOUND. KEYLESS ALARM HAS PROVISION FOR POS. & GROUNDING SWITCHES OR SENSORS. WILL PULSE HORN RELAY AT 1HZ RATE OR DRIVE SIREN. KIT PROVIDES PROGRAMMABLE TIME DELAYS FOR EXIT, ENTRY & ALARM PERIOD. UNIT MOUNTS UNDER DASH. REMOTE SWITCH CAN BE MOUNTED WHERE DESIRED. CMOS RELIABILITY RESISTS FALSE ALARMS & PROVIDES FOR ULTRA DEPENDABLE ALARM. DO NOT BE FOOLED BY LOW PRICES! THIS IS A TOP QUALITY COMPLETE KIT WITH ALL PARTS INCLUDING DETAILED DRAWINGS AND INSTRUCTIONS OR AVAILABLE WIRED AND TESTED

KIT #ALR-1 $9.95
#ALR-1WT WIRED & TESTED $19.95

VARIABLE REGULATED 1 AMP POWER SUPPLY KIT

- VARIABLE FROM 4 to 14V
- SHORT CIRCUIT PROOF
- 723 IC REGULATOR
- 2N3055 PASS TRANSISTOR
- CURRENT LIMITING AT 1 Amp

KIT IS COMPLETE INCLUDING DRILLED & SOLDER PLATED FIBERGLASS PC BOARD AND ALL PARTS (Less TRANSFORMER) KIT #PS-01 $8.95

TRANSFORMER 24V CT will provide 300MA at 12V and 1 Amp at 5V. $3.50

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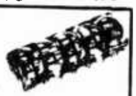
MEMORIES		DIGITAL		LINEAR		SHIFT REGISTERS		LED DISPLAYS	
1101	$.69	7400	$.09	376 mDIP	$.49	2510	$1.95	DL10A	$1.49
1103	.69	7416	.29	739 DIP	.89	2511	1.49	NSN 74R	.99
1702A	5.95	7427	.24	1414 DIP	1.39	2522	1.95	FND 359	.59
2708	24.95	7437	.19	75453 mDIP	.29	5016	1.19	MAN 5	.99
5262	.99	7454	.12	75491 DIP	.59				
74S200	3.25	7493	.39						
7489	1.75	7495	.69						
82S23	2.75	74145	.89						
93410	1.39	9602	.59						
		74C154	2.49						

DISCRETE LEDs

MV10B	6/$1.00
MV50	16/$1.00
MINI RED RL 209	12/$1.00

SPECIAL SALE



HP 5082-SERIES
MAG LENS FITS 14 PIN SOCKET
5 DIGIT RED .11 CC RHD
4 DIGIT RED .11" CC RHD $.57 ea.

10% OFF WITH $25 ORDER
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7404	.16	7464	.35	74157	.99
7405	.19	7465	.35	74158	1.79
7406	.20	7470	.30	74160	1.23
7407	.28	7472	.30	74161	.97
7408	.26	7473	.35	74162	1.39
7409	.19	7474	.28	74163	1.09
7410	.16	7475	.49	74164	.99
7411	.25	7476	.30	74165	.99
7413	.43	7481	.68	74166	1.25
7414	.65	7483	.88	74170	2.10
7416	.35	7486	.40	74173	1.49
7417	.35	7489	2.25	74174	1.23
7420	.16	7490	.43	74175	.97
7422	.30	7491	.75	74176	.89
7423	.29	7492	.48	74177	.84
7425	.27	7493	.48	74180	.90
7426	.26	7494	.78	74181	2.45
7427	.29	7495	.79	74182	.79
7430	.20	7496	.79	74184	1.90
7432	.23	74100	.98	74185	2.20
7437	.25	74105	.44	74187	5.75
7438	.25	74107	.37	74190	1.15
7440	.15	74121	.38	74191	1.25
7441	.89	74122	.38	74192	.95
7442	.59	74123	.65	74193	.85
7443	.73	74125	.54	74194	1.25
7444	.73	74126	.58	74195	.74
7445	.73	74132	.89	74196	1.25
7446	.81	74141	1.04	74197	.73
7447	.79	74145	1.04	74198	1.73
7448	.79	74150	.97	74199	1.69
7450	.17	74151	.79	74200	5.45

IC SOCKETS

Solder Tail - low profile

8 pin	$.17	24 pin	.42
14 pin	.20	28 pin	.59
16 pin	.22	40 pin	.69
18 pin	.29		

WIRE WRAP - gold plate
14 pin .49

LINEAR CIRCUITS

300	$.71	373	2.42	723	.62
301	.29	376	.68	733	.89
302	.53	380	1.30	739	1.07
304	.80	380-8	1.25	741	.32
305	.71	381	1.75	747	.71
307	.26	382	1.75	748	.35
308	.89	531	2.95	1458	.62
309k	1.35	540	2.95	1800	2.48
310	1.07	550	.79	3900	.49
311	.95	555	.45	7524	.71
319	1.13	556A	1.19	7525	.90
320T	1.39	560	3.39	8038	4.25
320k	1.39	562	3.39	8864	2.25
322	1.70	565	1.18	75150	1.75
324	1.52	566	1.95	75451	.35
339	1.58	567	1.95	75452	.35
340k	1.69	709	.26	75453	.35
340T	1.49	710	.35	75491	.71
372	2.91	711	.26	75492	.80

Date sheets on request. Add 30¢ each if item is priced below $1.00 each.

LED DISPLAYS

		EA.
DL10A	RED CA .27" LHD	$1.89
DL 707	RED CA .30" RHD	1.49
DL 507	RED CA .50" RHD	1.49
FND 359	RED CC .375" RHD	.89
DL 702	RED CC .30" LHD	1.39
NSN 74R	RED CC .30" RHD	1.49
DL 500	RED CC .50" RHD	1.49
MAN3	GREEN CA .27" LHD	1.39
MAN8	YELLOW CA .27" LHD	1.39
MAN82	YELLOW CA .3" LHD	1.89
MAN66	RED CA .6" LHD	2.19
DL747	RED CA .6" LHD	2.39
MAN2	Red 5x7 dot matrix .35"	3.95

DISCRETE LED's

		EACH
ME4	INFRARED CLEAR DOME .170"	.29
MV10B	CLEAR DOME .170"	.25
MV50	CLEAR AXIAL .09"	.12
MV50	RED — AXIAL .09"	.12
NSL100	RED .19"	.12
RL209	RED DIFF SUBMINIATURE .12"	.12
RLT-T1-03	WHITE DIFF. SUBMINIATURE NO FLANGE .124"	.15
RLC-200	RED DIFF. CURRENT REG. .190" CONST BRIGHTNESS 4.5-12.5V	.25
RLC-201	RED DIFF. CURRENT REG. CONST. BRIGHTNESS 4.5- .190"	.25
RL-4403	RED DIFF. FULL FLOOD .190"	.15
GREEN	SPOT .190"	.18
CLEAR	POINT .190"	.15

MULTIPLE DISPLAYS

		EA.
NSN 33	3 DIGIT RED .12" CC FITS 14 PIN SOCKET	$ .99
DL 33 B	3 DIGIT RED .12" CC MAG. LENS FITS 14 PIN SOCKET	.99
DL 33 B—	SAME AS DL33B EXCEPT — & 2 DIGITS	.59

SHIFT REGISTERS

		EACH
2502	1024 bit MULT DYN 16 pin	$2.95
2504	1024 bit MULT DYN 8 pin	2.95
2511	Tri-State Dual 50-100-200 bit STATIC 14 pin	2.95
2518	Hex 32-bit STATIC 16 pin	2.95
2519	Hex 40-bit STATIC 16 pin	2.95
2527	Dual 256 bit STATIC 8 pin	2.95
2532	Quad 80 bit STATIC 16 pin	3.95
5013	1024 bit accum. Dynamic 8 pin	1.75
5016	500/512 bit Dynamic 8 pin	1.59

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CENTRAL PROCESSING UNIT
8008 $16.95
8080A $19.95

2102 $1.49
1024X1 STATIC RAM 16 PIN

74S200 $3.25
256 BIT RAM TRI-STATE

1458 $.39
DUAL OP AMP

UART $6.95
AY51013A

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372	AF-IF Strip Detector DIP	2.93
546	AM Radio Receiver Subsystem DIP	.75
1310	FM Stereo Demodulator DIP	2.90
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1800	Stereo multiplexer DIP	2.48
ULN2208	FM Gain Block 34db (typ) mDIP	1.18
ULN2209	FM Gain Block 48db (typ) mDIP	1.35
2513	Character Generator 64x8x5 DIP-24	10.20
3046	Transistor Array DIP-14	.73

MM 5330 $6.95
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QUAD BI-LATERAL SWITCH

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2V. RED L.E.D., Pkg. of 5, PL-233	1.99	.59
40 Min. 8-Track Tape, TA-907	.69	.39
Elect. Cap. Kit, 50 Asst., CD-407	5.00	1.70
CB Converter for Car, CB-417	14.99	9.99
Resistors ½-1 watt, Pkg. 100, RR-077	1.79	.79
Volume Controls, 12 Asstd. VC-274	1.00	.49
Empire 999 Mag. Phono Cart. PC-188	9.99	6.99
3-6V DC Hobby Motors, 5 Asstd. MO-333	2.00	.59
Solder Terminal Strips, 40 Asstd. XM-501	1.30	.50
Double Face Foam Tape ¾"x52", TA-903	1.00	.80
Tape Mailers. 3" Pkg. 5, TA-936	.79	.39
Ceramic Disc Cap., 100 Asstd. CC-210	1.29	.80
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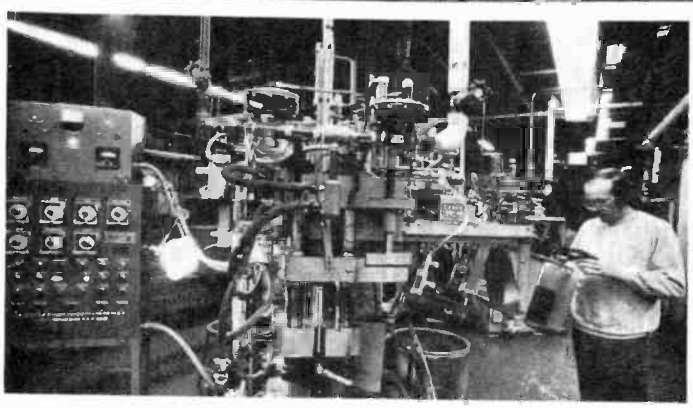

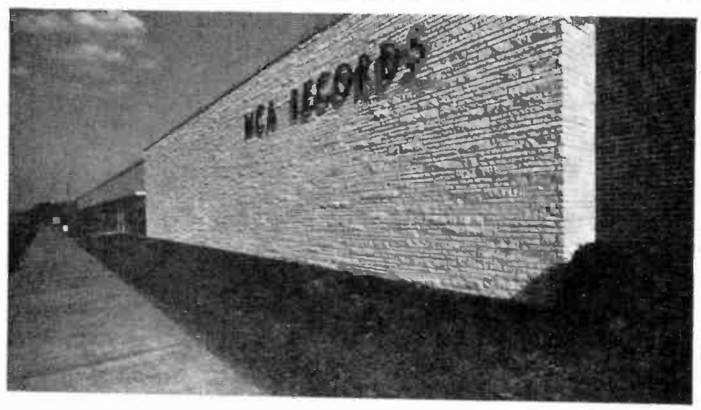

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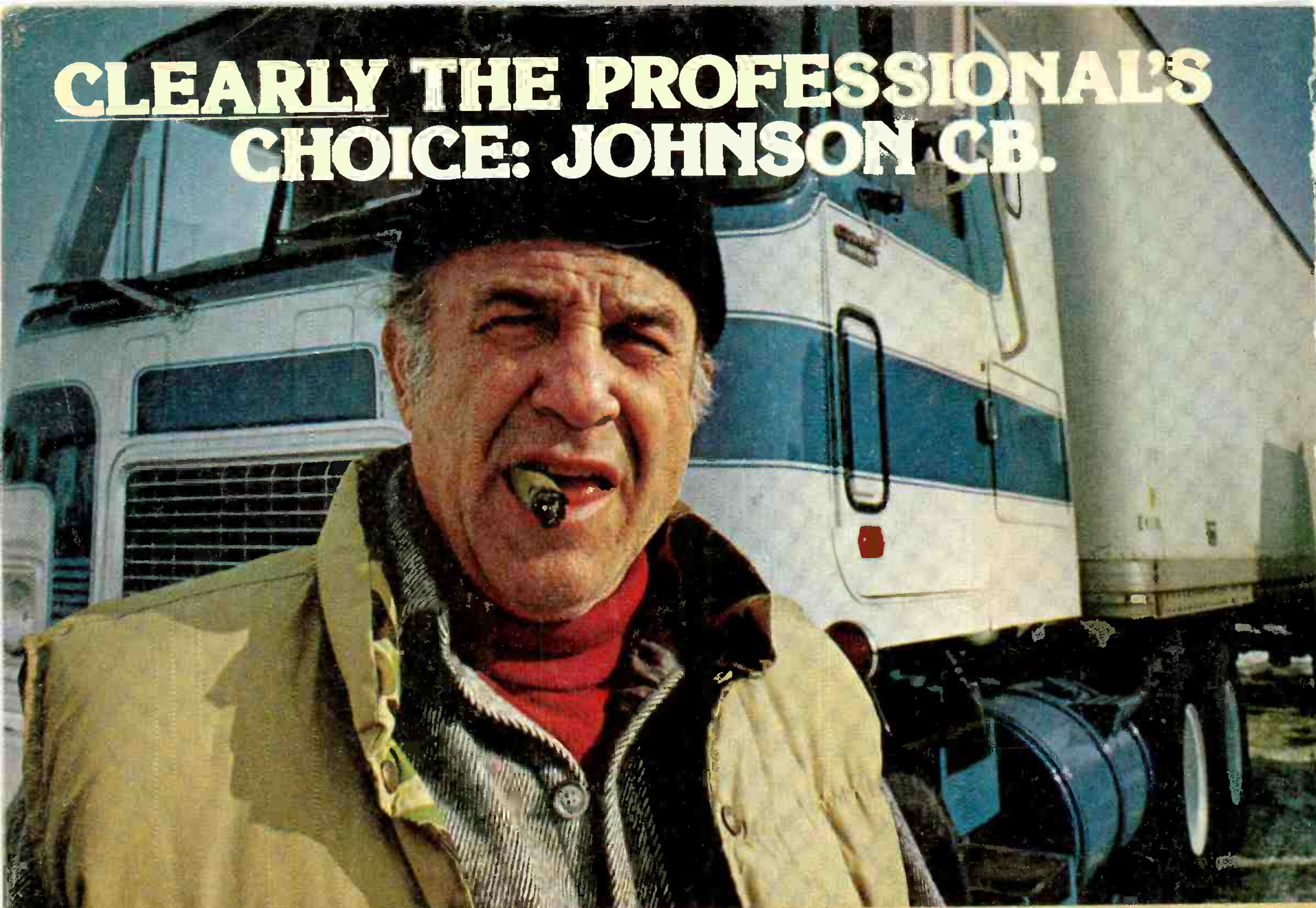

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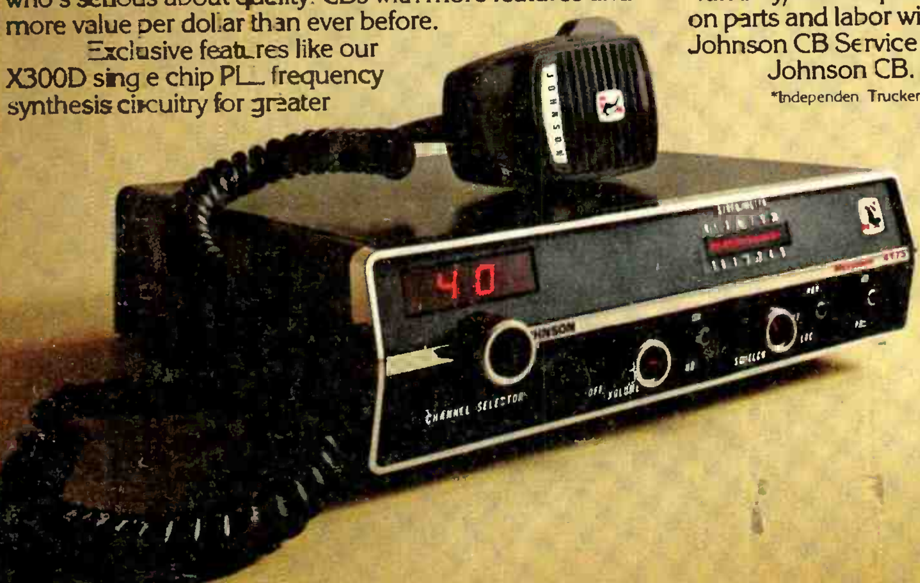

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