PROJECTS, COMPUTERS, HI-FI, CB, TV

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Radio-Electronics

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

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YOU CAN USE THEM

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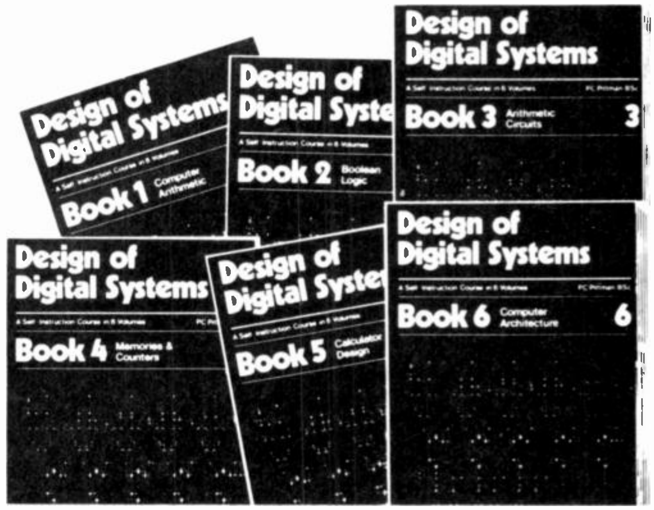
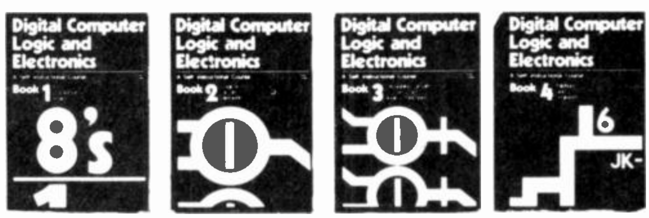


Design of Digital Systems is written for the engineer seeking to learn more about digital electronics. Its six volumes — each 11-1/2" x 8-1/4" are packed with information, diagrams and questions designed to lead you step-by-step through number systems and Boolean algebra to memories, counters and simple arithmetic circuits, and finally to a complete understanding of the design and operation of calculators and computers.

The contents of Design of Digital Systems include:

Book 1 Octal, hexadecimal and binary number systems; conversion between number systems; representation of negative numbers; complementary systems; binary multiplication and division.
Book 2 OR and AND functions; logic gates; NOT, exclusive-OR, NAND, NOR and exclusive-NOR functions; multiple input gates; truth tables; De Morgans Laws; canonical forms; logic conventions; Karnaugh mapping; three-state and wired logic.
Book 3 Half adders and full adders; subtractors; serial and parallel adders; processors and arithmetic logic units (ALUs); multiplication and division systems.
Book 4 Flip flops; shift registers; asynchronous and synchronous counters; ring, Johnson and exclusive-OR feedback counters; random access memories (RAMs) and read only memories (ROMs).
Book 5 Structure of calculators; keyboard encoding; decoding display data; register systems; control unit; program ROM; address decoding; instruction sets; instruction decoding; control program structure.
Book 6 Central processing unit (CPU); memory organization; character representation; program storage; address modes; input/output systems; program interrupts; interrupt priorities; programming; assemblers; computers; executive programs; operating systems and time sharing.



Digital Computer Logic and Electronics is designed for the beginner. No mathematical knowledge other than simple arithmetic is assumed, though the student should have an aptitude for logical thought. It consists of four volumes — each 11-1/2" x 8-1/4" — and serves as an introduction to the subject of digital electronics. Everyone can learn from it — designer, executive, scientist, student, engineer.

Contents include: Binary, octal and decimal number systems; conversion between number systems; AND, OR, NOR and NAND gates and inverters; Boolean algebra and truth tables; De Morgans Laws; design of logic circuits using NOR gates; R-S and J-K flip flops; binary counters, shift registers and half adders.

In the years ahead the products of digital electronics technology will play an important part in your life. Calculators and digital watches are already commonplace. Tomorrow a digital display could show your automobile speed and gas consumption; you could be calling people by entering their name into a telephone which would automatically look up their number and dial it for you.

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SEPTEMBER 1977 Vol. 48 No. 9

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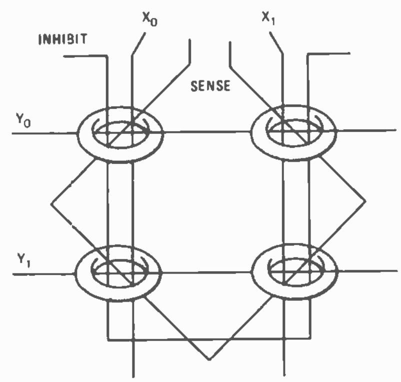

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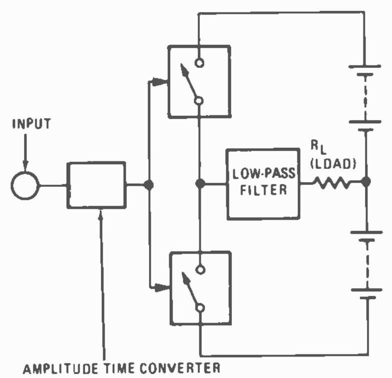

PULSE-WIDTH MODULATION amplifier looks like this. To find out how it works see page 59

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Subscription Service: Mail all subscription orders, changes, correspondence and Postmaster Notices of undelivered copies (Form 3579) to Radio-Electronics Subscription Service, Box 2520, Boulder, CO 80322

looking ahead

Picture IC? It's only a matter of time and effort—not technological breakthrough—before a thin-film transistorized color TV panel will be able to do the work of today's bulky picture tube. That's the opinion of Dr. T.P. Brody, head of a research team on electroluminescent displays at Westinghouse Research Laboratories in Pittsburgh. Dr. Brody's team already has demonstrated a thin-film panel ⅛-inch thick that can display a monochrome picture in real time, with no visible smear and with grey-scale rendition.

The panel was originally designed for alphanumeric display, but its grey-scale capability convinced the team to explore its TV possibilities. As Westinghouse describes it, the current panel is actually a giant integrated circuit measuring six inches square. It has 12,000 glowing picture elements in a 110 × 110-element format. These elements themselves are phosphor dots that light up when electricity passes through them. The matrix of dots is produced by vacuum-depositing thousands of tiny interlocked thin-film circuits onto a glass substrate, coating the circuits with a phosphor film and sealing the "sandwich" with a glass cover-plate. Each element consists of two thin-film transistors, a storage capacitor and a phosphor overlay. The transistorized matrix permits separate elements to be energized without activating others in the same row or column.

Although the current panel has low resolution, the research team is now working on a 262-line display designed especially for television experimentation. Remaining work, in addition to improving resolution, will be developing thin-film driver circuitry, developing color capability and removing blemishes. Color phosphors are already available, but Dr. Brody says development of a color panel will take "several more years of concentrated effort."

Star is born: It looks like the biggest new-product launching since color TV. Fifteen entries are at the starting gate for the all-industry debut of the home video recorder this fall. Although Sony has been offering its *Betamax* for about two years, and Quasar has been shipping its *Great Time Machine* in quantity for some six months, the big push is about to start, with 15 different brand names on three different types of Japanese videocassette recorders.

The latest to announce are Magnavox and Sylvania, both choosing the Matsushita-made VHS, which gets up to four hours recording onto a single cassette of half-inch tape. This is the same system adopted by RCA and Panasonic, and has partial compatibility with versions to be offered by JVC, Hitachi, MGA and Sharp. The latter machines provide two-hour capability on the same cassette, while the former have a 2/4-hour switch for full-speed or half-speed recording. *Betamax*-compatible VTRs, all providing 2-hour recording on a single cassette, will be offered by Sony, Zenith, Sanyo, Toshiba, Pioneer and Aiwa. Quasar will continue to offer its *Great Time Machine,* which is not compatible with the other two standards.

Sales are expected to be limited by supply for the rest of this year and at least a part of next. RCA estimates that the American public will buy about 250,000 units of all makes in 1977 and 750,000 next year. The going price is expected to remain at the $1000-and-up level until the shortage is over and competition erodes pricing.

Accessories: The videocassette recorder is a television accessory that costs more than the TV set. But the VTR is going to have its own accessories that will cost more than the recorder. JVC has already introduced what it calls the first home color TV camera. As a home product, it's priced at a rather steep $1500 and up. That's a bargain as color cameras go, the lowest-priced unit ever introduced. It uses a single vidicon tube, has a built-in microphone, and the $1500 version has an optical viewfinder and 25-mm lens, along with a control unit, that provides automatic color correction for a variety of light conditions. Higher-priced versions will be available with electronic viewfinders and zoom lenses. But that's not all—even the accessory has an accessory. JVC will offer a "telecine attachment," which converts the camera into a film or slide scanner to permit users to transfer their own home movies or slides onto videocassettes. It's a prism arrangement that uses any projector and the JVC camera to make a film scanner; it's expected to cost around $100.

And another accessory: Sony has confirmed our report of last month that it will offer a black box to convert its *Betamax* video recorder into—of all things—an audio recorder. But it undoubtedly will be the best audio recorder you ever heard, using pulse code modulation (PCM) with practically no distortion, zero crosstalk, zero wow and flutter, and virtually uniform audio frequency response. It's scheduled to be available here in about a year at approximately $1300—about the same price as *Betamax* itself.

Cassette games: Most programmable video games announced to date have used ROM's for programming. Now there's a discernible trend toward a switch to audio cassettes. Cassette-programmed video game/computer systems already have been introduced by Microelectronics Corp. and a few others. General Instrument and EMI of England have announced the most comprehensive cassette-program plans to date. GI is making the electronics, EMI is doing the programming. Cassettes have many advantages in home computer/game programming, according to GI. A standard C-60 cassette can store 1.5-million bits on one side, or 3-million bits if both sides are used—compared with about 160,000 for a ROM. To develop a programmed ROM requires about three months and a run of perhaps 10,000 or more is needed to make a profit. A cassette can be programmed in three to five days and runs can be as short as 300 to 500.

A cassette program can provide audio instruction—an important factor in such computerized courses as

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new & timely

The positive aspects of negative-ion generators

Ever since 1932, when an RCA scientist accidentally discovered that an electrostatic generator in his laboratory was releasing positive and negative ions and causing dramatic mood swings in his fellow workers, the topic has intrigued scientists. Studies here and abroad showed that atmospheric ions, those billions of electrically charged particles in the air all around us, had definite effects not only on personal well-being but also on an individual's capacity to recover from illness and disease.

For example, it has been noted that sometimes before a storm many people complain of fatigue and other symptoms; cattle also grow restless. What happens is that the air retains an excess of positive ions, causing distress and discomfort to both humans and animals. Observations made at the University of California at Berkeley and at the Hebrew University in Israel have shown that before a storm many "weather sensitive" people display moderately acute respiratory problems, migraines, nausea and vomiting. Negative-ion generation was able to reduce these symptoms. Burn victims, post-operative patients and persons suffering from depression have also been successfully treated by means of a negative-ion generator.

This generator is an electronic device housed in a small metal box. With a flip of a switch, a fan begins to turn releasing a flow of negative ions. The air begins to smell sweet and the patient feels better. Naturally enough after this discovery, negative-ion generators proliferated on the commercial market. Because fantastic claims were made for their therapeutic benefits, they were completely discredited. However, in the light of continuing laboratory experiments, negative-ion generators have now not only become "respectable," they have opened up a vista of unlimited possibilities.

While there is still much to be learned about atmospheric ions, it has been predicted that in a few years we will be able to control the ion level indoors as we regulate temperature and humidity, thereby helping us all to lead happier, healthier lives.

New mobile phone network permits more subscribers

The Illinois Bell Telephone Company of Chicago is presently testing a unique mobile telephone network that can service a greater number of subscribers. They have devised a system in which metropolitan areas are divided into circular cells about 1½ miles wide. Each cell is served by a radio telephone station, with power supplied from a single transmitter in the Chicago loop area. The stations, in turn, are controlled by a central computer.

The way it works is this: As the mobile phone user moves from area to area, he is "handed off" from one station to another. The quality and strength of his signal is measured at five-second intervals to determine whether to maintain the connection at the current station or switch to the next.

A Bell spokesman stated that the 1½-mile spacing had proved feasible in a series of tests in New Jersey, specifically Newark. In the Newark test, transmissions were made from a computer-equipped van, with interference being provided by other van-mounted transmitters placed wing-fashion around the 1½-mile cell test area.

Seizing upon the idea, other companies have requested permission to make similar tests. In the Washington, DC, area, the American Radio Telephone Service, Inc., plan to use a Motorola cellular system called Dynatac, in which hand-held as well as mobile phones are envisioned. Harris Corporation, another major electronics company, has petitioned the FCC for permission to test a digital transmission system using a single central station and remote-relay antennas. The on-off digital code of the computer would be used to generate the signals. The radio channel would be shared by sampling mobile telephone transmissions many times per second; this sharing system is called time-division multiple access.

It is felt that the cellular system, by allowing a greater re-use of radio frequencies, will accommodate many more mobile telephone users in urban areas, with enough traffic to justify installing the cells.

Alternate to CB radio for small business communicators

The small business that has been attempting to use CB communications but finds crowding intolerable now has an alternate in a new line, Motorola's *MOXY*, that is intermediate in price between CB and current FM business radio, yet offers the advantages of the latter.

MOTOROLA MOXY mobile radio

Crowding is reduced and reliability increased because each business user is assigned his own frequency. In addition, he can order a PL (*P*rivate *L*ine) or DPL (*D*igital *P*rivate *L*ine) squelch to screen out messages on his channel that are not intended for him.

The *MOXY* mobile radios are available in UHF, high band and low band. Power outputs range from 10 to 25 watts. They are less than 3 inches high, 7 inches wide and 11 inches long, weighing less than 3 pounds, thus can be installed easily in cars, trucks or tractors.

Plate-glass speaker can replace conventional systems

This is the success story of two acoustical-equipment makers, Les Barcus and John Berry, who, while tinkering around in their plant lab one day, wired an electronic sound energizer to a piece of ordinary window glass. Presto—a speaker, which has turned out to be a revolutionary device—the AudioPlate.

The AudioPlate is made of a 5- by 7-inch sheet of glass, ¼-inch thick, with a 1-inch energizer bonded to the back. The device projects sound of such clarity that conventional precise speaker arrangement may become a thing of the past. The manufacturers claim it can produce sound in its upper ranges up to 250,000 hertz, more than ten times that of most speakers. No one is really quite sure how it works. One theory has it that the energizer bends the glass, causing wave disturbances in it, which then disturbs the air sufficiently to produce sound.

Barcus-Berry, Inc., has already provided franchised distributors in the U.S. and abroad with public-address systems incorporating the AudioPlate, and hope to make a low-price model available to the hi-fi market before long.

Contest turns up wide range of new microprocessor applications

An agricultural monitor and controller and a system for monitoring electroencephalograms (EEG's) more easily during surgical operations were the first and second prize winners in the Schweber Electronics first annual Microprocessor Competition. This competition, according to Seymour Schweber, president of the company, is to "inspire people to narrow the gap between today's challenges and tomorrow's realities."

The agricultural monitor and controller, which won a $1,000 first prize for Peter J. Prossen of Prossen Industries, Westminster, CA, is described as part of a system to optimize irrigation practices, reduce the cost of irrigation and irrigation labor, and minimize water waste. Data measured include root stress, transpiration rate, temperature, rainfall, and various irrigation system pressures and flow rates.

Second prize went to John Doyle of Ottawa, Canada, who worked with the Ottawa General Hospital to develop his

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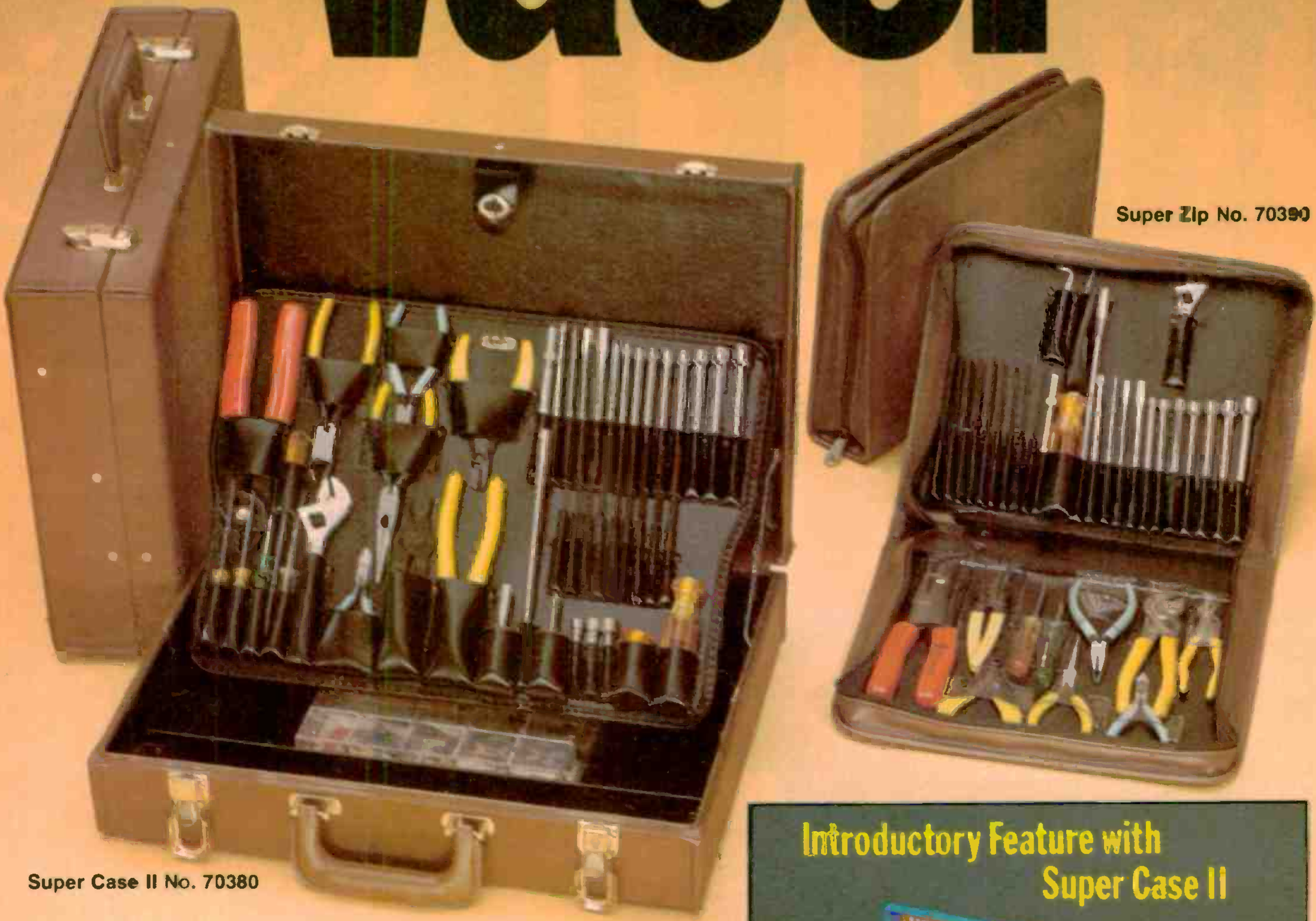
Vaco.



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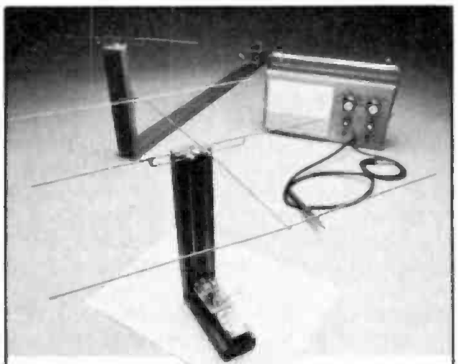

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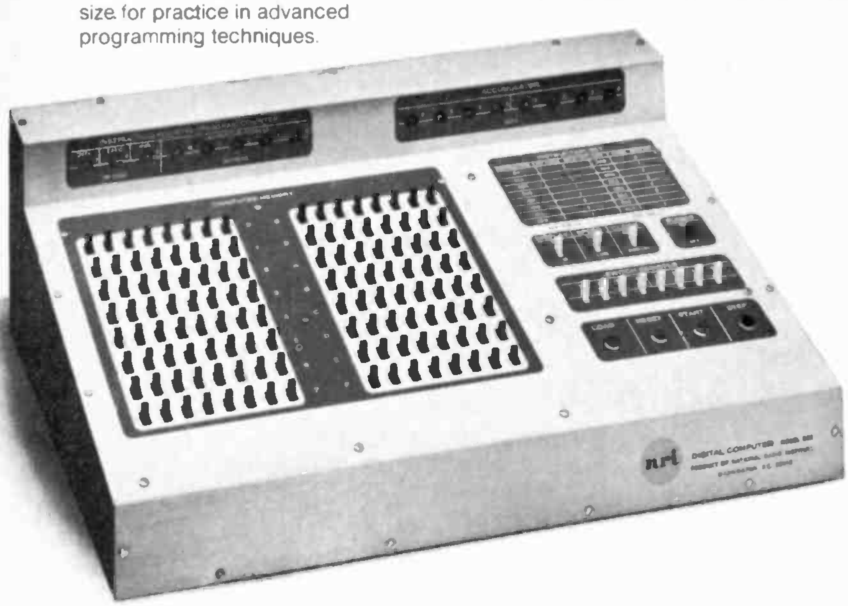

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new & timely

continued from page 6

EEG monitor. He received $500 for his entry.

Third and fourth prizes, both of $250, were tied between Dr. Jay S. Karmarker, electronic systems consultant of Santa Clara, and Derek McClure, of Wetaskiwin, CA. Dr. Karmarker designed a drug interaction computer that can determine the compatibility of various drugs. McClure's entry was an audiometric instrument with which a patient can test himself after minimal instruction from a technician. The fifth prize, also of $250, went to David B. Herburg, Nirmal Ratnakumar and Peter Lobban, all of Stanford University, who cooperated on a microprocessor controller for an epitaxial reactor. There were also five honorable mentions.

The competition will be an annual one. For information on entries, contact Mel Kutzin, MPU Center, Schweber Electronics, Westbury, NY 11590, phone 516-334-7474.

Planet Jupiter emits intense radiation field

Pioneer I and Pioneer II space probes have confirmed that the planet Jupiter is emitting radiation into a vast region of space. The radiation consists of high energy electrons that are emitted from a specific region of the planet's magnetic field. These high-energy electrons are apparently accelerated by the planet's magnetic field in the same manner as those signals generated by distant pulsars.

At the spring meeting of the American Geophysical Union in Washington, DC, Dr. John A. Simpson of the University of Chicago and others discussed the significance and implications of these findings. Physicists have long determined that pulsars, which are "hotspots" that spin at incredibly fast rates, release highly charged electronic particles that are responsible for much of the electromagnetic radiation that bombards the earth from all directions in the universe. Although Jupiter's spin rate is much slower, the planet is now believed to have features in common with pulsars.

Dealer training program draws record crowd

This past April, Downstate Communications, Inc. sponsored their second, highly successful dealer training seminar at Southern Illinois University, Carbondale, IL. DOW-COM president Craig Martin was enthusiastic about the turnout. It was "like a mini PC-77," he said, citing attendance by dealers and manufacturers from many areas.

Thirty-six manufacturers set up booths featuring mainly CB's and related equipment. In addition, a morning seminar was addressed by speakers drawn from industry leaders. Adding spice to the proceedings were door prizes. The grand prize of a Browning Golden Eagle CB radio was won by Mark Chaffee. Lee Kitay of Pittsburgh, PA, won a base-station antenna for having "travelled the farthest distance." The day ended in an appropriately festive fashion with a dinner party for the manufacturers hosted by DOW-COM's Craig Martin for the participants. R-E

GRAND PRIZE WINNER at the dealer training program is Mark Chaffee (center). He is shown being presented with a Browning Eagle by Gardiner Greene (left), president of Browning Laboratories, Inc.

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Cover photo by Walter Herstatt

Radio Electronics is a member of the *Institute of High Fidelity* and is indexed in *Applied Science & Technology Index* and *Readers Guide to Periodical Literature.*

Radio-Electronics magazine is published by Gernsback Publications, Inc.
200 Park Ave. S., New York, NY 10003
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letters

TRANSDUCERS

I have an answer to the letter that appeared in the May 1977 issue asking for information on dashboard digital readouts for drag races and rallies.

For position transducers, linear accelerometers, precision pendulums and gyroscopes, write to: Humphrey Instruments, 9212 Balboa Ave., San Diego, CA 92123. Other temperature transducers car be obtained from: Omega Engineering, Inc., Box 4047, Springdale Station, Stamford, CT 06907.

MARK POLLARD
Boulder, CO

2650 NEWSLETTER

We are announcing the 2650 Computer User Notes, a six-issue-per-year newsletter supporting the 2650 microcomputer system from Central Data Company (**Radio-Electronics**; April, May, June 1977 issues.)

Unlike previous computer newsletters, this publication will be professionally typeset with normal-sized print, display-size headlines, and pictures. Subscriptions are $5 in the U.S. and Canada, $10 foreign, from 2650 Computer User Notes, Box 158, San Luis Rey, CA 92068.

The new 2650 microprocessor system described in **Radio-Electronics** is just the sort of powerful, cost-effective, versatile (the S100-bus option, for instance) machine people have long wanted. Personally, I have been waiting three years for something sensible to come along—and this is it. An associate and I are ordering three of them. We're going to use them to edit newsletter copy and drive typesetting equipment (which includes a simple Lexitron/IBM-Executive strikeon machine and a Photon 713-20 phototypesetter). We'll also use the computer to keep track of subscriptions.

The first issues of the newsletter will be heavily concerned with the problem of getting up and running home-assembled boards. We will be advising of software availability, programming problems, solving the bottleneck of low-cost high-speed mass storage, and multiprocessing with other processors (thus stretching software availability). User applications will be a prime interest.

BILL McLAUGHLIN, Editor
San Luis Rey, CA

CORRECTION

The transistor types are incorrectly labeled in the schematic and parts list of the Electronic Music Box in the June issue. The author originally specified transistor Q1 as being any general-purpose PNP silicon device with H_{fe} greater than 50. Similarly, Q2-Q5 were specified as being general-purpose NPN silicon transistors. Thus, Q1 is a 2N3906 and Q2-Q5 are 2N3904's.

RINGBACK

Your article telling how to build a tele-switch for your home (April 1977 issue) didn't mention one important misconception about phone company equipment.

Ringback, the intermittent sound you hear in the earpiece after dialing, has no correlation with the number of rings occurring at the other end. The signal you hear is generated by equipment in your local phone company switching office. Even if the call were made within the same switching office, the ringback is sent out to you, the caller, only for your benefit so as to create a false sense of security that indeed the call has gone through.

A situation could come up where you think you've allowed your phone to ring once only, but it may have rung as many as three times, or not at all, depending on the equipment, or, I should say, on its availability at the moment it generates ring and ringback.

JONAS R. BIELKEVICIUS
Greenbelt, MD 20770

ELECTRONIC ROULETTE

I was very pleased with your construction article, "Build Electronic Roulette" in the December 1976 issue. I used the circuits shown to build a similar unit. I found a few errors that other readers should take note of before building the unit.

The first is on page 73. IC6 is shown having pin 1 connected to LED 28. This is incorrect. IC6 was inserted in the wrong direction in Fig. 3. Turn IC6 around so pin 1 goes to LED 17, pin 2 will go to LED 18, etc. *NOTE, the location of pin 1 of IC6 on page 72 is correct.* The schematic shows pins 2 and 3 of IC2 and IC3 shorted together. This does not appear in the foil pattern and must be included on the printed circuit board, otherwise, the counters will never reset. Add a line on the foil pattern from pin 2 to pin 3 on both IC2 and IC3.

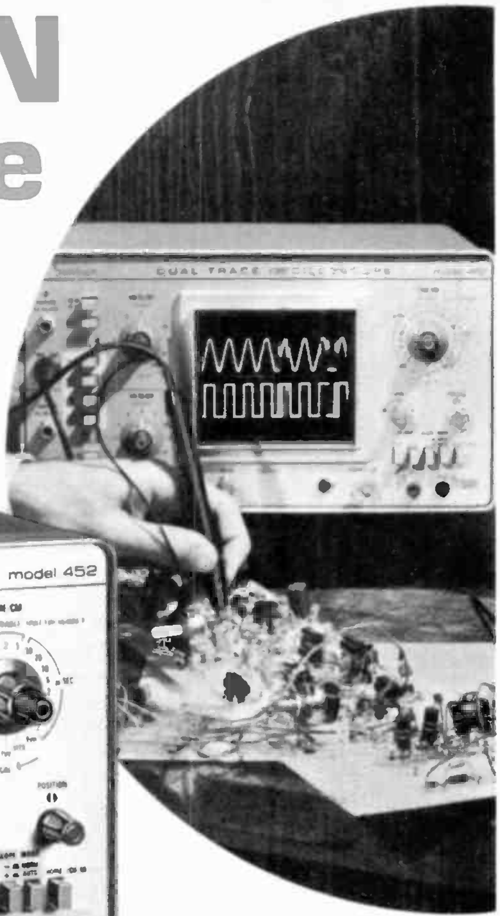
Next, the oscillator shows the top of R1, R3, and R4 connected to the positive side of the 5-volt power supply. On the foil pattern, extend the line at the top of R3 to R1 respectively. No oscillation will occur if this is not done. The foil pattern shows pin 18 of IC7 connected to pin 4 of IC4-b, and pin 19 of IC7 connected to pin 5 of IC4-c. Change pin 18 from pin 4, IC4-b to pin 5, IC4-c, and change pin 19 from pin 5, IC4-c to pin 4, IC4-b. Once done, the foil pattern will match the schematic.

Finally, two incorrect numbers on the schematic. The first on IC5. Pin 23 appears in two places. The one labelled on input AO is correct. Change input A3 from pin 23 to pin 20. The next is on IC3. Pin 12 should be connected to pin 1 instead of pin 2. The foil pattern is correct, however, for both of these points on the schematic.

continued on page 16

New SIMPSON 5" Dual-Trace 15 Mhz Scope

with triggered sweep. Reliable, versatile and easy to use. It's your best scope buy.



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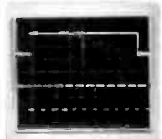
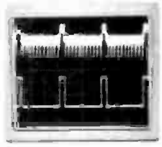
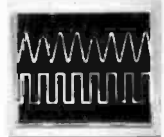
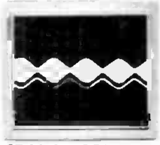
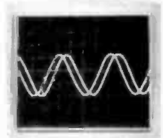

Check logic including countdowns and PLL


Display composite video and AGC pulse


Display op-amp input/output, A/D converter


27 MHz "CB" envelope and modulating signal


Check phase shift and distortion in amplifiers

See Your Local Electronics Distributor or Write for Bulletin T-837.

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CIRCLE 7 ON FREE INFORMATION CARD

LETTERS
continued from page 14

In addition to these corrections, I came up with a small modification. If a variable time constant is desired, replace R1 with a 0-500K potentiometer. Taper and type are not critical. Also, if the oscillation does not come to a smooth stop at the end of a spin, it can be eliminated by increasing the value of C1 to 3000 μF, and replacing C2 with a 220 μF 16-volt, electrolytic capacitor.
MIKE TORTORELLA
Essex Junction, VT

2650 COMPUTER QUESTIONS & ANSWERS

With reference to the article on the 2650 microcomputer on page 31 of the April issue, I have a few questions. For instance, in being capable of 16 lines of 80 characters, is it also the limit of the PC board memory? Do you have to transfer this to the tape before you can prepare another format? How many of these sets will a 30-minute tape take? Can you recall from the tape any portion from any part of the tape, or do you have to start at the beginning? What about a printout, can you add on a page printer, and, if so, what kind?
RAUL YZAGUIRRE
Premont, TX

The 80-character by 16-line display is indeed limited by the display memory. You can store any memory locations onto the cassette, and load them back again without running through the cassette from the beginning. A 30-minute tape will hold about 300,000 bytes of data (234 screens full). We have a teletype line printer hooked to it (300 LPM), and it works very well.—Jeff Roloff

In the April and May issues, pictured along with the 2650 computer article, is an ASCII encoded keyboard, which is used to input data to the computer. Nothing is mentioned in the article as to where this unit can be purchased, or any of the circuitry involved with it.
RONALD P. LE BLANC
Kincheloe AFB, MI

You can purchase any ASCII keyboard for use with our board. We, however, don't sell any. We have heard that Radio-Shack keyboards work well.—Jeff Roloff

MUSIC GENERATOR

With respect to my article on constructing a music generator in the June 1977 issue, the construction details were reproduced very faithfully, with the following exceptions:

The transistor type numbers are all interchanged on the schematic and parts list. NPN's are 2N3904, PNP's 2N3906. On the schematic, IC11-b in the Pitch Scaler should be ½ 4013: IC4-b in the Duration Scaler should have output pin No. 4.

Also, a small metal shield should be placed, with appropriate insulation, over R1 and soldered to the frame of S1, which, in turn, is grounded.

Additionally, credit should be given to Richard F. Voss, IBM, Yorktown Heights, NY, for the original research on the subject done at the Physics Department of the University of California at Berkeley, and for the introductory portion of the article. His name should have been included as co-author of the article.
RAYMOND A. CHAMBERLIN
Berkeley, CA

R-E

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

If you're shopping for your first multimeter, or moving up to digital from analog, there are a few things you should know.

First, look at more than price. You'll find, for instance, that the new Fluke 8020A DMM offers features you won't find on other DMMs at *any* price. And it's only $169.*

Second, quality pays. Fluke is recognized as the leading maker of multimeters (among other things) with a 30-year heritage of quality, excellence and value that pays off for you in the 8020A.

Third, don't under-buy. You may think that a precision 3½-digit digital multimeter is too much instrument for you right now. But considering our rapidly changing technology, you're going to need digital *yesterday*.

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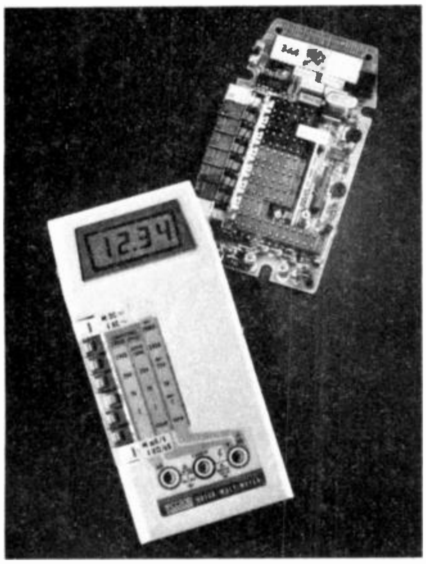

Why not analog? Because the 8020A has 0.25% dc accuracy, and that's *ten times better* than most analog meters.

Also, the 8020A's digital performance means things like 26 ranges and seven functions. And the tougher your home projects get, the more you need the 8020A's full-range versatility and accuracy. The 8020A has it; analog meters don't.

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You already know Fluke. And you probably own a benchtop-model multimeter.

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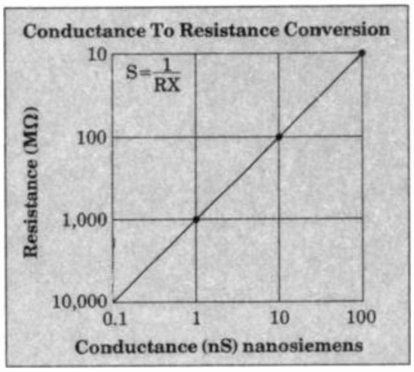
Nanosiemens?



Beginner or pro, you'll find the meter you now have can't measure nanosiemens. So what? With the 8020A *conductance* function, you can measure the equivalent of 10,000 megohms in nanosiemens. Like capacitor, circuit board and insulation leakage. And, you can check transistor gain with a simple, homemade adapter. Only with the 8020A, a 13-oz. heavyweight that goes where you go, with confidence.

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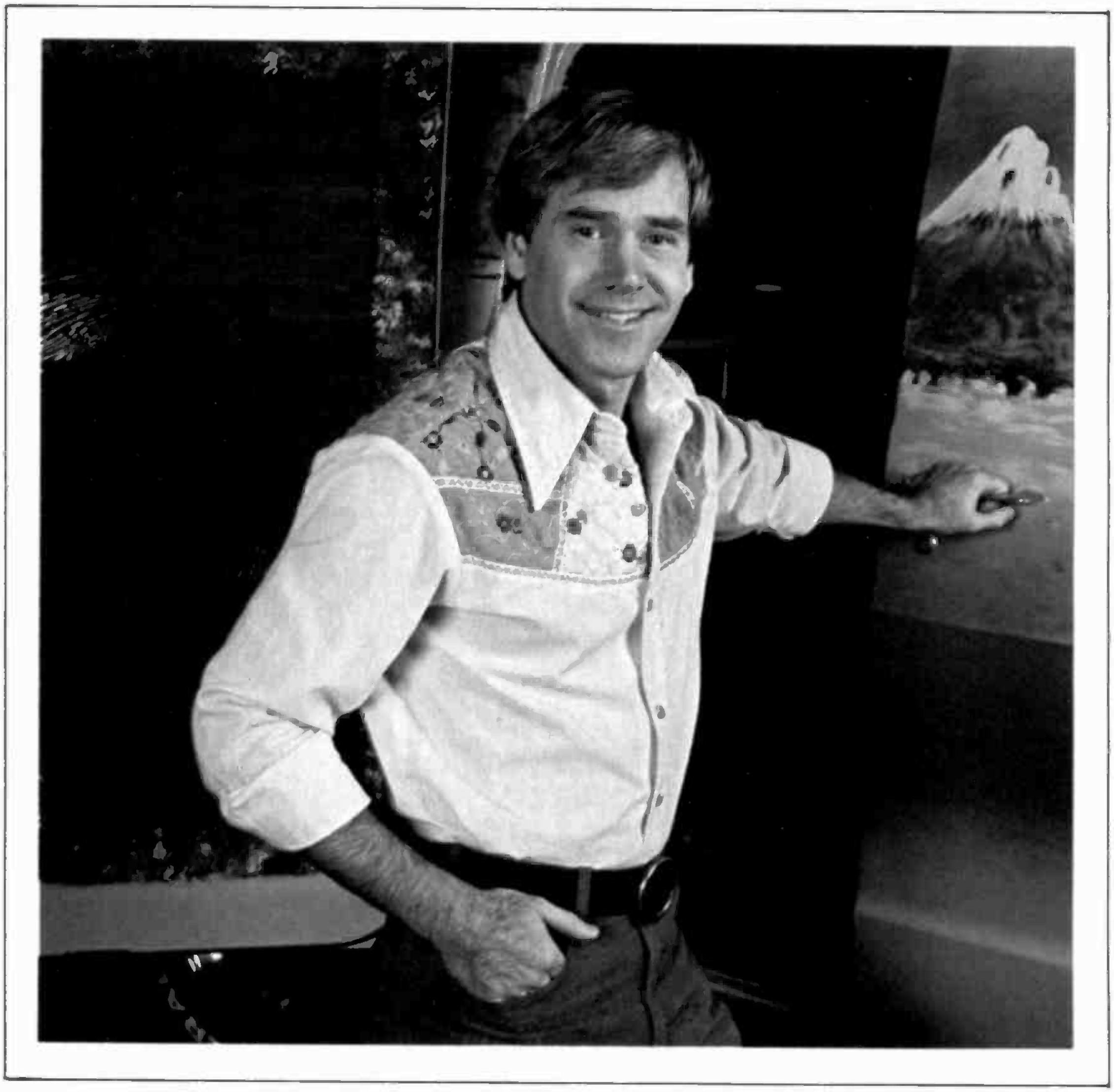

When you do, you'll probably pick CIE. You can't afford to settle for less when it comes to something like electronics training that could affect your whole life.

When you shop around for tires, you look for a bargain. After all, if it's the same brand, better price—why not save money?

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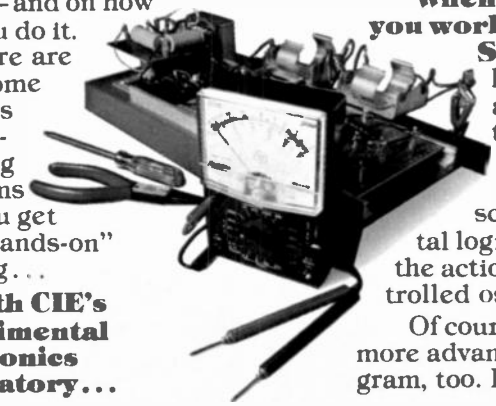
This is the next big important question. After all, your career will be built on what you can do—and on how well you do it.



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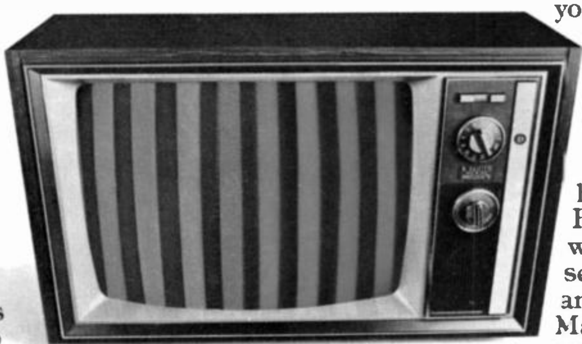
When you get your Zenith 19-inch Diagonal Solid-State Color TV you apply your new skills to some real on-the-job-type troubleshooting! You learn to trace signal flow... locate malfunctions... restore perfect operating standards—just as with any sophisticated electronics equipment!



Pattern simulated.

When you work with a completely Solid-State Color Bar Generator—actually a TV signal transmitter—you study up to ten different patterns on your TV screen... explore digital logic circuits... observe the action of a crystal-controlled oscillator!

Of course, CIE offers a more advanced training program, too. But the main point is simply this:

All this training takes effort. But you'll enjoy it. And it's a real plus for a troubleshooting career!

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For some troubleshooting jobs, you must have your FCC License. For others, employers often consider it a mark in your favor. Either way, it's government-certified proof of specific knowledge and skills!

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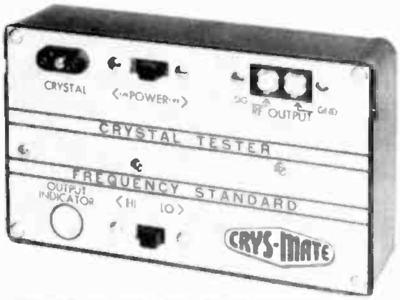
equipment reports

TeleMatic KC-720B CrysMate Crystal Tester



CIRCLE 90 ON FREE INFORMATION CARD

AN INSTRUMENT THAT WILL TEST RF CRYSTALS can be very useful. The TeleMatic Co., 2849 Fulton St., Brooklyn, NY 11207 made one quite a while ago. I have used it many times with good results. Now, they have introduced a "bigger and better" model, the CrysMate *model KC-720B*. It has the same features as the original plus some new ones. It checks crystals for activity, as the older one did. You plug the crystal into the front-panel socket. If it is good, an indicator light tells you so.

The new model also has a HI-LO switch. If the crystal is suspected of being low in activity or "weak" and the front-panel HI indicator light comes on, switch to LO. If the light goes out, this crystal should be suspected.

The crystal socket has the standard ½-inch (8-mm) pin spacing. This will fit the majority of crystals found in color TV, CB, etc. For crystals in larger cases, solder two short pieces of stiff No. 20 wire to two mini-clips and use these to hook it up. Keep the leads as short as possible to hold down the stray capacitance.

Many crystals work in a "third overtone" mode. If the crystal under test is one of these, a frequency counter or calibrated radio receiver will read the fundamental, since this has the highest amplitude output. A 15-MHz third-overtone crystal will read 5 MHz, etc. With an accurately calibrated receiver, you can tune a surprising number of harmonics. We have picked up good usable signals from a 1.0-MHz crystal as high as the 10th harmonic and, in some cases, even higher. (Keep this handy in your shirt pocket to check the *tracking* of a short-wave receiver; a beep every 1.0 MHz will tell how well the receiver dial tracks the actual frequency. Other frequencies may be used, of course.) You can use the same setup to find the frequency of unknown crystals. Tune for the strongest and lowest-frequency signal. This will be the fundamental.

To put an odd-ball marker frequency on a sweep-alignment curve, just feed the RF output of the CrysMate into the external-marker jack of the sweep generator. Most have this jack, but if yours doesn't, the signal can be coupled into the IF input with a couple of turns of insulated wire.

With the proper crystals, you can calibrate CB or amateur radios for frequency, band-edge, etc. Crystals in the set can be checked against replacements to make sure they are good or bad. In most cases, the CrysMate's RF output will be high enough to drive a frequency counter.

If you're using the CrysMate as a frequency standard, or making calibration adjustments

continued on page 24

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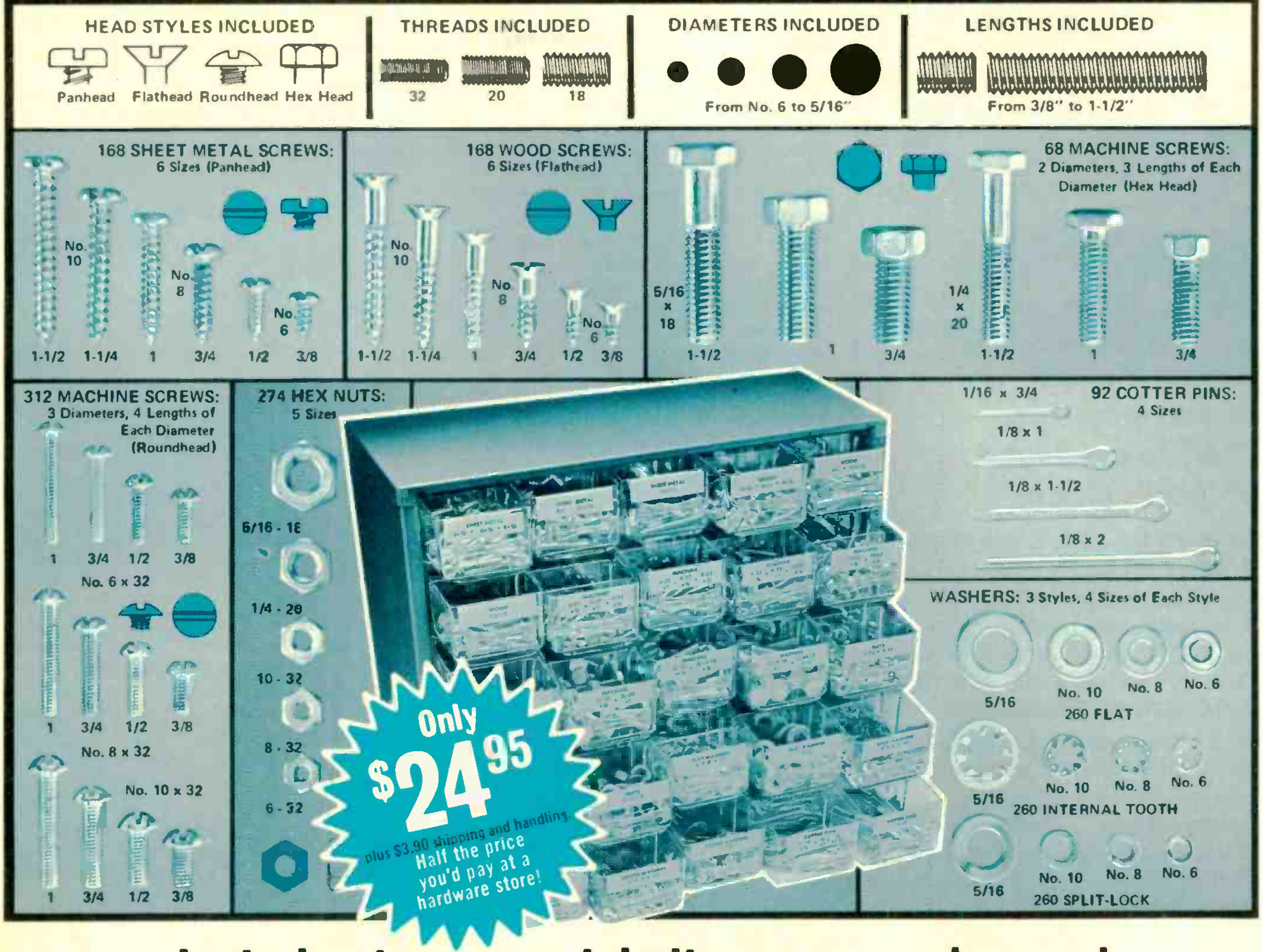

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G. R. Dalmadge, Sunnyvale, California

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J. D. Russell, Cicero, Illinois

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EQUIPMENT REPORTS
continued from page 22

where it must be on quite a while, set the switch to the LO position. The RF output will usually be ample; this reduces the battery drain quite a bit.

Model KC-720B is very compact, comes in a 3.5 by 6-inch plastic case just a bit over an inch deep. It is completely self-contained, powered by one standard 9-volt battery. It will operate at full output over a range down to 7.5 volts under load. Battery life in the original model was good, and should be good here since the basic circuitry is the same. The only limitations are that low-frequency crystals may not oscillate, or not oscillate with enough output to light the indicator lamp. This could be checked with a scope on the RF output terminals or on the calibrated receiver.

This instrument can also be used to put markers for each VHF channel on a TV tuner output curve! By using the 4.5-MHz marker provided on most sweep generators, you can check the response curve for each channel. Very handy for those "I got a problem only on Channel 6" jobs! **R-E**

Clarcothane Cleaning Solvent

CIRCLE 91 ON FREE INFORMATION CARD

EVER SINCE CARBON-TETRACHLORIDE WAS banned, we have been looking for something that would do the same job in cleaning up electronic apparatus, removing grease, etc. Clarkson Laboratories, Inc., Camden, NJ, has come up with *Clarcothane*. The full name is "1,1 trichlorethane."

It comes in the familiar 16-ounce aerosol can, with a long needle so you can get into tight places. The odor is considerably more pleasant than carbon-tet, and it seems to do the same job very well. We tried it on a couple of PC boards, controls and other items; it cleaned them nicely. It's a very good grease-remover and evaporates quickly.

The manufacturer says that it does not cause a toxic buildup in the body, and that it is completely safe on electrical parts and insulation. It will not burn, and has no flash point.

The familiar warning on the can tells you to "avoid prolonged breathing of the vapors," etc. and also states that "certain plastics" may be "softened." We tried it on several plastics but found no bad effects. **R-E**

OK Machine and Tool WSU-30 Wire-Wrapping Tool

CIRCLE 92 ON FREE INFORMATION CARD

WIRE WRAPPING HAS BEEN USED IN THE DIGITAL field for many years, and the wire-wrap tool has become a mainstay of the computer serviceman's tool kit. Design and debugging of systems with complex interconnection patterns requires a wiring technique that lends itself to rapid assembly and modification. Wire wrapping is used because it makes quick, reliable, neat connections without the danger of burning insulation or splashing solder among hundreds or thousands of closely spaced terminals and components.

Recently, hobbyists have been exposed to the wire-wrapping technique. They work with systems built up of 8 to 40 pin-integrated circuits which multiply to high total pin counts. So it's really not unusual to have inexpensive wire-wrap tools designed specifically for the hobbyist.

The Hobby-Wrap-30 Wire-Wrapping/Stripping/Unwrapping Tool (*model WSU-30*) is made by the OK Machine and Tool Corporation that also makes a complete industrial line of manual and powered wire-wrap equipment.

The *WSU-30* is an amazingly simple yet effective tool. Two tubular extensions of different length are axially mounted to an easily gripped hex-shaped center handle. The handle has a V-shaped wire stripper blade that removes the insulation from No. 30 (0.25-mm) wire. The stripped end of the wire is inserted in the small hole closest to the perimeter of the end of the longer tool extension. A slot along the length of the extension acts as a reservoir for the wire about to be wrapped.

The center hole at the same end is slid over a 0.025-inch square wire-wrap terminal, and the tool rotated clockwise for 10 turns. As the tool is turned, the wire is forced against the terminal and is deformed at the post corners for a low-resistance electrical connection. The tool is then lifted from the terminal.

The *WSU-30* has an unwrapper in its shorter extension. A central hole at this end fits over the terminal as on the wrap end, where a

continued on page 26

EQUIPMENT REPORT
continued from page 24

recessed notch traps the end of the wire. The wire is loosened and unwrapped when the tool is rotated counterclockwise, opposite to the original wrapping direction.

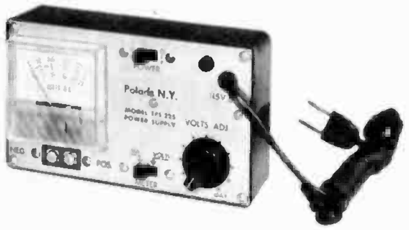
I used the *WSU-30* to wire an IC wiring panel. I found its very low mass and sound performance make it a useful tool; one that does its job effectively without getting in your way. I also had a couple of chances to try the unwrapper to fix a couple of errors.

The *WSU-30* Wire-Wrapping Tool sells for $5.95 and is available from local electronic suppliers, or direct from OK Machine and Tool Corporation, 3455 Corner Street, Bronx, NY 10475. The *WK-2-B* Wire-Wrapping Kit includes a tool, a 50-foot spool of Kynar wire and an assortment of 1-, 2-, 3- and 4-inch pre-stripped wires for about $12. **R-E**

Polaris TPS-225 DC Power Supply

THE POLARIS CO. HAS QUITE A FEW SMALL, handy test instruments. Their latest is the *model TPS-225* DC power supply. A bench DC power supply can be used to power small radios, CB sets, or even TV modules for out-of-set servicing.

The TPS-225 is completely isolated from the AC line. So, it can be used as either a positive or negative voltage supply. It's rated at up to 25 volts at a maximum current of 250 mA. The DC voltage is well-filtered, and can be continuously regulated from 0 up to 25



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volts. An internal solid-state regulator controls the voltage and also protects against shorts in the load. A short does no damage to either the equipment or the power supply; when the short is removed, the output voltage comes right back.

A panel meter reads the voltage or current; selection is by means of a slide switch conveniently located at the bottom of the panel. The voltage is adjusted by a control at the right, and the DC voltage is taken off at two screw terminals on the left.

The variable-voltage output can be used, for example, in servicing small and medium power stereo amplifiers. After output transistor replacement, just lift the set's own DC power supply and hook in the TPS-225. Turn the VOLTS ADJUST control to zero and set the METER switch to MA. Now bring the DC voltage up slowly without applying an input signal to the amplifier and observe the current being drawn on the meter. This is the key to the operation of the output stage. If it's too high, a problem still exists, usually in the bias. The instrument will supply ample current to check even fair-sized amplifiers, if you check one channel at a time. This can take the place of a variable-voltage line transformer and can be a great transistor saver.

The experimenter can use this unit for powering various solid-state projects; its usefulness is limited only by the ingenuity of the technician. For example, we had a question the other day: "Just how much current does this (color demodulator) IC draw?" By lifting the +24-volt supply lead and using the *model TPS-225* in its place, we could have had the answer instantly. Normal current in this case happened to be 22 mA, and this handy little instrument would have been a great help! It's also reasonably priced. For more information write: Polaris Co., 2849 Fulton St., Brooklyn, NY 11207. **R-E**

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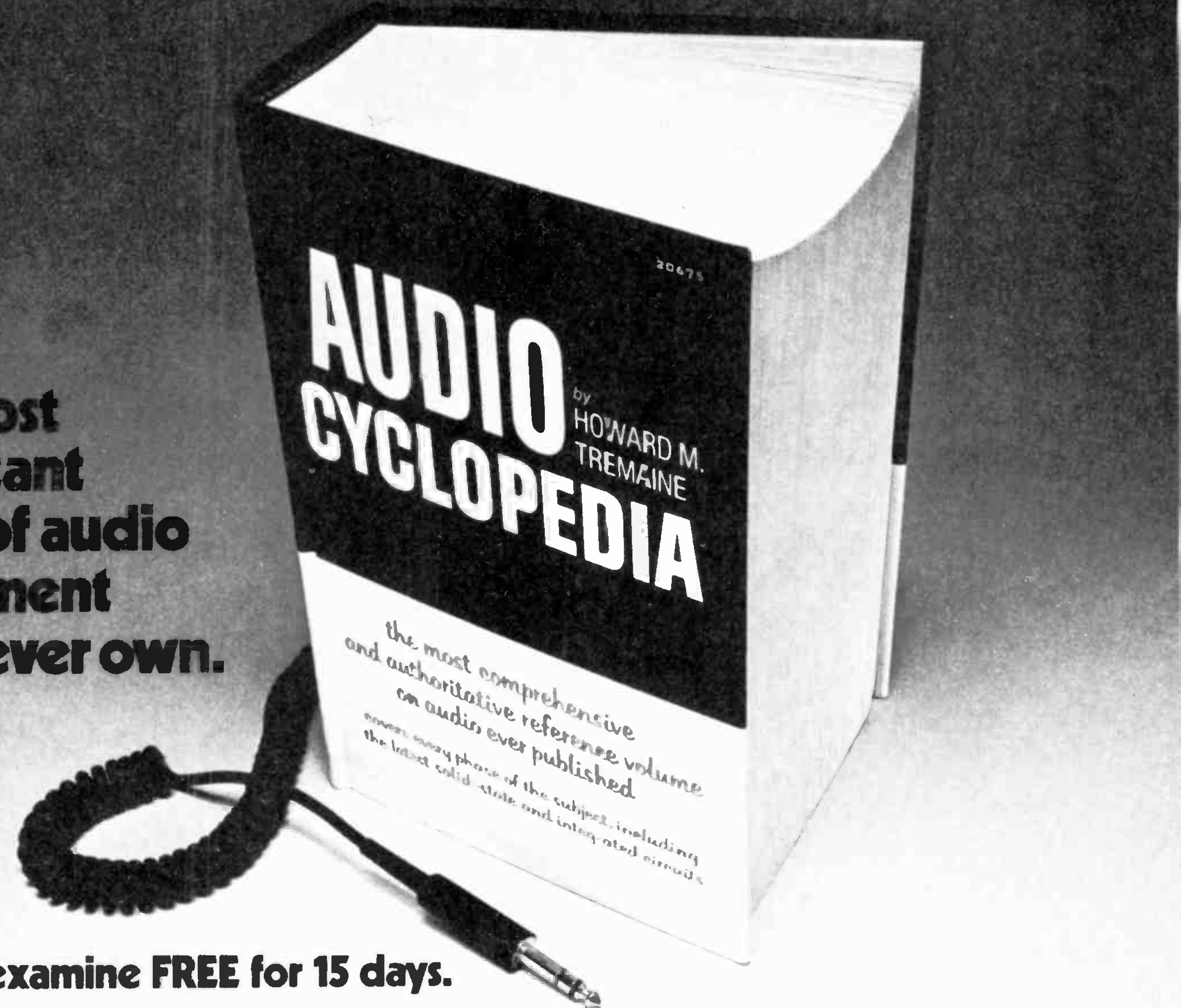

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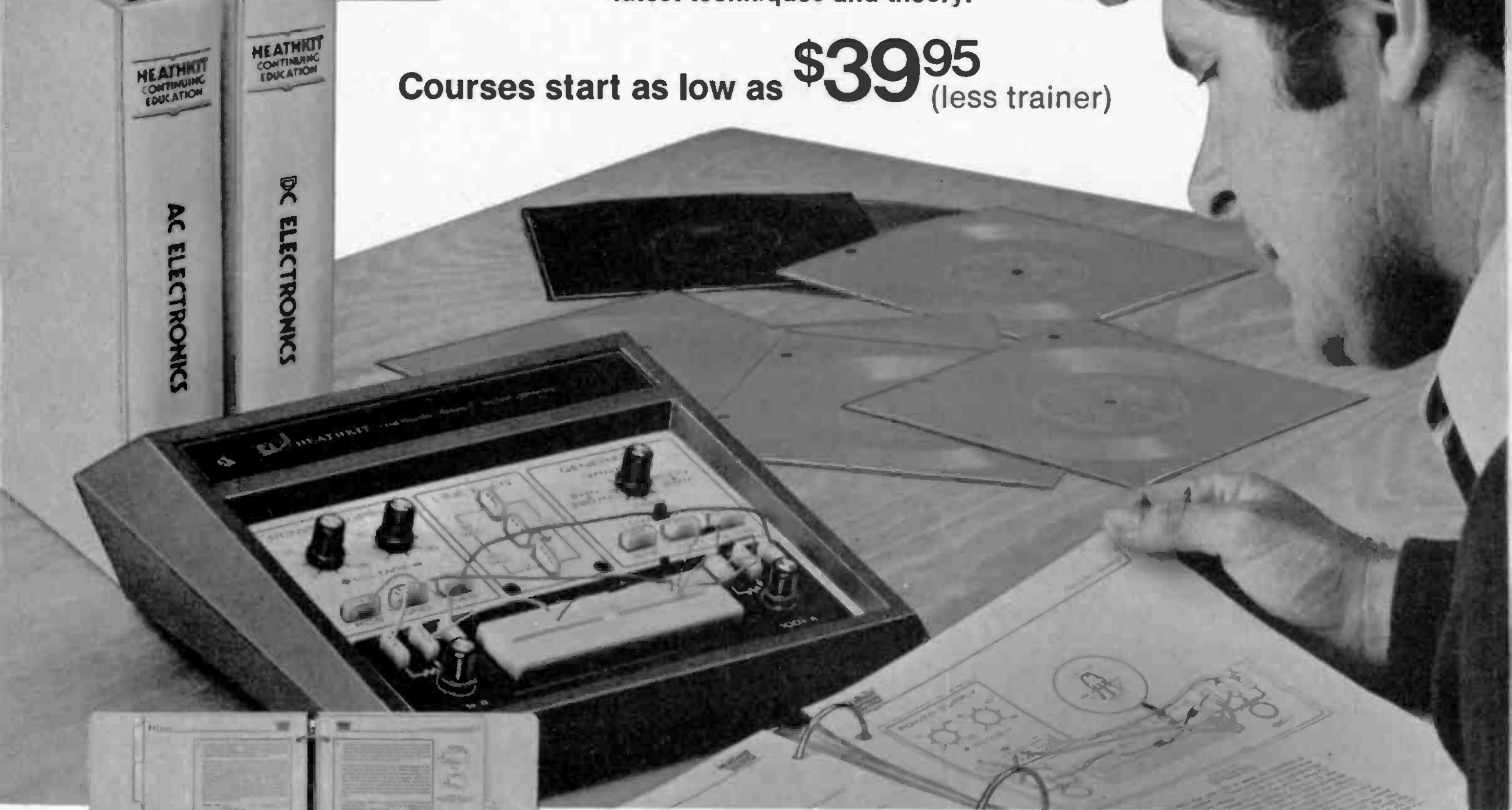

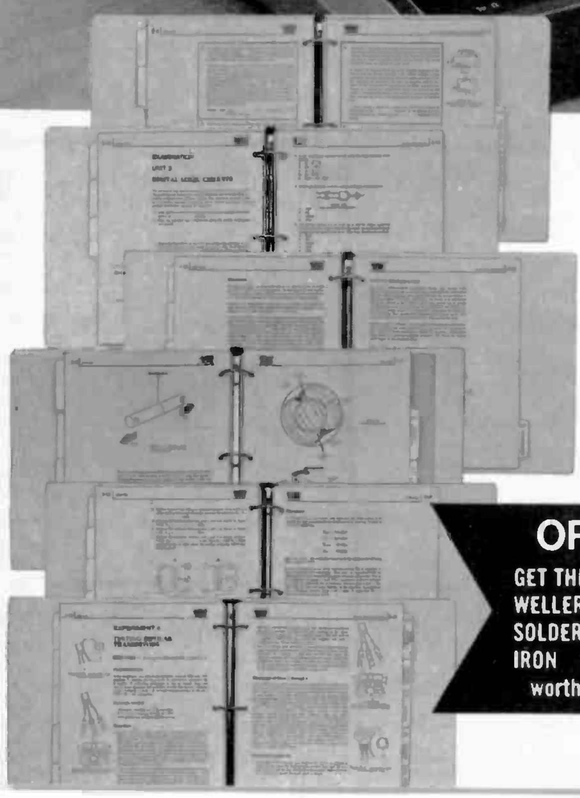

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PB-101	940	10	29.95	8 distribution buses, higher capacity
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PB-203	2250	24	75.00	Built-in 1%-regulated 5V, 1A low-ripple power supply
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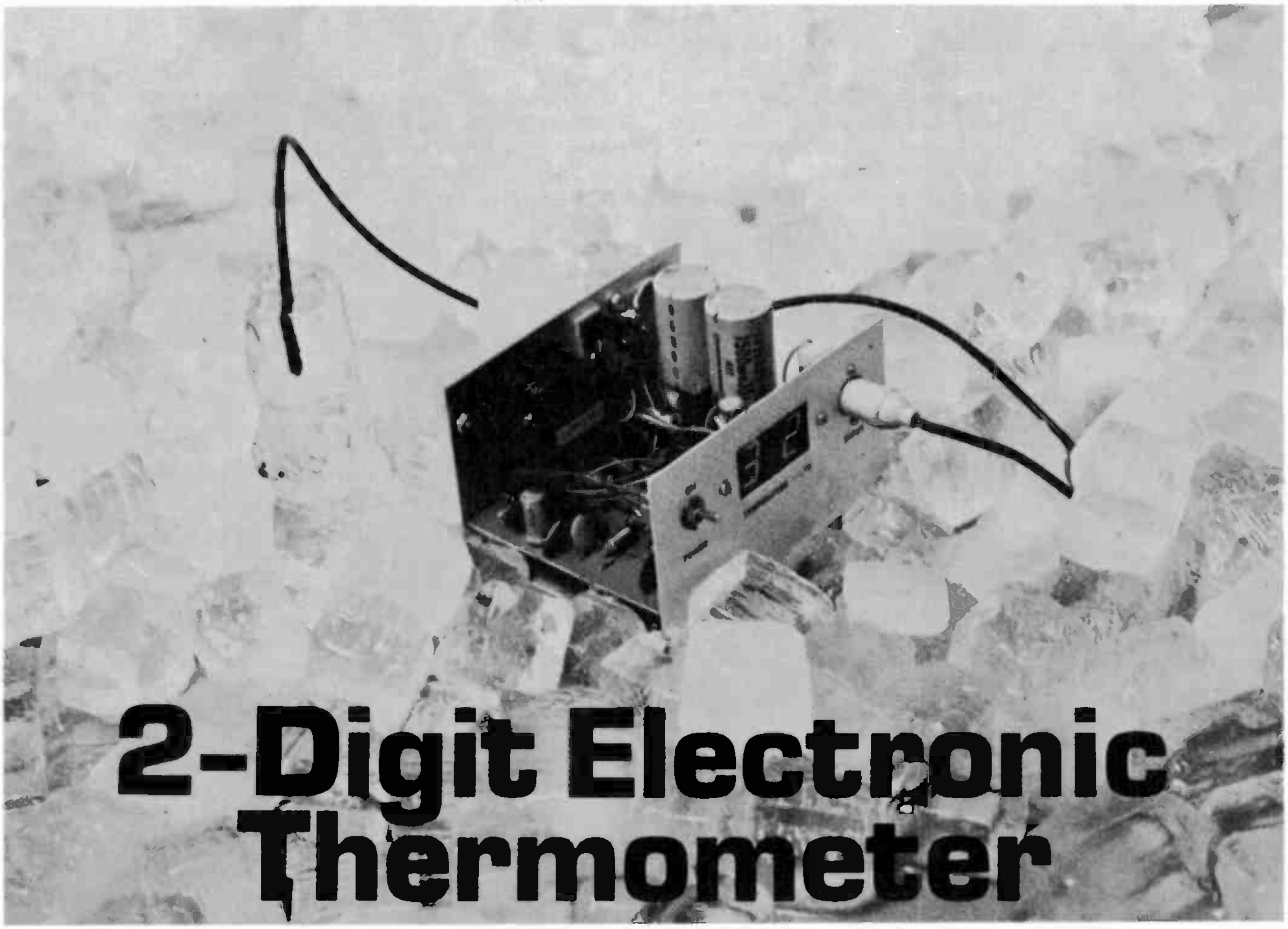
CONSTRUCTION



2-Digit Electronic Thermometer

Measure temperature easily with this electronic thermometer. It has a 2-digit LED display and covers a 100° F. range

WALTER SIKONOWIZ

HERE'S A DIGITAL THERMOMETER THAT MEASURES FROM 0° TO 99°F and displays the temperature on a 2-digit LED display with 0.6-inch high digits. The unit is relatively simple and should cost about $50 to build. The accuracy is such that readings will off by −2° at 30°F and +2° at 70°F. Restricting the temperature range and recalibrating the unit should yield better accuracy. However, the thermometer may be best suited to remote monitoring of outdoor temperatures requiring the 0° to 99°F temperature range.

About the circuit

The thermometer circuit combines two functional modules: The first module is a thermistor/resistor network whose output voltage is a nearly linear function of temperature over the 0° to 99°F range; the second module is a two-decade A/D converter. The maximum output of the temperature-sensing network is 2.2 volts, which is slightly less than the maximum voltage that the A/D converter will accept.

The block diagram (Fig. 1) and timing waveforms (Fig. 2) show how the circuit operates. During the display interval, when the output of monostable IC4 is high, the converter is inactive while the last conversion is being displayed. In this inactive state, the output of oscillator IC1 is inhibited, staircase generator IC2 is reset to zero and the displays are visible. The output of IC4 remains high for about 1 second, then drops for the duration of the conversion interval. When the output of IC4 goes low, it generates a negative pulse that clears the counters.

During the conversion interval, which can last a maximum of 10 milliseconds, the display is blanked. This rapid blanking cannot be seen and the rapid display changes that would occur during clocking of the counters remain invisible.

There is a delay of about 100 μs before the first clocking edge (negative) appears at the output of IC1. This delay permits the negative pulse to clear the counters. Each clocking edge from IC1 increments the counters and causes the staircase to increase by one step.

Comparator IC3 monitors the output voltage of the temperature-sensing network as well as the staircase-generator output. As soon as the staircase output exceeds the output of the temperature-sensing circuitry, IC3's output drops low and triggers IC4. Before another clocking edge can arrive, the oscillator is inhibited and the staircase generator is reset. The displays are also unblanked and show the count accumulated in the counters. When IC4's output again drops low, the whole process is repeated.

The schematic diagram is shown in Fig. 3. A 10-kHz multivibrator is formed by IC1, R2, R3, R4 and C10. When base drive is present, Q1 shorts out C10 and inhibits the multivibrator output. This method of inhibiting has another effect: The oscillator cannot operate until 100 μs after base drive is removed from Q1. The reason is that C10 must charge to its operating potential through R4. This allows time for the counters to be cleared.

Operational amplifier IC2 generates the positive-going staircase. Resetting the staircase generator is performed by FET Q2 which shorts out capacitor C14. If you cannot obtain the 2N4393 FET specified for Q2, you can substitute another, but test it to be sure it has a pinch-off voltage of less than 4.5 volts.

The output of IC2 couples to pin 3 of comparator IC3, while pin 2 receives the output signal of the temperature-sensing network. Capacitor C16 filters out any noise that might be picked up by the thermistor and its input leads. The comparator's output signal (at pin 7) couples to monostable IC4, whose own output is available at pin 3.

As can be seen in Fig. 3, IC4's output drives Q1's base, Q2's gate, the blanking terminals of display drivers IC7 and IC8 (pin 4), as well as a differentiator composed of R19, C19 and D9. The output spike from the differentiator clears counters IC5 and IC6. The output of oscillator IC1 goes to inverter Q4, which drives the clock input of the first counter. The four outputs of each counter go to a decoder/driver IC (either IC7 or IC8). Then R23 through R36 couple the driver outputs to the display digits. Finally, feedback from IC4's output to pin 6 of

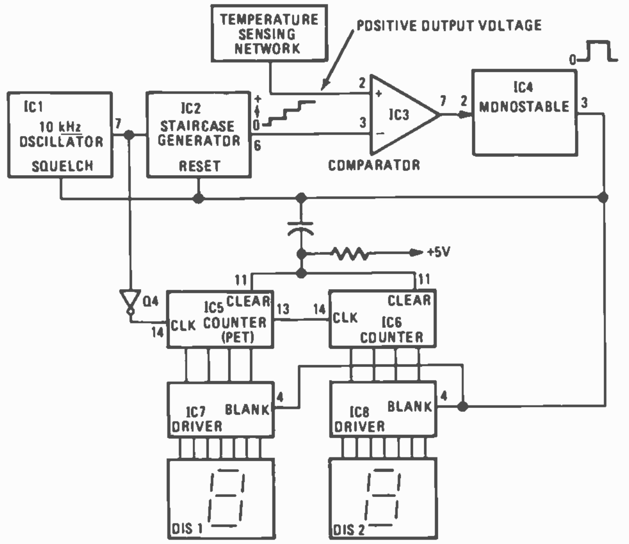


FIG. 1—DIGITAL THERMOMETER uses simple 2-digit A/D converter.

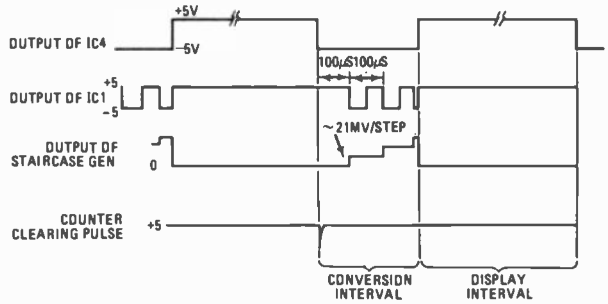


FIG. 2—TIMING WAVEFORMS of the thermometer circuit.

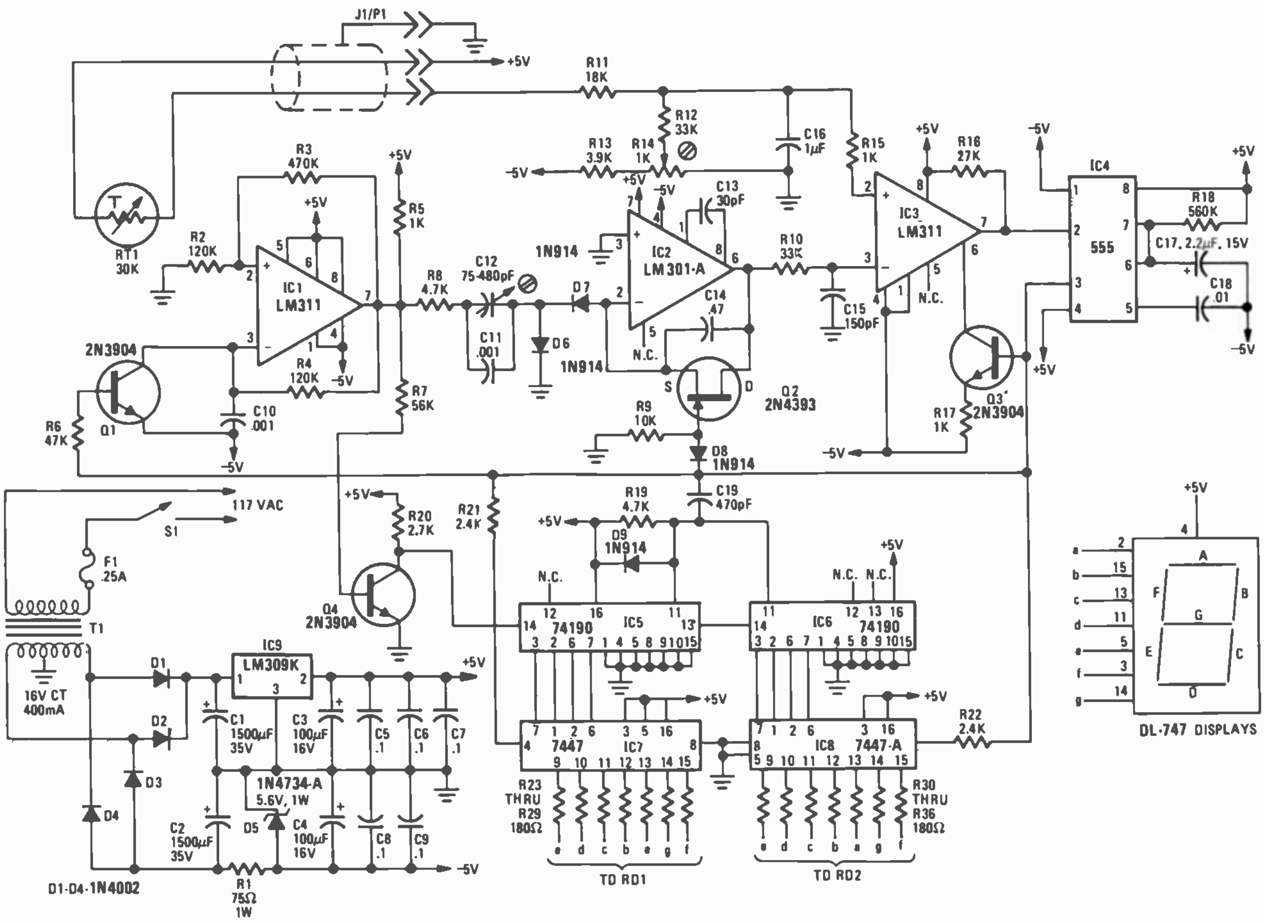


FIG. 3—COMPLETE SCHEMATIC. Power is supplied by IC regulator.

IC3, by way of Q3, eliminates an undesirable condition that results when pin 2 of IC3 is at a potential of 0 volts or less.

Construction

When constructing the thermometer be sure to include ceramic bypass capacitors for the power supply. The case should be made of metal and connected to the system ground. If the voltage regulator, IC9, is bolted directly to the chassis, with only a layer of silicone grease intervening, it will eliminate the need for a heatsink. Due to the many IC's used, it will probably be most convenient to use a PC board. The foil pattern is shown in Fig. 4 and the component overlay is shown in Fig. 5.

Two-conductor shielded cable, such as Belden No. 9452, is used to connect the thermistor to the rest of the circuitry. The shield should be connected to ground, while the two central conductors connect the thermistor to the positive supply and to R11. Use a 3- or 5-prong DIN plug-and-socket set with the shielded cable. Do not substitute for RT1, a 30K Fenwal UUT43J1 precision thermistor. Use 5% resistors for R11 and R12; these two resistors, along with R13 and R14, were chosen especially to complement the thermistor. The combination provides the most linear voltage-vs.-temperature response over the 0°-to-99°F range, as shown in Fig. 6.

The thermistor assembly should be weatherproofed against environmental extremes. First insulate the exposed thermistor leads with heat-shrinkable tubing, then use Epoxy cement to seal any remaining areas where water could seep in. Since the thermistor is only 0.1-inch in diameter and thus relatively fragile, it should be mounted safely. For example, it could be put into a small plastic pill bottle, in which numerous large air holes have been punched. When mounting the thermistor outdoors, place it where summer sun and winter ice cannot damage it.

The power transformer for the thermometer is a 16-volt center-tapped 400 mA unit. If you cannot find a similar transformer, you can order one directly from the company listed in the parts list. Capacitors C11 and C14 should be polystyrene types to assure low leakage, high stability and precise capacitance values. Finally, the display pinouts are for Litronix DL-747's; others can be used, but the pin connections may be different.

PARTS LIST

All resistors ¼ watt, 5% unless noted.

R1—75 ohms, 1 watt
R2, R4—120,000 ohms
R3—470,000 ohms
R5, R15, R17—1000 ohms
R6—47,000 ohms
R7—56,000 ohms
R8, R19—4700 ohms
R9—10,000 ohms
R10, R12—33,000 ohms
R11—18,000 ohms
R13—3900 ohms
R14—1000-ohm multiturn trimmer
R16—27,000 ohms
R18—560,000 ohms
R20—2700 ohms
R21, R22—2400 ohms
R23-R36—180 ohms
RT1—30,000 ohms precision thermistor (Fenwal UUT43J1. Write to: Customer Service, Fenwal Electronics, Framingham, MA 01701, for name and address of their distributor in your area.)
C1, C2—1500 μF, 35 volt, electrolytic
C3, C4—100 μF, 16 volt, electrolytic
C5-C9—0.1 μF, ceramic
C10, C11—1000 pF, polystyrene
C12—75-480 pF trimmer (Arco 466)
C13—30 pF, polystyrene
C14—0.47 μF, polystyrene
C15—150 pF, polystyrene
C16—1 μF, paper
C17—2.2 μF, 15 volt, tantalum
C18—.01 μF, ceramic
C19—470 pF, ceramic
D1-D4—IN4002
D5—IN4734A, 5.6 volt, 1 watt
D6-D9—IN914
IC1, IC3—LM311 voltage comparator
IC2—LM301A op-amp
IC4—555 timer
IC5, IC6—74190 synchronous up/down counter with mode control
IC7, IC8—7447A BCD-to-seven segment decoder/driver
IC9—LM309K voltage regulator, 5 volt
F1—¼ amp
J1—3-pin DIN jack
P1—DIN plug
Q1, Q3, Q4—2N3904
Q2—2N4393
S1—SPST toggle
T1—16 volt, center-tapped, 400 mA (Signal No. 241-4-16. Available from Signal Transformer, 1 Junius St., Brooklyn, NY 11212. $3.70 each, plus postage.)
DIS 1, DIS 2—DL-747 (Litronix seven-segment display.)
Misc.—Case, 2-conductor shielded cable (Belden No. 9452 or equal), miscellaneous hardware.

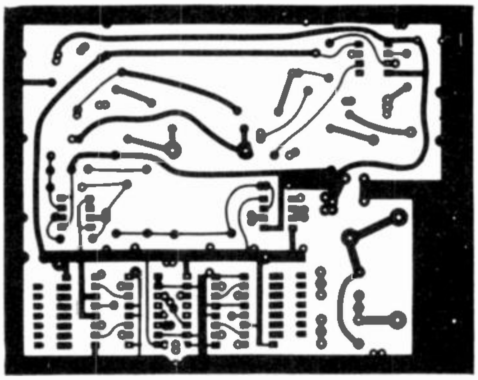


FIG. 4—FOIL PATTERN, shown half size.

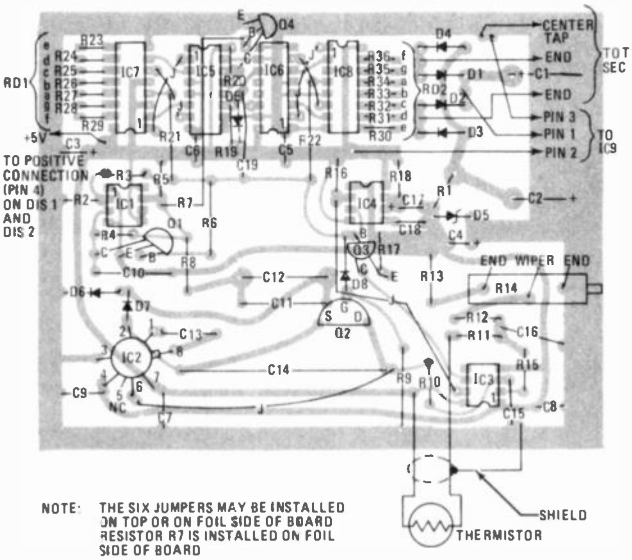


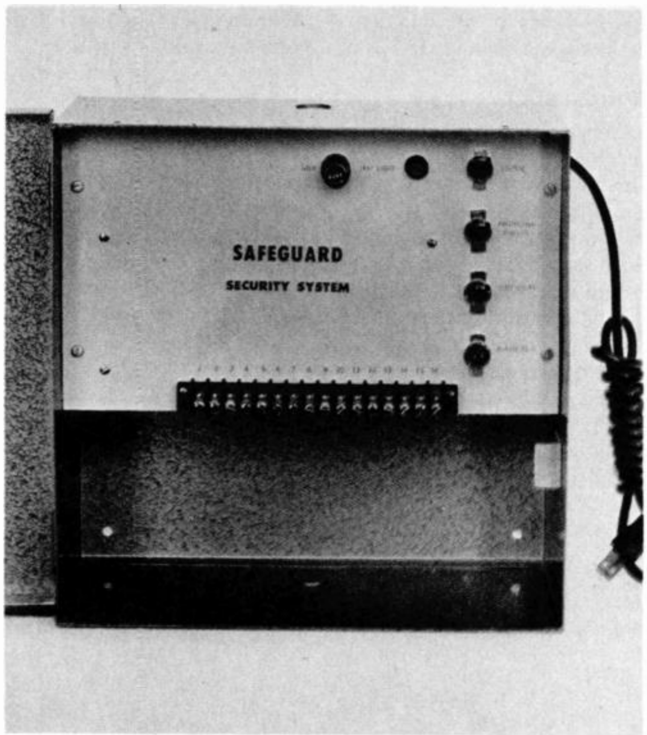
FIG. 5—COMPONENT PLACEMENT diagram.

Calibration

After construction, only the circuit calibration remains to be done. To adjust R14, use a 287K 1% metal-film resistor. Thermistor resistance at 0°F is theoretically 288K ±1.5%; the precision resistor is a very close match. By using the precision resistor, you can obtain an accurate 0°F temperature reference for the calibration. Connect the precision resistor into the circuit at the point where RT1 would normally be inserted. Apply power to the thermometer, and connect a high-imped-

continued on page 99

BEAT THE BURGLAR!



Build This Electronic Security System

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Special features of this security system include:

System test light that turns on any time the protective circuit is broken. Prevents false alarms—automatically indicates any tampering with circuit.

Automatic exit time delay. Just turn the system on; now you have three minutes before it activates the protective circuit. This eliminates the outside key-lock switch (which is hard to install) and there is nothing outside to be picked or tampered with.

Automatic accessory control to provide house power to turn on lights, siren, or other accessories.

Automatic entrance time delay. When you enter the building, just walk to the master control and turn the system off. There is an adjustable time delay of 10 to 45 seconds before the alarm sounds. You set this re-entry time to suit your needs—it's fully adjustable.

Day-Night circuit to switch in or out part of the alarm circuit to suit your changing needs.

Entrance-Exit time delay turn-off. This single switch eliminates the time delays so you get immediate response (alarm) when an intruder breaks in—to protect you while at home.

Automatic alarm turn-off. 8 to 10 minutes after the alarm starts it shuts itself off and automatically resets itself (just in case the burglar returns). This could be a very attractive feature for your neighbors if you decided to leave home for two

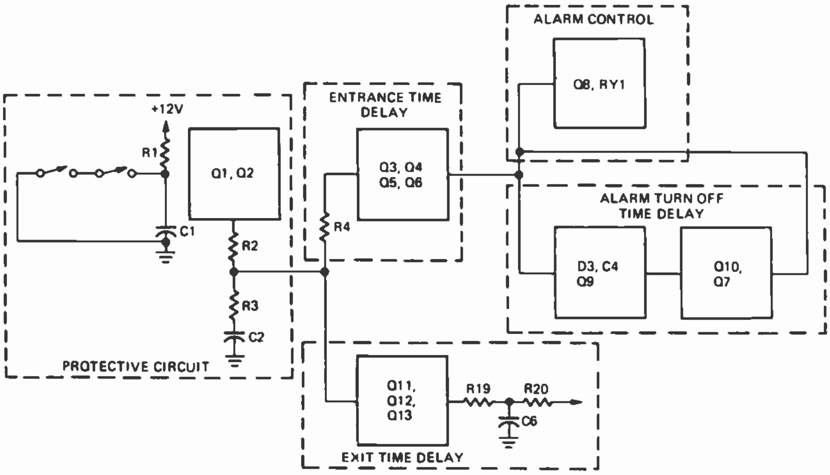


FIG. 1—BLOCK DIAGRAM DIVIDES the circuit up into its functioning sections, shows what transistors belong in each, and indicates connections to protective switches.

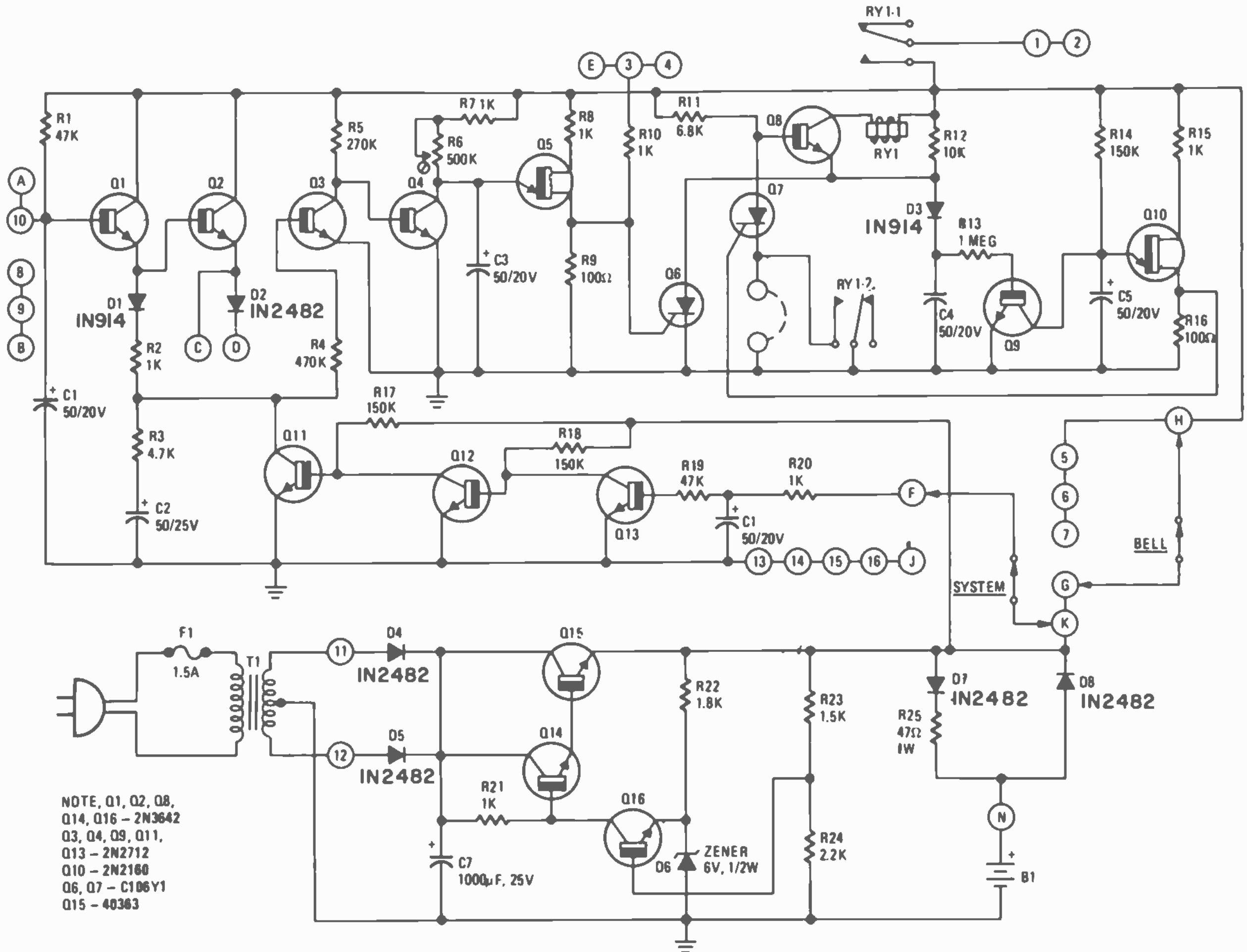


FIG. 2—COMPLETE CIRCUIT DIAGRAM of the Safeguard Security System.

PARTS LIST

All resistors are ¼-watt, 10%, unless noted.
R1, R19—47,000 ohms
R2, R7, R8, R10, R15, R20, R21—1,000 ohms
R3—4,700 ohms
R4—470,000 ohms
R5—270,000 ohms
R6—500,000-ohm, ¼ W, vertical-mount subminiature trimmer (Mallory MTC 55L1 or equal)
R9, R16—100 ohms
R11-6,800 ohms
R12—10,000 ohms
R13—1 megohm
R14, R17, R18—150,000 ohms
R22—1,800 ohms
R23—1,500 ohms
R24—2,200 ohms
R25—47 ohms, 1W
C1, C2, C3, C4, C5, C6—50 μF, 20V
C7—1,000 μF, 25V
D1, D3—1N914
D2, D4, D5, D7, D8—1N2482, 1A, 200 PIV
D6—Zener, 6V, ½ W, 10%
Q1, Q2, Q8, Q14, Q16—2N3642
Q3, Q4, Q9, Q11, Q12, Q13—2N2712
Q5, Q10—2N2160
Q6, Q7—C106Y1 (G-E)
Q15—40363 (RCA)
B1—batteries, (3) 4.5V alkaline rechargeable (RCA VS1563)
F1—fuse, 1.5A
RY1—Relay, DPDT, 12V DC, PC board mount (Potter Brumfield R10-E2-Y2)
L1—10V DC (Eldema ICE 5913)
Misc.—16-connector terminal strip (Cinch 16-140-Y), four SPDT toggle switches, metal spacers, panel, grommets, battery clips, key lock, metal cabinet.

Note: The following items are available from Electronic Products Co., Box 160412, Sacramento, CA 95816: Circuit board No. 627, $9.20.
Complete kit of all parts, circuit board, panel, metal cabinet and instructions. No. 627K, $65.00 plus postage for 10 lbs.

weeks and the alarm tripped while you were gone.

Automatic stand-by power in case the normal house power is interrupted for any reason. Rechargeable batteries are a feature and the recharging circuitry is built in and fully automatic.

Provision for fire sensors and panic button.

How it works

The block diagram of Fig. 1 shows the functions of the various parts of the circuit. The complete schematic appears in Fig. 2.

When protective circuit switches (Fig. 1) are closed, the base of Q1 is held at ground potential and the transistor remains off. When the protective circuit is broken, the bias provided by R1 turns on Q1 and charges C2 through R2 and R3. The only discharge path for C2 is through R3, R4, and the base-emitter junction of Q3. This causes Q3 to turn on, bringing the base of Q4 to ground potential and turning Q4 off. With Q4 off C3 (Fig. 2) is allowed to charge through R6 and R7 to the point where unijunction transistor Q5 fires and turns on SCR Q6. The R-C time constant of R6R7/C3 is the re-entry time delay.

The exit time delay is provided by the system switch (closed when system is off) which charges C6. Transistors Q11, Q12, and Q13 hold C2 at ground potential until C6 discharges through R19 and the base-emitter junction of Q13.

The 10-minute alarm turn-off works as follows: Transistor Q8 is held "on" by R11. However, relay RY1 cannot turn on because the emitter of Q8 does not have a complete path to ground until SCR Q6 is turned on. When Q6 turns on, RY1 acti-

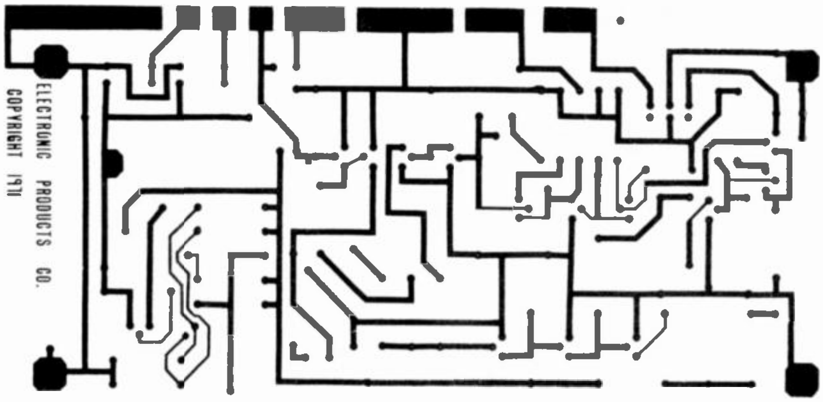
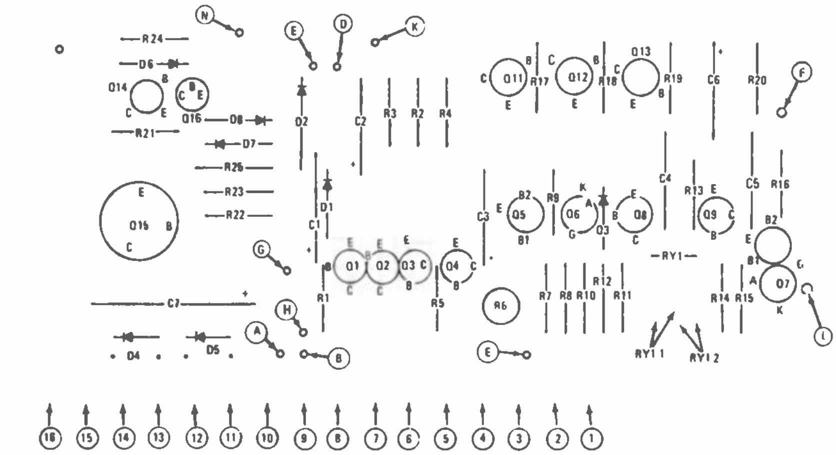


FIG. 3—PRINTED CIRCUIT BOARD, reduced to one-half its actual dimensions.



NOTE·
·THESE TERMINALS CAN BE USED FOR 2 MORE DIODES TO MAKE FULL-WAVE BRIDGE WHEN CENTER-TAPPED TRANSFORMER IS NOT AVAILABLE

FIG. 4—COMPONENT PLACEMENT diagram.

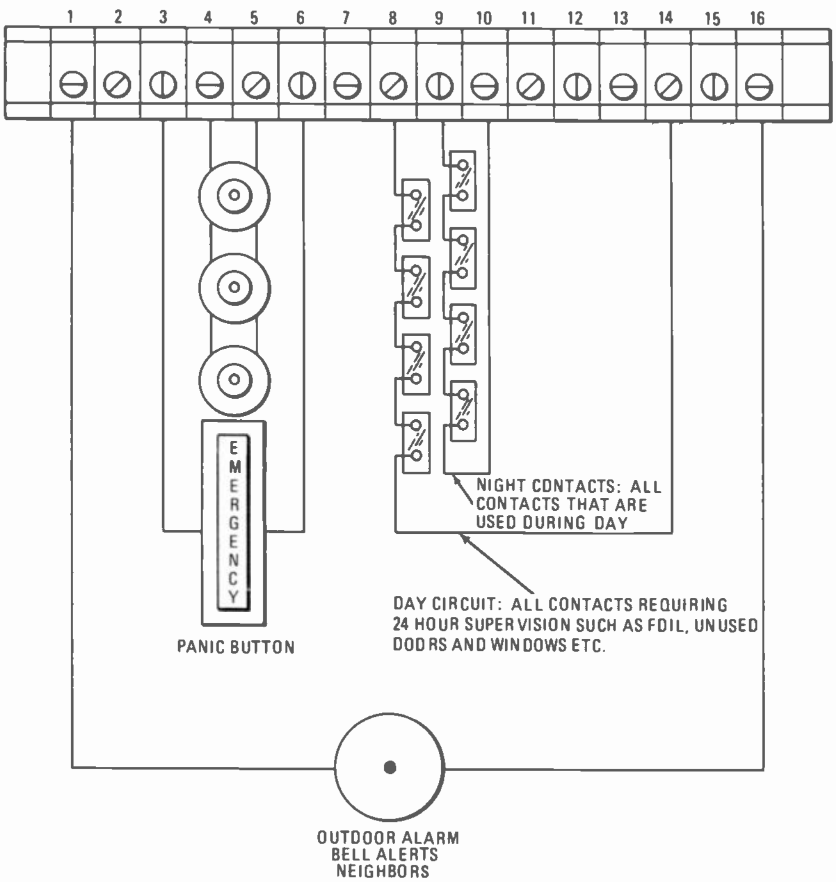


FIG. 5—THE TERMINAL STRIP. Numbers along top match circled numbers in schematic.

vates closing switches RY1-1 and RY1-2 and the alarm sounds. Prior to activation of Q6, capacitor C4 was charged to full potential through R12 and D3. When Q6 activates, it also back-biases diode D3 and the only discharge path for C4 is through R13 and the base-emitter junction of Q9. With Q9 on, C5 cannot charge and will remain at ground potential. When C4 has discharged, Q9 turns off. C5 charges through R14 and fires unijunction Q10 which triggers the SCR 7. Negative bias is then applied to Q8's base through Q7 and RY1-2. Q8 turns off, RY1 turns off, Q6 turns off because there is no longer a conductive path except through R12, which does not pass enough current to keep it turned on. When RY1 deactivates, switch RY1-2 opens, which turns off Q7. All components are now in the same active state as before the alarm.

The power supply design is straightforward and easy to follow. No heat sink is required for Q15 if the components specified are used. Batteries charge through D7 until their voltage is equal to the supply voltage, at which time diode D7 becomes back-biased, preventing further charging. R25 is a current-limiting resistor to protect the batteries. Diode D7 remains back-biased until supply voltage falls below battery voltage, at which point the batteries then supply power to the circuit.

Putting it together

Construction is straightforward and parts layout is not critical except in the SCR gate circuit, in which leads should be kept as short as possible. If you plan to etch and drill your own circuit board, the layout and parts placement are shown in Fig. 3 and Fig. 4.

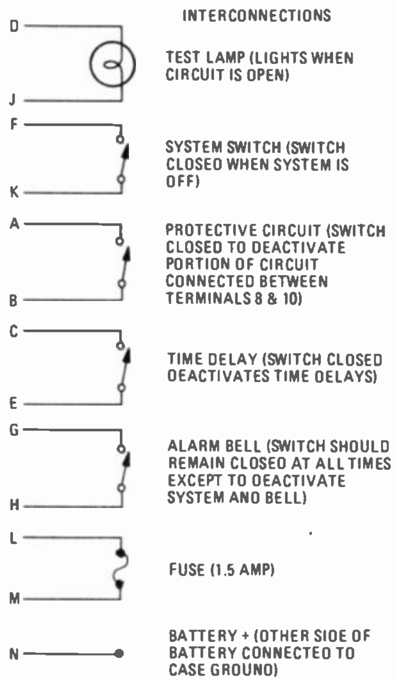
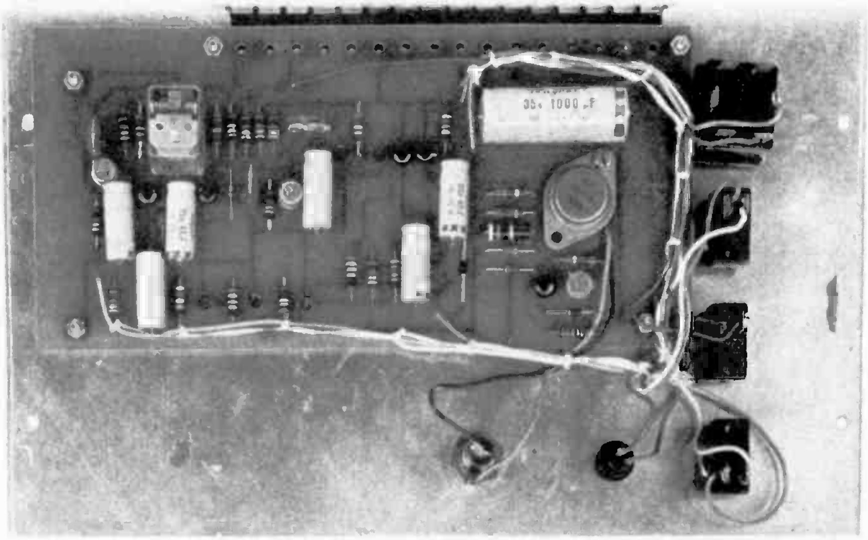
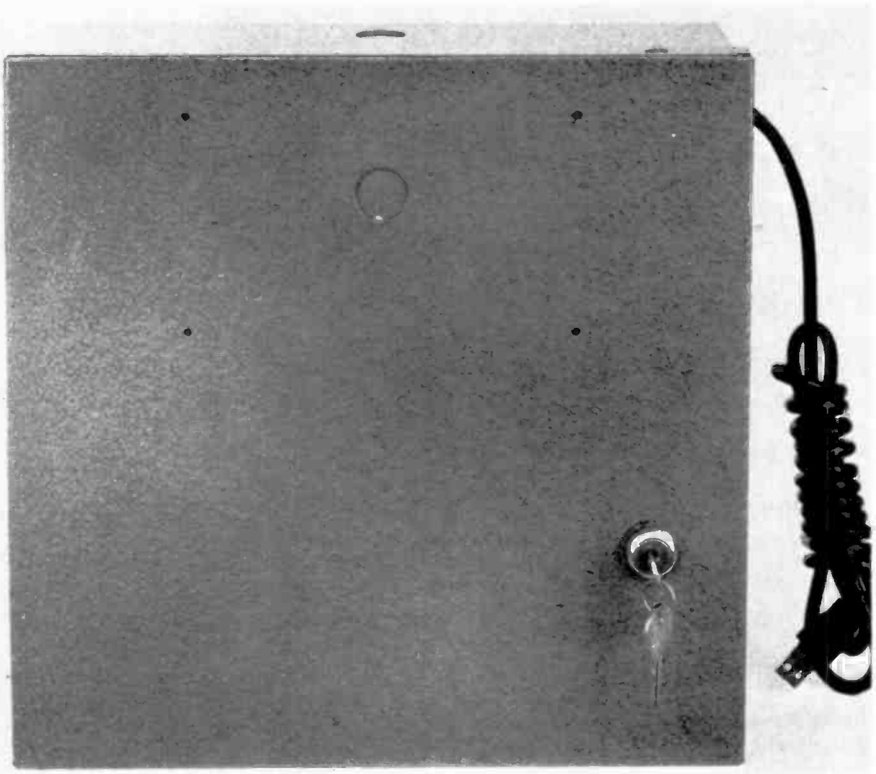


FIG. 6—INTERCONNECTIONS to items on panel. Letters match those on schematic.



REAR VIEW OF CONTROL PANEL shows circuit board and switches. Terminal strip is mounted on bottom edge of PC board.



THE ELECTRONIC SECURITY SYSTEM is housed within a steel enclosure. A key lock prevents tampering.

Insert resistors and capacitors in board and solder, then insert diodes and transistors and solder. This helps prevent excessive heat on the semiconductors. Next, connect the terminal strip to the foil side of the printed circuit board with 4-40 machine screws. Use one 4-40 nut and three washers as spacers between the terminal strip and the printed-circuit board so the ends of the leads on the terminal strip do not quite pass through the board. The metal leads on the terminal strip can now be soldered to the printed-circuit board.

The numbered locations on the schematic correspond with the pin numbers of the terminal strip (Fig. 5) and the printed circuit board layout. The lettered locations on the schematic and the printed circuit board layout are the interconnections for the test lamp, fuse, and switches and are detailed in Fig. 6.

Connect wires for the switches, fuse, and light to the printed circuit board, mount the board on the back of the metal panel, using 4-40 machine screws and two 4-40 nuts as spacers. Check to be sure that no leads from printed-circuit board or the terminal strip touch the metal panel. Mount the fuse, light and switches, dress wires around edge of printed-circuit board and connect to appropriate points. Mount transformer in cabinet with the center tap of the transformer secondary going to cabinet ground.

The connections for the various sensors to the terminal strip are detailed in Fig. 5. Remember when checking this system out, capacitor C2 must become fully discharged between tests. So you must turn the SYSTEM switch on between tests and wait the full 3 minutes (exit time) before the next test. Turning the BELL switch off will *not* discharge C2. Unless you turn the SYSTEM switch off and then back on you may get a false alarm.

Special Note: The time before the alarm turns itself off may be reduced or increased by changing the value of R13 and to some extent by changing the value of R14. Experiments with R13 show it can be increased to 5 megohms providing the beta of Q9 (the particular 2N2712 you use for this function) is not drastically different from normal for this unit.

For accessory control (house lights, siren, etc.) connect a 12-volt relay to terminals 2 and 15. **R-E**

Students to learn programming with hand-held calculators

A course for teaching fundamental programming with small calculators to students in high school was described to the recent annual conference of the National Council of Teachers of Mathematics by speakers from Texas Instruments.

Designed by the University of Denver Mathematics Laboratory and oriented to a series of motivational activity lessons, the course materials have been tested with both teachers and students. The format allows a teacher to move the students into simple straightforward programming quickly. They then proceed to advanced program techniques involving conditional and unconditional transfers, loops and subroutines. At each of these points the teacher selects applications or problem situations at various mathematical levels, to help the students understand the concepts covered.

The great advantage of the hand-held calculator as a learning tool is that it is readily available to teachers and students who would otherwise have to wait, after writing programs, for access to larger computers. Also, the initial and continuing costs for a computer-based course would be orders of magnitude greater than for one that uses calculators.

The course will be available late in 1977. Contact your local TI dealer or write: TI, Box 5012, Dallas, TX 75222

Build This

10 Function Digital Clock

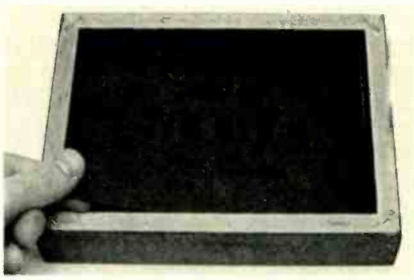
Part II. *Construction details for a multi-function digital clock that provides a simultaneous display of the time, date, alarm and countdown timer*

JEFFREY G. MAZUR

LAST MONTH, IN THE FIRST PART OF THIS article, we provided the complete schematic diagram and a detailed description of how the circuit worked. This month, the article concludes with the foil patterns and construction details.

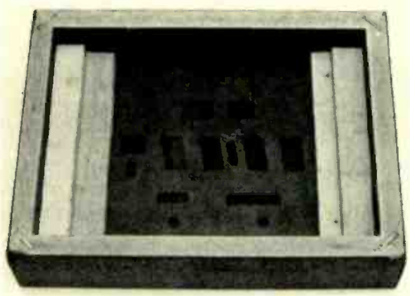
Construction

The clock is built on two separate printed circuit boards. A double-sided board holds all the clock circuitry, and a single-sided one contains the readouts. The foil patterns for the main board are shown in Figs. 5 and 6. The foil pattern for the display board is shown in Fig. 7. The two boards are connected by a 32-conductor cable. Since there are many connections on both sides of the clock board as well as feed-through holes for interconnecting the two sides, plated-through holes are a must on this board.



AFTER MOUNTING red plastic to the front of the frame, add a piece of black cardboard with cutouts for the displays.

Mount the power transformer directly on the clock board or, for a slimmer package, use a wall-type AC adapter transformer. If the adapter is used, the



MOUNT SUPPORTS for the two PC boards for the proper spacing.

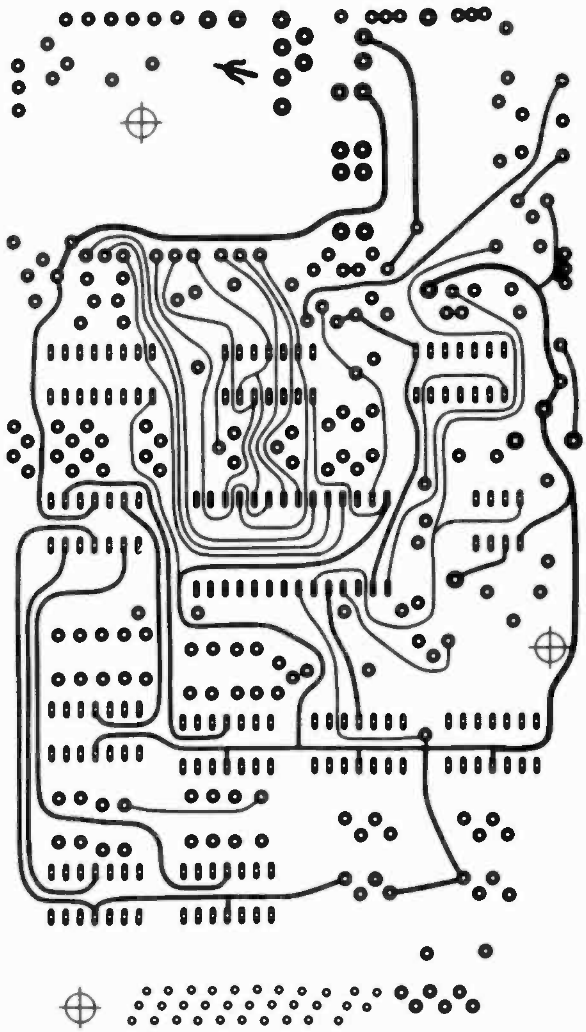


FIG. 5—FOIL PATTERN of component side of double-sided clock board. Actual board measures 7 × 4 inches.

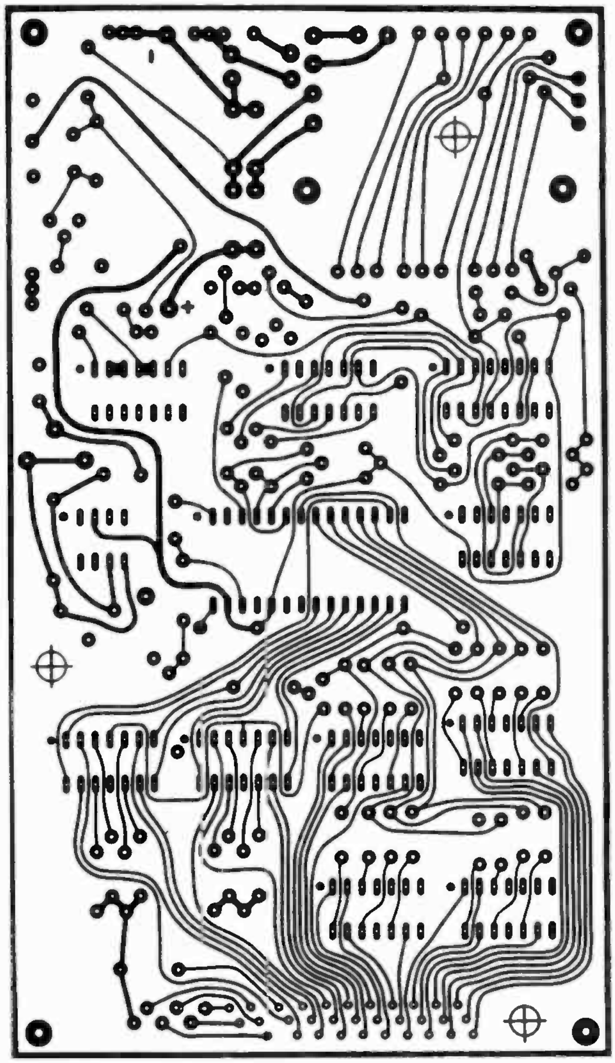


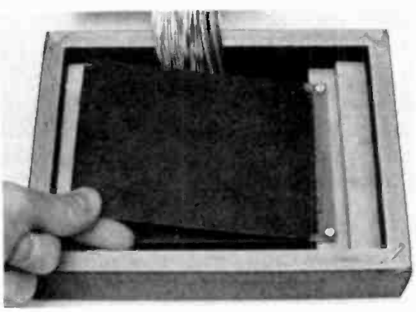
FIG. 6—FOIL PATTERN of bottom side of double-sided clock board.

two boards fit neatly into a standard 5 × 7-inch picture frame.

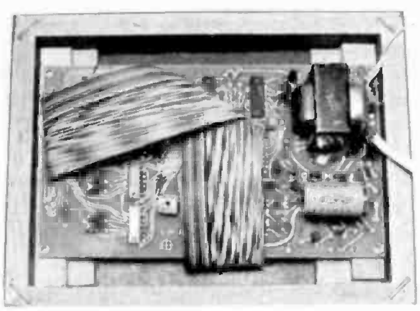
Before starting construction, decide on which options will be used. If a 24-hour format is desired, install D28. (See Fig. 8.) Resistors R17, R18, R26, transistor Q2 and the AM/PM digits can then be omitted if desired. For crystal timebase operation, omit R1, D1 and C2. If the power-line frequency (50 or 60 Hz) is going to be used as the timebase, *do not* install IC12. For 50-Hz operation, add D29. Temporarily place a jumper where resistor R5 would normally go. The component placement diagram for the display board is shown in Fig. 9. Mount the small alarm and timer displays on Molex pins to raise them up to the same height as the other displays. This gives a uniform appearance and reduces parallax problems when mounting the board behind the front panel. Make the front panel by cutting holes in a piece of black cardboard and mounting it to a solid piece of red plastic.

Mount the remaining components, including the 28-pin socket for IC11. Do not install IC11 at this time. Connect the display board to the clock board using ribbon cable. Then wire up all switches, being careful to install the diodes connected to them properly. Mount the TIME SET/DATE SET switch on the back or where it won't be accidentally moved. Mount the rest of the switches on the front, back or sides.

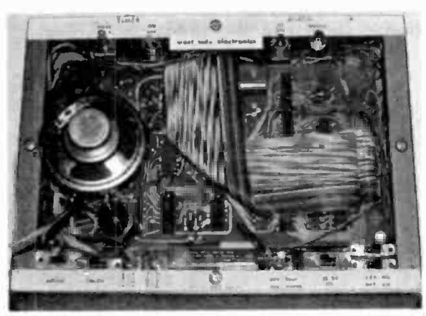
Check the boards carefully for shorts and proper component polarity. When everything looks in order, remove IC11 from its protective carrier and carefully install it in its socket. Then apply power. The display may register all 8's; this is a



INSULATE the back of the display board with a piece of cardboard.



CLOCK BOARD is mounted over the display board.



REAR VIEW of completed clock with clear plastic rear cover.

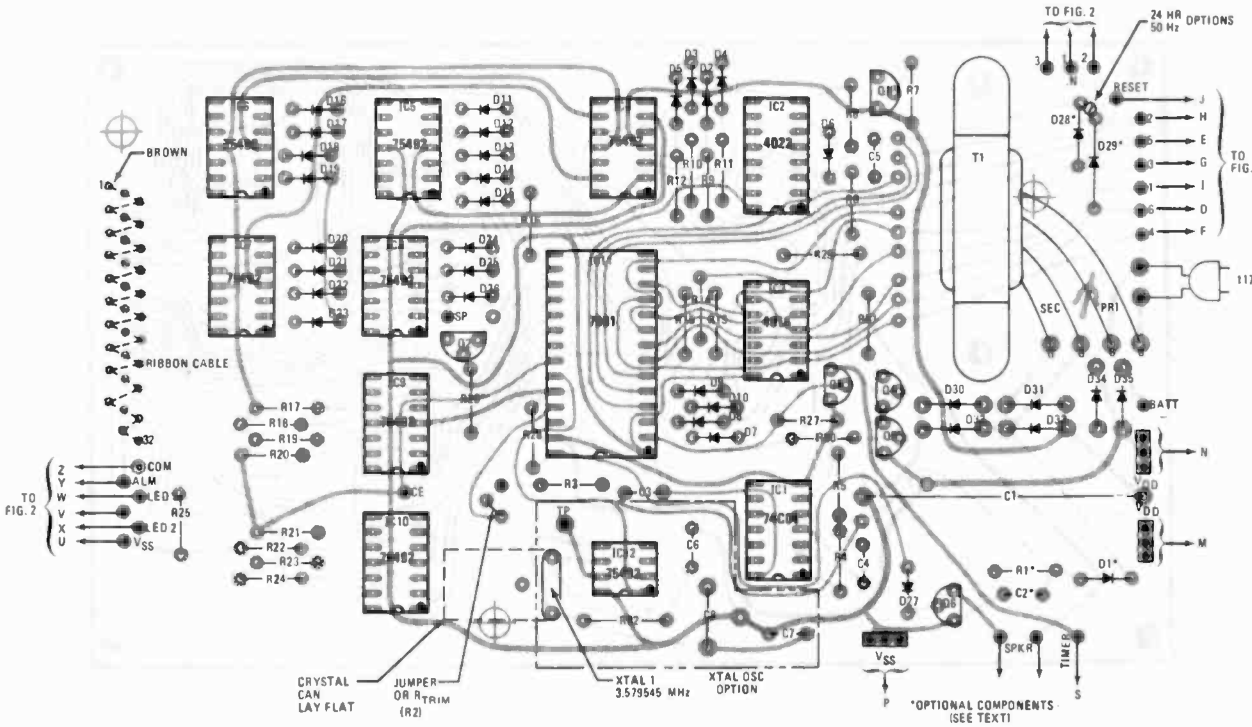


FIG. 8—**COMPONENT PLACEMENT** diagram of clock board.

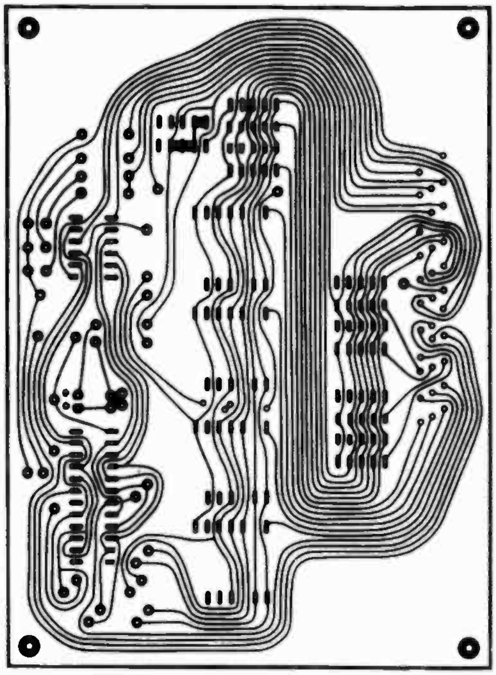


FIG. 7—FOIL PATTERN of single-sided display board. Actual board measures 4 × 5½ inches.

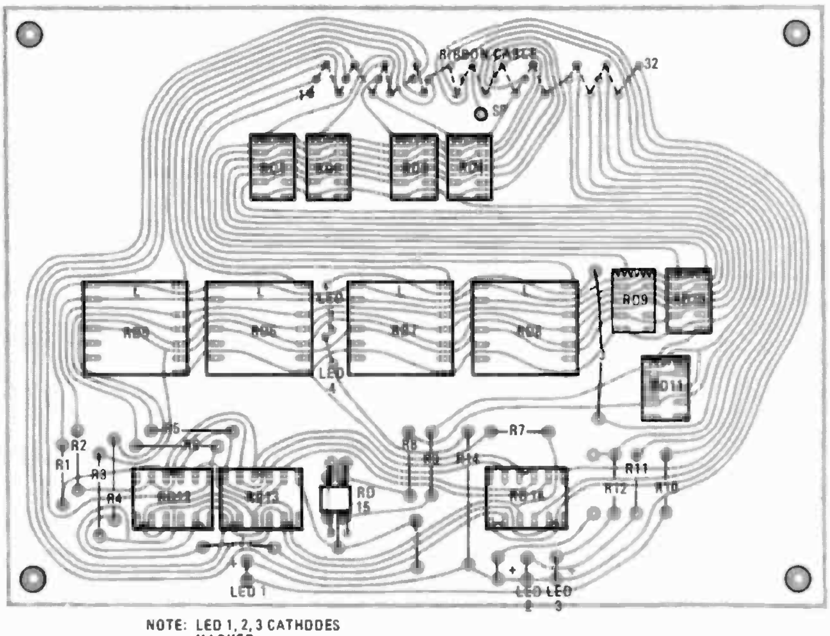
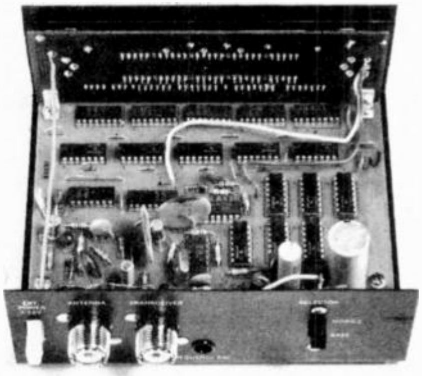


FIG. 9—**COMPONENT PLACEMENT** diagram of display board.

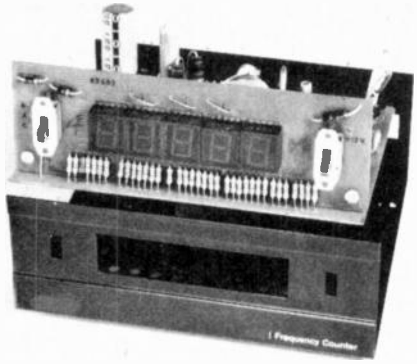
normal reaction. Set the date, time, alarm and timer displays using the SET and MINUTES/HOURS advance switches. Setting the time will automatically set the seconds to zero. The seconds will hold at zero until switching to another mode. This permits you to synchronize the clock to a standard time source such as the phone company. When setting one of the functions (time, alarm, date, etc.), all but the time display will be blanked.

If there is any flicker in the display or in certain segments, the external multiplexing frequency or the blanking time may be off. The output of the scanning oscillator (IC1) should be about 140 Hz. If this checks OK, then increase the value of capacitor C5 (blanking time) until no misreading occurs.

If the crystal timebase option is not used, the clock will revert to its internal backup oscillator in case of a power failure. This oscillator can be adjusted by replacing the jumper at R5 with a 5K potentiometer or a selected resistor. The value of R5 should be such that the D1 output of the 7001 (pin 8) is 1.05 kHz for 60-Hz or 875 Hz for 50-Hz operation. For short power interruptions (up to several hours), use a 9-volt battery. For longer protection, use eight AA-cells or a 12-volt lantern battery depending on available space. If rechargeable cells such as Ni-Cad's are used, then a trickle charge can be obtained by adding a resistor across D35. For DC operation in a car, boat, etc., connect the power across C1 (omit T1). Use a 9-volt backup battery to take over if the vehicle battery drops too low, for instance during starting. **R-E**



Build 30-MHz CB FREQUENCY COUNTER



Two circuit boards make this an easy unit to assemble. An accessory power supply adds line voltage operation

GEORGE SANTI

THERE IS ONLY ONE WAY THAT A CB OPERator can be certain that his CB transmitter is always operating on frequency, and that's by monitoring its output with a frequency counter whenever he is on the air. The frequency counter described in this article makes it easy for the CB'er to do just that. It can be used in the car with a mobile unit or at home with a base station.

The counter reads frequencies over a range of 5 Hz to 30 MHz. The display consists of five large (1½-inch high), bright LED readouts. A mode switch lets you select kHz or MHz readings. Once installed, the unit works automatically when you transmit. And while you're listening, only the decimal point of the display remains lit, reducing current drain to less than 70 mA.

For CB'ers, all 40 CB channels are covered. The unit can be mounted in a car and the frequency counter connects between the CB transmitter and the antenna by using standard SO-239 in-line connectors.

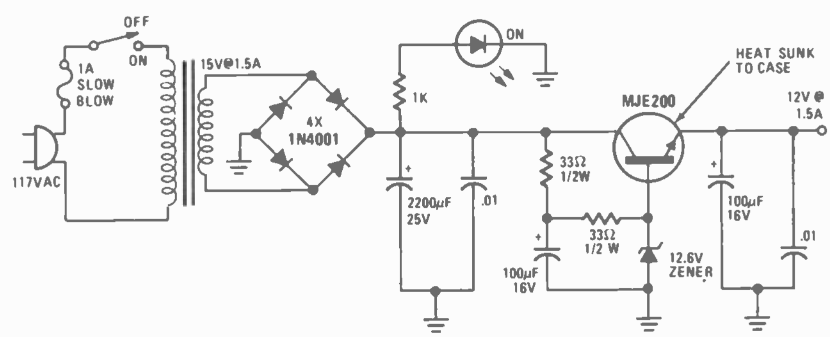
To use the counter with a base station, an additional 117-volt AC supply is needed. A schematic for such a supply is shown and an assembled version is available as described in the parts list.

Amateur radio operators can also use the counter to check their transmissions on all bands through 10 meters. Obviously, this is particularly important if he is using a VFO.

For experimenters, this counter offers an inexpensive accurate (±10 PPM) test instrument. It can be driven directly with 5-volt TTL signals.

SPECIFICATIONS

INPUT SENSITIVITY: 500 mV RMS-DC to 3MHz, 500 mV RMS linearly increasing to 5 VRMS-3 MHz to 27 MHz.
IMPEDANCE: 22,000 ohms at low frequencies, 200 ohms at 27 MHz.
FREQUENCY RANGE: 5 Hz to 30 MHz.
DISPLAYS: Five 0.5'' high LED's
OVERLOAD: Diodeprotected input
ACCURACY: ±1 digit ±time base stability
READOUT: kHz or MHz
TIMEBASE CRYSTAL FREQUENCY: 10 MHz, ±10 PPM accuracy, ±1 PPM stability
POWER REQUIREMENTS: 8-14 VDC at 1.2A. For base-station operation use 117 VAC regulated power supply (minimum 1.5A rating)
DIMENSIONS: 2⅞''H, 5⁵⁄₁₆''W, 6⅛''D
WEIGHT: 1.6 pounds



POWER SUPPLY provides 12 volts DC to operate the frequency counter off the 117-volt AC line.

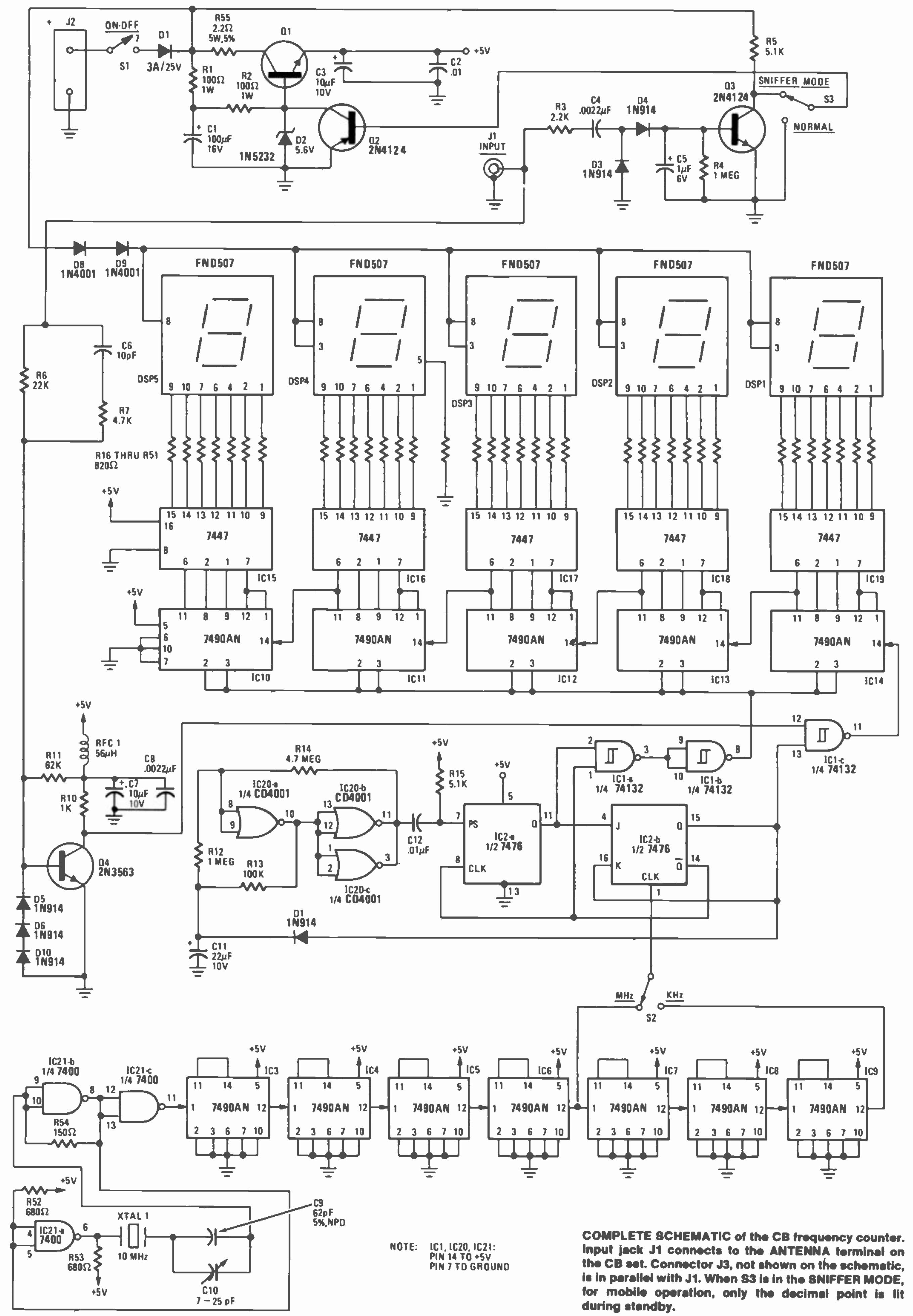
Building your counter

The unit is easy to build. All parts with the exception of front and rear panel switches and connectors mount on the two circuit boards. One board is the main circuitry, the other houses the display devices. Both boards are one-sided and the foil patterns printed here are actual size. Boards are also available from the supplier listed in the parts list.

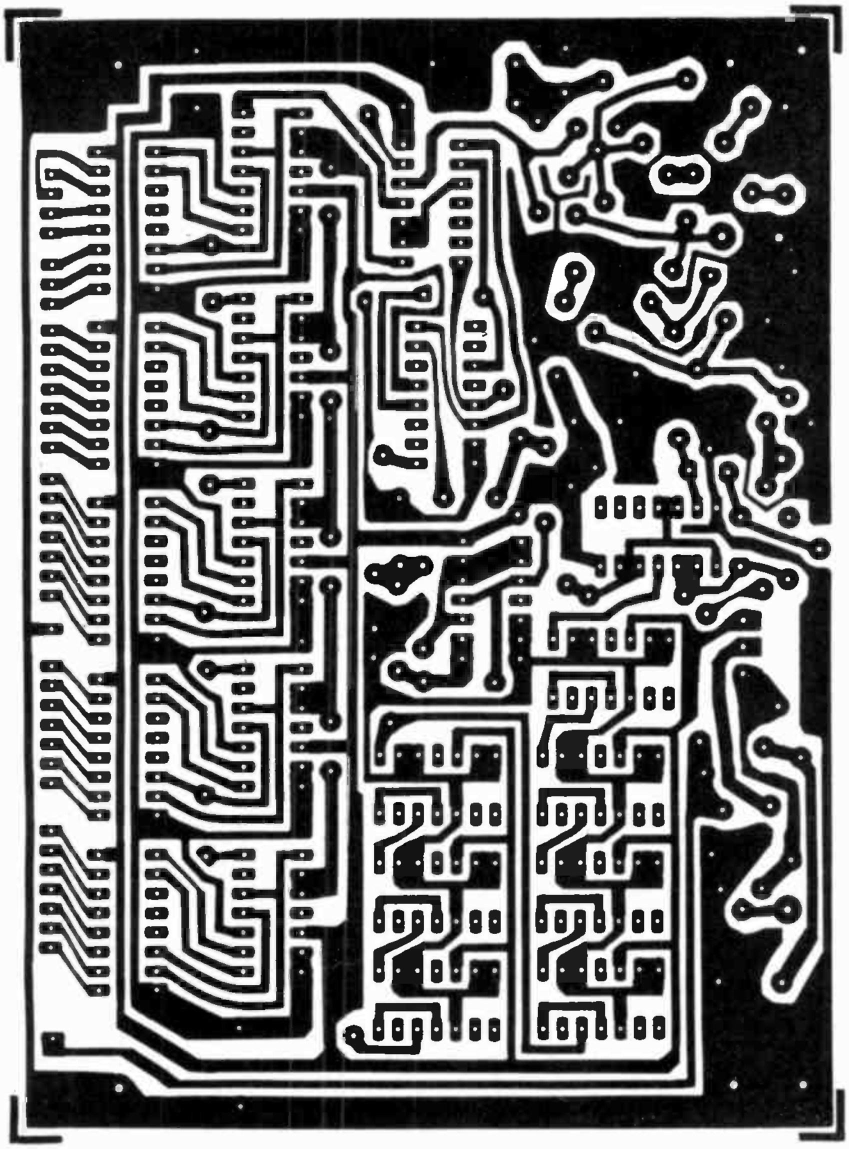
The resistors mounted on the display board have only one lead connected to that board. The other end of these resistors mate with matching holes in the main circuit board and interconnect the two boards. Once soldered into place, the two boards sit at right angles to each other and are firmly fastened together.

No special construction tips are needed. But do take care not to let solder blobs short foils, especially when soldering the IC pins into place.

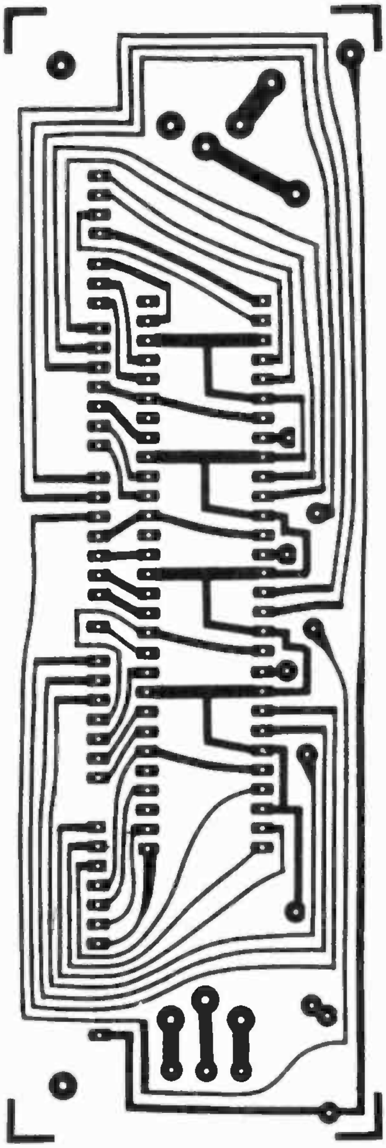
One point; you might want to try



COMPLETE SCHEMATIC of the CB frequency counter. Input jack J1 connects to the ANTENNA terminal on the CB set. Connector J3, not shown on the schematic, is in parallel with J1. When S3 is in the SNIFFER MODE, for mobile operation, only the decimal point is lit during standby.



FULL SIZE FOIL PATTERN for the main circuit board of the CB frequency counter. This one-sided board should be relatively easy to make.



FULL SIZE FOIL pattern for the display board makes it easy to duplicate.

PARTS LIST

All resistors ¼-watt 5% unless noted
R1, R2—100 ohms, 1W, 10%
R3—2200 ohms
R4, R12—1 megohm
R5, R15—5100 ohms
R6—22,000 ohms
R7—4700 ohms
R8, R9—not used
R10—1,000 ohms
R11—62,000 ohms
R13—100,000 ohms
R14—4.7 megohms
R16 thru R51—820 ohms (35 resistors)
R52, R53—680 ohms
R54—150 ohms
R55—2.2 ohms, 5W, 5%

Capacitors
C1—1,000 μF, 16V, electrolytic
C2, C12—.01-μF disc
C3, C7—10 μF, 10V, electrolytic
C4, C8—.0022-μF disc
C5—1 μF, 6V, electrolytic
C6—10-pF disc
C9—62-pF, 5% NPO, disc
C10—7-25-pF trimmer (Erie)
C11—22-μF 10V, electrolytic

Diodes
D1—3A, 25V or higher power rectifier
D2—1N5232B, 5.6V Zener diode
D3, D4, D5, D6, D7, D10—1N914
D8, D9—1N4001
DSP1, DSP2, DSP3, DSP4, DSP5—FND507 (0.5-inch high 7-segment LED display 15mA per segment)
F1—3A 3AG
J1—coax connector
J2, J3—2 connector male power jack
RFC1—56-μH choke

Integrated circuits
IC1—74132—Quad 2-input NAND Schmitt Trigger
IC2—7476—Dual J-K Master-Slave flip-flop
IC3 thru IC14—7490AN—Decade Counter
IC15 thru IC19—7447 BCD-to-seven-segment decoder drive
IC20—CD4001—Quad 2-input NOR gates
IC21—7400—Quad 2-input NAND gate
Q1—2N40631
Q2, Q3—2N4124
Q4—2N3563
S1—SPST switch
S2, 3—SPDT switch
XTAL1—10 MHz ±10 PPM.
Circuit Boards
Case
Hardware

The following parts are available from Guardsman Electronics, Box 215, Brooklyn, NY 11207.
Etched and drilled circuit boards (2); $11.00 postage prepaid.
10-MHz crystal; $3.50 postage paid.
Trimmer capacitor; $6.50 postage paid.
Set of 2 circuit boards, crystal and trimmer capacitor; $19.00 postage paid.
Complete kit of all parts including custom cabinet; $59.95 plus $1.50 postage and handling.
Assembled unit; $99.95 plus $1.50 postage and handling.
Power supply (assembled) 13.6VDC, 2.5A, $18.00 postage prepaid.

continued on page 50

Be the "New Professional" in electronics

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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.

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

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

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

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

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

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

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

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Career Training at Home

totype construction, breadboarding, test and measurement procedures, circuit operation and behavior, characteristics of electronic components and how to apply integrated circuits.

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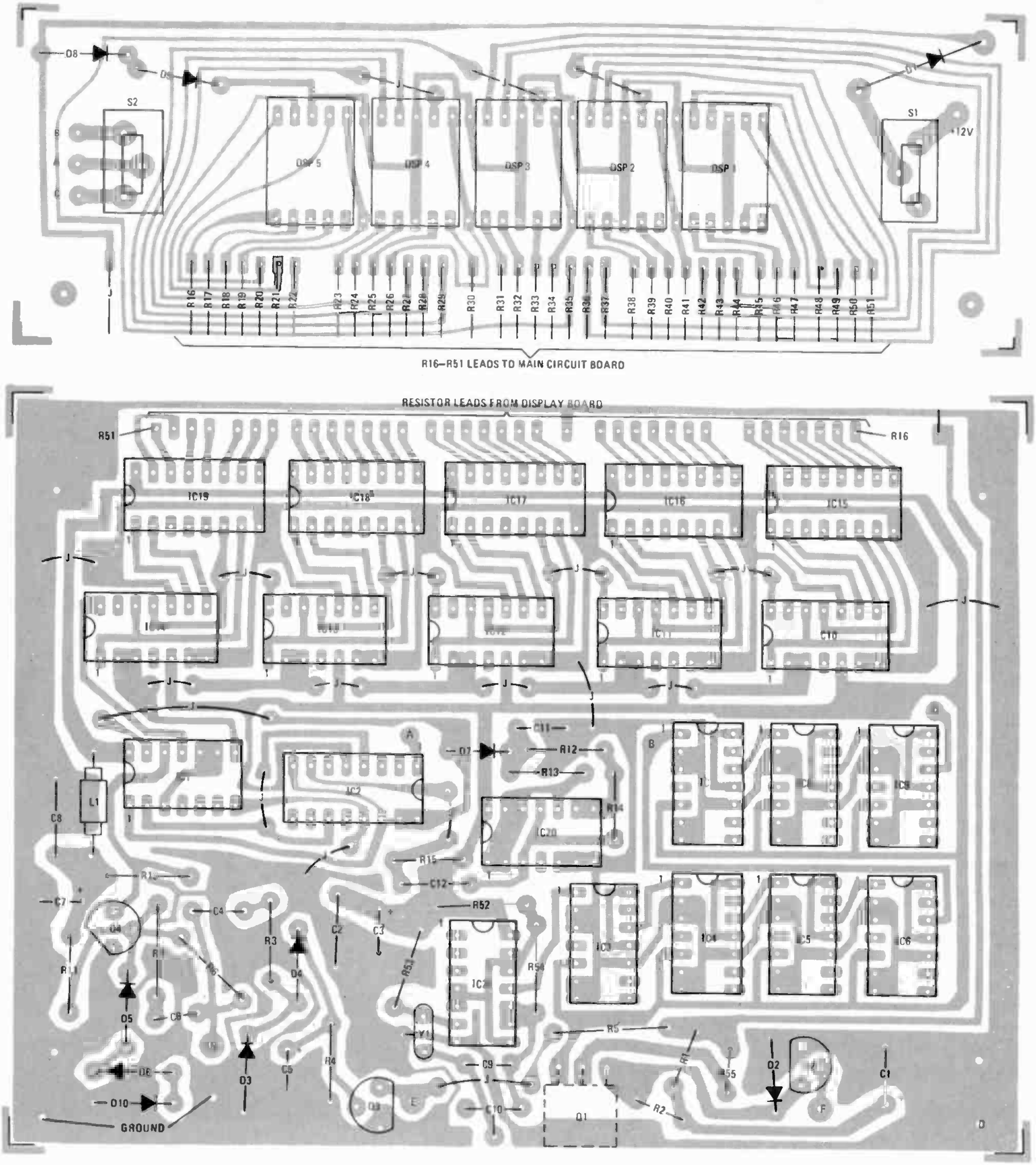


PARTS PLACEMENT DIAGRAMS shows exact posiions for parts mounting on both the main and display circuit boards.

continued from page 45

using IC sockets. Don't do it for this project if you intend to use the counter in a vehicle. Over a period of time the vibration will loosen the IC's and the counter will suffer from all kinds of strange problems. However, if you are using the counter with a base station, you can use IC sockets if you wish.

Installation

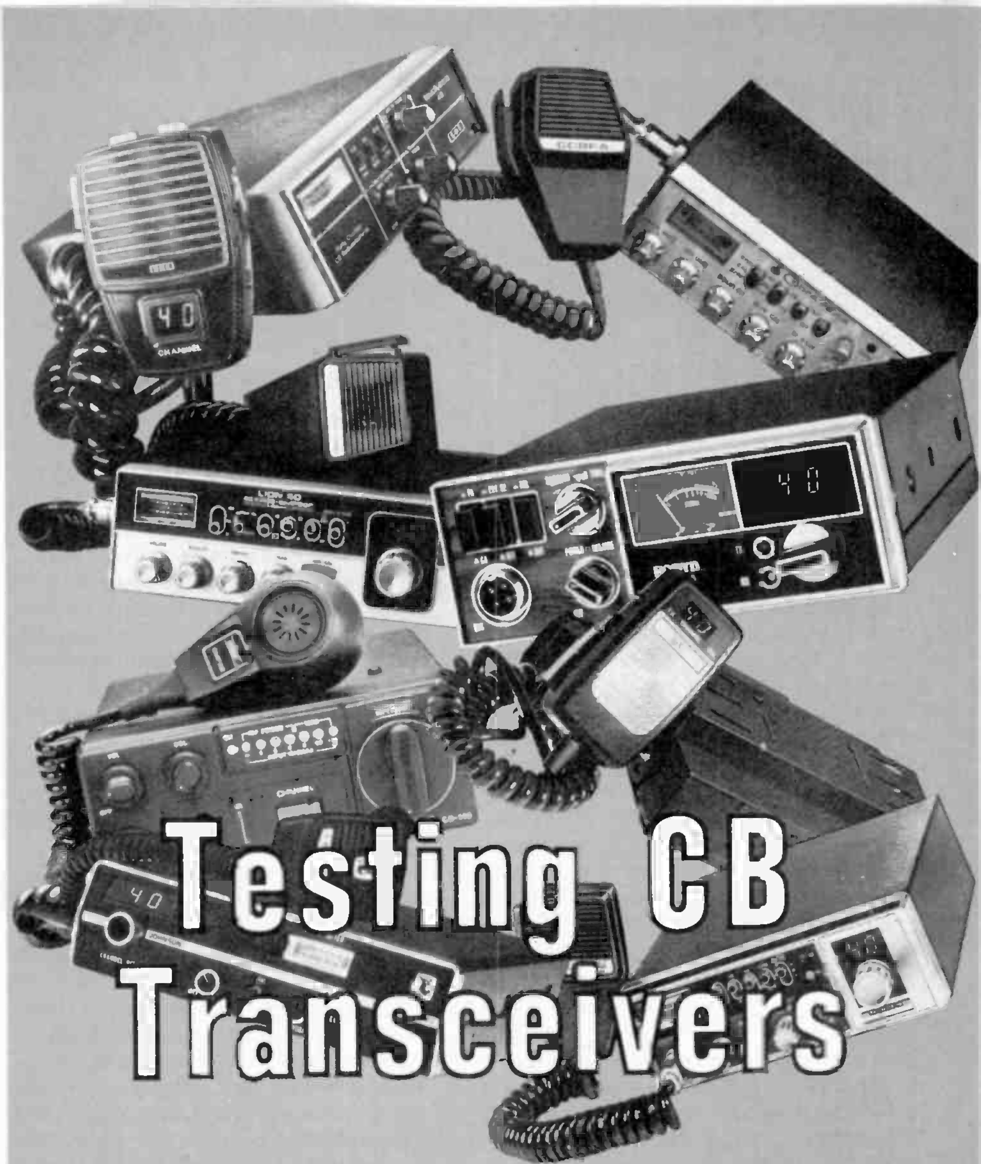
Installing the counter in a car is a relatively simple matter. It can be installed in any convenient location using mounting brackets. The most convenient location is usually under-dash as close to your CB rig as possible.

After mounting, the next step is to connect the counter to the car's 12-volt electrical system. To do this, assuming a negative-ground electrical system, connect the negative lead from the counter to the metal frame of the car and the positive lead to a fuse in the fuse box. If you would like the counter to turn off with the ignition switch, tie into a fuse that handles a switched accessory. For positive-ground electrical systems, reverse the connections.

Connect the antenna to the coaxial connector marked ANTENNA on the back panel of the counter and the CB rig to the one marked TRANSCEIVER. Finally, place the slide switch on the back panel in the MOBILE position and your all set.

A base installation is basically the same, minus the mounting headaches. Power is taken from the separate power supply.

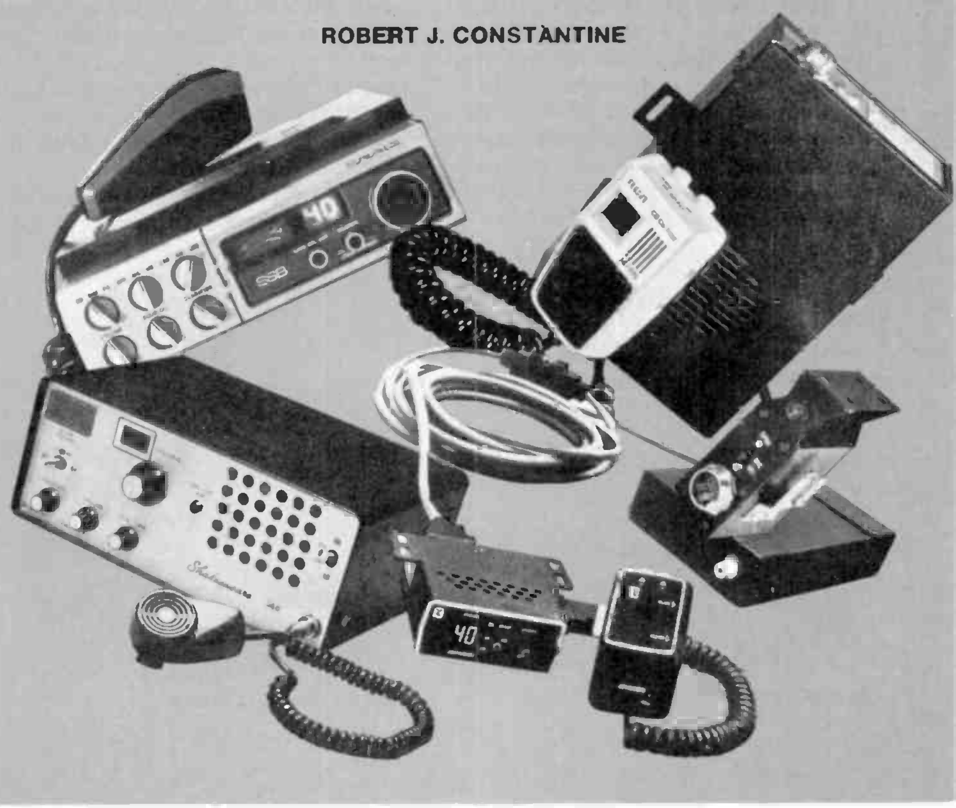
We think you'll find this an interesting and useful project. **R-E**



Testing CB Transceivers

If we wanted to find the very best CB transceiver, what tests should we make? Here are 24 that really tell you how a CB radio performs.

ROBERT J. CONSTANTINE



THE BASIC CLASS-D CITIZENS RADIO service has been around for many years, existing mostly as the refuge of gypsy cabs, toy-like hand helds and would be Hams. However, the explosion in popularity begun by truckers during the 1974-75 oil shortage and the 55-MPH speed limit has brought a tremendous influx of users with little or no previous two-way radio experience and a great many questions.

Adding to the confusion is the similar influx of CB manufacturers each elbowing for their share of the market the boom created. Many of them with the usual kind of over-zealous claims that seem to flourish in any gold rush economy. The fact that most CB sets are sold through non-technical retailers such as department and discount stores, automotive stores and truck stops, and marine hardware stores and tackle shops only compounds the confusion over quality and value even further.

Especially in the area of measuring and predicting performance in the real world, meaningful information has been non-existent. As any field service technician would be quick to point out, measurements made on the sterile bench of the testing laboratory can seem to be distantly related phenomena when compared to actual performance in the hostile environment of mobile, portable and marine service.

Mobile and marine service are especially demanding of a set's electrical and mechanical stability, and circuits and components designed to be economical performers in the living room or office are frequently disappointing and often unreliable when in equipment intended for use in the field, car or boat.

CB electronics in particular suffer in this respect because they must be built to an attractive price for one of the most competitive markets in the electronics industry. Frequently, the most unfortunate consequence of this is a lavish distribution of the manufacturing budget towards those aspects of appearance that enhance a product's appeal on the retailer's shelf, invariably at the expense of more sturdy internal construction that might enhance environmental and mechanical stability or assure long term durability.

Temperature & performance

Temperature stability is one of the most frequently overlooked causes of poor communication. In the United States, seasonal temperature extremes of 0°F to 125°F in direct sun surface temperatures are not at all uncommon. Yet many CB rigs currently in production will not operate over this range without drifting beyond legal (and useable) frequency tolerance.

Likewise a transceiver, to be trustworthy, must be able to operate under the widest power supply voltage variations

COBRA 29XLR

SBE TOUCH/COM 40

PEARCE-SIMPSON LION 40

experienced. A typical automotive electrical system in good condition delivers about 13.6VDC when the engine is running. But dead batteries or defective voltage regulators can extend this optimum voltage into a range with a low of 11.0VDC and a high of 16.0VDC. A motorist stuck in a blizzard or on a desert road might find his battery too dead to restart his engine but still charged enough to deliver 3A to his CB. But if his transmitter has drifted between channels it will not get a call through and may be worse than useless.

Temperature and supply voltage, however, are two variables that are frequently overlooked when specifying and purchasing equipment. Also ignored is mechanical stability. The tremendous vibration experienced by equipment bolted to transmission humps and under dashboards can do more than just shake a flimsy radio apart in time. It can also cause the transmitted carrier to be modulated in amplitude or frequency. The former being the cause of the annoying rumble or roar heard on some signals. The latter being a violation of FCC regulations.

(If we were going to test every new CB set before we purchased it, we would use the list of tests that follows. In the issues to come, **Radio-Electronics** *will publish test reports on CB radios. These reports will include actual lab measurements of some of the more vital performance specifications covered in the following text. All of these measurements will be made in our lab and will accurately reflect the performance of the equipment that we test.*—Editor)

The tests

1. Carrier Frequency Error. In this test we check the actual carrier frequency of each channel in the radio when transmitting into a 50-ohm dummy load at room temperature (70°F) and nominal supply voltage (13.6 VDC for mobiles, 117 VAC for base stations) to see how carefully the crystals are selected and aligned. Results will be listed for the greatest error above and/or below any assigned frequency.

2. Carrier Frequency Change with Temperature. Holding the voltage constant we measure the maximum excursion in each direction as the entire chassis is first chilled from +70°F to 0°F and then heated to +125°F over a period of approximately four hours on channel 9.

3. Carrier Frequency Change with Voltage. Holding the temperature constant at 70°F we vary the supply voltage from 11 to 16 VDC for mobiles and 100 to 130 VAC for base stations while measuring the maximum excursion in frequency of channel 9 to test the set's regulation.

4. Carrier Frequency—Worst Case. In this rigorous test we sweep the voltage ranges in test No. 3 at each 20°F increment in test No. 2 and measure the worst excursion of channel 9 in each direction. Any transceiver that remains within the .005% tolerance (approximately 1850 Hz) prescribed by the FCC during this test must be very well regulated and temperature compensated.

5. AM Carrier Power Output—Unmodulated. At nominal temperature and voltage we will measure the average carrier power into a 50-ohm load of each channel and report the highest and lowest readings. A difference of more than a few percent between these two may indicate an output network that is too selective or parasitic resonances elsewhere in the exciter.

6. AM Modulation Percentage. We measure the percentage of 1000-Hz sinusoidal audio modulation relative to the carrier power on each channel to insure that the modulator has enough power to fully swing the output symmetrically about the average value. Non-symmetrical irregularities are reported.

7. Mechanical Modulation. In this test, the chassis is clamped to a shake table and vibrated separately in each of three crossed axes with the mike audio terminals shorted while the output of the transmitter is observed for variations in amplitude or frequency. The presence of either will indicate loosely mounted components or poor solder joints. The vibration will sweep from 20 Hz to 2000 Hz at approximately 5 G's (sinusoidal).

8. Speech Processor Effectiveness. On sets with built in speech processing circuitry such as audio compressors or RF clippers we attempt to give a figure of merit as to their value. At nominal conditions on channel 9 we adjust external 600-Hz sinusoidal audio modulation to provide as close to 100% modulation as the modulation limiter will allow. We then monitor the output for any increases in average envelope power that can be obtained by increasing the audio input to saturation. We report the improvement in dB obtained to guide the user in evaluating manufacturers claims of superior "Talk Power". This test measures only average power however and this is not a complete indication of improved intelligibility as other factors of circuit design which determine the number of distortion products (unavoidably generated as part of the compression process) that fall within the RF passband will determine total articulation gains.

9. Harmonic and Spurious Supression. This expresses in dB relative to a 1000-Hz 100% modulated carrier any harmonically or non-harmonically related signal within the range of 500 KHz to 400 MHz. These signals, if present, cause

RAY JEFFERSON CB845

RCA CB CO-PILOT 14T275

SHAKESPEARE 740

ROBYN DG-130D

XTAL XCB-40

JOHNSON MESSENGER 4170

interference with other services—especially TV and FM radio. Therefore they are particularly interesting to base-station operators who must peacefully coexist with their non-CB neighbors. The current FCC standard is −60dB but a proposal to increase this to −100dB may be enacted (this will affect manufacturers only and existing equipment will be unaffected).

10. Opposite Sideband Suppression (SSB only). We measure the amount of unwanted sideband content in a 1500 Hz to determine the amount of harmful interference to users of the other half channel and the amount of power lost to the selected sideband. This suppression is determined by the IF filter and a good figure aids the receiver too.

11. Carrier Suppression (SSB only). The amount of residual carrier present in the output represents power robbed from the desired sideband's P.E.P. and can cause aggravating interference to distant SSB users. We measure this also in dB below the P.E.P. in the same two-tone conditions as used in test No. 10. A poor rating means a defective balanced modulator or poor shielding.

12. Peak Envelope Power—P.E.P. (SSB only). The power output is measured under the same conditions as in test No. 5 except using the above described two-tone modulation and a detector that responds to the peak value of the RF envelope—not the average. Legally limited to 12 watts, radios with properly adjusted Automatic Level Control should approach this closely.

13. Sensitivity. Under nominal conditions of temperature and supply voltage, a 1000-Hz 50% modulated RF signal is injected at the antenna terminals with the transceiver in the receive mode. The amount of this standard signal in microvolts (μV) necessary to produce ten times (20 dB normalized) the audio output voltage at the speaker terminals that the random air noise produces is termed its 20 dB S+N to N sensitivity. This is a direct measure of how weak a signal can be easily heard. Measurements made at a lower ratio such as 10 dB will yield a lower (better) figure but do not represent "armchair copy" legibility.

14. Squelch Sensitivity. Using the same conditions of standard modulation but advancing the squelch control just to the point of quieting the air noise, the RF input signal is measured that just breaks the squelch open. This shows how weak a signal can be heard while still enjoying the advantages of squelched operation.

15. Sensitivity—Tight Squelch. The sensitivity measurement taken under standard conditions but with the squelch control fully advanced. For purposes of local operation, this shows how strong a signal can be excluded.

16. Sensitivity—Image Channel. The process of mixing in all superheterodyne receivers produces a second undesirable channel in which signals may be received if not filtered out completely. We will measure the standard signal strength necessary on this image channel required to produce the same audio output as on the desired channel. Expressed in microvolts, it is a measure of the effectiveness of the RF and IF filtering and shielding.

17. Sensitivity—IF. Measuring the susceptibility of a radio to receive undesirable signals directly into its intermediate frequency we have a figure that can guide us away from a set with some strange responses. Interstage shielding is the culprit in most cases and is difficult to remedy.

18. Dynamic Range. To measure the dynamic range or ration of the weakest signal to the strongest signal a receiver can accommodate, we inject two equal level standard signals whose difference in frequency is equal to 27.065 MHz (Channel 9). Any overloading in the protection diodes, RF amplifier stage, mixer or IF stages before the filter will cause non-linear operation of that stage with a subsequent mixing of the two signals. We use test frequencies of 27.935 MHz and 55 MHz to include frequencies both inside and outside the RF bandpass to mimic the most troublesome type of interference—between other CB stations and local TV stations. The signals will be increased until cross modulation is observed on channel 9 and the difference in microvolts with test No. 13 expressed as dB.

19. Selectivity. This test measures a set's ability to discriminate against signals on the channel immediately adjacent to the one in use. Signals displaced by the 10-kHz channel spacing both above and below are separately injected and adjusted to produce the same audio output as a 10-μV signal on channel 9. The lower level in dB relative to 10 μV is reported.

20. Bandwidth Shape Factor. This tests the steepness of the skirst of the receiver's filter response and is vital for judging how well a set rejects interference from stations that are off frequency. We will measure the frequency off the carrier at which the receiver's response is 6dB down from its peak value and the frequency at which it is 60dB down. The smaller over the larger gives a simple numerical figure of merit. Sets with expensive multi-section crystal type or mechanical filters in the IF will shine here and should be highly prized because this is perhaps the most important single specification for today's crowded channels.

21. Noise Suppressor Effectiveness. We will inject a train of 25-μS pulses with a risetime of 2 nS into the antenna and measure the reduction, again in dB, with the filter switch on and off. These pulses simulate typical ignition noise and noise blankers that block an IF gate

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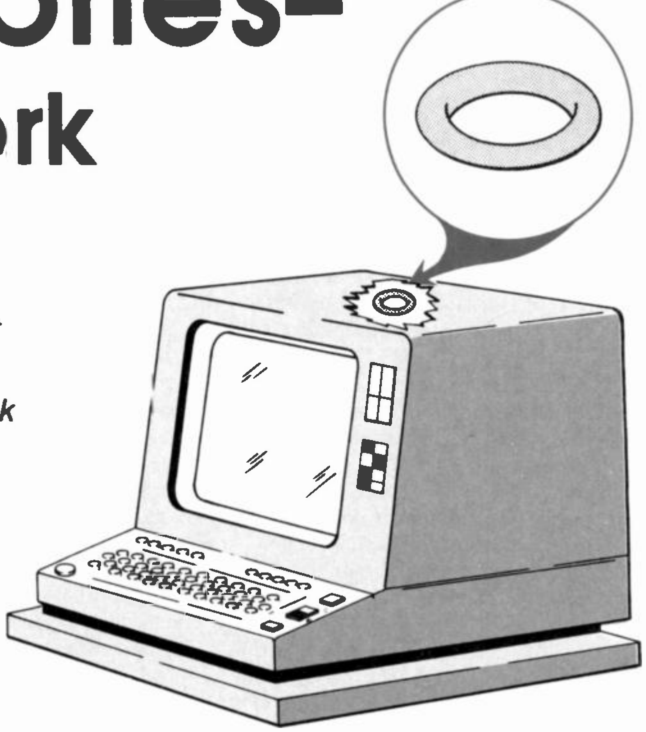
GEMTRONICS GTX-77

AUDIOVOX MCB-5000

SONY ICB-2500

Core Memories– How they work



With inexpensive core memories flooding the surplus market, it's a wonder that they haven't appeared in more hobby computer systems. Here's a look what they are and how they work

MARTIN A. SALA

THE MAGNETIC CORE IS ONE OF THE LEAST expensive and fastest means of storing data in a computer system. Magnetic core memories are *static:* they hold data when power is removed, don't have to be refreshed periodically and are usually of the random access (RAM) variety.

The actual method of storing ones and zeros in a core is simple. The basic core element is shown in Fig. 1. By passing conductors through the center of the ferrite cores and passing a current through the conductors in a set direction, a magnetic field is created that magnetizes the core. A logic 1 has then been written when the core is magnetized. (This process is similar to the one used in making permanent magnets.)

Just the opposite is done to read or clear a core. A current is sent through in the opposite direction, and consequently cancels any previous fields in the core. To read a core, an extra winding must be added: the *sense* winding.

When a core holds a logic 1 (is magnetized) the *read* current causes the magnetic flux to collapse and induce a voltage in the *sense* winding. If the core had held a logic 0 (been unmagnetized), no voltage would have been induced in the *sense* winding.

This method is basically the idea, but is much too simple to function in a real computer system. The type we shall be concerned with is known as the 3-D, 4-wire. Three-D means a three-dimensional array consisting of planes of cores arranged in an X-Y format in which the total number of words is equal to the number of cores per plane. (The number of bits per word is equal to the number of planes.) Four-wire signifies that four wires pass through each core. They are: *X Drive, Y Drive, Inhibit* lines and the *Sense* windings. (See Fig. 2.)

When a *read/write* (R/W) current passes through both X and Y drive lines, a core is magnetized (or demagnetized). If there is current on one drive line through one or many cores, those cores will not switch; it takes the sum of both X and Y currents to switch a core. The current on one line is known as the *half current.*

This half current is used to write a logic 0 into a core, with the help of the *Inhibit* lines. As a core is selected, an equal but opposite current on the Inhibit line cancels out the current on the Drive line parallel to it and thus creates a half current. Remember, the drive lines only select the core to be written—it is the Inhibit lines that determine whether or not the core will be logic one or zero. During the read cycle,

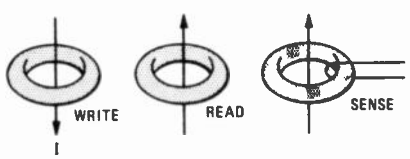


FIG. 1—ELEMENT OF CORE MEMORY. Current passing through the wire magnetizes the ring (core) when a strong enough current flows. A current in the opposite direction breaks down the magnetic field, producing a pulse of current in the Sense winding.

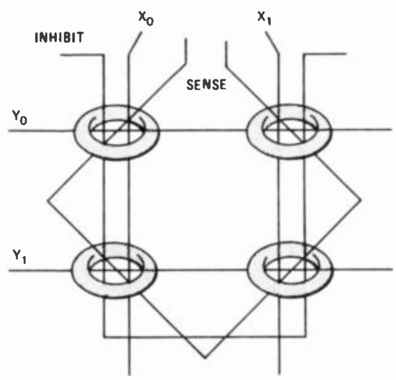


FIG. 2—HOW THE CORES ARE WIRED. The four wires are X-drive, Y-drive, Inhibit and Sense. There will be 64 X and 64 Y drive lines in a 4096-core plane (X_0 to X_{64}, etc.).

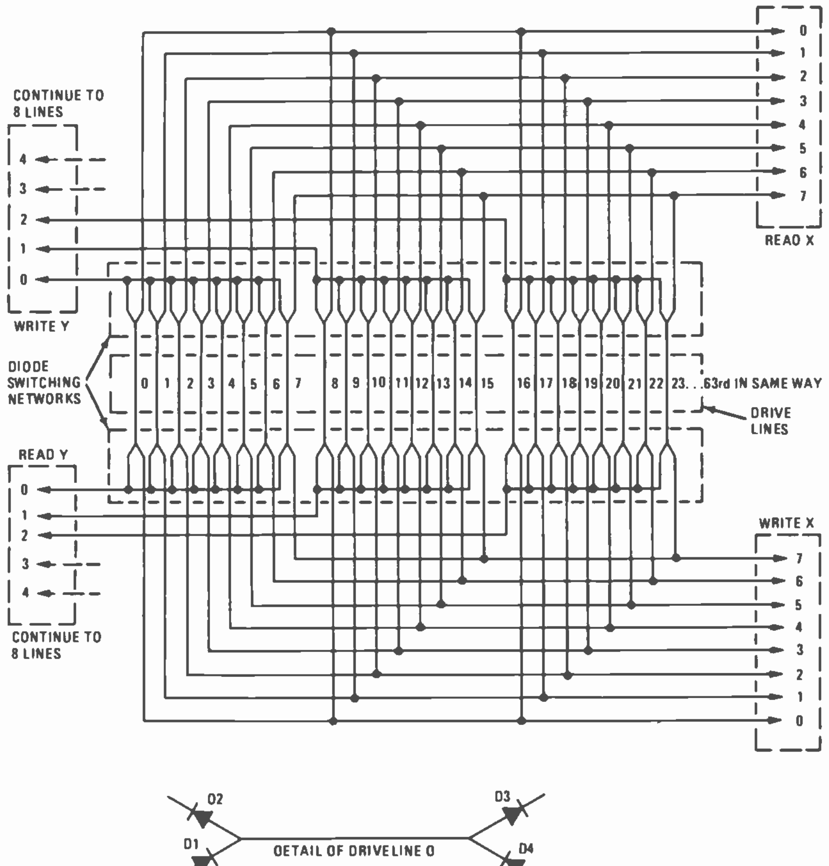


FIG. 3—A MEMORY CORE ASSEMBLY. There are no less than seven pieces of equipment in the circuitry shown here; the core stack itself, the two diode steering units and four switching units.

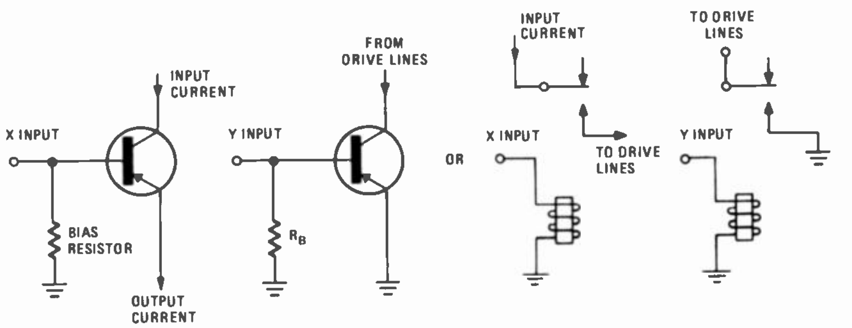


FIG. 4—TWO SWITCHING SYSTEMS. The actuating signals come from the address decoder, the output is to the drive lines.

the drive currents are reversed and cause the magnetic field stored in the core to collapse and create a voltage on the *Sense* winding.

Core memory design

Memories of the core type are basically easy to design. Circuitry is usually straightforward, with simple timing methods. All that one needs to service a core memory is an oscilloscope, a VOM and sometimes a signal generator.

One can start a core system with a stack of core planes with the desired number of bits and words. Try to obtain the core stack parameters (current values for the Drive and Inhibit lines, etc.). Input/output designations for the core stack are also necessary—the experimenter will be lost if he doesn't know what all the leads on the package are for.

Mount the core stack in a place relatively free from magnetic fields (away from motors, generators, solenoids and the like) and where cool air may circulate freely—continued use heats the Drive lines.

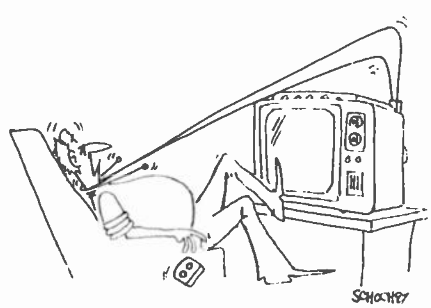
In the 4096-core unit partially illustrated in Fig. 3, there are 64 X-drive lines and 64 Y-drive lines. (Fig. 3 shows only eight of one of these sets of lines.) One of each must be selected to switch a core. An Address unit supplies the information as to which drive lines are to be selected and in which mode (*Read, Write,* etc.). One of the simplest circuits incorporates a steering network to partially decode the address and steer the currents in the proper direction for *read* or *write*. Figure 3 shows that by selecting one X and one Y input, any one of 64 lines may be picked. The input lines to the diode decoders are numbered 0 to 7 X and Y. (Only one of these sets of lines is shown, to keep the circuit as simple as possible.) It is when one of eight X lines and one of eight Y lines are picked that a specific drive line is enabled.

Switching a core

It takes a specific amount of current to switch a core. This current is switched on and off at the diode decoders desired by the X and Y circuits. They are usually made up of single transistors biased so that they turn on and off at logic 1 and 0. Logic 1 is normally 4 volts, logic 0 is 1.4-volts TTL (transistor-transistor logic) levels. See Fig. 4.

There are two sets of X and Y circuits. One sends current down the drive lines in one direction to write; the other in the opposite direction for the read operation. While transistors are most commonly used, one may use any desired technique: relays, switches, diodes, even vacuum tubes (all have been used) and need not incorporate the TTL methods described here.

So far the cores, mounted in their planes and assembled into stacks, the diode decoders and the switch and sink circuits have been discussed. How the cores receive their signals, how they are directed to certain cores in the stack, how they are called for and how information is restored to a core after it is destroyed by reading are still to be learned. **R-E**



TEST EQUIPMENT

all about RF signal generators

PART II—An in-depth look at the different types currently available, including how they work, their specifications, features and applications

CHARLES GILMORE*

LAST MONTH WE EXAMINED THE BASICS OF RF signal generators and the types of oscillator circuits that are commonly used. This time we continue our study of how RF signal generators work.

Modulators

As indicated last month, AM normally takes place at the output amplifier or a special modulator prior to the amplifier. Some of the earlier laboratory generators were MOPA (*M*aster *O*scillator *P*ower *A*mplifier) designs. Modulation was applied directly to the oscillator itself. Generally, it is very difficult to AM an oscillator without also creating some FM. Most of the older vacuum-tube RF signal generators used grid modulation of the power amplifier. Frequently the total percentage of modulation you can get from a particular signal generator is limited not only by the modulator, but also by the power amplifier itself. This is especially true at high output levels.

The more modern, all solid-state generators, use diode modulators between the buffer and the output amplifier. Frequently the amplitude modulator has a wider dynamic range than needed to provide maximum percentage of modulation required by the generator. This wider dynamic range, combined with DC coupling, permits the modulator to modulate the RF carrier with audio frequencies and also to vary the gain of the RF carrier as part of the automatic level-control (ALC) circuitry.

When the modulator is used for both automatic level control and modulation, the modulator has two inputs. One of these is AC coupled and its input signals are the internal tones generated by the modulator oscillators. The other input is a DC level derived from the automatic level control monitoring circuits.

Most signal generators provide two internal tones, one at 400 Hz, the other at 1 kHz. The two-tone modulation signal source normally consists of one of the common RC oscillator circuits. The amplitude of the audio oscillator may be continuously varied from zero to an amount which produces the maximum permissible modulation. Variation is controlled with a modulation level control on the front panel of the RF generator.

There are two ways to get a metered indication of the percentage of AM. The first, and simplest, is commonly used in the lower cost RF generators. The modulating signal supplied to the modulated circuits is sampled and applied to a full-wave rectifier. The output of the full-wave rectifier is applied to a DC meter that reads in percent of modulation. Such a system is relatively accurate if the modulation percentage does not change with changes in RF frequency, or modulating frequency.

The second form of indicating the amplitude modulation percentage is somewhat more complex but eliminates problems encountered with the simpler form. As you can see in Fig. 8, this system uses a wideband diode detector that monitors the output of the power amplifier. This output is filtered so no RF signal remains, leaving only the modulating waveform. This detected signal is applied to an AC voltmeter made up of a wideband fixed-gain amplifier and high-impedance, wideband, stable AC metering circuits.

The system eliminates problems encountered in the first method of monitoring as it measures the actual amount of modulating signal retrieved from the RF carrier. Frequently a more highly-filtered signal is also taken from this detector, as shown by the dotted line in Fig. 8. This signal is also applied to the modulator, forming the automatic level controls. The filtering on this line completely eliminates all RF carrier and

*Manager Design Engineering, Heath Co., Benton Harbor, MI.

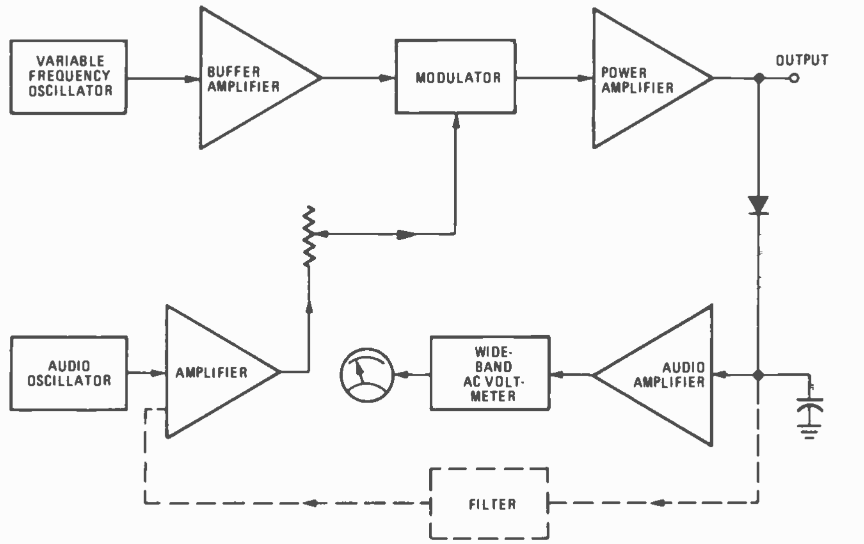


FIG. 8—AMPLITUDE MODULATION METER indicates the modulation percentage directly. The circuit is built around a diode detector.

modulation. The line, therefore, responds only to long-term variations in output level.

A modulator normally has three sources of input when automatic leveling is used—the automatic leveling input, the internal audio tones, and a source of external audio modulation. The automatic leveling input is always connected, regardless of the modulating mode. The user, however, may choose between one of the two modulating sources—either the internal oscillator or the external input.

Frequency modulation is done by direct modulation of the oscillator. In vacuum tube generators, a reactance modulator is common. It is a form of amplifier applied across the resonance circuits of an oscillator. Signals applied to the input of the reactance modulator appear as a change of reactance to the tuned circuit. This changes the oscillator frequency. The reactance modulator is a direct-coupled device so it not only responds to audio-frequency modulating signals, but to DC-controlled signals as well. For this reason, the reactance modulator can provide limited electronic frequency control.

In solid-state oscillator design, the reactance amplifiers are normally replaced by a variable-capacitance diode. It is direct-coupled as well, and performs the same function.

The amount of deviation is of greatest concern to the person using an FM signal generator. Wideband discriminators are not readily available to monitor the RF output of the generator and indicate the amount of deviation. Therefore, we use a method similar to the first method described for monitoring amplitude modulation to determine deviation. An AC voltmeter, calibrated in kHz of deviation, is connected to the output of the modulating amplifier.

Special circuits compensate the signal from the modulation amplifier before it reaches the modulator. They adjust the signal amplitude so that deviation produced by the signal of given amplitude from the modulating amplifier is consistent with band changes and as the RF generator is tuned across the band. Without such circuitry, the deviation meter is valid only at the calibration frequency. At all other frequencies, the deviation is either greater or less than indicated. If automatic leveling circuitry is incorporated into the FM generator, an AM modulator is connected at all times. It is usual for generators of this nature to be able to supply both AM and FM signals.

Attenuators

The output attenuator of an RF signal generator is one of the more critical components in determining its usefulness. A signal generator with a poor RF attenuator or, for that matter, one with high leakage and a good RF attenuator, is of little value in many applications. For example, to measure receiver sensitivity, the output of the signal generator must be reduced to an extremely low but known output level. The output attenuator must have valid calibration over extremely wide ranges of attenuation and frequency. Typically, output attenuators found on RF signal generators have at least 100 dB of attenuation. Attenuations of 120 dB to 140 dB are common.

There are two basic forms of attenuator—the piston attenuator and the step attenuator. The piston attenuator has been used for many years, and is being replaced by the step attenuator on newer designs. The piston attenuator (see Fig. 9) consists of a pickup loop and an impedance-matching network. This assembly is withdrawn into the metallic tube to increase attenuation. The exact amount of attenuation depends upon the position of the pickup loop within the tube. Theoretical attenuation is 32 dB each time the piston travels a length equal to the diameter of the tube. The diameter is based on the highest generator frequency so the tube always acts as a waveguide operating below cutoff frequency. For high levels of signal amplitude, the amount of attenuation is no longer uniform with displacement and the calibration marks on the dial no longer have uniform spacing.

Resistors R_1, R_2, and capacitor C_1 act as an impedance-matching network to match the loop impedance at all frequencies to the 50-ohm output of the generator. The impedance compensating network connects to a flexible coaxial transmission line, that feeds the generator output connector. This is normally a double-shielded coaxial cable to maintain a high degree of shielding.

The step attenuator commonly consists of a number of 50-ohm pi attenuators, as shown in Fig. 10. Each of these can be given different amounts of attenuation depending on the resistor values. A series of four or more such attenuators, each having a minimum attenuation of 10 dB, may be switched in and out through a

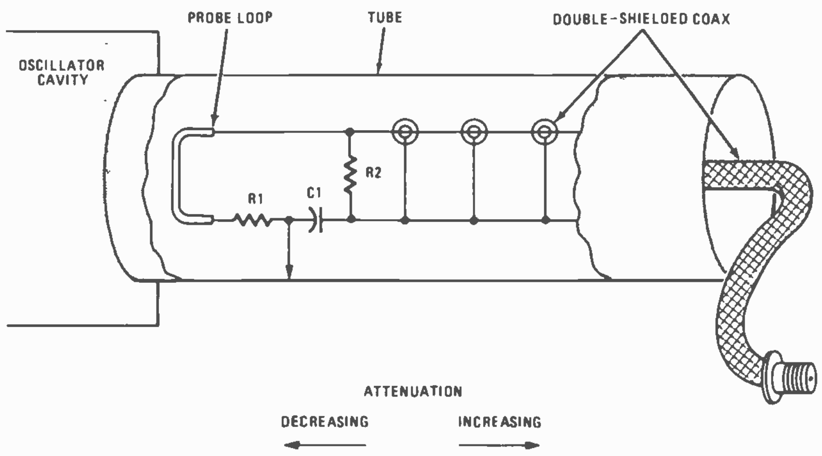


FIG. 9—PISTON ATTENUATOR consists of a pickup loop and an impedance-matching network. The attenuation is determined by the position of the pickup loop.

switching sequence similar to that shown in Fig. 10. This results in attenuations from 0 dB to the required maximum attenuation in 10-dB steps.

Because this attenuator is not continuously variable as is the piston attenuator, a fine attenuation control or vernier usually accompanies it. Today, circuit designers frequently combine the DC output of a vernier control with the other modulator signals. This signal is very similar to the automatic level control signals. In some lower-frequency lower-cost generators, the variable resistance element is placed at the output of the power amplifier. In this configuration the variable element provides variable attenuation of the RF carrier.

The output amplifier

Most new signal generators have some form of amplifier between the oscillator and the output attenuator. Within this group of generators, a large percentage have more than one amplifier. The final output amplifier is assigned the task of supplying the required maximum output level to the desired output impedance, usually 50 ohms, over a wide range of frequencies. These amplifiers normally come in two forms. The tuned amplifier is quite popular with vacuum-tube signal generator designs. The output impedance of vacuum-tube amplifiers is high, thus making the matching network for broadband design extremely complex. Although this imposes no particular user restrictions, it does require additional cost in design and manufacture of the generator.

The advent of low-cost wideband low-output impedance, solid-state power amplifiers permits using a broadband amplifier at the output stage of the RF signal generator. This is the amplifier most commonly used today. The broadband, solid-state power amplifier can now be made more efficient and with a much higher degree of linearity and, therefore, with lower harmonic distortion and intermodulation distortion products, and at a lower cost than its tuned vacuum-tube counterpart.

There are some generators that use no power amplifier or buffer. These normally decouple the oscillator from the load with attenuation networks. The attenuation network, of course, substantially reduces any reflected change in load, as seen by the oscillator.

Output level meter

Most RF signal generators have an output level meter. It is driven by a wideband RF voltmeter that monitors the output amplifier. The metering circuitry may be combined with the automatic leveling circuits if they exist in the generator. Occasionally dual meters are provided on an RF signal generator, but most generators switch select the metering function between the RF level and modulation percentage.

The RF voltmeter used for output level monitoring is confined to a single amplitude range, normally no more than 1 decade.

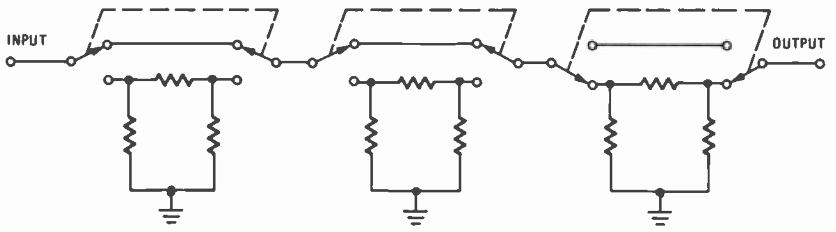


FIG. 10—STEP ATTENUATOR consists of many pi-type attenuators that are switched in or out of the main signal path.

Specifications

Specifications supplied for any particular RF signal generator are generally quite involved. A full understanding of these specifications is a must, if you are to make significant measurements. However, simple servicing and experimental projects can be undertaken without such an in-depth knowledge. The most important specifications to understand are those which differentiate the low-cost generator from the laboratory or high-quality service generator. These specifications are primarily in areas of attenuation, frequency stability, and frequency range, with secondary differences appearing in the area of signal purity and modulation characteristics.

Frequency range

One of the most important and definitely application-oriented specifications of the RF generator is its frequency range. The generator designed for use in the laboratory may not be suitable for VHF mobile servicing, and neither of these generators may be suitable for accurate analysis of 88- to 108-MHz commercial FM receivers. Frequency range is specified by noting the lowest and highest frequencies within the generator's capabilities.

Be careful when reviewing the specifications of low-cost signal generators, because the frequency range may include harmonic usage of lower range fundamental signals. For example, the Heathkit IG-102 RF signal generator is a low-cost generator with an upper fundamental frequency of 110 MHz. However, general operation is specified to 220 MHz by the use of harmonics. This characteristic is not used on the higher-cost generators. Although there are no truly typical ranges for RF signal generators, two types of generators do stand out. The first is the AM-HF (High Frequency) generator. The frequency range of typical units in this class lie between 50 kHz and 100 MHz. The second is the AM or AM/FM VHF generator. The frequency range of typical units in this class lie between 10 MHz and 500 MHz.

Frequency bands

Frequency bands indicate the number of switch settings the operator must make to cover the entire frequency range of the generator. The band specifications also indicate the frequency break points between bands.

Normally, the exact break points are not very important to the operator. However, some specialized applications may require the generator to be continuously tunable from one frequency to another. The generator must not have a band change within this range. Most generators have some tuning capability beyond their indicated absolute band limits. This is usually not more than a few percent at each end, but does insure a complete overlap from one band to another. The actual break points of the bands are primarily dependent upon the starting frequency and the tuning range of the generator.

Not all generators are continuously tunable. Many of those designed for specific applications, such as communications servicing, have segmented bands—they cover only those frequencies of interest to the user and do not continuously tune frequencies in between those of interest. For example, a communications oriented generator has one band from 25 to 54 MHz to cover low-band 2-way FM and the 6-meter amateur band. A second band covers 132 to 175 MHz and includes the 2-meter amateur band and the VHF 2-way radio communications band. A third band covers 420 to 550 MHz which includes the ¾-meter amateur band and the UHF 2-way communications band. Such a generator may also have a signal source at 455 kHz for IF and discriminator alignment. This source has limited or no attenuation or modulation capabilities.

Other generators may have an extremely limited range of frequencies if they are designed for servicing a particular type of equipment. For example, generators designed exclusively for the commercial FM receiver market may only cover 88 to 108 MHz.

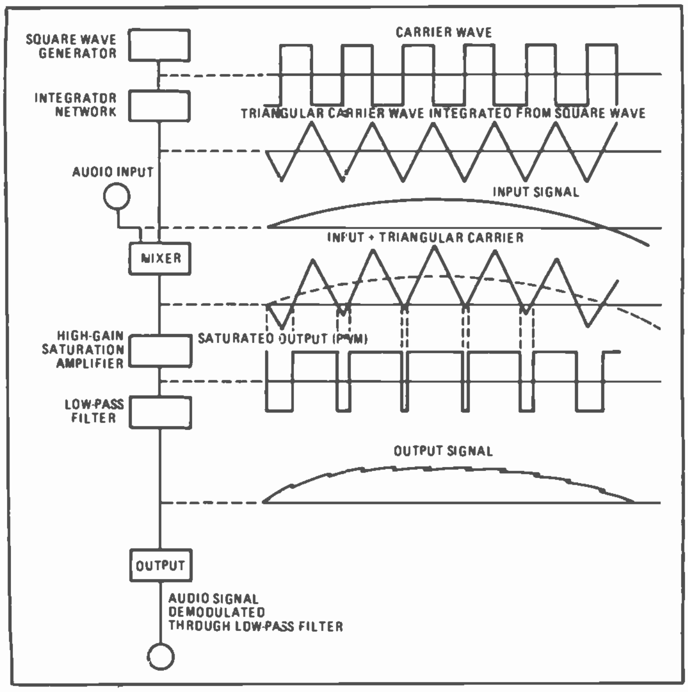
The tuning method

Most RF generators have switch-selected band changes and both coarse and fine variable controls within the

continued on page 92

Greater efficiency, smaller size and less weight are the advantages of the pulse-width modulated amplifier. Here's a look at how these amplifiers work

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR



Pulse-Width Modulation For HI-FI

LONG AGO, IN THE DAYS WHEN A TEN watts-per-channel output power capability for an amplifier was considered the requirement for true high-fidelity music reproduction, little attention was paid to amplifier efficiency. This is especially true in vacuum-tube amplifiers, where the additional power dissipation in the vacuum-tube heaters lowers efficiency even further.

In low-powered amplifiers (whether tube-type or solid-state), Class-A operation (in which the output devices or stages draw constant, full current regardless of the input audio signal) can still be found in mini-powered output stages of car radio amplifiers. Class-A operation is also found in a few medium-powered high-fidelity amplifiers where manufacturers and users are willing to sacrifice efficiency for low distortion and the total absence of crossover distortion.

As audio power needs grew (largely because of the increased popularity of smaller, lower-efficiency speakers) the design trend in high-fidelity amplifiers shifted to Class B. In Class-B audio amplifiers, the output devices conduct for approximately one-half of the input waveform cycle, and total current drawn by the output stages varies in proportion to the output power delivered to the loads. While the Class-B circuit is therefore much more efficient as a converter of DC power to audio power, its efficiency is greatest—around 70% or so—only when it is delivering its maximum rated power output to the load, as shown in Fig. 1. Since, under musical listening conditions, the average power delivered to the load may be some 10 or more dB lower than maximum (10%), even the more efficient Class-B circuit ends up with an *average* efficiency of around 20%. Translated to typical wattage values, that means that when a 200-watt-(rated) per-channel Class-B amplifier is delivering 20 watts-per-channel, 100 watts of input power must be supplied by the power supply—hardly a very efficient use of energy!

There is a more efficient audio amplifier circuit, known as Series E or Class G. This circuit is embodied in Hitachi's *model SR-903* stereo receiver that uses a smaller heat sink and has less overall weight as compared with other receivers using the more conventional Class-B amplifier-design approach. But long before Hitachi developed the Class-G circuit, other researchers were exploring still another means of improving audio-amplifier efficiency. Class-D or "switching" amplifiers have been discussed in the audio literature since the early 1960's. Now, Sony Corporation of Japan has shown promising prototypes of a stereo amplifier that uses Class-D amplification or, more properly, pulse-width modulation, for significantly higher efficiency than can be obtained either in Class-B or Class-G amplifier operation.

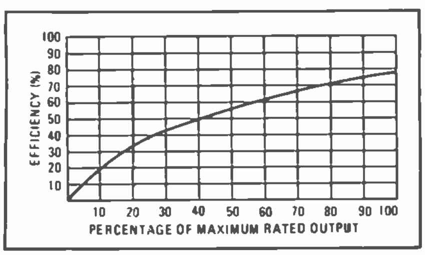


FIG. 1—EFFICIENCY of Class-B amplifier is greatest when it's delivering maximum rated output power.

How pulse-width modulation works

The theory of operation of a pulse-width modulation (PWM) amplifier is illustrated in its simplest form in Fig. 2. The audio input signal, having a continuously varying waveform amplitude, is converted to a series of pulses whose width is proportional to the instantaneous amplitude of the audio waveform itself. Some have theorized that the PWM amplifier is "digital," but a clear distinction must be made between true digital amplification and pulse-width modulation. In true analog/digital conversion, the "bit-code" appearing at the output of the A/D converter would determine the instantaneous amplitude of the input audio waveform. In a true PWM amplifier, the number of pulses per second appearing at the output of the amplitude-time converting circuit is *fixed*, and it is the varying width of successive pulses that conveys the audio waveshape.

Figure 2 shows that the converted

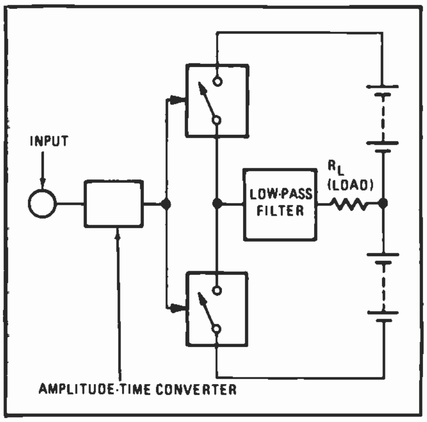


FIG. 2—CIRCUIT CONFIGURATION of a PWM amplifier.

pulse signals control the switching elements of the final power stage, the output of which is passed through a low-pass filter and on to the load. Since the final power stage is either in the saturated "on" mode or the totally "off" mode, there is theoretically no loss of energy in the operation of the circuit.

Figure 3 is a block diagram of each stage of the PWM amplifier. Alongside each stage is shown the waveform relating to that stage. In the Sony prototype PWM amplifier, a squarewave generator is used as the source of the fixed-frequency carrier. The squarewave frequency, which in this case is crystal-controlled, is around 500 kHz. The squarewave carrier is next converted to a triangular wave by means of an integrating circuit. This triangular waveshape and the input audio signal are mixed together and the resulting waveform is passed on to a saturating high-gain amplifier to obtain a series of pulses whose repetition rate is still the same 500 kHz, but the pulse width is in direct proportion to the amplitude of the audio input signal. The variable width pulses are then amplified by a pulse power-amplification stage and "demodulated" by a low-pass L–C type filter.

Amplitude-time converter

Figure 4 shows the basic configuration of the amplitude-time converter in greater detail. Since it is desirable to apply overall negative feedback to this type of amplifier (for the same reasons that negative feedback is used in conventional Class-A or Class-B amplifiers), the pulse-width modulated output is fed through a phase-inverter circuit and an integrator circuit, the combination of which provides a 6 dB-per-octave increase in the frequency response. To compensate for this rising frequency-response and its accompanying 90-degree phase delay, the audio input signal itself also has to be passed through an integrating circuit.

The total negative feedback applied to the PWM amplifier decreases with increasing frequency. For a 500-kHz carrier frequency, the negative feedback versus audio signal frequency is shown in Fig. 5. From this graph we see that the distortion-reducing benefits of overall loop feedback diminish at the high-frequency end of the audio spectrum. The higher the carrier frequency, the greater the amount of negative feedback that can be applied for lowering distortion. Higher carrier frequency also allows greater suppression of the carrier and its sideband components (shown in Fig. 6) for a given low-pass filter without that filter adversely affecting high-frequency audio response.

As the carrier frequency is increased, however, high-speed switching capability of the power output devices become a problem. A very high carrier frequency requires devices with good high-frequency characteristics and high power capability. Since the vertical field effect transistor (V-FET) does not exhibit significant storage time in pulse response and has excellent risetime and falltime characteristics, Sony found it especially useful for pulse-width modulation amplifier applications. In addition, since both N- and P-channel FET's are available, the drive circuit for a V-FET final power output stage can be relatively simple and

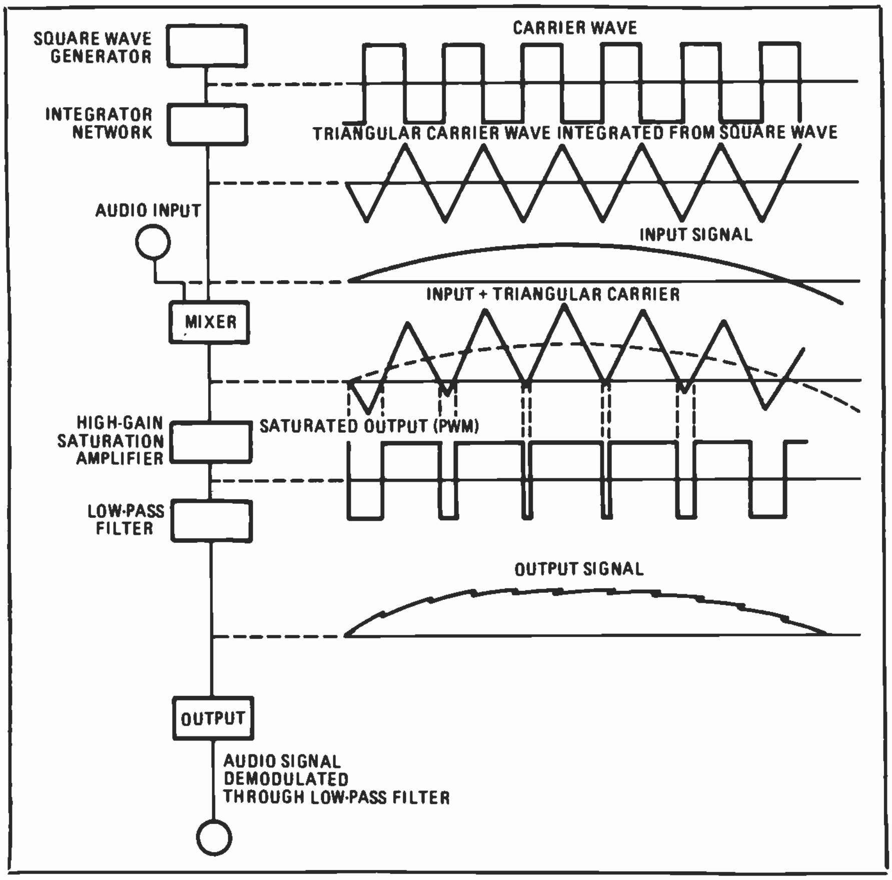


FIG. 3—CIRCUIT WAVEFORMS and block diagram of a PWM amplifier.

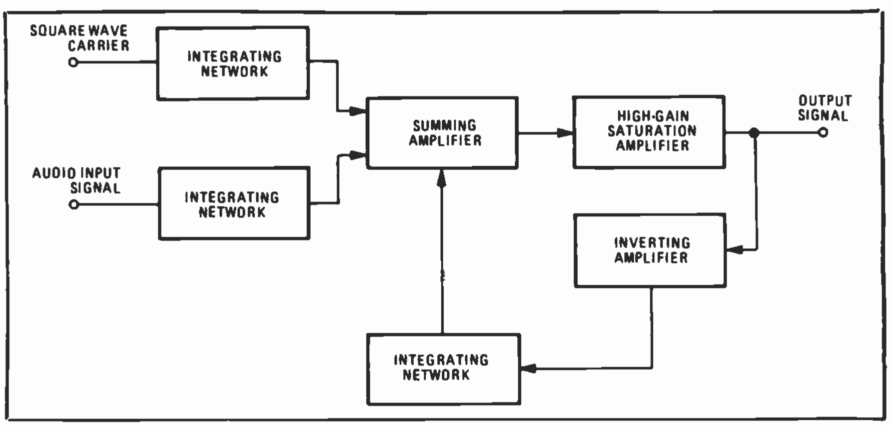


FIG. 4—AMPLITUDE-TIME CONVERTER provides a pulse-width modulated output in accordance with an analog input.

does not require a phase inverter stage.

Figure 7 shows the static characteristics of one of the two types of V-FET's used in Sony's prototype PWM amplifier (at $V_{gs} = 0$). The device shows good linearity from the forward to reverse range, which means that it can be regarded as a pure resistive component whose saturation resistance is the value of resistance seen when it is in the "on" state. This low saturation resistance also means that the return current generated

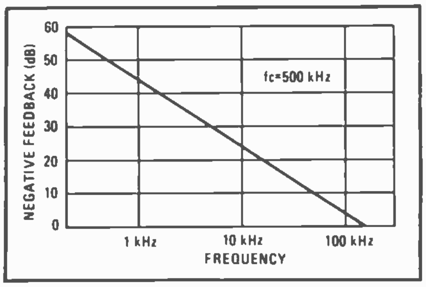


FIG. 5—NEGATIVE-FEEDBACK characteristic of PWM amplifier.

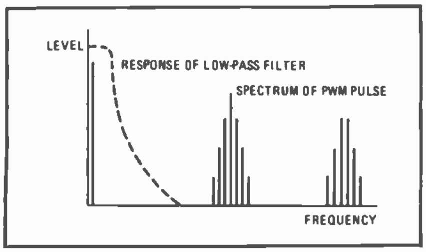


FIG. 6—FREQUENCY SPECTRUM of PWM pulse falls farther outside the response of a low-pass filter as the carrier frequency is increased.

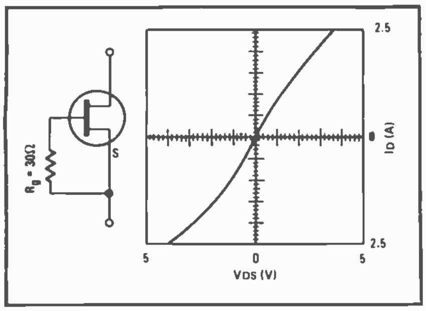


FIG. 7—CHARACTERISTIC CURVE of a V-FET.

by the inductive component of the low-pass filter network that follows (in the output circuit) can be easily dissipated within the V-FET.

A PWM amplifier

Figure 8 shows Sony's first prototype PWM amplifier. In this unit, a 500-kHz carrier frequency is used. While a low-pass filter just ahead of the output terminals effectively removes the carrier components from the audio signal, a fair amount of RF energy exists inside the chassis itself. This RF energy must be prevented from radiating outside the chassis and, for that reason, extensive shielding is used. The shielded chassis is of cast aluminum to reduce the number of welded or soldered joints that would act as "radiating antennas" at this high frequency.

One of Sony's local engineers disclosed that the company hopes to be able to increase the carrier frequency used in their PWM amplifiers in the near future. To obtain the benefits of a higher carrier-frequency (increased feedback at the high end of the audio spectrum and resulting lower distortion), it will be necessary to come up with "faster" switching devices for the output switching stages of the amplifier. Already, Sony is developing MOSFET's that can handle the power for such output applications.

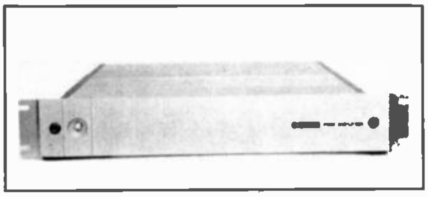


FIG. 8—PROTOTYPE PWM AMPLIFIER manufactured by Sony.

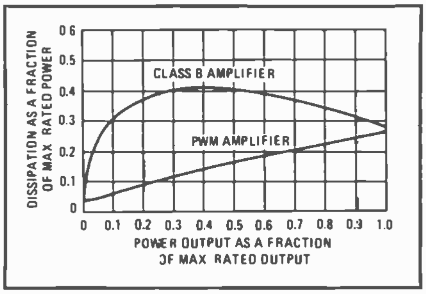


FIG. 9—POWER DISSIPATION of a conventional Class-B amplifier and the new PWM amplifier.

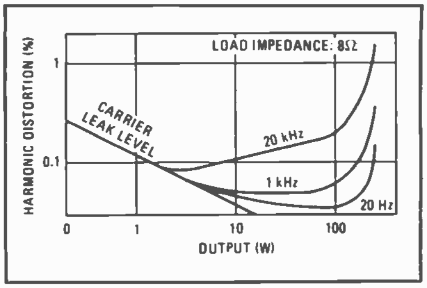


FIG. 10—HARMONIC DISTORTION characteristic of the PWM amplifier.

With increased amplifier efficiency comes lower internal power dissipation. The relative dissipation of a Class-B amplifier and that of the prototype PWM amplifier are compared in Fig. 9. The horizontal axis of the curve represents fractions of rated output while the vertical axis is calibrated in terms of internal power dissipation divided by the maximum rated output. In a Class-B amplifier, the poorest dissipation occurs between 0.2 and 0.7 of full-rated amplifier output (the range of power output most typically used). In the case of the PWM amplifier, dissipation increases linearly as a function of the actual output divided by the rated output and approaches that of a Class-B amplifier only when full-rated output is delivered.

The total harmonic distortion versus power output for the prototype amplifier, taken at frequencies of 20 Hz, 1 kHz and 20 kHz, is shown in Fig. 10. As stated before, the THD tends to increase at the higher audio frequencies.

Sony admits that some of the published distortion specs of the prototype PWM amplifier are not as good as those of some conventional hi-fi audio amplifiers. However, they maintain that the "softer" overload characteristic of the design (as in the more gradual rise of THD beyond 100-watts output shown in Fig. 10) results in a "warmer," less-strident sound, even when more power is required beyond published ratings. This contrasts with the steep rise in THD (and sharp clipping) characteristic of conventional Class-B amplifiers when they are driven beyond overload. Sony believes the PWM amplifier will find immediate acceptance in sound-reinforcement applications, and that shortly thereafter, as faster switching devices are perfected, the new technique will find equal application in super-high-fidelity audio amplifiers. **R-E**

New practice CET test available

An addition to the series of training course texts for CET's (**Radio-Electronics**, April 1977, page 95) is the *Journeyman Communications Electronics Option.* Questions similar to those in actual CET examinations are asked on AM, FM, sideband, transmitters, receivers, transistors and other subjects likely to be covered in the actual examination. Answers to all the questions (which are multiple-choice) are in the back of the book, as well as instructions on taking CET tests.

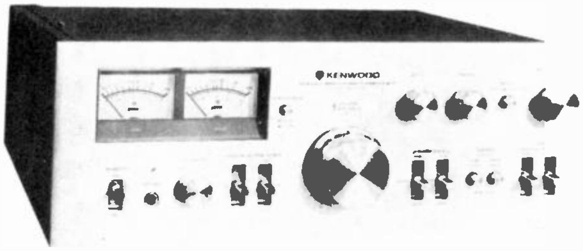
The series of practice CET Test monographs now numbers six: *Associate, Audio Journeyman, Consumer Journeyman* and *Industrial Journeyman* levels, as well as the present text. For digital servicing, *Servicing Logic Circuits* is available. All the monographs may be obtained from Bank Wilson Services, P.O. Box 3321, Warren, OH 44485. Price per volume, $3.00 for members, $4.00 for non-members.

Sylvania's service manager named dealers' man-of-the-year

John Borlaug, National Service Manager of GTE-Sylvania, was named the Time/NARDA Man of the Year at the NARDA national convention in Atlanta last spring. The award is presented annually by *Time,* the weekly newsmagazine, and the recipient is selected by the board of directors of NARDA (National Association of Retail Dealers of America).

The award was made for Mr. Borlaug's work, as chairman of the Electronic Industries Association (EIA) sub-committee on warranty, in bringing about industry-wide agreement on a standard service warranty. The accomplishment was hailed by some as a breakthrough in the service industry, and was one that was reached only after great effort on Mr. Borlaug's part. **R-E**

Radio-Electronics Tests Kenwood KA-8300



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CIRCLE 99 ON FREE INFORMATION CARD

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

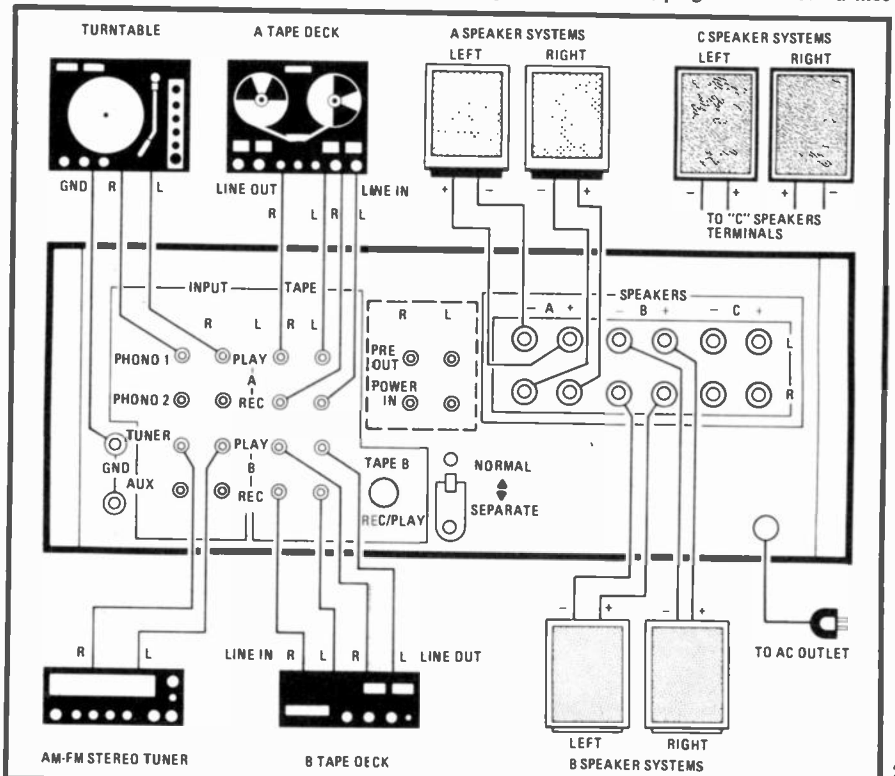
THE LATEST HIGH-POWERED AMPLIFIER FROM Kenwood Electronics, the *model KA-8300*, is one of the four new integrated amplifier models that were introduced late last year. Its front panel layout is shown in Fig. 1. Despite the apparent lack of clutter on this elegantly styled panel, there are more obvious and hidden features to discuss than immediately meet the eye. Those two prominent illuminated meters at the upper left, for example, are peak-reading power output meters. Instead of wiggling minimally as do many power meters now featured on many basic power amplifiers and some receivers, these meters are augmented by a two position METER RANGE switch that alters their full-scale reading from 100 watts to 3 watts. Readings can be clearly interpreted all the way from full power output down to 10 milliwatts.

Controls along the upper right section of the panel include step-type BASS and TREBLE controls, a mono/stereo MODE pushbutton and the program INPUT SELECTOR switch. The large controls at the center of the panel are dual-concentric VOLUME and BALANCE, and the VOLUME control has 41 discrete click-stop positions for easy resettability of preferred listening levels. To the left of these major controls, under the power meters, are a POWER on/off toggle switch, PHONE jack, a power-on indicator light, SPEAKER selector switch (up to three sets of speakers can be connected to the *KA-8300*, with the first two sets selectable singly or together and the third set selectable only by itself), a three position LOUDNESS switch (OFF, plus two degrees of loudness compensation) and a three position PRESENCE switch (that adds a boost in overall response centered either at 800 Hz or at 3 kHz).

Controls to the right of the VOLUME and BALANCE pair include two TURNOVER switches for bass and treble controls (with a tone-defeat position and selectable 150 Hz or 400 Hz turnover for bass; 3 kHz and 6 kHz for treble), low- and high-cut FILTER pushbutton switches, TAPE DUBBING and TAPE MONITORING switches (which permit taping through from one deck to another while listening to any other program source).

Figure 2 shows the layout of the rear panel of the *KA-8300* as well as the variety of associated equipment that can be used with it. In addition to the usual low- and high-level inputs (there are two pairs for phono), tape record outputs and a DIN combination socket which parallels the "Tape B" monitor circuitry, the unit is equipped with preamplifier output and main amplifier input jacks that are combined or separated by means of a slide switch, shipped with a retainer that keeps the switch in the NORMAL (combined) position. Speaker terminals are of the knurled screw type that, when loosened, permit direct insertion of stripped speaker wires without twisting.

Two chassis ground terminals are located adjacent to the two pairs of phono input jacks. The left and right ends of the rear panel are equipped with projecting structures that permit the user to stand the amplifier upright on its rear for easy handling and also prevent pushing the unit too close to a rear surface (wall or rear of custom cabinet), thus protecting rear connectors, plugs and cables—a nice



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MANUFACTURER'S PUBLISHED SPECIFICATIONS:

Power Output: 80 watts-per-channel, minimum continuous power, 8 ohm loads, from 20 Hz to 20 kHz. **Rated Harmonic Distortion:** 0.1% (0.04% at 1 watt). **IM Distortion:** 0.1% (0.04% at 1 watt). **Damping factor:** 50 at 8 ohms. **Residual Noise,** main amplifier: 100 dB. **Input Sensitivity:** Phono 1 & 2: 2.5 mV; Tuner, Aux, Tape: 150 mV. **Signal-to-Noise Ratio (A-weighted):** Phono: 72-dB below 5 mV; High Level: 90 dB. **Phono Overload:** 260 mV. **Frequency Response:** Phono: RIAA ±0.3 dB; High Level: 20 Hz to 40 kHz, +0, −0.5 dB. **Bass Control Range:** ±7.5 dB at 100 Hz or 40 Hz (depending upon turnover frequency selected); **Treble Control Range:** ±7.5 dB at 10 kHz or 20 kHz. **Bass and Treble Turnover Frequencies:** 400 Hz, 150 Hz, 3 kHz and 6 kHz. **Low Filter Cutoff:** −3 dB at 40 Hz, 12 dB-per-octave. **High Filter Cutoff:** −3 dB at 8 kHz, 12 dB-per-octave. **Presence Control Range:** +6 dB at 800 or 3000 Hz. **Power Requirements:** 120 V, 60 Hz, 550 watts (maximum). **Dimensions:** 16¹⁵/₁₆ W by 5⅞ H x 14¹³/₁₆-inches D. **Net Weight:** 35.3 lbs. **Suggested Retail Price:** $449.95.

TABLE I
AMPLIFIER PERFORMANCE MEASUREMENTS

	R-E Measurement	R-E Evaluation
POWER OUTPUT CAPABILITY		
RMS power/channel, 8-ohms, 1 kHz (watts)	99.0	Excellent
RMS power/channel, 8-ohms, 20 Hz (watts)	88.0	Excellent
RMS power/channel, 8-ohms, 20 kHz (watts)	86.0	Very good
RMS power/channel, 4-ohms, 1 kHz (watts)	110.0	Excellent
RMS power/channel, 4-ohms, 20 Hz (watts)	103.0	Good
RMS power/channel, 4-ohms, 20 kHz (watts)	100.0	Good
Frequency limits for rated output (Hz-kHz)	12-30	Excellent
DISTORTION MEASUREMENTS		
Harmonic distortion at rated output, 1 kHz (%)	0.02	Excellent
Intermodulation distortion, rated output (%)	0.06	Very good
Harmonic distortion at 1 watt output, 1 kHz (%)	0.04	Good
Intermodulation distortion at 1 watt output (%)	0.04	Good
DAMPING FACTOR, AT 8 OHMS	55	Very good
PHONO PREAMPLIFIER MEASUREMENTS		
Frequency response (RIAA ± __dB)	0.2	Excellent
Maximum input before overload (mV)	270	Superb
Hum/noise referred to full output (dB) (at rated input sensitivity)	68 (unweighted)	Very good
HIGH LEVEL INPUT MEASUREMENTS		
Frequency response (Hz-kHz, ± __dB)	15-55, 1.0	Excellent
Hum/noise referred to full output (dB)	86 (unweighted)	Very good
Residual hum/noise (min. volume) (dB)	100	Excellent
TONAL COMPENSATION MEASUREMENTS		
Action of bass and treble controls	See Fig. 4	Excellent
Action of secondary tone controls	See Fig. 5	Superb
Action of low frequency filter(s)	See Fig. 6	Excellent
Action of high frequency filter(s)	See Fig. 6	Excellent
COMPONENT MATCHING MEASUREMENTS		
Input sensitivity, phono 1/phono 2 (mV)	2.3/2.3	
Input sensitivity, auxiliary input(s) (mV)	150	
Input sensitivity, tape input(s) (mV)	150	
Output level, tape output(s) (mV)	150	
Output level, headphone jack(s) (V or mW)	50 mW (8 ohms)	
EVALUATION OF CONTROLS, CONSTRUCTION AND DESIGN		
Adequacy of program source and monitor switching		Excellent
Adequacy of input facilities		Excellent
Arrangement of controls (panel layout)		Superb
Action of controls and switches		Excellent
Design and construction		Very good
Ease of servicing		Good
OVERALL AMPLIFIER PERFORMANCE RATING		Excellent

TABLE II
OVERALL PRODUCT ANALYSIS

Retail price	**$449.95**
Price category	**Medium**
Price/performance ratio	**Excellent**
Styling and appearance	**Excellent**
Sound quality	**Superb**
Mechanical performance	**Excellent**

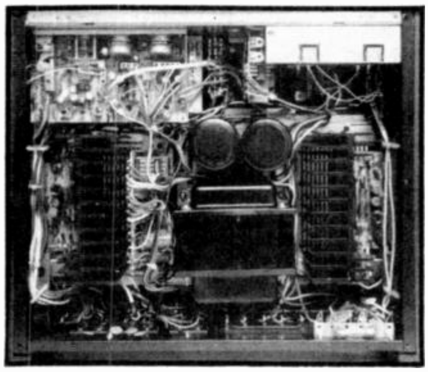
Comments: As many of the features normally found only on integrated amplifiers find their way into all-in-one receivers, makers of separate amplifiers are hard-pressed to find new features and performance levels that will justify the purchase of a separate amplifier or tuner. Kenwood seems particularly skillful in this, and, in the *KA-8300* they have come up with a great number of features which, though extremely useful, manage to leave the front panel of the unit with a totally uncluttered look that would not intimidate even the audio neophyte. The dual-position loudness control is a welcome addition, in that it permits proper operation of this often misused circuit for a variety of program source levels. The novel presence switch, with its selectable center frequencies is another innovation that appealed to us greatly in our listening tests and, of course, the power meters, with their two expanded scales permit their use at lowest and loudest listening levels. Kenwood's "tape through" feature, which permits dubbing from deck to deck while listening to other program sources, has been copied by other manufacturers since being introduced some years ago, but it is still a most welcome feature.

As for the sound delivered by this carefully designed and assembled integrated amplifier, it is clean and authoritative, suggesting a power output capability far in excess of that actually measured. In our view, Kenwood continues to be one of the lower-profile companies amongst the "big four", whose products deserve serious consideration from audiophiles who are ready to step up from an all-in-one receiver to a system comprised of separate components. Our test sample exceeded its published or claimed performance by a wide margin and, more important, it delivered sound that to our ears was equal to that produced by some of the more esoteric (and expensive) products which are currently being favored by some audiophiles. Construction is impeccably executed.

touch that we have not seen before.

Internal construction and circuitry

The main filter capacitors clearly visible in the Fig. 3 are 15,000 μf each and are located



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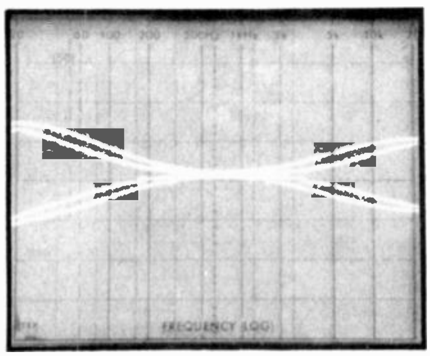
near a massive, cool-running power transformer near chassis-center. A predriver Class-A stage is used in the main amplifier section for reduced crossover distortion and direct coupled, complementary symmetry circuitry is used in the power output stages. High precision resistors and capacitors are used in the phono equalizer circuit. Volume control takes place at two points in the circuit: before and after the tone control section for best signal-to-noise ratios at all listening levels.

The *model KA-8300* has two kinds of protection circuits—one for the amplifier stages and one for connected speakers. The relay circuit that protects the speakers also provides a 4-second time delay on amplifier turn-on, preventing thumps and pops during power supply stabilization. Tone control circuits in this amplifier employ separate active amplifiers for bass and treble to reduce interaction effects and, like many other controls on the *KA-8300*, are directly mounted to their respective printed-circuit modules for a minimum of conventional circuit wiring. Kenwood maintains that this careful layout results in lower hum and less high-frequency attenuation.

Laboratory measurements

Generally speaking, the performance claims made for the *KA-8300* integrated amplifier by its makers are conservatively stated. Our measured results, listed in Table I, may be readily compared with Kenwood's published specifications. Kenwood could easily have rated this amplifier at 85 watts-per-channel over the full



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audio band and still conformed with FTC requirements. At the 80-watt level, the power band extended from 12 Hz to 30 kHz, as opposed to the nominal 20 Hz to 20 kHz

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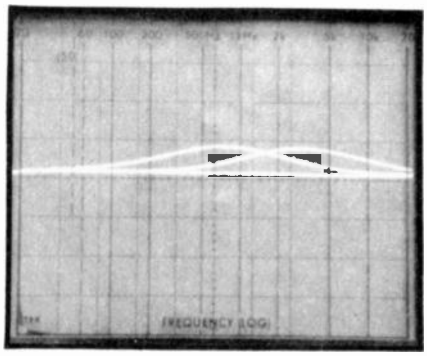
claimed. The frequency response of the high-level inputs was within 1 dB from 15 Hz to 55 kHz and RIAA phono equalization was accurate over the entire curve to within ±0.2 dB. Phono overload measured 170 millivolts while unweighted signal-to-noise, referred to rated sensitivity of 2.5 mV, measured a very satisfactory 68 dB.

The action of the BASS and TREBLE controls, in each of their selectable turnover modes, is shown in the spectrum-analyzer photo of Fig. 4, while the selectable PRESENCE control response range is shown in Fig. 5. The response of the high- and low-cut filters is compared with the flat response setting of the amplifier in Fig. 6. The two choices of center frequency for the PRESENCE control permit an added degree of flexibility when using this feature. The filters have a 12 dB-per-octave slope with turnover points well positioned for elimination of noise and rumble with minimum degradation of musical content when they are used.



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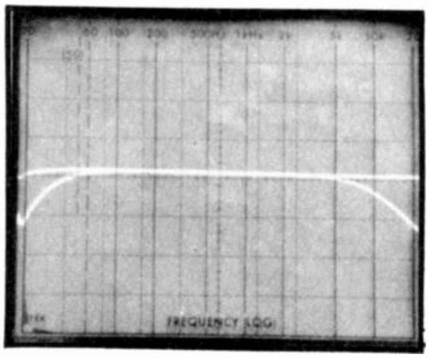

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A summary of our reaction to the *KA-8300* as well as overall comments regarding this top amplifier from Kenwood will be found in Table II, together with our overall product evaluation. For the demanding audiophile who is not quite prepared to invest in audio components in the $1000-plus category but still demands excellent sound reproduction and the flexibility offered only by a well designed integrated amplifier, the Kenwood *KA-8300* might well be a good choice. **R-E**

Epicure PR-4 Preamplifier


1

CIRCLE 101 ON FREE INFORMATION CARD

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

EPICURE PRODUCTS, INC., HAS ESTABLISHED A good reputation for itself in the high-fidelity loudspeaker field since its inception in 1967. The first electronic product introduced by the company under the Epicure label (they also market speakers under the EPI brand name) was their rack-mountable *model 1* power amplifier, rated at 125 watts-per-channel. *Model PR-4* is intended as a companion unit for that basic power amplifier, although of course it would function well when used with any other high-quality basic audio power amplifier.

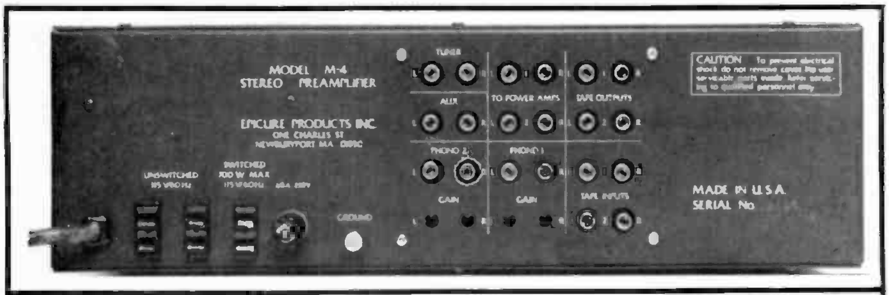
The front panel, shown in Fig. 1, is completely free of any rotary controls and uses pushbuttons and slide potentiometers for all control functions. Finished in black with walnut-finish end pieces, the sole indicator light to appear when power is applied is the illuminated word EPICURE at the upper center of the panel. Individual bass and treble slider controls for each channel are paired so they can be moved together or singly at the left of the panel. The top group of four pushbuttons take care of low- and high-cut filter activation, selection of the tone control turnover points and tone defeat. The tone control turnover-point pushbutton has two positions—"9 dB" and "18 dB." These, we suppose, denote the maximum boost or cut attainable from the tone controls at some extreme frequency. A more understandable designation would have been the frequencies of turnover of the bass and treble circuits (approximately 400 Hz or 80 Hz for the BASS controls; 1.5 kHz and 5 kHz for the TREBLE controls). With this single-button arrangement, it is not possible to select the "9-dB" action for the bass while

MANUFACTURER'S PUBLISHED SPECIFICATIONS:

Rated Output: 2.5 volts. **Frequency Response:** 20 Hz to 20 kHz, ±0.25 dB. **Harmonic Distortion at Rated Output:** 0.005%. **IM Distortion at Rated Output:** 0.005%. **Phono Input Sensitivity:** 1.5 mV. **High-Level Input Sensitivity:** 100 mV. **Phono Overload:** 150 mV. **Maximum Output:** 7 volts into 100K ohms; 3.5 volts into 600 ohms. **Filter Cut-Off Frequencies:** Low: 50 Hz at 12 dB per octave; High: 7.5 kHz at 12 dB per octave. **Overall Dimensions:** 15½ wide × 5 high × 8-inches deep. **Shipping Weight:** 19 lbs. **Suggested Retail Price:** $450.

TABLE I
PREAMPLIFIER PERFORMANCE MEASUREMENTS

	R-E Measurement	R-E Evaluation
DISTORTION MEASUREMENTS:		
Harmonic distortion at rated output, 1 kHz (%)	0.005	Excellent
IM distortion at rated output (%)	0.01	Very good
Harmonic distortion at 1V output, 1 kHz (%)	0.027	Noise limited
IM distortion at 1V output (%)	0.007	Excellent
PHONO PREAMPLIFIER MEASUREMENTS		
Frequency response (RIAA ± dB)	0.1	Superb
Maximum input before overload (mV)	80.0	See text
Hum/noise referred to full output (dB) (at rated input sensitivity)	71.0	Unweighted
HIGH-LEVEL INPUT MEASUREMENTS		
Frequency response (Hz-kHz, ±dB)	13-55	Excellent
Hum/noise referred to full output (dB)	88.0	Very good
Residual hum/noise (Min. volume) (dB)	96.0	Very good
TONAL COMPENSATION MEASUREMENTS		
Action of bass and treble controls	See Fig. 5	Excellent
Action of low-frequency filters(s)	See Fig. 6	Very good
Action of high-frequency filter(s)	See Fig. 6	Very good
COMPONENT MATCHING MEASUREMENTS		
Input sensitivity, phono 1/phono 2 (mV)	1.6-3.3 / 1.6-3.3	
Input sensitivity, auxiliary input (s) (mV)	250	
Input sensitivity, tape input(s) (mV)	250	
Output level, tape output(s) (mV)	250	
Output level, headphone jack(s) (V or mW)	N/A	
EVALUATION OF CONTROLS, CONSTRUCTION AND DESIGN		
Adequacy of program source and monitor switching		Very good
Adequacy of input facilities		Excellent
Arrangement of controls (panel layout)		Superb
Action of controls and switches		Good
Design and construction		Excellent
Ease of servicing		Excellent
OVERALL AMPLIFIER PERFORMANCE RATING		Excellent



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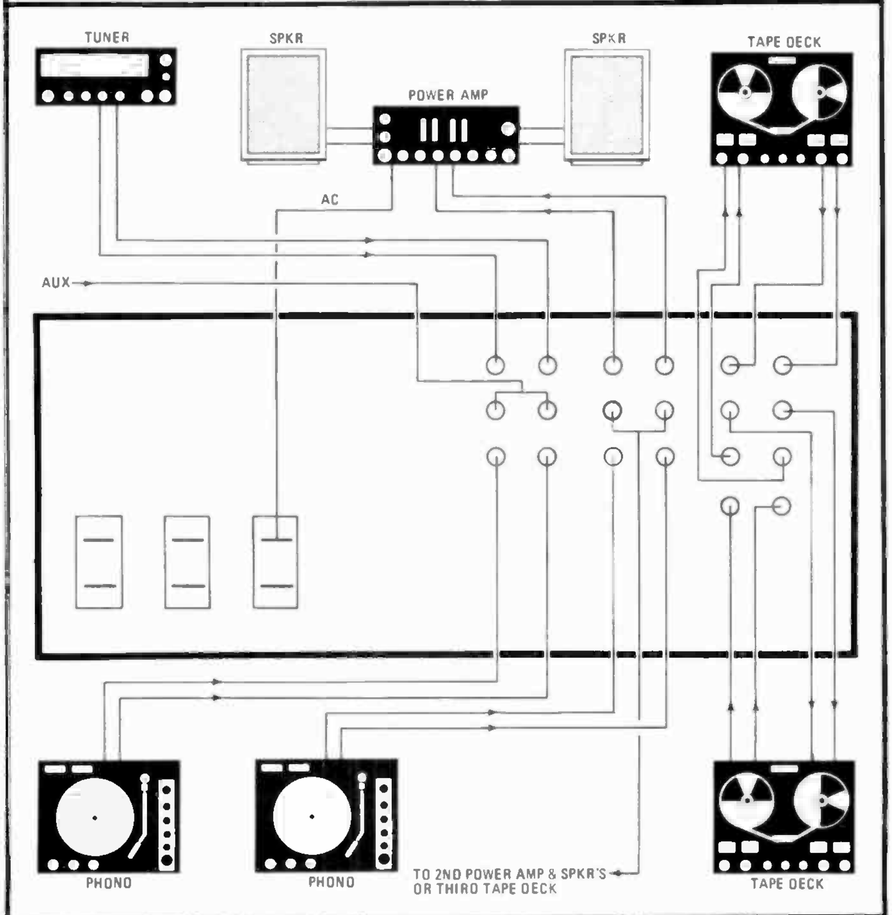

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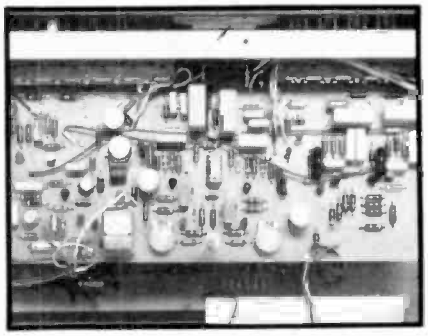
choosing the "18-dB" curve for the treble, since the control switch affects both ends of the spectrum.

Four buttons below those just described handle two tape monitor circuits and permit dubbing from one tape deck to another. Five more pushbuttons at the upper right are designated PROGRAM MODE and select either stereo, reverse, mono, left-only or right-only; while below these, six more pushbuttons are used for PROGRAM SOURCE selection (a pair of separate phono inputs, two tape play pushbuttons, aux and tuner). The single button at the lower right turns on power to the unit, while the paired slide controls at the extreme right act as individual channel gain controls, thereby eliminating the need for the more common balance control.

The rear panel of *model PR-4* (see Fig. 2) has two unswitched and one switched AC receptacles, a line fuseholder, chassis ground terminal and the usual array of input jacks and tape record output jacks. Two pairs of output jacks make it simple to feed a pair of stereo power amplifiers or a single power amplifier and a tape deck for recording program material that has been altered by the tone controls and filters. Below each pair of phono inputs are pairs of recessed screwdriver adjustment controls to set the sensitivity of each phono input pair to match levels of other program sources. The variety of equipment that can be connected to the Epicure *model PR-4* preamplifier/control is shown in Fig. 3.

Figure 4 shows an internal view of *model PR-4*. Two glass-epoxy circuit boards contain-



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ing nearly all the parts required are mounted at right angles to each other and interconnected by a multiconductor ribbon cable. The entire power supply (including a hum-bucking toroid power transformer) is mounted in its own separate shielded enclosure clearly visible at the lower left in Fig. 4.

The phono stages use a two-stage voltage amplifier in a DC-stabilized feedback pair, followed by a single-stage unity-gain buffer amplifier. Auxiliary phono inputs are grounded when not in use. It should be emphasized that two completely separate equalizer-preamplifier sections are used in this unit requiring no low-level input switching. The master volume control sliders are located ahead of the high-level stage, which provides a high overload capability for all high-level program sources. A buffer amplifier precedes the two-pole low and high-pass active filter circuits, followed by another buffer stage, Baxandall-type bass and treble controls, and a line amplifier that provides 20 dB gain from high-level inputs to outputs. According to Epicure, the wide bandwidth of this amplifying section (100 kHz for the −3 dB point) coincides with the small-signal high-frequency response so that the amplifier barely enters slew-rate limi-

continued on page 91

TABLE II OVERALL PRODUCT ANALYSIS

Retail price	**$450.00**
Price category	**Medium/high**
Price/performance ratio	**Very good**
Styling and appearance	**Very good**
Sound quality	**Excellent**
Mechanical performance	**Very good**

Comments: Epicure Products, Inc., seems to have adopted a middle-of-the-road approach in designing this preamplifier/control unit. While some manufacturers of "esoteric" preamps have been abandoning tone controls altogether (in the belief that the "true" audiophile would not want them in his or her system), Epicure has not only included bass and treble controls but has made them extremely versatile. Nevertheless, they do provide full bypassing of these controls for the purists among their customers. The emphasis on high performance in the phono-equalizer section seems to have paid off, for although the overload capability of the phono section is not the highest we have measured in recent months, we did not encounter any distortion problems while listening to a variety of wide dynamic range recordings. The ability to individually adjust the input sensitivity of each pair of phono inputs, and the fact that fully separate low-level gain stages are used for those two pairs is well worth the extra cost.

Except for the inclusion of those tone controls, Epicure seems to lean towards the increasingly popular "no frills" approach for better preamplifiers. The unit performed extremely well in our listening tests, is beautifully engineered and constructed and, with its high output capability, will provide plenty of headroom when used with any of the better, high-powered basic power amplifiers now available, including Epicure's own matching model 1 stereo power amplifier. Prospective purchasers may take issue with the front-panel styling of the *model PR-4* (it is a bit drab) but can hardly question the internal construction and layout, which is up to military grade standards. We have categorized this preamplifier as being in the medium-to-high price range. However, there are competitive preamplifiers on the market which offer no better sound reproduction and fewer control features.

state of solid state

A look at an interesting circuit that adds a vibrato effect to musical passages; plus an SCR array and an ultra-stable oscillator. **KARL SAVON** SEMICONDUCTOR EDITOR

TREMOLO AND VIBRATO CIRCUITS ARE POPULAR with musicians. Some want to hook them up to their electronic organs and guitars. Others want to play tape recorders or radios through them.

The effects of the tremolo and vibrato circuits are related: they both add some form of modulation to the original music. Both modulate the original music source with a low-frequency (usually sub-audio) control signal to give a pleasing "wobulation" to the music. It is most effective when the music source is purely tonal in nature with only the attack and decay envelope shapes of specific instruments.

Tremolo is amplitude modulation. The frequency of the source is unaffected. Only its amplitude wavers, usually following the sinusoidal envelope of the modulating signal. Tremolo is relatively easy to implement with fairly simple circuitry. Lower-cost electronic instruments that include either of the two effects will invariably use tremolo—it's less expensive.

Vibrato is the more pleasing of the effects. We recognize it as the frequency modulation mastered by the professional vocalist. Inevitably it is often combined, with a secondary amplitude modulation. Electronic organs sometimes go to great expense and extremes to produce vibrato mechanically. The most notable are the moving baffle and rotating speaker systems, where the sound source is physically moved. Some achieve true Doppler effects by changing the distance between

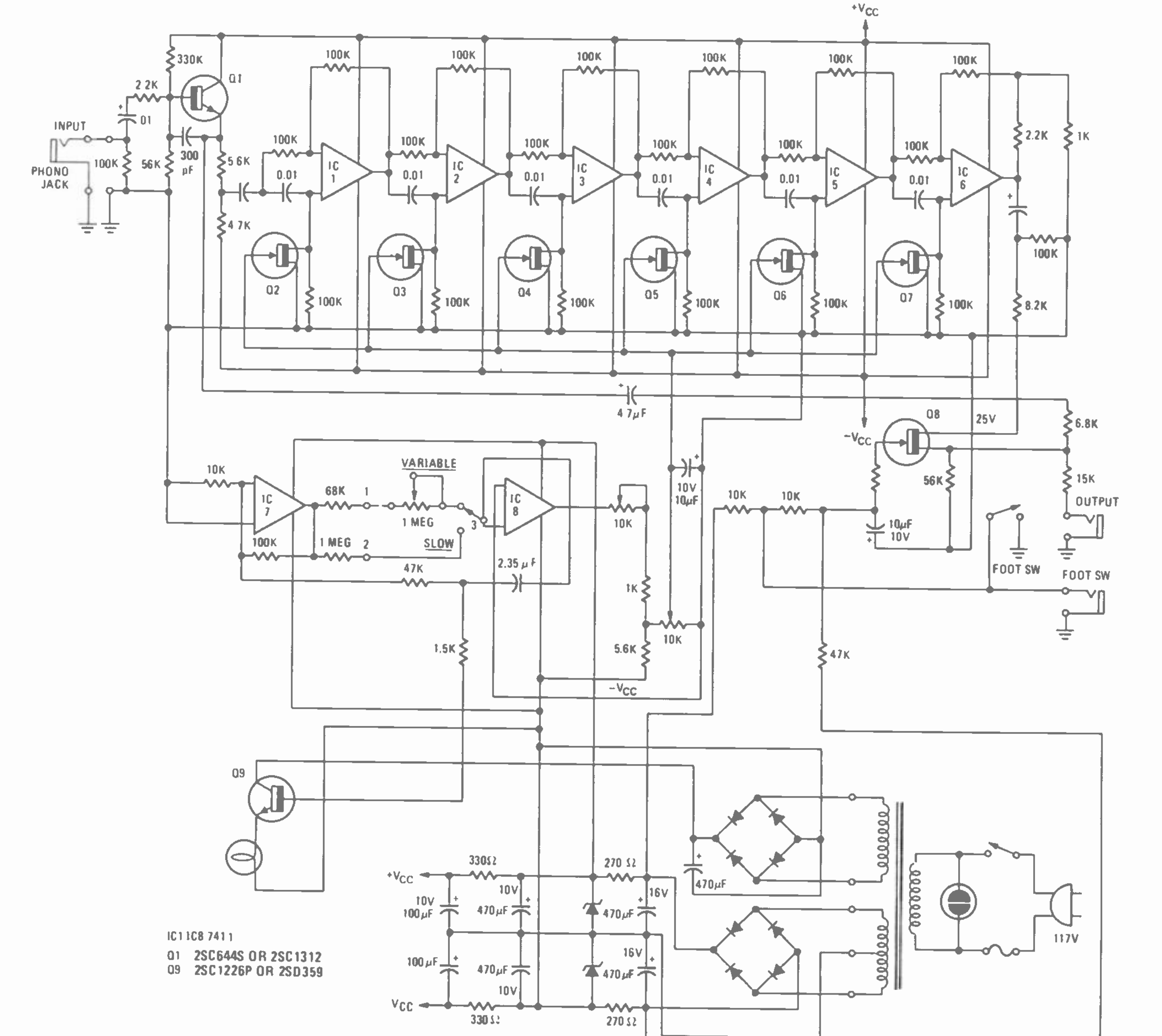

FIG. 1—PHASE SHIFTER that produces vibrato effects.

the source and the listener. At least one manufacturer uses undriven speakers as mechanical counterweights. When the modulation frequency is very low and the proper tonal quality is synthesized, the effect takes on the sound of a carillon.

Musical phase shifter

One way to produce a true vibrato is to phase-modulate the music source. Frequency is the rate of change of phase. If the phase is varied as a sine function, the frequency of the output will change at the same rate as the phase modulation with a cosine function. You may ask, "Isn't it simpler to frequency-shift the oscillator itself in the case of an electronic instrument tone generator?" Well maybe—but be careful. Whenever you design an oscillator to be frequency-shifted, its stability suffers as a rule. The act of building a frequency-shift system by its nature introduces sources of instabilities for undesirable shifts in frequency.

By phase-modulating the buffered oscillator output, the stability is unaffected. The frequency of the vibrato output will vary around the rock-stable original frequency.

This method is one that has been proven in the FM radio broadcast field. FM stations must hold their carrier frequencies to very tight standards. But they of course must find some way to modulate the carrier in frequency. Phase modulation is the answer. In this case the audio modulation signal is not just a simple low-frequency tone, but the entire audio baseband, and a conversion must be made so the effect of the phase modulation will be to produce a change in frequency proportional to the audio amplitude.

Dan Shannon of Brownsville, Texas, sent in the elegant vibrato circuit drawn in Fig. 1, an electronic phase-shifter that produces a true vibrato effect, pure frequency modulation without attendant amplitude modulation. It has eight op-amps, two bipolar transistors, and seven N-type FET's. He supplied no specifications, but the circuit does not look unduly critical and will probably work with a wide range of standard parts.

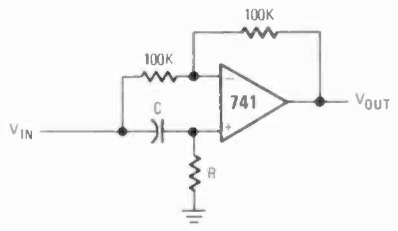

FIG. 2—A PHASE SHIFTER STAGE.

The signal from the input jack feeds the base of emitter follower Q1. The signal splits two ways, one path feeds the string of six phase-shifting 741 op-amps. A typical stage looks like the one in Fig. 2. Because of the op-amp's very high negative-feedback gain, let's make the familiar and reasonable assumption that the signal input at both the inverting and non-inverting inputs are equal in amplitude and phase. The inverting input then has a signal level equal to ½ (V_{in} + V_{out}). The non-inverting input is fed through a phase-shift network that consists of capacitor C and resistor R. This works out to V_{in} ($j\omega RC/(1 + j\omega RC)$), where j represents a 90° reactive phase-shift for sinewave inputs and $\omega = 2\pi f$ (f is the frequency of the input signal). Now this must equal the non-inverting input so with some algebraic juggling you end up with $V_{out} = V_{in}(1 - j\omega RC)/(1 + j\omega RC)$.

I've bothered to go into this much detail because this result is a very interesting circuit response. It can also be produced with a passive non-amplifying circuit, but there will be a loss of gain through it. First of all the magnitude of the gain or the signal output for the 741 phase-shifter remains fixed as the frequency changes. The stage gain is flat across the band.

These types of circuits are called all-pass networks because of their flat signal transmission.

How about phase? $\Delta\phi = \tan^{-1}2\omega RC$. In Fig. 1, R is made up of a fixed 100K resistor and the variable resistance of an FET. At any particular frequency the phase shift is a function of R or the control voltage of the FET. Though the phase shift changes with frequency, the function is linear. The output will be delayed in time but undistorted in waveform. Cascading the six stages multiplies the phase shift and increases the phase sensitivity of the circuit.

The output of the phase-shift chain is combined with a portion of the input from the emitter of Q1. FET Q8 is a transmission gate operated by a foot switch to turn the vibrato on and off as desired. Switched off, the unshifted signal path continues to provide a

continued on page 104

hobby corner

Part II. *Homebrew breadboard that's inexpensive, easy to build and versatile. The basic design can be easily modified.*

EARL R. SAVAGE, *K4SDS.*

IN LAST MONTH'S COLUMN, WE PROVIDED schematics for several of circuits of the breadboard system. This month, the column concludes with the rest of the schematics and the construction details.

Pulser switch

The trouble with the logic switches previously described is that they tend to "bounce" when making or breaking a connection. In fact, all mechanical switches have contact bounce. It usually doesn't matter because you don't care if something is turned on and off five or ten times very rapidly every time you throw the switch. In some circuits this bouncing can cause serious problems.

Suppose you are working with counters, for example, and you use one of the logic switches for a trigger. You throw the switch from LO to HI and the counter shows that you did it *eight times*. Surely that is no way to test a counter circuit!

The pulser switch (See Fig. 6) is "bounceless." The mechanical switch S1 is not connected to the output. Instead, it causes the two gates (7400) to change the state of the output. The gates don't bounce.

The two LED's, one red and one green, indicate the state of the output (LO or HI). Switch S1 is an SPDT type that was not used in the prototype. The prototype used two normally open momentary SPST pushbutton switches instead. Either arrangement is satisfactory.

Pulse generator

After the power supply, without which none of these circuits would operate, the pulse generator (See Fig. 7) is the most useful device in the breadboard. A pulse generator is often called a clock because its output "clocks" back and forth between a LO and HI level.

The generator is a 555 timer IC with an approximate squarewave output. The frequency is changed by selecting various capacitors with switch S1. The four values shown produce pulses at rates of about 0.1, 1, 10 and 100 pulses-per-second. These have been found adequate to meet all needs to date. Of course, you may change the values or increase or decrease the number of frequencies available.

The LED is included in order that the operation and state of the output of the clock can be monitored directly. This is an advantage when working with some types of circuits. Note, too, that the stated frequencies are only approximations because resistors R1 and R2, and the timing capacitors are not precision units. All you need is to be in the right ballpark—the expense of precision is unjustifiable.

Construction

Construction is greatly simplified by using a plastic parts box (6 × 11 × 2-inches) instead of a conventional metal cabinet. Mounting holes and even rectangular openings for the slide switches are easily made and there is no worry about insulating parts from the chassis. There are, however, disadvantages.

The box is clear plastic and it would be confusing at best to look through the panel. This was solved by painting the *inside* of the box *after* making all the holes but *before* mounting the parts. In fact, I made the various sections different colors—red, yellow, black, white, blue, silver.

The greatest disadvantage of this box

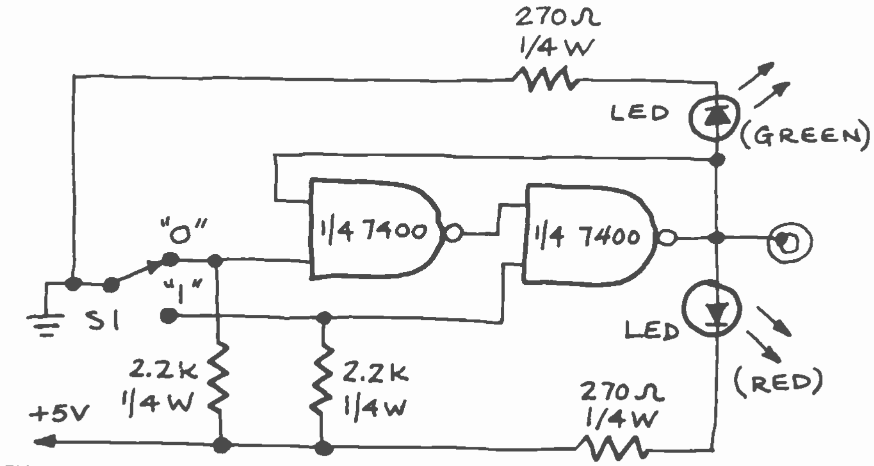

FIG. 6—PULSE SWITCH provides bounceless switching.

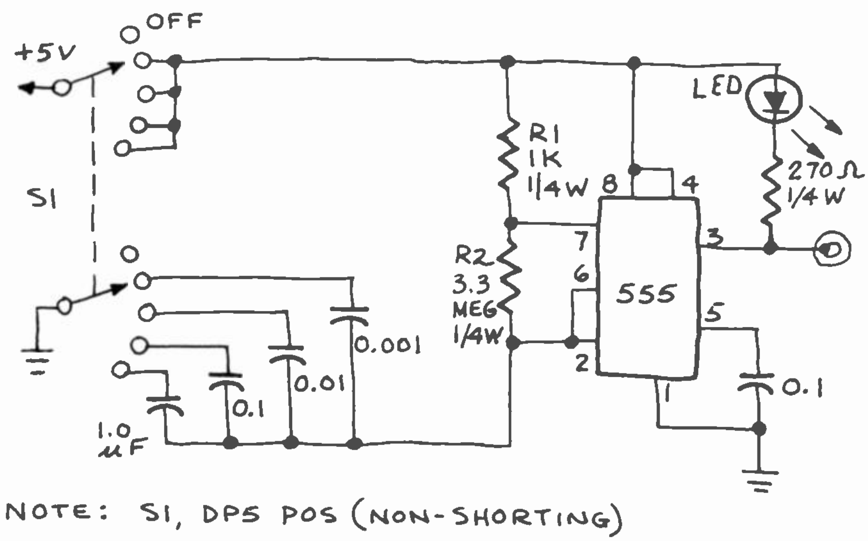

FIG. 7—PULSE GENERATOR produces squarewaves at frequencies of 0.1, 1, 10 and 100 hertz.

stopped most conveniently by putting an SPDT switch on pin 4 of the 555 circuit. When pin 4 is grounded, the counter stops; when it is connected to V_s (+5), the counter runs.

The 7490 circuit can be reset to 0 by connecting pins 2 or 3 to V_s; it can be reset to 9 by also connecting pins 6 or 7 to V_s. The reset and start/stop functions can be combined in a single DPDT switch.

Things to try

1. You can have an audible time signal by connecting a Sonalert between pin 3 of the 555 circuit and ground. If the Sonalert is connected between pin 11 of the 7490 and ground, it will sound a tone warning at count 8.

2. A second digit can be added so that the counter indicates up to 99 intervals. This will require a second 7490 circuit and four LED's for binary; or a second 7490, a 7448 circuit and a 7-segment digital unit for Arabic. In either case, connect the input (pin 14) of the second 7490 to pin 11 of the first 7490. Of course, a third, fourth and more digits can be added similarly.

3. A common anode digit and a 7447 circuit can be substituted for the 7448 and common-cathode digit.

4. Follow the 7490 with a 74145 (BCD-to-decimal decoder-driver) and 10 LED's to make a 0-to-9 sequential light counter. If interval T is made short, the light will appear to sweep up the line of LED's.

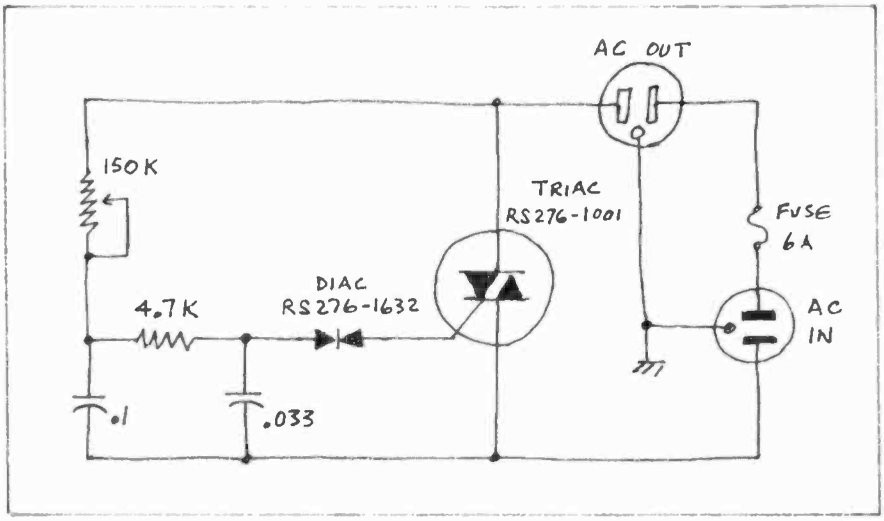

FIG. 5

Troublesome circuits

If you have trouble with any of these circuits, there could be three causes:

1. You may have made a wiring error, which is easy to correct unless something went up in smoke when you applied power. That's why wiring should *always* be checked before throwing the ON switch—we all make wiring errors from time to time.

2. One of the components may be bad or it may have a value outside of acceptable tolerance. Since sometimes this information is difficult to find, we'll try to call your attention to any parts that seem critical.

3. Typographical errors do occur on rare occasions. This is a toughie to correct in your project. About all we can say is that a correction will be printed as soon as possible.

continued on page 89

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CIRCLE 100 ON FREE INFORMATION CARD

computer corner

DAVID LARSEN, PETER RONY, and JONATHON TITUS*

MOST MICROCOMPUTERS MANIPULATE INFORmation eight bits at a time. For example, the 8080A microprocessor can move the eight bits from internal register to internal register, from internal register to memory, and between the accumulator and an external I/O device. It can also perform arithmetic and logic operations, the former including add, subtract, and compare, and the latter including AND, OR, EXCLUSIVE-OR, and COMPLEMENT. In this column, logic operations will be explored.

The basic rules governing one-bit logic operations are truth tables. A truth table can be defined as a tabulation that shows the relation of all output logic levels of a digital circuit to all possible combinations of input logic levels in such a way as to characterize the circuit functions completely.[1] The truth tables for the AND, OR, EXCLUSIVE-OR, and COMPLEMENT operations are:

AND

B	A	Q
0	0	0
0	1	0
1	0	0
1	1	1

OR

B	A	Q
0	0	0
0	1	1
1	0	1
1	1	1

EXCLUSIVE-OR

B	A	Q
0	0	0
0	1	1
1	0	1
1	1	0

COMPLEMENT

A	Q
0	1
1	0

These truth tables are called *one-bit tables* because data words A and B each contain only a single bit.

In discussing logic instructions, it is useful to employ *Boolean symbols.* Such symbols originate from the subject of *Boolean algebra,* which is the mathematics of logic systems. Alphabetic symbols such as A, B, C, . . . , Q are used to represent logic variables and 1 and 0 to represent logic states. This particular form of mathematics was originated in England by George Boole in 1847. It did not become widely used until 1938, when Claude Shannon adapted it to analyze multi-contact networks for telephone networks.

What should be learned about Boolean algebra are the basic Boolean symbols that are used in Boolean algebra computations, and thus all digital logic. These symbols include the following:

- $+$ which means *logical addition* and is given the name OR
- $\cdot$ which means *logical multiplication* and is given the name AND
- $\oplus$ which is given the name *EXCLUSIVE-OR* or XOR
- $\bar{A}$ which means *negation* and is given the name NOT

The negation symbol is a solid bar over a logical variable such as A, B, . . . , Q. Thus, the Boolean statement for a two-input AND gate is $Q = A \cdot B$, or simply $Q = AB$, where the equality symbol means that the variables or groups of variables on either side of the "=" symbol are the same, i.e., both are in the same logic state. It is useful to summarize the symbol operations for the three gates that are being considered:

AND	OR
$0 \cdot 0 = 0$	$0 + 0 = 0$
$0 \cdot 1 = 0$	$0 + 1 = 1$
$1 \cdot 0 = 0$	$1 + 0 = 1$
$1 \cdot 1 = 1$	$1 + 1 = 1$

EXCLUSIVE-OR	COMPLEMENT
$0 \oplus 0 = 0$	$\bar{0} = 1$
$0 \oplus 1 = 1$	$\bar{1} = 0$
$1 \oplus 0 = 1$	
$1 \oplus 1 = 0$	

Multibit logic operations are treated as many one-bit logic operations. No new principles of logic are involved. The corresponding bits of one binary word logically operate on the corresponding bits of the second binary word to produce an overall multibit logic result. The length of the binary words can be any number of bits: two bits, eight bits, thirty-two bits, etc. Since the 8080A microprocessor performs multibit logic operations on eight-bit words (bytes), all of the examples will involve full bytes.

Consider the eight-bit logic variable, A. The individual bits in this variable are labeled as A7, A6, A5, A4, A3, A2, A1 and A0, with A0 being the least significant bit (the 2^0 bit) and A7 being the most significant bit (the 2^7 bit). Also consider the eight-bit logic variable, B, that has individual bits that are labeled as B7, B6, B5, B4, B3, B2, B1 and B0. The logic operation, $A \cdot B = Q$, means the following eight one-bit logic operations:

$A0 \cdot B0 = Q0$	$A4 \cdot B4 = Q4$
$A1 \cdot B1 = Q1$	$A5 \cdot B5 = Q5$
$A2 \cdot B2 = Q2$	$A6 \cdot B6 = Q6$
$A3 \cdot B3 = Q3$	$A7 \cdot B7 = Q7$

The result of the logic operation is the logic variable Q that has a least significant bit of Q0 and a most significant bit of Q7. In other words, *multibit logic operations are performed bit-by-bit via a series of one-bit logic operations.* It is easier to perform multibit logic operations if the multibit binary words are placed one under the other. Thus, if $A = 11011111_2$ and $B = 00100011_2$, then $A \cdot B$ is

$$\begin{array}{r} 11011111_2 \\ \cdot\,00100011_2 \\ \hline 00000011_2 \end{array}$$

or $Q = 00000011_2$. In performing a logical AND, the relationships $0 \cdot 1 = 0$ and $1 \cdot 1 = 1$ were used in deriving the final result. (The subscript 2 reiterates the fact that a bit takes only two values.)

One of the more important uses for multibit logic operations is in situations in which the on-off state of external devices must be monitored. Consider the following system of eight devices:

Bit position	Device	Logic state information
Bit 0	pressure sensor	1 = pressure above set-point 0 = pressure at or below set-point
Bit 1	temperature sensor	1 = temperature above set-point 0 = temperature at or below setpoint
Bit 2	velocity sensor	1 = velocity above set-point 0 = velocity at or below set-point
Bit 3	flow rate sensor	1 = flow rate above set-point 0 = flow rate at or below set-point
Bit 4	concentration sensor	1 = concentration above set-point 0 = concentration at or below setpoint
Bit 5	Valve A	1 = valve A open 0 = valve A closed
Bit 6	Valve B	1 = valve B open 0 = valve B closed
Bit 7	Power	1 = power on 0 = power off

The group of eight bits is called the *status byte* for our system of eight devices. At any instant

* This article is reprinted courtesy of American Laboratories. *Dr. Rony, Department of Chemical Engineering, and Mr. Larsen, Department of Chemistry, are with the Virginia Polytechnic Institute & State University. Mr. Titus is president of Tychon, Inc., a microcomputer consulting firm in Blacksburg, Virginia.*

of time, the status byte will have a specific value. For example, the status byte 11100010_2 signifies that the pressure is at or below the setpoint, the temperature is above the setpoint, the velocity is at or below the setpoint, etc. There are 2^8 or 256 possible combinations.

The importance of logic instructions in a digital computer is that they permit the determination of the following characteristics about the external devices listed above:

- Which devices are on, open or above the setpoint?
- Which devices are off, closed, or at or below the setpoint?
- Since the last time we checked, which devices have gone from on to off, open to closed, or above the setpoint to at or below the setpoint?
- Since the last time we checked, which devices have gone from off to on, closed to open, or at or below the setpoint to above the setpoint?

In other words, using logical instructions, not only can the current state of the external devices be determined but also what changes have occurred since the last time that the devices were interrogated. Since it is not clear how this is done logically, a specific example based upon the eight devices described above should help.

Assume all eight devices have just been interrogated and the current status byte is found to be 11101010_2, where the least significant bit, bit 0, is on the far right. One second ago, the status byte was 11101001_2. What is the current state of each device, which devices have changed state during the last second, and in which direction? The steps to be employed to answer such questions are as follows:

STEP 1. Examine the current status byte. Determine the status of each external device from the logic state of its status bit.

The current status byte (CSB) is 11101010_2. From this value, it is concluded that the pressure, velocity and concentration sensors are all at or below their respective setpoints; the temperature and flow rate sensors are above their respective setpoints; and that valve A, valve B and power are all on.

STEP 2. Perform an EXCLUSIVE-OR operation between the prior status byte (PSB) and the current status byte (CSB). A logic 1 in the result indicates that the logic state of that device has changed.

The logic operation to be performed is

$$PSB \oplus CSB = Q1$$

where PSB = 11101001_2, CSB = 11101010_2 and Q1 is the result of the EXCLUSIVE-OR operation. Thus,

11101001	PSB
⊕ 11101010	CSB
00000011	Q1

and Q1 = 00000011_2. Only the pressure and temperature sensors have changed state.

STEP 3. Perform an AND operation between Q1 and the prior status byte (PSB). A logic 1 in the result indicates a device that has changed state from logic 1 to logic 0.

The logic operation to be performed is

$$PSB \cdot Q1 = Q2$$

where PSB = 11101001_2, Q1 = 00000011_2 and Q2 is the result of the AND operation. The following is obtained:

11101001	PSB
• 00000011	Q1
00000001	Q2

and thus can conclude that the pressure sensor has changed from being above the setpoint to now being at or below the setpoint (logic 1 to logic 0 transition).

STEP 4. Negate (or COMPLEMENT) Q2, then AND this complemented result with Q1. A logic 1 in the result indicates a device that has changed state from logic 0 to logic 1.

The logic operation that is now to be performed is

$$\overline{Q2} \cdot Q1 = Q3$$

Since Q2 is 00000001_2, the complemented value of Q2 must be 11111110. The result of the AND operation is obtained as follows,

11111110	$\overline{Q2}$
• 00000011	Q1
00000010	Q3

The result, Q3 = 00000010_2, leads to the

continued on page 89

Today's Semiconductors

KARL SAVON
SEMICONDUCTOR EDITOR

THE DATA SHEET FOR THE RCA CA3160 BIMOS operational amplifier (File Number 976) describes a device similar to the earlier CA3130 but with internal compensation. This means that in a host of applications you don't have to figure out the value of capacitors or more complex compensation networks to stop your favorite circuit from oscillating.

CA3160 application

Suppose you have a microcomputer or some kind of counter hooked up as a music generator or in a measurement system and you would like to convert its 8-bit parallel output into an analog voltage. Digital-to-analog converters tend to get complicated and expensive, but the one shown in Fig. 1 is neither. This circuit has nine parallel inputs labelled MSB1 to LSB9, from the most significant to least significant bits. The converter uses an R–2R precision resistor network to weight the various binary inputs to produce the DC output voltage. Speed is a virtue of this type of converter since there are no closed-loop comparisons or sequencing operations to slow things down. It's simply a matter of reading the parallel inputs and the time it takes the switches to settle and the circuit capacitance to charge.

The CA3160 in Fig. 1 acts as a voltage follower that takes the output of the resistor network and buffers it to feed the system output. To maintain converter accuracy, it is vital not to load the resistor network. It doesn't take much to disturb the DC output voltage. The situation is similar to measuring with a DC voltmeter. If the meter does not have a sufficiently high input impendance, it will load the finite impedance of the circuit and destroy the measurement accuracy.

The circuit uses five IC's; three CD4007's that serve as switches; the CA3160 voltage follower; and a CA3085 voltage regulator to supply a stable reference voltage. The system output cannot be any better than the reference voltage since all other errors are added to it.

The CD4007's are really COS/MOS amplifier stages. The input to each inverter amplifier is connected to each of the 9 digital inputs, and each corresponding output feeds one of the converter resistors. Starting at the most significant bit, notice that until you reach R7, the resistors keep doubling in value. Eight 806K's in parallel are about 100K; the next group on terminals 1 and 5 of IC3 combine to 100K, etc. A voltage on the most significant bit has the largest influence due to its lowest series resistance to the common output bus. As you move in the direction of the less significant bits, doubling the resistance value reduces their influence by one-half.

Assume for the moment that you are dealing with two input bits. These binary inputs are weighted in powers of two so that the most significant bit has a weight of 2 and the least significant bit has a weight of 1. If both bits are 0, the binary number is 0 and a 0-volt output is produced. If the least significant bit is a 1 and the most significant bit is a 0, the binary number is 1 and the output is one-fourth the reference voltage. A logic 1 on the most significant of the two bits and a logic 0 on the other equals a 2, which produces an output of one-half the reference voltage. Both bits at a logic 1 level produce an output equal to three-fourths of the reference voltage. By weighting each input in binary fashion, the converter produces equal steps from 0 to three-fourths of the reference voltage. The same pattern holds for the 9-bit converter except the range of output steps is from 0 to 511.

The circuit should double the resistance value down to the end of the chain, but this would require a resistance range of 256 to 1, which creates some real practical problems. By inserting the 1556-ohm series resistance, the total converter network resistance range is limited to only 16:1, a much more manageable figure. The actual choice of resistor values is a compromise between speed and accuracy. The larger the resistance the slower the R-C time constants, and the smaller the resistors the larger the effect of the 250-ohm output resistance of the CD4007's.

Resistors R8 and R9 combine to form a 1.612 megohm resistance. The voltage swing at its upper end has a specific, voltage influence on network output. Resistor R5, the next one in the chain, must have exactly one-half this influence. If we separate R5 from the resistors to its left, we can draw the equivalent circuit shown in Fig. 2. If the circuit is opened at point x, the voltage at that point will change by one-half the supply when the top of R5 is switched. The resistance of this circuit is the parallel value of the two 100K resistances, or 50K. Added to the 1556 series resistance, the total resistance comes to 1606 ohms, similar to the R8 and R9 resistance.

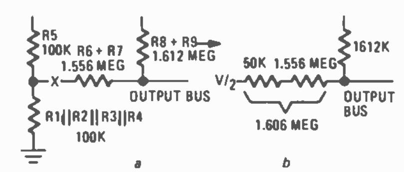


FIG. 2—EQUIVALENT CIRCUIT of the ladder network shown in Fig. 1 is shown in *a*. Simplifying the equivalent circuit yields the circuit shown in *b*.

The ladder network uses 1% metal film resistors. The most significant bits are assembled with parallel and series 806K resistors from the same lot. Paralleling resistors increases the probability of a good match between the components. The regulated voltage is adjusted higher than 10 volts to 10.01 volts to compensate for the loading of R2 to ground. **R-E**

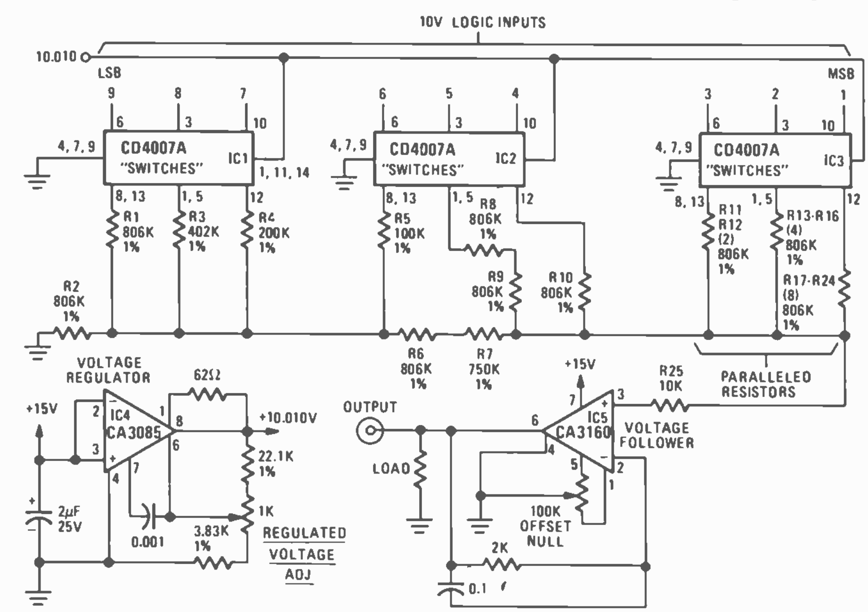


FIG. 1—DIGITAL-TO-ANALOG CONVERTER using the RCA CA3160 as a voltage follower.

service clinic

Attacking the intermittent. *Logic can win the battle.*

JACK DARR, SERVICE EDITOR

INTERMITTENTS ARE THE BANE OF OUR existence. They're responsible for more frustration, bad language, and monetary loss than anything else. Nobody ever made money on an intermittent. There aren't any hard and fast ways of handling them (especially "fast") but there are ways that can help; two of them. You could call them active and passive.

The passive method means "set it up on the bench and let it play till it cuts out." This can take up a lot of time since the stock intermittent will usually play indefinitely on the bench. (I may hold the U.S. record! I watched one set for more than 120 hours without catching it acting up; all summer, in fact.

Since surveys show that long delays in getting sets repaired and returned are a major cause of "consumer complaints" (even more than high service charges!) this method isn't too good.

The active way is best. "Don't just sit there; DO SOMETHING!" Attack it. Intermittents can be classified, and this gives us a place to start. There are two kinds; intermittent shorts or opens. Shorts are a bit easier. They can often be located from the burnt resistors or other signs of damage. Intermittent opens are another thing. They interrupt circuits causing the loss of signal, sync, sweep, and, in the easier ones, a loss of voltage. However, the nature of the fault will lead us to the *function* that is affected.

Intermittents are caused by one of three things:

Thermal: some part gets hot enough to open, change value, etc.

Physical: a bad *connection* somewhere that makes and breaks.

Voltage: the least frequent but still possible. Certain voltages go out of tolerance causing trouble. Solid-state sets with automatic hold-down circuits are quite prone to this. Either of the first two things can cause this, so this is really a "subclass "

There is no definite line of demarcation between these, of course. For example, a thermal might be a burnt resistor that is cracked. Thermal expansion can make it open, and it can also be made to act up by jarring the chassis. So, don't freeze on any single attack; be flexible. Use them all at once if necessary!

A "thermal" resistor, in this sense, means one that changes in value when it gets hot. It may even open entirely. This definitely includes those types which are supposed to change, such as thermistors. These may be changing too much or not enough. Now let's see about methods of attack.

Check the *characteristics* of the intermittent fault. If the trouble shows up within the first 8 to 10 minutes of operation, this could be a thermal resistor in a current-carrying circuit. Plate or collector load resistor, etc. The heat that makes it go bad is developed in the resistor itself from the current. This could be called a "conduction" thermal. Such resistors usually heat up enough during the first few minutes to go bad.

If the resistor is used in a "dry" circuit, with practically no normal current-flow, it too can be thermal. In this case, it is heated by radiation of heat from nearby parts or from the chassis. It could be called a "radiation" thermal. (The heat is "conducted" through the chassis, but let's not mention that; we'll be confused enough as it is!)

The main characteristic of such thermals is the much longer time-constant. This is normally at least an hour and may be far longer. These little gems are the ones that act up in the cabinet and just won't show up at all with the chassis out of the case, or even with the back off!

Where to start

Now, to the attack. If the problem shows these signs of being thermal, locate the function or circuit which is affected. For example; the problem is a sudden loss of picture and sound leaving a clean raster. Here we have three suspects; tuner, IF and AGC. Eliminate the tuner by checking with a tuner-substituter. Eliminate the AGC by clamping it. This leaves us with the IF strip. (Unless the previous tests showed that the trouble was in one of the first two. We should be so lucky?)

How do we attack? We've agreed that this shows signs of being thermal. So we heat things up or cool them off to see if we can *make* the problem show up. You can use a heat-gun, such as the Wahl *Thermal-Spot,* to heat up individual parts. You can also hold the tip of a soldering iron on the part long enough to warm it up. If this doesn't make it happen, try the opposite; cool things off with freeze-spray.

These tests are very useful for finding things like thermal transistors, of which there are quite a few. (I have a pet on my bench: At room temperature it works perfectly. Warm it or cool it only a very few degrees, and out it goes, only to come back when it returns to room temperature!)

These things are also useful for finding drifting resistors that cause such things as a gradual loss of vertical sync, color, etc. Heat or cool them while watching the screen. If you do find one, replace it and then check all of the others in the circuit. There may be more than one.

The physical or "jar-intermittent" can be made to show up by jarring the cabinet (the famous "Punt" treatment.) These shouldn't be too hard to find, but of course often are. If you can make it act up by jarring the cabinet, note which function is affected. This tells you where to start. Go to the area of this circuit and start tapping things *very lightly.* Use an insulated tool. Something like a plastic screwdriver is my favorite. You can tap with the end or hit harder with the handle if necessary. The part that is causing the problem will be the most sensitive to tapping. Use a very light touch until you find a place where only a very light tap will make it act up.

Bad solder joints are one common cause. Hairline cracks in PC board con-

This column is for the service technician's problems—TV, radio, audio or industrial electronics. We answer all questions submitted by service technicians on their letterheads individually, by mail, and the more interesting ones will be printed here.

If you're really stuck, write us. We'll do our best to help you. Don't forget to enclose a stamped, self-addressed envelope. If return postage is not included we cannot process your question. Write: Service Editor, Radio-Electronics, 200 Park Avenue South, New York, NY 10003

ductors are another. (These can *also* be thermal, when the board warms and expands.) Small electrolytic capacitors are another common cause. And do *not* overlook dirty tube-socket or other plug-in contacts. If you can get it pinned down to only a small area but can't *see* the one that is bad (not uncommon), you're justified in "shotgunning" this.

Remelt and add fresh solder to all of the joints in this area. This normally won't involve more than about a dozen at the most. This catches a good many of them though you never know just which one it was. (Who cares?)

The last class involves voltages. If they are high or low, they can cause intermittents. It may be the AC line voltage or one of the DC power supply voltages. A variable-voltage transformer is invaluable here. You can run the AC line voltage up or down to see if this makes the problem show up.

Look for "common-cause" circuitry. For example, many solid-state sets have a regulated low-voltage DC power supply. It feeds the horizontal output stage that in turn develops other low-voltage DC supplies. An intermittent condition in the primary DC supply will cause all of the rest to go bad, apparently affecting a great many circuits at the same time.

In one set, an intermittent Zener clamp in the low-voltage regulator let the output voltage go too high. This made the high-voltage rise, triggering the high-voltage shutdown circuit (which it was supposed to do). In cases like this, always go back far enough to make sure that the fault is not in circuits such as the DC low-voltage regulator and not in the high voltage at all. All of these regulated low-voltage supplies are critical.

All intermittents are annoying, and some can be infuriating. These are the "touchy" ones. The problem shows up; but touch any point in the circuit with a test-lead and it promptly goes back to working perfectly. There is an attack for these, too. One way is to use your scope, but do not make actual contact with the circuit. Hold the probe tip near, but NOT touching, the circuit. By increasing the vertical gain, you can get a pickup pattern and see whether a signal is present at certain points.

Another way is to connect a high-impedance voltmeter to test points, with the power *off*. When the set is turned on, you will be able to see the reading without causing the transient that shocks it back into operation. Still another way is to open the supply circuit and insert a milliammeter or ammeter. The current drain will give you a better idea of the nature of the fault; short or open. Use your ingenuity, and you will find numerous other ways of making tests in cases like this.

I might say in closing that I feel well-qualified to discuss the subject. Right now, my TV is intermittent, my *car* is intermittent, and I've got a flashlight that's not working all that well. Just as soon as I get this done, I'm going to have to go to work. **R-E**

reader questions

VERTICAL SYNC PROBLEM

Thank you for your suggestions on the vertical sync problem in this Wards Airline GEN-12440A, (Sams 1143). The horizontal sync was good, but the vertical weak. We found both capacitors C406 and C413 open. Replacing them cured the trouble. Now tell me how I got horizontal sync through capacitor C406?—R.S., Littleton, CO.

This is simple. (Note how simple all of these problems are, *after* they're solved.) Both of these are 3.3-μF *electrolytic* capacitors. They lose capacitance where a paper capacitor can't; it's either good or open.

Capacitor C406 is the coupling capacitor, and it had enough capacitance left to let the high-frequency horizontal sync get through, though it reduced the vertical sync amplitude. (Vertical sync works on amplitude.) Capacitor C413 is the screen grid bypass on the sync-separator 6GH8, and if it's open, you'll get quite a bit of degeneration and a loss of gain.

AGC PROBLEM

Here's one for your collection. I apparently had AGC problems in this Sears 529.7246 chassis. The set had a raster, but no snow or sound. Adjusting the AGC control had no effect. Checking DC voltages, I found No. 1 B+ source to the tuner read zero. This comes from the cathode of the 50C5 audio output tube. Read this voltage (from underside of chassis) and *it* was zero. Replaced 50C5 tube and still nothing.

Looking at the top side, I saw that the 50C5 and a pair of 12AV6's weren't lit. Since they use a series heater string, I'd assumed that all of the tubes were lit. Turns out that these three are fed through a 300-ohm 10-watt dropping resistor all by their little selves. This resistor is R231, even though the parts lists says C231. It was open and replacing it fixed the set.

Thanks to Joe Witt, of Maxi-Watt Electronics, Vineland, NJ.

RELAYS CHATTER ON PEAKS

Here's one for you on ham gear. I'm trying to drive a Heath SB-230 linear amplifier with a Hallicrafters SR-150 transceiver. This works well in all bands except the 7-MHz band, but here the relays chatter and cut out on voice peaks. Happens only in PTT (Push-to-talk). This must be RF getting in, but so far I can't find it.—F.K., Raytown, MO.

Speaking from a background of almost complete ignorance on actual amateur gear, I can give you a couple of ideas. You noted that the relay driver tube grid varied when the relay chatters. Try connecting a diode from this grid to ground, anode grounded. The idea of this is to clip the negative going peaks of the interfering signal and help hold the plate current steadier. Also, add more bypassing to ground on this grid.

(Feedback: "Tried diode to ground. It works. Fantastic!")

FUSE BLOWS

The 2.5 fast-blow fuse that supplies the +145 volts to the flyback in this Magnavox T982-12, blows within 30 seconds after turn-on. I've changed the horizontal output transistor, tripler and the flyback, and it still blows. It makes a perfect picture till the fuse goes. What's going on here?—B.H., Decatur, GA.

After the things you've changed, nothing. Hi! Seriously, something *else* is causing this, but what? I hunted through the schematic for about 15 minutes and finally came up with a good possible. This same fuse is also connected to a pulse supply that develops +250 volts. This is what took me so long; I couldn't find out where that 250 volts went.

Finally stumbled over it. This is the DC bias applied to the picture tube heater, and nothing else. You have a diode and a couple of electrolytic capacitors in that circuit. If any of these are bad, the fuse could blow; just disconnect the +250 volts and see.

HIGH-VOLTAGE ARCING

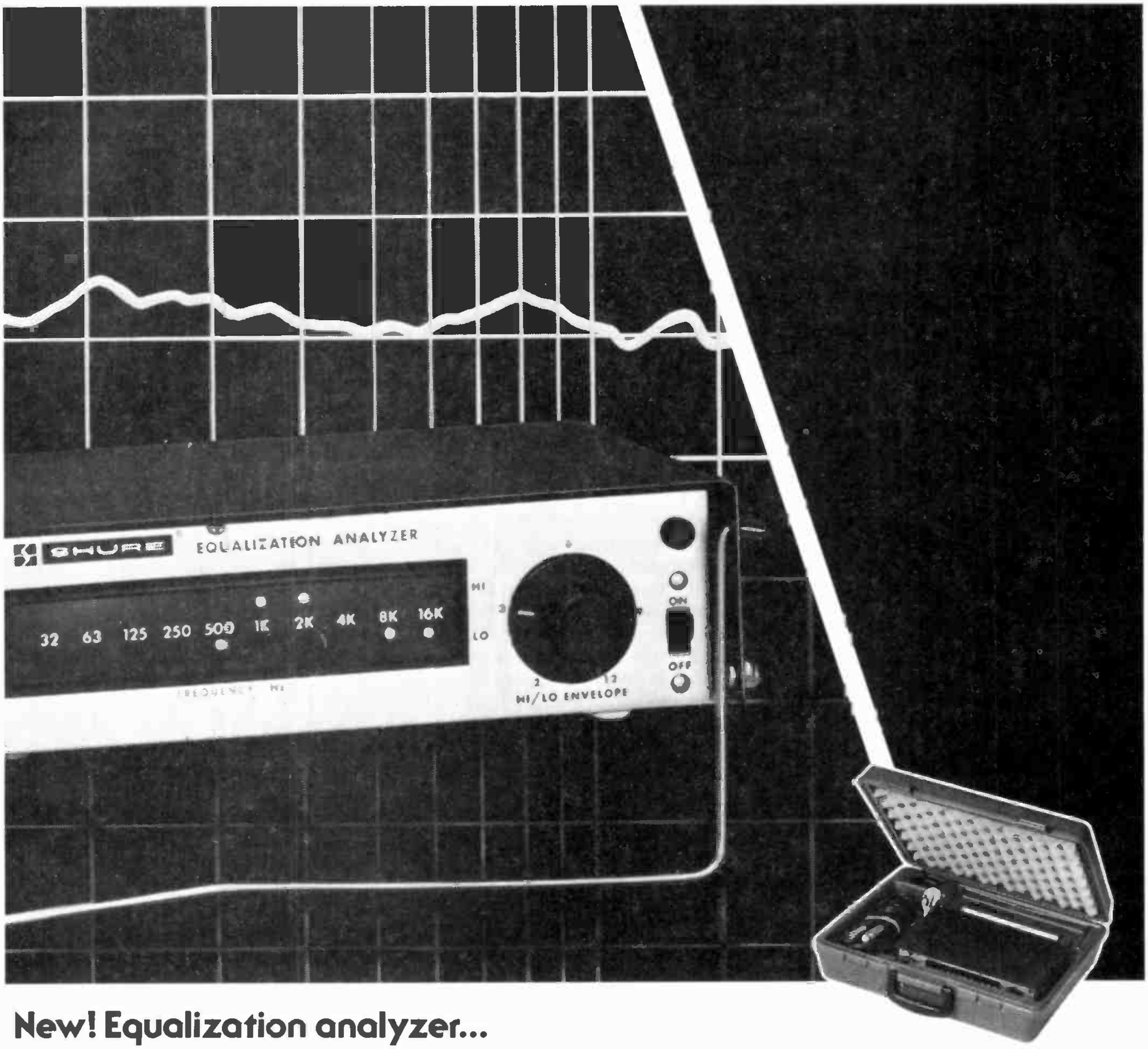
The high-voltage arcs all around the back of the picture tube in this Zenith 21X1C36. I can see arcs and flashes all around it. Sometimes the picture goes out of focus and then goes out. I suspect the picture tube but I'm not sure. How can I verify this?—J.H., Houston, TX.

This is one of those "might be the picture tube; might not" things. There *is* one way to tell. Hook the chassis up to a test jig! If you get the same symptoms, this is some kind of oddball problem in the grounding of the dag coating, etc. If this clears all symptoms up, the original is bad.

VOLTAGE-DEPENDENT RESISTOR

Where can I find a VDR used in a Motorola TS-597C? It's the one connected between the +250-volt source and the brightness control. The part number is 6C66263A08. Can't find it anywhere around here, even in the factory parts catalogue!—R.A., Thibodaux, LA.

This VDR can be replaced with an Oneida GB-308. This is rated 1.0 mA at 110-120 volts. This one will also replace an RCA 114862. Oneida parts are available at a lot of radio-TV supply houses. Their address is 853 North Cottage St., Meadville, PA 16335. **R-E**



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step by step

Antennas and transmission lines. *Improve reception with the right antenna system.* STAN PRENTISS

THIS SERIES HAS NEVER DISCUSSED ANtenna and transmission line characteristics, so a short discussion might be helpful to many—both in and out of the TV business—who are contemplating new installations.

Be assured there's more to retrieving a signal from the air than meets the eye, especially if you take time to ask: What "makes" this or that antenna or lead-in the best? You'll find that worthwhile products can almost always be judged fairly by their manufacturing specifications, especially if the maker has a history of reliability. Manufacturers of the better product lines, of course, usually make detailed specifications, such as antenna polar and gain graphs of transmission-line shielding and loss characteristics, available.

Obviously, prairie and mountain folk 100 miles from the nearest transmitter require antennas with very high gain and the best available 300-ohm "dry" transmission line for maximum signal pickup. Perhaps even a very high mast or tower with variable elevation and directional devices may be in order. The special circumstances and special needs are normally well known in the individual localities and need no discussion here. What we do wish to review and comment upon, however, are the vast numbers of installations within 50 miles of TV stations that probably would respond with a 25- to 50-percent improvement in signal pickup *if* installers would adhere to solid fundamentals.

Broadcast signals

Broadcasts stations are power limited—if you didn't already know—to prevent such problems as co-channel and adjacent-channel interference. In the northeast United States, the VHF stations must begin cutting back power when their towers have risen 1,000 feet above the average surrounding terrain. UHF cutbacks begin at 2,000 feet everywhere, while VHF around the Gulf coast and the remainder of the U.S. can have transmitters reaching 2,000 feet, the same as UHF, before power is curtailed. Broadcast power is also limited to 100 kilowatts for Channels 2 through 6; 316 kilowatts for Channels 7 through 13; and 5 megawatts for all UHF stations. Stations within 250 miles of the Canadian border are normally limited to 1 megawatt.

Received signals

Television signals between 54 and 890 MHz are broadcast virtually line-of-sight—especially signals in the 470-890 MHz spectrum. This energy consists of electromagnetic waves that are horizontally polarized. The radiator (broadcast antenna) length is inversely proportional to frequency. Naturally, what is broadcast can also be received, but FM and TV receiving antennas are far different from broadcast antennas because they must handle a much broader range of signals and do not require heavy castings for large power dissipation. And while broadcast antennas are very specially designed by teams of highly specialized engineers, receiving antennas may or may not be (depending on the company) so their characteristics are worth looking into. True, you do need structural strength in any receiving antenna to withstand winds of at least 75 MPH, as little wind resistance as possible, exterior coatings that will not succumb to salt spray, soot and other undersirable accumulations which tend to form leakage paths that reduce efficiency and signal pickup. You would also like as many transmission-attracting elements as possible. The *Yagi* is the best example of an antenna using a combination of parasitic and driven arrays. Parasitic elements help supply unidirectional patterns to aid both directivity and selective gain.

Some companies make a *Log Periodic* antenna, whose principles were first discovered by an antenna research group at the University of Illinois in 1954. But it's only been since 1963 that log periodics,

continued on page 86

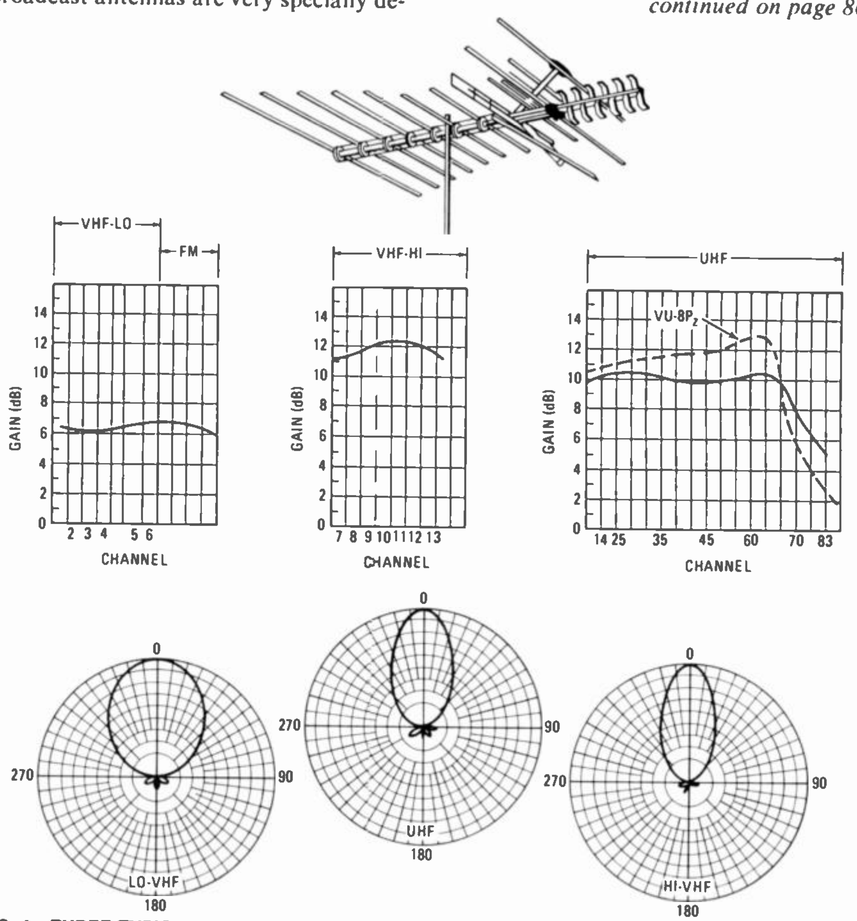

FIG. 1—THREE TYPICAL POLAR PATTERNS for a fringe-area antenna.

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CIRCLE 39 ON FREE INFORMATION CARD

STEP BY STEP TROUBLESHOOTING
continued from page 84

with their different length dipoles—each half-wave resonant at its own specific frequency—have been used extensively in consumer electronics. In the graphs of Fig. 1 you will note gains of 6 dB (as compared with a folded dipole—since an antenna has no actual gain of its own) for the low VHF band (and FM), between 11 and 12 dB for the higher VHF band, and a nominal gain of 10 dB for UHF channels 14 through 68. (Channels 69 through 83 are now ordinarily used only by translators and land mobile.) Now, take a quick look at the polar patterns (shown in Fig. 1) with their large front lobes and small side and back lobes and let's investigate these. An example will help illustrate what we mean.

Polar patterns

The polar pattern in Fig. 2 is drawn in 90-degree quadrants with the three inside circles representing 3, 10, and 20-dB losses. The 3-dB half-power point occurs about 15 degrees on either side of zero (the antenna's front lobe beamwidth is 30 degrees). That's what the antenna "sees" when pointed toward a transmitter. Obviously, this is somewhat narrow, and a beamwidth of 60 degrees would be more appropriate for metropolitan or suburban reception.

The real problems with this pattern are the back and side lobes that deliver a front-to-back ratio of only 13 dB—not especially good; 20 dB would be considerably more satisfactory. Unfortunately, these side lobes permit interfering frequencies (including ghosts) to enter almost the entire back area of the array, with only the area between the forward horizontal 35- and 90-degree markers free from spurious signals because of antenna rejection. In the broad, composite patterns of Fig. 1, the front-to-back ratio is at least 20:1 (26 dB), with insignificant back lobes, and beamwidths that range from some 60 degrees in the low VHF band, to about 30 degrees in the high VHF and UHF bands where directivity is somewhat more important.

Surprisingly, the characteristics in Fig. 2 are not all that bad. For had this pattern been broadened to at least a 60-degree beamwidth, it would probably make a good metropolitan antenna if there were no tall buildings or hills to induce reflected images. So tailoring an antenna for each location can not only improve your installation immensely, but often save the customer considerable cash when elaborate antenna systems are not needed. Of course, if you're right next to some television broadcast or other interfering transmitter, you'll have to use a high gain, narrow beamwidth antenna with rotor and, perhaps, pad it resistively to reduce excess gain. In any circumstances, know your area characteristics, consult the manufacturer's gain and polar patterns, and install an antenna that is adequate for the particular location. Don't guess!

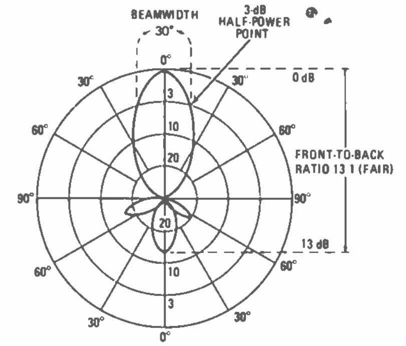

FIG. 2—30-DEGREE BEAMWIDTH ANTENNA, with rather large side and rear lobes.

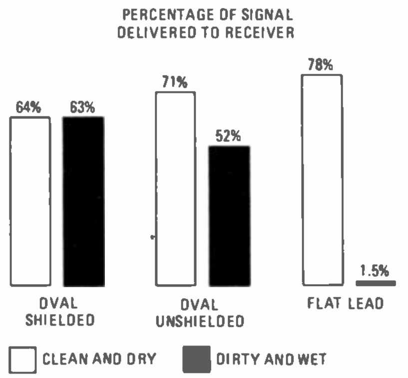

FIG. 3—TRANSMISSION LINE EFFICIENCY, for shielded and unshielded types. Note that the best line when dry is the worst one wet.

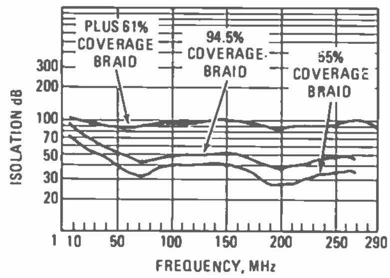

FIG. 4—DIFFERENCES IN ISOLATION for three types of shielding. Bottom, 55% coverage braid; middle, 94.5% coverage braid; top, dual-foil laminate plus 61% coverage braid.

Transmission lines

Just as important as antennas are transmission lines; if the two aren't matched, the resulting standing-wave ratio (SWR) can generate unacceptable losses, line interference and all sorts of nasty signal reflections and attenuation. SWR—for your information—is the difference (quotient) between the maximum and minimum currents (or voltages) across any single or multiple conductor. The incident (outgoing) and reflective (incoming) signals will form stationary valleys and energy peaks to distort incoming information one way or another. Certainly the best insurance against a high SWR is to terminate the line in its characteristic impedance, so no energy will be reflected back from load to source. Therefore, both antenna and receiver should always present a correct impedance match to any and all transmission lines.

Unfortunately, not all transmission cables are alike, as is evident in Fig. 3. This chart shows both shielded and unshielded 300-ohm lead-in characteristics under dirty-wet and good-dry conditions. Note that flat lead when old and wet is a drastic attenuator and really should be used only indoors, being especially vulnerable when allowed to lie on metal, gutters, or roofs. Adequately shielded cable can touch other objects, but should not be permitted to contact rooftops or other places that collect either water or dirt.

Coaxial cable versus twin lead is an old subject of discussion that often fails to take into consideration so many of the

continued on page 88

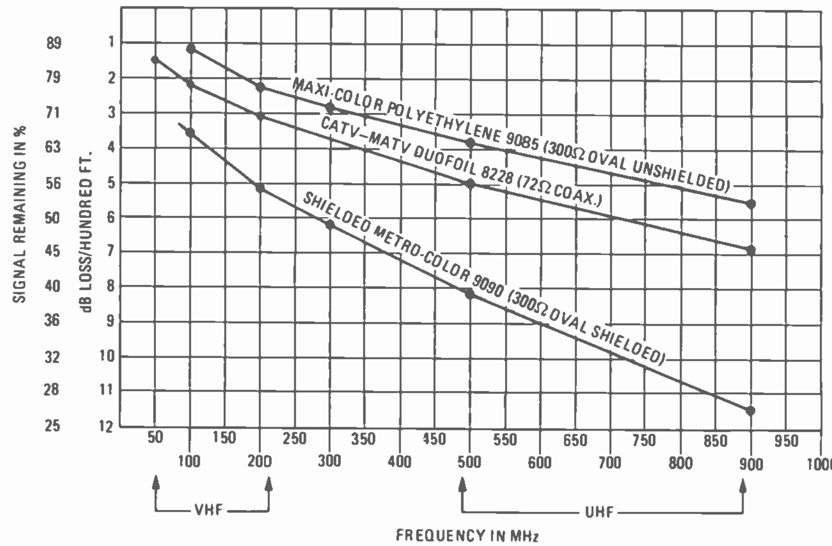

FIG. 5—LOSSES IN TRANSMISSION LINES. Top, low-loss oval unshielded line; middle, low-loss shielded 75-ohm coax; bottom, high-quality shielded 300-ohm lead. Characteristics of the 9283 are similar to those of the 8228 (middle curve).

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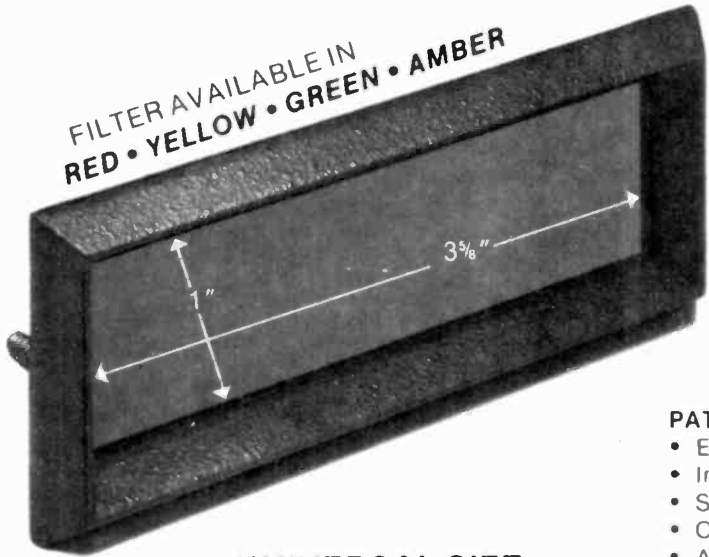

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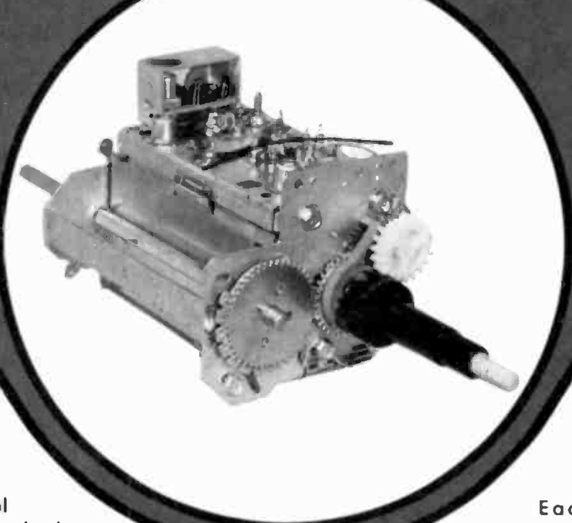

STEP BY STEP TROUBLESHOOTING
continued from page 86

new advances in transmission line use and construction. The Belden Corp., for instance, has recently developed an outstanding new CATV drop cable, the 9283, consisting of polyester film with aluminum foil bonded to the polyester core, and either a tinned copper or aluminum braid cover. Belden's tests (Fig. 4) show that with aluminum inner foil laminate plus 61 percent braid cover, there is 100-dB isolation from external interference. The cable, of course, is usuable for home TV installations as well as CATV. There's a little cost differential, but the price spread between the *best* 300-ohm line and this cable isn't overwhelming either.

Figure 5 shows the attenuation characteristics (both the dB loss and percentage of signal remaining) for comparable 8228 cable (without the addition of extra braid), as compared with both unshielded and shielded 300-ohm standard TV transmission lines. Note that the 8228 cable is within approximately 1.5 dB of Belden's best unshielded—the 9085—over the entire frequency range. (Losses of the 9283 are almost identical with those of the 8228.) Then add 0.5 dB for each top (antenna) and bottom (receiver) matching transformer (balun), and you have a difference total of 2.5 dB. Will this do your metropolitan-suburban job of keeping interference to a minimum as well as passing excellent signals? Try it within 50 miles or less of the transmitter and you will be more than pleasantly surprised. Further, the total electromagnetic field will be contained in the coax; SWR will be low because of the matching transformers, and you'll have considerably better UHF and improved VHF reception as a result. **R-E**

"Uncle Bill, Mother, Sis! Let us have our honeymoon before Fred gets to your TV sets!"

HOBBY CORNER
continued from page 73

You will notice that nothing has been said about a circuit being bad in the first place. That's because everything you see in this column has been checked out and built at least on a breadboard. *Any exceptions will be clearly marked "UNTESTED."*

Iron temperature control

Do you have a light dimmer or motor speed control on your workbench? Of course, it's handy for slowing down the drill or grinder when working in soft materials such as plastic. But at our workbench the soldering iron is usually connected to it.

Just having one all-purpose soldering iron instead of two or three for various uses can cause trouble with many solid-state circuits because excess heat can quickly ruin a part or even a circuit board. However, you can keep your iron at just the right temperature with a dimmer/speed control.

The control shown in Fig. 5 can be assembled quickly and easily. Be sure to provide a good heat sink for the triac. Although the 6-amp unit specified can readily handle any normal electronics iron, you might want to use the control with something heavier.

Once you use the dimmer/speed control with your iron you'll find you destroy fewer parts and boards and your iron and tip will last longer.

New CB guide

For beginning CB'ers, Radio Shack has published a second edition of *All About CB Two-Way Radio* (RS #68-1046). This updated nontechnical guide covers such topics as how CB got started, types of radios and antennas, how to set up fixed and mobile stations, FCC rules and regulations and plenty of ideas on using CB. **R-E**

Please remember that we want to hear from you—your needs, suggestions, ideas and circuits. Drop us a note. *73, Doc*

"Hey, Ed. He says he's your Uncle Charlie about a 10-30."

TESTING CB RADIOS
continued from page 53

completely during a noise pulse become apparent by their vastly improved performance over simple noise clippers.

22. Audio Output Power. At the level at which the audio output contains 10% distortion or full volume, whichever is greater, we will measure the AC voltage across the speaker terminals and, using the speaker's characteristic impedance, calculate the audio power in watts.

23. Public Address Output Power. We measure the power in watts directly into 8 ohms at the P.A. jack.

24. Power Drain. Measured in 6 watts at nominal line voltage in receive mode with audio squelched off.

The tests **Radio-Electronics** will use as a part of our CB Equipment Reports are conducted by an independent testing laboratory using the highest quality test equipment. We will from time to time add new tests if they are needed to rate as yet unknown features and delete those tests that do not seem important any longer. We will test at least two transceivers each month and may review an important new accessory occasionally if it requires a technical critique that fits our format. The actual tests will be performed on equipment supplied to us by the respective manufacturer and it is expected that they will be representative of the models in production. **R-E**

COMPUTER CORNER
continued from page 79

conclusion that the temperature sensor has changed from at or below the setpoint to above the setpoint (logic 0 to logic 1 transition).

The reason that such a series of logical operations is performed is to determine what type of corrective actions to apply to the system if it is not operating properly. If the temperature is below its setpoint, a heater may have to be turned on. If the concentration of a reactant is too high, valve B may have to be turned off to temporarily halt the flow of reactant into the system. If the pressure is above the setpoint, an emergency condition may exist and the power may have to be turned off for the entire system. With a properly interfaced microcomputer, all such decisions are easily and quickly made under software control and the necessary corrective actions initiated. However, mechanical and electromechanical devices typically have response times that are much longer than the decision times for a microcomputer. These response times must be taken into account in software design, and are important considerations in the field of digital controls. A discussion of response times is beyond the current scope of this column. **R-E**

REFERENCES:

1. GRAF, R. F., *Modern Dictionary of Electronics*, Howard W. Sams & Co., Indianapolis, 1972.

new books

INTERFACE INTEGRATED CIRCUITS HANDBOOK, National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, CA 95051. 464 pp. 6¾ × 9 in. Softcover $4.00.

This handbook gives specifications on the complete line of interface products—peripheral/power drivers, level translators/buffers, line drivers and receivers, memory and clock drivers, sense amplifiers, display drivers and optocouplers. The text is supported by graphs, charts and diagrams. Also included is a 72-page section of application notes on such topics as transmission lines, data transmission and high noise environments and driving gas discharge, and LED displays.

NOVICE AND GENERAL CLASS AMATEUR LICENSE Q & A MANUAL, by Marvin Tepper. Hayden Book Co., Inc., 50 Essex St., Rochelle Park, NJ 07662. 182 pp. 6 × 9 in. Softcover $6.35.

The ideal guide for anyone preparing to take an FCC Novice, Technician, Conditional or General Class amateur radio licensing exam. The book is brief and has FCC-type answers for each question and then explains most answers in detail. There are also chapters on the types of amateur licenses, FCC exam procedures, schedules, fees and locations, how to learn code, how to take the code in written exams, how to operate an amateur radio station and the latest FCC rules and regulations.

CB TESTING

continued from page 53

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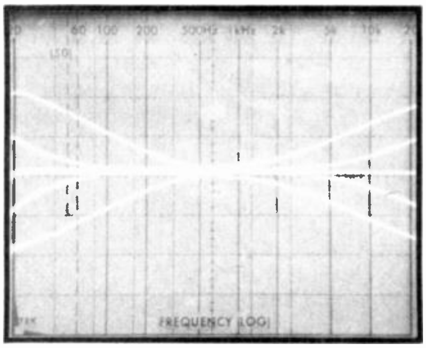
RE TESTS EPICURE PR-4
continued from page 69

tation before it becomes response-limited. This power bandwidth (at 7 volts RMS output) translates to a slew-rate of 4.8 volts-per-microsecond. Design has stressed minimization of transient intermodulation, and subsequent bench and listening tests attest to its success.

Laboratory measurements

Table I summarizes the results obtained in measuring the performance of the *model PR-4*. Distortion at rated output was so low that our readings were undoubtedly influenced by the residual test-oscillator distortion.



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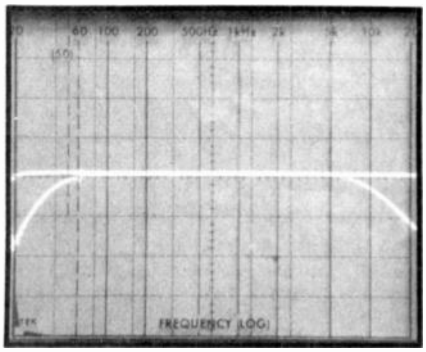

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The overload readings obtained for the phono input, although short of the 150 mV claimed, are actually referred to an input sensitivity of 1.5 mV. Translated to the more usual 2.5-mV input sensitivity of most phono input stages, the overload capability increases to around 133 mV and, referred to the *model PR-4*'s least sensitive phono input settings, the figure becomes 175 mV.

The dual ranges of the BASS and TREBLE tone controls were plotted using our spectrum analyzer; results are displayed in Fig. 5. Low- and high-cut filter action is similarly plotted in Fig. 6. As for the signal-to-noise ratio in phono, our measurements are referred to a 1.5-mV input, whereas the published specification is based on a 5.0-mV input.

Summary

The overall product analysis of the Epicure *model PR-4* is found in Table II. In actually using the preamplifier for listening and tape recording, we were pleased to see that the mode pushbuttons do not affect the tape outputs, so that signals available for recording are always stereo, even if a mono pushbutton is selected via the front panel. When this preamplifier was used together with a direct-coupled power amplifier, the transient response was extremely good and phono equalization was just about perfect. **R-E**

RF SIGNAL GENERATORS

continued from page 58

band. The fine control may be mechanical or electronic. The method of tuning may be of concern if the requirement for extreme frequency settability exists. An electronic vernier or a direct coupled variable capacitor vernier provides the lowest backlash method of fine frequency adjustment. The indicated difference between the two dial points required to get the same frequency when tuning from opposite directions is referred to as backlash. It makes setting an exact frequency quite difficult. Backlash can make it impossible to set a frequency at the same point on the dial when increasing frequency as when decreasing frequency.

A fine frequency control which is simply an edge-drive on a large coarse frequency control, or other forms of mechanical frequency vernier are much more inclined to have a high degree of backlash.

Frequency accuracy and readout

The expected accuracies, specified as a percentage of reading on band-switched LC oscillators, do not vary widely and figures such as ±4% are found on the lowest-cost generators, and only ±1% on some of the best. Frequency readout on such generators is normally on a circular or slide-rule dial. Each band has its own calibration. Dial calibration takes care of stray capacitance and inductance that may affect calibration.

If the generator has a digital readout, calibration accuracy becomes entirely different. The designer is no longer dependent upon the repeatability of various capacitors. The accuracy now becomes the accuracy of the digital frequency meter. This is almost entirely the accuracy of the crystal time base. Typical accuracies for digital frequency meters installed in RF signal generators are in the area of plus-minus one part per million ±(0.0001%). This results in approximately a ten thousandfold increase in accuracy.

Frequency stability

The frequency-stability specification covers a multitude of small variations. Each of the various frequency stability specifications presume independence from the effects of any other specification. Therefore, the total frequency stability specification of the generator must take into consideration the actual operating environment and not just any one single spec.

Frequency stability is normally defined for five different conditions. The two major ones are time and temperature. Stability with respect to time may be given for both short interval (10 minutes) and long interval (a few hours). It is usually given as a percentage of frequency setting per unit time. Drifts of 50 PPM/10 minutes are common on older generators with an order of magnitude improvement on newer generators. Long-term drifts may lie between 1 kHz and 10 kHz per hour for older generators. Once again, an order of magnitude improvement may be expected from newer generators.

Temperature stability is given as a percentage per degree centigrade. One degree centigrade is approximately 2°F at normal working conditions. The practical concern is change in frequency for change in temperature, rather than change in absolute calibration.

Two less important specs covering frequency stability indicate percentage frequency change due to load changes, and due to line voltage changes. The bandswitched LC oscillator often includes a stability specification for the time interval immediately following bandswitch operation. This specification may be read as a settling time.

Like all other specifications, these improve with generators of greater cost and lessen with generators of lower cost. On low-cost generators the specifications are frequently omitted.

Resettability

The resettability specification indicates the percentage of desired frequency to which a generator may be returned if it is set back to the same mark on the dial.

Amplitude range

Amplitude range is usually specified in both voltage and dBm. The minimum amplitude of generator output determines the suitability for testing radio receivers. There are few receivers that do not require a generator output that is substantially less than 1 μV (frequently as low as 0.1 μV) for making sensitivity checks. Simple receiver alignment and basic troubleshooting may be carried out at levels considerably in excess of the 1-μV level.

As noted, the output level specifications are usually given in both volts across 50-ohms and dBm (decibels relative to 1 milliwatt). Zero dBm is 223.6 mV, 1μV is -127 dBm, and 0.1 μV is -127 dBm. The maximum obtainable signal from a signal generator varies from 100,000 μV (0.1 volt or -7 dBm) to 3 V ($+22$ dBm). A maximum output of 1 V or $+13$ dBm is common.

The variation in output level is often a function of both price and frequency. VHF generators offer 1 V in modern designs and 100,000 μV output is common on older designs. HF generators usually offer a 3-V output on medium and upper price generators. Levels in excess of 100,000 μV are usually not necessary for radio receiver servicing. The high output levels may be required for research work or situations where

continued on page 100

new products

More information on new products is available from manufacturers of items identified by a Free Information number. Free Information Card follows page 108.

40-CHANNEL AM/CB TRANSCEIVER, *model Malibu 40,* is a rugged, economical set suitable for installation in commercial and pleasure vehicles. Features phased-locked-loop circuitry, 4-

pole ceramic bandpass filter, easy-to-read channel numbers, microphone, adjustable squelch and volume controls, and backlighted RF power-out/"S" meter. Suggested price: $159.95.—**SBE, Inc.,** Dept. P, 220 Airport Blvd., Watsonville, CA 95076

CIRCLE 80 ON FREE INFORMATION CARD

AUDIO THROUGH VHF/UHF FREQUENCY COUNTER, *model FC45,* is highly sensitive, with 25 mV average throughout band, with pickup loop; all direct-reading, 8-digit display; crystal checker; and all testing leads. The unit comes with optional prescaler, *model PR 47,* and power

adapter, *model PA202,* for use with other frequency counters. Accuracy is better than FCC requirements on all bands including UHF. Price: Frequency counter, $395; prescaler, $125; power adapter, $9.95.—**Sencore, Inc.,** 3200 Sencore Drive, Sioux Falls, SD 57107

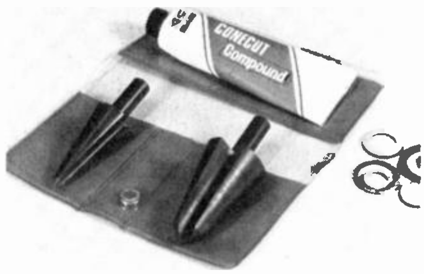
CIRCLE 81 ON FREE INFORMATION CARD

VOLTAGE SPIKE PROTECTOR, *model GESP-752,* limits voltage transients that might damage equipment. It plugs into a 120-volt grounded AC receptacle and protects TV's, stereos and other sensitive electronic equipment against lightning strikes that cause high-voltage surges. Contained within is a varistor that permits only a safe voltage level to enter protected equipment and does not interfere with normal current flow, or add to energy cost. Available from manufacturers' tube

products distributors. Suggested retail, $9.95.—**G-E, Tube Products Dept.,** Louisville, KY 40205

CIRCLE 82 ON FREE INFORMATION CARD

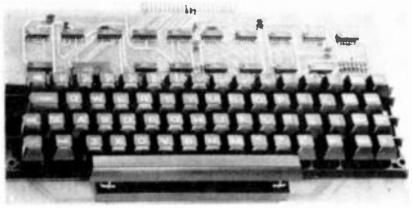
HOLE-DRILLING KIT, *model Conecut 3420,* contains two drill bits, cutting compound and fiber hole gauges. It is particularly adapted for easy CB antenna installation, plumbing, electrical and hobby uses. Holes can be drilled in thin material,



such as steel, sheet metal and formica, among others.—**GC Electronics,** 400 So. Wyman St., Rockford, IL 61101

CIRCLE 83 ON FREE INFORMATION CARD

KEYBOARD ENCODER KIT, *Archer model 277-117,* contains printed-circuit board with instruction manual and parts. Completed encoder can be used to provide inputs to many devices requiring ASCII-encoded alpha-numerical characters. Kit comes with repeat key, negative-going/positive-going data-valid strobe, latch outputs, shift and shift-lock capability, true or false outputs and six extra control keys. Circuit board with parts



and assembly manual: $14.95. All parts, except hardware and case: $57.80.—**Radio Shack,** 2617 W. 7th St., Fort Worth, TX 76107

CIRCLE 84 ON FREE INFORMATION CARD

RADAR DETECTOR, *BEARTECTOR PR-7 Series II,* resists extreme temperature and input voltage variations and interference generally found in automotive environments. The unit features a front-panel "running light" to indicate when device is working, volume and squelch controls are similar to CB equipment. Mounts on dash with self-adhesive Velcro pads for easy removal to

guard against theft. Power cord plugs into cigarette lighter socket. The *Series II* measures 4½ X 6 X 3½ inches, power from + 12 or − 12 volts. Unit carries a full 90-day parts and labor warranty and is available through CB and electronics dealers and distributors.—**Prime Electronics, Inc.,** 8605 Quivira Rd., Lenexa, KS 66215

CIRCLE 85 ON FREE INFORMATION CARD

CATHODE-RAY OSCILLOSCOPE, *Miniscope MS-15,* weighs only 3 pounds and measures 2.7 X 6.4 X 7.5 inches. Other features are a 15-MHz

bandwidth, 0.25-inch division spacing and a graticulated rectangular viewing area 4 divisions high by 5 divisions wide. Also provided are internal/external triggering with automatic and line synchronization modes and horizontal input; 12 vertical gain settings from 0.01 to 50 volts per division; 21 time-base settings from 0.2 ms to 0.5 sec. per division, and optional 10:1 probe and carrying case. Power is from batteries or AC line. Price: $289.—**Non-Linear Systems, Inc.**, P.O. Box N, Del Mar, CA 92014

CIRCLE 86 ON FREE INFORMATION CARD

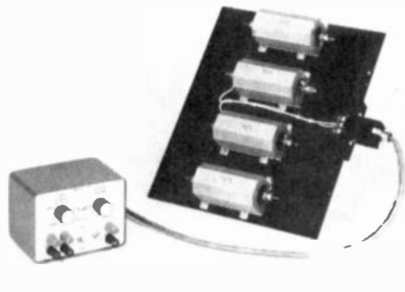
RMS VOLTMETER/AMPLIFIER, *model 9601A*, is a general-purpose instrument for use in high-risk areas such as power-generating stations. Measures and amplifies AC voltages of 10 Hz–1 MHz

and over. Basic reading accuracy is ±3%. Battery operating time is 8 hours continuous from 0°–5° C and 4 hours at −40° C; AC power is 115 volts or 230 volts RMS ± 10% at 47–420 Hz.

Accessories include retractable tip, ground cable, spare fuse, AC power cable, test probe and manual. The instrument weighs 9.5 lbs and measures 7¾ × 8⅜ × 6-inches. Priced at $995.—**Ballantine Laboratories**, P. O. Box 97, Boonton, NJ 07005.

CIRCLE 87 ON FREE INFORMATION CARD

PRECISION LOAD SYSTEM, *model 240*, is designed specifically for use as a dummy load for audio equipment. It can provide 4-, 8-, 16-ohm, 1% loads, with power-dissipation capability at 250 watts per channel at 8 ohms, and 500 watts



at 4 or 16 ohms. Unit has speaker-monitoring capability. Load resistors are heat-sink-mounted, with an impedance-matched cable/connector to control unit permitting out-of-way placement. Price: $275.—**BPI-Audio Test Instruments**, 7853 Balboa Ave., San Diego, CA 92111

CIRCLE 88 ON FREE INFORMATION CARD

VOM PACKAGE, *model 100-T*, comes in a leather carrying case complete with VOM, temperature probe, VOM leads, a clamp-on AC ammeter, and a plug-in separator for standard-line-cord current readings.

The *model 390* VOM includes five AC/DC ranges for 0-1200 volts; four DC milliamp ranges from 0.6 to 600 mA; and four resistance ranges from 10K to 10 megohms full scale. Two direct-reading temperature scales from −50° to 150° and from +50° to 300° F are included with the probe. Its 20 ranges, fused R X 1-ohm circuit, diode overload protection (20 K ohms/VDC sensitivity, 5 K ohms per VDC) and accuracy (3% on DC and temperature scales, 4% on AC) give the *model 100-T* wide versatility.

The *model 10* clamp-on ammeter permits current readings in six ranges up to 300 amperes without circuit interruption. The *model 101* plug-in line separator permits clamp-on AC measurements at 0.6 and 0.3 amps. Also included is a 42-inch lead for the AC clamp-on probe. Complete package price: $120.—**Triplett Corp.**, Dept. PR, Bluffton, OH 45817

CIRCLE 89 ON FREE INFORMATION CARD

CB CONNECTOR, *Adapta-Con model C-714*, is a special 4-pin-pattern device needing absolutely *no soldering*. Push-on pin connectors are crimped onto the proper wires. Unit is included as standard equipment with both manufacturer's

power mike and hand-held mike. Unit price: $2.50. With power mike: $35. With hand-held mike: $9.95.—**Superex Electronics Corp.**, 151 Ludlow St., Yonkers, NY 10705

CIRCLE 96 ON FREE INFORMATION CARD

BURGLAR ALARMS, *61,119, 61,120*, are lightweight and adaptable to many home/office/automotive uses: The portable unit (*61,119*) can be slipped into purse or briefcase, the mobile alarm (*61,120*) is ideal for permanent installation in automobiles, vans, boats, etc. Both models are programmed with 2-digit code combinations that make it virtually impossible for a burglar to turn them off. Switches activate a 10-dB alarm. Size and weight: 10½ ounces, 3¼ X 5⅝ X 1¾ inches.

Price: $79 each.—**Edmund Scientific Co.,** 555 Edscorp Bldg., Barrington, NJ 08007

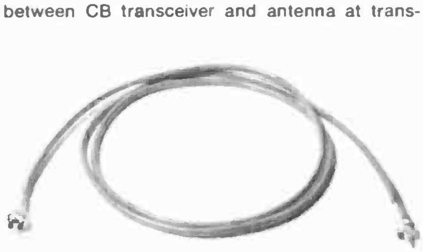
CIRCLE 97 ON FREE INFORMATION CARD

CB HEADPHONE, *CB-MET*, is the first to incorporate power-mike circuitry, with power assist from a self-contained preamp and variable-gain adjust control. Specifications also include 8-ohm anti-blast earphone circuitry matched to external

speaker jack. Unit output is -45 dB re 1 volt. Powered by one AA cell, unit also includes safety switch. Suggested price: $60.—**Superex Electronics Corp.,** 151 Ludlow St., Yonkers, NY 10705

CIRCLE 98 ON FREE INFORMATION CARD

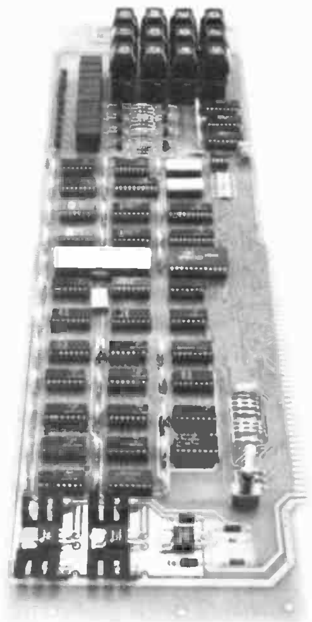
CB FILTER CABLE reduces harmonic interference to TV channels 2, 5, 6 and 9. Connected between CB transceiver and antenna at trans-



ceiver antenna terminal, cable comes in 6-foot and 18-foot lengths.—**Vitek Electronics, Inc.,** 200 Wood Ave., Middlesex, NJ 08846.

CIRCLE 102 ON FREE INFORMATION CARD

CPU BOARD is S-100 bus-compatible for use with a motherboard and bus peripherals, or can replace existing CPU board and front panel to operate as a minicomputer. Features two oper-



ating modes: one allows user to step through program while unit is running; other mode prevents microcomputer from shutting off after HALT instruction. Buffering assures proper data transfer and Schottky IC's reduce power consumption. The kit is $250; assembled, $325.—**Morrow's Micro-STUFF,** P.O. Box 6194, Albany, CA 94706.

CIRCLE 103 ON FREE INFORMATION CARD

CIRCLE 77 ON FREE INFORMATION CARD

CIRCLE 72 ON FREE INFORMATION CARD

LOOKING AHEAD
continued from page 4

language, which EMI plans to introduce. In addition, cassette-programmed games and educational material can provide a recording feature—for example, an on-screen TV drawing made using the game/computer may be preserved for posterity (or to show Mom when she gets home). Probably the most important advantage of all is cost—the more comprehensive cassette programs are expected to retail for $5 or less, as compared wth $20 for ROM programs. The GI-EMI computer system is expected to be available to manufacturers early next year, with some end-products to show up in time for the Christmas 1978 market.

In the meantime, about a dozen companies are expected to field various video game/computer systems this year, featuring such diversions as space war, tank battles, aerial dogfights, auto racing, blackjack, chess, quizzes of all kinds, and even the beginnings of a video quick-reference encyclopedia.

Big as life: Projection TV isn't very big—as a business, that is. Although there may be more than 50 companies assembling projection sets, their total output has been small to date. The largest company in the field is still Advent, which, unlike most other entities, markets a unit with specially designed electronics and three projection tubes and lenses. Major American television manufacturers have all looked into this business and decided to stay out. Sony has a single-tube projector that it appears to be phasing out. If American manufacturers are shunning the three-tube projector, Japanese TV makers seem to be taking strong interest, with three such units due from major companies within the next year. Panasonic has quietly shown some of its dealers a three-tube system designed in a one-piece cabinet with a screen five feet in diameter. MGA (Mitsubishi) may offer a two-piece system with six-foot screen in the United States before Christmas. Sony is working on a three-tube system, presumably for introduction next year. Does all this Japanese activity mean the American manufacturers will come along after all, as they did in VTR?

CB bargains: The CB manufacturers haven't yet overcome the problems created by the shock of transition from 23 to 40 channels, and the result is some almost unbelievable bargains in transceivers. The 23-channel units haven't yet been cleared from the pipelines—as a glance at the ads will show—and some have been advertised recently as low as $49.95, far below the cost of manufacture. Unfortunately for the industry—but fortunately for the consumer—the price-cutting has spread to 40-channel units as inventories rise, and even these can sometimes be spotted at half their list prices. Industry sources predict an almost certain shakeout among manufacturers, and an eventual adjustment of supply to demand, which will mean a gradual increase in prices.

If you already own a CB, there's a bright side to the picture for you, too. Along with prices of new transceivers, the "fence" prices for stolen CB's have declined to such a low point that it's hardly worth the effort to break into cars any more. Why would anybody try to steal 'em from cars when you can just about steal 'em from dealers—legally?

DAVID LACHENBRUCH
CONTRIBUTING EDITOR

next month

OCTOBER 1977

■ **Build The Flanger**

It's an add on to your electronic music system that produces a very special effect.

■ **Car Clocks Roundup**

Everything you ever wanted to know about electronic, digital readout car clocks.

■ **Vari-Proportional Amplifier**

New kind of high-efficiency amplifier that you'll want to know about

■ **CB Antennas**

Pro and cons . . . When to use which kind . . . Getting out . . . And more

PLUS

Hobby Corner, Computer Corner, Jack Darr's Service Clinic, State Of Solid State, Equipment Reports, and much more.

ELECTRONIC THERMOMETER

continued from page 35

ance voltmeter to read the voltage with respect to ground at pin 2 of IC3. Adjust R14 until you get a 0-volt reading on the voltmeter's most sensitive scale.

The second part of the calibration, the adjustment of C12 requires a 16.7K, 1% metal-film resistor. As before, connect the precision resistor into the circuit in place of RT1. Adjust C12 so that the display just changes from "99" to "0."

If you neither have nor want to buy a 16.7K precision resistor, the following procedure can be followed: Using a standard, accurate thermometer as a reference, fill a large bowl with hot and cold tap water to 99°F, stir carefully during this process. Plug the thermistor assembly into the thermometer, and immerse the waterproofed thermistor in the water. Adjust C12 to obtain a reading of "99." The thermometer is now ready to be used. At temperatures below 0°, the display will remain at 0. On the other hand, a temperature of 105°F appears as "5." However, the thermometer's accuracy is rapidly degraded as the temperature rises above 100°. **R-E**

RF SIGNAL GENERATORS

continued from page 93

receivers are tested for overload and intermodulation distortion.

Accuracy

Output amplitude accuracy at any particular attenuator setting is specified as plus-minus a number of decibels. Common values for this specification are ±3 dB for the very poorest of generators to better than ±1 dB for extremely good generators. It is well to remember that while ±1 dB sounds like a good figure, it is equivalent to saying ±10%, and ±3 dB is a little less than ±30%. High accuracy attenuations at UHF and substantial amounts of attenuation at UHF are extremely difficult to obtain, and even more difficult to validate.

Accuracy of the output amplitude is even further influenced by other parameters. One of these is accuracy of the output leveling circuitry. Once again, the accuracy of output leveling is usually given as plus-minus a number of decibels. If the signal generator does not use automatic leveling, then the output attenuator is only accurate if the signal generator has been "red-lined." [*Red-lining is manually leveling the generator, usually by adjusting an output amplitude control until the output level meter needle is resting on a reference mark (red line).*]

Output impedance

Output impedance is given in ohms and indicates the characteristic impedance of transmission line the generator is intended to drive. Almost all generators are 50 ohms, with the exception of those designed for television work, which are 75 ohms. The output impedance specification may include a VSWR (*V*oltage *S*tanding *W*ave *R*atio) specification, indicating the accuracy of the 50-ohm spec. If the generator load is a pure resistance at the characteristic impedance of the transmission line, the VSWR of the generator output is of little or no significance. Most generators, due to attenuator design, only specify output amplitude accuracy when the generator is driving a non-reactive load at the specified output impedance.

Leakage

The leakage specification should, in many ways, be combined with the output attenuator specification. It is the leakage specification that indicates the ultimate level below which reducing the output attenuator may produce no further decrease in the signal supplied to the load. Frequently the output leakage specification is rated in μV, as it indicates the ability of the generator to make receiver sensitivity measurements. For example, a generator may be specified as being able to make 0.1 μV measurements.

In the case of an extremely low-cost generator, although the attenuator and variable level control may be set for less than 1-μV output, the leakage specification indicates the generator can only make receiver sensitivity measurements of 5 μV or greater.

There may be a high degree of attenuation beyond which the attenuator itself may no longer supply increased attenuation. This is to say, some signals directly bypass the attenuator and appear at the output. This problem is different than a leakage problem.

A leakage specification only indicates the presence of signals in the area of the generator. A receiver may be a substantial distance from the generator, fed signals through a long coaxial cable, having known loss and good shielding, and receiver sensitivity measurements can be made.

to be continued

Service Questions

INTERMITTENT HIGH VOLTAGE

The high voltage in this CTC-17X RCA would pop on and off, but only at very short intervals, separated by long periods of working perfectly. In my first letter, you suggested several places to check. I finally found that the color-difference amplifiers and the blanker tubes were the cause; their plate voltages all went to full B+.

You'd suggested the common cathode resistor R728 as one possibility. It checked good. Then I got to wondering why the *blanker* plate also went to B+. After some hours, I soldered the ground strap between the PW-700 board and chassis, near R728, and cured the problem.

Further checking showed why. This same strip is also the ground return for the *heaters* of the difference-amplifier tubes and the blanker. When the heaters went out, the plates went to B+! Thanks.—R.W., Toms River, NJ.

HORIZONTAL "SAG" IN RASTER

This is a funny problem. In this Bradford WTG-53421 TV, the raster will show a horizontal sag about 20 minutes after you put the back on the cabinet. Before this, it works fine. This has to be a heat problem, but where?—W.O., Solon, OH.

You are so right; this has to be a thermal problem. From past experience with problems of funny-shaped rasters, I'd suspect a filter capacitor that is opening up when hot. I've seen rasters shaped like butterflies, hourglasses and lots more.

Try waiting till the "thing" appears, then spray coolant on each of the filter capacitors. Alternately, blow hot air on them, one at a time, with the back off. This should help catch it. The basic cause of this is oddball feedback through the DC power supply.

HORIZONTAL-OUTPUT CURRENT RUNAWAY

This Admiral 12H10 chassis came in with no drive on the horizontal-output tube. A plate resistor was open in the horizontal oscillator. Now the breaker trips after about 15 seconds. Horizontal-output cathode current starts out at 200 mA, then after about 5 seconds rapidly climbs to 400 mA and then the breaker trips.

I tried unhooking the picture tube; everything was fine; 24 kV, 220 mA steady. Then I tried the chassis on the test jig and got the same results—runaway after 5 seconds. Replaced flyback and yoke, thinking of shorted turns—no good. Any ideas will be more than welcome.—J.H., Winston-Salem, NC.

One correction: if the flyback or horizontal winding of the deflection yoke is shorted, you'll have excessive cathode current even with the picture tube disconnected. Since the thing shows the same symptoms on its own tube and a test jig, it seems to be something in the picture tube bias.

Go and check the bias voltages on the picture tube. A good picture tube can be driven to 4—5 mA of beam current, and the maximum output of the average high-voltage circuit is quite a bit less than that. It seems that two picture tubes are showing you the same symptom, and the bias would be the most likely thing. Grids too far positive or cathodes too far negative are one and the same problem.

SPEED CONTROL PROBLEM

This Sony 800B tape recorder was plugged in wrong. Now it runs at 15 IPS at all times! I found a tantalum capacitor that was causing the difference-amplifier transistor to turn off. Replaced it. Now the transistor is turned on at all times. What else?—V.C., Lansing, MI.

Be sure that you replaced that tantalum capacitor with the right polarity. Putting these in backward builds up some very peculiar troubles that weren't there to start with. Also, check ALL transitors in that voltage-regulator circuitry. R-E

equipment reports

JFD Electronics FM-500 Amplified FM Antenna

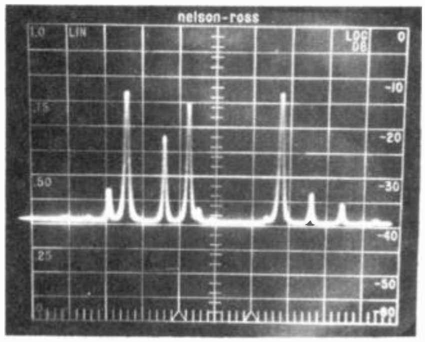
CIRCLE 95 ON FREE INFORMATION CARD

A WELL DESIGNED AND PROPERLY INSTALLED FM antenna makes the difference between poor and good stereo and monaural FM reception. Many attempts have been made to replace an outdoor rooftop antenna with a compact electronic device like the one described in this report. Unlike many of the others, this one works. Measuring only 11 inches in diameter, 1½ inches thick and weighing 1¼ pounds, the *FM-500* uses solid state circuitry to amplify both monaural and stereo FM signals. The antenna itself can be placed right on top of the FM receiver or tuner, or can be mounted on a wall indoors, hidden in an attic, or even mounted outdoors. However, for outdoor installation, a separate mounting kit is required.

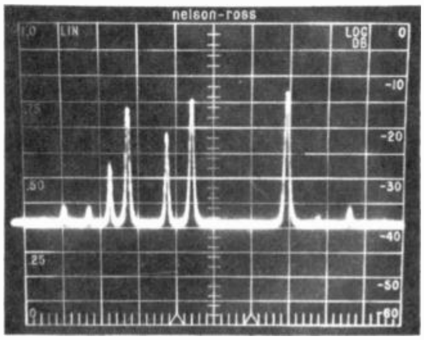
Inside the FM-500 is an omni-directional condensed element whose balanced output is fed directly into a low-noise, solid state preamplifier. The element is a modified dipole formed in a manner so that its radiation pattern is changed from that of the basic figure eight dipole's shape, to a nearly circular pattern. The output of the element connects directly to the input of the broadband, tuned preamplifier with a medium 10-dB gain. A low-noise bipolar transistor gives the lowest possible noise figure. The amplified output of the antenna preamp section is then fed along a shielded coaxial cable tansmission line to the power supply/balan unit. The signal is converted from the unbalanced coaxial line to a balanced 300-ohm twin lead output for easy connection to the antenna input terminals of the FM receiver

The power supply for the antenna is a transformer type unit that provides 15 volts DC to the preamp and diplexes this voltage on the same coax cable that carries the FM/RF signal to the receiver. The power supply uses only 1.4 watts so the unit can be operated continuously and both use less than 75 cents worth of electricity per year.

The overall antenna system is omnidirectional. It has a nominal gain of 8 dB over a reference dipole. The system noise figure is less than 5 dB for a 200 kHz bandwith. The photographs compare the response of the FM-500 antenna mounted outdoors with a JFD Model AFM150 turnstyle antenna mounted outdoors. The parameters of the display are



a



b

RELATIVE STRENGTHS OF SIGNALS received with JFD AFM150 turnstile FM antenna outdoors (a) and FM-500 antenna indoors (b).

sweep width 20 MHz (2 MHz/CM). Center frequency 98 MHz, vertical scale, log dB scale, zero dB reference line is 0 dB Mv. As you can see, performance of the FM-500 is more than adequate. Where it is possible to install a conventional outdoor, FM antenna, do so. But when you can't you will find great improvement in your FM reception when you use the FM-500 in place of an indoor or built-in antenna for FM. **R-E**

(continued on page 104)

new books

WORLD RADIO TV HANDBOOK, 31st Annual Edition—1977, by Jens Frost. Billboard Publications, Inc., 2160 Paterson St., Cincinnati, OH 45124, and Gilfer Associates, Box 239, Park Ridge, NJ 07656. 480 pp. plus 48-page insert, *Listen to the World.* 5¾ × 9 in. Softcover $10.95.

Truly a master guide for users of international radio and television, this book contains exact information on worldwide shortwave, longwave and medium-wave stations. The *Table of Contents* lists 224 countries ranging from Afars and Issas to Zambia. In the *General Index* are such topics as "Broadcasts in English," "Abbreviations," "DX Clubs," "HF Broadcast Reception Conditions for 1977," "Most Suitable Broadcasting Bands for 1977," "Shortwave Stations of the World," and "World Time Charts and Tables."

The coverage of long- and medium-wave stations (150 to 1,600 kHz) is broken down into five geographical zones. Stations are listed according to frequency, kilowatt power, country and station location. Shortwave stations are listed alphabetically by country. Also covered are call letters, frequency, mailing address, names and positions of principals, program schedules, principal languages, and scores to the stations' musical signature.

The insert *Listen to the World* introduces the beginner to the material he'll need as a serious listener and covers such current topics as the sunspot minimum and how to listen to clandestine stations.

SOLID-STATE CIRCUIT TROUBLESHOOTING GUIDE, by Art Margolis. TAB Books, Blue Ridge Summit, PA 17214. 224 pp. 5½ × 8¼ in. Softcover $4.95; hardcover $7.95.

This is a new printing of an old book, but it's certainly worth mentioning again. This practical guide book, once and for all, will help clear up any misunderstandings readers may have about solid-state circuits. The first four chapters discuss the various types of solid-state devices—diodes, transistors, FET's, integrated circuits and silicon controlled rectifiers. Then, getting into the real meat of the subject, the author describes how these devices work in typical circuits the reader is likely to encounter, and shows how to go about finding faulty components.

Individual chapters are devoted to RF amplifiers, IF amplifiers, audio and video amplifier circuits, power amplifiers, oscillators, converters, remote control circuits, sync separators and power supply circuits. In each instance, the author takes the reader through typical circuits, describing how each type works and how the truest professional approaches a troubleshooting problem so as to solve it in the quickest and best possible manner.

GAMES WITH THE POCKET CALCULATOR, by Sivasailan Thiagarajan and Harold D. Stolovitch. Dymax, Box 310, Menlo Park, CA 94025. 47 pp. 10¾ × 8¼ in. Softcover $2.00.

The two dozen calculator games in this book all involve an element of conflict and competition, and all share the following features: An inexpensive calculator with a 6-digit display will work fine; all the games permit people at different levels to compete on equal grounds; a single instrument can be shared by friends and opponents; the games are fast-paced and permit immediate replay without loss of interest; and the two dozen games have sufficient variety to intrigue those who love numbers and those who hate them.

Each game is described in a consistent format that interweaves a complete sample game along with the rules to provide concrete illustrations. All the games emphasize mental manipulation and use the calculator to provide immediate feedback and reinforcement, which facilitates learning of number facts and principles. All the games have been repeatedly tried and tested by various interested groups.

BROADCAST ENGINEERING & MAINTENANCE HANDBOOK, by Patrick S. Finnegan. TAB Books, Blue Ridge Summit, PA 17214. 532 pp. Hardcover $19.95.

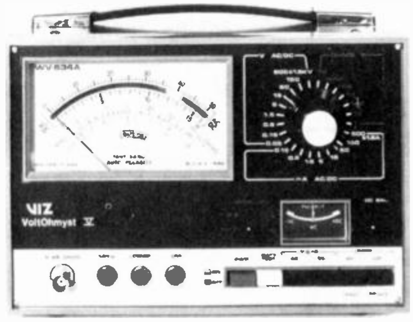
This data-packed reference work for broadcast engineers, technicians and managers gives timely maintenance tips, installation techniques and measurement methods for the entire broadcast chain. The same approach used to design a system is incorporated in understanding and troubleshooting it. The thrust of this book is how-to-do-it information that can be put to immediate use. All the procedures an engineer needs are included, from simple tasks like inspecting a transmitter building to running a proof of performance.

Separate chapters cover AM and FM transmitters, inspections, antennas, automation and how to get the most out of the station's test equipment. One big chapter tells how all the standard electronics techniques are adapted to broadcasting and another chapter gives complete coverage to installation. A book within a book tells how to maintain tape machines, adjust equalization, align, bias, and more. Also, there is plenty of hard-to-find, practical information about program automation equipment.

EQUIPMENT REPORTS

continued from page 102

VIZ WV-534A Voltohmyst V



CIRCLE 94 ON FREE INFORMATION CARD

THE VIZ MFG. CO. HAS RECENTLY DEVELOPED the Voltohmyst V, *model WV-534A*, which sells for $150. This compact, versatile autopolarity analog meter reads up-scale on all DC voltages and current measurements. The reading polarity is shown on a small separate meter just below the main movement. Because you never have to reverse the test leads, it's also possible to read a greater number of ranges with the same number of range switch positions.

The Voltohmyst V has nine AC/DC 0.05- to 500-volt ranges; a 1500-volt range available at a special jack; and eight 0.15-amp to 500-mA current ranges, also both AC or DC. A 1.5-amp range has its own jack. All voltage and current ranges are read on only the 0-to-50 and 0-to-15 meter scales. The scales are *linear*, with no crowding at either end.

Resistance is read in seven ranges—from R × 1 to R × 1 megohm. Either HI (1.5 volt applied) or LO (50 mV) can be used on any range. For quick transistor checking, hook the test prods to any two leads and note the reading. To reverse polarity, just pull out the OHMS ADJUST knob.

The autopolarity feature can be used to advantage in tests that require reading a dip, or even in such zero-crossing tests as adjusting a discriminator. Just set the Voltohmyst V to about half-scale, and then tune for a reading that drops to zero and rises again. The polarity meter will indicate which is which.

The high frequency range of the Voltohmyst V makes it useful for audio-frequency-response testing. The input circuitry is frequency-compensated from 1 dB to 50 kHz.

A dB scale reads 0 dB for 1 mV (dBm) across 600 ohms. Calibration is +6, −20 dB, which is read directly on the AC, 0–1.5-volt range. A calibration chart for the other AC voltage ranges is given in the manual.

The circuitry is powered by 8 AA-cell batteries, plus a 1.5-volt "C" cell for the ohms ranges. If alkaline batteries are used, they can be recharged by the *WG-479* AC adapter, which plugs into the side of the case.

The Voltohmyst V is housed in a rugged light blue plastic case containing all the test leads and the *WG-479*.

The scale reduction allowing the use of larger figures makes it easy to read. All controls are easily accessible, and a high-voltage probe, *WG-411A*, is available as an accessory. **R-E**

STATE OF SOLID STATE

continued from page 71

vibrato-free output.

IC7 and IC8 is an oscillator circuit that controls the amount of phase shift. The output of IC8 feeds control FET's Q2 through Q7. The shift rate of the system is determined by the frequency of the oscillator, which has both a variable and fixed-rate mode. Visual indication of the vibrato rate is provided by the incandescent lamp driven by power transistor Q9 switched by the oscillator output from IC8.

Bridge rectifiers complete the circuit by providing the positive and negative voltages for the op-amps as well as the other circuitry.

High-power transistors from TRW

Three new gold-metalized transistors from TRW are believed to be the highest power-rated equivalent devices commercially available. The PT9780, 9785, and 9790 are rated from 12 to 50 volts and 100 to 150 watts. Gain is 13 to 15 dB at full rated power.

They are designed for single-sideband applications in military, amateur, and marine radio equipment.

The transistors are available from stock and sell for $41.85 to $52.10 each in 100 quantities.

TRW has also updated their RF semiconductor catalog. The 16-page catalog includes HF, UHF, VHF, SSB, and microwave transistors. Also detailed are mobile power amplifier and CATV amplifier modules. For more information write to: TRW Semiconductors, 14520 Aviation Blvd., Lawndale, CA 90260.

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BI-LINEAR amplifier, 2-30 MHz, 60-150 watt. Construction plans, $3.00. **WILSON,** Box 5516-FI, Walnut Creek, CA 94596

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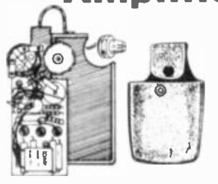

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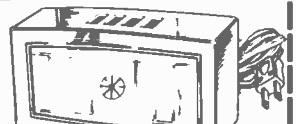

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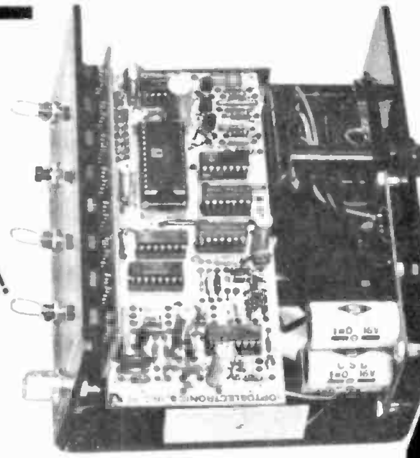

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STABILITY: WITHIN 1 PPM PER HOUR AFTER WARM UP [.001% XTAL]
IC PACKAGE COUNT: 8 [ALL SOCKETED]
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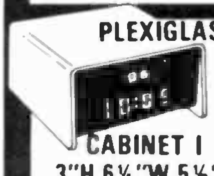
INPUT POWER REQUIRED: 8-12 VDC OR 115 VAC AT 50/60 HZ.
POWER CONSUMPTION: 4 WATTS
INPUT CONNECTOR: BNC TYPE



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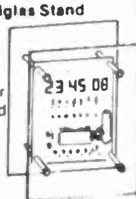

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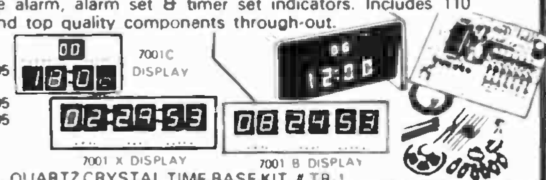

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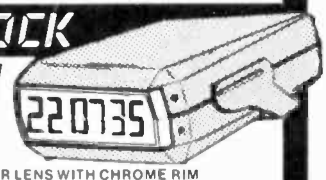

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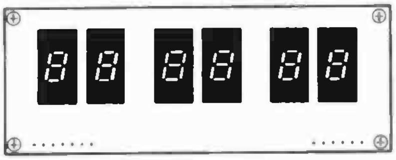

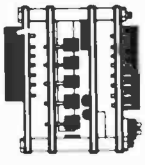

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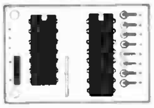

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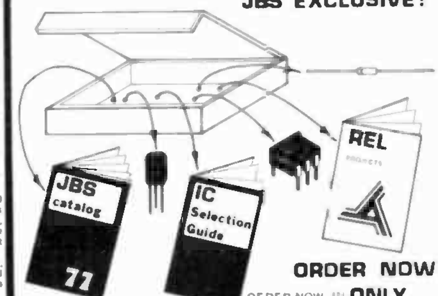

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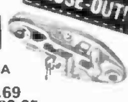

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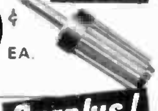

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CD4026	$3.95	CD4518	2.50	74C193	2.75
CD4027	.69	MC14566	3.00	74C195	2.75
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LM320K-15	1.35	NE565H	1.25	75453CN	.39
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74LS05	.35	74LS76	.49	74LS162	2.25
74LS08	.29	74LS83	1.75	74LS163	2.25
74LS10	.29	74LS85	2.49	74LS164	1.95
74LS13	.69	74LS86	.49	74LS175	1.95
74LS14	.75	74LS90	1.25	74LS181	3.69
74LS20	.29	74LS92	1.25	74LS190	2.85
74LS26	.39	74LS93	1.25	74LS191	2.85
74LS27	.39	74LS95	1.95	74LS192	2.85
74LS28	.39	74LS96	1.89	74LS193	2.85
74LS30	.29	74LS107	.59	74LS194	1.89
74LS32	.39	74LS109	.59	74LS195	1.89
74LS40	.39	74LS112	.59	74LS257	1.75
74LS51	.29	74LS132	1.25	74LS260	.55
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- Displays hour, minute, second, month & day
- Free set of replacement batteries
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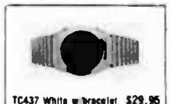

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XC209	Green	4/$1
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XC209	Yellow	4/$1

.190" dia.

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XC111	Yellow	4/$1
XC111	Orange	4/$1

.200" dia.

XC22	Red	10/$1
XC22	Green	4/$1
XC22	Yellow	4/$1
XC22	Orange	4/$1
SSL-22	RT	4/$1

.185" dia.

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XC526	Yellow	4/$1
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XC526	Clear	4/$1

.200" dia.

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¾" x ¾" x 1/16"
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DL707 UL338

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MAN 7	Common Anode	300	1.25	DL707	Common Anode	300	.99
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NEW! 25 Pin version with colon & am/pm indicator

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HP 5082-7300 Series — Multi-Digit

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- 7 segment Monolithic • Red Display

2 Digit	$.79
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5 Digit	1.19

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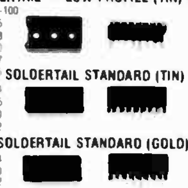

	1-24	25-49	50-100		1-24	25-49	50-100
8 pin	$.17	.16	.15	24 pin	$.38	.37	.36
14 pin	.20	.19	.18	28 pin	.45	.44	.43
16 pin	.22	.21	.20	36 pin	.60	.59	.58
18 pin	.29	.28	.27	40 pin	.63	.62	.61
22 pin	.37	.36	.35				

SOLDERTAIL STANDARD (TIN)

14 pin	$.27	.25	.24	28 pin	$.99	.90	.81
16 pin	.30	.27	.25	36 pin	1.39	1.26	1.15
18 pin	.35	.32	.30	40 pin	1.59	1.45	1.30
24 pin	.49	.45	.42				

SOLDERTAIL STANDARD (GOLD)

8 pin	$.30	.27	.24	24 pin	$.70	.63	.57
14 pin	.35	.32	.29	28 pin	1.10	1.00	.90
16 pin	.38	.35	.32	36 pin	1.75	1.40	1.26
18 pin	.52	.47	.43	40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

10 pin	$.45	.41	.37	24 pin	$1.05	.95	.85
14 pin	.39	.38	.37	28 pin	1.40	1.25	1.10
16 pin	.43	.42	.41	36 pin	1.59	1.45	1.30
18 pin	.75	.68	.62	40 pin	1.75	1.55	1.40

50 PCS. RESISTOR ASSORTMENTS $1.25 PER ASST.

SPECIAL

ASST. 1	5 ea.	10 OHM 27 OHM	12 OHM 33 OHM	15 OHM 39 OHM	18 OHM 47 OHM	22 OHM 56 OHM	1/4 WATT 5%	50 PCS.
ASST. 2	5 ea.	68 OHM 180 OHM	82 OHM 220 OHM	100 OHM 270 OHM	120 OHM 330 OHM	150 OHM 390 OHM	1/4 WATT 5%	50 PCS.
ASST. 3	5 ea.	470 OHM 1.2K	560 OHM 1.5K	680 OHM 1.8K	820 OHM 2.2K	1K 2.7K	1/4 WATT 5%	50 PCS.
ASST. 4	5 ea.	3.3K 8.2K	3.9K 10K	4.7K 12K	5.6K 15K	6.8K 18K	1/4 WATT 5%	50 PCS.
ASST. 5	5 ea.	22K 56K	27K 68K	33K 82K	39K 100K	47K 120K	1/4 WATT 5%	50 PCS.
ASST. 6	5 ea.	150K 390K	180K 470K	220K 560K	270K 680K	330K 820K	1/4 WATT 5%	50 PCS.
ASST. 7	5 ea.	1M 2.7M	1.2M 3.3M	1.5M 3.9M	1.8M 4.7M	2.2M 5.6M	1/4 WATT 5%	50 PCS.

ASST. 8R Includes Resistor Assortments 1-7 (350 PCS.) **$7.49 ea.**

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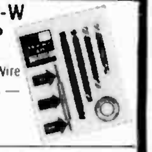
$34.95
(batteries not included)

- Battery Operated (Size C)
- Weighs ONLY 11 Ounces
- Wraps 30 AWG Wire onto Standard DIP Sockets (.025 inch)
- Complete with built-in bit and sleeve

WIRE-WRAP KIT — WK-2-W

WRAP • STRIP • UNWRAP

- Tool for 30 AWG Wire
- Roll of 50 Ft. White or Blue 30 AWG Wire
- 50 pcs. each 1", 2", 3" & 4" lengths — pre-stripped wire.



$11.95

WIRE WRAP TOOL WSU-30

WRAP • STRIP • UNWRAP - $5.95

WIRE WRAP WIRE — 30 AWG

25 ft. min. $1.25 50 ft. $1.95 100 ft. $2.95 1000 ft. $15.00
SPECIFY COLOR — White - Yellow - Red - Green - Blue - Black

WIRE DISPENSER — WD-30

- 50 ft. roll 30 AWG KYNAR wire wrap wire **$3.45 ea.**
- Cuts wire to desired length
- Strips 1" of Insulation **Specify** — Blue-Yellow-White-Red

HEAT SINKS

205-CB 680-75A

205-CB	Beryllium Copper w/Black finish for TO-5	$.25
291-36H	Aluminum for TO-220 Transistors & Regulators	$.25
680-75A	Black Anodized Aluminum for TO-3	$1.60
401-A	Black Anodized Aluminum — predrilled mounting holes for TO-3	$1.75

DIP SWITCHES SPST Slide Action

#206-4	(8 pin dip)	4 switch unit	$1.75 ea.
#206-7	(14 pin dip)	7 switch unit	$1.95 ea.
#206-8	(16 pin dip)	8 switch unit	$2.25 ea.

TV GAME CHIP SET — $14.95

Includes AY-3-8500-1 chip and 2.010 mhz crystal — if purchased separately would cost $18.95.

ZENERS — DIODES — RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3.3	400m	4/1.00	1N4005	600 PIV	1 AMP	10/1.00
1N751A	5.1	400m	4/1.00	1N4006	800 PIV	1 AMP	10/1.00
1N752	5.6	400m	4/1.00	1N4007	1000 PIV	1 AMP	10/1.00
1N753	6.2	400m	4/1.00	1N3600	50	200m	6/1.00
1N754	6.8	400m	4/1.00	1N4148	75	10m	15/1.00
1N959	8.2	400m	4/1.00	1N4154	35	10m	12/1.00
1N965B	15	400m	4/1.00	1N4305	75	25m	20/1.00
1N5232	5.6	500m	.28	1N4734	5.6	1w	.28
1N5234	6.2	500m	.28	1N4735	6.2	1w	.28
1N5235	6.8	500m	.28	1N4736	6.8	1w	.28
1N5236	7.5	500m	.28	1N4738	8.2	1w	.28
1N456	25	40m	6/1.00	1N4742	12	1w	.28
1N458	150	7m	6/1.00	1N4744	15	1w	.28
1N485A	180	10m	6/1.00	1N1183	50 PIV	35 AMP	1.60
1N4001	50 PIV	1 AMP	12/1.00	1N1184	100 PIV	35 AMP	1.70
1N4002	100 PIV	1 AMP	12/1.00	1N1185	150 PIV	35 AMP	1.50
1N4003	200 PIV	1 AMP	12/1.00	1N1186	200 PIV	35 AMP	1.80
1N4004	400 PIV	1 AMP	12/1.00	1N1188	400 PIV	35 AMP	3.00

SCR AND FW BRIDGE RECTIFIERS

C36D	15A @ 400V	SCR	$1.95
C38M	35A @ 200V	SCR	1.95
2N2328	1.6A @ 200V	SCR	.50
MDA 980-1	12A @ 50V	FW BRIDGE REC.	1.95
MDA 980-3	12A @ 200V	FW BRIDGE REC.	1.95

TRANSISTORS

MPS A05	5/$1.00	2N3567	3/$1.00	PN4249	4/$1.00
MPS A06	5/$1.00	2N3568	4/$1.00	PN4250	4/$1.00
2N2219A	3/$1.00	2N3569	4/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	2N3643	4/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	2N3704	5/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3705	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3706	5/$1.00	2N4409	5/$1.00
2N2484	4/$1.00	2N3707	5/$1.00	2N5086	4/$1.00
2N2906A	4/$1.00			2N5087	4/$1.00
2N2907A	5/$1.00	2N3711	5/$1.00	2N5088	4/$1.00
2N2925	5/$1.00	2N3724	$.65	2N5089	4/$1.00
2N3053	2/$1.00	2N3725	$1.00	2N5129	5/$1.00
2N3055	$.89	2N3903	5/$1.00	2N5138	5/$1.00
MJE3055	$1.00	2N3904	4/$1.00	2N5139	5/$1.00
MJE2955	$1.25	2N3905	4/$1.00	2N5209	5/$1.00
2N3392	5/$1.00	2N3906	4/$1.00	2N5951	5/$1.00
2N3398	5/$1.00	2N4013	3/$1.00	C106B1SCR	2/$1.00
		2N4014	3/$1.00	2N5432	$2.00
		2N4123	10/$1.00		

CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10 pf	.05	.04	.03	.001µF	.05	.04	.035
22 pf	.05	.04	.03	.0047µF	.05	.04	.035
47 pf	.05	.04	.03	.01µF	.05	.04	.035
100 pf	.05	.04	.03	.022µF	.06	.05	.04
220 pf	.05	.04	.03	.047µF	.06	.05	.04
470 pf	.05	.04	.035	.1µF	.12	.09	.075
100 VOLT MYLAR FILM CAPACITORS							
.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22
+20% DIPPED TANTALUMS (SOLID) CAPACITORS							
.1/35V	.28	.23	.17	1.5/35V	.30	.26	.21
.15/35V	.28	.23	.17	2.2/25V	.31	.27	.22
.22/35V	.28	.23	.17	3.3/25V	.31	.27	.22
.33/35V	.28	.23	.17	4.7/25V	.32	.28	.23
.47/35V	.28	.23	.17	6.8/25V	.36	.31	.25
.68/35V	.28	.23	.17	10/25V	.40	.35	.29
1.0/35V	.28	.23	.17	15/25V	.63	.50	.40
MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS							
Axial Lead				**Radial Lead**			
.47/50V	.15	.13	.10	.47/25V	.15	.13	.10
1.0/50V	.16	.14	.11	.47/50V	.16	.14	.11
3.3/50V	.15	.13	.10	1.0/16V	.15	.13	.10
4.7/25V	.16	.14	.12	1.0/25V	.16	.14	.11
10/25V	.15	.13	.10	1.0/50V	.16	.14	.11
10/50V	.16	.14	.12	4.7/16V	.15	.13	.10
22/25V	.17	.15	.12	4.7/25V	.15	.13	.10
22/50V	.24	.20	.18	4.7/50V	.16	.14	.11
47/25V	.19	.17	.15	10/16V	.14	.12	.09
47/50V	.25	.21	.19	10/25V	.15	.13	.10
100/25V	.24	.20	.18	10/50V	.16	.14	.12
100/50V	.35	.30	.28	47/50V	.24	.21	.19
220/25V	.32	.28	.25	100/16V	.19	.15	.14
220/50V	.45	.41	.38	100/25V	.24	.20	.18
470/25V	.33	.29	.27	100/50V	.35	.30	.28
1000/16V	.55	.50	.45	220/16V	.23	.17	.16
2200/16V	.70	.62	.55	470/25V	.31	.28	.26

CIRCLE 10 ON FREE INFORMATION CARD

CRYSTALS
THESE FREQUENCIES ONLY

Part #	Frequency	Case/Style	Price
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

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

EXAR

WAVEFORM GENERATORS		MISCELLANEOUS		TIMERS	
XR-205	$8.40	XR-2211CP	$6.70	XR-555CP	.39
XR-2206CP	4.49	XR-4136	.99	XR-320P	1.55
XR-2207CP	3.85	XR-1468	3.85	XR-556CP	1.85
		XR-1488	5.80	XR-2556CP	3.20
		XR-1489	4.80	XR-2240CP	3.25
		XR-2208	5.20		
STEREO DECODERS				**PHASE LOCKED LOOPS**	
XR-1310CP	$3.20			XR-210	5.20
XR-1310EP	3.20			XR-215	6.60
XR-1800P	3.20			XR-567CP	1.95
XR-2567	2.99			XR-567CT	1.70

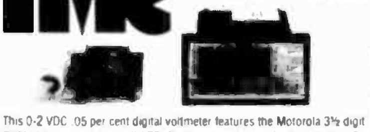
CONNECTORS
PRINTED CIRCUIT EDGE-CARD
156 Spacing-Tin-Double Read-Out
Bifurcated Contacts — Fits .054 to .070 P.C. Cards

15/30	PINS (Solder Eyelet)	$1.95
18/36	PINS (Solder Eyelet)	$2.49
22/44	PINS (Solder Eyelet)	$2.95
50/100	PINS (Wire Wrap)	$6.95
50/100A (.100 Spacing)	PINS (Wire Wrap)	$6.95

25 PIN-D SUBMINATURE

DB25P	PLUG	$3.25
DB25S	SOCKET	$4.95

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.

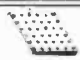
A. 0-2V DVM with Case	$49.95
B. 5V Power Supply	$14.95

Etching Kits

32 X A-1	P.C. Etch Materials Kit enough for 5 circuit boards	$29.95 ea.
27 X A-1	Etched Circuit Kit	$ 9.95 ea.
Plugboards		
3662	Complete kit — only add water. 6.5 X 4.5 X 1/16 Epoxy glass P-Pattern-44 P.C. Tabs spaced .156	$ 6.95 ea.
22/44	Mating connector for plugboard — 22 pin double readout	$ 2.95 ea.
8800V	Universal Microcomputer/Processor plugboard — Epoxy Glass — complete with heatsink and mounting hardware 5.313 X 10 X 1/16 copper clad	$19.95 ea.

Vector

1/16 VECTOR BOARD



	0.1" Hole Spacing Part No.	P-Pattern L	W	Price 1	2-Up
PHENOLIC	64P44 062XXXP	4.50	6.50	1.72	1.54
	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

Vector
SLIT-N-WRAP WIRE WRAP TOOL
- Slits and opens insulation exposing bare wire
- No pre-cutting or pre-stripping.
- Comes complete with two - 100 ft spools #28 AWG wire

Model P180 $24.50

HEXADECIMAL ENCODER 19-KEY PAD

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

$10.95 each

63 KEY KEYBOARD

This keyboard features 63 unencoded SPST keys, unattached to any kind of P.C.B. A very solid molded plastic 13" x 4" base suits most applications.

$24.95

HD0165 16 LINE TO FOUR BIT PARALLEL KEYBOARD ENCODER $7.95

TOOLS

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 - 8¾" 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 $6.95/10 roll package

MICROPROCESSOR COMPONENTS

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

CPU'S

8080	Super 8008	24.95
8080A	Super 8008	29.95
2650	8 BIT MPU	26.50

SR'S

2504	1024 Dynamic	$ 3.95
2518	Hex 32 BIT	7.00
2519	Hex 40 BIT	4.00
2524	512 Dynamic	2.49
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

ROM'S

2513(2140)	Char. Gen. upper case	$ 9.95
2513(3021)	Char. Gen. lower case	9.95
2516	Char. Gen.	10.95

RAM'S

1101	256 x 1	Static	$ 1.49
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	1.49
91L02	1024 x 1	Static	2.25
74200	256 x 1	Static	4.95
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	11.95
82S23	32 x 8	Open C	5.00
82S123	32 x 8	Tristate	5.00
74S287	1024	Static	1.95
3601	256 x 4	Fast	1.95
2708	8K	Eprom	27.95
6301-1	1024	Tri-State Bipolar	3.49
6330-1	256	Open Collector Bipolar	2.95
6331-1	256	Tri State Bipolar	1.95

SPECIAL REQUESTED ITEMS

FCM3817	$ 5.00					8T97	2.40
AY-3-8500-1	$16.95						
MC3061P	3.50	CD4508	6.75	825115	25.00	3341	6.95
MC4016P (74416)	7.50	CD4515	6.50	5841	9.95	9368	3.95
MC14583	3.50	CD4520	2.70	MK50240	17.50	MC1408L7	9.95
MC14562	14.50	MCM6571	17.50	11C90	19.95	LD110/LD111	25.00/set
CD4059	9.95	MCM6574	17.50	DS0026CH	3.75	AY-5-9100	17.50 ea
CD4070	.95	MCM6575	17.50	TIL308	10.50	95H90	13.95
MC14409	14.95	MC14419	14.95	ICM7208	22.00	ICM7209	7.50
MC14410	14.95	ICM7045	24.95	ICM7207	7.50	HD0165	7.95

PARATRONICS
ALLOW 1 TO 3 WEEKS DELIVERY

Featured on February's Front Cover of Popular Electronics

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

TRIGGER EXPANDER — Model 10
Adds 16 additional Bits — Connects direct to Model 100A (Optional baseplate permits mounting to 100A for integrated unit) (Baseplate — $12.00) Model 10 — $229.00

BUGBOOK ®
Continuing Education Series

BUGBOOK I & II - Basic concepts of TTL Logic — over 90 experiments	$17.00/set
BUGBOOK IIa - Introduces UART — recommended for RTTY enthusiast	$5.00/book
BUGBOOK III - Explores 8080 chip — introduces Mark 80 Microcomputer	$15.00/book
555 TIMER APPLICATIONS SOURCEBOOK WITH EXPERIMENTS — over 100 design techniques	$6.95/book
CMOS-M-DESIGNERS PRIMER AND HANDBOOK a complete CMOS instruction manual	$6.00

Introductory Offer — all 6 books (worth $49.95)
SPECIAL - $42.95

CONTINENTAL SPECIALTIES

PROTO BOARD 6
$15.95
(6" long X 4" wide)

MAX-100 Frequency Counter
20 MHz-100MHz — 8 digit — .6" LED
Available September 15, 1977 $134.95

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	120.00

(includes power supply)

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

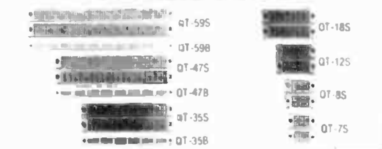
PROTO CLIPS

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

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

$5.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax

Spec Sheets - 25¢ — Send 35¢ Stamp for 1977A Catalog
Dealer Information Available

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James ELECTRONICS

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PHONE ORDERS WELCOME — (415) 592-8097
All Advertised Prices Good Thru September

Timeband
A Trademark of Fairchild Camera and Instrument Corporation

Digital Alarm Clocks

C-500 - Ivory Case
C-5003 - Ebony Case
$16.95

- 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-8211
Woodgrain Case
$19.95

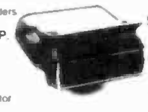
Timeband by FAIRCHILD — LAMP CLOCK

- 24 hour alarm
- Doze button
- Alarm-on indicator
- .8" high Red LED Display
- AM/PM Indicator
- High intensity lamp
- Lamp shuts off when collapsed

Model C-590 (Ivory) $29.95

DIGITAL AUTO INSTRUMENT
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.



1. TACHOMETER 0-9900 RPM 4, 6 or 8 Cylinders
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

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
Heavy Duty Carry Case $5.95

Stop Watch Chip Only (7205) $19.95

QUARTZ DIGITAL AUTO CLOCK OR ELAPSED TIMER!

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

12 or 24 Hour
115 VAC

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.

$17.95

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

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.

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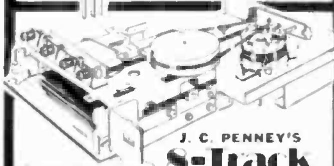

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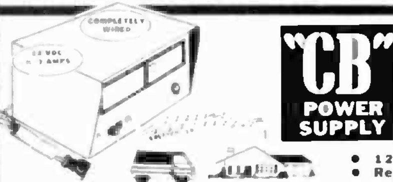

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SN7405	.18	SN7470	.28	SN74151	.63
SN7406	.19	SN7471	.69	SN74153	.63
SN7407	.24	SN7472	.26	SN74154	.99
SN7410	.14	SN7473	.31	SN74155	.78
SN7411	.19	SN7474	.31	SN74156	.68
SN7413	.39	SN7475	.48	SN74157	.64
SN7414	.61	SN7476	.33	SN74158	.78
SN7416	.24	SN7478	.79	SN74160	.89
SN7417	.24	SN7480	.33	SN74161	.87
SN7420	.14	SN7482	.59	SN74163	.87
SN7423	.26	SN7483	.69	SN74164	.95
SN7427	.26	SN7485	.88	SN74165	.95
SN7430	.14	SN7486	.29	SN74166	1.15
SN7432	.24	SN7488	2.95	SN74173	1.19
SN7437	.24	SN7489	1.75	SN74174	.93
SN7438	.24	SN7490	.69	SN74175	.88
SN7440	.14	SN7491	.63	SN74177	.77
SN7441	.79	SN7492	.45	SN74179	1.49
SN7442	.49	SN7493	.45	SN74180	.69
SN7443	.61	SN7494	.69	SN74181	1.95
SN7444	.61	SN7495	.69	SN74182	.69
SN7445	.69	SN7496	.69	SN74184	1.89
SN7446	.79	SN7498	.69	SN74190	1.15
SN7447	.69	SN74100	.99	SN74191	.99
SN7448	.75	SN74107	.29	SN74192	.83
SN7450	.14	SN74112	.19	SN74193	.83
SN7451	.14	SN74113	.19	SN74194	.83
SN7453	.14	SN74114	.19	SN74195	.75
SN7454	.14	SN74121	.31	SN74197	.75
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BARREL KIT #87 NAT. IC BONANZA! 100 for $1.98 — Hobby and untested, factory mixed in barrels. Linears, 7400's, ROMS, DTL'S, registers, clock and calculator chips and more. Wt. 12 ozs. Cat. No. 9R2860

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74LS02	.28	74LS37	.33	74LS93	.57	74LS160	1.02	74LS253	.84
74LS03	.28	74LS38	.33	74LS107	.39	74LS161	1.02	74LS257	.75
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	81LS95	.77
74LS22	.28	74LS83	.79	74LS154	1.10	74LS197	.86	81LS96	.77
74LS26	.33	74LS86	.39	74LS155	.75	74LS247	.79	81LS97	.77
74LS27	.33			74LS156	.75			81LS98	.77

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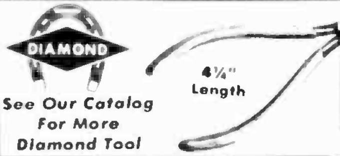
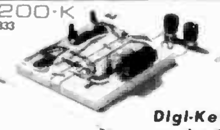
7400	.21	7476	.32	74181	2.15	4012	.23	4520	1.14
7401	.21	7480	.70	74182	.79	4013	.40	4527	1.68
7402	.21	7482	.70	74184	2.19	4014	.96	4528	.88
7403	.21	7483	.70	74185	2.19	4015	.96	4585	1.23
7404	.21	7485	.89	74188	3.50	4016	.40	2102-1	1.79
7405	.21	7486	.28	74189	3.50	4017	1.05	8080A	12.95
7406	.25	7489	2.19	74190	1.23	4018	1.05	CA3046	.75
7407	.25	7490	.44	74191	1.23	4019	.23	LM2111N	1.25
7408	.21	7491	.70	74192	.88	4020	1.14	LM309K	1.80
7409	.21	7492	.44	74193	.88	4021	1.14	LM324A	1.28
7410	.21	7493	.44	74194	.88	4022	.96	LM340T-5	1.25
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	.60
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	8095	.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	1.19	4072	.23	uA733CA	.75
7451	.21	74163	.88	75494	1.19	4073	.23	uA741CV	.44
7453	.21	74164	.96	82S25	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		



See Our Catalog For More Diamond Tool

MS54 $6.58

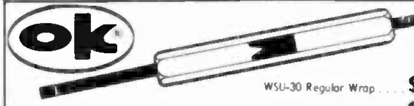


A·C·E 200·K
Part No. 923333
$18.95

- Two 5 way binding posts
- Size: 4 9/16" by 5 9/16"
- Kit form — lowest cost

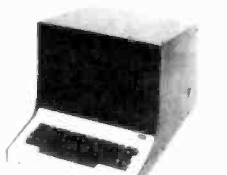
728 SOLDERLESS PLUG-IN TIE POINTS
CAPACITY UP TO 8 16-PIN DIP's

Digi-Key Stocks the Entire AP Line



WSU-30 Regular Wrap . . . $5.95
WSU-30M Modified Wrap . . . $6.95

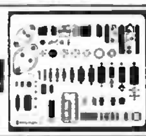
STRIPS — WRAPS — UNWRAPS



TOTALLY ASSEMBLED CRT AT LOWER THAN KIT PRICE

CRT TERMINAL
$895.00
MANUAL ONLY
$2.00

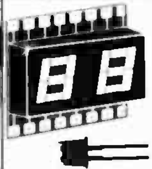
Bishop Graphics 5"x6"



1X Scale PC Design Template

The Digi-Key Catalog features many more quality Bishop Graphics products.

No. 3365 $12.50



LED DIGITS and LAMPS

FND357 .375" Single Digit, CC		$1.35
FND500 .5" Single Digit, CC		$1.35
FND507 .5" Single Digit, CA		$1.35
FND800 .8" Single Digit, CC		$2.50
FND807 .8" Single Digit, CA		$2.50
NSN373 .3" Dual Digits, CC		$2.20
NSN374 .3" Dual Digits, CA		$2.20
NSN583 .5" Dual Digits, CC		$2.60
NSN584 .5" Dual Digits, CA		$2.60
NSN783 .7" Dual Digits, CC		$3.00
NSN784 .7" Dual Digits, CA		$3.00
NSL5053 T-1¾ Lamp	$1.80/10	$16.00/100
NSL5056 T-1¾ Lamp	$1.80/10	$16.00/100

SILICON TRANSISTORS

			MPS3640	.16	1.55/10	PN5133	.16	1.55/10
MPS918	.16	1.55/10	MPS3641	.16	1.55/10	PN5134	.16	1.55/10
MPS930	.16	1.55/10	MPS3643	.16	1.55/10	PN5137	.16	1.55/10
MPS2222A	.16	1.55/10	MPS3646	.16	1.55/10	PN5138	.16	1.55/10
MPS2369A	.16	1.55/10	2N3904	.16	1.55/10	PN5139	.16	1.55/10
MPS2712	.16	1.55/10	2N3906	.16	1.55/10	2N5210	.16	1.55/10
MPS2907A	.16	1.55/10	2N4124	.16	1.55/10	DK3055	.68	6.59/10
MPS3392	.16	1.55/10	2N4126	.16	1.55/10	2N3055	.99	9.20/10
MPS3393	.16	1.55/10	2N4401	.16	1.55/10	MJ2955	.99	9.20/10
MPS3394	.16	1.55/10	2N4403	.16	1.55/10	MPF102	.36	3.35/10
MPS3395	.16	1.55/10	2N4410	.16	1.55/10	2N5457	.48	4.50/10
MPS3563	.16	1.55/10	2N5087	.16	1.55/10	MPSA13	.28	2.60/10
MPS3565	.16	1.55/10	2N5089	.16	1.55/10	MJ2955	.99	9.20/10
MPS3638	.16	1.55/10	PN5129	.16	1.55/10	TIP120	.99	9.20/10

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5% CARBON FILM RESISTORS
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CLOCK MODULES

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.

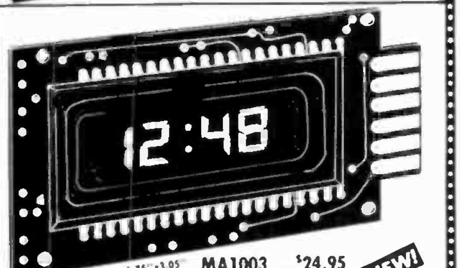
MA1002A	$10.50	MA1010A	$13.00
MA1002A SET	$13.95	MA1010A SET	$16.45
MA1002C	$10.50	MA1010C	$13.00
MA1002C SET	$13.95	MA1010C SET	$16.45
MA1003	$24.95		

MA1002 0.5" High Digits

Actual Size: 1.375"x3.05"

MA1010 0.84" High Digits

Actual size: 1.75"x3.75"



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

ELECTROLYTIC CAPACITORS

VALUE	RADIAL LEADS		AXIAL LEADS		VALUE	RADIAL LEADS		AXIAL LEADS	
.47/50V	.08	.65/10	.11	.90/10					
1/50V	.08	.65/10	.11	.90/10	100/50V	.21	1.17/10	.29	2.30/10
2.2/50V	.08	.65/10	.12	.90/10	220/10V	.13	1.08/10	.18	1.42/10
3.3/50V	.08	.65/10	.12	1.00/10	220/16V	.15	1.16/10	.20	1.55/10
4.7/35V	.08	.65/10	.12	.95/10	220/25V	.21	1.71/10	.29	2.35/10
4.7/50V	.08	.68/10	.12	1.00/10	220/35V	.25	2.03/10	.35	2.79/10
10/16V	.08	.65/10	.11	.90/10	220/50V	.29	2.35/10	.40	3.23/10
10/25V	.08	.65/10	.12	1.00/10	330/6V	.14	1.12/10	.19	1.48/10
10/35V	.09	.70/10	.13	1.10/10	330/10V	.15	1.16/10	.21	1.64/10
10/50V	.10	.75/10	.14	1.15/10	330/16V	.21	1.66/10	.31	2.45/10
22/16V	.06	.67/10	.12	1.00/10	330/25V	.23	1.86/10	.38	3.07/10
22/25V	.09	.70/10	.13	1.05/10	330/35V	.33	2.66/10	.43	3.43/10
22/35V	.11	.85/10	.15	1.19/10	330/50V	.54	4.30/10	.60	4.81/10
22/50V	.12	1.00/10	.17	1.32/10	470/6V	.15	1.21/10	.20	1.61/10
33/16V	.09	.75/10	.12	1.00/10	470/10V	.21	1.71/10	.31	2.45/10
33/25V	.10	.81/10	.14	1.15/10	470/16V	.23	1.81/10	.33	2.66/10
33/35V	.13	1.05/10	.17	1.34/10	470/25V	.29	2.35/10	.43	3.43/10
33/50V	.14	1.13/10	.19	1.52/10	470/35V	.41	3.27/10	.47	3.78/10
47/10V	.09	.71/10	.13	1.04/10	470/50V	.54	4.30/10	.75	6.03/10
47/16V	.10	.81/10	.14	1.15/10	1000/6V	.22	1.90/10	.35	2.76/10
47/25V	.13	1.05/10	.17	1.30/10	1000/10V	.24	1.96/10	.38	3.07/10
47/35V	.14	1.13/10	.19	1.51/10	1000/16V	.29	2.35/10	.43	3.43/10
45/50V	.15	1.21/10	.21	1.71/10	1000/25V	.42	3.33/10	.68	5.42/10
100/10V	.10	.77/10	.14	1.13/10	1000/35V	.60	4.81/10	.75	6.03/10
100/16V	.11	.85/10	.17	1.30/10	2200/6V	.36	2.86/10	.43	3.43/10
100/25V	.13	1.10/10	.20	1.55/10	2200/10V	.42	3.33/10	.60	4.81/10
100/35V	.17	1.41/10	.25	1.93/10	2200/16V	.54	4.30/10	.68	5.42/10

DATA BOOKS

TTL IC's 595 p	$4.00
Linear IC's 957 p	$5.00
CMOS 74C 256 p	$3.00
Memory IC's 592 p	$3.00
Interface IC's 464 p	$4.00
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MOS/LSI IC's 713 p	$4.00
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Analog Manual 637 p	$5.95

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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	5.70/10
24 Pin W-W	.96	9.10/10
28 Pin W-W	1.12	10.00/10
40 Pin W-W	.92	8.75/10

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Red or Black 30 ga. Kynar
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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
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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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1N5227B	3.6v	.15	$11/C
1N5228B	3.9v	.15	$11/C
1N5229B	4.3v	.15	$11/C
1N5230B	4.7v	.15	$11/C
1N5231B	5.1v	.15	$11/C
1N5232B	5.6v	.15	$11/C
1N5233B	6.0v	.15	$11/C
1N5234B	6.2v	.15	$11/C
1N5235V	6.8v	.15	$11/C
1N5236B	7.5v	.15	$11/C
1N5237B	8.2v	.15	$11/C
1N5238B	8.7v	.15	$11/C
1N5239B	9.1v	.15	$11/C
1N5240B	10v	.15	$11/C
1N5241B	11v	.15	$11/C
1N5242B	12v	.15	$11/C
1N5243B	13v	.15	$11/C
1N5244B	14v	.15	$11/C
1N5245B	15v	.15	$11/C

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

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2-56 1/4 Screw	.99/C	7.20/M
2-56 1/2 Screw	.99/C	7.65/M
4-40 1/4 Screw	.55/C	3.60/M
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
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No. 6 Lockwasher	.45/C	3.00/M
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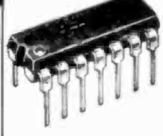

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Z-80 CPU KIT COMPLETE - $149. kit

Z-80 Chip & Manual $49.95 — Z-80 Manual - $7.50 Separately

From the same people who brought you the $89.95 4K RAM KIT. We were not the first to introduce an Imsai/Altair compatible Z-80 Card, but we do feel that ours has the best design and quality for the lowest price!
The advance features of the Z-80 such as an expanded set of 158 instructions, 8080A software compatibility, and operation from a single 5VDC supply, are all well known. What makes our card different is the extra care we took in the hardware design. The CPU card will always stop on an M1 state. We also generate TRUE SYNC on card, to insure that the rest of your system functions properly. Dynamic memory refresh and NMI are brought out for your use. Believe it or not, not all of our competitors have gone to the extra trouble of doing this.
As always this kit includes all parts, all sockets, and complete instructions for ease of assembly. Because of our past experience with our 4K kit we suggest that you order early. All orders will be shipped on a strict first come first served basis. Dealers inquiries welcome on this item. Kit includes Zilog Manual and all parts. Kit shipped with 2 MHZ crystals.

THE WHOLE WORKS **$89.95**

4K LOW POWER RAM BOARD KIT

Imsai and Altair 8080 plug in compatible. Uses low power static 21L02—1 500 ns. RAM'S. Fully buffered, drastically reduced power consumption, on board regulated, all sockets and parts included. Premium quality plated through PC Board.

For 250 ns RAM's add $10.00

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S.D. Sales announces the inexpensive way to beat the wire wrap jungle. Our latest kit gives you 124 solderless quick connect terminals, enough for eight 16 pin IC's and provides 50 x 8 common buss matrix. Has regulated +5VDC and +/− 15VDC, all at 1 AMP. Voltage regulation at 100%. Also includes a pulse generator variable from 10hz to 50mhz and .01 sec. to 100 nano seconds. Generator output is +5V. In kit form only and includes all parts, sockets; front panel measures 7¼"x8¼", and hardware. case not available.

CAR/BOAT KIT **$34.95** *New Item!* *Music to your Ears!*

MUSICAL HORN

Musical Horn Kit for car, boat, or home. Plays any tune from Mozart to Led Zeppelin. Change tunes in seconds; complete solid state electronics. Standard or custom tunes available at $6.95 each (you supply us with the sheet music — we supply electronics for your favorite tune.) One song supplied with original order. Standard tunes available: DIXIE — EYES OF TEXAS — ON WISCONSIN — YANKEE DOODLE DANDY — NOTRE DAME FIGHT SONG — PINK PANTHER — AGGIE WAR SONG — ANCHORS AWAY — NEVER ON SUNDAY — BRIDGE OVER RIVER OUI — CANDY MAN.

HOME KIT **$26.90**

Home kit includes speaker which operates from your door bell. When door bell is pushed your favorite tune is played. Car/boat kit DOES NOT include speaker. Uses standard 8ohm PM speaker. Allow 4 weeks delivery on both kits.

Limited Quantity! **$9.95 kit**

6 DIGIT ALARM CLOCK KIT

We made a fantastic kit even better. Redesigned to take advantage of the latest advances in IC technology. Features: Litronix Dual ½" displays, Mostek 50250 super clock chip, single I.C. segment driver, SCR digit drivers. Greatly simplified construction. More reliable and easier to build. Kit includes all necessary parts (except case). For P.C. board add $3.00; AC XFMR add $1.50. Do not confuse with Non-Alarm kits sold by our competition! Eliminate the hassle — avoid the 5314!

NEW! WITH JUMBO LED READOUTS!

1000 MFD Filter Caps. Rated 35 WVDC Upright style with PC leads. Most popular value for hobbyists.	SLIDE SWITCH Assortment. Our best seller. Includes miniature and standard sizes, single and multiposition units. All new.	POWER RESISTOR 15 OHM 25W BY CLAROSTAT	RESISTOR ASSORTMENT ¼W 5% & 10% PC leads. A good mix of values! Special!	P.C. LEAD DIODES 1N4148/1N914 100/$2. 1N4002 - 1A 100 PIV	Just received a good mixed lot of National TO-92 plastic transistors. PNP & NPN, even a few FET's. 40-50% yield. Untested Asst.	DISC CAP ASSORTMENT P.C. Leads. At least 10 different values. Includes .001, .01, .05 plus other standard values.
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AMD-1702A

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FACTORY PRIME UNITS! BRAND NEW!
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10/$40. $4.95 ea.

★ Special! ★

3.579545 MHZ Time Base Crystal $1.25	11,000 MFD 50WVDC Computer Grade Cap $3.00 each
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Not only are our RAM'S faster than a speeding bullet but they are now very low power. We are pleased to offer prime new 21L02-1 Low Power and Super Fast RAM's. Allows you to STRETCH your power supply farther and at the same time keep the wait light off!

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7404 — 9c	7437 — 10c	74123 — 32c
7406 — 11c	7438 — 10c	74151 — 9c
7407 — 11c	7451 — 9c	74155 — 22c
7410 — 9c	7474 — 16c	74193 — 35c
7416 — 13c	7475 — 24c	8233 — 35c
7420 — 9c	7486 — 16c	Intel — 1302 — 45c

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PROFESSIONAL TIMING ACCURACY ... Only $49.95

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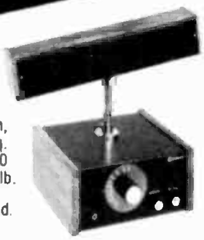

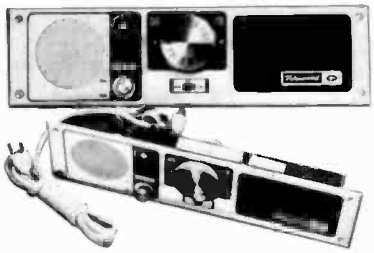

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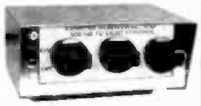

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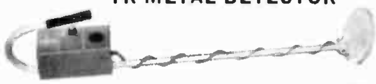

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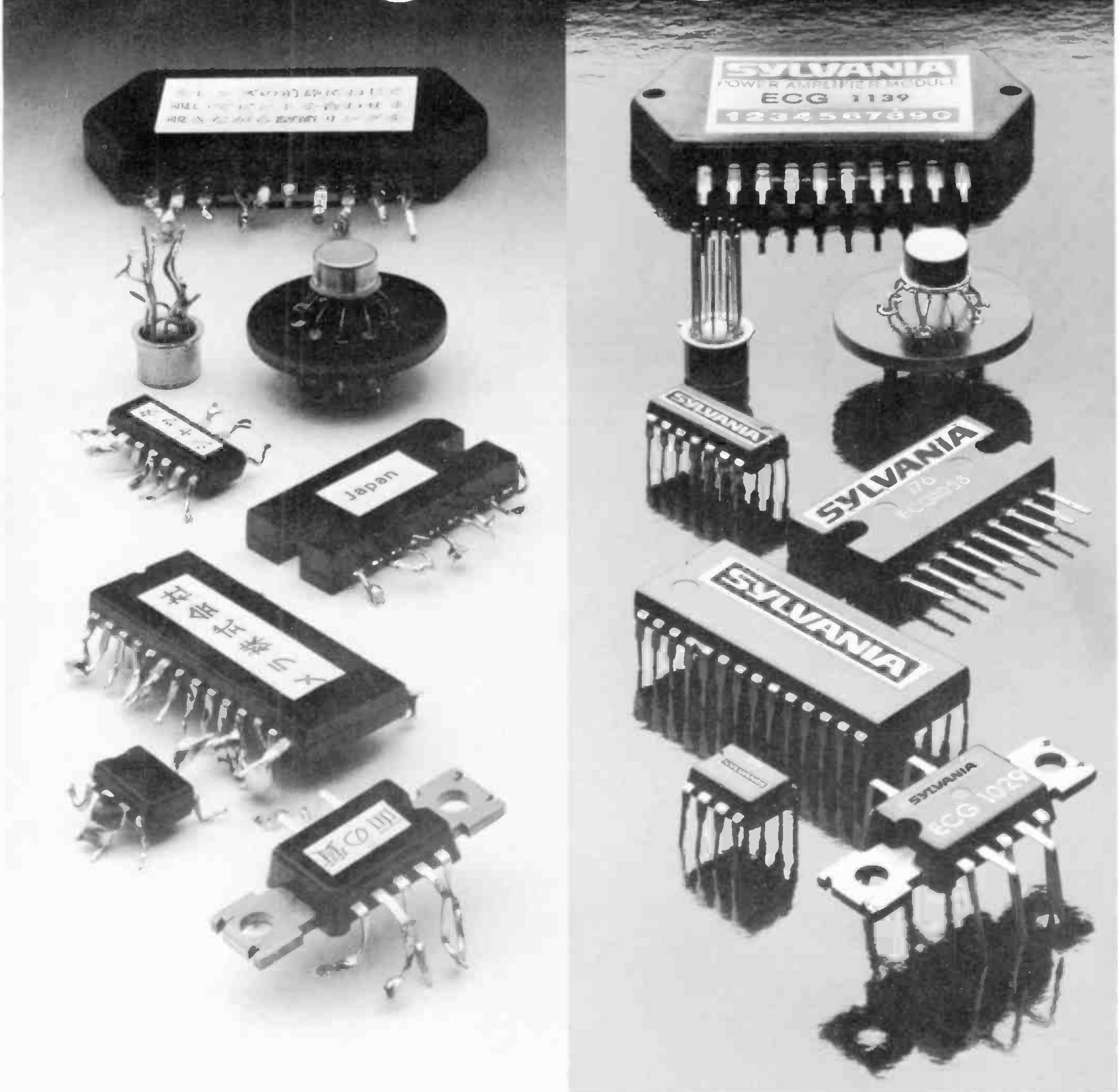

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