NEW DBX SYSTEM — PLL FOR CB

$1.00 ■ APR. 1977

Radio-Electronics

34140 IND

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

build this
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on one board

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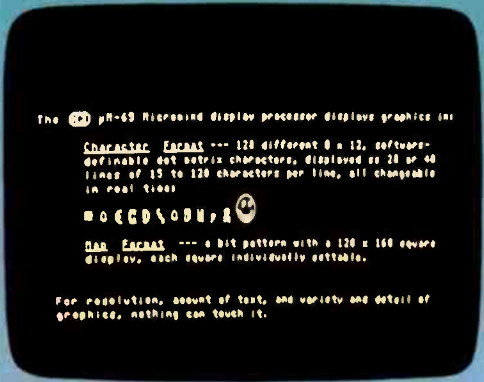


Key Into Maxi-Power @ Micro-Price

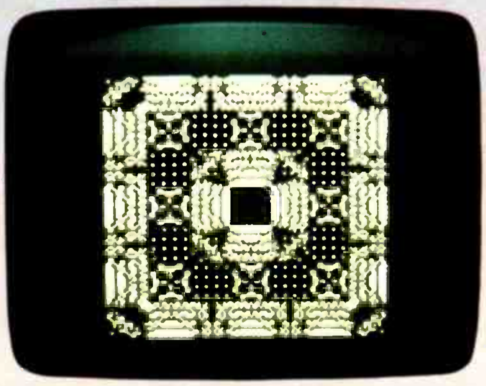
Micromind is an incredibly flexible, complete and expandable, hardware/software, general purpose computer system. You won't outgrow it.

Hardware includes an 80 key, software-definable keyboard, I/O interface board, 6500A-series microprocessor (powerful enough for advanced computing), a high-detail graphics and character display processor, power supply, rf modulator, and connections for up to 4 tape recorders plus TV or monitor. An interconnect bus

permits 15 additional microprocessors, parallel processing and vastly increased computing power.

System software—including ECD's own notsoBASIC high level language, on advanced error-correcting tape cassettes—provides a word processing editor, a powerful assembler, a debugger, a file system, graphic routines, and peripheral handlers. We also include dynamic graphic games: Animated Spacewar and Life.

ECD's standard Micromind μM-65 supplies 8K bytes of memory. Additional 32K byte expansion boards and a mapping option give Micromind expandable access to 64 Megabytes. Utilizing software-controlled I/O channels, Micromind's advanced encoding techniques load data from ordinary tape recorders at 3200 bits per second.



Micromind comes to you ready-to-use, factory assembled and fully tested. Among microcomputers, it has the largest memory capacity and the fastest storage. You're looking at the work of the finest display processor on the market. You won't find a microcomputer with a more powerful CPU. You won't find a computer with a more flexible keyboard. You won't find anything to touch it at **$987.54.**

So, quit the kluge scene and key into Micromind. You'll be a main frame performer, with all the comforts of home. We're not fooling...this is the cat's μ!

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CIRCLE 53 ON FREE INFORMATION CARD

HOT

A new consumer concept lets you buy stolen merchandise if you're willing to take a risk.

We developed an exciting new consumer marketing concept. It's called "stealing." That's right, stealing!

Now if that sounds bad, look at the facts. Consumers are being robbed. Inflation is stealing our purchasing power. Our dollars are shrinking in value. The poor average consumer is plundered, robbed and stepped on.

So the poor consumer tries to strike back. First, he forms consumer groups. He lobbies in Washington. He fights price increases. He looks for value.

So we developed our new concept around value. Our idea was to steal from the rich companies and give to the poor consumer, save our environment and maybe, if we're lucky, make a buck.

A MODERN DAY ROBIN HOOD

To explain our concept, let's take a typical clock radio retailing for $39.95 at a major retailer whose name we better not mention or we'll be sued. It costs the manufacturer $9.72 to make. The manufacturer sells the unit to the retailer for $16.

THE UNCLE HENRY PROBLEM

Let's say that retailer sells the clock radio to your Uncle Henry. Uncle Henry brings it home, turns it on and it doesn't work. So Uncle Henry trudges back to the store to exchange his "lousy rotten" clock radio for a new one that works ("lousy" and "rotten" are Uncle Henry's words).

Now, the defective one goes right back to the manufacturer along with all the other clock radios that didn't work. And if this major retail chain sells 40,000 clock radios with a 5% defective rate, that's 2,000 "lousy rotten" clock radios.

CONSUMERS PROTECTED ALREADY

Consumers are protected against ever seeing these products again because even if the manufacturer repairs them, he can't recycle them as new units. He's got to put a label on the product clearly stating that it is repaired, not new, and if Uncle Henry had his way the label would also say that the product was "lousy" and "rotten."

It's hard enough selling a new clock radio, let alone one that is used. So the manufacturer looks for somebody willing to buy his bad product for a super fantastic price. Like $10. But who wants a clock radio that doesn't work at any price!

ENTER CONSUMERS HERO

We approach the manufacturer and offer to steal that $39.95 radio for $3 per unit. Now think of it. The manufacturer has already spent $9.72 to make it, would have to spend another $5 in labor to fix and repackage it, and still would have to mark the unit as having been previously used. So he would be better off selling it to us for $3, taking a small loss and getting rid of his defective merchandise.

Consumers Hero is now sitting with 2,000 "lousy rotten" clock radios in its warehouse.

Here comes the good part. We take that clock radio, test it, check it and repair it. Then we life test it, clean it up, replace anything that makes the unit look used, put a new label on it and presto—a $39.95 clock radio and it only cost us $3 plus maybe $7 to repair it.

Impossible-to-trace ★ ★ Guarantee ★ ★

We guarantee that our stolen products will look like brand new merchandise without any trace of previous brand identification or ownership.

We take more care in bringing that clock radio to life than the original manufacturer took to make it. We put it through more tests, more fine tuning than any repair service could afford. We get more out of that $10 heap of parts and labor than even the most quality-conscious manufacturer. And we did our bit for ecology by not wasting good raw materials.

NOW THE BEST PART

We offer that product to the consumer for $20—the same product that costs us $3 to steal and $7 to make work. And we make $10 clear profit. But the poor consumer is glad we made our profit because:

1) We provide a better product than the original version.
2) The better product costs one half the retail price.
3) We are nice people.

BUT THERE'S MORE

Because we are so proud of the merchandise we refurbish, we offer a longer warranty. Instead of 90 days (the original warranty), we offer a five year warranty.

So that's our concept. We recycle "lousy rotten" garbage into super new products with five year warranties. We steal from the rich manufacturers and give to the poor consumer. We work hard and make a glorious profit.

To make our concept work, we've organized a private membership of quality and price-conscious consumers and we send bulletins to this membership about the products available in our program.

Items range from micro-wave ovens and TV sets to clock radios, digital watches, and stereo sets. There are home appliances from toasters to electric can openers. Discounts generally range between 40 and 70 percent off the retail price. Each product has a considerably longer warranty than the original one and a two week money-back trial period. If you are not absolutely satisfied, for any reason, return your purchase within two weeks after receipt for a prompt refund.

Many items are in great abundance but when we only have a few of something, we select, at random, a very small number of members for the mailing. A good example was our $39.95 TV set (we had 62 of them) or a $1 AM radio (we had 1257). In short, we try to make it fair for everybody without disappointing a member and returning a check.

EASY TO JOIN

To join our small membership group, simply write your name, address and phone number on a slip of paper and enclose a check or money order for five dollars. Mail it to Consumers Hero, Three JS&A Plaza, Northbrook, Illinois 60062, %Dept. RA.

You'll receive a two year membership, regular bulletins on the products we offer and some surprises we would rather not mention in this advertisement. But what if you never buy from us and your two year membership expires. Fine. Send us just your membership card and we'll fully refund your five dollars plus send you interest on your money.

If the consumer ever had a chance to strike back, it's now. But act quickly. With all this hot merchandise there's sure to be something for you. Join our group and start saving today.

CONSUMERS HERO®

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THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

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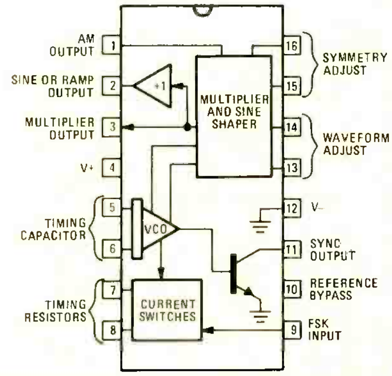
APRIL 1977 Vol. 48 No. 4

ON THE COVER

A 2650-based microcomputer with impressive features. Built on a single PC board, the microcomputer contains RAM, ROM, video and cassette interface. Add a power supply, keyboard and video monitor for a complete working system. Get started in the microcomputer revolution today. Construction details starts on page 31 of this issue.



VERSATILE XR-2206 FUNCTION GENERATOR is put through its paces in practical circuits you can build. Story starts on page 36.

SELECTING THE RIGHT MULTIMETER for servicing is important. Tips start on page 67.

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looking ahead

VTR: It could be that RCA's reticence about going full-speed-ahead on the videodisc has something to do with the success of the home video-cassette recorder in the United States. RCA insists—as it did in the days when it was developing its own VTR—that videocassette and videodisc are non-competitive. But RCA, along with Zenith and Magnavox (all three are videodisc proponents), all now concede that the success of Sony's Betamax so far in the United States has prompted them to take a new look at the potential of home VTR. Any American manufacturers that enter the videocassette market are expected to buy decks from Japan, at least initially, rather than introduce a new and incompatible system to the already chaotic market.

How does this market stand today? Sony's Betamax dominates it. It was there first, and it works well. Demand is currently higher than supply, but Sony is increasing its production capacity to 250,000 recorders per year (to be divided between the Japanese and North American markets). In the U.S., Quasar is marketing the Great Time Machine—Matsushita's VX-2000—and Sanyo is selling V-Cord II, developed by its Japanese parent and Toshiba. Japan Victor Co.'s Video Home System (VHS), which is being pushed as a stop-Betamax machine, has now been embraced by giants Hitachi, Sharp, Mitsubishi, and even Matsushita (parent of both Quasar and Panasonic), which says it will make both VHS and VX-2000. But Sanyo and Toshiba indicate they'll probably go to Betamax if V-Cord II doesn't make it as a standard. To complicate the whole matter, Betamax appears to be not one system but two—the current Betamax, with one hour's playing time per cassette, and a new version which gets two hours out of the same cassette. So there are now five home VTR standards—Betamax I and presumably Betamax II, VHS, VX-2000 and V-Cord II. EIA-Japan is working valiantly to establish a single "standard," but with all Japanese electronics manufacturers as its members, it's faced with alienating more members than it pleases by picking a standard. So, as usual, the public is the guinea pig.

Videodisc update: As this column has frequently warned, never make any plans on the videodisc. It's a moving target, and continues to be. The latest move toward a farther horizon is by RCA, whose president Edgar Griffiths recently said that *if* RCA makes videodiscs and players, they probably won't be introduced into the market until late 1978. And the *if* depends on 3 factors: (1) Increasing the playing time from the current 30 minutes per side. (2) Making certain that the player is susceptible to cost reduction. (3) Developing a program library that will create and sustain demand for players and discs.

"Technical problems have been licked", said Griffiths. "We could introduce it now without any trouble." Playing time has been extended to 60 minutes per side in the labs—meaning that a full two-hour feature film could be recorded on a single disc. In the price area, the goal is to introduce the player at $500 to $600, preferably $500, but to be prepared to cut the price to $400 as production revs up. Griffiths' statement of RCA's disc goals and conditions amounts to a one-year postponement of the introduction date. The RCA president correctly pointed out that the company "never said" it would introduce in late 1977, but many RCA officials had informally indicated that was the target date.

Officials of North American Philips say that "very limited marketing" of its optical videodisc system, under the brand name of its subsidiary Magnavox, is still scheduled for late this year, but they decline to estimate when the players and discs will be available nationwide. They also refuse to comment on whether they are working to increase the 30-minute playing time of the disc or to develop a two-sided disc. Philips' and Magnavox's stated target price is $500 for the player.

Worldwide pocket TV: Probably the first television set that will work almost anywhere in the world, and certainly the lightest-weight TV ever offered to the public, is the two-inch *Microvision* developed by Sinclair Radionics, a British calculator manufacturer, to be offered here for $300. The black-and-white set measures 6 by 4 by 1½ inches and can fit in a large pocket, weighing only 26 ounces. It has three continuous-tuned bands (varactor tuning)—low VHF, high VHF and UHF, with a three-position standards switch covering American, European and British channels, and is designed to pick up stations all over the world except in some Eastern European countries. It can play four hours on four built-in AA NiCad rechargeable batteries. Most of its circuitry is on five bipolar IC's.

The makers of CB's: What percentage of the 40-channel CB models sold in America are made in the United States? You'd probably be surprised at the answer, which comes out to about five percent. An analysis of the first 297 40-channel CB radios approved by the FCC, conducted by the industry newsletter *Television Digest,* found that only 16 models offered under six brand names were made in the U.S. The remainder came almost entirely from factories owned by Japanese companies—mostly in Japan, but some apparently in Taiwan and Korea.

In terms of number of models, Cybernet of Japan is the leading producer, accounting for 61 models sold under 14 brands. Runner-up is Uniden, with 30 models under nine brandnames, followed by Funai Electric, making 13 models for nine marketers. On the basis of the FCC's list of approved models (which includes manufacturer as well as the brand name), the manufacturers that are building CB radios in the U.S. are E.F. Johnson (for itself and General Motors), Emergency Beacon, Hallicrafters, Motorola, Pathcom and Regency.

Emerson TV again: Old brand names never die—they're just sold. The pioneer Emerson brand is appearing on a line of TV sets again, made in Korea.

continued on page 93

3 things that TV servicemen want most in a Color Bar Generator

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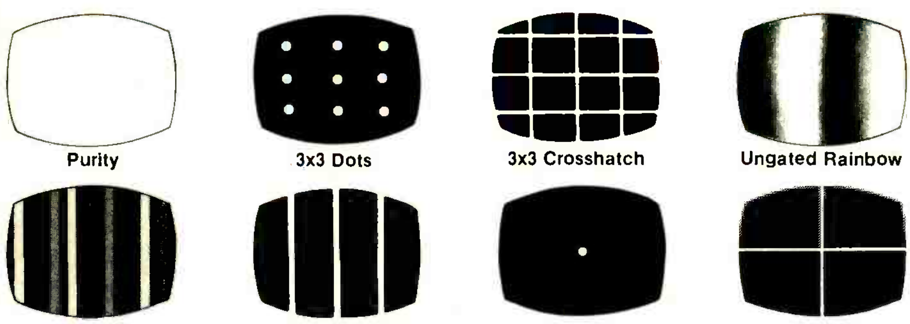

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CIRCLE 28 ON FREE INFORMATION CARD

new & timely

New semiconductor crystal may have unique properties

A monolayer crystal, a material not found in nature and never before prepared in the laboratory, has been synthesized by five Bell Labs scientists. The new material was assembled atomic-layer by atomic-layer by a crystal growing process called MBE (*M*olecular *B*eam *E*pitaxy).

MBE is a method of crystal growing that permits precise control over a crystal's composition and dimensions. Several atomic or molecular beams of controlled intensities are aimed from a heated oven at a base material (substrate). To maintain a temperature at which the atoms on the surface of the base material are mobile enough to form a smooth layer, the substrate rests on a heated block. The whole process is carried on in an ultra-high vacuum.

MAKERS OF THE MONOLAYER CRYSTAL. Left to right: Bell Labs scientists Albert Savage, Raymond Dingle, William Wiegmann, Arthur C. Gossard and Pierre M. Petroff study the development of their new semiconductor.

To assemble the crystal with different materials, shutters turn off the beam from one oven or turn it on from another.

The scientists started with a base of gallium arsenide—a semiconductor often used in making LED's, etc. On this, they laid down a one-atom-thick layer of gallium atoms, followed by layers of arsenic, aluminum, arsenic, then gallium atoms. Because of the similarity of their outer electron shells (equal valence), these materials will bond together in a single crystal much as if they were a single material.

The sequence was repeated hundreds of times to produce a crystal resembling a thin, highly polished mirror. The electron microscope shows the crystal to have an alternating layered structure of atom-thin sheets of gallium arsenide and aluminum arsenide.

No immediate applications are in view for the new material. (As was said of the laser in its early days, it is the answer to a problem that has not yet been found.)

Because the monolayer crystal has new electronic and optical properties, it is likely that—like the laser—uses will be found for it.

Glass-fiber optical waveguides are now in practical use

Some 34,000 cable-TV viewers are now watching programs brought to them on a glass-fiber instead of a coaxial cable. These space-age viewers are in the area of Hastings, England. The pioneering company that introduced the glass line is Rediffusion, Ltd., a large concern that for some years has served more than a million subscribers on the more conventional metal lines.

The optical cable, which has been in use since March, 1976, is 1.427-kilometers long and contains two strands of hair-thin low-loss glass fiber, developed by Corning Glass Works, of Corning, NY, and inserted into the existing cable, with proper terminations.

Magnetic bubble substrates produced almost defect-free

Single-crystal gadolinium-gallium-garnet has been produced in almost defect-free form, a Swiss gallium and phosphorous producer claims. The nonmagnetic crystal material is used as a substrate for magnetic bubble memories.

The producer, Alusuisse, states that almost defect-free boules weighing up to 4 kilograms have been grown.

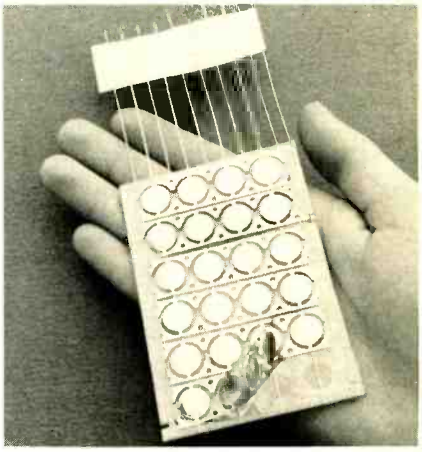
GADOLINIUM GALLIUM GARNET single-crystal boule and wafer.

The boule is drawn from a melt in an iridium crucible, and corrosion of the crucible ordinarily tends to cause iridium inclusions in the boule. Alusuisse states that controlling the temperature gradients minimizes corrosion.

The full-grown boule is ground into cylindrical shape, and wafers, as seen in the photo, are cut from it.

New X-Y keyboard design to cut costs in two

A new low-profile keyboard developed by Texas Instruments promises to cut costs to high-volume users to roughly half present prices. Based on an X-Y matrix technology, the new keyboards will sell for 4¢ per switch position in quantities of 100,00 pieces.



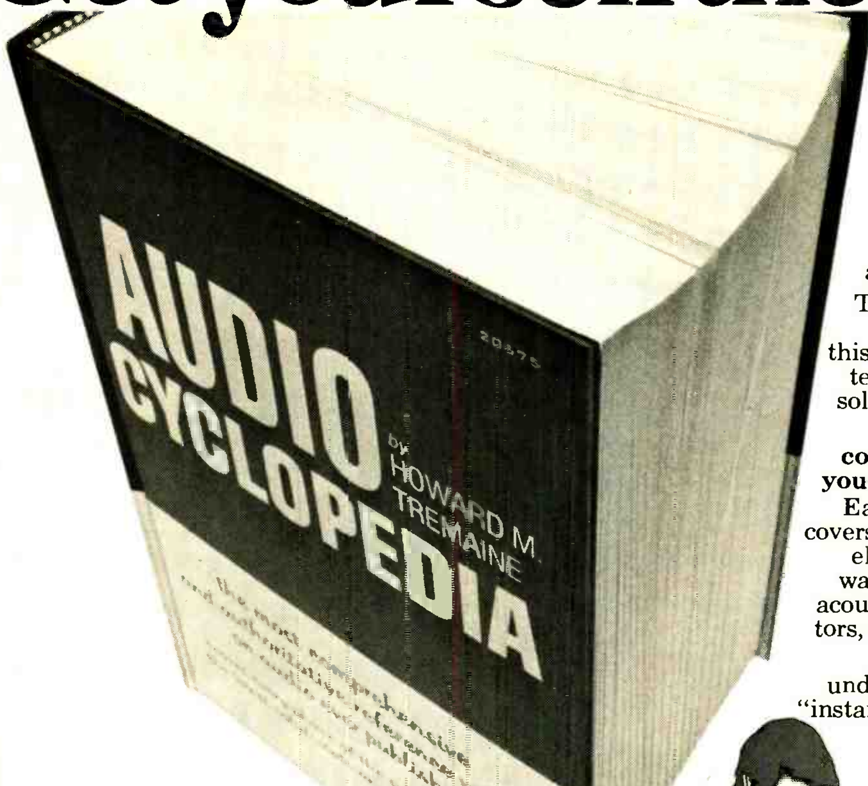
THE NEW LOW-COST X-Y KEYBOARD. Running under the centers of the discs are "Y" wires. Each of the six other (X) wires is connected to one row of discs. A section of the lower row is lifted to show the wires.

Intended for TI's 1200 and 1250 calculators, the new keyboard is now being offered to designers for a multitude of non-calculator applications—credit-card verifiers, telephone-data handling equipment, electronic games and other products with digital control.

Key to the low cost is the elimination of individually assembled switches as well as an arrangement of wire interconnectors which avoids the need for high-cost circuit boards. Instead of individual snap-acting switches, TI has developed a technique for manufacturing the disc switches in strips. Each switch in the strip functions independently. The carrying frame also functions as an electrical circuit element so that switches in any row (the X direction) are electrically common. Individual wires laid under each switch column form the Y direction circuit element. The X wires are located between switch columns and are connected to the disc strips. In this way, all circuit elements emerge at the top of the keyboard, automatically forming

continued on page 12

Get yourself the big one!



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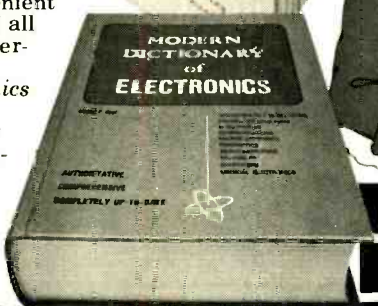

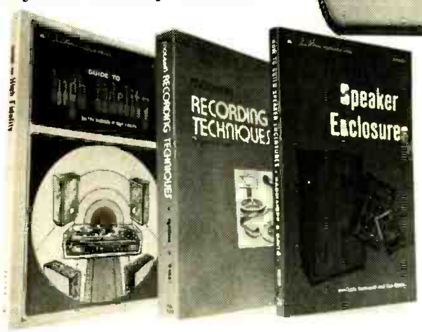

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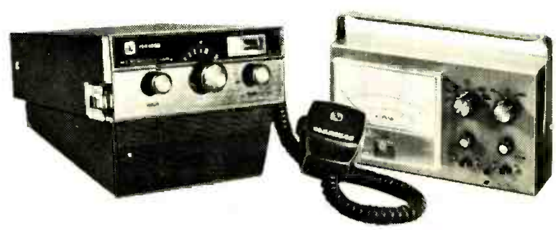

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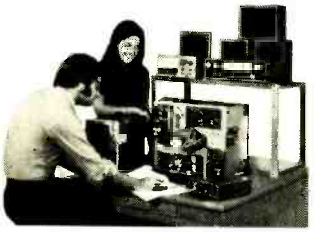

All courses are available with low down payment and convenient monthly payments. All courses provide professional tools and "Power-On" equipment along with NRI kits engineered for training. With the Master Course, for instance, you build your own 5″ wide-band triggered sweep solid state oscilloscope, digital color TV pattern generator, CMOS digital frequency counter, and NRI electronics Discovery Lab.

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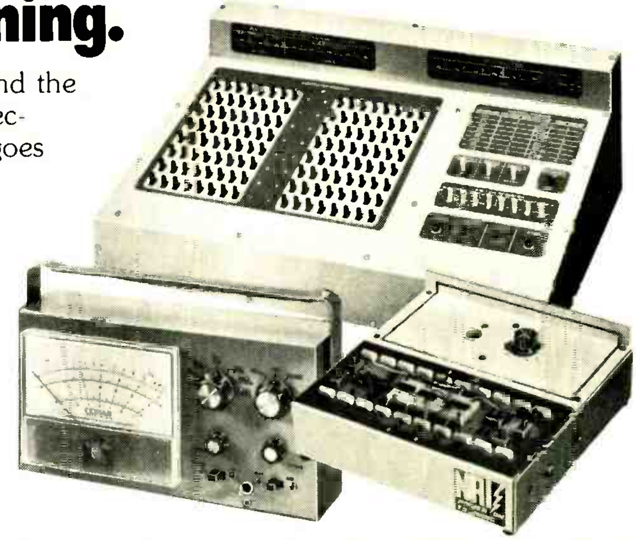

Digital electronics is the career area of the future . . . and the best way to learn is with NRI's Complete Computer Electronics Course. NRI's programmable digital computer goes far beyond any "logic trainer" in preparing you to become a computer or digital technician. With the IC's in its new Memory Kit, you get the only home training in machine language programming . . . experience essential to trouble shooting digital computers. And the NRI programmable computer is just one of ten kits you receive, including a TVOM and NRI's exclusive electronics lab. It's the quickest and best way to learn digital logic and computer operation.

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new & timely

continued from page 6

an integral leadframe. The supporting board is a sheet of engineering grade structural thermoplastic.

Personal-computer fair at National Computer Conference

The National Computer Conference at Dallas, TX, June 13–16, stamping ground of the giants of the computer industry, will recognize individual computer owner-users with a Personal-Computing Program and Fair this year. Special space will be provided for exhibits of non-commercial personally or group-owned small computing hardware and software implementations, games and recreation, music and art, amateur radio, scientific, miscellaneous and general applications of the personal computer.

A one-page description of any proposed entry will be the basis for the preliminary selection of exhibits. The description must be cleanly typed, double-spaced on one side of the paper, with the entrant's or group's name, address and telephone number on the page. Deadline for the Fair Entry description is March 15, 1977. One hundred entries will be selected and the entrants notified before April 15, 1977.

The fair entry to be on display will usually be a working system. If the project does not lend itself to a working system (for example, certain types of computer art that may take weeks to produce), the display is to be viewer-oriented with illustrations that show the methods used and convey the end purpose and product of the project.

Prizes will be awarded in eight categories: Hardware and Software Implementation; Games and Recreation; Music, Art and Sensitive Sciences; Amateur Radio; Scientific Applications; Business Applications; General Applications; and special awards of the Judges.

For information, contact: Harold Mauch, Personal Computing Chairman, PerCom Data Co., 4021 Windsor, Garland, TX 75042 (Phone 214-276-1968).

Lenchitz, Walker and Skinner receive Hugo Gernsback awards

The Hugo Gernsback Memorial Award carries on a practice initiated by Hugo Gernsback himself—encouraging radio and electronic students through monetary grants. Every year, an outstanding student in each of eight leading electronics home-study schools receives a check for $150, to help pay for the training. These students are selected by the schools through essays in which the students tell why they decided to study electronics, what they have obtained through study and what they intend to do in the future. In recent years, through the generosity of test instrument manufacturers, awards have been made to the students who place second and third.

This month's outstanding student is Harry Lenchitz, Somerville, MA, who is two-thirds through a course with Cleveland Institute of Electronics and is currently employed as an engineering assistant at MIT. He writes, in effect:

"My home study course has helped me in two ways. It has given me the necessary background in electronics, as well as the personal habits necessary to carry out my duties as a technician in a large research facility. Through the programmed course material, I have acquired a firm technical foundation in electronics. This enables me to troubleshoot and repair complex instrumentation and control systems.

"More important, home study has developed my personal responsibility and initiative. Without class schedules to meet, or instructors to depend on, I developed my own study schedule and learned to use reference materials more effectively. The results have carried over directly into my job. I have accepted more responsibility for maintaining research equipment. My scheduling and methods are entirely my own, and my co-workers and superiors know I can be depended on to complete my job."

The runner-up receives a B & K Digital Multimeter from the manufacturer. He is Allen Walker, Staples, MN. He is 22 years old and is employed by Pako Corp. He writes:

"Can a person learn to his utmost ability and gain something else, besides the subject matter, from his efforts? Home study gives me this opportunity. In the classroom, there is a constant struggle to keep to the class pace. When it is too fast, your comprehension suffers. If too slow, it dulls your interest and enthusiasm, and again your learning suffers. But in home study one sets one's own pace, challenges oneself, and keeps one's learning capacity at its maximum.

"That something else is self-discipline and self-stimulation. A correspondence student gains organizational, goal-setting and problem-solving abilities that will be invaluable to him in life."

Third-place James Skinner, who obtains a Special Service Multimeter from VIZ, is 57 years old and graduated from the CIE Master Course. He says:

"The CIE home study course was a great challenge to me. When I started, I knew very little about electronics, but with the aid of their books and instructors I became a graduate from CIE and passed my FCC Elements. I received my Radio Telephone Operator license—First Class, and have worked part time in radio and television stations."

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letters

COUNTDOWN TIMER ON 50 HZ

Having read your two-part article on a digital countdown timer, I'm interested in knowing if it is feasible for 50-Hz operation.

JEAN-PIERRE FRANKENHUIS
Paris, France

Conversion to 50-Hz operation is simple. Figure 1-a shows the pertinent circuitry for 60-Hz operation and Fig. 1-b shows modifications for 50-Hz. Change IC17

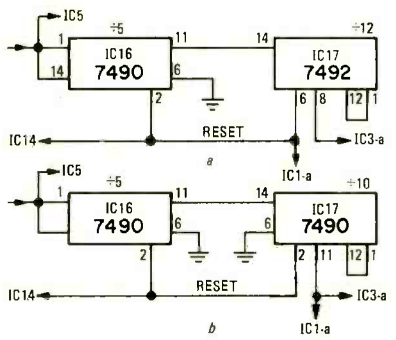


Fig. 1

from a 7492 to a 7490. Connect pin 2 of IC17 to the reset line, ground pin 6 and connect pin 11 to IC1-a and IC3-a as shown. Do not make a connection to pin 8.

On the circuit board layout, remove the connections from IC17 pin 3 to pin 10 and from pin 3 to ground. Do not change the power connections.—George R. Baumgras

A NEW FORCE ANSWERED

I would like to answer a question involving the letter from John W. Ecklin, entitled "A New Force" (Letters Column, October 1976 issue.) I am sure the effect described has been observed by a number of people, myself included.

The general rule involved states that a material with a high permeability (such as iron) will move in such a way as to allow the greatest amount of magnetic field to flow within it. (It is similar to electricity seeking the lowest resistance path.) This is based on Lenz' Law and the tendency of systems to seek the lowest energy state.

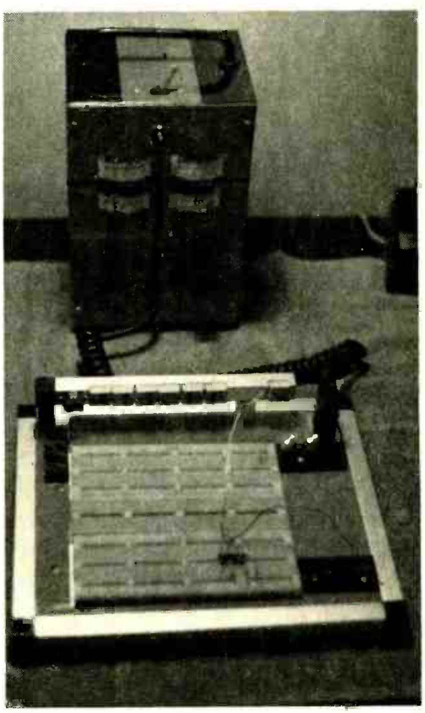
One way iron can obey this law is to turn so that the magnetic lines-of-force flow through the entire length of the iron. If the iron is prevented from doing this (such as by the three loops of thread), it will then move to an area with a denser magnetic field—in this case closer to the wire. Of course, either the iron or the wire could move, and I saw a dramatic example of this on a piece of equipment I worked on several years ago. There was some power wiring lying rather loosely in a steel cabinet that occasionally would be subjected to a surge of over 100 amperes, *alternating* current. Every time this happened, the wire slapped down against the steel cabinet walls loud enough to be heard across the workshop.

Another example you can try yourself. Substitute a length flexible copper wire for the tip on a soldering gun. Trigger the gun briefly (to avoid burning up the wire) and no matter which way the AC flows, the wire will pull towards an iron bar or sheet.

PETER LEFFERTS
Electro-Audio Research Labs
San Martin, CA

IC BREADBOARD

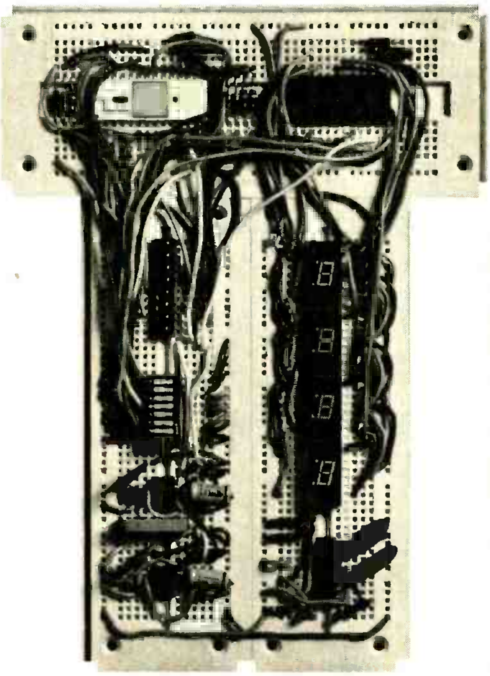
I built a modified version of the IC Breadboard (February 1975 issue). A photo of the layout is enclosed. The power module consists of 4 separate power supplies—two positive and negative, zero- to 24-volt, power supplies. One 5-volt supply powers the test strips and the other powers all circuitry below the test board. The power module is equipped with a switch-controlled AC outlet and a relay that controls all voltage outputs to give the board a total on/off condition.



The breadboard module features: remote power clips (plus V, 5V, gnd, neg V); an on/off switch controlling 12 logic-status indicators with associated transistor circuitry below the board. Two of the indicators also power small miniature

(continued on page 16)

ANNOUNCING THREE NEW BREAKTHROUGHS IN SOLDERLESS BREADBOARDING.



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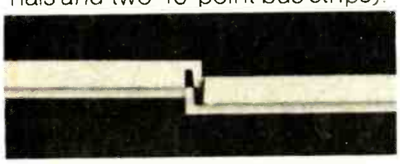
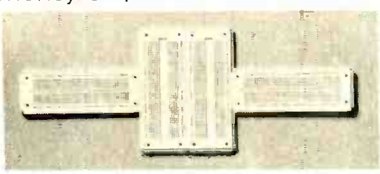


Sockets lock together, snap apart to handle any size circuit with ease.

But don't let the low price fool you: EXPERIMENTOR sockets are precision-molded of durable, abrasion-resistant material, and feature CSC's non-corrosive, prestressed nickel-silver contacts for positive connections and longer life. All contacts are identified, too... with molded-in designations for easier circuit assembly and diagramming.

2. Compatibility CSC EXPERIMENTOR sockets end the "big-chip blues." They're the only ones with full fan-out capabilities for microprocessors and other larger DIP's, as well as 4-16-pin units. EXPERIMENTOR 600's 6/10" center is ideal for microprocessor's, clock chips, RAM's, ROM's, PROM's, etc. While EXPERIMENTOR 300's smaller 3/10" center is perfect for smaller DIP's. Both units, of course, accept transistors, LED's, resistors, capacitors, pot's—virtually all types of components with plug-in ease. As well as #22-30 solid hook-up wire for interconnections. Eliminating heat and lead damage to expensive components. And saving you more money. on parts.



Mix or match both models; arrange them vertically or horizontally.

3. Flexibility With CSC EXPERIMENTOR sockets, you can arrange your breadboard to suit your circuit... instead of vice versa. An exclusive snap-together interlocking system lets you instantly connect them. Vertically or horizontally. So you can mix or match 3/10 and 6/10" centers... expanding or contracting to meet your requirements.

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Both models feature 94 five-point terminals (vertical lines) and two 48-point bus strips (one strip shown).

WHY WAIT? CSC EXPERIMENTOR sockets are available now from your CSC dealer, or by phone from CSC, at $9.95* for the 300 and $10.95* for the 600. Call 203-624-3103 (East Coast) or 415-421-8872 (West Coast)—major credit cards are accepted.

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CIRCLE 25 ON FREE INFORMATION CARD

LETTERS
continued from page 14

speakers that click on any logic transitions which quickly prove that the ear is quicker than the eye. Two frequency sources with LED outputs are located on the right end of the horizontal bar. The generator consists of a scaled-down 10-MHz crystal source through transistor coupling for blow-out protection. One outlet provides 10 steps from 5 Hz to 10 MHz and the other from 0.5 Hz to 5 Hz. Continuing clockwise is the power supply jack plug, great for battery operation through the remote power clips, and on the bottom right a five-digit frequency counter. The jack for the frequency counter is a transistor socket, and two inputs are used—one for slow signals and the other for fast signals.

The horizontal logic indicators were necessary since I preferred to work on a well lit bench and LED's were useless in the light. Construction below the board was limited to anything that would work on only 5 volts and be no thicker than one IC.

Future construction plans include a 2-, 4-, or 8-channel scope multiplexer, and two jacks (one for the multiplexing and one for normal single-channel testing).

The frame of the breadboard is constructed from aluminum stock obtained from a furniture store, and the base plate is covered with contact paper to provide insulation in the event a jumper wire becomes unhooked.

MARVIN KONOPIK
U.S. Liaison Office
Peking
Peoples Republic of China

P.S. In case you wondered whether Peking would become the mecca for electronic parts—not in 1977. The sales market consists of a few dozen resistors and capacitors of which none are ever in decimal sizes (10K, 1μF, etc.). Resistors are cigar sized, pots are baseball size, diodes are unmarked and unbanded, switches either don't work or are missing poles, and batteries clearly marked 'leak proof' are dripping on the shelf and are definitely for sale. Radios and TV's are cheap (to spread the word) and radios are sold with their backs removed and the insides on display to the customer. Happiness is making do with 2 resistors only in series instead of one, and buying the last zip cord on the market since last summer. I did make a rare purchase of some 100-ohm resistors that a factory inadvertently sent to the store, so I have hope on finding something close to 10K before I depart.

NESDA-ILLINOIS CONVENTION

I thought that your readers might be interested in knowing that the National Electronic Service Dealers Association Illinois, Inc., will hold its Annual Convention on May 14 and 15 at the Ramada Inn in Bloomington, IL. The agenda includes such activities as technical and business management seminars, election of new officers, CET tests, auction (bring your "useless" equipment and "white elephants" to sell), prizes and entertainment. The Hospitality Room will be hosted by the Bloomington-Norman Electronic Technicians Association. The Profitable Service Management (PSM) seminar will be conducted by an experienced instructor—Mr. Jack Hopson, CET.

The cost of the PSM seminar only, including lunch, is $25. Registration for the convention only, including all meals and Saturday evening banquet, is $26. The convention and seminar is $46. For more information write: Convention Chairman, William Fey, 217 E. Front, Bloomington, IL or George Sopocko, 5631 W. Irvine Park Rd., Chicago, IL. Or call the NESDA-Illinois office at 312-545-3622.

GEORGE SOPOCKO
NESDA-Illinois President
Chicago, IL

ROAD RALLY CLOCK

The article on the Digital Car Clock (January 1977 issue) was excellent. However, there was one small problem. Road rallies are timed by decimal minutes (hundredths of minutes) instead of seconds. This allows for greater resolution and timing accuracy. If someone could design a clock with a hundredths readout instead of seconds, rallyists everywhere would be grateful. For that matter, a rally computer kit or construction article would be welcomed with open arms. (I'd buy one without hesitation.)

ORAN SANDS
Indianapolis, IN

COMPUTER HEATHKIT USERS GROUP

The Computer Heathkit Users Group is being formed for the exchange of information on the use of Heath Co. products by computer hobbyists. For more information write: CHUG, 267 Willow St. "R", New Haven, CT 06511.

CHARLES FLOTO
New Haven, CT **R-E**

Powerful satellite transmitter broadcasts educational programs

Students at Stanford University in California and Carleton University in Ottawa, Canada, are attending each other's engineering courses by way of a satellite stationed over the equator at 116 degrees west longitude.

The satellite, called Hermes and operated by the Canadian Department of Communications research laboratory in Ottawa, is equipped with a 200-watt transmitter—the most powerful yet carried by a communications satellite. It operates on frequencies between 11 and 14 GHz, much higher than any used by earlier communications satellites. It is expected that the higher frequencies will make it possible to use smaller and less expensive antennas at the transmitting and receiving earth stations.

Besides transmitting educational broadcasts, satellite Hermes is being used by U.S. and Canadian researchers on alternate days in nearly 40 projects. It is used to establish communications between hospitals, medical libraries, widely separated French-speaking and Indian communities, and to communicate with other groups in remote parts of the Dominion of Canada.

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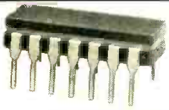

TTL Digital ICs

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7400	276-1801	$ .49	29¢
7402	276-1811	$ .49	29¢
7404	276-1802	$ .59	29¢
7406	276-1821	$ .69	39¢
7408	276-1822	$ 49	29¢
7410	276-1807	$ 49	29¢
7413	276-1815	$1.19	69¢
7420	276-1809	$ 49	29¢
7427	276-1823	$ .69	39¢
7432	276-1824	$ 69	39¢
7441	276-1804	$1.59	89¢
7447	276-1805	$1.99	89¢
7448	276-1816	$1.99	89¢
7451	276-1825	$ 49	29¢
7473	276-1803	$ .79	39¢
7474	276-1818	$ .79	39¢
7475	276-1806	$1 19	69¢
7476	276-1813	$ .79	49¢
7485	276-1826	$1.59	99¢
7486	276-1827	$ 69	49¢
7490	276-1808	$1 19	69¢
7492	276-1819	$1.19	69¢
74123	276-1817	$1.69	89¢
74145	276-1828	$1.49	1.19
74150	276-1829	$1 79	1.39
74154	276-1834	$1.79	1.19
74192	276-1831	$1.69	99¢
74193	276-1820	$1.69	99¢
74194	276-1832	$1.69	1 19
74196	276-1833	$1.69	1.19

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74C08	276-2305	$ 69	39¢
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74C76	276-2312	$1 59	69¢
74C90	276-2315	$2.29	99¢
74C192	276-2321	$2.49	1 29
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4020	276-2420	$2 49	1.49
4027	276-2427	$1.29	89¢
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4511	276-2447	$2.69	1 69
4518	276-2490	$2 49	1 49

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386CN	276-1731	$1.99	99¢
555CN	276-1723	$1 49	89¢
556CN	276-1728	$2.99	1 29
566CN	276-1724	$2.99	1.29
567CN	276-1721	$2.99	1.99
723CN	276-1740	$ 99	59¢
723H	276-009	$ .99	59¢
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3911N	276-1706	$2.19	1.99
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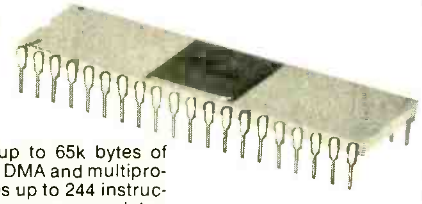

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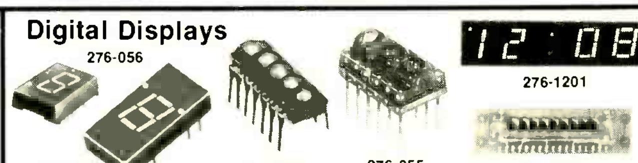
M Clr LED	276-040	2/99¢	2/69¢
S Red LED	276-042	2/99¢	2/69¢
Infrared Det	276-140	$1 19	
Infrared Em.	276-141	$1 19	
Solar Cell	276-115	$1 49	
Photocell	276-116	$ 99	
FPT 100	276-130	$ 79	

Digital Displays



276-056 276-053 276-059 276-055 276-1201 276-060

Digits	Size	Drive	Cat. No.	Reg.	SALE
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1	0.3"	Cath	276-062	$2 99	1 99
1	0.3"	Anod	276-1210	4/$8.97	4/6 95
1	0 3"	Cath	276-1211	4/$8 97	4/6 95
1	0 6"	Anod	276-056	$3 99	2 99
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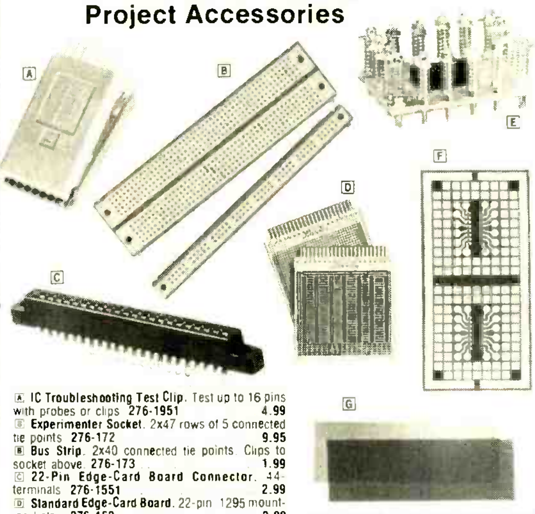

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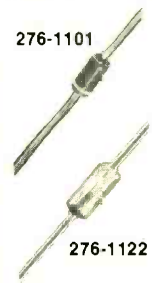

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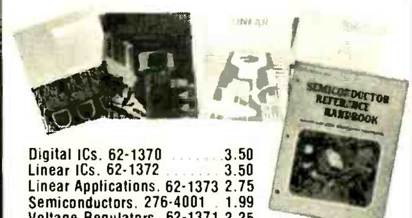

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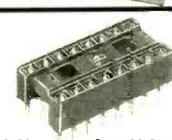

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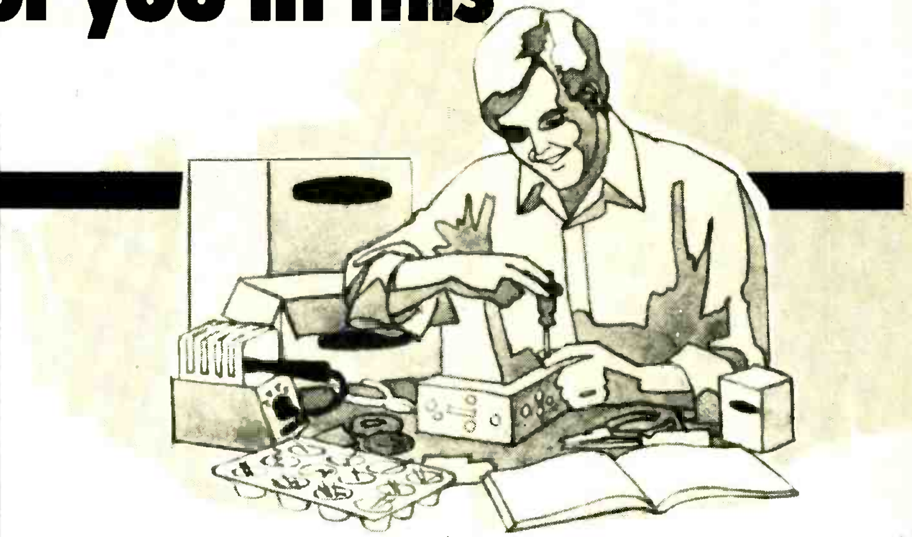

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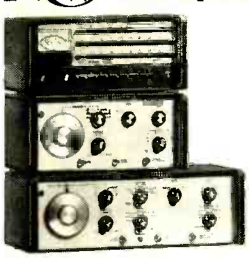

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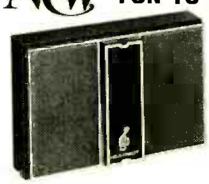

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KOMPUTER KORNER

PETER RONY, DAVID LARSEN, and JOHN TITUS*

CONTAINED WITHIN THE 78-INSTRUCTION SET OF the 8080 microprocessor IC is the 16-bit OUT instruction. The OUT instruction comprises two successive 8-bit bytes. and can be written in binary notation as 11010011_2 $XXXXXXXX_2$. The OUT instruction can also be written in 8-bit octal code such as 323_8 YYY_8, or in 8-bit hexadecimal code, such as $D3_{16}$ ZZ_{16}. A discussion of how one converts 8-bit binary code into either octal or hexadecimal code can be found in Reference 1.

In the above notations, $XXXXXXXX_2$ represents an 8-bit byte that can range in value from 00000000_2 to 11111111_2; YYY_8 represents a three-digit octal code that can range from 000_8 to 377_8; and ZZ_{16} represents a two-digit hexadecimal code that can range from 00_{16} to FF_{16}. A quick calculation will demonstrate that 11111111_2, 377_8, and FF_{16} all represent the same 8-bit binary word.

* Dr. Rony, Department of Chemical Engineering, and Mr. Larsen, Department of Chemistry, are with the Virginia Polytechnic Institute & State University, Blacksburg, Virginia. Mr. Titus is president of Tychon, Inc., Blacksburg, Virginia.

The choice of a coding system is up to you. Binary code is awkward to write and difficult to remember. Octal code is used in the popular Digital Equipment Corporation PDP 8 and PDP 11 minicomputer software and is easy to remember. Hexadecimal code is more natural for an 8-bit binary word and is popular among microprocessor manufacturers. Note well that the way you write the code on paper will not affect the way the microcomputer will execute a program. Both octal and hexadecimal code must be converted back to binary code that is stored in successive 8-bit memory locations. The code conversion can be done in several ways. by hand or by a computer program.

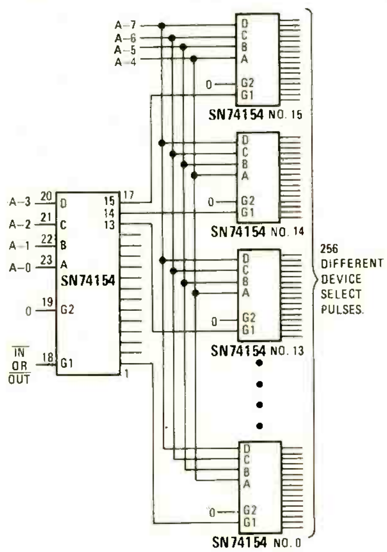

FIG. 1

The second 8-bit byte, $XXXXXXXX_2$, in the 16-bit OUT instruction is the *device code* for the output device. A total of 256_{10} different devices can be addressed with such a code. How this is done is shown in full detail in Fig. 1, a device decoding circuit of seventeen SN74154 IC's. Since this is a rather complicated circuit, let us first discuss the simpler decoding circuit of Fig. 2.

The SN74154 integrated circuit is a 4-line-to-16-line decoder that allows you to input any 4-bit binary word ranging from 0000_2 to 1111_2 and to select any single output among sixteen different output channels labeled 0 to 15_{10}. G1 and G2 are the *strobe* or *gating* inputs to this chip. When these inputs are both at logic 0, the SN74154 IC is *enabled* and the output channel that corresponds to

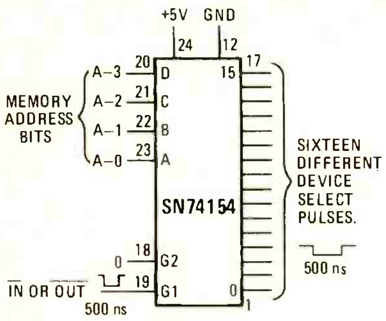

FIG. 2

the binary input at pins 20 to 23 is at logic 0. When either G1 or G2 is at logic 1, the SN74154 IC is *disabled*—inoperative—and all sixteen output channels are at logic 1 irrespective of the binary input at pins 20 to 23.

The basic trick that the 8080 microcomputer employs is to *enable* the SN74154 chip for a very short period of time, 500 ns to be exact. This is done with the aid of a negative clock pulse at G1. This negative clock pulse, called $\overline{IN}$ or $\overline{OUT}$ in Reference 1 or $\overline{I/O\ R}$ or $\overline{I/O\ W}$ in the Intel Corporation literature[2], is generated by the microprocessor chip with the aid of some additional circuitry. $\overline{IN}$ and $\overline{I/O\ R}$ refer to the 16-bit IN instruction; $\overline{OUT}$ and $\overline{I/O\ W}$ refer to the 16-bit OUT

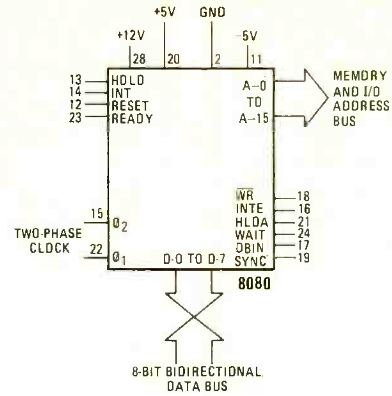

FIG. 3

instruction that we are discussing in this column. During this 500-ns period of time, the device code appears on the *memory address bus* and can be used as inputs to the SN74154 chip to select a desired output channel.

The memory address bus is a group of 16 output pins on the 40-pin 8080 integrated circuit chip (Fig. 3). A *bus* can be defined as:

bus—A path over which digital information is transferred from any of several sources to any of several destinations. Only one transfer of information can take place at any one time. While such transfer is taking place, all other sources that are tied to the bus must be disabled.

The important point here is that two types of information can appear on the 16-bit memory address bus; either the 16-bit memory address for a memory location addressed by the 8080 microprocessor chip, or the 8-bit device code in the second 8-bit byte of an IN or OUT microprocessor instruction, but not both at the same time. The IN or OUT microprocessor instruction requires 5 μs for execution, and the device code appears only during the last 1.5 μs of this time. When the device code appears on the memory address bus, the bus is subdivided into two 8-bit bytes, each byte containing the address code. Thus, you have your choice of bits A-0 through A-7 or A-8 through A-15 for the device code.

This 8-bit device code is connected directly to one or a group of SN74L154 IC's, as is shown in Figs. 1 and 2. In Fig. 2, only four of the eight bits are used, whereas in Fig. 1, all

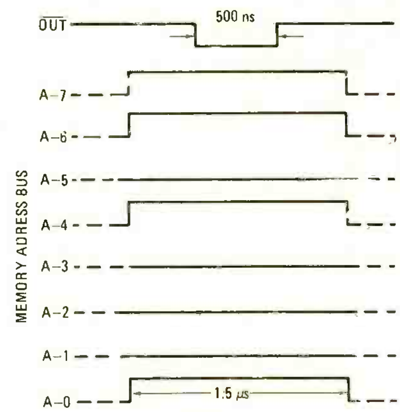

FIG. 4

eight bits are decoded into 256_{10} different output or input device-select pulses. Each output device is addressed uniquely by the $\overline{OUT}$ function pulse and a corresponding 8-bit device code. The same is true for each input device, only the $\overline{IN}$ function pulse is employed instead of the $\overline{OUT}$ function pulse at the gating input G1 to the SN74154 IC. Each device select pulse lasts for only 500 ns, the time that the SN74154 IC is gated.

Figure 4 is a set of timing diagrams that summarizes the external consequences of the 16-bit OUT instruction:

1. An 8-bit device code appears on the memory address bus, in this case the code for device 11010001_2 or 321_8, for a period of 1.5 μs.
2. During this 1.5 μs, an OUT function pulse is generated for a period of 500 ns as a device-select pulse.
3. These nine output lines (A-0 to $\overline{OUT}$) are used as inputs to the seventeen SN74154 IC's shown in Fig. 1. This circuit generates a 500-ns negative device-select pulse for device 321_8. All the remaining 255_{10} outputs from the decoders remain at logic 1 during this time.

This device-select pulse can be used to turn on the solid-state relay shown in the circuit in last month's column. The program that is analogous to one given previously, is simply:

Memory address	Octal instruction	Description
0	323	Send device-select pulse to device given by the following 8-bit device code
1	321	Device code for clear input to SN7474 flip-flop
2	166	Halt the microcomputer

Summary

We have discussed the interfacing technique called *accumulator I/O*, which is also known as *isolated I/O* in the Intel Corporation literature.[2] A much more exciting interfacing technique is *memory I/O*, which is also known as *memory mapped I/O*,[2] in which an I/O device appears to the microcomputer CPU as a simple memory location. Without question, memory I/O will be the most popular interfacing technique among all the different microprocessor families. One important advantage of this technique is the considerable number of IC's that have already been designed for memory I/O applications. Included among such chips are the 8255 programmable peripheral interface, the 8251 universal synchronous/asynchronous receiver/transmitter (USART), the MC6820 peripheral interface adapter, and the XC6850 asynchronous communications interface adapter. We shall discuss this alternative I/O technique in a future column. **R-E**

References:

1. *Bugbook III. Microcomputer Interfacing Experiments Using the Mark 80 Microcomputer, an 8080 System*, E&L Instruments, Inc., Derby, CT, 1975.
2. *Intel 8080 Microcomputer Systems User's Manual*, Intel Corporation, Santa Clara, CA, 1975.

Japan moves toward fiber optics for national two-way cable TV system

An experimental interactive (two-way) CATV network that could eventually provide every household in Japan with services ranging from request entertainment to police and fire protection began test operation on November 15.

The field trial is taking place in Higashi Ikoma, a model city near Osaka. The Higashi Ikoma optical video information system gives the project its name, HI-OVIS. The field trial will supply information that can be used to extend the system to the entire country.

The project was begun in 1972. At that time, no problems were seen in the way of an interactive system using a variety of computer-controlled communications units, but during development the limitations of a coaxial-cable system emerged. The bulk, cost and relatively narrow transmission area per cross-section of cable were obstructions to the geographical scope, multichannel requirements and future flexibility of the net.

The possibilities of optical lines, at that time thought to be ten years from practical use, were considered, and the services of Arthur D. Little, a research organization that was independently exploring the near-term future of optical technology, were engaged. The American-based organization reported that optical-fiber technology had not only progressed far enough to be utilized, but was ideally suited to the combination of analog and digital signals and varying bandwidths of the communications media in the HI-OVIS project.

Besides the usual television screen, the home-centered system will have a keyboard that may be used for a number of purposes. These will include request TV programs; request data (supplied in still-picture form and providing various types of specialized information, including news); facsimile; computer-assisted instruction, for both children and adults; cashless transactions, such as payment of utility bills; TV shopping and reservations.

TV retransmission and independent broadcasts will be available. These would include re-runs of current CATV programs, plus such special items as stock market broadcasts, not included in the regular CATV programs. In addition, FM broadcast and request FM transmissions can be supplied.

The system will include a protection service. Detectors will be installed in each home to detect intrusions, heat, smoke, etc., and respond to the appropriate agency.

After the Higashi Ikoma field trial the Japanese government plans to extend the system to the series of small cities—of no more than 100,000 residents—being established around crowded population centers, such as the Tokyo-Osaka corridor. The new system will play an important part in this "String of Pearls" concept by linking the cities with mainstream programming, while also serving communal and regional needs. The "wired cities" will give people a wider and more comfortable choice of homesites without cultural isolation.

Metric system being accepted by 67 percent of manufacturers

A gradual switch toward the metric system for dimension of products is taking place in electronic manufacturing, reports the Distributor Products Division of the Electronic Industries Association (DPD,EIA). Out of 106 manufacturers replying to a recent EIA survey, more than half had established a formal policy for conversion, and some 67 percent are now making some items to metric dimensions.

There are some obstacles in the way of speedy conversion, most notable of them being cost and psychological difficulties. One manufacturer reported that he was making items to metric measurements "when he had to," and another reported converting English measurements to metric. But at least one is using metric measurements as fundamental and converting to English for domestic buyers. (That way the queer fractions appear in the inch and foot, rather than the meter and centimeter measurements.)

The electronics technicians who will work with the new dimensions, and who already find it easier to say "100 K" than "100 thousand" will probably have no difficulties.

equipment reports

Scelbi Computer 8008/8080 Programming Manuals

CIRCLE 37 ON FREE INFORMATION CARD

MICROCOMPUTER FANS HAVE AN INSATIABLE appetite for program listings and programming manuals. There is not enough good instructive material around. Engineering computer texts are usually away over the head of most hobbyists. Microcomputer data sheets and manuals familiarize you with a specific device and cannot be expected to give much in the way of programming technique.

The four Scelbi books that are the subject of this review contain a rare mixture of useful programs and substantial illustration of technique. If you use them as texts and study them without skipping, you will be much more confident when you approach your next programming task. Minimizing memory was a secondary concern of the writers; the first was the ease of following the logic.

While the four books are written for 8008- and 8080-based microcomputers, I highly recommend them for owners of any type computer. If you want to run the programs on your machine they can be converted, which although a fairly tedious job, is much easier than starting from scratch. It is an unbeatable educational experience to boot.

And I practice what I preach since I have taken the floating point arithmetic package from *Machine Language Programming for the 8008 and Similar Microcomputers* and converted it to run on the JOLT microcomputer that uses the MOS Technology 6502 μP. The manageable game programs presented in *Scelbi's First Book of Computer Games for the 8008/8080* is an ideal place to start such a try at translating from one instruction set to another because of their uncomplicated fundamental structure.

Now to the books themselves. *Machine Language Programming for the 8008 and Similar Microcomputers* starts out at the most basic level of any of the texts and proceeds through a sophisticated program development. The manual begins with a description of the instruction set of the 8008 and talks about flow charts and hand assembly techniques. It covers 2's complement number representation and methods of converting between octal and decimal base number systems. Moving on, the manual demonstrates common programming problems by listing and explaining fully table search and sorting routines. Mathematical operations follow and more importantly the floating point package I mentioned earlier. The floating-point package uses four memory bytes (8-bit words) to store each number. Three words are used for the 23-bit mantissa plus 1-bit sign, and one word for the exponent and its sign. The data input, output, multiplication, addition, subtraction and division routines are explained in detail but in down to earth language.

Listed below is the terminal printout of my converted floating-point package. The first line beginning with the asterisk is the JOLT monitor printout following the initial carriage return. Next the program counter is set to 0100 using the colon alter command.

```
* 7052 30 2A FF 01 FF
.: 0100
.G 12 × 12 = +0.1440000E+03
144 / 12 = +0.1200000E+02
123456E10 + 876543E10 =
+0.1000001E+17
99999.9 – 11111.1 = +0.8888883E+05
1E6 × 22.2 = +0.2220001E+08
1E7 / 10 = +0.1000000E+07
1E9 / 1E–4 = +0.1000000E+14
10 – = +0.1000000E+02
10 – 1 = +0.9000000E+01
12E30 × 20E–2 = +0.2400009E+31
```

Following the command prompting dot on the third line is the **G** or go command that starts program execution. The input data routine accepts numbers in integer, fixed point, and scientific notation. **E** stands for exponent and signifies that the succeeding digits are powers of ten. **1E–4** is 1×10^{-4} or 0.0001. Output is always in the normalized form **±0.-------E±--**. Seventh place inaccuracies are caused by accumulated conversion errors and can be eliminated by a little more work.

As with all four books a complete assembled listing for the 8008 is given. The other three have dual listings for both the 8008 and 8080. Published in a large 8½ × 11-inch format, the 200-page edition is priced at $19.95.

Scelbi's First Book of Computer Games for the 8008/8080 includes complete descriptions and program listings for Space Capture, Hexpawn and Hangman.

Space Capture uses an eight by eight space checkerboard in which you must capture an alien ship by surrounding it with PHASOR hits. The initial program message describes the game perfectly:

> "SPACESHIP CAPTURE. YOU HAVE 15 PHASOR SHOTS WITH WHICH TO DESTROY MY TRAVEL SECTORS. IF ALL MY ADJACENT SECTORS ARE DESTROYED I AM CAPTURED. IF YOU HIT ME OR RUN OUT OF PHASOR ENERGY, THEN YOU LOSE!."

Messages are stored one character per word in a contiguous block of memory. Messages are separated by blank characters. You can shorten the statements to conserve memory or alter them to your own taste.

Hexpawn is a simplified chess game that uses a 9-square board with three pawns on each side. The game is won by getting one of your pawns to the opposite side of the board or destroying all the computer's men.

Hexpawn is very instructive in technique because the computer learns as it plays. At the start of the first game the computer is literally empty-headed and loses easily. But every time the machine makes a mistake and loses it remembers the error by blanking out the move in a memory table. The next time the same situation is encountered the computer will not repeat the mistake. It reaches the point where you can no longer win—the best chance you have is forcing a draw.

Moves are printed out with three octal digits representing either side's board positions. Memory storage requirements are five 256-word pages and can be reduced to under four pages by shortening text messages.

Hangman is the familiar word game of the same name. One of a series of words stored in memory is randomly selected by the computer. The game offers tremendous language learning possibilities. By starting with the simpler words of a language you are studying and then gradually increasing the difficulty of the vocabulary you learn while enjoying yourself.

An 8-bit word-buffer holds the word selected from the list. The guess-buffer is initially filled with hyphens which are replaced with letters from the word buffer as matches occur between the word buffer and the guessed letter. A program loop sequentially tests the characters in the word buffer for a match.

The printout below shows how Hangman looks on the terminal. Scelbi's computer game book sells for $14.95.

```
WANT A NEW WORD?  Y
GUESS A LETTER:   A
NOPE! H———
GUESS A LETTER:   E
GOOD. YOU HAVE:       ————E–
GUESS A LETTER:   O
GOOD. YOU HAVE:       –O——E–
GUESS A LETTER:   N
NOPE! HA———
GUESS A LETTER:   P
GOOD. YOU HAVE:       –O——ER
GUESS A LETTER:   L
NOPE! HAN——
GUESS A LETTER:   T
GOOD. YOU HAVE:       –O—TER
GUESS A LETTER:   C
GOOD. YOU HAVE:       CO—TER
GUESS A LETTER:   M
GOOD. YOU HAVE:       COM—TER
GUESS A LETTER:   P
GOOD. YOU HAVE:       COMP–TER
GUESS A LETTER:   U
GOOD. YOU HAVE:       COMPUTER
CONGRATULATIONS!
WANT A NEW WORD?  N
GOODBYE!
```

The next book is entirely devoted to a single fascinating game. *Scelbi's Galaxy Game for the 8008/8080* works with 64 sectors in space each having a matrix of 64 quadrants. You can give commands that give short and long term scans, fire torpedos and phasors, and navigate your ship. Every move you make consumes energy and energy conservation is crucial. Then there is the additional consideration of protecting yourself with energy shields. Firing at enemy ships and missing causes immediate retaliation. Space refueling stations are scattered through space, but don't collide with one or hit one with a weapon or you are apt to run out of fuel.

Each time the game is started the space objects are distributed randomly in the sectors. Random numbers are generated by executing a sequence of arithmetic operations at high speed while waiting for the operator's response to the initial message. Even conscious effort of a knowing player has no influence on the random number.

Fourth and most complicated is the text titled *SCELBAL—A Higher Level Language for 8008/8080 Systems*. SCELBAL (*SC*ientific *EL*ementary *BA*sic *L*anguage) is a form of the popular Basic computative language useful for scientific and general problem solving. The 400 8½ × 11-inch pages of SCELBAL will reveal many of the mysteries of computer art to the devoted reader. The text simplifies the program by looking at the overall plan with the help of flow charts and then expands each of the main chart blocks.

SCELBAL requires 8K of memory and includes a close facsimile of the floating-point package in the first book as an essential component. Although SCELBAL does not include extended features such as trigonometric and logarithmic functions, after a study of the book and some research in representing functions as truncated series, the reader should be able to add his own functions (with additional memory). No doubt periodic updates or reader submissions in this vein will be published later on.

SCELBAL has three basic modes of operation. Most significant is stored program operation where line numbers are typed at the beginning of each line. These are stored for later execution using the RUN command. The second mode is direct execution. If line numbers do not precede the statements they will be executed immediately after the carriage return. In this mode the program operates something like a calculator.

Third is the command mode. SCELBAL detects four commands. Entering LIST triggers a printout of your program. SAVE and LOAD store and reload programs stored on paper tape, magnetic tape cassettes, or any external storage device. SCR clears the program buffer and variable storage memory areas in preparation for a new program.

User programs can contain 26 variables but more can be handled with the extended array capability. 8K of memory leaves about 1250 words for higher level program storage. The SCELBAL manual is priced at $49.95.

All four publications are available from Scelbi Computer Consulting, Inc., 1322 Rear—Boston Post Road, Milford, CT 06460. **R-E**

Heathkit AA-1640 Power Amplifier

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IF YOU ARE DIGITALLY DEXTEROUS, DETERmined, dauntless, patient, possessed of intellectual curiosity and like to accept challenges, here is THE project for you—the Heathkit model AA-1640, a 200-watts per channel stereo power-amplifier.

If you like the feeling that there's a worthy reward at the end of a demanding project, the AA-1640 will more than satisfy it. In fact, you're likely to feel that you actually did little to earn such a large reward for your efforts and time.

My "journey" with the AA-1640 was not a smooth one. While I worked with great care and patience, it was still possible to commit "boo-boos." While I found the instruction manual complete in terms of installation details, I found it confusing in a number of spots. While Heath comes on strong with a pledge that it will be a "silent partner" in your project, its implementation of that partnership leaves a bit to be desired.

Construction

My total investment of time was 70 hours—a lot to spend on a single project. But it was done pleasurably, over a period of two months, in working sessions of one to two and a half hours. The latter is the maximum I would recommend: going beyond that can put a strain on your concentration capabilities and could easily result in mistakes. In fact, the company advises you to "proceed at a leisurely pace . . . to avoid getting tired from working too long at one time." Actually, I found myself wanting to go beyond a two and a half hour maximum; this, I hear, is called "kit fever"—a driving impulse that keeps you going beyond reasonable limits.

Were I to build another AA-1640, I could lower the time figure by about 15 hours. I'm certain an experienced kit builder could put the unit together in 50 to 60 hours at the outset. I found myself spending a lot of time rechecking parts numbers and hardware sizes because of an overly cautious nature. To show you the amount of parts/hardware involved, it required over three hours to initially check them against the packing lists.

One of the first things that impressed me about the AA-1640 amplifier was the way it was packed. It came in three boxes. One contained the meters and related circuit boards. Another contained a single item—the power transformer, a 25-pound "monster." The third contained the rest of the kit. Splitting the kit enabled Heath to ship via United Parcel, a company noted for handling electronic products with care. Packing the kit in three boxes also substantially reduced the chances of internal damage, as for example, the power transformer loosening from its moorings and slamming into a lighter, more vulnerable part of the kit.

The second thing that impressed me was the sense of security I had after reading a note from Bob Ellerton, Technical Consultant, "your personal consultant during the assembly and checkout of your kit . . . we're partners in the project." While I'd built two other electronic kits several years ago—an integrated amplifier and a stereo tape recorder—I still had a certain amount of stage fright. The note dispelled it. (My personal consultants actually were members of the Heathkit Electronic Center staff in Manhattan.)

Being a cautious type, I decided to "ground" myself before starting by perusing the construction manual. Again I was impressed, this time by the manual's thoroughness. Much of it is well thought out.

My first sense of reward came at the end of less than two hours of working time, which consisted of checking out one of several parts lists and wiring the test meter—a device indispensable for putting this kit together. The meter did what it was supposed to during its checkout.

My second came an hour and a half later, on completion of the input amplifier circuit board. I was relieved to find that rewiring (and reheating) a miswired transistor had not affected its capabilities.

My third came two and a half hours later on completion of the power-supply circuit board, the largest so far. At this point I felt that I would have few problems completing the set, with no real complications as long as I steadfastly observed each nitty-gritty detail as outlined.

My first apparent trouble occurred some eight working hours later at the end of wiring the first of two output-amplifier circuit boards. The meter did not respond as it should have at one check point (page 50 of the manual)—it barely moved. Following instructions, I rechecked the entire board for solder connections, shorts, etc. Finding none, I then continued following instructions and replaced a capacitor. I got the same miniscule meter reading, nowhere near as broad as indicated in the manual. I was stumped and decided to wire the second board and see what happened when I checked it out, for comparison and as a kind of double check. I also figured that if I had trouble with it, I would take both boards to my Heathkit consultant for help.

On completing the second amplifier circuit board, and comparing it part for part, placement for placement with the first, I ran the same checks. As with the first board I got correct meter readings at all but one check point—the same one. This suggested there might be an error in the manual, the instructions, or what have you. I headed for midtown Manhattan with the manual for help from the Heathkit center.

There I was told that while the manual reading showed a span of one-fifth of the meter scale, that the miniscule reading I had obtained was, indeed, desirable and that I had no problem. Relief! However, I left feeling a bit miffed that the manual did not spell out the fact that a virtual no-reading reading was OK.

A major disappointment occurred some 26 working hours later when I conducted the input amplifier tests (page 110 of the manual). Nothing. Zero. . . . Thinking the tuner/preamp combination was at fault, I checked it out. It worked. On rehooking the units and starting a recheck, I blew a fuse. I attributed this to having accidentally shorted the tips of a pair of bare blue wires that extended from the innards of the kit. That stopped me cold. At this point I decided to stop by the kit center for advice. There I was told that I had probably blown two diodes as a result of my inadvertent short and was given free replacements plus a new fuse.

Wiring them in and turning on the set, I heard a momentary buzz and saw a puff of smoke. It was one of the replacement diodes. This suggested I take the amplifier in to Heath for a look-see and additional assistance.

After explaining the matter at the Heathkit center, I was told that I had probably shorted a relay that caused the diode to blow. In the process of asking for further explanation and what I might do next to correct the problem, I was informed that others were waiting for their questions to be answered and that there were phone calls lined up for the technician to answer. Rather than risk trying to comprehend a hurried, impatient explanation of what then seemed to be a complicated matter in such a hectic, pushy atmosphere, I opted to leave the unit for repair. I was told it would be ready in two weeks.

It was ready in exactly one month. I was informed that the delay was caused by a total remodelling of the Heathkit center and employee vacations. My invoice read "Fuse blown by defective D101,102 (diodes), defect caused by left-channel circuit-breaker wires not being connected. Protection board now works. Initial tests all OK, now ready

continued on page 92

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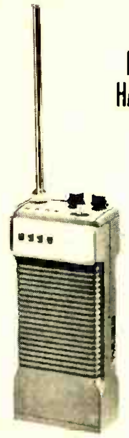

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Build 2650-Based Microcomputer System

Part I. *Built on a single printed-circuit board, this 2650 microcomputer contains a video and cassette tape interface and resident supervisor program. Add a keyboard, video monitor, cassette tape recorder and power supply for a complete working system*

JEFF ROLOFF

AN EASY-TO-USE COMPUTER SYSTEM MUST have essentially four major sections. There is, of course, the actual processing section that usually (at least for small users) contains a microprocessor IC. There must also be input and output sections so that the processor can communicate with the outside world. The last section that is essential for a computer's operation is the memory. This is used to store programs and data, and it can be either a memory that needs to be accessed very quickly when running a program or a memory used to store information for long periods of time, such as cassette tape.

The 2650 computer project presented here has all of the above circuits mounted on a single printed-circuit board. In addition, there is a versatile supervisor program that allows you to easily create your own programs. The heart of the unit is the Signetics 2650 microprocessor. Basically, it is a simple to use microprocessor with a powerful instruction set. The input device can be any ASCII-encoded keyboard, which simply hooks to an input port of the computer. The output device is a high quality 80-character by 16-line video display generator which is fully controlled by the processor. There are also parallel input and output ports (one each) to allow you to communicate with any other peripheral device, such as a line printer or a floppy disc. The

SPECIFICATIONS

DISPLAY GENERATOR

Display Format: 16 lines of 80 characters. User programmable character generator selected by setting bit 6 of the stored data to logic-1 level. Bit 7 available for any special user application.

Method of Accessing: The processor writes correct RAM location to place a character on the screen.

Output: Composite video, 1 volt P-P nominal, 75 ohms, 7.1 Mhz.

Cursor: Written by processor just like any other character. Supervisor uses a square dot centered in character field.

Screen Blanking: During horizontal or vertical retrace, between character lines and whenever the processor is accessing the display memory.

Display Addressing: Starts (upper left hand corner) at address H1000, and ends at H14FF. As addresses are incremented, the display position moves downward.

Additional User RAM: A total of 768 bytes starting at address H1500. Actually a part of the display memory, but this is transparent to the user.

PROCESSOR

Type: Signetics 2650 microprocessor.

Buffering: All processor signals buffered for TTL fan-out of 10.

Memory: 1K bytes of PROM which contains supervisor program. 768 bytes of RAM unused by display is available for user programs. PROM is on-board expandable to 4K bytes.

Control Lines: Pause and stop-clock lines allow single stepping of programs. Disable-lines for address data, and control buses to allow DMA (Direct Memory Access) or dual processor operation.

CASSETTE INTERFACE

Recording Format: 300 baud, 1200/2400-Hz Kansas City Standard.

Output Voltage: 100 mV P-P.

Misc. Size: 8½-inch square printed-circuit board.

Power Consumption: 3 amps at 5 volts.

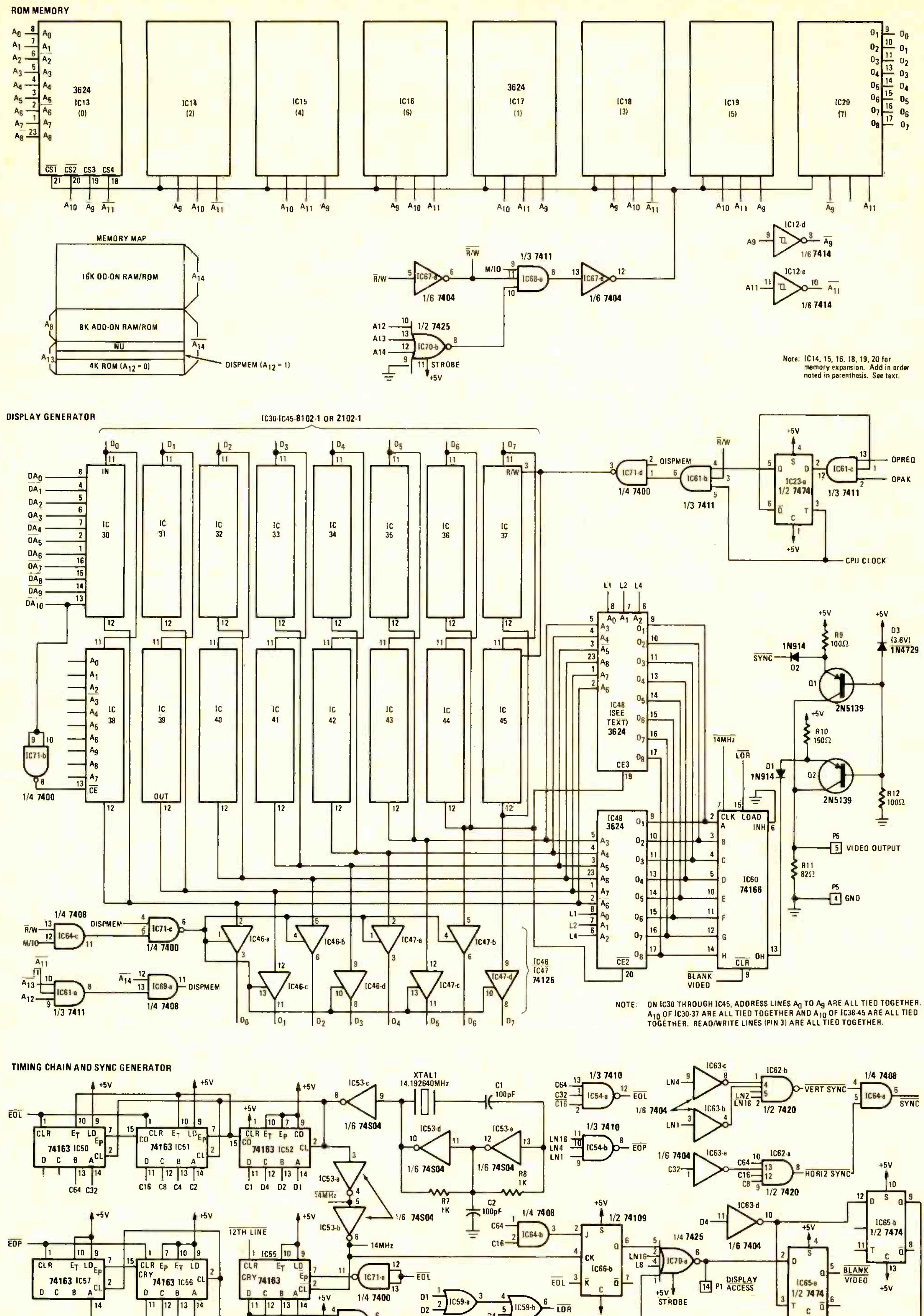
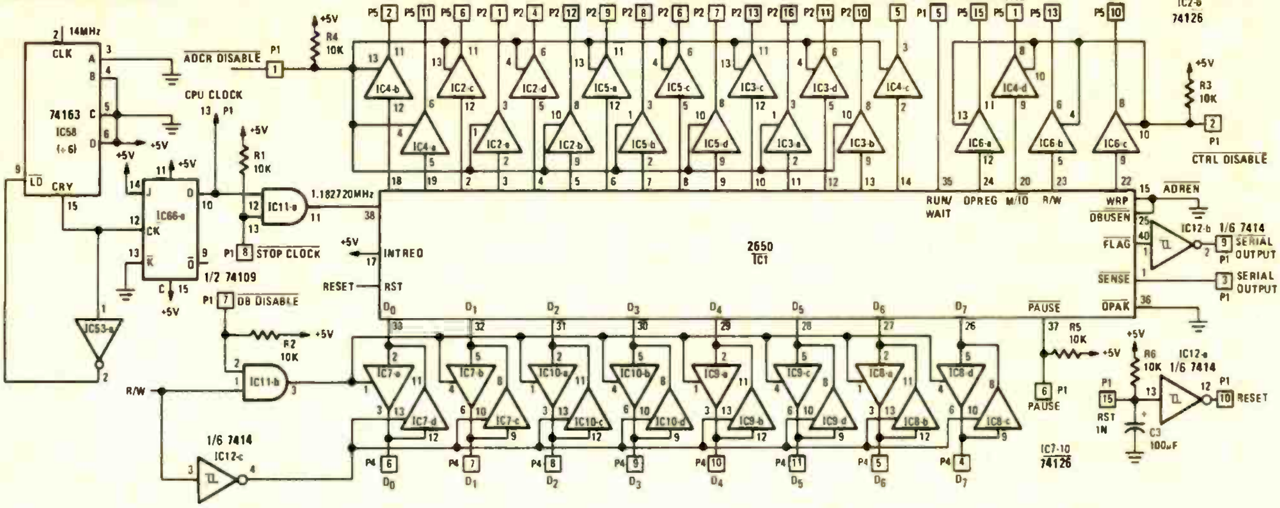
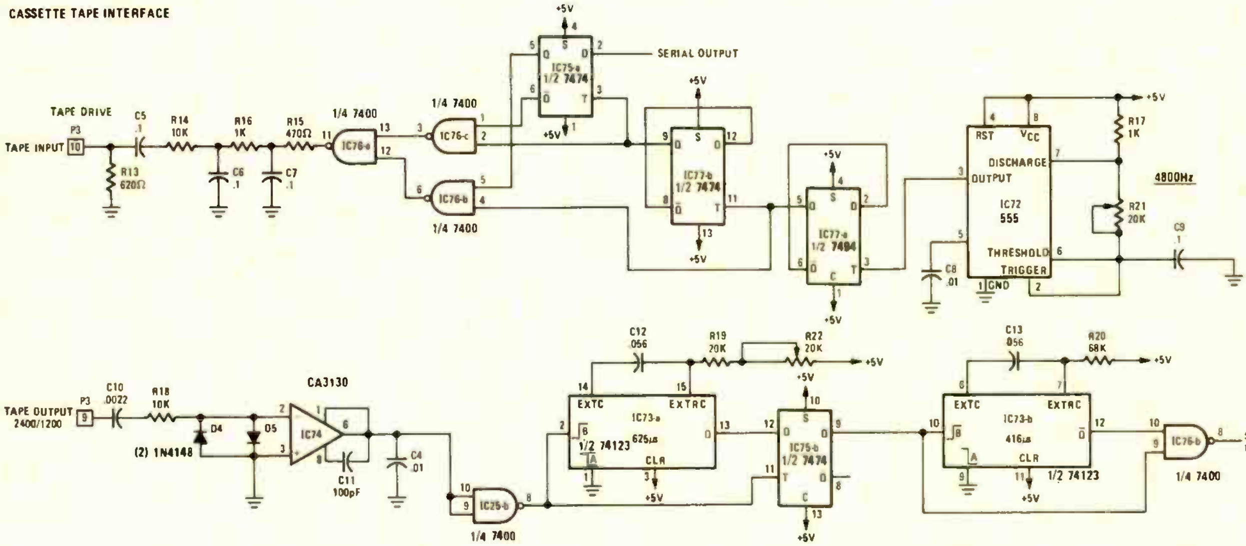


FIG. 1—COMPLETE SCHEMATIC of 2650-based microcomputer. All circuitry, including cassette-tape interface and video display generator, mount on single PC-board. Connection to peripheral devices is made via six IC sockets.

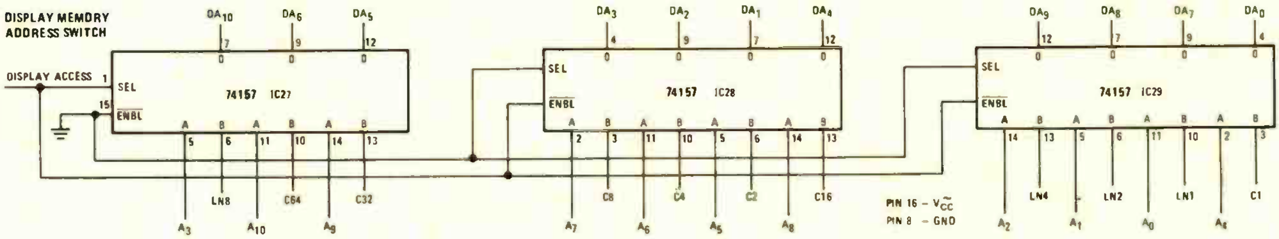
PROCESSOR AND BUS DRIVERS



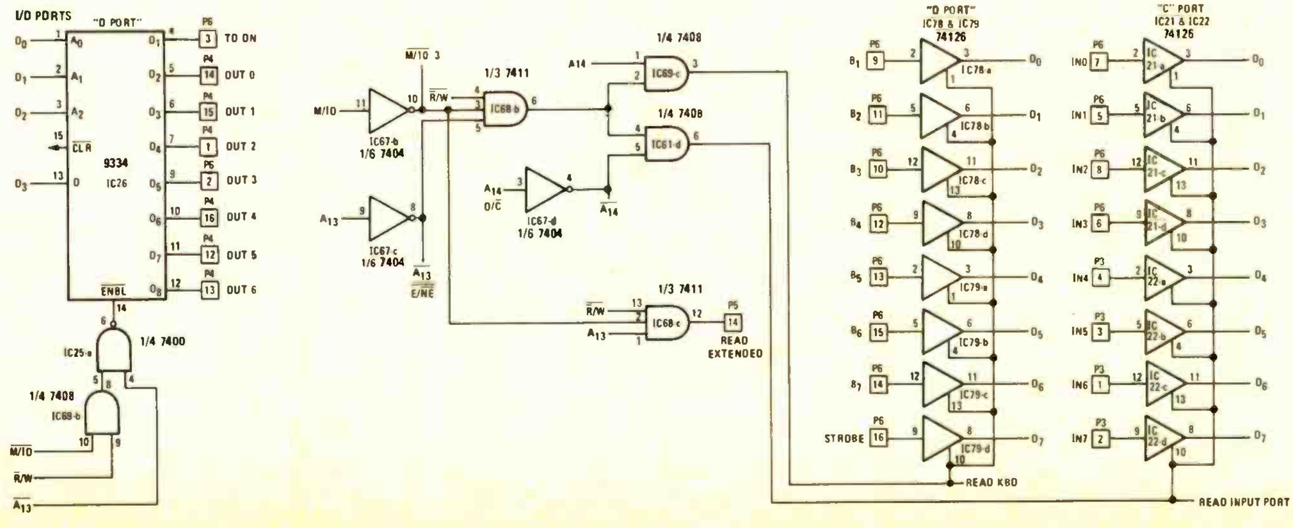
CASSETTE TAPE INTERFACE



DISPLAY MEMORY ADDRESS SWITCH



I/O PORTS



PARTS LIST

All resistors ¼ watt, 5%.
R1-R6, R14, R18—10,000 ohms
R7, R8, R16, R17—1000 ohms
R9—330 ohms
R10—150 ohms
R11—82 ohms
R12—100 ohms
R13—620 ohms
R15—470 ohms
R19—20,000 ohms
R20—68,000 ohms
R21, R22—20,000-ohm trimmer potentiometer
C1, C2, C11—100 pF, disc
C3, C14—100 μF, 16 volt, electrolytic
C4, C8—0.01 μF, disc
C5, C6, C7, C9, C15-C29—0.1 μF, disc
C10—0.0022 μF
C12, C13—0.056 μF, ±10% polyester film
D1, D2—1N914 diode
D3—1N4729 Zener
D4, D5—1N4148 diode
Q1, Q2—2N5139 transistor
IC1—2650 microprocessor (Signetics)
IC2-IC10, IC21, IC22, IC78, IC79—74126
IC11, IC64, IC69—7408
IC12—7414
IC13, IC17—3624, pre-programmed PROM containing supervisor program
IC14-IC16, IC18-IC20, IC48—3624, PROM (see text)
IC23, IC24, IC65, IC75, IC77—7474
IC25, IC71, IC76—7400
IC26—9344, 4-bit by 2-bit multiplier (Fairchild)
IC27-IC29—74157
IC30-IC45—2102-1, RAM (Signetics)
IC46, IC47—74125
IC49—3624, pre-programmed PROM character generator, upper case
IC50-IC52, IC55-IC58—74163
IC53—74S04
IC54—7410
IC59—7432
IC60—74166
IC61, IC68—7411
IC62—7420
IC63, IC67—7404
IC66—74109
IC70—7425
IC72—555, timer
IC73—74123
IC74—CA3130
XTAL1—14.192640 MHz series-resonant crystal
MISC.—One 40-pin DIP socket for IC1, six 16-pin DIP sockets and printed-circuit board.

The following parts may be ordered from: Central Data Company, P.O. Box 2484, Station A, Champaign, IL 61820.

IC49—3624, pre-programmed PROM character generator, upper case, $27.

IC13, IC17—3624, pre-programmed PROM containing supervisor program, $27 each.

PC board, predrilled and etched, $30.

An assembled and tested microcomputer board, $325.

number of ports can be easily expanded to 256.

The on-board memory consists of 1024 bytes of PROM used to store the supervisor program along with 2048 bytes of RAM used for the video-display generator and for program storage. The external storage device is a cassette-tape recorder. An on-board cassette-tape interface IC is provided that uses the 1200/2400 Hz, 300-baud standard to store the data. When the cassette interface is not being used, data lines are available for serial I/O (*I*nput/*O*utput) data transfer. The computer operates off of a single +5-volt supply. When it comes right down to it, *all* that you need to get rolling in microcomputers is the board described in this article, plus an ASCII-encoded keyboard, a video monitor, a cassette-tape recorder and a power supply.

Something more should be said about the supervisor program at this time since it pulls all of the hardware together to form a simple to use computer system. The program allows you to have cassette-tape input or output to or from any memory block (in a standard format, in any length that you want), display or change memory, set a software breakpoint (stop) address, inspect and set the CPU registers, and jump to any memory location to execute your program.

Theory of operation

Figure 1 shows the schematic for the 2650 microcomputer system. Because of the architecture of the 2650 microprocessor, the Processor and Bus Drive circuit is very simple. All of the output lines of the 2650 are buffered by tri-state buffers, and the data bus is buffered in both directions, with only one set of buffers being enabled at a time.

Figure 2 shows the timing relationships for the 2650 microprocessor. Note that both OPREQ (operation request) and the address lines become stable somewhere in an interval of about 600 ns, depending on the individual 2650, the temperature and the power supply voltage. The 1.18 Mhz TTL clock for the 2650 is derived from the output which is a division of the 14-MHz master oscillator used in the display unit.

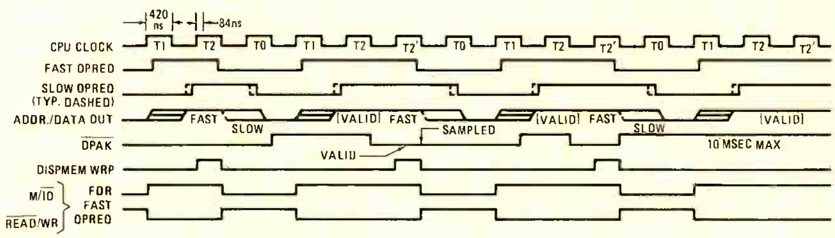


FIG. 2—2650 MICROPROCESSOR timing relationships.

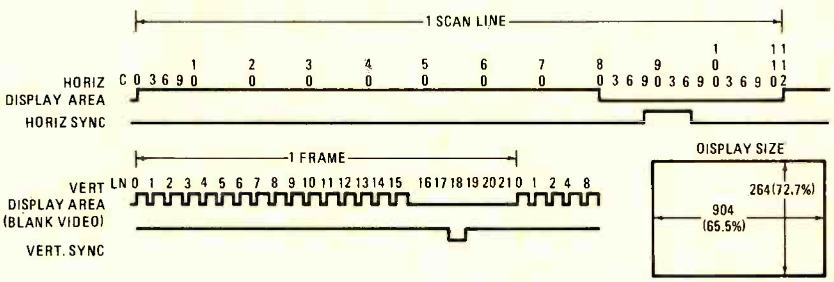


FIG. 3—TIMING DIAGRAM of horizontal, vertical and sync signals supplied to video monitor.

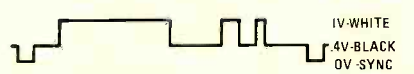


FIG. 4—COMPOSITE VIDEO SIGNAL supplied to video monitor.

Because the microprocessor and the display unit use the same RAM (unless you expand the RAM), a priority arrangement for the memory had to be devised. Since the processor could be in the middle of an access when the display needs the memory again, the display checks to see if the processor is accessing RAM, and if it is, the display waits. After the processor is finished accessing the memory, the processor is locked out from accessing the memory again until the display is through. The display releases the memory to the processor whenever it is doing inter-line or vertical blanking, which accounts for about 53% of the time. Therefore, the processor runs at about half-speed when continually accessing the display memory, which is very seldom. When the display is using the memory, pin 36 (OPAK) of the 2650 is high.

Data is transferred between the processor and peripheral devices via the parallel input and output ports. The keyboard should be hooked to the input port by connecting it to the correct pins of plug P6. The data from the keyboard is read by the READ DATA command. The other input port is read by a READ CONTROL command. The bit settable output port is accessed by the WRITE DATA instruction.

The Timing Chain and Sync Generator circuit divides the 14 Mhz clock in several stages to form the various signals needed to interface with a video monitor. Derived from these divisions of the master clock are the signals HORIZONTAL SYNC, VERTICAL SYNC, and BLANK VIDEO (composite blanking). Figure 3 shows the relation between the vertical and horizontal timing and the sync pulses.

The Display Memory circuit consists of sixteen 2102-1 RAM IC's and up to two 3624 PROM's. The 3624 PROM's are used for both the character generators and the supervisor program (as opposed to 1702's) so that the whole system could run off of a single supply. The use of PROM's for character generators also allows you to create your own characters, symbols or limited graphics. If bit 6 of the ASCII data is low, it selects one of the character generators (IC49), while if it is high it selects the other (IC48). The outputs of the character generators are fed into a parallel-to-serial converter where they are sent out at a 14 Mhz rate. They are then mixed with the sync pulses to form the composite video signal that is sent to the monitor. The video output voltages are shown in Fig. 4.

Since the processor and the display share the display memory, the address lines of the display memory must be switched between the processor address bus and the display timing generator. The Display Memory Address Switch circuit does this. When the Display Generator is not writing characters (and therefore not accessing memory), the DISPLAY ACCESS line is low, which selects the processor address bus to be gated to the RAM. When the display is not blanking the video, however, the Timing Chain and Sync Generator circuit selects the addresses for the RAM in an ordered fashion.

There is a special pattern by which the display accesses the RAM. This pattern allows all locations of memory not used by the display section (there are 768 of these bytes) to be confined to one memory block, not just several bytes here and there scattered throughout memory. A memory map for the display is shown in Fig. 5. When the address of the RAM is incremented, the

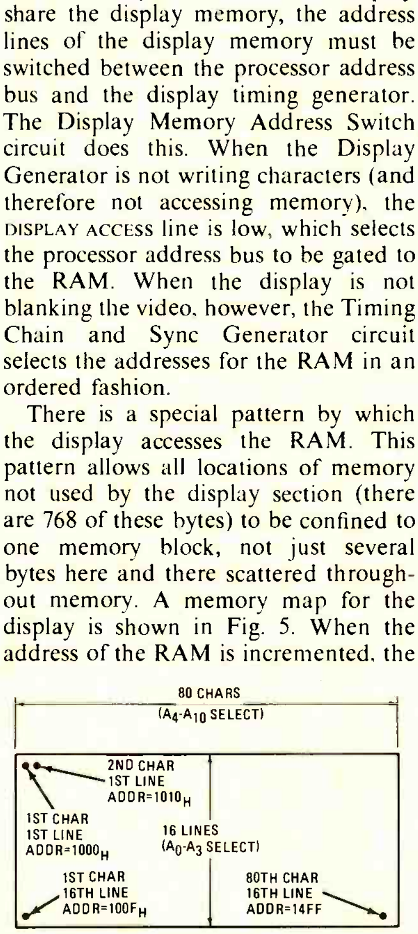


FIG. 5—RANDOM ACCESS MEMORY is simultaneously used for the video display and program storage.

PIN NO.	P1	P2	P3	P4	P5	P6
1	$\overline{\text{ADDR DISABLE}}$	A_{11}	IN6	OUT 2	M/ID	GND
2	$\overline{\text{CTRL DISABLE}}$	GND	IN7	+5V	A14	OUT 3
3	SERIAL INPUT	+5V	IN5	GND		TD-ON
4		A_{10}	IN4	D_7	GND	+5
5	RUN/WAIT (OUT)	A_0		D_6	VIDEO OUT	IN1
6	$\overline{\text{PAUSE}}$	A_6		D_0	A_{12}	IN3
7	$\overline{\text{DB DISABLE}}$	A_5		D_1	+5V	IN0
8	$\overline{\text{STOP CLOCK}}$	A_7	GND	D_2	+5V	IN2
9	SERIAL OUT	A_8	TAPE RECORDER EARPHONE	D_3	GND	B_1
10	$\overline{\text{RESET OUT}}$ (SQUARED)	A_1	TAPE RECORDER MICROPHONE	D_4	WRP	B_3
11	+5V	A_2		D_5	A_{13}	B_2
12	+5V	A_9		OUT 5		B_4
13	CPU CLK	A_4	GND	OUT 6	$\overline{\text{R}}$/W	B_5
14	DISPLAY ACCESS	+5		OUT 0	READ EXTENDED	B_7
15	$\overline{\text{RESET IN}}$	A_9		OUT 1	OPREQ	B_6
16		A_3		OUT 4	$\overline{A_{13}}$	STROBE

FIG. 6—PIN CONNECTIONS of DIP sockets used to connect microcomputer to external devices.

character on the video display moves down one line. When it gets to the bottom line, the next character is on the top line, one character to the right of the present one. Therefore, when the display memory is filled, every memory location from address 1000 to 14FF is filled with data. If you wish to write characters across a line, you must increment the address by 16, thus moving you to the right one position. So from locations 1500 to 17FF you may put your own programs and data, just as if the video display wasn't there.

It may help to show what would happen if the memory addressing scheme was worked out another way. If the addresses were incremented as the characters were being printed on a line, then addresses 80 to 127 would be left unused, along with 207 to 254 and so on to form 16 groups of 48 characters each. All of these groups are separated by 80 characters, and programs cannot be written in them unless they are less than 49 bytes long! The addressing format can be ignored by someone programming the unit, for it is transparent to the programmer. It was thought that it would be appropriate, however, to bring it out here for a more hardware oriented person.

The PROM memory consists of up to eight 3624 4K-bit PROM's that are selected as a function of the upper six address lines. The first two IC sockets (IC13 and IC17) on the PC board are usually filled with the supervisor program. It should be pointed out that other programs could be written that would allow the board to have a special purpose such as an intelligent terminal or a process controller. These programs could either replace the supervisor program or be added to the empty sockets.

The last circuit is the Cassette Interface, which connects to the serial input and output pins of the 2650 processor. The modulator consists of an oscillator and gating circuitry to allow either 1200 or 2400 Hz go to the tape recorder's microphone jack. The demodulator consists of a limiter (IC74) and two Monostable Multivibrators (IC73-a and IC73-b). The output of monostable IC73-a goes low if the input frequency is not fast enough to keep retriggering it (somewhere between 2400 and 1200 Hz). This output is latched by IC75-b, and the other monostable (IC73-b) takes care of bias and distortion problems. This output is sent to the serial input (sense) line of the 2650.

Installation

Connecting the circuit board to external devices is accomplished through the use of DIP plugs and sockets. Figure 6 shows the pin connections of these sockets.

Connection to your video monitor is made using plug 5, pins 4 and 5. Pin 4 is the ground, and pin 5 is the 1 volt P-P composite-video signal. Plug 6 is used to connect to your keyboard. The pin numbers that correspond to the ASCII data bits can be found in Fig. 6.

The strobe signal must be low going, and should ideally be active as long as the key is depressed. Note that the supervisor program will not accept a very short strobe pulse, since the software is used to detect the strobe. If your keyboard strobe is small (less than 1 ms), you can add the circuit shown in Fig. 7 to be sure that the program will catch every keypress.

Most keyboards have a strobe that lasts as long as a key is depressed, so it is then simply a matter of hooking up the

continued on page 90

XR-2206 IC Function Generator Circuits

Part I. The XR-2206 IC is a versatile function-generator with many applications. Here are some of the more interesting circuits you can try.

R. M. MARSTON

THE XR-2206 IC IS A FUNCTION GENERATOR that is capable of generating high quality sine, square, triangular, ramp, and pulse waveforms at frequencies from a fraction of a Hz to several hundred kHz with a minimum of external circuitry. The output frequency can be swept over a 2000:1 range using a single control-voltage or variable resistance. In addition, the IC has facilities for AM, FM, PSK (*P*hase-*S*hift *K*eying) or FSK (*F*requency-*S*hift *K*eying) operations.

Manufactured by Exar Integrated Systems, Inc., 750 Palomar Ave., Sunnyvale, CA 94086, the XR-2206 is available from many distributors. It is housed in a standard 16-pin DIP and can be powered from either a single supply in the range 10 to 26 volts or a split-voltage supply in the range ±5 to ±13 volts. When used as a sinewave generator, the THD is typically 2.5 percent without adjustment but can be reduced to about 0.5 percent with external trimmer controls. The sinewave output has a typical maximum amplitude of 2 volts RMS and an output impedance of 600 ohms. The frequency stability of the IC is excellent—20 PPM (*P*arts *P*er *M*illion)-per-degree Celsius for thermal changes and 0.01 percent-per-volt for supply voltage changes.

The XR-2206 integrated circuit has many useful applications. It can readily be used as a simple waveform generator or as a complex function generator with a variety of modulation facilities.

How it works

Figure 1 shows the functional block diagram and pin connections of the XR-2206. The heart of the IC is a voltage-controlled oscillator (VCO) that is driven by a pair of current switches. The VCO's main timing-capacitor is wired between pins 5 and 6, and can have any value in the range 1000 pF to 100 μF. The VCO's main timing resistor is wired between the negative supply voltage (V–) and pin 7 or pin 8 of the IC. The resistor can have any value in the range 1K to 2 megohms.

The frequency of oscillation, f_0, is determined by the external timing-capacitor C_T and by the timing resistor R_T. The frequency is given as:

$$f_0 = \frac{1}{R_T \times C_T} \text{ Hz.}$$

For optimum thermal stability and minimum sinewave distortion, R_T should have a value in the range 4K to 200K ohms.

The timing resistor can be connected to either pin 7 or pin 8, or two timing

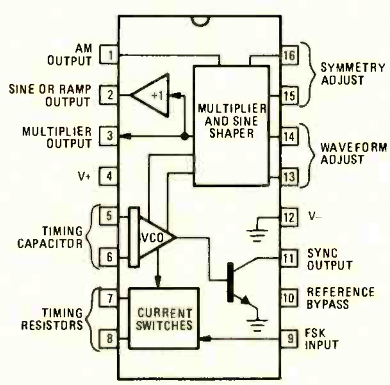
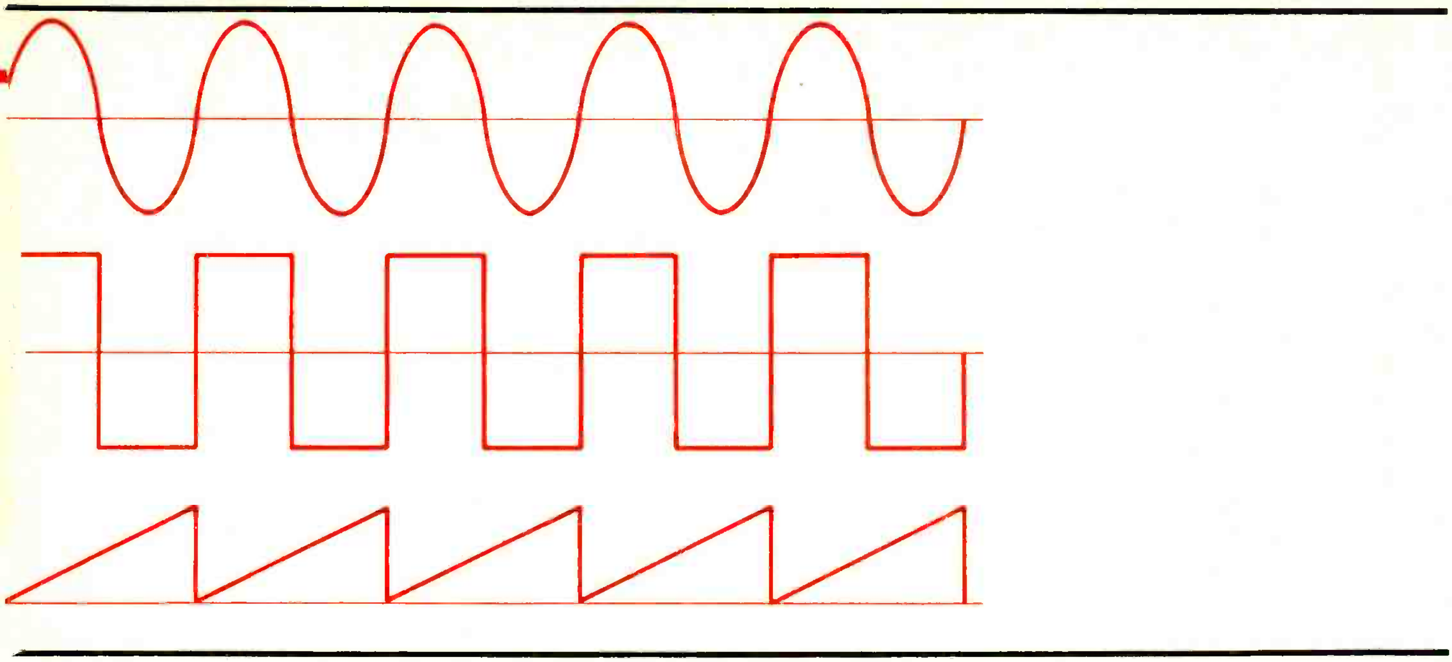


FIG. 1—XR-2206 FUNCTION GENERATOR, block diagram and pin connections.

resistors with different values can be connected for FSK operation. Either the pin-7 or pin-8 timing resistor is selected by applying a suitable voltage to the FSK input terminal (pin 9) of the IC. If pin 9 is open-circuited or connected to a bias voltage greater than 2 volts, the pin-7 resistor is selected. Conversely, if pin 9 is biased below 1 volt, the pin-8 timing resistor is selected. This FSK facility enables the output signal to be switched alternately between two independently adjustable frequencies, to produce, for example, a warble-tone signal.

The VCO produces two basic waveforms simultaneously. One of these is a linear ramp that is fed to an internal multiplier and sine shaper. The other is a rectangular waveform that appears on pin 11 via a built-in buffer transistor. In very simple terms, the action of the VCO is such that the timing capacitor C_T first charges linearly via the timing resistor R_T to produce the internal rising ramp waveform. Simultaneously, the voltage appearing on pin 11 switches sharply from a low to a high state. The ramp waveform continues to rise until it reaches a predetermined threshold voltage, at which point the rectangle output switches sharply to the low state and C_T starts charging in the reverse direction via R_T to produce a falling-ramp waveform. The ramp continues to fall until a second threshold voltage is reached, at which point the rectangular output switches sharply back to its original 'high' state and the whole timing process then repeats.

The VCO produces symmetrical triangle and square waveforms if the same timing resistor is used to control both charging cycles of the timing capacitor. Alternatively, if the rectangular output waveform appearing on pin 11 is connected to the FSK terminal (pin 9), the VCO will automatically switch between the pin-7 and pin-8 timing resistors on alternate half cycles. If timing resistors with different values are used, the IC will simultaneously produce non-symmetrical linear-ramp (or



sawtooth) and non-symmetrical square (or pulse) output waveforms.

The VCO is actually a current-controlled multivibrator, in which the timing current is controlled by the resistors connected to pins 7 or 8, or by external voltages that are connected to these pins via suitable current-limiting resistors. This makes it possible to externally frequency modulate or frequency sweep the output waveforms.

The ramp output of the VCO is fed to the multiplier and sine-shaper circuit. This circuit acts like a gain-controlled differential amplifier that provides a high impedance output at pin 3 and a 600-ohm buffered output at pin 2. With pins 13 and 14 open, a ramp waveform is available at pins 2 and 3. With a resistance of a few hundred ohms between pins 13 and 14, the circuit exponentially cuts off the peaks of the ramp signal from the VCO, producing a sinewave output at pins 2 and 3. With suitable adjustment, the sinewave distortion can typically be reduced to a mere 0.5 percent.

The gain and output phase of the multiplier can be varied by applying a bias or signal voltage to pin 1. The output is linearly controlled by variations above and below a level equal to half the supply voltage. The output is zero when the pin-1 voltage is at half the supply voltage, and rises as the voltage goes above half the supply voltage. When the voltage is reduced below the half-supply level, the output-signal level again increases but its phase is reversed. This characteristic can be used to amplitude modulate (AM) or phase shift key (PSK) the output signal of the waveform generator at pins 2 and 3.

The high output impedance of pin 3 is internally connected to the input of a built-in unity-gain amplifier stage that produces a buffered 600-ohm output at pin 2. The input signal to the buffer amplifier (and hence the output signal at pin 2) can be varied by connecting a voltage divider between pin 3 and a ground point. This can be used to provide simple gain control of the output, or it can be used for keying or pulsing the output signal at pin 2.

A final point to note about the XR-2206 IC is that the DC level at pin 2 is approximately the same as the DC level at pin 3. Thus, the DC level at pin 2 can be shifted by applying a suitable bias voltage to pin 3. In most applications, pin 3 is biased halfway between the positive and negative supply voltages. In split-supply circuits, this means that the output signal swings about the zero-volt (common) line.

Sinewave generators

Figure 2 shows the connections for using the XR-2206 as a simple sinewave generator that is powered from a single power-supply. Here, the timing resistance is provided by the series combination R1 and R2, and the output frequency can be varied over more than a decade range with any given value of timing capacitor C1. When C1 has a value of 1 μF, the frequency can be varied from 10 Hz to 100 Hz via R1, and when C1 has a value of 1000 pF, the frequency can be varied from 10 kHz to 100 kHz. Note that the timing resistance is connected to pin 7 of the IC. This timing pin is automatically selected since the FSK terminal (pin 9) is unbiased. The circuit generates a sinewave output at pin 2, since a 220-ohm resistor is wired between pins 13 and 14. Typically, the sinewave distortion is less than 2.5% with this simple connection.

The DC level of the sinewave at pin 2 is equal to half the supply voltage because pin 3 is biased at that level by voltage divider R6—R7, which is shunted to a low impedance by C3—C4. The DC level of the sinewave signal is removed by capacitor C5. Potentiometer R5 varies the amplitude of the sinewave

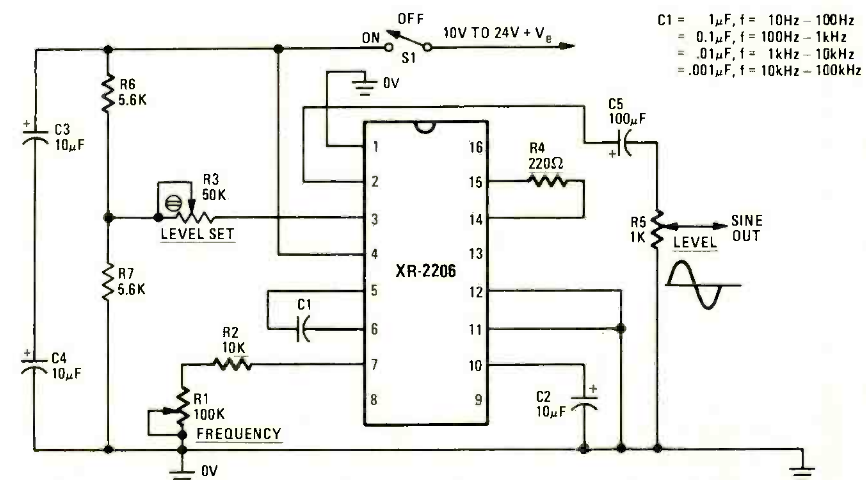


FIG. 2—SIMPLE SINEWAVE generator uses single-voltage supply.

and provides the final output signal.

The maximum amplitude of the output sinewave is determined by LEVEL PRESET control R3. To set up R3, first disconnect R4 from pin 13 so that a triangular output waveform is obtained, then decrease R3 until all clipping is removed from the triangular waveform. Note the R3 setting. Now reconnect R4 to pin 13 and check that a good sinewave output is obtained. The maximum sinewave amplitude can be reduced by moving R3 below the noted setting, but the amplitude must not be increased by moving R3 above this setting. Sinewave distortion may be reduced below the typical 2.5% value by carefully adjusting the value of R4.

The circuit shown in Fig. 2 can be used with any power supply in the range 10 to 24 volts. The circuit can be modified for split-supply operation by replacing all ground connections with the negative output of the supply, and by connecting the LEVEL PRESET control R3 directly to the common or ground line. These modifications are shown in the circuit of Fig. 3. Note that the R6–R7 voltage divider is eliminated and that decoupling capacitor C5 is no longer required since the sinewave output signal is automatically centered at the zero volt level.

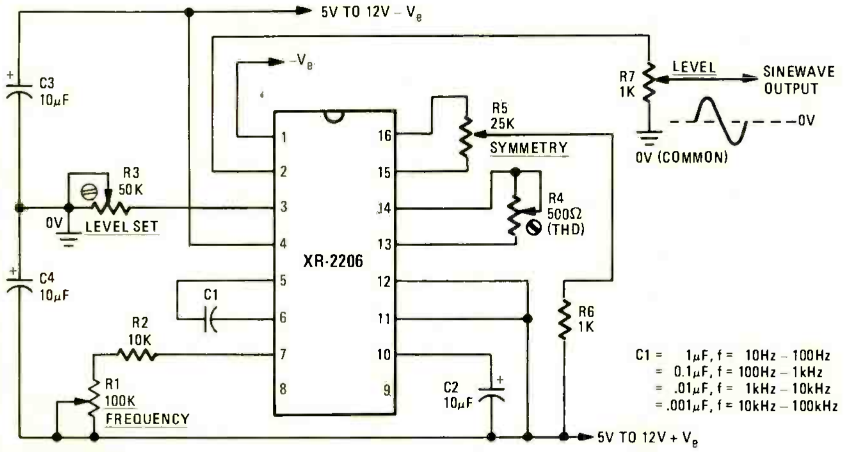


Fig. 3—HIGH-PERFORMANCE SINEWAVE generator uses split-voltage supply and has adjustments for waveform symmetry and distortion.

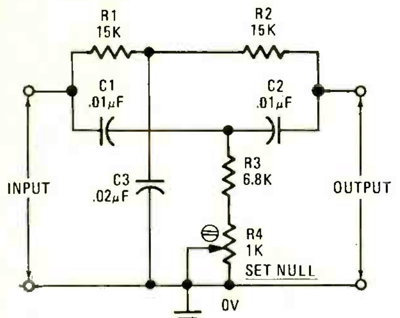


FIG. 4—TWIN-T FILTER aids in adjusting for minimum distortion.

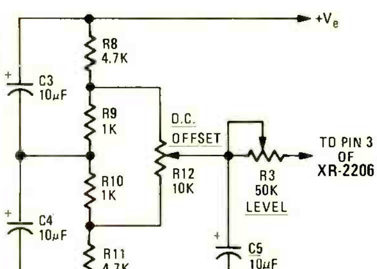


FIG. 5—ADD-ON MODIFICATION for applying a DC offset to the output signal in the Fig. 3 circuit.

The Fig. 3 circuit also shows how the total harmonic distortion (THD) of the sinewave signal can be reduced to a typical value of 0.5% with the aid of R4 and R5. Here, R4 trims the THD and R5 is a symmetry adjust control. These controls must be adjusted alternately to give the best sinewave output waveform, after first setting R3 to give a non-clipped triangle waveform as described earlier.

In the absence of a distortion meter, the simple twin-T 1-kHz filter shown in Fig. 4 can be used in conjunction with an oscilloscope or millivoltmeter to set the sinewave generator for minimum distortion at 1 kHz. The procedure for using the filter is to apply the sinewave output of the generator to the input of the filter and connect the output of the filter to the input of an indicator such as a scope or millivoltmeter. Set the output of the generator to 1 volt RMS at approximately 1 kHz. Next, adjust the output frequency of the generator and the SET NULL control R4 of the filter to give a minimum output indication. Finally, adjust the R4 THD and R5 SYMMETRY controls of the generator to reduce the output of the filter to the minimum possible value. The output of the filter corresponds to approximately 0.1% THD-per-mV RMS. For example, if the indicator shows a reading of 5 mV RMS, the THD of the generator is approximately 0.5%.

When using the low-distortion sinewave facility, it may be noted that the signal appearing at pin 3 of the IC is similar to the signal at pin 2, but has a lower distortion and a higher output impedance than pin 2. Also, the signal at pin 3 is closely centered on the common or ground line, while the signal at pin 2 is offset by a few hundred millivolts. The pin-3 terminal can also supply a greater undistorted signal voltage than the pin-2 terminal.

If required, DC offset can be applied to the output signal at pin 2 and pin 3 in the circuit shown in Fig. 3. This is accomplished by applying a bias to the ground side of R3 as shown in the add-on circuit of Fig. 5.

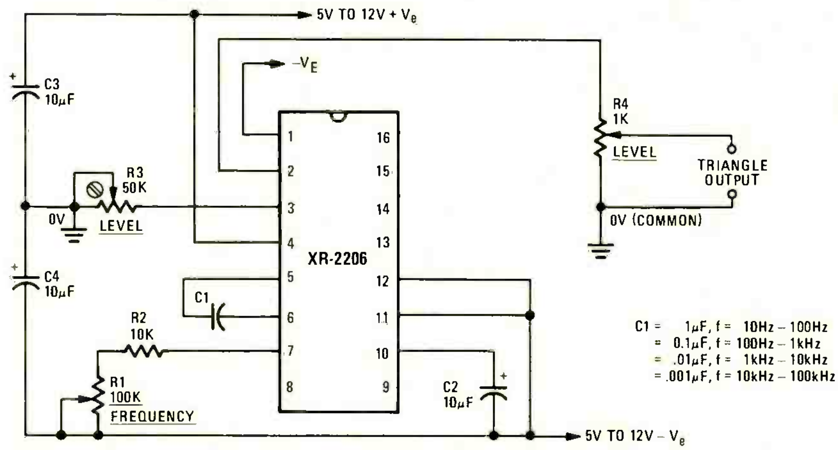


FIG. 6—TRIANGULAR WAVEFORM generator provides a variable-frequency output signal.

Triangle and squarewaves

The XR-2206 IC can generate triangular waveforms by using the basic circuits of Figs. 2 and 3 without the sinewave shaping resistors. Figure 6 shows the practical circuit of a variable-frequency split-supply triangular waveform generator. When used with a 9V–0–9V supply, the unloaded output will provide a signal amplitude of about 12 volts peak-to-peak before clipping occurs.

Fixed-amplitude squarewave signals can be generated, either independently or simultaneously with sine or triangular waveforms, by simply wiring a load

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Turn-On Appliances Via Long Distance

An add-on device that enables you to turn on and off appliances or sequently turn on multiple appliances by ringing your telephone

JAMES GUILDER

THE TELEPHONE IS PROBABLY ONE OF THE most important of all those appliances that can have a bearing on our daily lives; yet it is the one most often taken for granted. We usually think of it as merely a means of communication but in this article we will see how the telephone can become a "Magic Genie" that can control many simple household tasks while we are away from home.

The project described in this article is designed to operate with the ordinary house telephone. To better understand how it works, we must first look at the basic phone instrument and see how it operates.

One of the more common telephones in use today is the *model 500* used in the Bell Telephone System. It is the model that will be considered. A typical schematic of the 500-type telephone is illustrated in Fig. 1.

Sound is picked up by the telephone transmitter (microphone) as variations in pressure caused by a vibrating diaphragm. Sound is reproduced in the telephone receiver. It contains an electromagnetic earphone.

It's possible to make a telephone with just the receiver, transmitter and some additional switches. But such an instrument would be difficult to use because your voice would be loud in your receiver and low in the receiver of the party you were talking to. The same thing would be true on the other end. To eliminate this, telephone engineers have included varistors in the telephone instrument. (Varistors are voltage variable resistors in which the resistance varies inversely with the voltage.) So if the voltage across a varistor increases, the resistance decreases and vice versa. This means that the average voltage across the receiver in the phone remains relatively constant. The voltage produced in your receiver by your microphone is reduced to the same level as the voltage coming from the distant microphone.

In Fig. 1 varistor RV1 suppresses dial pulse clicks in the receiver. The balancing network, composed of varistor RV2, resistor R2, and capacitors C2 and C3 with the windings of the induction coil, forms a hybrid arrangement that provides simultaneous two-way operation over a two-wire circuit. Capacitor C1 and resistor R1 make up a dial pulse filter to suppress high-frequency interference to nearby radio receivers. Varistors RV2 and RV3 with R1 also reduce the efficiency of the transmitter on short loops from the central office to maintain satisfactory transmission volume. All of the components marked with an asterisk (*) are located within the network block

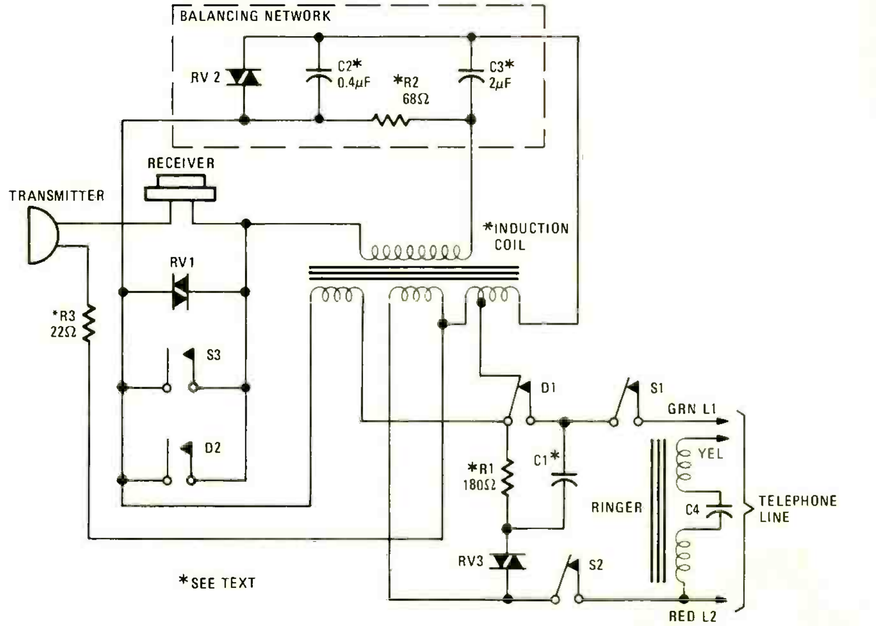

FIG. 1—500-TYPE TELEPHONE contains transmitter, receiver and network for balancing the signal level between the two.

located inside Western Electric and ITT telephones. In phones produced by Automatic Electric, these components are on a printed circuit board in the phone.

While most telephones have three wires coming out of them—green (L1), red (L2) and yellow—the green and yellow wires are often connected together. The yellow and red wires are used to make the telephone ring. To do this, between 60 and 90 volts at 20 Hz is applied to the ringer, which consists of two coils in series with a capacitor. The ringing coils of the bell and capacitor C4 are designed so that once the bell starts to ring, the ringing signal is reinforced and even a small electrical current will cause the bell to continue to ring.

The ringer assembly is connected to the telephone line at all times because it is connected before the hook switch that disables the rest of the telephone until the receiver is lifted off the hook. If the telephone company wants to determine how many phones are connected to a line, it either measures the capacitance of the line or the current drawn during ringing.

When the receiver is lifted off the hook, switches S1 and S2 close, while switch S3 opens. When S1 and S2 close, the phone resistance, that normally varies between 600 and 900 ohms, is placed across the line. The 48 volts across the line when the phone is on the hook drops to about 5 volts.

To dial a phone number, the line must be interrupted (opened and closed) at a repetition rate of 10 pulses per second. This is done by contact D1, located on the back of the telephone dial. If, for example, the number 7 is dialed, D1 (normally closed) opens and closes 7 times. While this is happening, D2 stays closed. The moment the dial is moved from its normal resting position, contact D2 closes and stays closed until the dial returns to its resting position. This short circuits the receiver to prevent the dial clicks from being heard.

Build the Teleswitch

How would you like to be able to call your house after an evening out, turn the electric coffee pot on, and have a fresh pot of hot coffee waiting for you when you get home? Or maybe you'd like to turn the lights on and off in your house while you are away on vacation so potential burglars won't realize that you are not home.

You can do these things and more with Teleswitch. If you want to, you can turn on a whole series of devices in sequence, just by making one phone call every time a device is to be turned on. And the best part of the whole thing is that you do not get charged for a phone call, even if it is long distance. The reason for this is that Teleswitch does not answer the phone. It simply uses the ring signal to activate whatever devices are connected to it.

Do not worry about anyone else turning things on accidentally. Teleswitch is designed so that unless the phone rings *exactly once*, and *only once*, nothing will happen.

There are two versions of Teleswitch: sequential, multiple-device and on/off switching. The sequential type will turn on a series of electrically operated appliances one after the other. This is good if you have several things to control remotely such as an electric coffee pot, warming tray, lights, etc. The disadvantage of this device is that to turn something off, it requires a sepa-

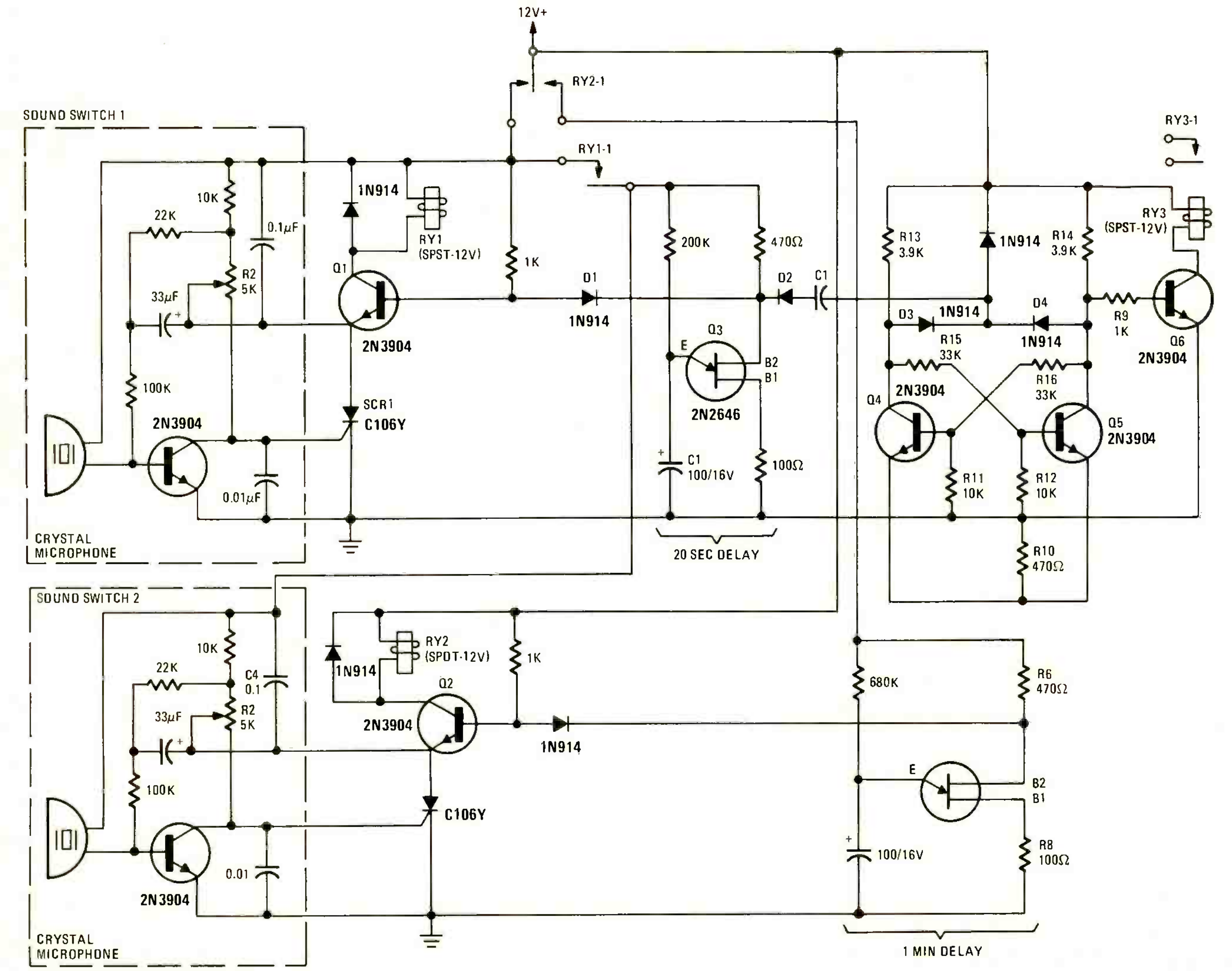

FIG. 2—ON/OFF-TYPE TELESWITCH responds only to single telephone ring.

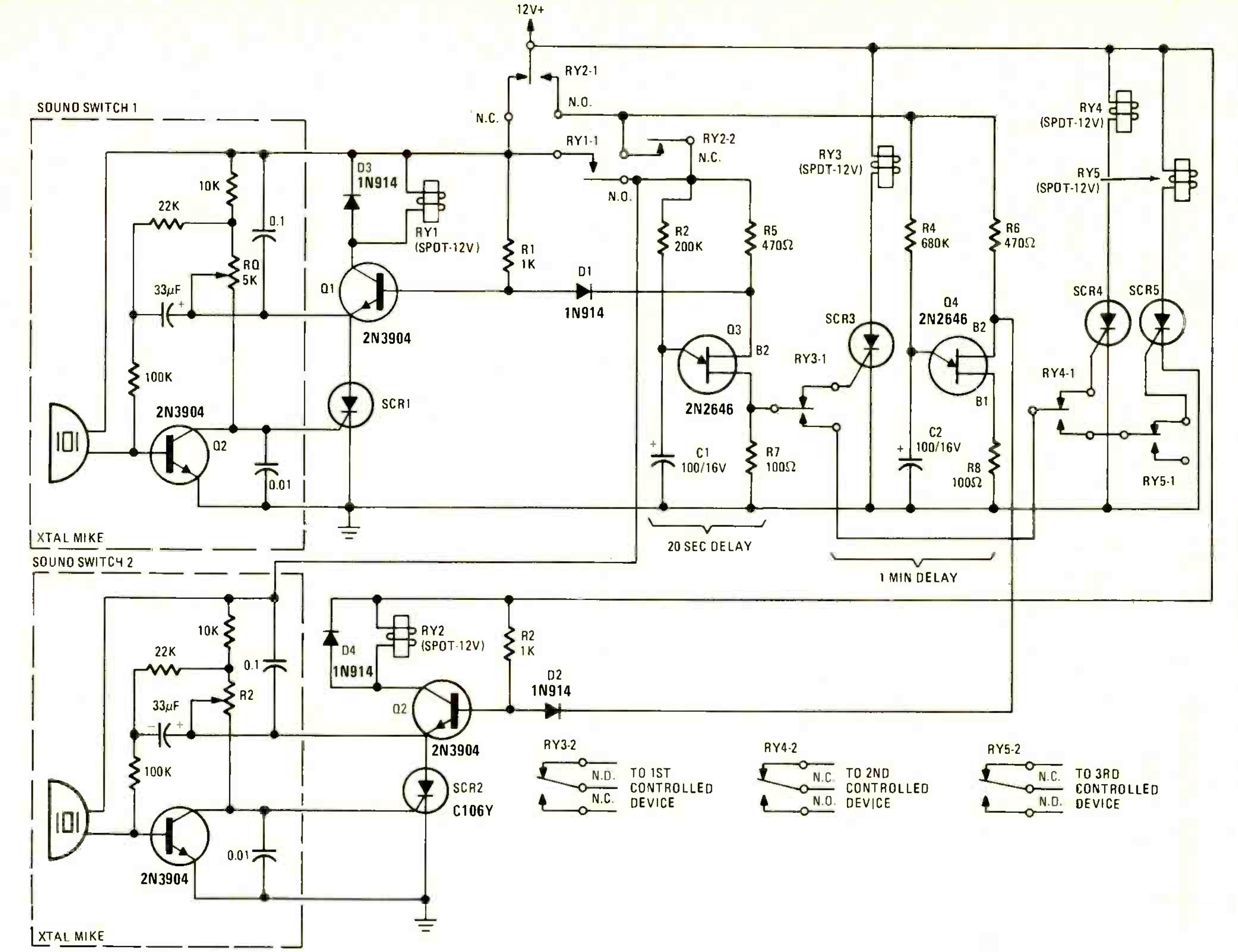

FIG. 3—SEQUENTIAL-TYPE TELESWITCH sequentially turns on multiple appliances.

rate relay in the sequence chain.

This turn-off problem can be eliminated if you are only interested in turning one device or group of devices on and off together. This configuration uses a flip-flop circuit to control a relay that turns whatever is connected to it on and off. The first time you dial, it turns the device on. The next time, it turns it off.

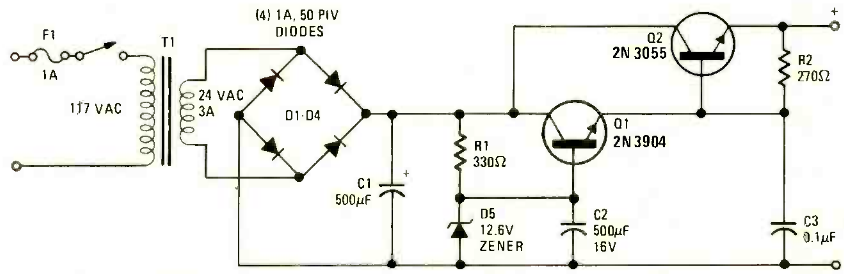

FIG. 4—POWER SUPPLY FOR TELESWITCH. Output voltage is determined by Zener diode. Power is taken from 117 VAC line.

About the circuit

This device uses two sound switches. When the telephone rings the crystal microphone picks up the sound of the bell and triggers SCR1 which closes relay RY1 (Fig. 2). Transistor Q1 is held on by resistor R1 and is used to reset the sound switch by applying a negative pulse to its base.

When RY1 closes, its contacts apply voltage to the second sound switch and to a 20/second unijunction timer circuit.

If the telephone rings only once, which is what happens if you place a call to turn something on, capacitor C1 has enough time to charge and trigger unijunction transistor Q3. The time required for C1 to charge is determined by the R3–C1 combination. The values shown give a delay of about 20 seconds.

When Q3 is triggered, it produces a pulse that is used to turn SCR3 on and Q1 off. SCR3 latches relay RY3 on. One set of contacts on RY3 is used to prepare the circuit to trigger SCR4 on the next signal. This is done by transferring the gating pulse from SCR3 to the gate of SCR4 or SCR5, etc. The other set of contacts of RY3 are used to control the first item to be turned on.

While all this is happening capacitor C2 is building up a charge. When the charge on C2 reaches the triggering voltage for unijunction Q4, a reset pulse is generated that resets the sound switches by turning off Q2 and SCR2 and de-energizing RY2 if the call was not a legitimate control signal. The components used produce a delay of about 1 minute from the time the phone first rings until the reset pulse is generated.

What this means is that sequential devices cannot be activated unless there is an interval of at least 1 minute. This delay helps prevent accidental activation by random phone calls.

On-off switching

For on/off switching, the second version of Teleswitch, shown in Fig. 3, should be used. It is similar to the sequential type in that it uses two sound switches and two unijunction transistor

Ma Bell, the FCC and You

There is a gray area of regulatory conditions surrounding the use of privately-owned telephone equipment on telephone company lines. The famous 1968 "Carterfone Decision," that permitted attachment of privately owned *"foreign"* equipment to the telephone lines, was not a Federal Court decision as most people believe. The Federal Court referred the case to the Federal Communications Commission because of its technical nature. Thus the decision was only an FCC opinion, and not a court ruling.

That decision was against the restrictive practices of the telephone company and said, essentially, that the attachment of customer-owned *"foreign"* equipment, that increases the utility of the phone to the user, should be permitted providing that such attachment does not pose a hazard to the telecommunications network, telephone company equipment, its employees, or the public.

As a result of the Carterfone Decision, telephone companies modified their tariffs, permitting such connections, but with wording inserted that requires a "voice connecting arrangement."

The FCC has since entered into hearings with the telephone companies, the state Public Utilities Commissions, and telephone equipment manufacturers to finally implement the intent of the 1968 decision. While moving slowly, progress has been made; and in most cases, the agreements reached and the tariff changes have all been in the direction of allowing private equipment to be connected to the line. AT&T itself has changed its tariffs recently to allow certain equipment, that contains a telephone company-approved connecting device, to be connected to the line.

But these telephone company-approved devices increase the cost of the equipment sold and many people feel they are unnecessary. Experts in the field find it illogical and unreasonable for AT&T to use foreign attachments without the "voice connecting arrangement," but to require it when the identical device is purchased directly by the telephone user.

An Electronics Industry Association staff vice-president for communications and industrial electronics has reported that more than 1800 phone companies nationwide already use independently made attachments without the so-called protective devices for interconnect.

The FCC has indicated to AT&T that the Bell System should not require connecting arangements for equipment when the same type of equipment provided by the telephone companies themselves is not connected through these voice-connecting arrangements. The Bell System, for example, offers a telephone answering machine on a rental basis and does not connect that unit through the connecting arrangement they want to require others to use.

Many experts believe that it is now perfectly legal and permissible to connect telephone accessories to the regular phone line providing that these devices do not interfere with normal telephone operations, deprive the phone company of its lawful revenue, or create a hazard to its equipment or personnel.

The FCC's position regarding interconnect is quite clear and has been expressed many times. Even where a potential for harm exists, the FCC is determined to investigate the facts and to assure that only minimum restriction and regulations will be allowed as are absolutely required to prevent such harm.

Many believe that it is only a matter of time before the restrictive interconnecting arrangements will no longer be required. For the time being, would-be users of telephone accessories have three choices:

1. Use only equipment that is inductively or acoustically connected to the telephone line.
2. Pay to have the telephone company install a connecting arrangement and pay a monthly service charge.
3. Ignore the tariffs and connect your telephone accessories directly to the telephone line. (This, of course, would be illegal.)

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timing circuits. The difference between the two is that the output of Q3 triggers a flip-flop (Q4 and Q5) instead of an SCR. The negative going pulse from Q3's B2 terminal does two things. First it goes via isolating diode D1 to the base of Q1 and turns off SCR1 and its associated relay. The negative pulse is also applied via isolating diode D2 to the triggering circuit of the bistable flip-flop. Capacitor C4 blocks any DC levels while diodes D3 and D4 serve as steering diodes which cause pulses to change the flip-flop from one state to another, forming the on/off switching action.

The output from one side of the flip-flop is fed to Q6, which acts as a relay driver and closes the relay on every other pulse.

As with the first version of Teleswitch, this one requires exactly one ring of the telephone to activate. More than one ring will trigger sound switch 2 and disable the entire system for one minute.

Construction

Teleswitch is best built on a chassis that measures at least 5 × 9 × 2 inches. Depending on how many sequential devices you are going to control, you may want to use a larger chassis, with enough room to mount all of the controlled outlets.

Mount both sound switches next to each other in the middle and towards the rear of the chassis.

Drill two ⅛-inch holes at the spot where the crystal microphones will be mounted so that the ring signal can be picked up more easily. The controlled outlet(s) are mounted next, after you have first drilled a 1⁵⁄₁₆-inch hole to accommodate the outlet. This outlet is similar to the ones commonly found in homes except that it does not have two receptacles, only one. It can be purchased in any electrical supply store. After drilling the main hole for the outlet, make the two small holes for the retaining screws. Remember to select a chassis large enough to mount the number of controlled outlets you are going to have.

Layout of components requires no special attention. Perforated phenolic circuit boards can be used, and any convenient arrangement will do. A 12-volt power supply should be used. If a large number of high-current relays are needed, make sure the supply can handle all the current required; otherwise a higher current transformer and power transistor will be needed.

The schematic of a suitable power supply is shown in Fig. 4. The AC voltage is stepped down by the transformer to 24 volts and then rectified by the bridge rectifier. The rectified voltage is then fed to a resistor/Zener-diode circuit, where a reference voltage is produced, and fed to the collectors of Q1 and Q2. The Zener reference voltage, which determines the output voltage of the supply, is applied to the base of Q2 which is connected in a Darlington configuration with Q1. Output is taken across the series combination of the 270-ohm resistor and the 0.1-μF capacitor.

The components for the supply are not critical. Just about any NPN power transistor can be used instead of the 2N3055 specified, and any low-frequency small-signal NPN can be used for Q2. The output voltage of the supply equals the Zener voltage minus the voltage drop across the two transistors, or $V_z - 1.2$. To change the output voltage of the supply, simply change the Zener diode.

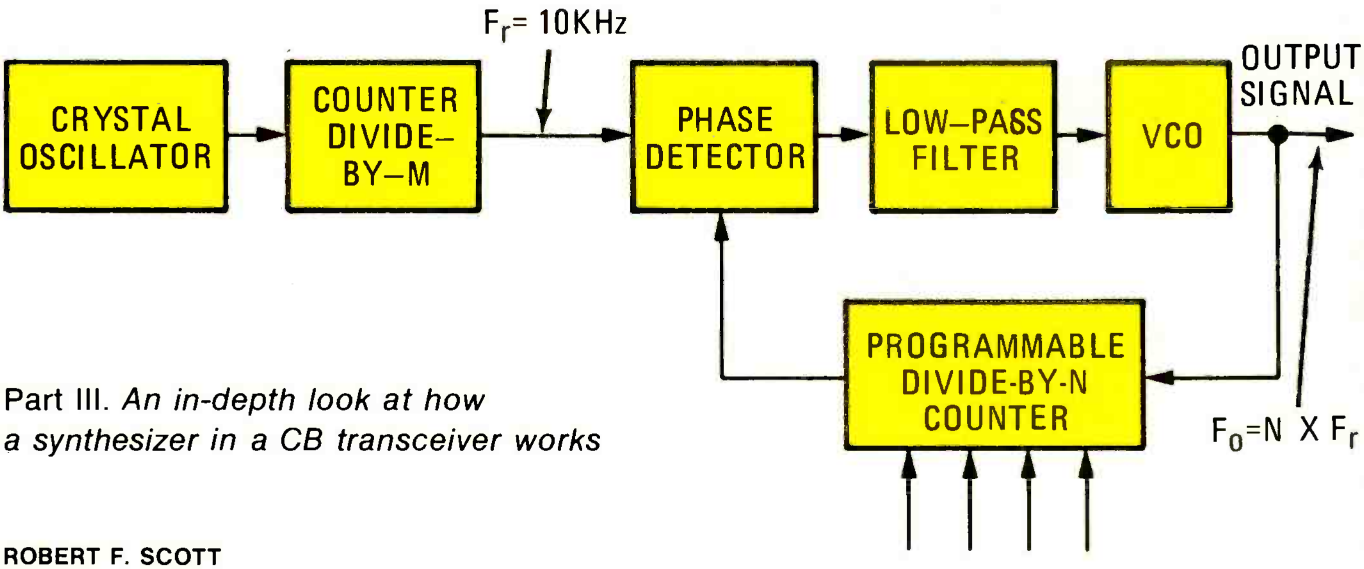
If a large amount of current is required, the transistor will become very hot and it may be necessary to mount it on a heat sink. As long as you can hold a finger on the transistor for a minute while it is operating, you're okay. If you have to pull your finger away immediately, use a heat sink. But be careful, don't burn yourself.

Installation and operation

To use the Teleswitch it is only necessary to place the telephone on top of the chassis and plug in the devices to be controlled. You must adjust the thresh-

continued on page 95

Using PLL for CB Frequency Synthesizers



Part III. *An in-depth look at how a synthesizer in a CB transceiver works*

ROBERT F. SCOTT
TECHNICAL EDITOR

DURING THE LAST TWO MONTHS, WE HAVE taken a broad look at the phase-locked loop as it is applied to frequency synthesis in CB transceivers. Last month, we saw how the Motorola XC3390 frequency-synthesizer IC might be used in a CB set. In this, the concluding installment of the series, we get a chance to examine some actual circuits as used in the G-E *model 3-5800A* 23-channel transceiver. (By the time this issue reaches you, the *3-5800A* will have been discontinued and replaced by the *model 3-5819* and other 40-channel models.)

The Motorola XC3390 IC contains nearly all the components and circuitry needed for a frequency synthesizer. The only external components required are the 30.72-MHz reference crystal, loop amplifier and filter, and the VCO. The synthesizer develops the RF-channel carrier frequencies used in the transmit mode and the two mixer injection-frequencies for the receiver. Compare this with the digital frequency synthesizer in the G-E *model 3-5800A*. A block diagram of this synthesizer is shown in Fig. 1.

Note that this synthesizer uses two crystals for full control of all transmit and receive frequencies. There are two IC's and eleven transistors. The receiver's first mixer injection-frequency is on the *high* side of the channel carrier and ranges from 37.66 to 37.95 MHz to develop the 10.695-MHz first IF. The second mixer injection-frequency is on the *low* side at 10.24 MHz to develop the 455-kHz second IF.

The synthesizer is switched between the receive and transmit modes by the control voltage on the R/T line. In the receive mode, the control voltage is +7 (regulated) and is applied to terminal *b* of the synthesizer and to all receiver circuits including the AF preamplifier. In addition, this +7 volts is applied to the emitters of the mike preamp transistor (not shown) and transistor Q904 (shown in Fig. 2) in the unlock switching circuit, biasing these two transistors off.

Figure 2 shows how the synthesizer is connected into the receiver and transmit circuits of the transceiver. When the mike PUSH-TO-TALK switch is pressed, the R/T line is grounded, the receiver circuits are disabled, the synthesizer is set for transmit operation and the Q904 emitter is grounded. Transistor Q904 now saturates, effectively grounding the emitter of the transmit buffer Q901 to activate the transmitter.

Synthesizer operation

When the synthesizer R/T terminal is high (set to receive), the digital frequency divider in IC802 is set for receive operation and R/T switching transistor Q811 is saturated, grounding out any possible transmit-frequency output through D802.

The VCO frequency is controlled by the voltage on the variable-capacitance diode (D801). When in the receive mode, the VCO operates 455 kHz above the channel carrier frequency.

The 10.24-MHz reference oscillator (Q801) generates the second mixer input signal at terminal *b* and is summed with the VCO frequency in mixer Q803. The amplified 10.24-MHz reference signal is divided by 2 to develop a 5.12-MHz signal for the input to the reference divider (pin 5 of IC802, Fig. 3).

The crystal-controlled offset oscillator (Q806) operates on the third overtone of the 8.650-MHz crystal to generate 25.95 MHz as one of the inputs to mixer Q808 where it is heterodyned with the VCO frequency. The low-pass filter (C835, L808 and C836) selects the difference frequency for the sampling input (pin 4) of IC802. The difference frequency ranges from 1.47 to 1.75 MHz, depending on the channel in use.

In IC802, the reference divider divides the 5.12-MHz input by 512 to develop 10 kHz as one of the inputs to the PLL phase detector. The variable sampling signal (f_o) on pin 4 goes to the programmable divider where it is divided by factor *n* to develop a 10-kHz signal. The phase-detector/charge-pump combination develops a correction voltage that is filtered, amplified and used as the control voltage for the variable-capacitance diode that controls the frequency of the VCO.

The out-of-lock detector develops a

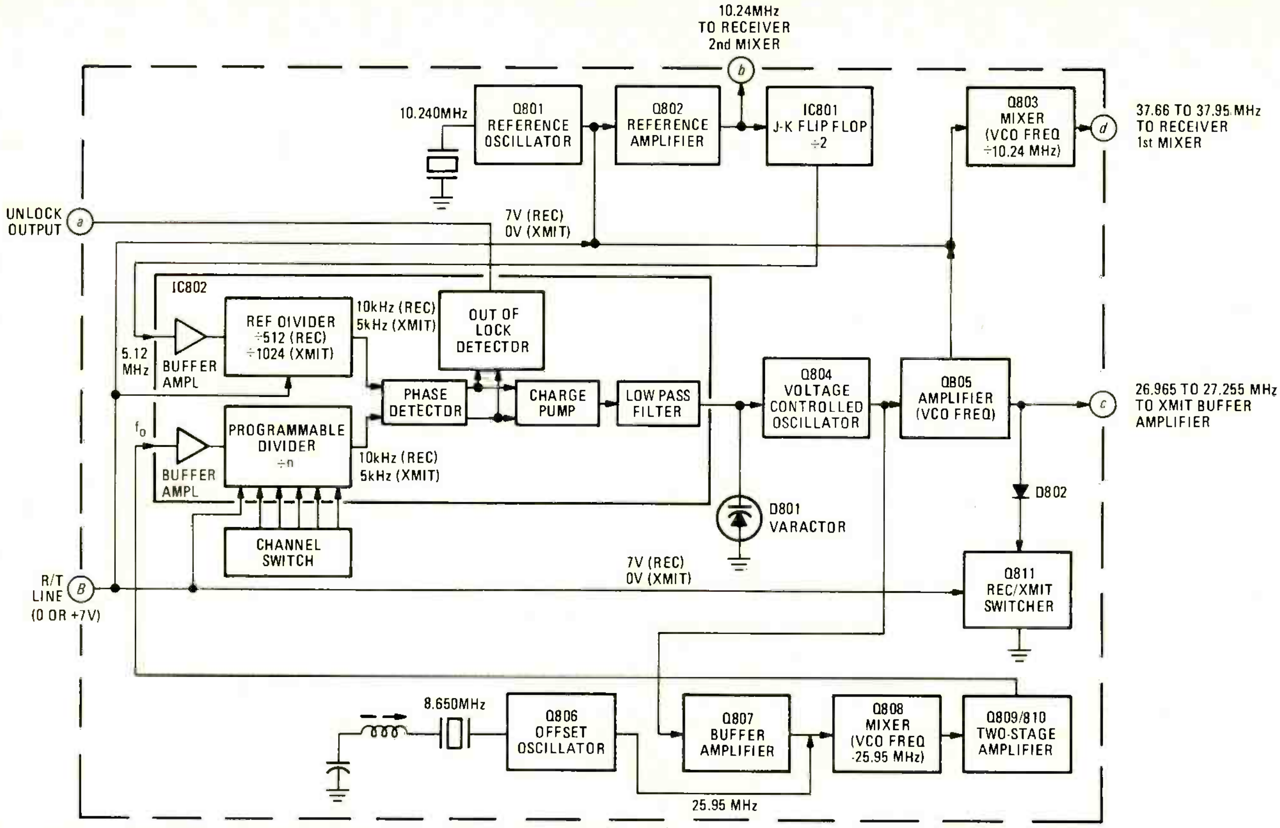


FIG. 1—**DIGITAL FREQUENCY SYNTHESIZER** in the G-E *model 3-5800A* uses only two crystals for full control of all transmit and receive frequencies.

positive voltage at terminal *a* whenever there is a difference in the frequency or phase of the two signals applied to the inputs of the phase detector. This positive voltage is fed through R602 and R605 to the base of Q602 in the unlock switching circuit (Fig. 2), turning it on.

Diode D303, normally back-biased by the voltage on the AGC line, conducts through Q602, and shorts the AGC line to the B– line. This mutes the receiver by cutting off the RF and IF amplifiers. Similarly, the receiver (and transmitter) circuits are disabled while switching from one channel to another. This is done by momentary closure of a switch connected to pin 12 of the CHANNEL SELECTOR. This applies +7 volts to the base of Q602 through R603.

Transmit frequency synthesis

When the R/T line is grounded, Q803 is biased off so that the 38-MHz output does not appear at terminal *d*. At the same time, the digital frequency dividers in IC802 are set for transmit operation and Q811 is turned off, removing shorting diode D802 from the Q805 collector circuit so that the transmitter drive signal appears at terminal *c*. The frequency of the VCO is adjusted to the channel center-frequency by the DC control-voltage from IC802.

When in the transmit mode, the only output of the 10.24-MHz reference oscillator that is used is the one applied to the divide-by-2 flip-flop in IC801.

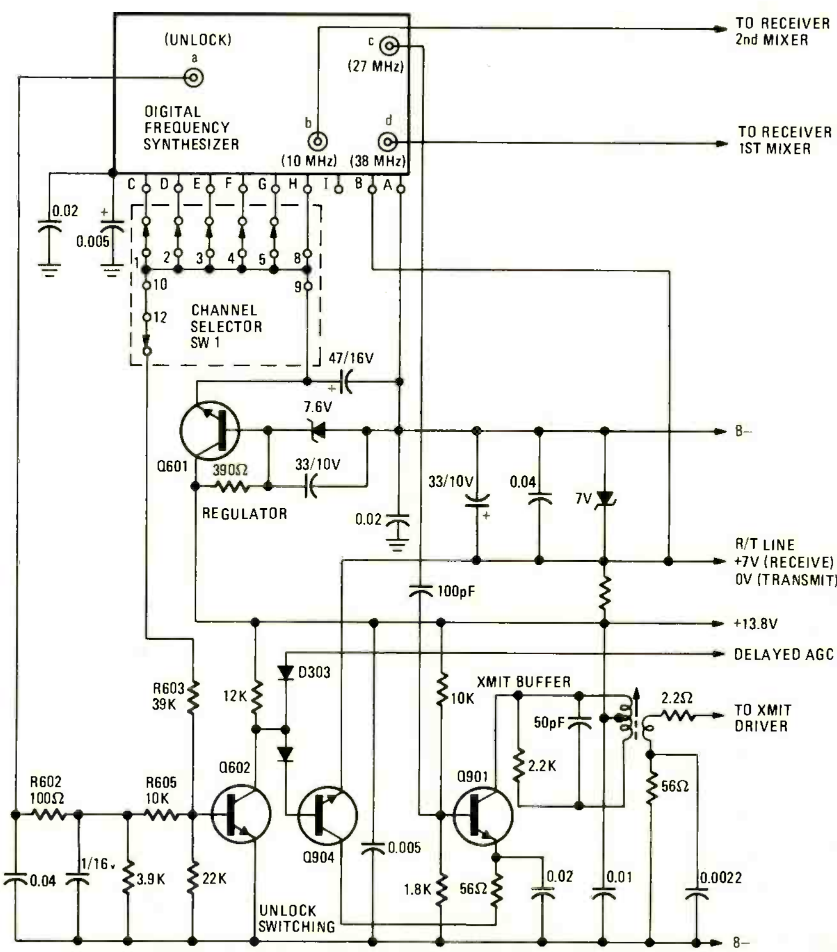


FIG. 2—**SYNTHESIZER CONNECTIONS** to receive and transmit circuits of transceiver.

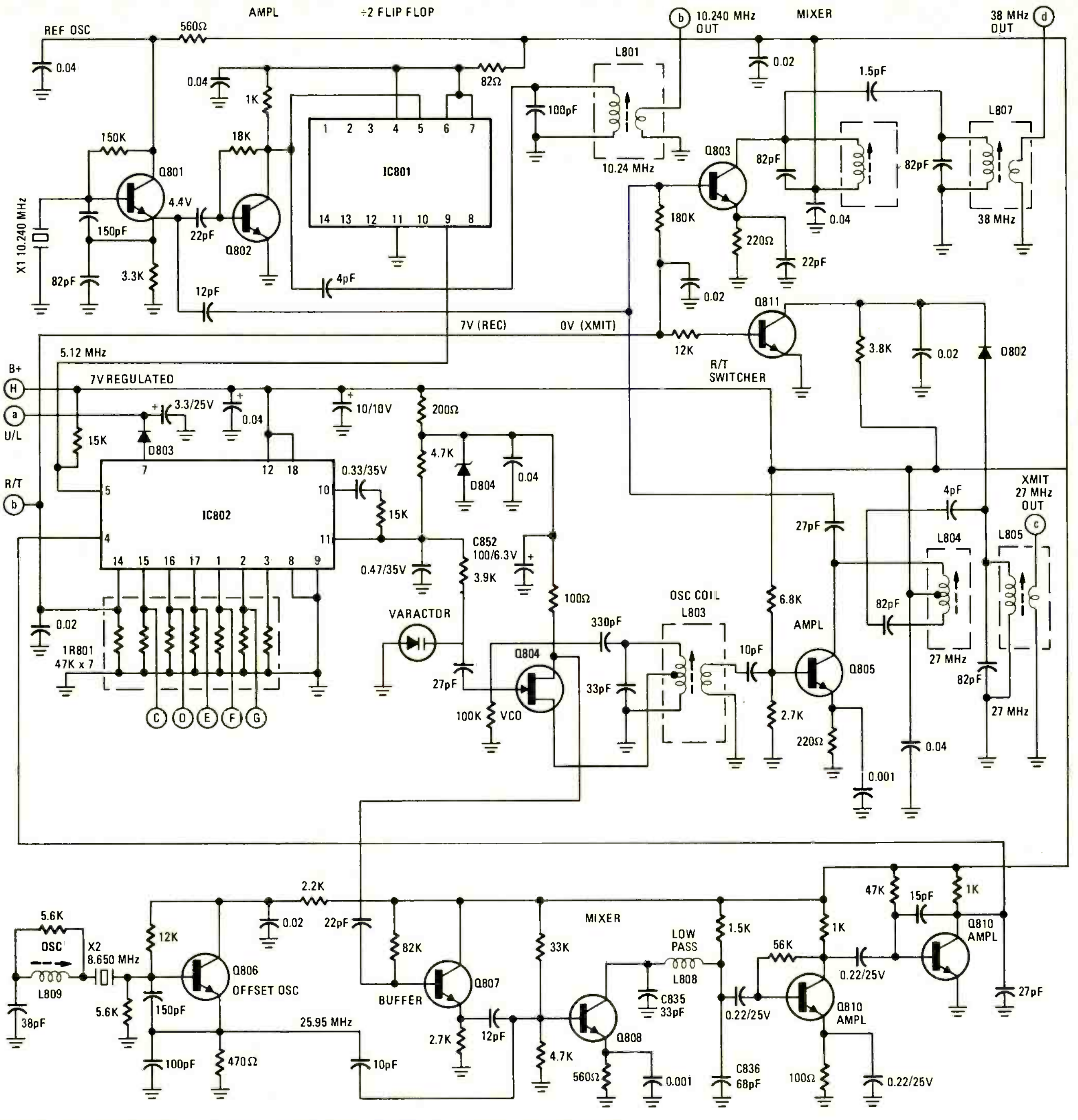


FIG. 3—PHASE-LOCKED-LOOP FREQUENCY SYNTHESIZER in the G-E model 3-5800A.

The 25.95-MHz output of the offset oscillator is mixed with the buffered output of the VCO in the base circuit of mixer Q808.

The low-pass filter eliminates the sum frequency and passes the difference frequency to the sampling input of IC802. The difference frequency will range—depending on the channel selected—between 1.015 and 1.305 MHz.

The 5.12-MHz signal fed to IC802 is divided down to 5 kHz by the divide-by-1024 reference divider. Frequency f_o fed to the sampling input of IC802 is divided in the programmable divider by whatever factor *n*—determined by binary-coded voltages from the CHANNEL SELECTOR—will result in a 5-kHz signal.

The two 5-kHz inputs to the phase-detector/charge-pump combination develop a correction voltage that controls the VCO in the same way it does in the receive operation. When The VCO is off frequency, the out-of-lock detector and switching circuit disable the transmitter until the voltage-controlled oscillator is back on frequency.

Well, that about wraps up the PLL circuit in the G-E *3-5800A*. There are other interesting circuits that we hope to present in another story. While preparing this series on the PLL, I was intrigued by the possibilities of using the basic ideas that we've covered in a broadcast-band receiver.

The phase-locked-loop approach should eliminate distortion caused by mistuning and oscillator drift. Ceramic IF filters can provide a bandpass shape-factor with good bandwidth and minimum interference from adjacent channels. I don't know when I'll have the time to develop a receiver of this type, so why don't you take a crack at it?

No doubt there'll be other IC's developed to simplify PLL circuitry. We'll report on them as soon as technical details are released. **R-E**

Increase Dynamic Range For Better HI-FI

Compression/expansion process increases dynamic range and delivers age-old audio dream of a tape copy that sounds better than the original

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

HAVE YOU EVER WONDERED HOW SOME record companies have been able to "restore" old recordings (notably, those old 78 RPM Caruso records), enhance them with new orchestrations using modern, electronically recorded orchestras and even reduce their background noise? In many cases, computers have been responsible for this audio miracle. Computers have been used to analyze audio signals, differentiate them from random noise and more. But, as you might guess, the cost of such audio restoration is enormous and hardly lends itself to home hi-fi use.

Noise reduction

Several noise reduction schemes have been developed for home use, the most familiar is the Dolby "B" noise reduction system. Dolby works well in reducing any noise that might be added to a program source *during the recording process*, but, as most readers realize by now, Dolby cannot help a program source (records, tapes, FM) that already has noise in it. As far as Dolby is concerned (or JVC's ANRS system, which is similar in operation to and compatible with Dolby), it "looks" upon such noise content as part of the original program material.

In the February, 1975 issue of **Radio-Electronics**, we described a system developed by a company called dbx, Incorporated. This system is capable of encoding and decoding discs or tapes for a significant increase in dynamic range and noise reduction. It can work wonders with "live" recordings in that dynamic ranges as high as 100 dB (difference in level between the softest musical passages and the loudest) can first be linearly compressed so that wide dynamic ranges can be accommodated on a home or professional tape deck.

Most tape decks used for home applications have a dynamic-range capability of no more than 55 to 60 dB. If the 100-dB dynamic range of music is first compressed into 50 dB, that music can be made to "fit" onto the tape and will lie somewhere between the tape-noise "threshold and the tape-saturation level, as shown in Fig. 1. If a linear expander

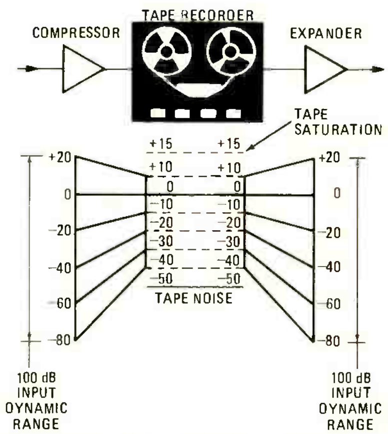


FIG. 1—COMPRESSION/EXPANSION process reduces the dynamic range of input signals so that it fits within the limitations of magnetic tape and then restores the original dynamic range during playback.

(operating in a reciprocal manner) is used during playback, the entire 100-dB range of the original music can be reproduced faithfully. What's more, audible tape noise (the "noise floor") can be effectively reduced by as much as 30 dB in the process, All well and good, so long as you are recording "live" music. But again, as with Dolby, the moment you try to "transcribe" a program source having limited dynamic range and audible noise using this dbx "compander" action, all you can hope to do is end up with no further increase in noise and no further compression of the program. You cannot restore original dynamic range or reduce pre-existing noise using this system.

One-sided noise reduction systems have been developed that require no prior encoding. The simplest, and best known of these, is the high-cut filter present on most modern amplifiers and receivers. Such filters arbitrarily and steeply attenuate frequencies above a predetermined point, reducing high-frequency hiss and noise. Unfortunately, such passive filters reduce the treble content of the reproduced music as well. More sophisticated "dynamic" filters operate on the principle of continuously varying bandwidth. When no highs are present, the filter bandwidth is reduced; while when musical highs must be reproduced, the filter bandwidth "opens up" automatically allowing the "highs" to come through. The trouble

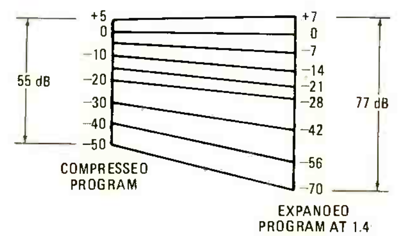


FIG. 2—INPUT/OUTPUT relationship for a linear expansion of 1.4.

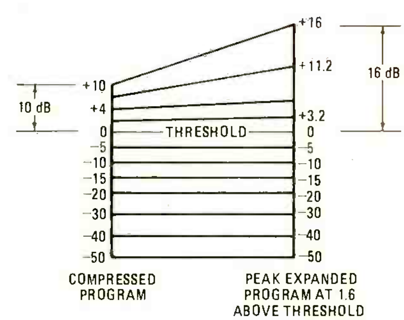


FIG. 3—PEAK UNLIMITING provides expansion only when input signal is above a predetermined threshold.

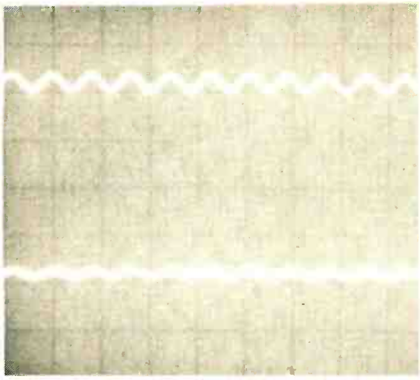


FIG. 4—LOW AMPLITUDE input signal (upper trace) is reduced further (lower trace) by expansion.

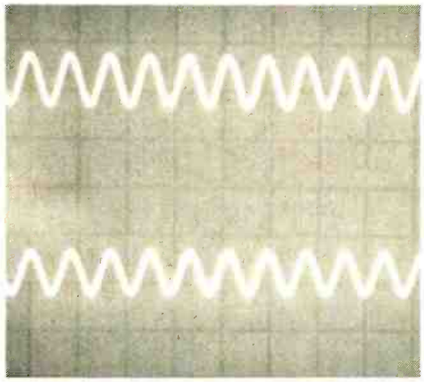


FIG. 5—INPUT SIGNAL at the threshold point of the expander is unchanged by the expansion process.

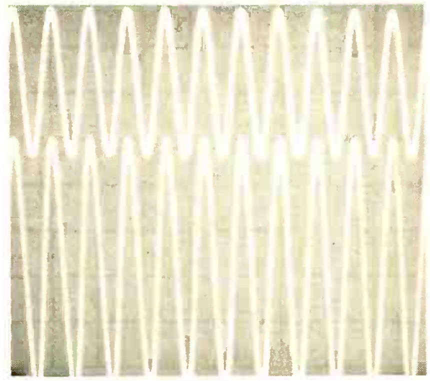


FIG. 6—HIGH AMPLITUDE input signal (upper trace) is increased (lower trace) by the expansion process.

with most of these dynamic filters is that you can hear them working, and residual hiss tends to be audible depending on the musical material being reproduced.

Increasing dynamic range

Another way dynamic range can be restored (and noise reduced at the same time) is by means of an expander. Two types of expanders (*models 117* and *119*) have been marketed for some years now by dbx, Inc., that offer variable expansion capability. They can be set for varying degrees of *linear* expansion (in which louder signals are made still louder and softer signals are made still softer), as shown in Fig. 2. Or, they can be set for peak expansion only—the loudest signals are made louder, while all other levels are reproduced at their original amplitude. The latter application works well for program sources that have been peak-limited (FM programs are a good example of this). To understand how expansion works in the "peak-unlimiting" mode, consider Fig. 3. In this mode, expansion only takes place above a predetermined threshold (that is varied by means of a front panel control on the dbx *model 117* or *model 119*).

Figures 4, 5 and 6 show what happens when signals of varying amplitude are applied to a linear expansion system. In each case, the upper trace represents the input. Gain was set identically for both upper and lower traces in each scope photo. In Fig. 4 we see a low-level signal applied to the expander, and the output is even lower in amplitude. In Fig. 5 the input signal has been increased in amplitude so that it is just about at the "threshold" point of the expander, and the output level almost equals the input level. A higher amplitude input signal results in a still greater (expanded) output signal, as shown in the lower trace of the scope photo in Fig. 6.

Obviously, such an expander can be used effectively for listening to stored program sources that are known to have been compressed in one way or another. But what if we were to try to *record* such a program source onto tape. Our problems would be worse than before. Since the low-amplitude signals have been made still lower in amplitude, they will be buried below the tape-noise threshold. The loudest passages, that have been further expanded, will push the recording level right up into tape saturation. Figure 7 shows the record/playback response from 20 Hz to 20 kHz at 0-dB recording level on a high-quality cassette machine. Note the effects of high-frequency tape saturation as we approach the high-frequency end of the spectrum. Not only is the output attenuated, but, if we could examine the actual waveforms above 5 kHz or so, we would see that they are highly distorted. So, expansion may be great for *listening* to previously recorded programs, but makes matters worse if it is first applied to a program source that is to be recorded on tape.

Compansion

Referring back to Fig. 1 and dbx's other innovative product—the 2:1/1:2 Compander (known as their *120 series*)—suppose we used *both* products in series before making a recording. In other words, if we first expanded our program source (listening all the while to make sure we had applied the correct degree and rate of expansion) and then applied the resultant signal to the 2:1 compressor and recorded it, we could

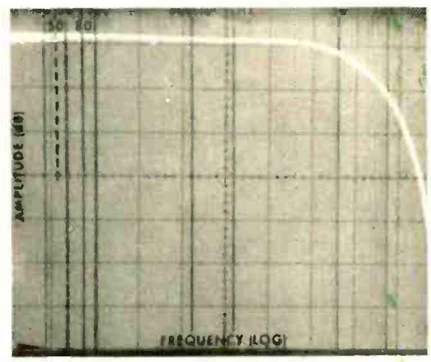


FIG. 7—RECORD/PLAYBACK RESPONSE of a cassette deck at a 0-dB recording level.

INCREASED DYNAMIC-RANGE is made possible by the dbx model 128.

"contain" even the previously expanded program source within the tape's available 55 or 60-dB dynamic range.

Realizing that such a combination of products could actually deliver the age-old audio dream of a "copy that sounds better than the original", dbx has now come up with a new unit, the *model 128*. Essentially, the product is nothing more than a combination of their earlier *model 117* (or *model 119*) expander, and their later *120 series* 2:1/1:2 compander. By combining both products in one, the *model 128* offers much simpler and more flexible "patching in" facilities.

With the new *model 128*, the audio enthusiast can restore dynamic range to a prerecorded program while reducing playback noise, then copy the enhanced program in dbx encoded format to prevent the build-up of additional noise (and to *contain* the newly arrived-at extended dynamic range within the limitations of the tape). Simply stated, this new product makes it possible to produce a tape copy that has greater dynamic range and less noise (and therefore sounds better) than the original!

To illustrate the benefits of 2:1/1:2 companding, we used another capability of our spectrum analyzer. It is possible to set the filters within the analyzer to a manual mode, so that while the scope beam sweeps across the screen, the filters are fixed to a pre-determined frequency. We set the filter to pass a 1-kHz signal and made a continuous recording of that tone at a level that would have corresponded to tape saturation—the highest practical recording level. In Fig. 8, therefore, the entire

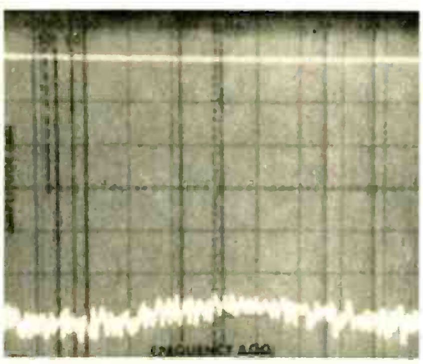


FIG. 8—1 kHz INPUT SIGNAL at 0-dB reference level (upper trace) causes tape saturation. Record and playback of 1-kHz signal reduced to −60 dB results in output that is buried in tape noise (lower trace).

upper trace represents the playback *level* of this signal from our tape recording, and all references to frequency on the scope screen should be disregarded. Storing this trace at the upper portion of the screen, we then ran some tape while attempting to record the same frequency at a level 60-dB lower than before. The resultant recording was played back, and, as can be seen by the lower trace, consisted almost entirely of random noise (the low-level signal having been "buried" below the noise of the tape).

Next, we repeated both recording sessions, but this time the signals were first fed to the *model 128*, with the RECORD button depressed so as to apply the fixed 2:1 compression. The recorded levels obtained are shown in Fig. 9.

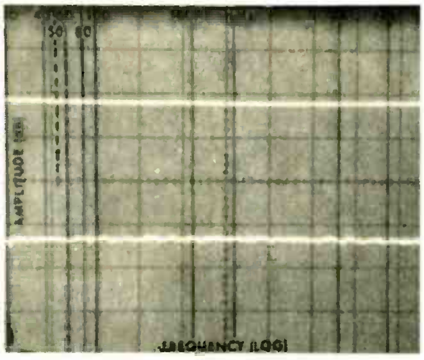


FIG. 9—RECORD/PLAYBACK of 0 dB and −60 dB 1-kHz input signals after fixed 2:1 compression.

Note, that our high-level signal shows up during ordinary playback as being some 12-dB lower than was the case in Fig. 8, while our original −60-dB tone now appears to be only some 30-dB lower than the original 0-dB recorded level. In other words, the difference in amplitude between the high-level and low-level recorded signals has been reduced from 60 dB to 30 dB.

Next, the recordings were played back using the 1:2 expansion capability of the dbx *model 128*. To do this, it is simply necessary to push the PLAY button.

In Fig. 10 we see that the high-level signal has been restored to its original amplitude. But, in reproducing the low-level (−60 dB) signal and displaying it

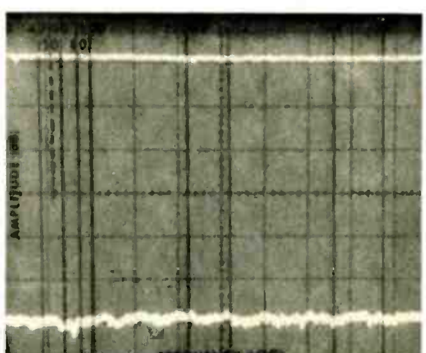


FIG. 10—RECORD/PLAYBACK of 0 dB and −60 dB 1-kHz input signals using fixed 2:1 compression to record and fixed 1:2 expansion during playback. Comparison with Fig. 8 shows reduction in noise.

as the lower trace, notice that this signal now is quite definable as a straight line and is no longer buried below the tape noise as was the case when the compress-expand sequence was not used.

Finally, we returned to the sweep mode of the spectrum analyzer and made a frequency sweep from 20 Hz to 20 kHz at a level that previously resulted in high-frequency tape saturation and attenuation (see Fig. 7). This time, the signal was first compressed by the dbx *model 128*. Results, during playback, are shown in Fig. 11. As expected, the *actual* recording level on the tape is some 10-dB lower than in the case of Fig. 7, and because of this lower

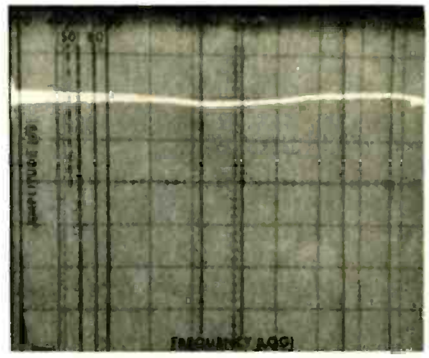


FIG. 11—FREQUENCY RESPONSE of a cassette deck at a 0-dB input-signal level using fixed 2:1 compression.

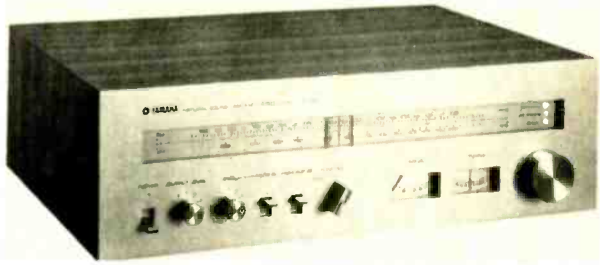
recording level, response is seen to extend far beyond what it did in Fig. 7. Since response on the actual tape is now flat (and free of distortion caused by tape saturation), it will remain so even after it is expanded by the *model 128*.

From all our experiments and listening tests, it would appear that dbx, by combining both dynamic range enhancement and compression-expansion in a single instrument, has made it possible for home recordists to actually produce taped copies of any program source that contain less noise and more dynamic range than the originals. **R-E**

NBS modifies time broadcasts

Beginning February 1, 1977, the broadcast frequencies of the National Bureau of Standards time-signal station WWV, Boulder, CO will be 5, 10 and 15 MHz, and those of WWVH, Kauai, Hawaii, will be 2.5, 5, 10 and 15 MHz. The 2.5, 20 and 25 MHz frequencies are abandoned on WWV, though the broadcasts on 2.5 MHz continue on WWVH. The changes are the result of a survey that showed that the abandoned frequencies were seldom or never used by most of the users of time signals.

WWV and WWVH broadcasts include: standard frequencies, Universal Time Coordinated (UTC) second ticks, voice announcements of UTC minute and hour, storm information for portions of the Atlantic and Pacific Oceans, Omega Navigation System status announcements, geophysical alerts of events in progress and a summary of selected solar and geophysical events in the past 24 hours. A detailed description of the services provided may be obtained from the National Bureau of Standards Time and Frequency Services Section, Boulder, CO 80302. **R-E**



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CIRCLE 99 ON FREE INFORMATION CARD

Radio-Electronics Tests Yamaha CT-800 Tuner

LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

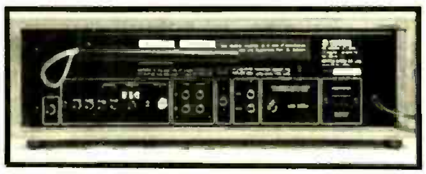
SOME TIME AGO, YAMAHA INTRODUCED THEIR CT-7000 tuner, a unit that features selectable bandwidth and sells for around $1200.00. There is a wide price gap between that excellent product and the next tuner in their line, the CT-800, and so we were curious to learn whether the performance of this much lower priced unit came anywhere near that of the higher priced model. In many respects it does, and there is evidence of the same careful design and engineering that seems to be typical of Yamaha's most recent products.

The front panel of the CT-800, shown in Fig. 1, is all one color, including the back-plate behind the long, narrow dial-area cutout. The FM dial scale is linearly calibrated, with markings at every quarter of a megahertz. Below is a convenience logging scale, while below that is a non-linear AM frequency scale with markings at every 50 kHz. The dial pointer resembles the familiar hair-line slider.

To the right of the frequency scales, but still within the dial area opening, are three red indicator lamps. The upper one lights when tuning to an incoming stereo signal, the lower one lights when power is applied to the tuner, while the middle indicator is associated with Yamaha's unique AFC (*A*utomatic *F*requency *C*ontrol) circuit. When a user touches the large tuning knob at the lower right of the panel, this AFC light dims (even in the presence of a received signal), indicating that the internal AFC circuit has been defeated by touching the knob. When center-of-channel tuning has been accomplished with the aid of the zero-center tuning meter below and your fingers let go of the knob, the light brightens, indicating proper tuning. The light is off altogether in the absence of a signal, or when tuning to extremely weak signals.

The second meter adjacent to the center-of-channel tuning meter is a conventional signal-strength meter. The center-of-channel tuning meter is actually calibrated in kHz, from 0 to 150, to indicate actual departure from center tuning. Other controls along the lower section of the front panel include a toggle-type on/off switch, an OUTPUT LEVEL control, a muting threshold LEVEL control (interstation noise silencing is variable on this tuner to take care of different reception conditions), an associated MUTING on/off switch, a HIGH BLEND switch (that reduces noise in weak-signal stereo FM reception at the expense of high-frequency stereo separation) and a three position FUNCTION switch for AM, FM MONO, or FM AUTO-STEREO selection.

The rear panel of the CT-800 is shown in Fig. 2. Screw type terminals are provided for external AM, 300-ohm and 75-ohm FM antenna connections. A coaxial connector duplicates the 75-ohm terminals for transmission lines equipped with that type of plug.



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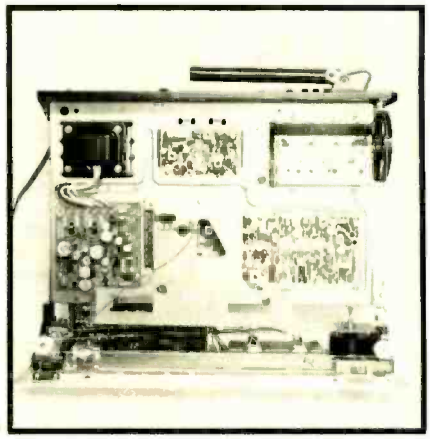
Fixed and variable pairs of output jacks come next, the latter controlled by the front panel volume control. A jack labelled IF OUT is, in reality, a detector output jack ahead of any de-emphasis or multiplex decoding circuitry and is intended for possible use with a 4-channel FM decoder if and when the FCC approves one of the several 4-channel systems currently under investigation.

MANUFACTURER'S PUBLISHED SPECIFICATIONS:
IHF Usable Sensitivity: Mono: 1.7 μV (9.8 dBf). **DIN Stereo Sensitivity:** 40 μV (for 40 kHz deviation, 46 dB S/N). **Quieting Slope:** 55 dB at 5 μV (19.2 dBf); 60 dB at 10 μV (25.2 dBf). **Selectivity:** 80 dB. **Capture Ratio:** 1.0 dB. **Signal-to-Noise Ratio:** Mono: 75 dB; Stereo: 72 dB. **Frequency Response:** 20 Hz to 15 kHz, ±1.5 dB. **AM Rejection:** 55 dB. **IF Rejection:** 100 dB. **Image Rejection:** 90 dB. **Spurious Rejection:** 100 dB. **Total Harmonic Distortion:** Mono: 0.15% at 400 Hz; Stereo: 0.3% at 400 Hz. **Stereo Separation:** 45 dB at 1 kHz, 35 dB from 50 Hz to 10 kHz. **Subcarrier Rejection:** 60 dB. **Muting Threshold:** Variable, from 10 μV to 50 μV. **AM Sensitivity:** 25 μV. **AM Selectivity:** 30 dB. **AM S/N Ratio:** 45 dB. **AM Image Rejection:** 70 dB. **AM THD:** 0.8%. **Power Requirements:** 120 V, 50/60 Hz, 12 watts. **Dimensions:** 17¼ W × 5½ H × 12-¾-inches D. **Net Weight:** 16½ lbs. **Suggested Retail Price:** $370.00.



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Two more jacks are intended for connection to the horizontal and vertical inputs of an oscilloscope. The display obtained when such connections are made is useful for properly orienting your antenna for minimum multipath distortion. A line fuseholder and one unswitched convenience AC receptacle are located at the right end of the rear panel. The usual pivotable AM ferrite-bar antenna completes the rear panel layout. An internal view of the CT-800 chassis is shown in Fig. 3. Connection of possible associated equipment is illustrated in Fig. 4.

FM performance measurements

The major FM performance measurements of the Yamaha CT-800 is listed in Table I. Of particular interest is the quieting characteristic of this tuner. Note that only 2.4 μV (12.8 dBf) of signal strength was required to achieve the 50-dB quieting point. It is unfortunate that Yamaha chose not to conform to the new IHF/IEEE/EIA Tuner Standards in their published specifications, shown elsewhere in this test report. Perhaps they have not had time to reprint the owner's manual to take into account these more meaningful specifications, although they did manage to publish the less stringent standard DIN specifications used in Europe.

Mono and stereo ultimate signal-to-noise ratios (84 dB and 72 dB, respectively) are as good as any we have been able to measure on any tuner or receiver and we were somewhat amazed at Yamaha's conservatism at rating the mono S/N figure at only 75 dB. The one area that could bear improving is the AM

TABLE I

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Yamaha** Model: **CT-800**

FM PERFORMANCE MEASUREMENTS

SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE	**R-E Measurement**	**R-E Evaluation**
IHF sensitivity, mono (μV) (dBf)	1.7 (9.8)	**Excellent**
Sensitivity, stereo (μV) (dBf)	10.0 (25.2)	**Good**
50-dB quieting signal, mono (μV) (dBf)	2.4 (12.8)	**Superb**
50-dB quieting signal, stereo (μV)	33 (35.6)	**Very good**
Maximum S/N ratio, mono (dB)	84	**Superb**
Maximum S/N ratio, stereo (dB)	72	**Excellent**
Capture ratio (dB)	1.0	**Excellent**
AM suppression (dB)	55	**Fair**
Image rejection (dB)	95	**Very good**
IF rejection (dB)	100	**Excellent**
Spurious rejection (dB)	100	**Excellent**
Alternate channel selectivity (dB)	82	**Very good**
FIDELITY AND DISTORTION MEASUREMENTS		
Frequency response, 50 Hz to 15 kHz (±dB.)	1.5	**Fair**
Harmonic distortion, 1kHz, mono (%)	0.15	**Very good**
Harmonic distortion, 1kHz, stereo (%)	0.12	**Excellent**
Harmonic distortion, 100 Hz, mono (%)	0.18	**Very good**
Harmonic distortion, 100 Hz, stereo (%)	0.17	**Excellent**
Harmonic distortion, 6 kHz, mono (%)	0.21	**Good**
Harmonic distortion, 6 kHz, stereo (%)	0.35	**Very good**
Distortion at 50 dB quieting, mono (%)	0.8	**Good**
Distortion at 50 dB quieting, stereo (%)	0.35	**Very good**
STEREO PERFORMANCE MEASUREMENTS		
Stereo threshold (μV) (dBf)	10.0 (25.2)	**Good**
Separation, 1 kHz (dB)	45	**Excellent**
Separation, 100 Hz (dB)	39	**Very good**
Separation, 10 kHz (dB)	36	**Excellent**
MISCELLANEOUS MEASUREMENTS		
Muting threshold (μV) (dBf)	13 to 65 (27.5 to 41.5)	**Good**
Dial calibration accuracy (±kHz @ MHz)	–0.4 @ 108	**Poor**
EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION		
Control layout		**Excellent**
Ease of tuning		**Superb**
Accuracy of meters or other tuning aids		**Excellent**
Usefulness of other controls		**Very good**
Construction and internal layout		**Excellent**
Ease of servicing		**Very good**
Evaluation of extra features, if any		**Excellent**
OVERALL FM PERFORMANCE RATING		**Excellent**

TABLE II

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Yamaha** Model: **CT-800**

OVERALL PRODUCT ANALYSIS

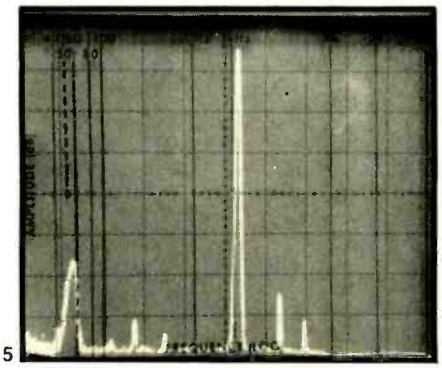
Retail price	**$370.00**
Price category	**Medium/high**
Price/performance ratio	**Excellent**
Syling and appearance	**Excellent**
Sound quality	**Excellent**
Mechanical performance	**Very good**

Comments: Yamaha has managed to incorporate much of the performance capability of their much more expensive CT-7000 tuner in this lower priced model. We were particularly impressed with their very sophisticated AFC circuit which offered the advantages of automatic frequency control without its disadvantages. Unlike other AVC circuits (which usually make it impossible to tune to a weak signal that is close in frequency to a strong one), this one allowed us to accurately tune and hold signals at all levels. The double set of outputs was also welcome, since it permits connection of the variable amplitude outputs to the rest of the hi-fi component system while the fixed level output jacks can be connected directly to a tape recorder without interposing other components that might introduce distortion. In considering selection of a high-quality tuner for one's own component high-fidelity system, it is important to evaluate available program sources in relation to the performance capability of the tuner. Unfortunately, with few exceptions, FM broadcasting in the United States has undergone serious deterioration in the past several years. In many instances, tuners have greater performance capability than do typical FM broadcast installations. Thus, even if one purchases Yamaha's much higher priced tuner, or those of other makers in a similar high price category, chances are that performance will be limited by the broadcast situation rather than the tuner's capability. It would seem, then, that this medium priced tuner would be a good choice for one who is serious about FM listening. It certainly can handle the present signals we are receiving and should be capable of better reproduction even if more and more stations clean up their studio and transmitter practices.

suppression capability that figures importantly in multipath rejection. In the case of this tuner, the AM suppression measured only 55 dB, exactly as claimed. For their much more expensive CT-7000, this figure is specified at 60 dB. Other rejection figures were excellent, and alternate channel selectivity was a high 82 dB.

The slight drop-off in frequency response at 15 kHz (–1.5 dB) is due, in part, to the excellent 19-kHz rejection filter. We saw no evidence of carrier leak-through when making stereo noise and distortion measurements.

As for harmonic distortion, we have measured lower figures on other tuners, but not much lower. Surprisingly, the single-figure reading obtained for mid-frequencies in mono was higher (0.15%) than that obtained with the same modulating frequency in the stereo mode (0.12%). Since this is not typical of results we have obtained with the majority of tuners and receivers measured, we decided to look further into the matter and investigated the harmonic content by means of our spectrum analyzer.



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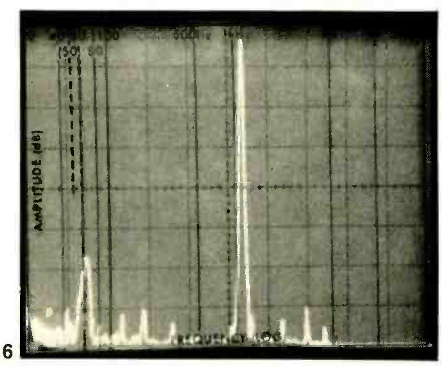
The tall spike in Fig. 5 represents the fundamental, desired 1-kHz tone as recovered from the tuner. The smaller peaks to the right indicate the amounts of second and third harmonic present in the signal. Each vertical division in the display represents a 10 dB change in amplitude. As can be seen in Fig. 5, the second harmonic in the mono 1 kHz signal is some 60 dB below the fundamental, while the third harmonic is approximately 65-dB below the reference output level, and, there are no visible higher-order harmonics present.



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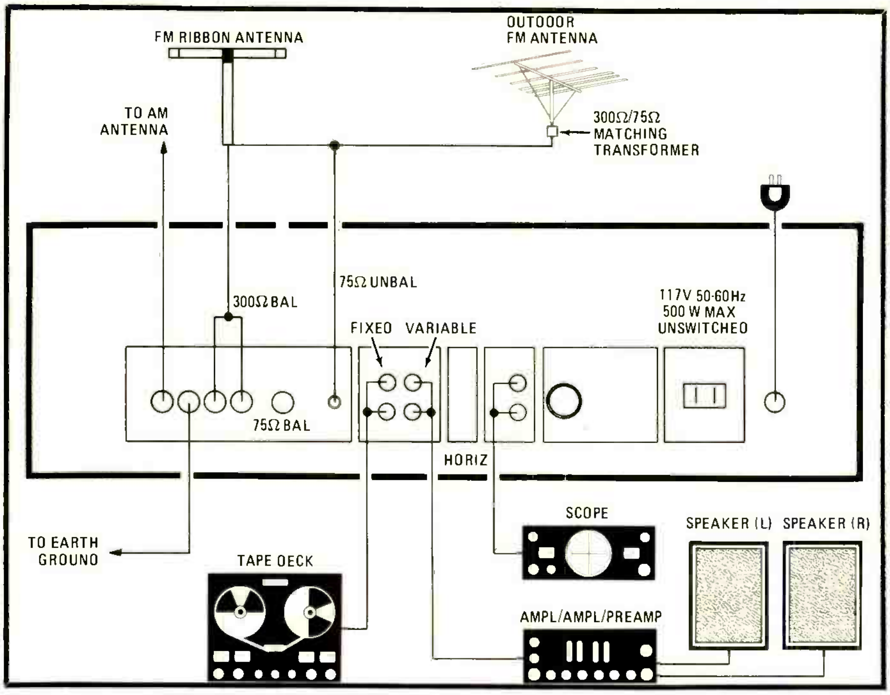
In the case of the recovered stereo 1-kHz signal (Fig. 6), the second harmonic is significantly lower than for the mono signal, the third harmonic is the same, but we see evidence of fourth harmonic contribution and even a minute amount of fifth harmonic. While the single-number reading in stereo



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seems better or lower than the reading in mono, these displays show that the audible effects of that distortion may be quite different for mono and stereo. Of course, in the case of this Yamaha tuner, both the mono and stereo THD are so low as to be insignificant, but the importance of identifying the nature of harmonic distortion in general is well illustrated by these disparities and the related scope photos. For those curious about the "pips" appearing to the left of the fundamental in each scope photo, it should be pointed out that these are simply 60-Hz hum (and its harmonics) that is caused by external pickup and is *not* being produced by the tuner under test.

Dial calibration was off by anywhere from 0.1 MHz (at the 88 MHz end of the dial) to 0.4 MHz (at the high end of the dial) on our sample. In view of the long and well-calibrated dial scales provided on this tuner, we would hope that this is not representative of typical units and that frequency alignment is better maintained as a general rule by final testers of the product.

Use and listening tests

Tuning action is extremely smooth and easy with the Yamaha CT-800. We felt that the minimum setting of the muting control could have been even a bit lower (ours measured 13 μV), especially in view of the excellent quieting slope of the tuner and because those requiring a higher threshold setting could easily achieve it with the aid of the muting LEVEL control. As it is, to really pick up those distant weak signals we had to operate with the MUTE switch in the OFF position. Even at signal strengths of 10 μV, quieting was well above 60 dB and such signals were received with low enough distortion to enjoy them monophonically. The 10 μV level is also the stereo switching threshold, at which point stereo signals have already been "quieted" to 40-dB below 100% modulation.

The high-blend switch does reduce background noise for weak signals and, to our ears at least, its use did not seriously affect stereo separation. We did detect a slight roll-off at the extreme low end that showed up only on program material containing ultra-low bass. A recheck of low-end frequency response disclosed that there is indeed a roll-off of some 1.5 dB at 30 Hz, the lowest frequency normally broadcast over FM.

Our overall product analysis, taking price and performance into account, is listed in Table II, together with our summary comments. Based upon present FM broadcast practices, we strongly doubt whether anyone would need a better tuner than the Yamaha CT-800. We do wish they had seen fit to incorporate the alternate 25-microsecond de-emphasis needed for proper enjoyment of Dolby FM broadcasts, but there are available external passive add-on networks that can perform this transition and, although they do reduce output level, the Yamaha has plenty of output to drive most preamplifier and amplifiers to rated output. **R-E**

Kenwood KR-7600 AM/FM Receiver

MANUFACTURER'S PUBLISHED SPECIFICATIONS:
FM TUNER SECTION
Usable Sensitivity: 1.7 μV (9.8 dBf). **50-dB Quieting:** mono, 3.0 μV (14.8 dBf); stereo, 37 μV (36.6 dBf). **S/N Ratio:** mono, 75 dB; stereo, 70 dB. **THD** 1 kHz: mono, 0.15%; stereo, 0.25%. **Capture Ratio:** 1.5 dB. **Selectivity:** 80 dB. **IF Rejection:** 100 dB. **Image Rejection:** 85 dB. **Spurious Rejection:** 85 dB. **AM Suppression:** 65 dB. **Frequency Response:** 20 Hz to 15 kHz, +0.5, −1.5 dB. **Muting Threshold:** 2.2 μV (12.0 dBf). **Stereo Separation:** 1 kHz, 40 dB; 50 Hz to 10 kHz, 35 dB. **Subcarrier Rejection:** 65 dB.

AM TUNER SECTION
Usable Sensitivity: 20 μV (external antenna). **S/N Ratio:** 50 dB. **Image Rejection:** 45 dB. **Selectivity:** 35 dB. **IF Rejection:** 35 dB.

AMPLIFIER SECTION
Rated Power Output: 80 watts continuous per channel, 8 ohms. **Power Bandwidth:** 20 Hz to 20 kHz. **Rated Harmonic Distortion:** 0.3% (0.05% at 1 watt). **Rated IM Distortion:** 0.3% (0.1% at 1 watt). **Damping Factor:** 45. **Input Sensitivity:** Phono, 2.5 mV; Aux and Tape, 150 mV; Mike, 1.5 mV. **Phono Overload:** 180 mV (1 kHz). **S/N Ratio** (IHF A-weighted): Phono, 75 dB; Aux and Tape, 90 dB; Mike, 65 dB. **Frequency Response:** Phono, RIAA ±0.5 dB; Aux and Tape, 20 Hz to 50 kHz, −1dB; Mike, 70 Hz to 20 kHz, −3 dB. **Bass Control Range:** ±8 dB at 100 Hz. **Treble Control Range:** ±8 dB at 10 kHz. **Acoustic/Presence:** +3 or +6 dB at 50 Hz and 800 Hz (selectable). **Low- and High-Cut Filter:** −10 dB at 100 Hz and 10 kHz.

GENERAL SPECIFICATIONS
Power Requirements: 120 volts, 60 Hz, 550-watts maximum. **Dimensions:** $20\frac{5}{8}$ W × $5\frac{29}{32}$ H × $14\frac{3}{8}$-inches D. **Net Weight:** 38.1 lbs. **Suggested Retail Price:** $529.95.

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CIRCLE 101 ON FREE INFORMATION CARD

KENWOOD'S EXCELLENT REPUTATION FOR CONSISTENTLY good high-fidelity component designs and products should be further enhanced with the introduction of their newest line of stereo receivers. Rather than test their highest powered *model KR-9600*, we thought it might be more interesting to see just how much performance and control flexibility they managed to incorporate in the "second-from-the-top" *model KR-7600*, shown in Fig. 1.

Although the traditional "black-out" dial area has been preserved from earlier designs, the front panel has a very clean, squared off look that is both contemporary in feel and devoid of meaningless frills. The metallic side-pieces can be replaced with optional handles, if desired. The framed dial-area

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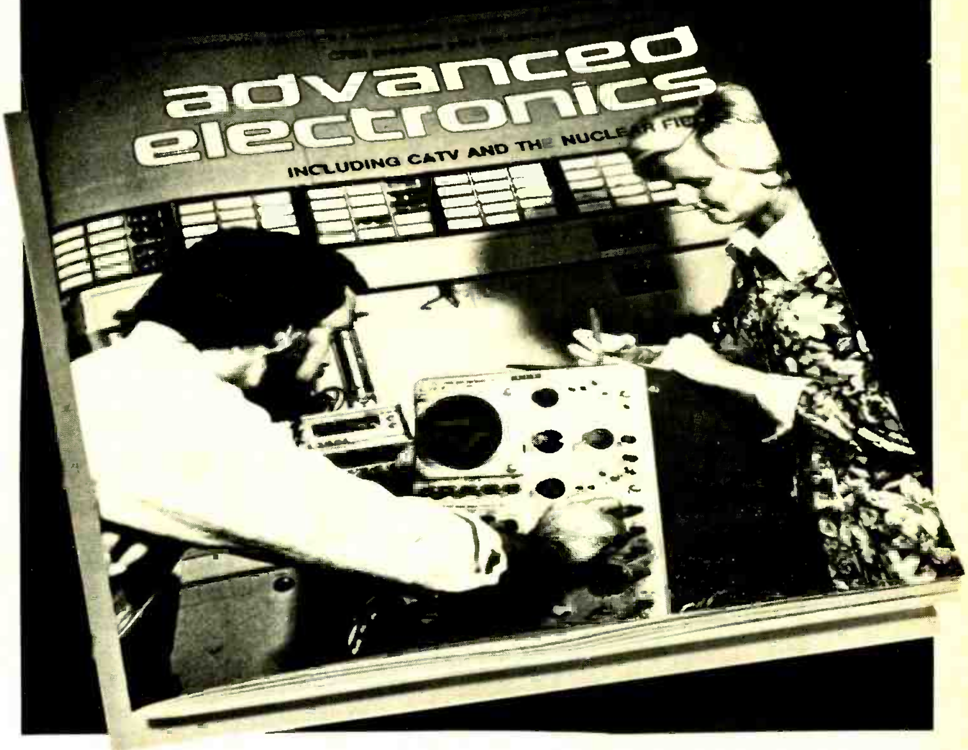

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illuminates in blue (frequency numerals), orange (meter areas) and white (logging scale) when power is applied. Above the linear FM-frequency and the conventional AM-frequency scales are a series of illuminated words that denote the program source selected and indicate the presence of a received stereo FM signal. The dial pointer is illuminated by tiny LED's. Rather surprisingly, Kenwood did not provide calibration marks on the FM scale itself, preferring to denote every second megahertz by a numeral. Referencing of favorite, closely spaced stations must therefore be made using the arbitrary log-scale below.

The lower portion of the main dial-area cutout has a pair of tuning meters (signal strength and center-of-channel) as well as eight identical pushbuttons (in clusters of three, three and two). The left-most pushbuttons handle low- and high-cut filters and tone-control bypass or defeat. Three more pushbuttons handle channel reverse, mono/stereo mode and loudness compensation. The remaining two pushbuttons provide selectable FM de-emphasis (75 μs for ordinary listening; 25μs for Dolbyized FM programs) and FM muting. While Dolby circuitry is not actually built into the unit, a provision is made for connection of an appropriate adapter that is used with the 25-μs position of the de-emphasis button is used.

Controls along the brushed-aluminum lower portion of the front panel include seven identical rotary knobs (all of them metal-turned), three lever switches and a tiny microphone level control that, when pulled outward, connects a microphone input jack located just below it so that microphone signals can be mixed into any other program source. The larger rotary knobs handle SPEAKER selection (including an OFF position for headphone-only listening), BASS, TREBLE, BALANCE, VOLUME, a TAPE switch for monitoring and dubbing, and a program SELECTOR (including two phono inputs). The toggle switches turn on power and introduce fixed amounts of boost at 50 Hz and 800 Hz—a feature that Kenwood calls its acoustic control. The usual stereo phone jack is located near the SPEAKER switch.

All connection terminals on the rear panel of the *KR-7600* are recessed sufficiently so that the entire receiver can be pushed up against a wall without damaging plugs, cutting wires, etc. Since heat sinks are well forward of the rear panel and contained within the chassis itself, such placement poses no hazards thermally or otherwise. Rear-panel facilities include the aforementioned PHONO and AUX input jacks, two sets of TAPE PLAY and TAPE and REC jacks, and ADAPTER OUT and ADAPTER IN jacks (for a Dolby add-on or a 4-channel decoder, or even a graphic equalizer) that are interconnected by means of solid-wire jumpers when not used. One set of TAPE REC and TAPE PLAY jacks is duplicated in the form of a DIN multi-pin socket. Three sets of speaker terminals of the spring-key type are located at the right, above three convenience AC outlets (one switched, two unswitched) and the external AM, 75-OHM and 300-OHM FM antenna terminals. An FM DETECTOR jack is also provided for possible future use with 4-channel FM adapters. A ground terminal is located just above the PHONO input jacks. To have mounted a pivotable AM ferrite antenna bar on the rear panel would have defeated the advantage of the recessed rear panel, so this necessary

TABLE I
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Kenwood** Model: **KR-7600**

FM PERFORMANCE MEASUREMENTS

SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE	**R-E Measurement**	**R-E Evaluation**
IHF sensitivity, mono: (μV) (dBf)	1.7 (9.8)	**Excellent**
Sensitivity, stereo (μV) (dBf)	15.0 (28.7)	**Fair**
50 dB quieting signal, mono (μV) (dBf)	2.6 (13.5)	**Excellent**
50 dB quieting signal, stereo (μV) (dBf)	38 (36.8)	**Fair**
Maximum S/N ratio, mono (dB)	75	**Excellent**
Maximum S/N ratio, stereo (dB)	69	**Very good**
Capture ratio (dB)	1.5	**Excellent**
AM suppression (dB)	65	**Superb**
Image rejection (dB)	85	**Very good**
IF rejection (dB)	100 +	**Excellent**
Spurious rejection (dB)	88	**Good**
Alternate channel selectivity (dB)	82	**Excellent**
FIDELITY AND DISTORTION MEASUREMENTS		
Frequency response, 50Hz to 15 kHz (±dB)	+0, −1.5	**Very good**
Harmonic distortion, 1 kHz, mono (%)	0.13	**Excellent**
Harmonic distortion, 1 kHz, stereo (%)	0.30	**Good**
Harmonic distortion, 100 Hz, mono (%)	0.11	**Excellent**
Harmonic distortion, 100 Hz, stereo (%)	0.30	**Very good**
Harmonic distortion, 6 kHz, mono (%)	0.25	**Good**
Harmonic distortion, 6 kHz, stereo (%)	0.57	**Good**
Distortion at 50-dB quieting, mono (%)	0.75	**Good**
Distortion at 50-dB quieting, stereo (%)	0.5	**Very good**
STEREO PERFORMANCE MEASUREMENTS		
Stereo threshold (μV) (dBf)	12.0 (26.8)	**Fair**
Separation, 1 kHz (dB)	45	**Excellent**
Separation, 100 Hz (dB)	44	**Excellent**
Separation, 10 kHz (dB)	39	**Superb**
MISCELLANEOUS MEASUREMENTS		
Muting threshold (μV) (dBf)	2.3 (12.4)	**Excellent**
Dial calibration accuracy (±kHz at MHz)	0.2	**Good**
EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION		
Control layout		**Excellent**
Ease of tuning		**Very good**
Accuracy of meters or other tuning aids		**Excellent**
Usefulness of other controls		**Excellent**
Construction and internal layout		**Superb**
Ease of servicing		**Excellent**
Evaluation of extra features, if any		**Excellent**
OVERALL FM PERFORMANCE RATING		**Very good**

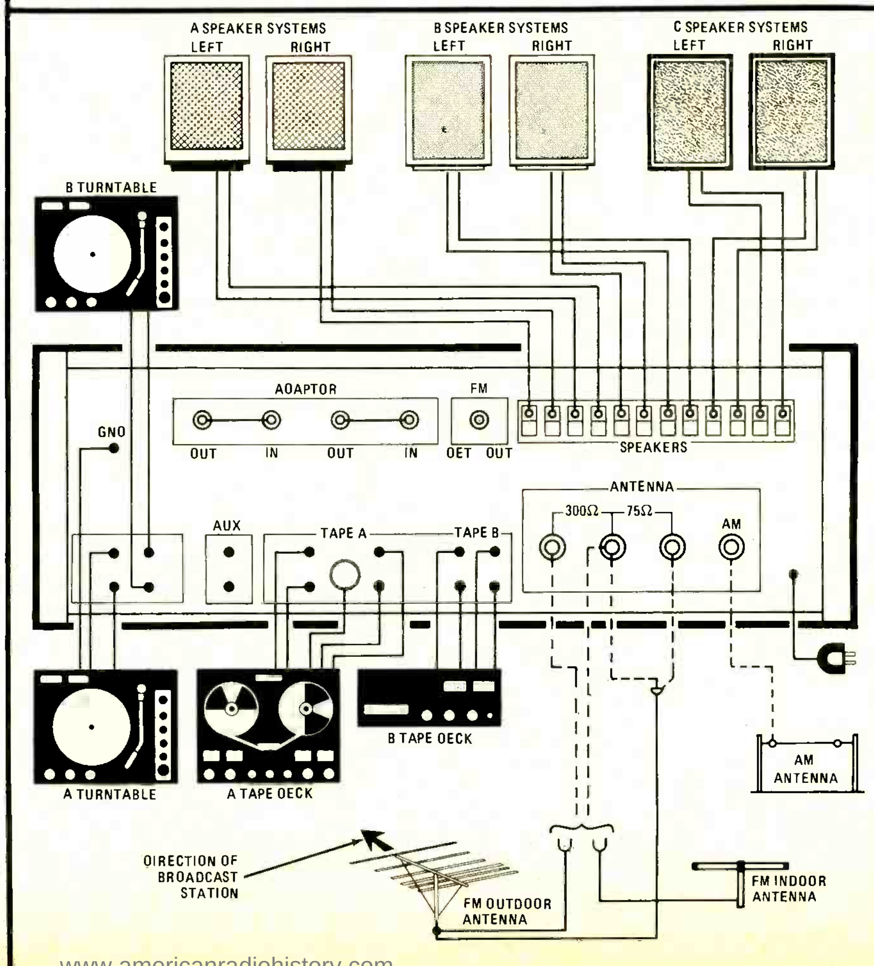

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TABLE II

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Kenwood** Model: **KR-7600**

AMPLIFIER PERFORMANCE MEASUREMENTS

	R-E Measurement	R-E Evaluation
POWER OUTPUT CAPABILITY		
RMS power/channel, 8-ohms, 1 kHz (watts)	90	Excellent
RMS power/channel, 8-ohms, 20 Hz (watts)	86	Excellent
RMS power/channel, 8-ohms, 20 kHz (watts)	85	Excellent
Frequency limits for rated output (Hz-kHz)	15-30	Excellent
DISTORTION MEASUREMENTS		
Harmonic distortion at rated output, 1 kHz (%)	0.07	Excellent
Intermodulation distortion, rated output (%)	0.26	Good
Harmonic distortion at 1 watt output, 1 kHz (%)	0.03	Excellent
Intermodulation distortion at 1 watt output (%)	0.03	Excellent
DAMPING FACTOR, AT 8 OHMS	45	Very good
PHONO PREAMPLIFIER MEASUREMENTS		
Frequency response (RIAA ± dB)	0.5	Good
Maximum input before overload (mV)	185	Very good
Hum/noise referred to full output (dB) (at rated input sensitivity)	78	Excellent
HIGH LEVEL INPUT MEASUREMENTS		
Frequency response (Hz-kHz, ± dB)	15-47, 1.0	Excellent
Hum/noise referred to full output (dB)	86	Very good
Residual hum/noise (min. volume) (dB)	91	Very good
TONAL COMPENSATION MEASUREMENTS		
Action of bass and treble controls	See Fig. 8	Very good
Action of secondary tone controls	See Fig. 9	Excellent
Action of low frequency filter(s)	See Fig. 10	Fair
Action of high frequency filter(s)	See Fig. 10	Fair
COMPONENT MATCHING MEASUREMENTS		
Input sensitivity, phono 1/phono 2 (mV)	2.7/2.7	
Input sensitivity, auxiliary input(s) (mV)	170	
Input sensitivity, tape input(s) (mV)	170	
Output level, tape output(s) (mV)	170	
Output level, headphone jack(s) (V or mW)	0.44/8 ohms	
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)		Good
Action of controls and switches		Excellent
Design and construction		Excellent
Ease of servicing		Very good
OVERALL AMPLIFIER PERFORMANCE RATING		Very good

TABLE III

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Kenwood** Model: **KR-7600**

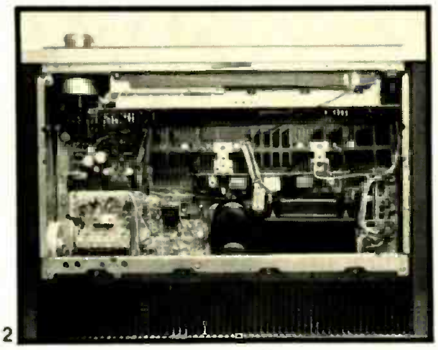
OVERALL PRODUCT ANALYSIS

Retail price	**$529.95**
Price category	**Medium/high**
Price/performance ratio	**Excellent**
Styling and appearance	**Very good**
Sound quality	**Excellent**
Mechanical performance	**Excellent**

Comments: Kenwood's objective in designing this receiver seems to have been to offer to consumers every bit as much flexibility from a receiver as they might obtain from a separate tuner and amplifier. They have succeeded in nearly every aspect of this goal. Physically, the unit has internal and external design touches which set it apart from the usual receiver. The recessed rear panel is an example of good design that should have long ago been thought of by component manufacturers. Controls are well organized on the front panel, with the exception of the volume control which seems to get lost among similarly styled and sized controls and takes a bit of getting used to. Rather than complicate the front panel with secondary rotary controls or multiple-turnover switches, Kenwood's addition of discrete "boost" lever switches for ultra-low and midrange presence augmentation is a novel and useful new control approach. We listened to the *KR-7600* for the better part of a full week, using it to drive both low- and high-efficiency speaker systems. Transient response was very good, and bass was tight and well controlled. The particularly steep quieting characteristics of the FM-tuner section enabled us to log more than 50 listenable mono and stereo signals in our listening area, and the high selectivity permitted such a high count without adjacent or co-channel interference. Two minor points of criticism are in order. The "jumpers" associated with the adapter jacks are a bit of a nuisance. Had a shorting slide switch been substituted, the jacks could have served additional functions (such as separation of the preamp input section from the rest of the amplifier) which are otherwise not provided for on the rear panel. It would have been nice, too, if one more position had been offered on the speaker switch, which would have allowed simultaneous operation of "speakers A" and "speakers C." As it is, only Speakers A and B can be listened to simultaneously. Offsetting these minor points are the excellent audible performance, the considerable flexibility and, what has come to be called the high performance/cost ratio of this latest effort from Kenwood.

component is located within the chassis itself. Since the rear panel is non-metallic, this poses no problem as far as AM reception is concerned.

A partial view of the inside of the *KR-7600* chassis is shown in Fig. 2. A four-section tuning capacitor is used for the FM and MOSFET RF stages. A three-stage six-



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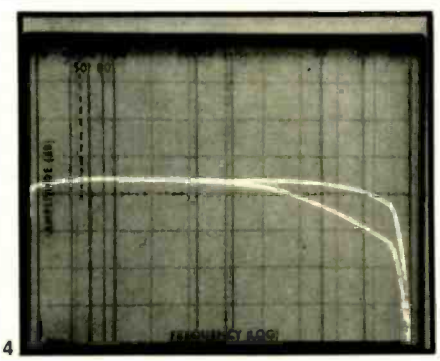
element linear phase IF-filter arrangement and integrated circuitry are used in the FM IF section, followed by a quadrature-detector circuit that feeds a phase-locked-loop multiplex-decoder circuit. The equalizer/preamplifier uses operational-amplifier IC's, as do the tone control stages that follow. The direct-coupled circuit of the main power-amplifier section uses complementary pairs of NPN-PNP transistors for both the driver and power-output stages. An elaborate protection circuit arrangement prevents possible damage from overload conditions and includes gold-plated contact relays for speaker protection.

Figure 3 shows the variety of components that can be connected to and used with this receiver. Not shown are the possible Dolby or other adapters and accessories that might be interconnected via the extra adapter jacks, if the jumpers are removed. In such applications, the accessory device must always be connected to provide a feed-through path for the program signals, otherwise the jumpers must be reconnected.

Tuner measurements

Table I summarizes results obtained from measurements made of the FM-tuner section of the receiver. Usable and 50-dB quieting sensitivities were excellent. Stereo figures were a bit poorer, as might be expected, but came close to meeting the published specifications for noise, THD and 50-dB quieting. It



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is possible that a slight misalignment may have been responsible for the relatively high stereo sensitivity and threshold figures, although they certainly cannot be faulted in terms of absolute numbers obtained.

Separation was far better than claimed.

continued on page 82

RETICON®

SAD-1024
DUAL 512 STAGE ANALOG DELAY LINE

The **SAD-1024** is a general-purpose **S**erial **A**nalog **D**elay device fabricated using N-channel silicon-gate technology in a bucket-brigade configuration to obtain flexible performance at low cost.

KEY FEATURES:

- **Two independent 512-stage delay sections.**
- **Clock-controlled delay: 0.5 second to less than 200 μs.**
- **N-channel silicon-gate bucket-brigade technology.**
- **Designed for self-cancellation of clocking modulation.**
- **Wide signal-frequency range: 0 to more than 200 kHz.**
- **Wide sampling clock frequency range: 1.5 kHz to more than 1.5 MHz.**
- **Wide dynamic range: S/N > 70 dB.**
- **Low distortion: less than 1%.**
- **Low noise: typically limited by output amplifier.**
- **Single 15 volt power supply.**

TYPICAL APPLICATIONS:

- **Voice control of tape recorders.**
- **Variable signal control of amplitude or of equalization filters.**
- **Reverberation effects in stereo equipment.**
- **Tremolo, vibrato, or chorus effects in electronic musical instruments.**
- **Variable or fixed delay of analog signals.**
- **Time compression of telephone conversations or other analog signals.**
- **Voice scrambling systems.**

DEVICE DESCRIPTION

The SAD-1024 is a dual 512-stage Bucket-Brigade Device (BBD). Each 512-stage section is independent as to input, output and clock. The sections may be used independently, may be multiplexed to give an increased effective sample rate, may be connected in series to give increased delay at a fixed sample rate or may be operated in a differential mode for reduced even-harmonic distortion and reduced clocking noise. Each section has its output split into two channels so that in normal operation, output is provided over each full clock period. The SAD-1024 is manufactured using N-channel silicon-gate technology to fabricate a chain of MOS transistors and storage capacitors into a bucket brigade charge-transfer device. It is packaged in a standard 16-lead dual-in-line package with pin configuration as shown in Fig. 1. Only V_{dd} and GND are common to the two separate delay sections. Fig. 2 shows the functional equivalent circuit diagram. Some of the many applications are listed above.

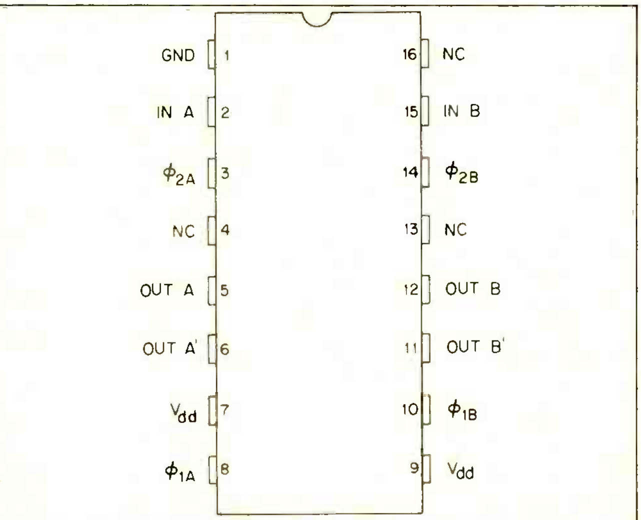


Figure 1. Pin Configuration. Note: Unused outputs should be connected to V_{dd}; all other unused pins should be connected to GND, Pin 1, including those marked N.C.

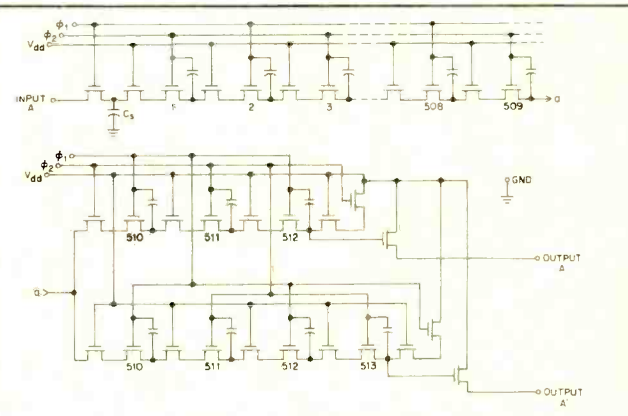


Figure 2. Equivalent Circuit Diagram of either 512-Stage Section of the SAD-1024.

DRIVE AND VOLTAGE REQUIREMENTS

Normal voltage levels and limits are given in the tabular specifications. Clock inputs are two-phase squarewaves (ϕ_2 is the complement of ϕ_1) which swing between ground and V_{dd}. The two V_{dd} inputs (pins 7 and 9) should be connected together to a single power supply. Unused outputs only should be connected to V_{dd}; other unused terminals (including those marked N.C.) should be connected to ground.

The input analog signal is connected through the first MOS transistor

DEVICE CHARACTERISTICS AND OPERATING PARAMETERS

PARAMETER	SYMBOL	MIN	TYP	MAX	UNITS
Clock Voltage[1]	ϕ_1, ϕ_2	10	15	17	volts
Drain Supply Voltage[1]	V_{dd}	10	15	17	volts
Sampling Freq.	$F_{\phi1}, F_{\phi2}$	0.0015	–	1.5	MHz
Clock Rise Time	t_{cr}		30		ns
Clock Fall Time	t_{cf}		50		ns
Clock Line Cap	C_c		110		pF
Signal Freq. Bandwidth (3dB point)		See Fig. 7	200		kHz
Signal to Noise		See Fig. 4			
Distortion		See Fig. 5			
Gain[2]			1.2		
Video Input Capacitance	C_{in}		7		pF
Video Input Shunt Resistance[3]	R_{in}			200K	ohms
Output Resistance	R_o	See Fig. 6			
Input Bias[4]			+6		volts

ABSOLUTE MAXIMUM VOLTAGES

TERMINAL	LIMITS	UNITS
Any terminal[1]	+20 to –0.4	volts

Notes:

1. All voltages measured with respect to GND (pin 1).
2. The value of gain depends on the output termination resistance. See Fig. 6
3. Effective AC shunt resistance measured at 1 MHz.
4. The input bias voltage varies slightly with the magnitude of the clock voltage (and V_{dd}) and may be adjusted for optimum linearity at maximum signal level. The value shown is nominal for 15 volt clocks.

CAUTION

Static discharge to any lead of this device may cause permanent damage. Store with shorting clip or inserted in conductive foam. Use grounded soldering irons, tools, and personnel when handling devices. Avoid synthetic fabric smocks and gloves. It is recommended that the device be inserted into socket before applying power.

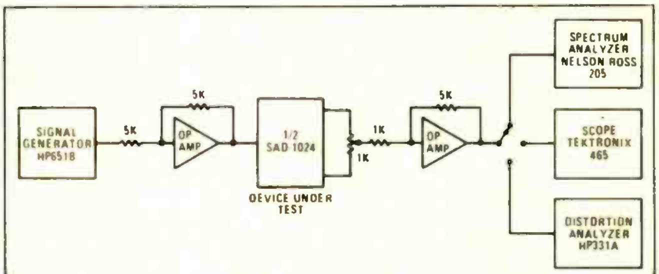


Figure 3. Test Set-up used to obtain the data of Figures 4, 5 and 6.

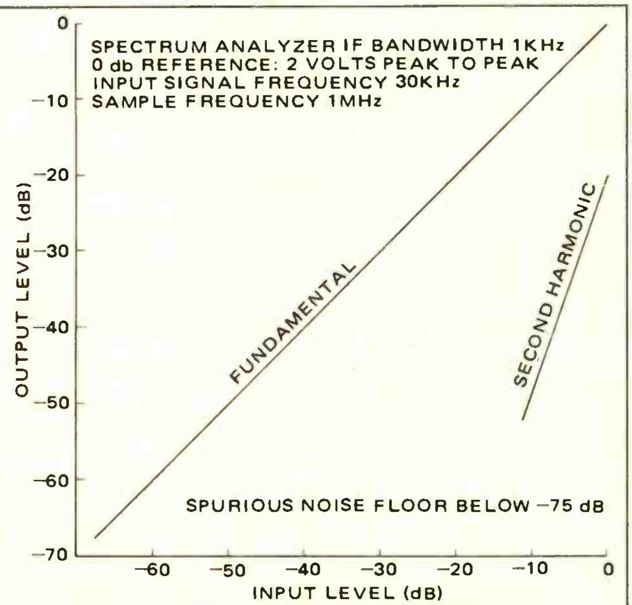


Figure 4. SAD-1024 Transfer Characteristic.

to the input storage capacitor while ϕ_1 is high; the charge is then transmitted to the next bucket-brigade stage when ϕ_1 is low, ϕ_2 high. Thus the signal samples are those values in existence at the positive-to-negative transitions of ϕ_1 and the input sample rate F_s is the same as $F_{\phi1}$. As with all sampled-data devices, the input bandwidth should be limited to a value less than one-half the sampling clock frequency (usually to a value less than 0.3 F_s). Further, to recover a smooth delayed analog output a post filter having steep cutoff (e.g., 36 dB per octave) is desirable.

PERFORMANCE

Typical performance of the device is shown in the specification and in the curves of Figs. 4-7. This data was obtained with the test configuration of Fig. 3. Internal dispersion becomes the limiting factor for sampling clock frequencies above 1.5 MHz.

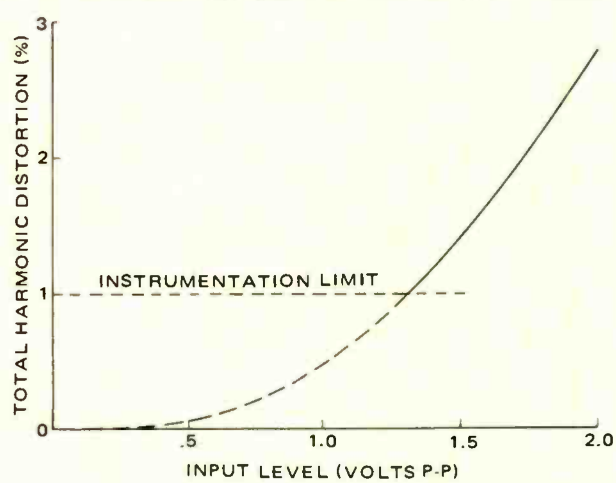


Figure 5. SAD-1024 Distortion vs. input Level.

Figures 4 and 5 indicate the linearity and show the rapid increase in distortion as the input level is increased toward saturation. For inputs less than approximately 500 millivolts RMS, the distortion is less than one percent. Between this point and the noise floor there is approximately 70 dB of dynamic range.

Figure 6 shows the loading effect of the output terminating resistor. The data indicates the output source followers have approximately .400 ohms internal impedance. For this test, each output was connected through a terminating resistor to ground, thus isolating any interaction between the two output followers.

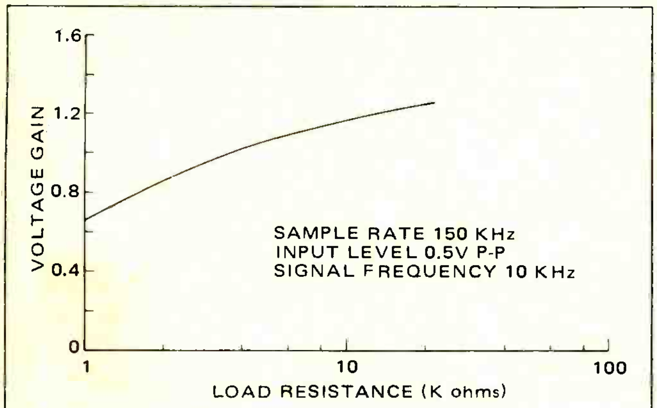


Figure 6. Dependence of Gain on Load Resistance.

Figure 7 shows the frequency response of the device when terminated as shown. The dotted lines indicate the range of variation from device to device.

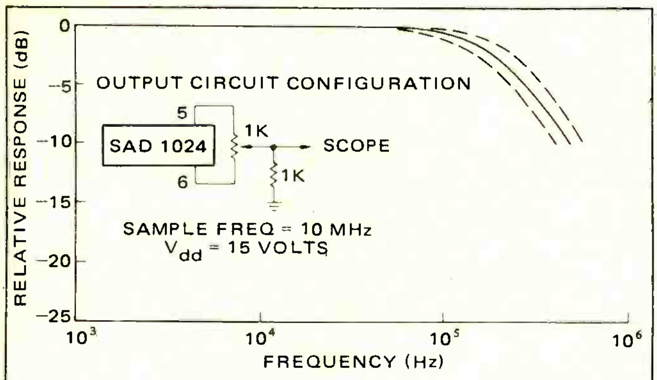


Figure 7. Frequency Response showing Typical Variation Device to Device.

AUDIO APPLICATIONS

Many desirable and interesting acoustical effects may be synthesized with delay elements such as the Reticon SAD-1024 Bucket Brigade Delay device. These effects include enhancement and control of reverberation, generation of chorus, flanging, vibrato and other musical effects, and reduction or cancellation of flutter and wow. The most important feature of a delay device for such application are:

1. Wide bandwidth and flat frequency response
2. Large dynamic range
3. Simplicity of application
4. Magnitude and range of delays
5. Freedom from undesirable side effects
6. Stability
7. Low cost

APPLICATION IN PRACTICAL CIRCUITS

I. Reverberation

Acoustic reverberation is caused by the build-up of sound in an enclosed space. The build-up occurs because of the addition of sound components from simply-reflected and multiple-reflected pencils or rays of sound returned from internal reflecting surfaces. Similarly, the sound field present when sound from the source is suddenly terminated does not die away immediately but decays in an exponential manner as the reflected sounds diminish by acoustic absorption.

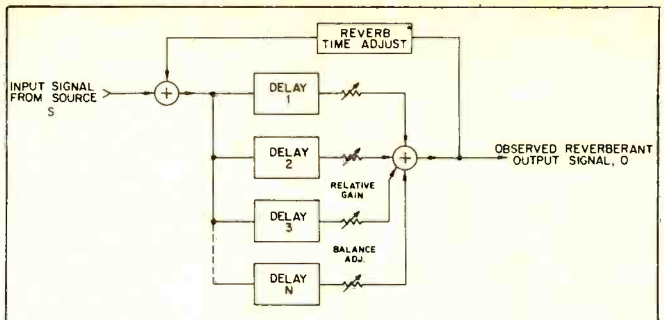


Figure 8. Production of Synthetic Reverberation

Reverberation can thus be synthesized as in Fig. 8. Each delay element represents the time of travel in some possible path from the source S to the observer at O. Feedback adds the effect of multiple-reflection paths. Differing path lengths are represented by differing delays. A single delay element can produce reverberant effects, but would be excessively frequency sensitive with the reverberant sound having distinct flutter. Several different path lengths (delays) are desirable. Attenuation in a path represents its acoustic absorption loss; therefore, the adjustment of loss allows the control of reverberation time.

In an actual room, the direct sound is received first, followed by simple reflections, and then by an increasingly complex mix of multiple reflections. Thus an equivalent synthetic reverberator must be equipped to generate and handle a similarly complex combination of signals.

II. Vibrato and Other Effects

Vibrato is defined as a slight pitch variation at a cyclic rate, usually of the order of 5 to 10 Hz, such as that produced by the rapid oscillatory movement of the fingering hand of a violinist. It is customarily used to add a richness to the sound. The result of vibrato is the combinations of sounds from various paths to give a slight chorusing effect. Such pitch variations can be synthesized by changing the delay element's clock rate in slow cyclical manner (see Fig. 9). Changing the clock rate alternately increases and decreases the delay through the device and hence the pitch in a fashion analogous to the Doppler effect. If the clock-rate changes slowly, we can consider the transit time of the delay element to be constant for any particular instant of the input waveform.

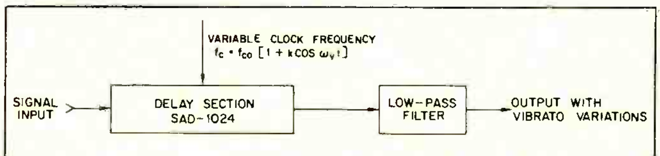


Figure 9. Block Diagram of Circuit for Producing Vibrato Effects

III. Chorus (Multiple Voice) and Phasing Effects (Flanging)

If a solo voice or instrument is joined by the same sound delayed by approximately one to five milliseconds, the resultant is a very popular "spacey" sound. The phenomenon sounds as if there were two voices or instruments present. This is particularly true if the pitch of one is varied slightly (i.e., the two are not exact replicas). If the resultant signal is again delayed and added as before, the effect is that of four voices, etc., until delay becomes so large as to cause blurring. Delay can thus be used to enhance or modify the apparent size of a group of musicians (or speakers, etc.). The SAD-1024 is readily adapted to such use. Figure 10-a shows two delay elements in a stable, nonfeedback arrangement of this application. Additional delay elements can be added, as desired, without loss of stability.

Chorus produced by simple delay alone (without modifying pitch or other characteristics) is likely to sound thin and lifeless because each reproduction is an exact counterpart of the previous signal. The effect of slightly different sources can be produced by varying the clock rates by a small amount as in vibrato (and as indicated in Fig. 10-b). The amount of variation is much less than with vibrato, because the pitch change should not be evident. What is wanted is just enough difference between the direct and delayed signal to make them appear to come from separate sources, i.e., in "chorus".

When the desired effect is that of several different voices added to-

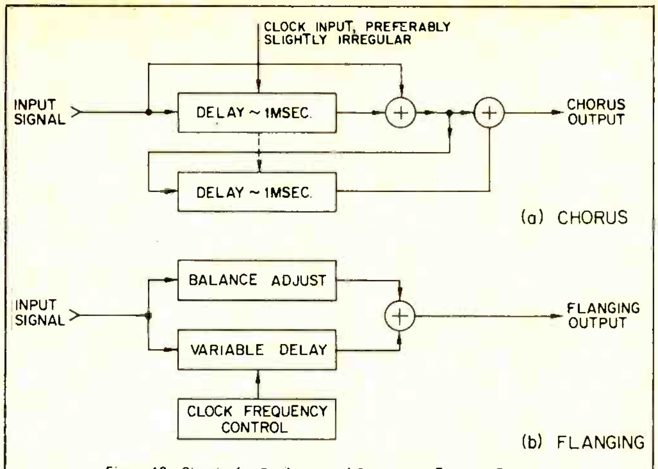


Figure 10. Circuits for Production of Chorus and Flanging Effects

gether, it is possible to vary the clock rate slightly but in a random rather than regular manner. Such a clock rate might be derived from noise passed through a narrow-band filter. The output frequency is changed as in vibrato, but the randomness simulates the slight differences in sources, rather than conventional vibrato with one or more deterministic sources. The exact combination desired is subject to artistic interpretation; no rules can be given.

IV. Wow and Flutter Control

There is need to compensate for imprecise speed control of tape recorders. As illustration, suppose a live performance is taped on a recorder having undesirable speed irregularities, of a limited nature, and is then played back on the same or another machine. The original irregularities appear, but in reversed sense, if the playback is at a constant speed. Flutter and wow components are added to those originally present, if the playback device has speed irregularities. Thus, it is more important that speed be well controlled; however, economic factors limit the actual precision attainable. Suppose that a supersonic signal were recorded and recoverable at playback (the bias frequency is a possible candidate). This frequency could be selected by filter, amplified, and used to control a servo, or more simply, an external delay element could be controlled. The result

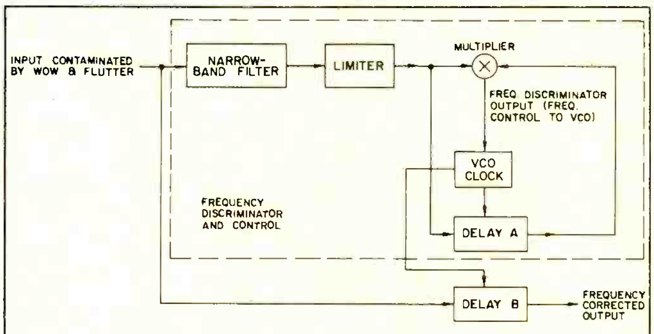


Figure 11. Circuit for Compensation for Wow and Flutter

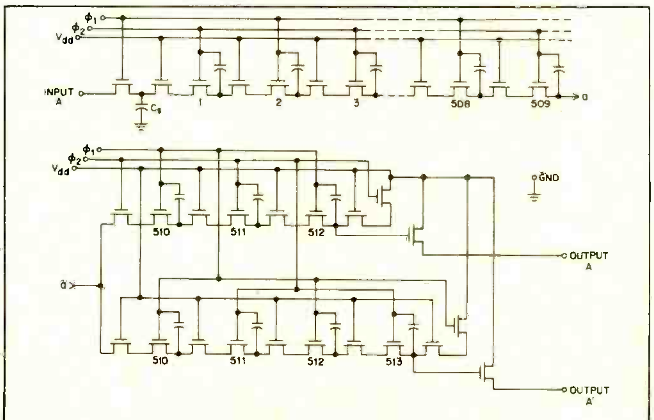


Figure 12. Equivalent Circuit Diagram for One Section SAD-1024

would be to maintain the output supersonic signal at a constant frequency, hence forcing substantial reduction, if not complete cancellation of the combined variable speed effects. One section of SAD-1024 could be used, in this application, as a precise linear frequency discriminator, and a second section could be used as a variable delay control. Figure 11 is a possible circuit configuration. Delay circuits A and B are driven by the common variable clock. The effect of the discriminator is to detect any changes in the frequency of the (supersonic) pilot tone in its passage through channel A. The corrective effect is the same for the desired signals in channel B. This tends to restore the original undistorted sound. There is no average speed (or pitch) change, but effects due to speed variations are reduced or nearly eliminated.

Stability is a potential problem because of the phase shift introduced by the delay A and the discriminator filter; proper feedback design is required.

V. Delay Implementation

To assist in understanding how best to apply the SAD-1024 in delay applications, let us briefly review its operation, Fig. 12 is the equivalent circuit for a 512-bucket delay section and applies to either section of the SAD-1024. Figure 13 shows a SAD-1024 connected in the SC-1024 evaluation circuit which is available from the manufacturer (Reticon). For evaluation and initial application, it is recommended that the SC-1024 evaluation board be used. The SAD-1024 requires a single 15-volt power supply, and an input bias of approximately +6 volts (to common). The requirement for only a single power supply is in direct contrast to requirements for P-channel devices which require typically three and sometimes four separate voltages. The single power-supply requirement is a distinct economic advantage. The bias, along with an input buffer and an output filter amplifier, is supplied by the SC-1024 evaluation board. The board requires plus and minus 15-volt supplies (i.e., two supplies are required because of the operational amplifiers used on the SC-1024 board). Clock input is at TTL level.

VI. Functioning of the SAD-1024

Let us first consider an example of Section A of the SAD-1024 and of the evaluation circuit operating alone (see Fig. 13). Further, let the input TTL clock frequency be 200 kHz and the signal input frequency be a kHz sinewave. The input clock rate is divided by two, by flip-flop U1, to give complementary squarewaves for ϕ_{1A} and ϕ_{2A} of 100 kHz rate (10 μs period). While ϕ_{1A} is high (nearly +15 volts), the input transistor (N-channel MOS) turns on to connect input A through to C_s (see Fig. 12). The input buffer AR2 (see Fig. 13) inverts the input waveform and superposes it on an approximate 6-volt bias. The instantaneous value of this combined input sample is then "frozen" on C_s when ϕ_{1A} drops to its low state of nearly zero volts. However, note that ϕ_{2A} is now high and as a result C_s is connected to the first boot-strap capacitor at the output of cell 1. During this half period there is readjustment of charge between C_s and cell 1.

During the next half of the clock period, ϕ_{1A} again goes high and ϕ_{2A} low to connect cell 1 to cell 2 and disconnect cell 1 from C_s. A new sample of the input is again placed on C_s. In this way, each sample at the input is passed along, bucket-by-bucket, to appear at output A with a delay of 512 half-periods of ϕ_{1A}.

In this example, the output appears at A 2.56 ms after it was input.

Delay: T_D = 512 half periods X 5 μs/half period
= 2560 μs.

Note that only one sample per clock period is selected, and the corresponding output appears at A only while ϕ_{1A} is high. When ϕ_{1A} falls and ϕ_{2A} rises, the output from A drops to its fixed low state, and the signal value now appears at A'. At the input to cells 510 the circuit was split into two equal paths, path A' having one extra cell and one extra half-clock period of delay. Thus, the summed outputs A and A' effectively provide continuity over the full clock period. Each input sample is delayed to give, by combining the outputs, a full stair-step approximation of the continuous analog input. The output filter amplifier inverts the signal, smooths the stair-steps, and discriminates against residual clock glitches. The smoothed output is a phase-locked replica of the input with 2.56 milliseconds of delay. This amount of delay at 5 kHz represents a phase delay in cycles of 2.56 milliseconds divided by the 0.2 millisecond period or 12.8 *cycles*. Note that the delay is a constant *time* delay, independent of the signal frequency. This leads to a linearly increasing (undistorted) phase delay with increasing signal frequency.

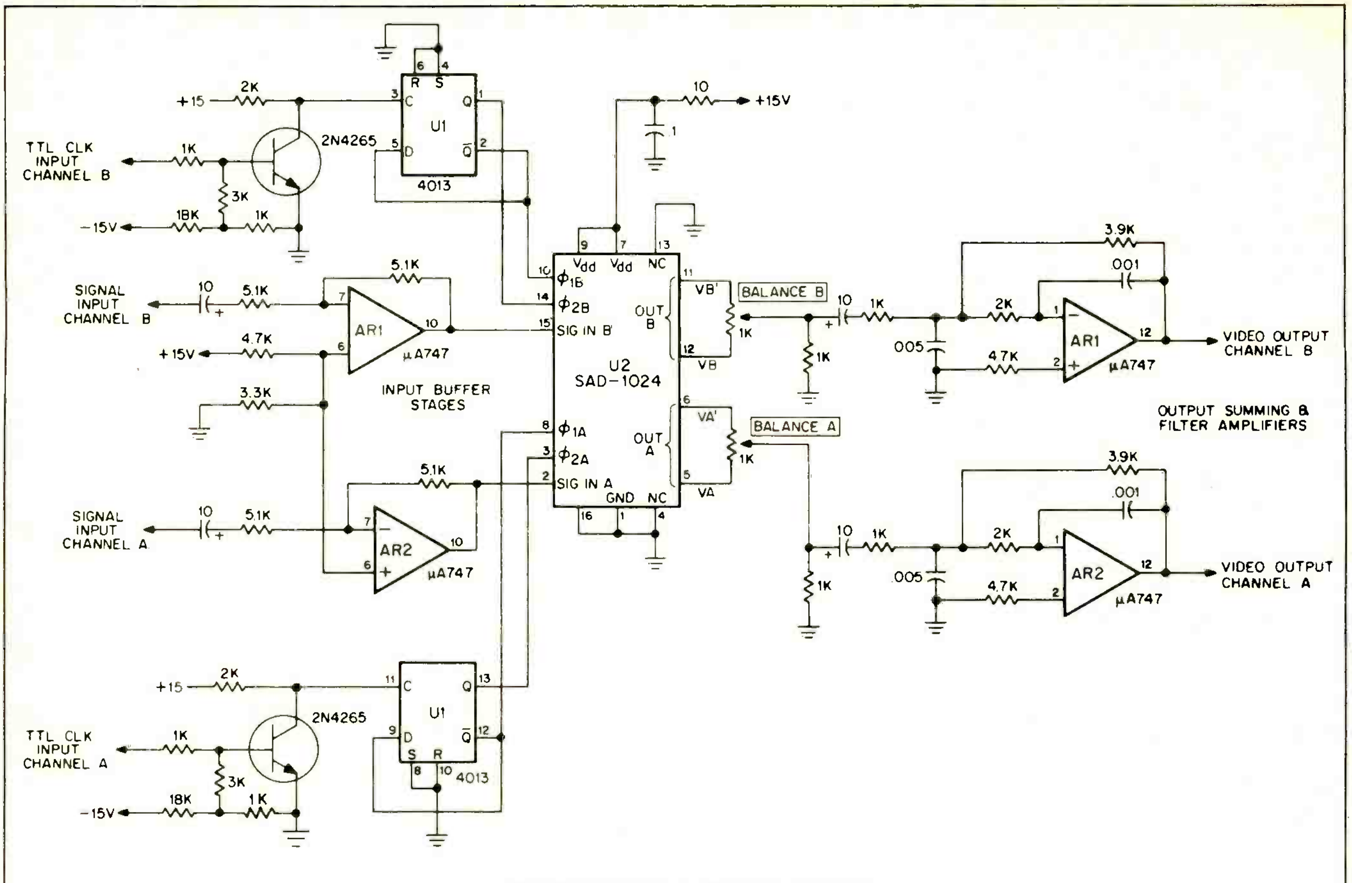


Figure 13. SAD-1024 in the SC-1024 Evaluation Circuit.

The 5 kHz signal is "sampled" twenty times during each of its cycles. This permits good reconstruction of the input waveform. Theoretically, signals up to one-half of the sampling frequency can be completely recovered (Nyquist theorem). Practically, input signals with components (all with the clock-frequency-fixed constant time delay $T_D = 512/(2F_{\phi 1A})$) up to one-third or more of the sampling frequency may be processed with good reconstruction.

In a mathematical sense, each component of the input is convolved with the Fourier transform of the sampling frequency, F_c, to give a sin x/x amplitude-response modifier at the output (with ideal filtering). The first "zero" of the sin x/x amplitude modifier occurs at F_c. At the theoretical upper-limit analog input frequency of $F_c/2$, there would be an amplitude factor of $(\sin \pi/2)/(\pi/2) = 0.637$ (3.92 dB loss). At $F_c/3$ the factor becomes 0.827 (1.65 dB loss). In any real-world situation, these factors must be multiplied by any input and output filter factors, which cause its response to be other than ideal, and by the effective transfer factor of the memory device itself.

In a bucket-brigade device, each charge transfer leaves behind a very slight amount of the charge. This charge-transfer inefficiency is cumulative over all N charge transfers. This effect causes reduction in the high-frequency response of the device, in addition to the sin x/x factor above, but still directly related to the clock frequency. The signal frequency for a given loss thus tends to be a constant fraction of the clock frequency, until charging time constants become dominant. Because of the combination of the two effects, it is very important that the effect from charge transfer inefficiency be as small as possible. N-channel devices such as the SAD-1024 are substantially better than their P-channel counterparts in control of charge-transfer inefficiency.

VII. Practical Details Applicable to Use of the SAD-1024

It has been suggested that the SC-1024 evaluation board be used to permit easy, effective use of the devices. Let us here consider just the devices and their care and feeding.

The devices are sampled-data devices. Inputs may be continuous, but only those values in existence at a particular time in the clock cycle are accepted and transmitted. The properly-combined outputs are stair-step approximations to the analog input. In addition, some residual clock glitches appear at the output because of the practical impossibility of complete cancellation.

Also, these devices are MOS devices and are subject to possible damage from static discharges. Internal protection is provided, but limited because of the tradeoffs balancing performance with the adverse effects on performance of more complete protection; as a result, moderate care in handling is a must. Susceptibility to damage is comparable to that of standard CMOS logic devices; comparable care should be adequate.

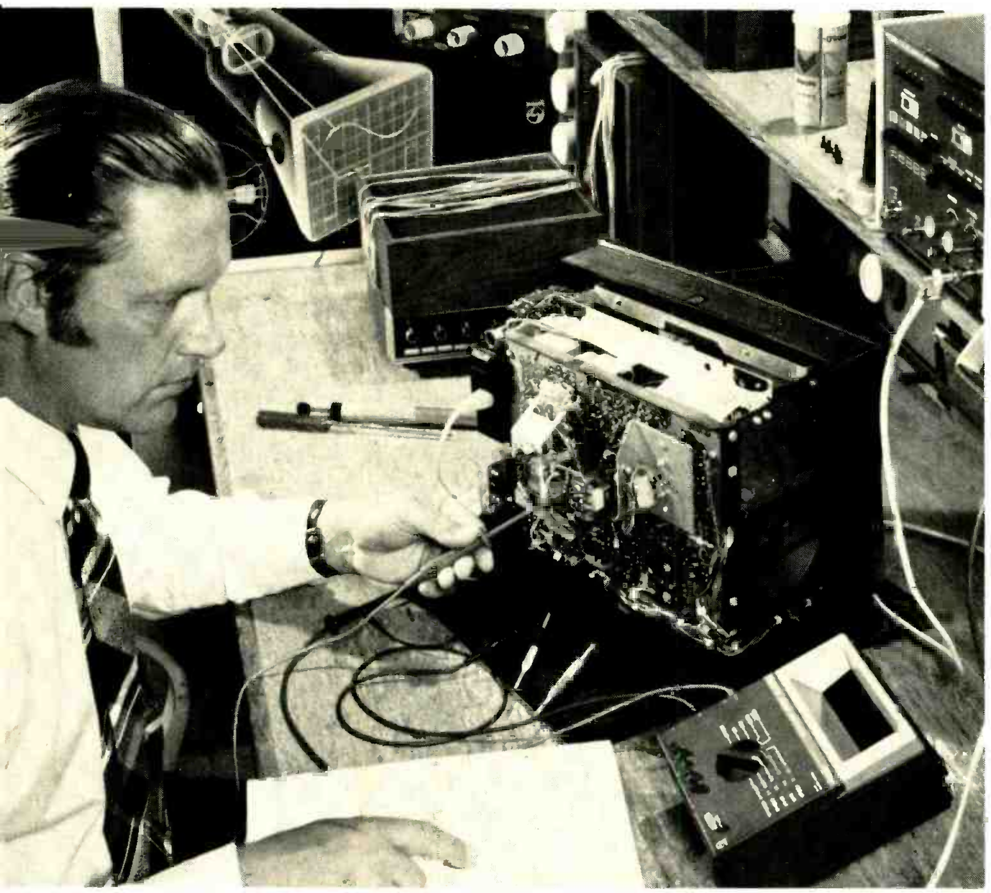
What do these operating characteristics and features mean? The following discussion treats various points to be considered.

The input signal must be inherently limited to a frequency band less than $F_{clock}/2$, or, if it is not so limited, an input filter should be used to prevent foldover distortion (i.e., aliasing). Many audio signals will be so limited and no input filter will be required. The clocked, sampled nature of the signals through the devices means that some output filtering is desirable. This can be introduced as a separate filter or provided by the band-limiting nature of following devices. An output filter is implicit in the figures. If filtering is provided by following devices, such as amplifiers, etc., it is important that inadvertent input overload of the following device be prevented. Such overload could lead to audible distortion or even failure of components. Some simple output filtering is desirable even if following devices provide band limiting.

The input bias of roughly 0.4 times the clock amplitude is chosen to allow equal signal swing above and below the bias level before distortion occurs. In critical applications, such as those having maximum input, some bias adjustment may optimize conditions to permit lowest distortion and maximum output. For lower signal levels, the adjustment is not critical and may be fixed.

Output source followers must be supplied with a current path. Their drains are internally tied to V_{dd}. As shown in the circuit of Fig. 13, a low-resistance path to ground is functional. To obtain a higher resistance load, it would be possible to connect a higher-value resistance to a point move negative than ground. Such a circuit would be useful where unity gain through the device is desired. R-E

Servicing With MULTIMETERS



The multimeter has been—and probably will always be—the basic electronic test instrument. However, selecting the type that's best for you can be a problem. Here are some valuable hints on meter selection

A.N.M. KLUIJTMANS*

SERVICING TV SETS DEMANDS A STRICTLY limited—but nonetheless awkward—set of measurements. So the multimeter used must be particularly versatile and, for field use, particularly rugged.

Modern multimeter circuitry can cope with the requirements, but the user must carefully select the most suitable general-purpose instrument. Input selection and protection, the range of facilities, essential accessories and the choice between analog and digital display must all be considered.

Most of the voltages we measure in a TV set are DC—ranging from a few millivolts up to 30 kV for color, less for monochrome. The range of voltages found in a typical color set can be seen from Fig. 1. About the only AC measurement necessary is to check the incoming line supply.

One of the problems is that pure DC levels are practically nonexistent—as can be seen from Fig. 2. Most have pulse levels superimposed with voltages often double that of the level being checked. Add to this the number of stray signals that can appear in a TV set and there is an obvious need for good AC filtering and effective shielding on any multimeter input.

Boost voltages

Checking TV boost voltages is a typical problem. Normal values of 1 kV often have a superimposed peak pulse of 1200 volts. A commonly-occurring pulse form has a 15-kHz repetition rate and 10-μs duration—quite enough to destroy a meter.

The simplest solution is to measure from some other point than the chassis ground. A typical measuring point is a tube 300-volt supply as shown in Fig. 3. But this is not too convenient when making a general circuit examination and several voltages are being checked.

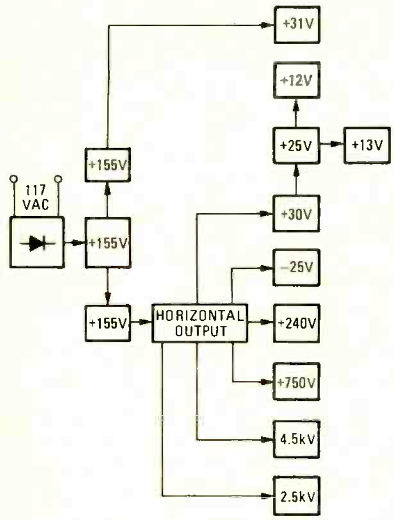
Now, however, it is possible to find multimeters with enough overload protection to allow accurate measuring of boost voltages without taking special precautions. With monochrome sets, the boost voltage is tied up with the horizontal width control and needs careful regulation. So a 1% accuracy on a 1-kV range with 1200-volt overload protection is needed.

Checking boost voltage on a color set also has to be done accurately. Don't ignore the value of the boost voltage. Too high a value can cause high current peaks and the resulting inductive voltages can point-weld transistors in hybrid driver circuits.

With the 30 kV found on many color picture tubes, however, attenuation is necessary. Instead, a special probe is used (see Fig. 4). This 100-times attenuator uses accurate resistors to reduce

*Philips Test and Measuring Instruments Department, Eindhoven, The Netherlands.

the 30 kV to a manageable 300 volts. The operator is protected from the high voltage by the length of the probe. One word of warning, avoid handling the internal probe resistor—it is highly susceptible to damage by moisture.



For smaller voltages, an attenuator to help cut down the effect of peaks can be made using a simple RC circuit. It can easily halve the voltage levels and gives added protection by integrating the signal slopes.

Overload protection essential

With measurements ranging from kV to mV and with low-frequency and high-frequency signals present, overload protection on all ranges is essential and should be built in to the service instrument. Protective action can be either some form of overload indication or even automatically switching off the instrument. Arc-over protection is also a must.

Any digital meter should be able to take at least a 1-kV overload, even on the 200-mV range. Arc-over protection should be at least 1600 volts. Fuse protection forms an essential back-up against excessive overloading.

FIG. 1—THE LINE INPUT in a color TV receiver supplies from a few volts up to 20 or 30 kV, as can be seen from this example.

For analog instruments the situation is more difficult because of the danger of mechanical damage during overload. A relay to disconnect the input, backed again by fuse protection is best for the voltage ranges. A fuse is good enough for the current ranges, but it is worth looking for an instrument that has some kind of diode protection to guard against damage before the fuses act.

Also make sure that fuses are easy to replace and that spares are always available. Ideally, spare fuses should be kept inside the instrument (see Fig. 5.)

Analog or digital

Choosing between analog and digital instruments (Fig. 6) is difficult and really a matter of personal choice. Digital readouts offer much higher accuracy, in theory, and are perhaps necessary for accurate supply voltage measurements—they are also easier to read. But analog instruments are better for peak-and-dip measurements when aligning coils, and other trend measurements.

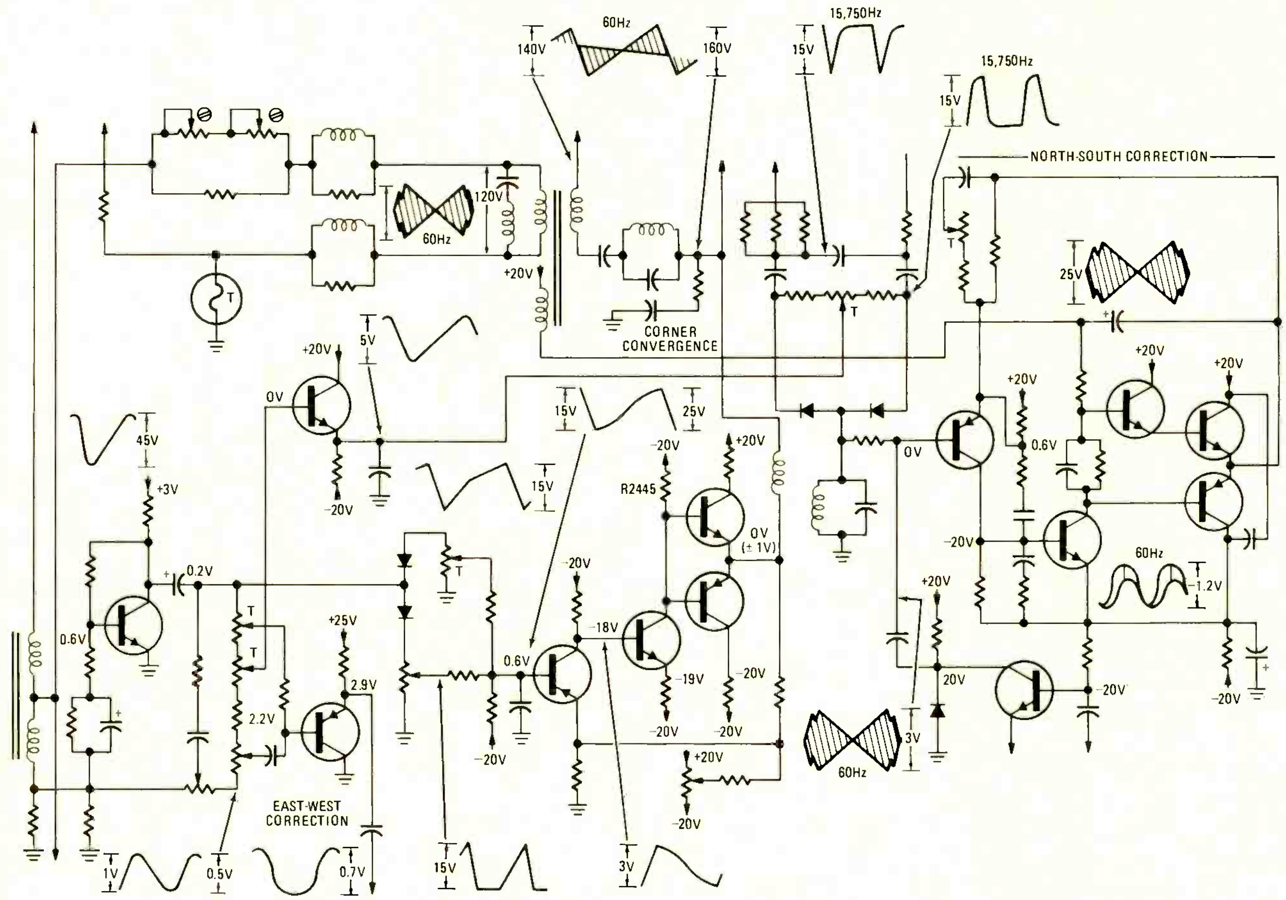


FIG. 2—ALTHOUGH DEFINITE VOLTAGE LEVELS are often given on a TV circuit diagram, most DC levels have large pulse levels superimposed, making for awkward measurements.

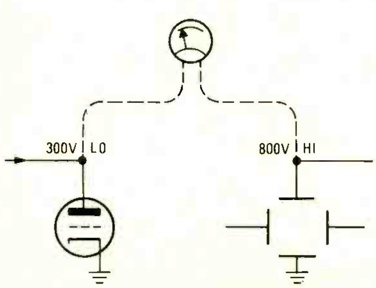


FIG. 3—TO OVERCOME THE PROBLEM of trying to read too high a voltage, use some other level than the chassis ground. A typical measuring point is the 300V tube supply here, making it much easier to measure the voltage on a CRT deflection plate. But the drawback is that when checking a series of voltages—both low and high—it is necessary to keep changing the reference point.

A digital meter is particularly useful for locating faults such as short circuits in yoke deflection coils. Being essentially very low resistance, any short circuit is going to make only a small difference to the resistance reading—requiring the high resolution of the digital meter to detect it.

Check the facilities

With all the emphasis on voltage

FIG. 4—TO MEASURE really high voltages—such as the 30-kV boost voltage often found in a color TV—some form of attenuator is essential. This special probe provides 100-times attenuation using highly accurate resistors. The length of the probe provides some protection for the user.

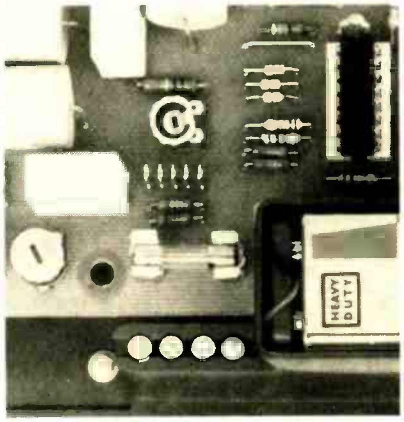


FIG. 5—IF FUSE PROTECTION is used in a multimeter, replacement should be easy and spares always on hand. For a meter being used in the field, spare fuses should preferably be carried in the instrument itself.

FIG. 6—CHOOSING BETWEEN ANALOG AND DIGITAL INSTRUMENTS often has to be a matter of personal choice. A digital meter is better for accurate measurements, while an analog meter is ideal for peak-and-dip and other trend readings.

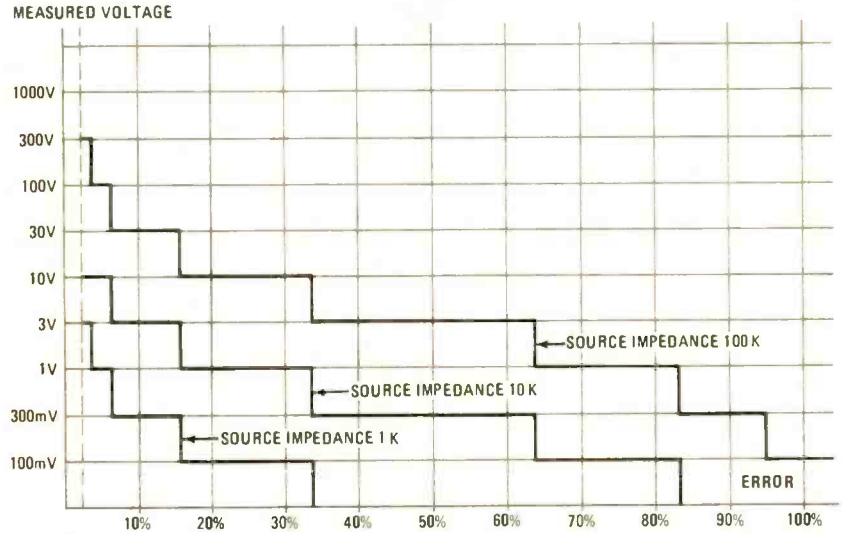


FIG. 7—HIDDEN ERRORS caused by the 20K input impedance of a conventional multimeter loading the circuit under test can build up to very high levels. Modern multimeters have input impedances of 10 megohms, eliminating the loading problems.

measurements there hardly seems any need for a multimeter, a simple voltmeter should do the job. But there are obviously many occasions when other measurements have to be made—typically checking resistors on one of the circuit boards.

Resistance measurements are also useful for locating faulty semiconductors. With the increasing use of solid-state circuitry, much of it still discrete components, it is useful to be able to check diode junctions in suspect transistors. A simple forward and reverse junction measurement gives a fast qualitative check on the transistor condition, when a transistor tester is not readily available.

The meter you select should also have a high input impedance if you want accuracy figures to mean anything. Any instrument added to a circuit is going to influence that circuit due to its loading. A conventional 20,000-ohm input can lead to quite serious errors depending on the resistance of the source being measured. Figure 7 gives some idea of the extent of these hidden errors.

High input impedances—around the 10-megohm mark—are possible with digital multimeters as they are in TVM's and FETVM's. The use of LSI circuitry makes high input impedances economical.

Another advantage of LSI is that it often makes it possible to extend the facilities of the multimeter. Typical is

FIG. 8—GOOD CLEAR PRESENTATION of results makes a meter easy to use. So it is worth looking for a meter that uses the minimum of scales. The use of linear resistance-measuring circuits helps presentation as well.

FIG. 9—EVEN THE BEST cared for service instrument sometimes slips, or is knocked against a tool. Some sort of protection—such as the rubber rings mounted on this meter—are useful.

the addition of temperature measurement. Checking the temperature of transistors often helps localize the area of a circuit fault. Measurements of voltage levels, currents and resistance in the neighborhood of the "hot" transistor will then pinpoint the faulty component.

Easy to use

An important aspect of any service instrument is how easy is it to use. A typical multimeter is going to be used to carry out a variety of measurements at the same time. So changing leads every time you change from voltage to resistance, can be time consuming—and annoying. So it is worth looking for an instrument that uses one set of leads for the majority of measurements.

The meter readout is important too. The average multimeter has a plethora of scales in different colors and different positions. It is worth looking for a meter

continued on page 88

Improve INSTALL

To get the best possible recep where the signal is—up high. to installing antenna towers

SOME ANTENNA INSTALLERS AVOID TOWER installations. They believe them to be expensive and time consuming, and to require a great deal of skill. Actually, the new TV/FM antenna towers are relatively inexpensive and easy to put up. The average tower can usually be installed in two man-hours, once you get the hang of it.

Towers get the antennas up high, where the best signals are. They cause no roof damage. They help protect the antenna from damage by corrosive chimney fumes. Towers can easily be climbed for servicing the antenna, the downlead, the rotator or the preamp.

Two basic types of towers are available: self-supporting and bracketed. As the name implies, self-supporting towers can stand alone. Since they require a concrete base, self-supporting towers take longer to install. Generally, they are for people who want the installation away from the house or for people who object to attaching the tower to the house.

Most people prefer bracketed towers. These are easier to install. This article illustrates the step-by-step procedures for putting up a bracketed tower.

Step 1—Prepare the ground.

The baseplate must rest on flat, solid ground. Use a spade to clear away grass. Make sure the baseplate rests flat on the ground, as shown in Fig. 1.

Step 2—Assemble 2 or 3 sections.

When installing bracketed towers, it's a good idea to get the bracket up as high as possible. Therefore, you want to pick the highest convenient point on the house.

Assemble enough tower sections on the ground to reach that point. Since each tower section is 8 feet, two or three tower sections are almost invariably enough.

*Staff Engineer, Jerrold DSD Division

Use the bolts, nuts and lockwashers supplied to fasten the sections together securely (see Fig. 2).

FIG. 1—LEVELING THE BASEPLATE makes a good foundation for the whole job.

FIG. 2—SECTIONS ARE FASTENED, preferably on the ground before raising.

Attach the baseplate to the bottom of the tower, as shown in Fig. 3.

Assemble the house bracket and attach it to the tower (see Fig. 4) in approximately the right position with the nuts finger-tight. (With the nuts this loose, the bracket will stay in place, but you can slide it up and down on the tower to find the correct position, once the tower is against the house.)

Step 3—Fasten bracket and base plate.

Use a ladder. Put the baseplate on the spot prepared in Step 1 and lean the tower against the house. Then climb the ladder and fasten the house bracket in

FIG. 3—BOLTING THE BASEPLATE to the legs of the tower.

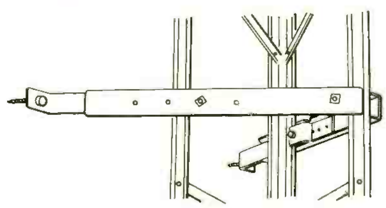


FIG. 4—DETAIL OF HOUSE BRACKET.

TV Reception— A TOWER

tion, the antenna must be Here's a step-by-step approach to gain the necessary height

JERRY SCHWARTZ*

place with two ⅜-inch lag screws into the side of the house.

Be sure the lag screws bite deep into solid wood. Otherwise, the tower may fall, damaging the house. Remember, the tower installation is only as solid as the bracket itself.

If you must fasten the house bracket to a part of the house with an overhang, attach a 3- or 4-foot 2 by 4 to the soffit. Then, screw the bracket to the 2 by 4 as shown in Fig. 5.

Once the house bracket is firmly in place, use a level to make sure the tower is vertical (see Fig. 6). Finally, drive three 3-foot base stubs into the ground, to hold the baseplate firmly in place, as shown in Fig. 7.

Step 4—Add tower sections.

Once the baseplate and house bracket are firmly fastened in place, you have a solid base from which to work. You don't need a ladder any more, because you can climb the tower.

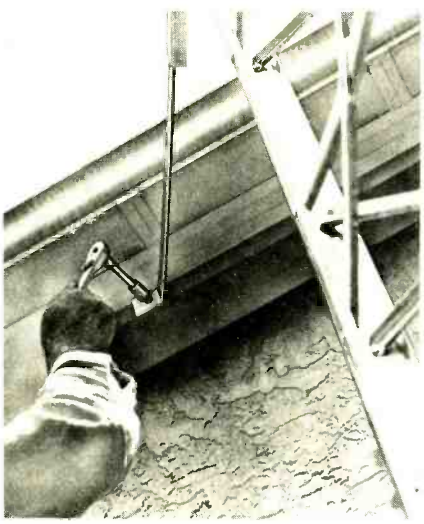


FIG. 5—BRACKET MUST BE FASTENED securely to a solid part of the house.

When you climb a tower, be sure to use a safety belt. With the safety belt attached to the tower at all times, it is impossible to fall. Be sure the belt runs through the tower, not around it.

FIG. 6—CHECK FOR VERTICAL orientation with a spirit level or a plumbline.

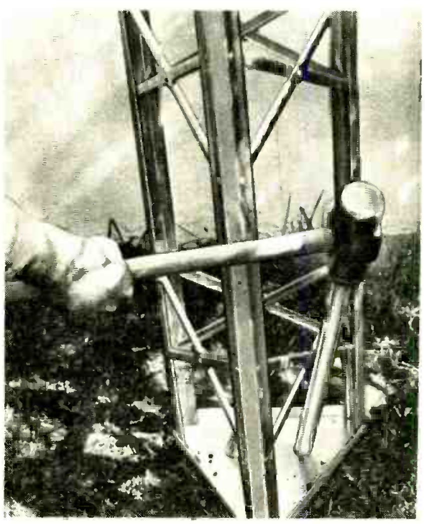


FIG. 7—THREE-FOOT BASE STUBS hold the baseplate firmly in place.

One-man installation is easy. Just use a long rope with a hook on the end of it. Climb to the top of the tower. Fasten your safety belt securely and hook your leg around the tower for added support. Then, lower the hook, snag one of the tower sections, pull it up and lower it into place. Two-man installations are easier and save time. (One man on the ground, one on the tower.)

Once the new section is in position secure it in place with bolts, nuts and lockwashers.

Additional sections can be added in exactly the same way. Be sure to prepare all sections on the ground within easy reach of the rope and hook so you don't have to climb up and down the tower between sections.

Step 5—Attach the rotator

The top section of the tower comes complete with a baseplate, a top plate and a unique mast thrust bearing (see Fig. 8). Most rotators can be attached easily to the baseplate, using an 8-inch piece of mast and the U-bolts supplied. CDE *model AR-30* and Channel Master Rotators can be attached directly to the L bracket. CDE *models AR-33* and *AR-40* are mounted to the baseplate, using ⅜-inch hex nuts as spacers between the rotator and the tower rotator baseplate.

In every case, the rotator fits inside the tower and the mast thrust bearing supports virtually all the weight of the antenna. This lengthens the life of the rotator considerably, and helps it to work more smoothly.

Attach the rotator to the top section of the tower (with rotator wire connected) before it is raised into place.

Step 6—Install the antenna

On the ground, attach the antenna securely to the mast. Unfold all

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Attach the lead-in wire securely to the antenna terminals and then raise the antenna and mast into place.

Lower the mast through the thrust bearing into the rotator. Then orient the antenna (as per the instructions of the rotator manufacturer) and tighten the mast into place.

If a rotator is not used, simply skip Step 5. Secure the mast to the tower base and top plate, using the L-brackets and U-bolts supplied.

FIG. 8—THE TOWER'S TOP SECTION is equipped to hold a rotator, if needed.

Step 7—Run wires down the tower

As explained in previous steps, the antenna lead-in and rotator wires should be attached in advance. They can be run down the tower easily.

Use low-loss coaxial cable for all tower installations. The coax cable and

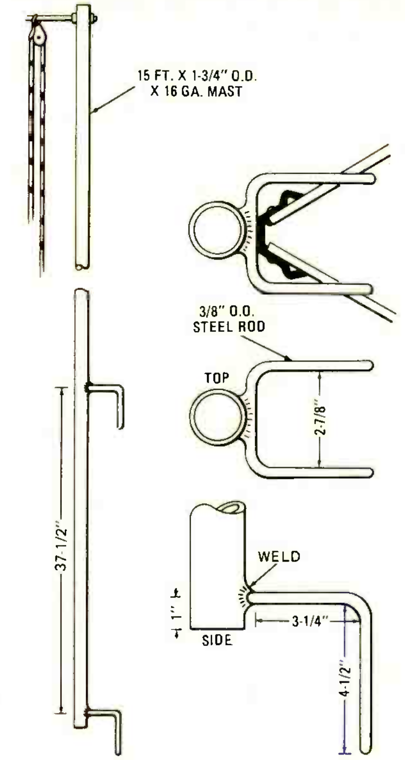

FIG. 9—HOW TO MAKE A GIN POLE that simply slips over the cross-braces.

the rotator wire can easily be taped into opposite grooves of the same tower leg with waterproof tape.

If you do decide to use twin lead, attach wrap-around standoffs to one of the tower legs. Space the standoffs 6 to 8 feet apart and avoid touching metal with the twin lead.

Gin poles

If you plan to install many towers, a gin pole is a very handy accessory to have. You can use it like a crane to lift sections into place. The gin pole relieves strain on the installers arms.

Figure 9 shows how to make a gin pole from a mast and some steel rod. (Figure 9 shows 1¾-inch O.D. mast, but 1¼-inch will do the job.)

Hook the completed gin pole to the top of the tower at the **X** braces. Attach the rope that runs through the pulley to the next tower section, about a foot above the middle. Pull the section up and guide it into place on the top of the section on which you are standing.

Once the new section has been bolted securely into place, you can unhook the gin pole, climb the new section and hook the gin pole in place to haul up the next section.

Alternate installation method

Another method of erecting a tower works very well, but takes two men.

The tower is completely assembled on the ground. One man climbs a ladder to the roof, with a rope. The other man stays on the ground. The man on the roof pulls the tower up, using the rope, and the man on the ground pushes, until the top of the tower is resting against the edge of the roof. The tower is held in place temporarily by a safety rope.

Then the man on the roof attaches the antenna and mast to the tower.

Finally, the two men position the tower vertically and secure it in place, using the house bracket and base stubs driven through the baseplate.

So putting up a tower is not as hard as you might think! With a little practice, you can put up even a tall tower with amazing speed, whether you do it alone or have someone to help. **R-E**

Personal-computer gear feature of new store in Boston

A personal-computer user show was the main feature of the recent opening of the Computer Warehouse Store in Boston, MA. Selling used computers and computer accessories of all types (including equipment that originally sold for $100,000 alongside of simple $25 power supplies), the new store attracted customers and hobbyists from several States.

One enthusiast, Bill Walde, the first president of the N.E. Computer Society, had two systems with him. He had built one himself from plans published in an electronics magazine—the other was one of the most sophisticated of the microcomputer kits available at the store.

Robert Tripp, publisher of the only New England magazine in the computer hobby field, demonstrated one of the smallest and cheapest microcomputers that can still handle applications like checkbook checking.

According to the Computer Warehouse Store, hobbyists now have 103 clubs, of which the Southern California Computer Society, alone, has 6,000 members. Now, there are more than 80 stores devoted to the computer hobbysist, as compared to none a little more than a year ago.

The grand opening of the Boston establishment ran for two days with a total attendance of more than 2,350, and during which prizes were given away every hour. A grand total of $100,000 (original value) worth of equipment was given away.

George Bailey dies at 89 was world's No. 1 amateur

George F. Bailey, who for 12 years was president of the American Radio Relay League and the International Amateur Radio Union—the world's leading "ham"—died December 19 at the home of his daughter in Nashville, TN. He was 89 years old.

In his business life as a manufacturer of floor coverings, Dr. Bailey had been an ardent amateur, and for 12 years was the contact to the Grenfell Mission in Labrador, maintaining schedules every morning. When he retired in 1937, he became more active, and in 1935 was the first American amateur to contact Europe on 5 meters, as well as the first to work all States on single sideband. He was division director, national vice president, and in 1940 became president of the American Radio Relay League, holding the office until 1952.

In 1941 he was called to Washington to recruit an electronics training group under the National Defense Council. The following year he was appointed chief of the scientific personnel office of the Office of Scientific Research and Development.

In 1945, Dr. Bailey became executive secretary of the Institute of Radio Engineers (IRE), a post he held until the IRE merged with the AIEE to become the Institute of Electrical and Electronic Engineers in 1963. He became the Institute's Executive Consultant until 1966.

Dr. Bailey was a graduate of Harvard (1907) and received a D. Sc. from Lawrence College in 1958. He was a Fellow of the IRE and received its Distinguished Service Award in 1962. Previously he had received the Certificate of Merit from President Truman for his contribution to the American war effort. An honorary member of the Veteran Wireless Operators Association, he was awarded its Marconi Medal of Service. A charter member of the Armed Forces Communications and Electronics Association, he was its president 1954-56. **R-E**

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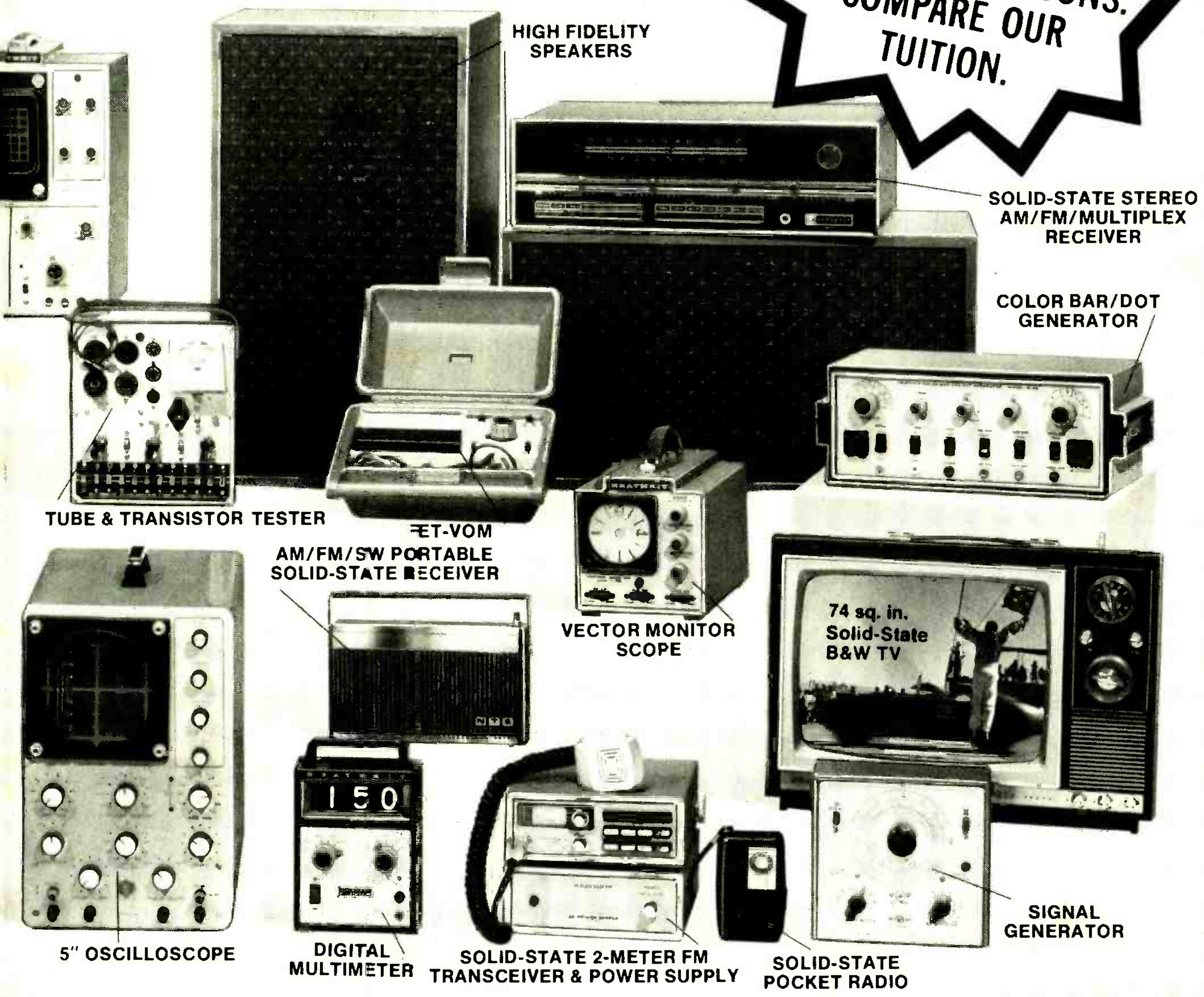

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R-E's Service Clinic

High-voltage hold-down

The high voltage, the DC and the hair-trigger shutdown

JACK DARR
SERVICE EDITOR

SINCE THE ADVENT OF SOLID-STATE TV circuitry, we have seen the introduction of a *few new HEW circuits* (sorry about that)—all of them aimed at preventing the high voltage from going too high. Unlike the original high-voltage regulators that simply loaded down the high voltage itself, these circuits work on a different principle; most of them use redundant regulators. There are several of them, in all parts of the chassis, all doing the same thing.

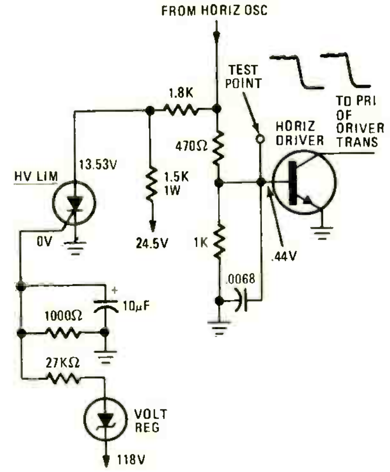


FIG 1

One is a "shut-down" circuit that kills the high voltage by grounding the DC voltage supply to the horizontal oscillator or driver stages. It is usually like the circuit in Fig. 1. An SCR is connected across the 118- and 24.5-volt DC lines feeding the horizontal stages. It is gated on by the output of the horizontal circuitry. If the 118-volt line rises too high, the SCR fires and the horizontal drive is removed, shutting down the horizontal output stage. There are many variations; one senses the actual beam current of the picture tube. It is in series with the "bottom end" of the high-voltage supply.

However, this article deals mainly with another regulator—this one is in the "primary" DC supply circuits. In all sets using scan-derived DC voltage supplies, the horizontal oscillator, driver and horizontal output stage must get DC voltage as soon as the set is turned on. This is done by rectifying the AC line voltage, filtering and feeding it through a voltage-regulator circuit. Typical output will be about +120-volts DC. A partial circuit of this type of regulator is shown in Fig. 2. This one is used in Sylvania's EO-4 chassis.

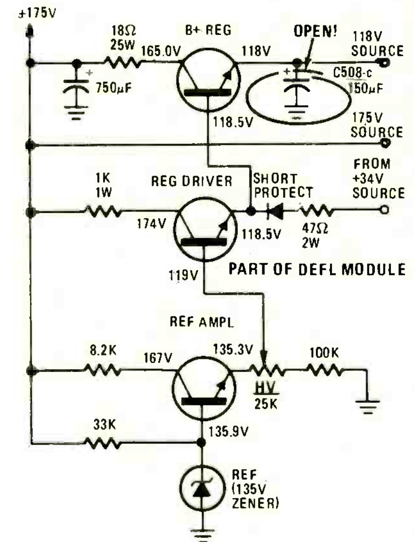


FIG 2

In all of these sets, the high-voltage output is *directly* proportional to the DC voltage output of this regulator. So, if this DC voltage rises 10%, so does the high voltage. When the high voltage reaches an unsafe level, the high-voltage shutdown circuit, which is completely *separate*, shuts down the horizontal stages and the set. This action is quite fast, and sometimes hard to catch!

As in all circuits, increasing the complexity increases the difficulty of diagnosis. However, there is one key test point that should always be checked first: primary +120-volt DC supply voltage. If it is not right on the button, you'll have problems and no clues. So let's look at a couple of real cases.

In a Sylvania EO-4 chassis there was a wild variation of high voltage when the brightness control was turned up or down. Turning the brightness control to minimum raised the high voltage so far that the high-voltage shutdown turned the set off. During tests with brightness set near normal, the AC line voltage was varied from 90 to 120 volts, and the +120-volt line stayed very close to normal. (This led us somewhat astray.) However, when the brightness control was turned down, the +120-volt line *rose* and the shutdown tripped.

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

After much testing and checking, we finally found the cause. It was an *open* filter capacitor—150-μF C508-C on Sams Photofact sheets—on the +120-volt output of the regulator. The actual mechanism of this fault hasn't been analyzed yet, but replacing this capacitor cleared up the problem. For a crystal-ball guess, the open capacitor reduced the ability of the regulator to hold the output voltage steady by taking away the reservoir effect of a filter capacitor.

In another case with similar symptoms (a Packard-Bell 98C38 chassis), a small surge resistor in the AC input was found open. Replacing it made the set work, and it was returned. Back again three days later, just quit. This time the +120-volt DC supply measured +150 volts. However, the set would run until the brightness control was turned down. The +120-volt regulator seemed to be the obvious cause. Detailed checking in this circuit produced the following:

1. The high voltage reads 29 kV at full brightness. Turning the brightness down, it rises to 41 kV and the shutdown trips.

2. The +120-volt output of the regulator is +150 volts. So it is the most likely cause: check regulator circuitry.

3. The pass transistor Q901 is shorted base-to-emitter (see Fig. 3): replace it. Performance gets a little better, but the high voltage still goes to 35 kV with brightness down. (There's some improvement, but not enough.)

4. Check Q602, the regulator control. Then, if the collector-emitter junction is open, replace the transistor. Problem solved? Not yet. Q602 is running much too hot, and the DC voltage isn't correct.

5. Check bias on Q602. The base voltage is way off. Suspect SR602, the 123-volt Zener diode, 2%, bias clamp for Q602. (No tests needed: case of SR602 is blown apart. Replace.)

6. Turn on. Reset current-limiter for +120 volts. The high voltage now is 23.5 kV, both high voltage and DC voltages are now steady. Uncross your

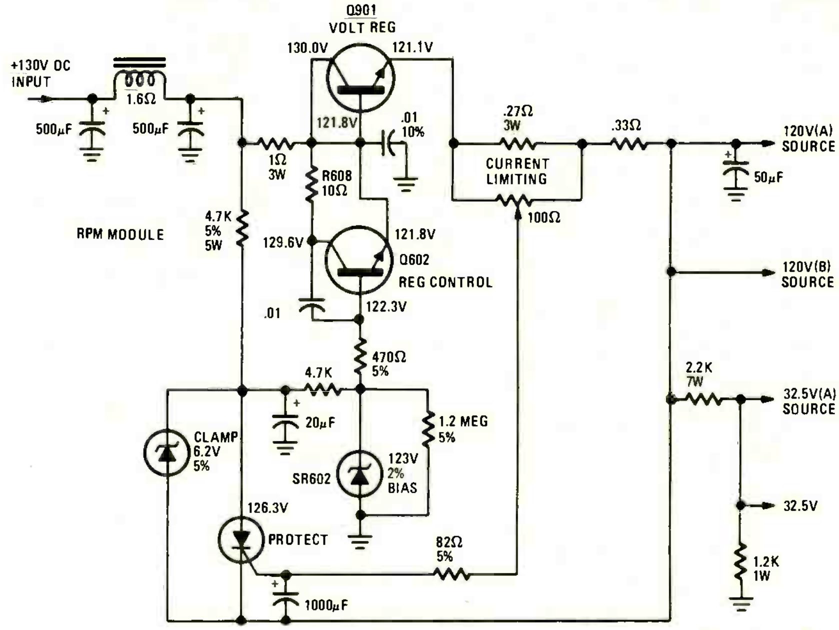


FIG 3

fingers, and watch it for a while. Works very well.

(Thanks very much to Joseph Rotello of Communications Services, 5801 E. 22d St., Tucson, AZ for this skillful and detailed analysis, which was copied almost verbatim. This is a perfect example of what I was (and am) going to suggest for the conclusion of this Clinic. When you find any problem with similar characteristics, be sure to check this primary voltage regulator circuit *first*. Second key point, *don't stop* when you find the first faulty part. Check all stages and make sure that they are working properly, with no damaged parts.)

The key clue here, and in all of these circuits, is in the reactions of the +120-volt DC supply. It *must* be tightly regulated to hold this voltage at the right level. If it won't, everything will be fouled up for three feet in all directions. Example: A Truetone had odd color problems. I found a bad pass transistor in the regulator without too much trouble, but it took me too long to find that the error-amplifier transistor was also bad.

The chances for catastrophic failure in these circuits are the same as in any transistor circuit. They use a high degree of direct coupling, making "domino failures" that much more likely. You can see this in the Packard-Bell circuit of the last case. The chain reaction started at the high DC input to the regulator, and went all the way through to ground, demolishing parts as it went. Be sure to check all resistors, diodes, etc. in the bias networks.

In these two cases, the main fault was in the low-voltage primary regulator. However, the redundant high-voltage shut-down stage was still working normally. This circuit too can cause similar problems, so don't overlook it. It may be a little eager, and trip too soon.

This turned up in an early version several years ago. It used an SCR, that fired whenever the brightness control was moved in either direction. We finally had to get a specially-selected SCR from the factory to make it work as it was intended to. So, keep an eye out for "hair-trigger" units, that fire when they really shouldn't. It can happen and cause you to waste a lot of time. **R-E**

reader questions

TUNER DRIVE MOTOR BURNS UP

The tuner drive motor in this RCA CTC-68 burned up. The new motor starts to run just as soon as the set is on. The tuner doesn't move! The motor shaft snaps in and it turns, but stops in a minute; you can hear it humming, and it gets hot. What's causing this?—J.H., Homestead, FL.

Well, you may have two problems. It sounds as if the tuner is *stuck* and jamming the motor. The other problem could be a shorted triac, which controls the motor. The motor shouldn't start to run as soon as power is turned on. Try disconnecting the gate lead of the triac (pin 2); if the motor keeps on trying to run now, the triac is probably shorted. (This could be due to the heavy current drawn if the tuner *is* jammed. Could have blown the triac as well as the original motor. Make sure the tuner is free to turn.)

LOST COLOR

I fixed a couple of things in this CTC-36 RCA and now I have no color; just red and green rainbows. All of the DC voltages, etc., seem to be close, and tubes good by substitution. Where to go?—G.B., Seattle, WA.

If you do have colored rainbows, this usually means that the bandpass amplifier stages are working. No color sync, though. Check the burst amplifier stage, the transformer and the 3.58-MHz oscillator stage. I've found similar problems due to an open lead on the burst-amplifier transformer, etc.

(Feedback: Whee! That did it. One of the leads on the burst amplifier transformer was loose!)

THERMISTOR BURNING

When I opened up this E0-2 Sylvania, it was shut down. I pushed the circuit breaker and the fire flew! Literally! The thermistor in the input was melting. I changed it and the new one burned up, too. So, I changed it again and replaced the varistor too, and the same thing. Explanation?—G.B., Seattle, WA.

This is the thermistor in the degaussing coil circuit. If you have a big fat short in your DC power supply, for instance a shorted diode, you'll get a terrific current through the thermistor. Check the DC power supply for grounds or bad diodes.

(Feedback: That's a good explanation, all right! One of the diodes in the DC power supply had a dead short!)

WEAK VIDEO

I have several problems in an RCA CTC-25. The video is weak, there are retrace lines and I have bending in the picture. The raster is full. I read +300 volts on both plate and screen of the 6LF8 1st video amplifier. The grid voltage is off, too. What is this?—M.G., Woonsocket, RI.

The key clue here is the very high DC voltage on the 1st video amplifier. If the plate and screen voltages are the same, the stage isn't conducting at all. It appears that the video signal is leaking through the interelectrode capacitance of the tube. This is causing the retrace lines and probably the other problems due to the lack of a proper video signal on the AGC, sync, etc. Check this stage; the cathode circuit may be open.

HIGH-VOLTAGE DROPS

Here's an unusual problem. In this Sears 564-80161 chassis, the high-voltage drops after a couple of minutes, but the cathode current of the 31JS6 goes away up. I substituted all the tubes in the circuit. Now, here's the fun: If I plug the chassis into a variable-voltage line transformer and reduce the line voltage to about 100 volts or less, the current decreases and the high-voltage increases. During this time, the B+ voltages show little change. Any bright ideas?—G.P., Miami, FL.

Here's one based on previous experience with a similar circuit. Check the *diode* in the heater circuit of these tubes. You may find that it is leaking. You said "the heaters of the tubes are fed with a negative DC supply." This isn't precisely true. The diode in the heater circuit is a *dropping diode*: the tube heaters are fed half-wave rectified AC. So if the diode is leaking, you will get quite a little bit *more* heater voltage; this will

R-E TESTS KENWOOD

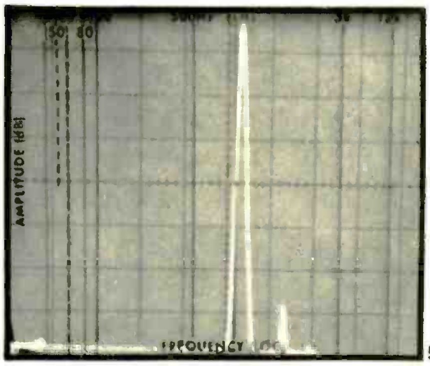
continued from page 57

with readings of nearly 40 dB obtained even at the high 10-kHz test frequency. The oscilloscope photo of Fig. 4 shows the de-emphasis characteristics of the tuner section, with the upper trace corresponding to the 25-μs position of the de-emphasis switch and the lower trace corresponding to 75-μs de-emphasis. The center-of-channel meter was perfectly aligned to indicate precise tuning at the minimum distortion points in both FM and stereo-FM reception.

Amplifier and preamplifier measurements

Amplifier, preamplifier and control-section measurements are summarized in Table II. The power-amplifier exceeded its output and distortion ratings by a wide margin, both at mid-frequencies and at the low- and high-frequency extremes. Had Kenwood been less conservative, they could have easily rated this receiver as an 85 watts-per-channel unit or, they could have extended the quoted FTC power bandwidth from 15 Hz to 30 kHz—the frequency limits for which the full 80 watts-per-channel output power was delivered at the rated harmonic distortion of 0.3 percent. As things stand, the amplifier had a harmonic distortion of only 0.07 percent at its rated output using a 1-kHz test signal. This decreased to 0.03 percent at the 1-watt power level, with no evidence of rising distortion at even lower power levels that might have been evident if there was significant crossover or notch distortion in the amplifier design.

The phono-input stages were able to handle input signals as high as 185 mV before exhibiting overload distortion, and



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signal-to-noise measured 78 dB. Bearing in mind that Kenwood specified 75 dB using A-weighting, the 78-dB figure we obtained was unweighted and referred to an input sensitivity of 2.5 mV.

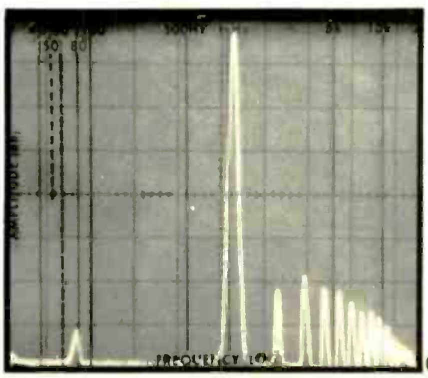

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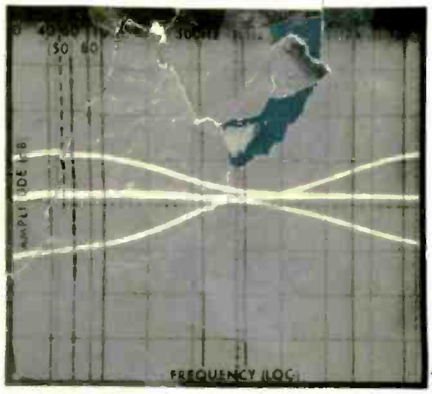
Figure 5 is a spectrum analysis of a 1-kHz output signal at the rated 80-watts-per-channel level (8 ohms, both channels driven). Harmonics seen to the right of the fundamental 1-kHz peak consist primarily of some second-order and, to a lesser degree, third-order components. We drove the amplifiers hard into clipping and again swept through the audio range from 20 Hz to 20 kHz, using the spectrum analyzer. In Fig. 6, we see the expected increase in the third harmonic, as well as progressively diminishing higher-order harmonics.

The tone control range of the BASS and



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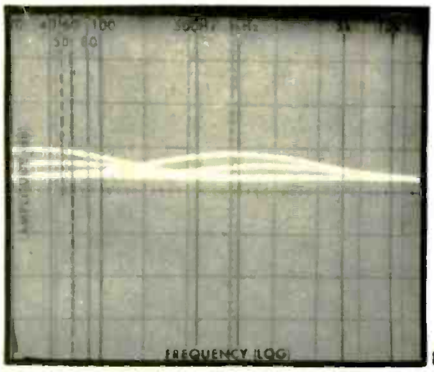
TREBLE controls of the *KR-7600* is more moderate than on some receivers we have measured, with around 8 dB of boost provided at 100 Hz and 10 kHz, as specified by Kenwood (see Fig. 7). Actually, the need



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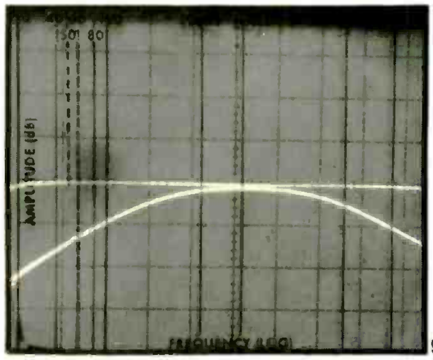
for greater boost in one's system would only suggest that something is mighty wrong with some other component, and Kenwood was wise to keep the range within these bounds. Many newcomers to hi-fi tend to over-boost



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lows and highs, which often results in amplifier clipping and overload at those frequency extremes.

Of particular interest were the extra ACOUSTIC controls mentioned earlier. The raise the cathode temperature of the 31JS6, 6BK4 and other tubes. When you reduced the line voltage, the heater voltage of the tubes went back to about normal.

Incidentally, there are several sets that started out using this type of circuit. Most of the newer ones have dropped it. The makers recommend replacing the dropping diode with a plain old-fashioned resistor of suitable value and wattage to give the tubes the correct heater voltage.

V[illegible]ICAL PROBLEM

This Ze[illegible]C31 has an intermittent loss of ve[illegible] I have changed tubes and c[illegible] parts with no luck. Where should [illegible] now?—J.S., Coshocton, OH.

One good place to look would be in the vertical size and linearity controls. Sometimes they develop a bad contact under the slider, especially if the control hasn't been moved for quite a while.

(Feedback: "You're right. There was a bad vertical-linearity control in it. Someone had shoved the wrong tool in and broke it. A new vertical linearity control fixed it up.")

GREEN FLASHES

There is an intermittent problem in this Zenith 19DC21. It has green flashes on the screen, and once in a while the whole picture will go green. Happens so fast I haven't been able to get a check. Could this be the picture tube?—J.L., Gonzales, CA.

Possibly. However, there are several things I'd check first. For one, it could be a bad G-Y amplifier transistor. Try exchanging the green-output transistor with one of the others and see if your problem changes color.

(Feedback: "Your idea was right on. I swapped the red and green amplifier and then the screen had red flashes. Leaky transistor.")

HORIZONTAL BAR

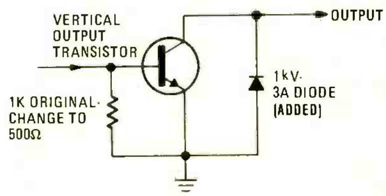
There is a horizontal bar across the center of the screen in this Sylvania E02-1. It is due to stretching of the scan at this point—the lines are too far apart. The odd thing is that if you roll the picture down with the hold control, the bar stands still. I thought I'd seen everything, but I hadn't.—G.D., San Juan Capistrano, CA.

I don't think any of us has seen everything. Anyhow, I know I haven't. One very likely cause for this would be a problem in the pincushion-corrector circuitry, since this can affect the scan. One of the resistors shunted across the pincushion coils may have changed value. Check this.

(Feedback: "That was it. R377 had changed to about 500 ohms. Replacing it made everything just fine.")

PREMATURE TRANSISTOR FAILURE

I have run into several of these Sylvania E02-1 chassis that knocked out the vertical-output transistor every 3–4 months. I made the following changes (see diagram) and haven't had a



problem since.

My thanks to George Dyer, consultant, San Juan Capistrano, CA, for this one.

PICTURE POPS IN AND OUT

The picture pops in and out on this RCA CTC-28. What shall I do?—S.C., Mentone, CA.

Substitute a signal from a working TV, check AGC and all that. (First answer)

I gave you the wrong symptoms. The picture pops in and out of focus. Sorry about that!

That's OK. Check the focus rectifier, transformer and circuitry.

(Feedback: "That was it; arcing in the focus transformer.") **R-E** response of each of the fixed boost positions of these two extra controls is shown graphically in the scope photo of Fig. 8. The low-boost control was particularly effective in adding that extra amount of emphasis to the lowest octave of audio when using less-than-perfect speaker systems, while the midrange boost positions acted much like a two-step "presence" control and will lend extra sense of presence to vocal program materials.

Filter responses are shown in the scope photo of Fig. 9. The 6 dB-per-octave roll-off rate render these filters only moderately more useful than the tone controls, though the maximum attenuation provided at the frequency extremes are somewhat greater than could be achieved by full counterclockwise rotation of either the BASS or the TREBLE controls.

Summary and listening tests

Our overall summary product analysis of Kenwood's *KR-7600* together with comments regarding its design and performance will be found in Table III. While many hi-fi component manufacturers content themselves with cosmetic changes alone when introducing a "new" line, Kenwood has gone further and truly redesigned their receiver line from the inside out—judging by this model. Workmanship is excellent, and the choice of components used seems geared towards long-term durability and reliability. **R-E**

More shows and conferences for the computer hobbyist

The magazine *Personal Computing* is sponsoring three computer conference-shows this Spring, and is planning more for later in the season.

The Western Personal Computer Show is on March 19 and 20, in Los Angeles, the Eastern show May 7 and 8, in Philadelphia and the New England show June 18 and 19, in Boston. Exhibitions, seminars and special presentations, and tutorial workshops will be featured at all the conferences.

Special areas of the exhibition halls are being set aside for personal computing in education, in the home, in ham radio and in small businesses.

Later shows are being planned for the South, Southwest, Canada and Europe.

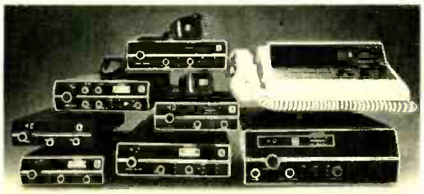
NEW MEXICO JOINS NESDA

NEW MEXICO ELECTRONIC SERVICE ASSOCIATION receives 34th NESDA State Affiliate Charter. Receiving the NESDA charter is Arlin Pennington, president. The occasion is the quarterly Board of Directors meeting, held at the Clovis Country Club in Clovis, NM.

new products

More information on new products is available from the manufacturers of items identified by a Free Information number. Free Information Card follows page 98.

40-CHANNEL CB TRANSCEIVERS. The *4000 series* provides a complete range of 2-way 40-channel radios. Phase-lock-loop circuit is a single IC made especially for the manufacturer.



All units have large LED channel display with automatic brightness control for easy readability. The new radios include six mobile and two base stations. The *Messenger 4120, 4140, 4145, 4170, 4175, 4230, 4250* and the *Viking 4740*. For the CB'er demanding maximum performance, the *Messenger 4175* features dual crystal filtering for adjacent channel noise rejection, a noise blanker, automatic channel brightness control and local/normal/extended control circuitry at $249.95.—**E.F. Johnson Co.,** Waseca, MI 56093.

CIRCLE 77 ON FREE INFORMATION CARD

DIGITAL MULTIMETER, *Model 3435A* is a $3^1/_2$-digit unit that has a 'Touch-Hold' Probe available as an accessory. It permits the user to 'freeze' the reading on the display. Intended for both bench and field use, the unit is autoranging on AC and DC volts and resistance. AC and DC current ranges are selected manually. Lighted front panel indicators display the function and its units. The digital multimeter covers a DC measurement range from 200 mV full scale to 1200 V full scale with a midrange accuracy of ±(0.1% of reading + 1 digit).

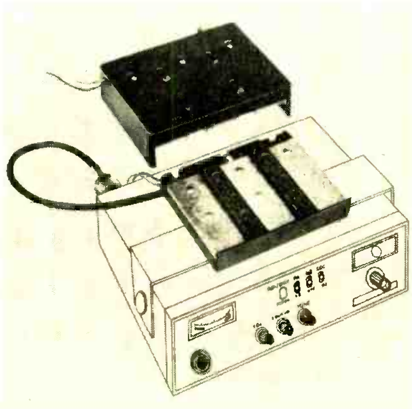
AC measurement range is 200 mV full scale to 1200 volts RMS full scale with a midrange accuracy of ±(0.3% of reading + 3 digits) over a 30 Hz to 100 kHz bandwidth. AC current measurements are made over a frequency band of 30 Hz to 10 kHz with a midband accuracy of (1.7% of reading + 4 digits). Resistance range is 10 milliohms to 20 megohms with a midrange accuracy of ±(0.2% of reading + 2 digits). Open circuit voltage on the ohms terminal when set to its lowest range does not exceed 5 volts, preventing damage to most solid-state devices.

Input protection is provided to 1.2 kV on any DC range, 1700V (DC + peak AC) on any AC range, and 250V RMS on any resistance range. A front-panel fuse protects the instrument from overload when measuring current. Two power supplies available: Internal AC and rechargeable lead acid batteries. Price: $400 with rechargeable batteries; $335 AC only; $40 'Touch-

Hold' probe; $87 RF probe; $75 high-voltage probe.—**Hewlett-Packard Co.,** 1501 Page Mill Rd., Palo Alto, CA 94304.

CIRCLE 78 ON FREE INFORMATION CARD

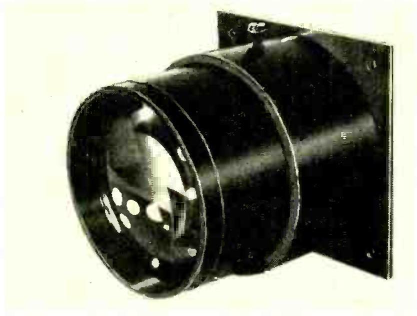
MAGNETIC CB RADIO MOUNT is especially designed for two-way communications equipment. The *"Easy Mount"* uses three permanent magnets to make positive contact, assuring maximum signal transfer with perfect VSWR match. The unit can be installed under the dash or on the transmission hump. All necessary hardware and instructions are included. Addi-



tional optional top sections permit the user to transfer the transceiver from vehicle to vehicle or to a boat, trailer, office, or home. Weight, 1.25 pounds; Profile, 1$^1/_8$ inch; Mounting Area, 4$^3/_8$ inches wide by 3$^1/_4$ inches deep.—**Cornell-Dubilier Electronics,** 150 Avenue L, Newark, NJ 07101.

CIRCLE 79 ON FREE INFORMATION CARD

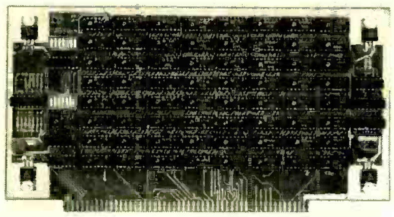
PROJECTION TV LENS, new f2.8 especially designed for large screen television viewing.



The lens is 5 inches in diameter with a focal length of 12 inches and is finished in anodized gold. Supplied with a mount, the lens is $195.00.—**Miami Projection TV,** 304 N.E. 79th St., Miami, FL 33138.

CIRCLE 80 ON FREE INFORMATION CARD

8K RAM BOARD, *Model MB6* is Altair, IMSAI plug compatible. Uses low-power, 500ns, static RAM's and low-power Schottky support chips.



Memory protect feature can be set in blocks of 256, 512, 1K, 2K, 4K and 8K bytes. This allows the user greater flexibility and ease in programming. An additional RAM is used in the memory protect circuit. Assembled, $295.00; as an 8K kit, $250.00. The 4K kit is available for $169.00.—**Solid State Music,** 2102A Walsh Ave., Santa Clara, CA 95050.

CIRCLE 81 ON FREE INFORMATION CARD

LEAD-FREE FLUX-CORE SOLDER, *model Silver Solder 96S,* has been specifically formulated for soldering requirements where it is necessary to

use a lead-free solder, where high service stresses and temperatures exclude the use of other soft solders and for stainless steel. *Silver Solder 96S* can be furnished either with a non-

CIRCLE 73 ON FREE INFORMATION CARD

corrosive rosin based 5-core flux for electronic applications or with a 4-core acid flux for mechanical joining applications. It is also available as a solder cream.—**Multicore Solders,** Dept. D, Westbury, NY 11590.

CIRCLE 82 ON FREE INFORMATION CARD

MICROCOMPUTER SYSTEM, *Expanded-68,* based on the Motorola/AMI/Hitachi 6800 microprocessor chip set. Comes complete with 8K of memory, power supply, 16-digit keyboard, TCC3 adapter, hexidecimal LED display, expansion cabinet, 36-pin edge connector, and *Mik-bug.*

Also available for direct interfacing are: dual floppy disc drive, IMP-1 printer, 132-column printer, TV interface, and full ASCII keyboard.—**Electronic Product Assoc., Inc.,** 1157 Vega St., San Diego, CA 92110.

CIRCLE 83 ON FREE INFORMATION CARD

REMOTE CONTROL HEAD, *Model 100RC,* allows remote power level control of linear and bi-linear amplifiers used with amateur transceivers. Indicator light and power level control knob enable the operator to visually monitor modulation and adjust for optimum RF output while minimizing signal distortion and disturbance to other channels. Designed for use with

most major brand linear amplifiers, the unit permits installation of an amplifier in an auto trunk or other secure area.—**Power Plus,** 16255 Ventura Blvd., Encino, CA 91436.

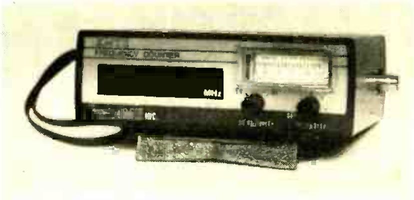
CIRCLE 84 ON FREE INFORMATION CARD

40-CHANNEL CB TRANSCEIVER, *Model Lion 40* is a deluxe full-feature set with LED channel read-out, HetroLock™ circuitry and 3-position

frequency variance capacity. HetroLock uses three crystals to keep the unit on precise FCC frequencies. Receiv-O-Slide™ varies frequencies about 1 kHz to pull in other stations operating slightly "off frequency", but this special tuning does not affect the transmitter's precision. Integral SWR/CAL/RF/S meter, CB monitor switch and volume control power switch. Transmitter operates in either positive or negative ground in cars, boats, trucks and recreational vehicles. $249.95—**Pearce-Simpson,** 4701 N.W. 77th Ave., Miami, FL 33166

CIRCLE 85 ON FREE INFORMATION CARD

FREQUENCY MEASUREMENT SYSTEM, *model FC200B,* gives 7-digit accuracy from 0 to 200 MHz in a completely portable unit designed for use with VHF two-way communications equipment. The built-in field strength meter allows simultaneous checks on transmitter frequency and radiated signal-strength patterns. Typical input sensitivity is below 20 mV, with 50 mV

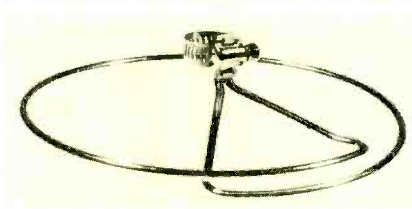


sensitivity guaranteed at 200 MHz. Automatic display-blanking prevents erroneous low-level readings. Input sensitivity is selectable, allowing approximately 12 dB of alternation for high-level or noisy signals. The unit is fully functional with the included BNC telescoping antenna, allowing fast convenient checks on mobile equipment. Accurate checks can also be made by using a single turn of wire as a pick up for testing local oscillators, etc., without disturbing the surrounding circuitry.

Internal crystal stability is 0.00001%/C° over 0° to +50° C. Internal gating accomplishes automatic round-off of last digit, giving a ±½-digit accuracy plus timebase uncertainty. Built-in indicators give overflow and low-battery warning. The counter weighs 1.5 lbs. and measures 5.5 × 3.75 × 1.75 inches. $279 includes counter, AC power pack, telescoping antenna, attache carrying case, and 1-year warranty.—**AME Inc.,** Unit 1, 1819 Underwood Blvd., Delran, NJ 08075.

CIRCLE 86 ON FREE INFORMATION CARD

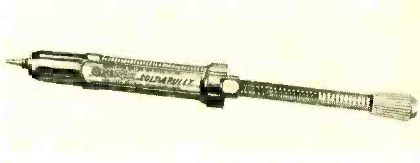
ZING RING, *model 1114,* claimed to improve CB antenna's performance by providing a 360° launching pad for the signal. A gutter-, mirror-



or bumper-mounted antenna is not centered and does not offer these necessary performance features. Without a 360° primary ground plane, the signal has a lop-sided and weak radiation pattern in certain directions. The *Zing Ring* provides this primary ground plane and centering effect to enhance the omni-directional radiation pattern.—**Gold Line Connector, Inc.,** P.O. Box 893, East Norwalk, CT 06855.

CIRCLE 87 ON FREE INFORMATION CARD

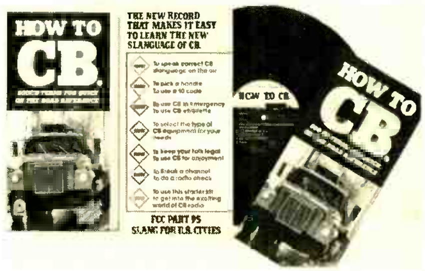
DESOLDERING TOOL. Manual desoldering tool which protects sensitive FET and MOSFET semiconductor devices from failure due to static electricity while isolating operator from a direct short. Named the *Silverstat Soldapullt,* this tool is a hand-held, spring-loaded vacuum device that incorporates all of the features found in this manufacturer's deluxe *Soldapullt* such as a fully enclosed loading shaft, high-low vacuum adjustment, and fast bayonet-type disassembly



for ease of maintenance. The bonus feature of the *Silverstat* is its conductive plastic tip and barrel housing which allow any built-up static charge to drain off harmlessly through the hand to ground.—**Edsyn Inc.,** 15958 Arminta St., Van Nuys, CA 91406.

CIRCLE 88 ON FREE INFORMATION CARD

CB RECORD—*How to CB.* This is a complete package consisting of record and brochure that gives the beginning CB operator all the informa-



tion he needs to get started in CB radio.—**Pickwick International, Inc.,** 135 Crossways Park Dr., Woodbury, NY 11797.

CIRCLE 89 ON FREE INFORMATION CARD

CIRCLE 56 ON FREE INFORMATION CARD

MULTIMETER SERVICING
continued from page 69

that tries to combine scales and simplifies reading (Fig. 8). With modern circuitry the instrument designer has the facilities to select a sensible range of scales to provide an easy-to-read solution.

Linear resistance ranges are a great help to this ease of use. Many meters now use a constant-current system that feeds a constant current through the resistance being measured and the reading can then be made on the voltage scales. The result is a linear reading with 2 or 3% accuracy instead of the problems found with the traditional logarithmic scale.

In the field.

Ruggedness is particularly important with a field instrument. The easiest way to approach a service call is to carry all tools and so on in the same bag, but this can have drawbacks. Taking care of the bag may become second nature—but there is always the occasion when a tool hits against the instrument, or it slips and hits the floor. So it's worth checking to see that the instrument will stand the occasional knock—or can be easily protected against the rough and tumble of service life.

The use of large-scale integration—cutting down the number of components and vulnerable connections—helps make a modern multimeter highly shockproof, but the case still needs some protection. A typical service accessory that is highly useful is a rubber protecting ring (as can be seen in Fig. 9) guarding against most misuse.

A choice of power supplies is also important when selecting an instrument for use in the field and in applications where you want to be isolated from the power line. For ease of use a self-contained instrument is ideal—preferably using rechargeable batteries and an optional AC supply when required for workbench use. Any unit that uses rechargeable batteries should be fully rechargeable overnight.

If the meter is powered by batteries, some form of power-saving circuitry to make the batteries run the instrument as long as possible, is desirable.

One method is to have the display operate only on pushbutton demand—the reading staying lit for some 20 or 30 seconds. Some form of battery-low warning is also useful.

Wide choice

There is a wide choice of multimeters on the market, but not all are suitable for service use. The points covered here should aid in the selection of a rugged, versatile instrument to make TV servicing easier. R-E

EXAR FUNCTION GENERATOR
continued from page 38

resistor between pin 11 and the positive supply line. Figure 7 shows a simple variable-frequency split-supply circuit that produces squarewave signals only. The output is taken directly from pin 11. The XR-2206 data sheets refer to pin 11 as a "sync output" terminal, since the signal appearing at this point is not suitable for directly driving low-impedance loads but is intended only for driving high-impedance loads such as oscilloscope input or synchronization terminals, etc. The risetime and falltime
continued on page 90

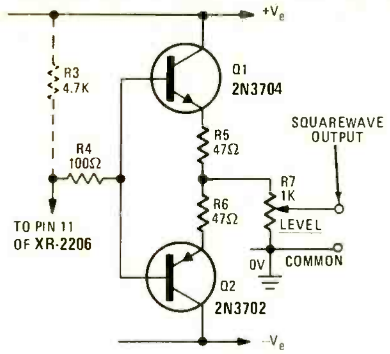


FIG. 8—ADD-ON MODIFICATION for the circuit shown in Fig. 7 provides low-impedance variable-amplitude squarewave output.

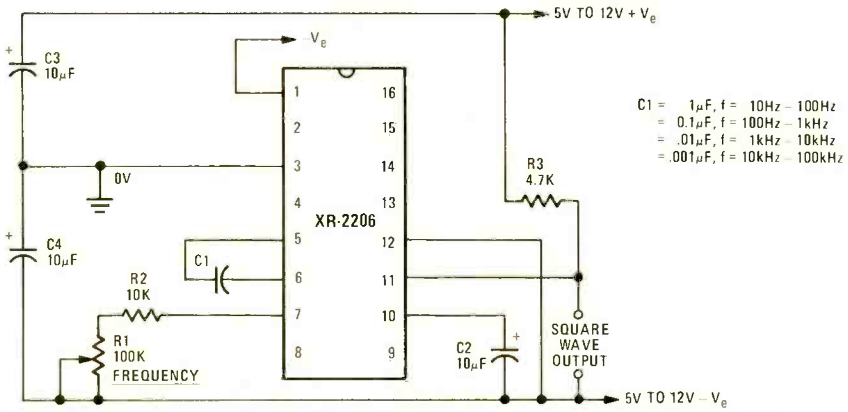


FIG. 7—SIMPLE SQUAREWAVE GENERATOR provides a variable-frequency output signal.

of the output signal are typically 250 ns and 50 ns, respectively, when pin 11 is loaded by 10 pF.

Figure 8 shows a simple add-on buffer stage that can be used to provide a low-impedance variable-amplitude squarewave output signal. The circuit is a simple complementary emitter-follower that is driven directly from the pin-11 squarewave output of the IC. Short circuit output protection is provided by the 47-ohm resistors (R5 and R6) in series with the transistor emitters. The output level is fully variable from maximum to zero using LEVEL potentiometer R7. The output signal is referenced to zero volts (ground) and can be used to drive high- or low-impedance external loads.

continued next month

BUILD A COMPUTER
continued from page 35

wires to the correct pins of the DIP plug. If you have a keyboard with tri-state outputs, they can be always enabled. Then their outputs can be wired to the inputs of the on-board buffers as in a normal keyboard.

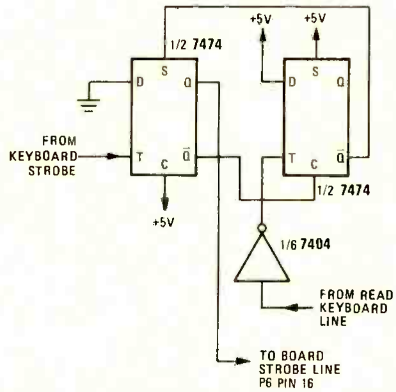


FIG. 7—DURATION OF STROBE pulse from keyboard is increased using this add-on circuit.

To hook up your cassette-tape unit, you use plug 3 of the board. Pin 10 is for the record jack and pin 9 is for the earphone jack. Pin 14 of plug 3 can be used to turn off and on the tape recorder (using the auxillary control line) by simply hooking up a relay and switching transistor to the circuit as shown in Fig. 8. You may need to adjust the volume and tone controls on the

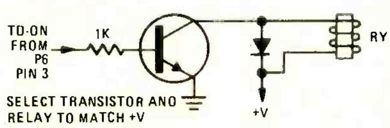


FIG. 8—AUTOMATIC CASSETTE TAPE operation is obtained by adding driver transistor and relay.

tape recorder in order to get perfect data storage (no errors on loading).

continued next month

next month

MAY 1977

■ **Build A Programmable Frequency Divider**

IC's and printed-circuit board construction make it easy to duplicate this valuable test instrument.

■ **Build A CB Preamp**

Improve your CB reception. Add this inexpensive preamp. You'll be surprised at the difference it makes.

■ **ABC's Of Room Equalization**

A new easy way to match your listening room to your hi-fi gear.

■ **Build A Speaker Phone**

Hands off talking and listing when you use your telephone is the purpose of this device.

■ **Heath's New Programmable Color TV Kit**

Set up the evenings programs and the set takes care of itself—it changes channels and reorients the antenna rotator.

■ **WARC '79**

A report on the pending World Administrative Radio Conference and its potential effects on you.

PLUS

Jack Darr's Service Clinic

All About Function Generators

Lab Tested Hi-Fi Reports

Komputer Korner

EQUIPMENT REPORTS

continued from page 29

for amplifier testing." There was a P.S. also, which read "Good job. Fred!"

My confidence somewhat restored, but still wary, I worked up the output amplifier assemblies. This is a truly sticky mechanical proposition involving the use of a thermal compound to coat output transistors and their insulators. (I challenge any kitmaker to work with this stuff and *not* get it all over the heat sinks!)

All the tests involving the output amplifier combinations (circuit board/ heat-sink assemblies) checked out. This despite the fact that I checked the units side-by-side rather than sequentially, through a misinterpretation of the instructions. I determined that the error of my procedure was a boxed paragraph on page 117 which I felt was out of place on that page in that it anticipated work not yet done.

And now the Big Moment. Double checking all my connections and all the procedures, I turned on the preamp and tuner, then the amplifier. Sound! Music! Beautifully reproduced music! Ah . . . but from only one channel. I was deflated.

After a thorough check of connections, etc., I removed the top cover. A bare wire confronted me . . . not there before. It turned out to be the tip of one speaker wire. The wire had broken off from the connector when I had inserted the speaker plug. I carefully managed to make a solid, albeit temporary connection, and replaced the fuse that had blown when the wire had been pushed out and had shorted to the chassis. I turned up the gain control . . . to be confronted with mushy, distorted sound from the previously dead channel. Again I was deflated.

A phone call to the Heathkit center brought advice to switch the input connectors to see if both preamp channels were working in terms of proper connections. They were. I was then advised to check the preamp transistors. I removed them, checked them, found them OK, and replaced them.

The final bit of advice was to remove both amplifier channel sections and reverse them, to thus check out connection points and to positively localize the trouble as being in one amplifier section. In the process, a phrase from the manual kept running through my head. It was: "About 90 percent of the kits that are returned for repair do not function properly due to poor connections and soldering. Therefore, many troubles can be eliminated by a careful inspection of connections to make sure they are soldered properly." Actually, I felt that first rate soldering was my main forte in this project. On removing the malfunctioning amplifier segment, I decided to follow up on that phrase. I was wrong. In the center of the heat-sink I noticed a capacitor, one of whose ends passed through a power transistor terminal then into the circuit board. The circuit board connection was OK, but the transistor terminal connection was solderless. Careful as I had *thought* I had been, I had goofed.

I soldered the connection, mounted the amplifier section, connected it, and hooked up the equipment. Sound! Beautiful sound, now coming out of *both* amplifier channels! The job was done.

Comments

What do I now have for my efforts and involvement? A $489.95 (mail-order price) amplifier that reproduces music on the order of amplifiers costing $1,000 and more. I know that from making comparisons with equipment my audio buff friends possess. Phono records I had relegated to second rank status in my collection because they sounded distorted in heavy transient passages, have been restored to first rank status because I now hear these same passages

continued on page 94

LOOKING AHEAD
continued from page 4

The Emerson name was purchased by radio and stereo importer Major Electronics from National Union Electric, Emerson's last parent. Major, which changed its name to Emerson Radio Corp., then licensed the television rights to Empire Ultrasonics, which plans to import a line of color and black-and-white televisions from Korea with the familiar Emerson brand name and trademark.

Microprocessor games: Second entry into the programmable video game market, after Fairchild's VES, is RCA's Studio II. List-priced at $150, it has two calculator-type keyboards. The first three cartridges are *TV Schoolhouse I, Fun with Numbers* and *Space War*, at $15 each. It also has five built-in games, including math quiz, bowling, car racing and doodling. Fairchild now has six cartridges available at $20 each, the latest additions being *Spitfire* (airplane game), *Space War* and *Math Quiz*. Among the earlier cartridges are *Blackjack, Tank War* and doodling games.

Where do games leave off and computers begin? It's too early to tell, but as games increase in sophistication the line between them will become increasingly blurred. One item that's definitely a computer and not a game is the $495 Personal Electronic Transaction (PET) device being readied for sale by Commodore, developed by its subsidiary MOS Technology. With its own built-in cathode-ray tube readout, the unit has an alphanumeric keyboard and is designed as an all-purpose household computer. It will accept specially programmed audio cassettes, or the owner can program his own. Since it speaks standard computer language, it can communicate by phone with other computers or central information banks. R-E

CB'ers and local police cooperate to reduce crime

The police department of Gardena, CA, in seeking new ways to reduce crime, is taking advantage of the rapidly increasing popularity of CB radio. Believing that "Neighborhood Watch" programs already in existence could be improved with radio communication, the police contacted the local REACT (*R*adio *E*mergency *A*ssociated *C*itizens *T*eams), C-CAP (California Community *A*lert *P*atrol) and several CB social clubs, to propose cooperation.

The response was overwhelming, both from the CB'ers and from businesses in the area. Craig Corp, which is headquartered in nearby Compton, made a Craig 4201 CB base station available to the police department. For a time it was monitored by police personnel, but other duties often caused the station to be unattended. Calling on the citizens for help, the department found a large enough number of volunteer monitors to maintain the station on a 24-hour, 7-day basis.

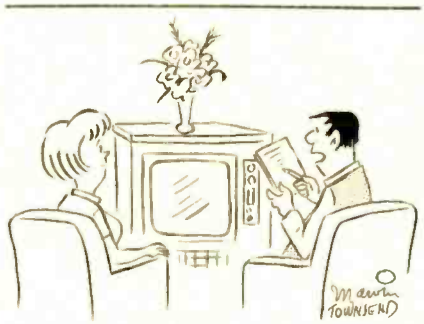
Standards were set for monitors. They are required to be licensed CB operators with some experience in radio procedures, undergo a criminal background screening and be able to monitor the radio for at least one 4-hour shift per month.

In two months in late 1976, more than 2,000 calls were received. They ranged from traffic accidents to reports of crimes in progress. Some 150 volunteers work at the base station, and larger numbers are involved in the projects. R-E

EQUIPMENT REPORTS

continued from page 92

undistorted with the kind of definition you'd obtain in a concert hall. I hear high-frequency sounds with a clarity and sweetness that I still find hard to believe. My wife hears the highs without wincing, as she did whenever I played certain records before. I can now play music at high volume levels without listening fatigue. There is no audible distortion at any point of the sound spectrum. My speaker systems now produce a kind of solid satisfying bass I did not think they could deliver. In sum, I feel that I have obtained the best audio bargain I could possibly have obtained. I am unabashedly proud of my AA-1640. **R-E**



No matter how I figure it, the money we'd save on a service call wouldn't be enough to go out for an evenings entertainment!

TELESWITCH
continued from page 42

old level of each sound switch so it triggers on the telephone ring. This is done by adjusting the value of the potentiometer on each sound switch so that the SCR will latch after the first ring.

If the sequential Teleswitch is used and you want to turn things off remotely, remember that you have to connect that device to the power line through a normally closed relay so that the relay contacts can be opened when the relay is activated.

To test the unit, have someone telephone you, but do not answer the phone. Let it ring a few times and then have the caller wait 1 minute and call back.

If the unit is operating properly, a relay click should be heard after the first ring and another relay click after the second ring. If so, the controlled device should remain off. After a total of 1 minute from the first ring, the sound of a relay opening should be heard. This is RY2 disconnecting power from the reset timer. Now the teleswitch is rTady to accept a new ring signal.

Have your friend call again, this time allowing the telephone to ring only once. Twenty seconds after that ring, the device connected to the controlled outlet should turn on.

For the sequential version of the circuit, the next single ring should turn on the second outlet. In the on/off version, the next single ring of the telephone will turn the controlled outlet that is now on, to off. **R-E**

Certified Electronic Technicians now have training courses

A series of training monographs and simulated CET tests for CET's and those who wish to become CET's is now being prepared by Bank Wilson Services of Warren, Ohio. Mr. Wilson, who writes the official CET tests and is the Director or Training for the Ohio association, presented the program to the November ISCET officers' meeting, which sanctioned both the monograph and practice CET Test projects.

The monographs are specialized treatises on practical servicing subjects, the first one (now available) being titled *Logic Circuits for Service Technicians*. Avoiding abstract theory, it tells how the circuits work, what they are used for, and how to test and troubleshoot them.

The practice tests are available in five categories: Associate Level, Audio Journeyman, Industrial Journeyman, Consumer Journeyman and Communications Journeyman. They are being sold to ISCET members at $3 each, to non-members for $4.

All persons interested or wishing to order the materials can obtain information by writing direct to Bank Wilson Services, P.O. Box 3321, Warren, OH 44485. **R-E**

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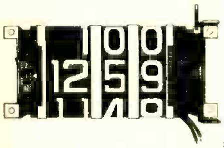

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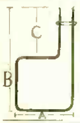

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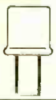

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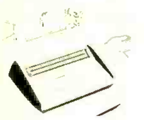

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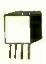

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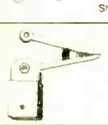

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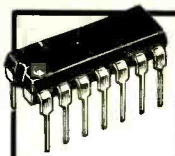

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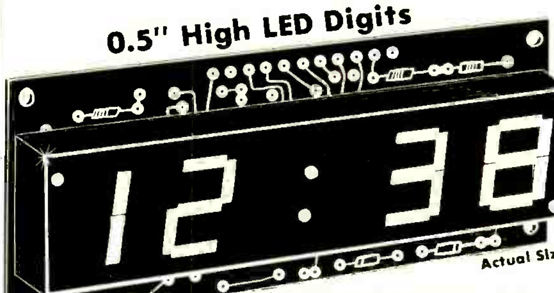

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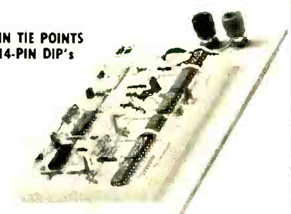

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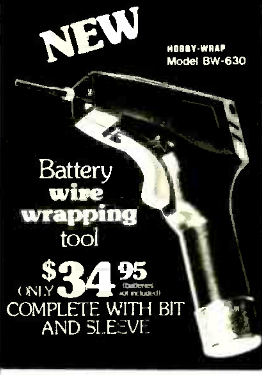
2.2/50V	.08	.65/10	100/10V	.10	.77/10	470/16V	.23	1.81/10
3.3/50V	.08	.65/10	100/16V	.11	.85/10	470/25V	.29	2.35/10
4.7/35V	.08	.65/10	100/25V	.13	1.10/10	1000/10V	.24	1.96/10
4.7/50V	.08	.68/10	100/50V	.21	1.71/10	1000/16V	.29	2.35/10
10/16V	.08	.65/10	220/10V	.13	1.08/10	1000/25V	.42	3.33/10
10/25V	.08	.65/10	220/16V	.15	1.16/10	2200/10V	.42	3.33/10
10/50V	.10	.75/10	220/25V	.21	1.71/10	2200/16V	.54	4.30/10
22/16V	.08	.67/10	220/50V	.29	2.35/10	2200/25V	.58	4.67/10
22/25V	.09	.70/10	330/10V	.15	1.16/10	3300/16V	.89	7.14/10
			330/16V	.21	1.66/10			



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1/30V	.11	.90/10	33/50V	.19	1.52/10	330/25V	.32	2.54/10
3.3/35V	.12	.95/10	47/16V	.14	1.15/10	470/16V	.32	2.55/10
3.3/50V	.12	1.00/10	47/25V	.17	1.30/10	470/25V	.37	3.00/10
4.7/25V	.11	.90/10	47/50V	.21	1.17/10	1000/10V	.33	2.65/10
4.7/35V	.12	.95/10	100/10V	.14	1.13/10	1000/16V	.39	3.15/10
4.7/50V	.12	1.00/10	100/16V	.17	1.30/10	1000/25V	.56	4.50/10
10/25V	.12	1.00/10	100/25V	.20	1.55/10	2200/10V	.50	3.96/10
10/50V	.14	1.15/10	100/50V	.29	2.30/10	2200/16V	.62	4.95/10
22/16V	.12	1.00/10	220/10V	.18	1.42/10	2200/25V	.79	6.36/10
22/25V	.13	1.05/10	220/16V	.20	1.55/10	3300/16V	.95	7.63/10
22/50V	.17	1.32/10	220/25V	.29	2.35/10	4700/16V	1.09	8.70/10
33/16V	.12	1.00/10	220/50V	.40	3.23/10	10000/10V	1.15	9.19/10
			330/10V	.14	1.16/10			

WIRE-WRAPPING TOOL

$5.95
Wraps, Unwraps & Strips 30 ga. Wire

I.C. SOCKETS

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

¼ & ½ WATT 5% CARBON FILM RESISTORS

5c each in multiples of 5 per value
$1.70/100 & $12.00/1000 of same value
1 ohm thru 1.0 megohm

INTEGRATED CIRCUITS — TTL, CMOS, LINEAR & MOS

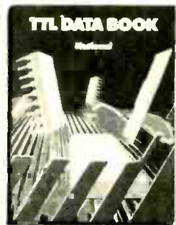
7400	.21	7476	.32	74181	2.15	4012	.23	4520	1.14
7401	.21	7480	.70	74182	.79	4013	.40	4527	1.68
7402	.21	7482	.70	74184	2.19	4014	.96	4528	.88
7403	.21	7483	.70	74185	2.19	4015	.96	4585	1.23
7404	.21	7485	.89	74186	3.50	4016	.40	2102-1	1.99
7405	.21	7486	.28	74189	3.50	4017	1.05	8080A	24.95
7406	.25	7489	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	.69
7423	.35	74123	.61	74366	.67	4033	1.51	MC1456V	1.00
7425	.35	74125	.40	74367	.67	4034	3.50	MC1458V	.53
7426	.25	74126	.40	74368	.67	4035	1.14	MC3302P	1.15
7427	.33	74132	.70	8093	.40	4040	1.14	NE536T	3.24
7428	.28	74141	.88	8094	.40	4041	.79	NE540L	2.04
7430	.21	74145	.70	9095	.67	4042	.79	NE555V	.48
7432	.25	74147	1.63	8096	.67	4043	.70	NE556A	.88
7433	.30	74148	1.30	8097	.67	4044	.70	NE560B	3.83
7437	.25	74150	1.16	8098	.67	4046	1.86	NE561B	3.83
7438	.25	74151	.70	75150	1.16	4049	.40	NE562B	3.83
7440	.21	74153	.65	75450	.88	4050	.40	NE565A	1.25
7442	.53	74154	1.03	75451	.61	4051	1.26	NE566V	1.28
7443	.63	74155	.70	75452	.61	4052	1.26	NE567V	1.36
7445	.70	74156	.70	75453	.61	4053	1.26	uA709CV	.44
7446	.70	74157	.70	75454	.61	4060	1.58	uA710CA	.44
7447	.70	74160	.88	75491	.81	4066	.79	uA711CA	.53
7448	.70	74161	.88	75492	.84	4071	.23	uA723CA	.60
7450	.21	74162	.88	75493	1.09	4072	.23	uA733CA	.75
7451	.21	74163	.88	75494	1.19	4073	.23	uA741CV	.44
7453	.21	74164	.96	82525	2.19	4075	.23	uA747CA	.70
7454	.21	74165	1.15	4000	.23	4081	.23	uA748CV	.49
7459	.21	74166	1.26	4001	.23	4082	.23	uA7805CU	1.25
7460	.21	74170	2.64	4002	.23	4502	.79	uA7806CU	1.25
7470	.30	74173	1.42	4006	1.23	4510	1.14	uA7808CU	1.25
7472	.30	74174	.98	4007	.23	4511	1.05	uA7812CU	1.25
7473	.30	74175	.93	4008	.79	4514	2.80	uA7815CU	1.25
7474	.30	74176	.79	4009	.44	4515	2.80	uA7818CU	1.25
7475	.49	74177	.79	4010	.44	4516	1.23	uA7824CU	1.25
		74180	.70	4011	.23	4518	1.14		

WIRE WRAPPING WIRE IN BULK

Red or Black 30 ga. Kynar
100' $2.00 500' $8.50 1000' $15.00

SILICON DIODES

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



DATA BOOKS

TTL IC's 595 p. $4.00
Linear IC's 957 p. $5.00
CMOS IC's 256 p. $3.00
Transistors 288 p. $3.00
Memory IC's 592 p. $3.00
Interface IC's 464 p. $4.00
Volt. Regs. 128 p. $3.00
Linear Appl. 1 432 p. $4.00
Linear Appl. 2 246 p. $3.00
Audio 196 p. $3.00

HARDWARE

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
No. 4 Lockwasher	.45/C	3.00/M
No. 6 Lockwasher	.45/C	3.00/M
No. 8 Lockwasher	.45/C	3.00/M

DOUBLE-DIGIT DISCOUNT SCHEDULE

Merchandise	Discount	Merchandise	Discount
$ 0.00-$24.99	NET	$100.00-$499.99	Less 15%
		$500.00-$999.99	Less 20%
$25.99-$99.99	Less 10%	$1000.00 & Up	Less 25%

Then Add the Standard Charge Below

STANDARD SHIPPING/HANDLING CHARGE

If your merchandise total after discount is between

$ 0.00-$ 4.99 . . add $2.00 — $ 50.00-$99.99 . add $0.25
$ 5.00-$24.99 . . add $0.75 — $100.00 & up . . No Charge
$25.00-$49.99 . . add $0.50

Includes shipping and insurance to USA & Canada

COD ORDERS ACCEPTED FOR SAME DAY SHIPMENT — CALL 218-681-6674

SILICON TRANSISTORS

MPS918, MPS930, MPS2222A, MPS2369A, MPS2712, MPS2907A, MPS3392, MPS3393, MPS3394, MPS3395, MPS3563, MPS3565, MPS3638, MPS3638A, MPS3640, MPS3641, MPS3643, MPS3645, MPS3646, 2N3904, 2N3906, 2N4124, 2N4126, 2N4401, 2N4403, 2N4410, PN4888, 2N5087, 2N5089, PN5129, PN5133, PN5134, PN5137, PN5138, PN5139, 2N5210, PN5964 . . . . 16, $1.55/10, $13.60/100 of same part no.

MPF102 .36 $30.60/C 2N5457 .48 $41.00/C MPSA13 .28 $24.00/C 2N3055 .99 $85.00/C

Double Digit Discounts Save You Even More!

½ WATT ZENER DIODES

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

Send for free catalog or mail reader's service card

"Only Quality Components Sold!"

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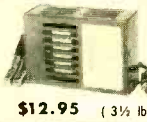
DIGI-KEY CORPORATION

Box 677, Thief River Falls, MN 56701 218-681-6674

CIRCLE 61 ON FREE INFORMATION CARD

U.S. GOV'T ELECTRONIC SURPLUS

• Nationally Known - World Famous **SURPLUS CENTER** offers finest, most expensive, Government Surplus electronic units and components at a fraction of their original acquisition cost.



AUTOMATIC BATT. CHARGER

• (ITEM #11-018) - - Charges 12-volt batteries at 2-ampere rate. Turns off when battery reaches full charge, turns on when battery is low, automatically. Can be mounted permanently in engine compartment. 5½" x 3¾" x 2¼".

$12.95 (3½ lbs.)

SNAP-AROUND VOLT-AMMETER

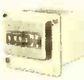
• (ITEM #21-1028) - - "MINIPROBE" clamp type AC ammeter-voltmeter. Small enough to carry in shirt pocket. Will measure 0 to 50-amperes, 0 to 250-volts. Furnished with test leads. Overall size 4-1/2" x 2-3/4" x 1". (1 lb.) List $33.00 **$22.95**

STANDARD DIAL TELEPHONE

• (ITEM #715) - - Same as used on commercial systems in U.S.A. Use as extension to private system. Connect several together for local intercom system. Instructions furnished.

$8.79 Original Cost $24.50 (9 lbs.)

RUNNING TIME METER



• (ITEM #2188) - - Record number of operating hours of electric lights, electrical devices such as refrigerators, furnaces, etc. Records total hours, tenths and hundredths to 9,999.99 hours. For 115-volts, 60-cycles. 4¼" x 3" x 2½". (2 lbs.)

Cost $29.00 **$4.39**

SPECIAL SALE Correspondence Course In ELECTRICAL ENGINEERING

Prepaid in U.S.A. **$11.79**
Outside U.S.A. **$12.79**

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THE ECONOMICAL ANSWER TO HOME MONITORING OF NURSERIES, ENTRANCES, DRIVEWAYS...BUSINESS and INDUSTRIAL SURVEILLANCE...ITV...AMATEUR TV PLUS HUNDREDS OF OTHER APPLICATIONS. MODEL XT-1A, SERIES D - KIT FORM $185; ASSEMBLED $275. SOLID-STATE. WORKS ON ANY TV SET. OPTIONAL SOUND KIT $28.95.

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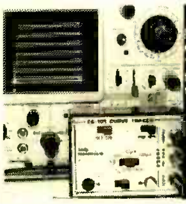

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SIZE 2¼" x ¾" x ½"

NON semi surplus. Monthly picture flyer, Quality. Low price. Send 25¢. U.S. only. **STARTRONICS,** Box 683, McMinnville, OR 97128

The New Yorkers Who Hustle the Wind.

Street life in a metropolitan area often inspires genius. And that genius can be funneled two ways—good or bad.

The 11th Street Movement in Manhattan's Lower East Side has funneled their genius on the good side with a unique energy saving project involving windmills and solar panels.

This project is just part of the Emergency Energy Conservation Program operated by the Community Services Administration. CSA has established many demonstration programs designed to find new and better ways to help the poor and elderly cope with what for them is a continuing energy crisis.

The program has a broad base, covering everything from development of low cost solar heating and wind generators to experiments with energy conserving farming technologies.

But helping people help themselves isn't an easy task. Simply put, it demands community support—Your support and the support of local and state governments.

If you think this effort is worthwhile, take action, contact your local Community Action Agency or Community Services Administration Washington, D.C. 20506.

There are thousands of people who want to help themselves. Like the 11th Street Movement—they learned how to catch the wind, so they'll no longer be a victim of the elements.

COMMUNITY SERVICES ADMINISTRATION

CIRCLE 23 ON FREE INFORMATION CARD

6 Digit LED Clock Kit - 12/24 hr.

$9.95 ea. QTY. 12 OR MORE $10.95 ea. QTY. 6-11 $11.95 ea. QTY. 1-5

KIT INCLUDES
- INSTRUCTIONS
- QUALITY COMPONENTS
- 50 or 60 Hz OPERATION
- 12 or 24 HR OPERATION

6-LED Readouts (FND-359 Red, com. cathode)
1-MM5314 Clock Chip (24 pin)
13-Transistors
3-Switches
6-Capacitors
5-Diodes
9-Resistors
24-Molex pins for IC socket

LARGE **.4" DIGITS!**
ORDER KIT #850-4
AN INCREDIBLE VALUE!

"Kit #850-4 will furnish a complete set of clock components as listed. The only additional items required are a 7-12 VAC transformer, a circuit board and a cabinet, if desired."

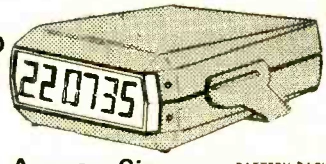
Printed Circuit Board for kit # 850-4 (etched & drilled fiberglass) $2.95
Mini-Brite Red LED's (for colon in clock display) pkg. of 5 .... 1.00
Molded Plug Transformer 115/10 VAC (with cord) 2.50
NOTE: Entire Clock may be assembled on one PC Board or Board may be cut to remote display.
Kit # 850-4 will fit Plexiglas Cabinet II.

MOBILE LED CLOCK

12 OR 24-HOUR OPERATION
12 VOLT AC or DC POWERED FOR FIXED OR MOBILE OPERATION.
SIX LARGE **.4" DIGITS!**

KIT OR ASSEMBLED

MODEL 2001



ACCURATE TIME WITH ADJUSTABLE XTAL TIME BASE

Approx. Size:
1¾"H x 4"W x 4½"D

BATTERY BACK-UP FOR POWER FAILURE OR TRANSPORTING FROM HOUSE TO CAR. ETC.

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

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

ASSEMBLED UNITS ORDER #2001 WT WIRED & TESTED (LESS 9V BATTERY) **$39.95 EA.** 3 OR MORE **$37.95 EA.** Assembled Units May Be Mixed With Kits for Qty. Price
WIRED FOR 12 HR OP IF NOT SPECIFIED OTHERWISE

6 Digit-LED Clock-Calendar-Alarm Kit

This is a complete, top of the line, Kit for the person that wants the best. Some of the many features and options are: 12/24 time, 28-30-31 day calendar, alternates time (8 sec) and date (2 sec) or can display time only and date on demand, 24 hr alarm - 10 minute snooze, alarm set indicator, 50/60 HZ. line operation or use with Xtal time base (#TB-1), built in OSC for battery back-up / AC failure, Aux. timer, CHOICE OF DIGITS.

Kit #7001B	6 - .4" Digits	$39.95
Kit #7001C	4 - .6" Digits & 2-." [Seconds]	$42.95
Kit #7001X	6 - .6" Digits	$45.95

Kits are complete (less cabinet) including PC boards, power supply, IC socket, 9 switches, 16 transistors and all parts required for above features and options **[All #7001 Kits Will Fit Cabinet I]**

CPU

$19.95 ea.
NS8080AD
Micro Processor Chip
Prime National LSI
40 Pin socket
$ .50 with each 8080A!

450 ns **MEMORY**
Fairchild 1K Ram
low, low, low power.

2102L1PC	$1.95 ea.
25-99	$1.75 ea.
100-199	$1.60 ea.
200 or more	$1.45 ea.

JUMBO RED LED's 12/$1.00 50/$3.95

PRINTED CIRCUIT BOARDS for CT-7001 Kits sold separately with assembly info. PC Boards are drilled Fiberglass, solder plated and screened with component layout. Specify for # 7001B or # 7001C (Set of 2) $7.95

JUMBO DIGIT CLOCK KIT

A complete Kit (less Cabinet) featuring: six .5" digits, MM5314 IC, 12/24 Hr. time, 50/60 HZ., Plug-Transformer, Line Cord, Switches, and all Parts.
[Ideal Fit in Cabinet II]
Kit #5314-5 .... **$19.95 ea. 2/$38.**

JUMBO DIGIT CONVERSION KIT

Convert small digit LED clock to large .5" displays. Kit includes 6-.5" LED's, Multiplex PC Board & easy hook-up info.
Kit #JD-1CC For common Cathode
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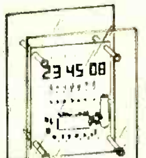
$9.95 ea. 2/$19.

SEE THE WORKS Clock Kit Clear Plexiglas Stand
- 6 Big .4" digits
- 12 or 24 hr. time
- 3 set switches (back)
- Plug transformer
- all parts included

Plexiglas is Pre-cut & drilled
Size: 6"H, 4⅓"W, 3"D



A SUPER LOOKING CLOCK!
Kit #850-4 CP **$23.50 ea. 2/$45.**

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.4" Char. Ht. 7 segment LED RED Com. Cath. Direct pin replacement for popular FND-70.
95¢ ea, 10/$8.50 100/$79.00

SET OF 6 FND-359 WITH MULTIPLEX PC BOARD $6.95

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74S22	.45
74S40	.45
74S50	.45
74S51	.55
74S60	.85
74S64	.55
74S74	.85
74S75	1.75
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74S86	.95
74S107	.95
74S112	.95
74S113	1.40
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74S138	1.75
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7815	TO-3	1.25
7815	TAB	1.25
78L 15	TO-5	.75
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7824	TO-3	1.25
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MM 5314		3.95
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CT-7002		13.95
50380		3.95
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18	.31	.28	.26
24	.50	.45	.40
28	.60	.55	.50
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2N4249	TO-92	5/$1.00
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2N6027	PUT	2/$1.00
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Black, White or Clear Cover

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

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3"H, 6¼"W, 5½"D

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7-SEG LED

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XAN-654	GREEN	.6"	NDP	$1.95
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COMMON ANODE				
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XAN-351	GREEN	.3"	RHDP	$1.50
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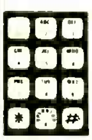

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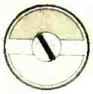

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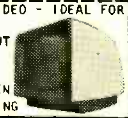

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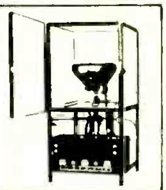

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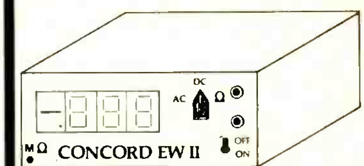

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If you buy the large cell & motor together............ $12.00
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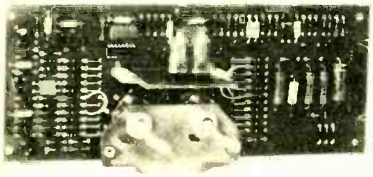

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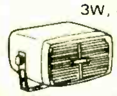

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MULTI-TURN TRIM POTS Similar to Bourns 3010 style 3/16"x5/8"x1-1/4"; 50, 100, 1K, 10K, 50K ohms
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200	.07	.20	.35	1.15	4.25
400	.09	.25	.50	1.40	6.50
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74H08	.25	74H50	.25	74H101	.58
74H10	.25	74H52	.25	74H102	.58
74H11	.25	74H53	.25	74H103	.60
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74H21	.25	74H60	.25	74H108	.72

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74S03	.59	74S20	.65	74S74	.68
74S04	.72				

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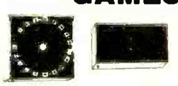

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SN7444N	.85	SN74174N	.99
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SN7493AN	.46	SN74249N	1.75
SN7494N	.74	SN74251N	1.40
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SN7496N	.69	SN74278N	2.45
SN7497N	2.85	SN74279N	.59
SN74100N	.99	SN74283N	1.45
SN74104N	.43	SN74284N	4.50
SN74105N	.43	SN74285N	4.50
SN74107N	.29	SN74290N	.85
SN74109N	.49	SN74293N	.85
SN74110N	.54	SN74298N	1.98
SN74111N	.74	SN74351N	1.92
SN74116N	1.75	SN74365N	.65
SN74120N	1.40	SN74366N	.65
		SN74367N	.65
		SN74368N	.65
		SN74390N	1.40
		SN74393N	1.40
		SN74490N	1.90

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SN74LS00N	.25	SN74LS138N	1.49
SN74LS01N	.25	SN74LS139N	1.49
SN74LS02N	.25	SN74LS145N	1.25
SN74LS03N	.25	SN74LS151N	1.25
SN74LS04N	.30	SN74LS153N	1.25
SN74LS05N	.30	SN74LS155N	1.45
SN74LS08N	.25	SN74LS156N	1.45
SN74LS09N	.25	SN74LS157N	1.25
SN74LS10N	.25	SN74LS158N	1.20
SN74LS11N	.25	SN74LS160N	1.95
SN74LS12N	.25	SN74LS161N	1.95
SN74LS13N	.69	SN74LS162N	1.95
SN74LS14N	1.35	SN74LS163N	1.95
SN74LS15N	.25	SN74LS164N	1.98
SN74LS20N	.25	SN74LS168N	2.25
SN74LS21N	.25	SN74LS169N	2.25
SN74LS22N	.25	SN74LS170N	2.80
SN74LS26N	.40	SN74LS174N	1.40
SN74LS27N	.30	SN74LS175N	1.40
SN74LS28N	.30	SN74LS181N	3.50
SN74LS30N	.25	SN74LS190N	1.95
SN74LS32N	.37	SN74LS191N	1.95
SN74LS33N	.39	SN74LS192N	1.95
SN74LS37N	.39	SN74LS193N	1.95
SN74LS38N	.39	SN74LS194A	1.40
SN74LS40N	.30	SN74LS195A	1.40
SN74LS42N	1.10	SN74LS196N	1.45
SN74LS48N	1.10	SN74LS197N	1.45
SN74LS47N	1.10	SN74LS221N	1.35
SN74LS48N	1.10	SN74LS240N	2.50
SN74LS49N	1.10	SN74LS241N	2.50
SN74LS51N	.25	SN74LS242N	2.40
SN74LS54N	.25	SN74LS243N	2.40
SN74LS55N	.25	SN74LS244N	2.50
SN74LS63N	1.75	SN74LS247N	1.30
SN74LS73N	.49	SN74LS248N	1.30
SN74LS74N	.49	SN74LS249N	1.30
SN74LS75N	.69	SN74LS251N	1.55
SN74LS76N	.49	SN74LS253N	1.55
SN74LS78N	.49	SN74LS257N	1.60
SN74LS83AN	1.49	SN74LS258N	1.50
SN74LS85N	1.75	SN74LS261N	2.95
SN74LS86N	.58	SN74LS266N	.59
SN74LS90N	.99	SN74LS279N	.75
SN74LS91N	1.15	SN74LS283N	1.40
SN74LS92N	1.10	SN74LS290N	1.35
SN74LS93BN	.99	SN74LS293N	1.35
SN74LS95AN	1.60	SN74LS295AN	1.75
SN74LS96N	1.75	SN74LS298AN	1.75
SN74LS107N	.49	SN74LS324AN	2.25
SN74LS109N	.55	SN74LS352AN	1.45
SN74LS112N	.49	SN74LS353AN	1.70
SN74LS113N	.49	SN74LS365AN	.75
SN74LS114N	.49	SN74LS366AN	.75
SN74LS122N	.89	SN74LS367AN	.75
SN74LS123N	1.09	SN74LS368AN	.75
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CD4026BE	1.45
CD4027BE	.44
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CD4050BE	.39
CD4051BE	1.20
CD4052BE	1.20
CD4053BE	1.25
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CD4056BE	1.50
CD4060BE	1.50
CD4066BE	.65
CD4068BE	.25
CD4069BE	.25
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CD4071BE	.25
CD4072BE	.30
CD4073BE	.30
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CD4076BE	1.10
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CD4081BE	.25
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CD4520BE	.89
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CD4531BE	1.25
CD4539BE	1.20
CD4555BE	.75
CD4556BE	.75
CD4585BE	1.80
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74C160/40160PC	1.65
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74C163/40163PC	1.65
74C174/40174PC	1.50
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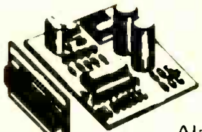

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7404–19c	7430–19c	74LS74-59c	7495–75c	74164-1.10
74L04–29c	7432–34c	7475–69c	7496–89c	74165-1.10
74S04–44c	7437–39c	7476–35c	74121-38c	74174–95c
74LS04-49c	7438–39c	7480–49c	74123-65c	74181-2.50
7406–29c	7440–19c	7483–95c	74132-1.70	74191-1.25
7408–19c	7447–85c	7485–95c	74S138-1.95	74192-1.25
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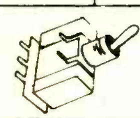

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XR-2567	2.99			XR-215	6.60
				XR-567CP	1.95
				XR-567CT	1.70

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 (.100 Spacing)	PINS (Solder Eyelet)	$6.95

25 PIN-D SUBMINATURE

DB25	PLUG	$3.25
DB25	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

VECTOR WIRING PENCIL

Vector Wiring Pencil P173 consists of a hand held featherweight (under one ounce) tool which is used to guide and wrap insulated wire fed off a self-contained replaceable bobbin onto component leads or terminals installed on pre-punched P Pattern Vectorbord. Connections between the wrapped wire and component leads, pads or terminals are made by soldering. Complete with 250 FT of red wire. $9.95

REPLACEMENT WIRE — BOBBINS FOR WIRING PENCIL

W36-3-A-Pkg. 3	250 ft. 36 AWG GREEN	$2.40
W36-3-B-Pkg. 3	250 ft. 36 AWG RED	$2.40
W36-3-C-Pkg. 3	250 ft. 36 AWG CLEAR	$2.40
W36-3-D-Pkg. 3	250 ft. 36 AWG BLUE	$2.40

1/16 VECTOR BOARD

	0.1" Hole Spacing Part No.	P-Pattern L	W	Price 1	2-Up
PHENOLIC	64F44 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
	169F44 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

HEAT SINKS

205-CB	Beryllium Copper Heat Sink with Black Finish for TO-5	$ .25
291-.36H	Aluminum Heat Sink for TO-220 Transistors & Regulators	$ .25
680-.75A	Black Anodized Aluminum	$1.60

HEXADECIMAL ENCODER 19-KEY PAD

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

$10.95 each

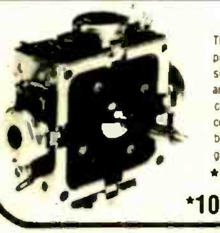
63 KEY KEYBOARD

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.

$19.95

HD0165 16 LINE TO FOUR BIT PARALLEL KEYBOARD ENCODER $7.95

JOYSTICK



These joysticks feature four * potentiometers, that vary resistance proportional to the angle of the stick. Sturdy metal construction with plastics components only at the movable joint. Perfect for electronic games and instrumentation.

*5K Pots $6.95

*100K Pots $7.95

MICROPROCESSOR COMPONENTS

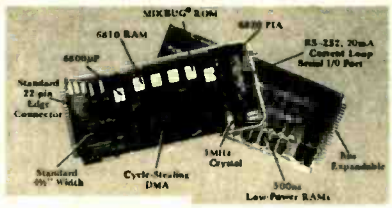
8080A	CPU	$19.95	8228	System Controller - Bus Driver	$10.95
8212	8 Bit Input/Output	4.95	MC6800L	8 Bit MPU	35.00
8214	Priority Interrupt Control	15.95	MC6820L	Periph. Interface Adapter	15.00
8216	Bi-Directional Bus Driver	6.95	MC6810AP1	128 x 8 Static RAM	6.00
8224	Clock Generator/Driver	10.95	MC6830L7	1024 x 8 Bit ROM	18.00

CPU'S		
8080	Super 8008	24.95
8080A	Super 8008	19.95
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	7.95
3341	Fifo	6.95
74LS670	16 x 4 Reg	3.95
UART'S		
AY-5-1013	30K Baud	$5.95
ROM'S		
2513	Char. Gen.	$ 9.95
2516	Char. Gen.	10.95
745387	1024-Bit Programmable	1.95

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	8.95
7489	16 x 4	Static	2.49
8101	256 x 4	Static	6.95
8111	256 x 4	Static	6.95
8599	16 x 4	Static	3.49
91L02	1024 x 1	Static	2.25
74200	256 x 1	Static	6.95
93421	256 x 1	Static	2.95
MM5262	2K x 1	Dynamic	2 for 1.00
PROMS			
1702A	2048	Famos	$ 9.95
5203	2048	Famos	14.95
82S23	32 x 8	Open C	5.00
82S123	32 x 8	Tristate	5.00
74S287	1024	Static	7.95
3601	256 x 4	Fast	3.95
2708	8K	Eprom	34.95
6301-1	1024	Tri-State Bipolar	3.49
6330-1	256	Open Collector Bipolar	2.95
6331-1	256	Tri-State Bipolar	2.95

GEMINI-68 The Unique Microprocessing System

Standard 4½" Boards - Dual 22 pin edge Connector NOT A KIT



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STAND ALONE CPU BOARD — Has 384 bytes of RAM on board, serial I/O (RS-232 and 20 ma current loop, cycle stealing direct memory access (DMA), built in soft-ware — selectable echo-back capability. Part # SA-CPU Board **$279.95**

CPU BOARD — Same as above but only has 128 bytes of RAM on board used with 8K RAM board listed below. Part # Gemini 68 CPU Board **$259.95**

8K RAM BOARD — Uses low power static RAMS, 500ns cycle time, 1.5 Amps Max. Part # Gemini 68 RAM Board **$269.95**

8K EPROM BOARD — Uses 5204 EPROMS by AMI or NATIONAL. Shipped with all decode and miscellaneous IC's, except the 5204 EPROMS. Part # Gemini 68 EPROM Board **$ 89.95**

Allow approximately four weeks per delivery

SPECIAL REQUESTED ITEMS

MC3061P	3.50	CD4508	6.75	82S115	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

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BUGBOOK I & II - Basic concepts of TTL Logic — over 90 experiments **$17.00/set**

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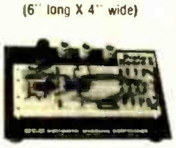
CONTINENTAL SPECIALTIES

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



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

PROTO CLIPS	
14 PIN	$4.50
16 PIN	4.75
24 PIN	8.50

DESIGN MATES

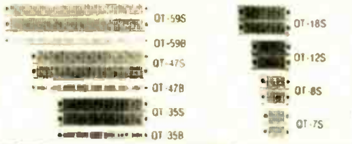
DM1 - Circuit Designer 54.95

DM2 - Function Generator 69.95

DM3 - RC Bridge 59.95

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

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

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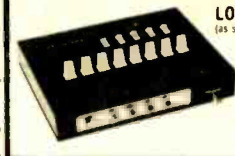
Panatronics LOGIC ANALYZER KIT

(as shown in Feb. Popular Electronics)



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(includes IC, power supply, PC Board, case and manual)

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- Switches 300 ohm to 300 ohm
- Switches 75 ohm to 300 ohm
- RF coax connecting cable (16ft.) with RCA phono plyes

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"Hear the highway action"

- Off-on volume control
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- Portable — attaches to visor
- 23-Channel operation
- Long range reception (Battery not included)

Actual Size - 4" x 3" x 1½

$9.95

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

Timeband™

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DIGITAL ALARM CLOCK $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
- SPECIFY BLACK OR IVORY

DIGITAL QUARTZ CAR CLOCK

Complete kit from mounting bracket of the injection molded case down to the three conductor power cord and all components including MM5314 clock chip. Features quartz accuracy of .01%, six digit, .35" high LED display, and P.C. Boards. Works on any 12 volt system — motorcycles, boats, vans, motorhomes, autos and trucks.

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.

$9.95 Per Kit

printed circuit board

T²L 5V 1A Supply

This is a standard TTL power supply using the well known LM309K regulator IC to provide a solid 1 AMP of current at 5 volts. We try to make things easy for you by providing everything you need in one package, including the hardware for only **$9.95 Per Kit**

CIRCLE 79 ON FREE INFORMATION CARD

7400N TTL

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SN7402N	.21	SN7470N	.45	SN74156N	.99
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SN7408N	.25	SN7479N	5.00	SN74165N	1.10
SN7409N	.25	SN7480N	.50	SN74166N	1.25
SN7410N	.18	SN7482N	.98	SN74167N	5.50
SN7411N	.30	SN7483N	.70	SN74170N	2.10
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SN7417N	.35	SN7490N	.45	SN74176N	.90
SN7420N	.21	SN7491N	.75	SN74177N	.90
SN7421N	.33	SN7492N	.49	SN74180N	.99
SN7422N	.49	SN7493N	.49	SN74181N	2.49
SN7423N	.37	SN7494N	.79	SN74182N	.95
SN7425N	.29	SN7495N	.79	SN74184N	1.95
SN7426N	.29	SN7496N	.89	SN74185N	2.20
SN7427N	.37	SN7497N	4.00	SN74186N	15.00
SN7429N	.42	SN74100N	1.00	SN74187N	6.00
SN7430N	.26	SN74107N	.39	SN74188N	3.95
SN7432N	.31	SN74121N	.39	SN74190N	1.19
SN7437N	.27	SN74122N	.39	SN74191N	1.25
SN7438N	.27	SN74123N	.50	SN74192N	.89
SN7439N	.25	SN74125N	.60	SN74193N	.89
SN7440N	.15	SN74126N	.60	SN74194N	1.25
SN7441N	.89	SN74132N	1.09	SN74195N	.75
SN7442N	.59	SN74136N	.95	SN74196N	1.25
SN7443N	.75	SN74141N	1.15	SN74197N	.75
SN7444N	.75	SN74142N	4.00	SN74198N	1.75
SN7445N	.75	SN74143N	4.50	SN74199N	1.75
SN7446N	.81	SN74144N	4.50	SN74200N	5.59
SN7447N	.69	SN74145N	1.15	SN74279N	.90
SN7448N	.79	SN74147N	2.35	SN74251N	1.79
SN7450N	.26	SN74148N	2.00	SN74284N	6.00
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CD4007	.25	CD4046	2.51	74C42N	2.15
CD4009	.59	CD4047	2.75	74C73N	1.50
CD4010	.59	CD4049	.79	74C74	1.15
CD4011	.25	CD4050	.79	74C90N	3.00
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CD4013	.47	CD4053	2.95	74C107N	1.25
CD4016	.56	CD4060	3.25	74C151	2.90
CD4017	1.35	CD4066	1.75	74C154	4.00
CD4019	.55	CD4069	.45	74C157	2.15
CD4020	1.49	CD4071	.45	74C160	3.25
CD4022	1.25	CD4081	.45	74C161	3.25
CD4023	.25	CD4511	2.50	74C163	3.00
CD4024	1.50	CD4518	2.50	74C164	3.25
CD4025	.25	MC14566	3.00	74C173	2.60
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LM301CN	.35	LM377N	4.00	LM1414N	1.75
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LM304H	1.00	LM380CN	1.05	LM1496N	.95
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LM308CN	1.00	NE510A	6.00	LM3065N	.69
LM309H	1.10	NE531H	3.00	LM3900N	.55
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LM310CN	1.15	NE540L	6.00	LM3909	1.25
LM311H	.90	NE550N	.79	LM5556N	1.85
LM311N	.90	NE555V	.39	MC5558V	1.00
LM318CN	1.50	NE560B	5.00	LM7525N	.90
LM319N	1.30	NE561B	5.00	LM7535N	1.25
LM320K-5	1.35	NE562B	5.00	8038B	4.95
LM320K-5.2	1.35	NE565H	1.25	LM75450	.49
LM320K-12	1.35	NE565N	1.75	75451CN	.39
LM320K-15	1.35	NE566CN	1.25	75452CN	.39
LM320T-5	1.75	NE567H	1.95	75453CN	.39
LM320T-5.2	1.75	NE567V	1.50	75454CN	.39
LM320T-8	1.75	LM703CN	.45	75491CN	.79
LM320T-12	1.75	LM709H	.29	75492CN	.89
LM320T-15	1.75	LM709N	.29	75494CN	.89
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LM320T-24	1.75	LM711N	.39	CA3013	2.15
LM323K-5	9.95	LM723H	.55	CA3023	2.56
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LM340K-6	1.95	LM741CH	.35	CA3059	3.25
LM340K-8	1.95	LM741CN	.35	CA3060	3.25
LM340K-12	1.95	LM741-14N	.39	CA3080	.85
LM340K-15	1.95	LM747H	.79	CA3081	2.00
LM340K-18	1.95	LM747N	.79	CA3082	2.00
LM340K-24	1.95	LM748H	.39	CA3083	1.60
LM340T-5	1.75	LM748N	.39	CA3086	.85
LM340T-6	1.75	LM1303N	.90	CA3089	3.75
LM340T-8	1.75	LM1304N	1.19	CA3091	10.20
LM340T-12	1.75	LM1305N	1.40	CA3123	2.15
LM340T-15	1.75	LM1307N	.85	CA3130	1.39
LM340T-18	1.75			CA3140	1.25
LM340T-24	1.75			CA3600	1.75
LM350N	1.00			RC4194	5.95
LM351CN	.65			RC4195	3.25

74LS00 TTL

74LS00	.29	74LS74	.49	74LS139	1.95
74LS02	.29	74LS75	.69	74LS151	1.55
74LS03	.29	74LS76	.49	74LS153	1.89
74LS04	.35	74LS83	1.75	74LS157	1.55
74LS05	.35	74LS85	2.49	74LS162	2.25
74LS08	.29	74LS86	.49	74LS163	2.25
74LS10	.29	74LS90	1.25	74LS164	1.95
74LS13	.69	74LS92	1.25	74LS175	1.95
74LS14	1.75	74LS93	1.25	74LS181	3.69
74LS20	.29	74LS95	1.95	74LS190	2.85
74LS26	.39	74LS96	1.89	74LS191	2.85
74LS27	.39	74LS107	.59	74LS192	2.85
74LS28	.39	74LS109	.59	74LS193	2.85
74LS30	.29	74LS112	.59	74LS194	1.89
74LS32	.39	74LS132	1.25	74LS195	1.89
74LS40	.39	74LS136	.59	74LS257	1.75
74LS51	.29	74LS138	1.89	74LS260	.55
74LS55	.29			74LS279	.79
74LS73	.49			74LS670	3.95

CLOCK CHIPS

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MM5311	6 Digit, BCD Outputs, 12 or 24 Hour	4.95
MM5312	4 Digit, BCD Outputs, 1 PPS Output	4.95
MM5314	6 Digit, 12 or 24 Hour, 50 or 60 Hz	4.95
MM5316	4 Digit, Alarm, 1 PPS Output	6.95
MM5318	Video Clock Chip, For Use With (MM5841 - $9.95)	9.95
CT7001	6 Digit, Calendar, Alarm, 12 or 24 Hour	5.95

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7400	Pin-out & Description of 5400/7400 ICS	$2.95
CMOS	Pin out & Description of 4000 Series ICS	$2.95
Linear	Pin-out & Functional Description	$2.95

ALL THREE HANDBOOKS $6.95

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FTK0003	.357" High Common Cathode Digit	.75
FTK0004	0.8" High Common Cathode Digit	2.00
FTK0005	0.8" High Common Anode Digit	2.00

0.8" HIGH DISPLAY ARRAYS

FTK0010	12 Hour, 3½ Digit Clock Display	7.00
FTK0011	24 Hour, 4 Digit Clock Display	8.00

LED LAMPS

FTK0020	10 Red LED Lamps	1.00
FTK0021	5 Mixed Colored LED Lamps	1.00
FTK0022	10 LED Mounting Clips	1.00
FTK0023	5 Three Piece LED Mounting Adapters	1.00

PHOTO TRANSISTORS

FTK0030	5 Flat Lens Photo Transistors	1.00
FTK0031	5 Round Lens Photo Transistors	1.00
FTK0032	3 Flat Lens Photo Darlingtons	1.00
FTK0033	3 Round Lens Photo Darlingtons	1.00

PHOTO ARRAYS

FTK0040	9-Element Tape Reader Array	16.00
FTK0041	12-Element Card Reader Array	24.00
FTK0042	Reflective Opto Coupler	4.00

COUPLERS

FTK0050	3 General Purpose Opto Couplers	1.00
FTK0051	Darlington Opto Coupler	1.00

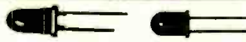
MOS CLOCK CIRCUITS

FTK0400	Digital Clock/Calendar Circuit (FCM7001)	7.00
FTK0401	Digital Clock/Calendar with BCD Outputs (FCM7002)	7.00
FTK0402	Direct Drive Digital Clock Circuit with AC Output (FCM3817A)	5.00
FTK0403	Direct Drive Digital Clock Circuit with DC Output (FCM3817D)	5.00
FTK0405	Direct Drive Digital Clock/Calendar Circuit (FCM7015)	6.00

KITS

FTK0106	Automobile Clock Kit	40.00

DISCRETE LEDS



.125" dia.		
XC209	Red	10/$1
XC209	Green	4/$1
XC209	Orange	4/$1
XC209	Yellow	4/$1

.190" dia.		
XC111	Red	10/$1
XC111	Green	4/$1
XC111	Yellow	4/$1
XC111	Orange	4/$1

.200" dia			.185" dia.			.200" dia.		
XC22	Red	10/$1	XC526	Red	10/$1	XC556	Red	10/$1
XC22	Green	4/$1	XC526	Green	4/$1	XC556	Green	4/$1
XC22	Yellow	4/$1	XC526	Yellow	4/$1	XC556	Yellow	4/$1
XC22	Orange	4/$1	XC526	Orange	4/$1	XC556	Orange	4/$1
SSL-22	RT	4/$1	XC526	Clear	4/$1	XC556	Clear	7/$1

.085" dia. MV50 — 6/$1

INFRA-RED LED ¼ x ¼ x 1/16 Flat 5/$1.00

SPECIAL * — XC556 Red 100/$8.00 1000/$60.00 — SPECIAL *

DISPLAY LEDS

DL707  DL338

TYPE	POLARITY	HT		TYPE	POLARITY	HT	
MAN 1	Common Anode	.270	2.95	MAN 3640	Common Cathode-orange	.300	1.75
MAN 2	5 x 7 Dot Matrix	.300	4.95	MAN 4710	Common Anode-Red	.400	1.95
MAN 3	Common Cathode	.125	3/1.00	DL701	Common Anode-red ±	.300	.99
MAN 4	Common Cathode	.187	1.95	DL704	Common Cathode	.300	.99
MAN 7	Common Anode	.300	1.25	DL707	Common Anode	.300	.99
MAN 7G	Common Anode-green	.300	1.95	DL 728	Common Cathode	.500	1.95
MAN 7Y	Common Anode-yellow	.300	1.95	DL741	Common Anode	.600	1.50
MAN 52	Common Anode-green	.300	.99	DL 747	Common Anode	.600	2.25
MAN 64	Common Anode-red	.400	.99	DL 750	Common Cathode	.600	2.49
MAN 74	Common Cathode	.300	1.50	DL 338	Common Cathode	.110	.50
MAN 82	Common Anode-yellow	.300	.99	FND70	Common Cathode	.250	.75
MAN 84	Common Cathode-yellow	.300	.99	FND503	Common Cathode	.500	1.00
MAN 3620	Common Anode-orange	.300	1.75	FND507	Common Anode	.500	1.00

FACTORY REJECTS ATARI GAME BOARDS

BOARD A — 8½" x 16" — **$6.95 ea.**
Over 60 each reusable IC's
Misc. Transistors, Resistors, Diodes, Caps, Crystals, Switch, etc.
ONLY 500 EA. AVAILABLE

DELUXE BOARD B — 11½" x 18" — **$9.95 ea.**
Over 100 each reusable IC's
Misc. Transistors, Resistors, Diodes, Caps, Crystals, Switches, LEDS, etc.
ONLY 500 EA. AVAILABLE

NEW AY-3-8500-1 TV GAME CHIP

- Score display
- Selectable angles, speed and bat size
- Auto or manual ball service
- Realism sounds
- 6 Games — tennis, hockey/soccer, squash, pelota practice and two rifle games

28 Lead Dual In Line

The circuit is intended to be battery powered. Minimum number of external components required for complete system.

$24.95

IC SOLDERTAIL — LOW PROFILE (TIN) SOCKETS

	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)

	1-24	25-49	50-100		1-24	25-49	50-100
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)

	1-24	25-49	50-100		1-24	25-49	50-100
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

	1-24	25-49	50-100		1-24	25-49	50-100
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

Plastic Push Button Switch

- 18 AWG Solid Wire - 5" Long
- .50 (wide) X .60 (high) ⅜-27 Thread
- 8 AMP @ 14 Volt - 1 AMP @ 110 Volt

		1-9	10-Up
J-188-1	Push On Push Off	.59	.49
J-188-2	Normally Open	.59	.49
J-188-3	Normally Closed	.59	.49

MINATURE TOGGLE SWITCH

JMT-221	DPDT	on/off/on	$1.95
JMT-223	DPDT	on/none/on	$1.75
JMT-121	SPDT	on/off/on	$1.50
JMT-123	SPDT	on/none/on	$1.25

CLIPLITE 8/$1.49

LED MOUNTING SYSTEM use with XC556 LEDS
Specify Colors — Red - Green - Amber - Yellow

DIP SWITCH

These switches feature 7 SPST slide switches in a molded dip. They are ideally suited for microprocessor applications **$1.95**

50 PCS. RESISTOR ASSORTMENTS $1.75 PER ASST.

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.) **$10.95 ea.**

$5.00 Minimum Order — U.S. Funds Only
California Residents — Add 6% Sales Tax
Spec Sheets - 25¢ — Send 35¢ Stamp for 1977A Catalog
Dealer Discount Available — Request Pricing

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WIRE WRAP CENTER

HOBBY-WRAP TOOL-BW-630

- Battery Operated (Size C)
- Weighs ONLY 11 Ounces
- Wraps 30 AWG Wire onto Standard DIP Sockets (0.25 inch)
- Complete with built-in bit and sleeve

$34.95
(batteries not included)

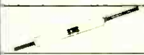
WIRE-WRAP KIT — WK-2-W

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 white 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

CUTTER CRIMPER TOOL (CS-8)

- Plier Nose (serrated-jaw)
- Scissors Action Cutting
- 6 Bolt Cutters (4-40, 5-40, 6-32, 8-32, 10-32, 10-24)
- Crimp Stations (7mm Auto — 22-20 to 12-X0 elect.)
- "Up-Front" Wire Cutting
- Scissors Action Stripping (No. 22-20 to No. 10)
- Crimp Stations — insulated (2w-20 to 12-10 elect.)

Actual Size - 8¼" length **$8.50**

Permacel Electrical Tape

- ¾" (wide) X 66 ft. (long) • All weather • Not import

$1.25 per roll — $9.95 per 10 roll package

ZENERS — DIODES — RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
1N746	3.3	400mm	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	8/1.00	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	PN3567	3/$1.00	PN4249	4/$1.00
MPS A06	5/$1.00	PN3568	4/$1.00	PN4250	4/$1.00
2N2219A	3/$1.00	PN3569	4/$1.00	2N4400	4/$1.00
2N2221	4/$1.00	2N3704	5/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	2N3705	5/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3706	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3707	5/$1.00	2N4409	5/$1.00
2N2484	4/$1.00	2N3711	5/$1.00	2N5086	4/$1.00
2N2906A	4/$1.00	2N3724	$.65	2N5087	4/$1.00
2N2907A	5/$1.00	2N3725	$1.00	2N5088	4/$1.00
2N2925	5/$1.00	2N3903	5/$1.00	2N5089	4/$1.00
2N3053	2/$1.00	2N3904	4/$1.00	2N5129	5/$1.00
2N3055	$.89	2N3905	4/$1.00	2N5138	5/$1.00
MJE3055	$1.00	2N3906	4/$1.00	2N5139	5/$1.00
MJE2955	$1.25	2N4013	3/$1.00	2N5209	5/$1.00
2N3392	5/$1.00	2N4014	3/$1.00	2N5951	5/$1.00
2N3398	5/$1.00	2N4123	10/$1.00	C106B1SCR	2/$1.00
				2N5432	$2.00

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

	1-9	10-49	50-100		1-9	10-49	50-100
.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

	1-9	10-49	50-100		1-9	10-49	50-100
.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	1-9	10-49	50-100	Radial Lead	1-9	10-49	50-100
.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

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- Continously variable from 5V to 20V
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- 4400 MFD of filtering.
- Drilled Fiberglass PC board
- One hour assembly
- Makes an excellent bench or lab power supply
- Kit includes all components
- Yes, Case is included

ONLY $9.95

VARIABLE POWER SUPPLY KIT #2
Same as above but with 1 amp output also with case - **ONLY $12.95**

POSITIVE VOLTAGE REGULATORS

LM340-6	LM340-15
LM340-8	LM340-18
LM340-12	LM340-24

To 220 Case. Your choice **ONLY $ .85**

NEGATIVE VOLTAGE REGULATORS

7905	7915
7906	7924
7912	To 220 case

Your choice - **ONLY $ .85 each**

FINNED HEATSINK for above Regulators 2-3/4" high
2-1/2" wide
1" deep
ONLY $ .40 each

TRANSISTORS

2N3904	6 / 1.00
2N3906	6 / 1.00
2N3055	.65
2N4400	6 / 1.00
2N5401	6 / 1.00
*2N2907	15 / 1.00

*(House numbered and are PC lead)

BATTERY CLIP
Standard 9V battery clip with 4-½" tinned leads 15 / $1.00

2N4249 @ 4/1.00
2N4443 400V 8 amp SCR @ .65

TN2021 RCA 200V - 115W T03 NPN @ 1.25

Potter Brumfield Relay
115 VAC - 4PDT @ 1.00

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LM380 8 Pin Mini Dip @ .75

Memorex Computer Boards @ 4.25 (5 pieces)

Color Organ
60 Watt @ 2.00

Sockets - Pulled from new PC Boards Guaranteed 100%
24 PIN low Profile 4/1.00
40 PIN Low Profile 3/1.00

TRANSISTOR ASSORTMENT
A good selection of PNP NPN transistors, PC Lead
Spec included for numbers in assortment 20/1.00
(100% Satisfaction Guaranteed)

IN4004	400 PIV	1 amp	@ 15/1.00
IN4007	1000 PIV	1 amp	@ 10/1.00
IN4148	Switching		@ 20/1.00

MAN 8 @ 1.25 each

FND 800 .80 character c.c. only 2.50

REPEAT OF SELLOUT

12 HOUR BASIC CLOCK KIT INCLUDES:
- FCS 8000 3-½ Digit .80in. Characters
- FCM 7010 Direct Drive Radio Alarm Clock chip
- 1 case (Punched for readout)

ALL THIS ONLY **$9.50** (Specs Included)

DRILLED PC BOARD
For above only **$2.50**
Transformer for above **$1.00**

WATERGATE SPECIAL: Telephone relay automatically starts and stops tape recorder. No batteries required. KIT COMPLETE with all parts—drilled PC board and case. **$10.95**

5V POWER SUPPLY—5 volt, 1 amp regulated power supply kit for all your TTL supply requirements. FEATURES: line regulation .005% Load regulation 50mV Kit includes all components, PC Board, Transformer, Fuse and Pilot Light. Nothing else to buy!. . . . . **$ 6.50**

LINEARS

LM710	14 Pin	.25	NE555	.45
LM711	14 Pin	.25	NE556	.95
LM741	Can, 14 Pin	.25	NE565	.95
	Mini-Dip		NE566	.95
LM748	Can	.25	NE567	1.10
LM324	14 Pin	.40	1458 (5558)	.49
LM309K		.95		
LM3900		.35		
LM380	8I Pin Mini-Dip	.75		
LM380	14 Pin	1.00		

60 HZ CRYSTAL TIME BASE—This 60 Hz crystal time-base enables MOS Clock circuit to operate from a DC power source ideal for car, camper, van, boat, etc.
- 60 Hz output with an accuracy of .005% (typ.)
- Low power consumption 2.5mA (typ.)
- Small size will fit most any enclosure
- Single MOS IC oscillator/divider chip
- 5-15 volts DC operation

only $5.95
2 for $10.00

LOW POWER SCHOTTY

74LS00	.25	74LS74	.49
74LS02	.25	74LS90	.85
74LS04	.30	74LS132	.90
74LS08	.25	74LS138	.89
74LS10	.25	74LS139	.89
74LS11	.32	74LS155	.90
74LS20	.31	74LS157	1.00
74LS21	.33	74LS162	1.39
74LS22	.33	74LS163	1.39
74LS27	.30	74LS175	1.09
74LS30	.31	74LS193	1.09
74LS32	.33	74LS258	1.09
74LS37	.40	74LS367	.70
74LS38	.35	74LS368	.70

TRANSFORMERS
12V CT 500ma @ 2.00
10V 1 AMP @ 3.25

TTL 100% GUARANTEED! OR YOUR MONEY BACK.

7400	.19	7425	.30	7454	.19	74100	$1.
7401	.19	7426	.27	7470	.38	74123	.65
7402	.19	7427	.19	7472	.25	74125	.47
7403	.19	7432	.34	7473	.25	74141	.75
74L04	.29	7437	.39	7474	.39	74145	$1.
7404	.19	7438	.39	7475	.59	74154	$1.
7406	.29	7440	.19	7480	.49	74161	.95
7408	.19	7442	.65	7485	.95	74163	$1.10
7409	.19	7443	.65	7490	.75	74164	$1.10
7410	.19	7444	.69	7491	.75	74174	.95
7411	.29	7446	.89	7492	.75	74175	$1.80
7413	.50	7447	.85	7493	.70	74180	.80
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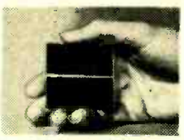

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