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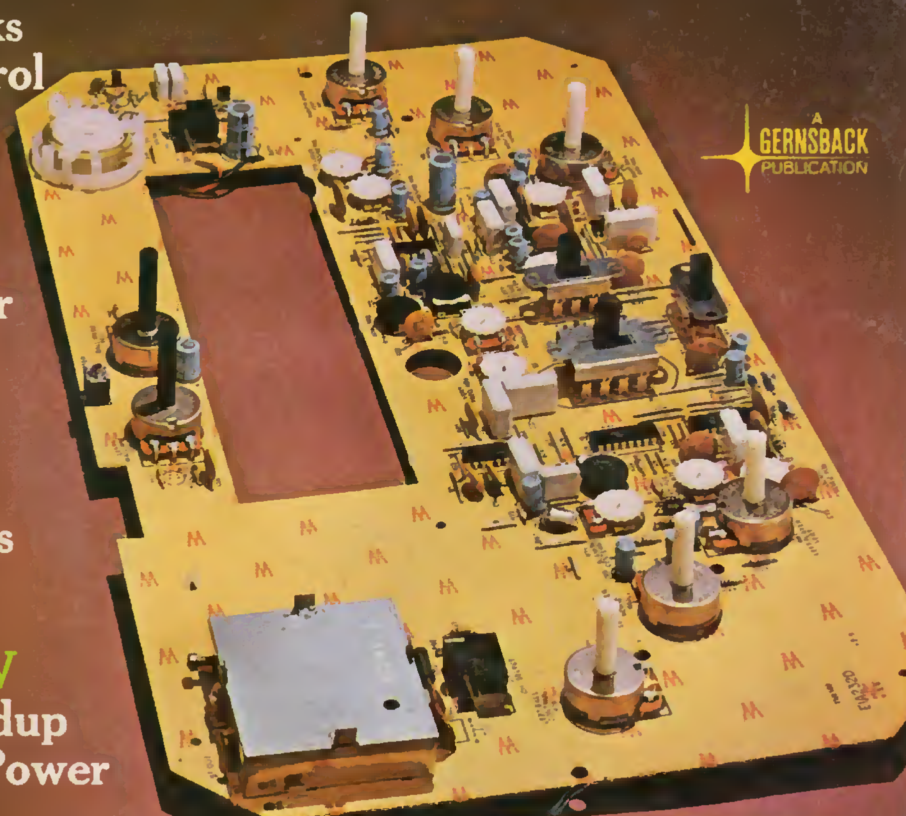

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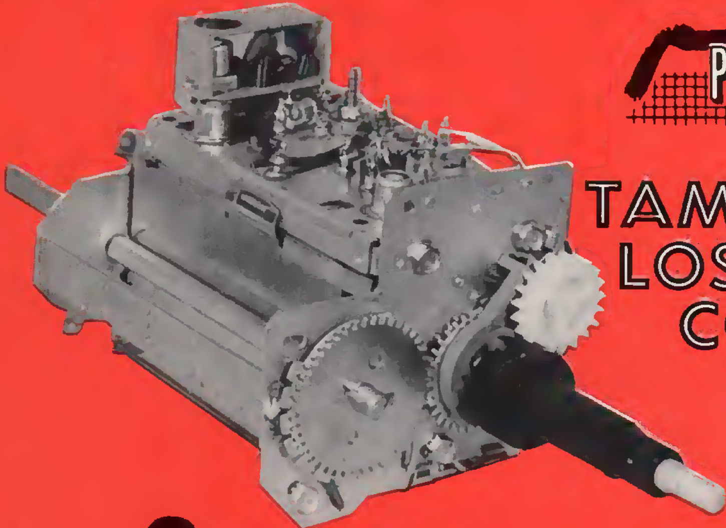

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Our terms are cash with order, BankAmericard or Master Charge. If you send in an early payment we will make an early shipment. By the same token, a late payment will result in a late shipment. (After 60 days past due, the balance of the deal is cancelled. All payments must be made within 10 months).

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*The Comter II Computer Terminal has a full alpha-numeric keyboard and a highly readable 32-character display. It has its own internal memory of 256 characters and complete cursor control. Also has its own built-in audio cassette interface that allows you to connect the Comter II to any tape recorder for both storing data from the computer and feeding it into the computer. Requires an RS232 Interface Card.

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NOTE: When ordering software, specify paper tape or cassette tape.

Warranty: 90 days on parts for kits and 90 days on parts and labor for assembled units. Prices, specifications, and delivery subject to change.

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GTE SYLVANIA

Circle 3 on reader service card

Radio-Electronics®

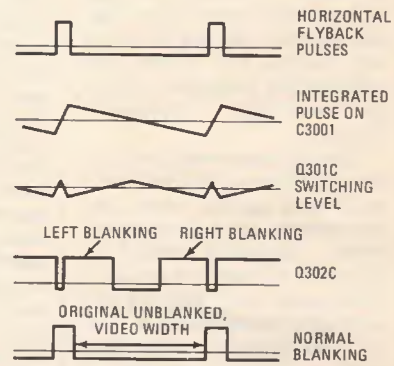
THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

Electronics publishers since 1908

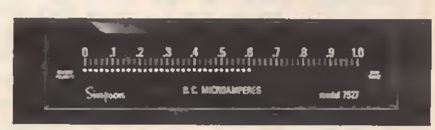
DECEMBER 1975 Vol. 46 No. 12

ON THE COVER

TV games are cropping up everywhere. Save the 25¢ and play at home using your own game and TV set. The new Odyssey game by Magnavox is described in great detail in this issue. Turn to page 29 now.



ZOOM IS WHAT ZENITH calls their TV picture enlarger. These waveforms make it work. The details are on page 34.



DIGITAL PANEL METERS are in. But do you really know how many are available? Here's a quick rundown. ...see page 35

Radio-Electronics, Published monthly by Gernsback Publications, Inc., 200 Park Avenue South, New York, NY 10003. Phone: 212-777-6400. Second-class postage paid at New York, NY and additional mailing offices. One-year subscription rate: U.S.A., U.S. possessions and Canada, $8.75. Pan-American countries, $10.25. Other countries, $10.75. Single copies 75c.

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looking ahead

Trinitron upgraded

The picture tube that launched a revolution in small-screen color is now being overhauled and will be manufactured in both the United States and Japan. The new version is claimed to have a 60% increase in brightness and far greater contrast than the current models. The tube is Sony's Trinitron—the one that sparked color tube makers all over the world to design models with in-line guns and vertical phosphor stripes, the so-called "slot-mask" tubes,

Sony is combining its Trinitron single-gun, slit-mask principle with another trend that has swept the color-tube industry—"negative matrix," pioneered by Zenith's Chromacolor tube. Sony was the last holdout against negative matrix. The negative matrix tube uses a black material to separate the phosphors for greater contrast. Increased brightness is achieved by enlarging the electron beam so that it fully illuminates the phosphor stripe or dot on the screen. Additional brightness can be attained by increasing the transparency of the faceplate, since the added contrast provided by the black material on the screen reduces the need for tinted glass. Sony is using both techniques to enhance brightness.

The first tubes to use the new Trinitron will be 17- and 19-inch units with 114° deflection, to be incorporated in sets for sale in the United States in 1976.

Radiowriting

In a little-noted action last March, the FCC amended its rules to permit transmission of visual material via the SCA multiplex subcarriers of FM stations (normally used for such services as background music for restaurants, and so forth). One of the first groups to take advantage of this change is Fax Net Inc., headed by the television pioneer John Porterfield, which is establishing a new broadcast service called Radioprinter.

Radioprinter is a method of relatively low-cost electronic delivery of written material and will be used to transmit specialized news and educational services to subscribers in financial, medical, marketing and traffic fields. Each station's subcarrier is capable of sending out four encoded Radioprinter broadcasts simultaneously, covering all subscribers within a radius of about 50 miles. A subscriber to any of the special services —which could be a financial news ticker, a daily trade magazine or price information designed for retail chains—leases a receiver and special high-speed teleprinter. A decoder permits him to receive only the service or services to which he subscribes. Porterfield says he plans to franchise FM stations in 50 major markets to use his system and that he is now in discussion with publishers and others who would use his service as a substitute for mail or wireline communication. The system has been tested for a year on FM station WCLR, Chicago. A future variation on this system, he suggests, might use slow-scan TV or facsimile.

TV via FM

Television pictures are already being transmitted by FM stations in at least two school systems—South Bend, IN and Hancock, MI. The latter has started an elaborate experimental program of educational slow-scan teaching using WGGL-FM, an educational station in Houghton, MI. A standard videotape is first made, then fed into an electronic signal compressor that selects only portions of the image for squeezing into the narrow bandwidth of the FM station (frames are changed once every 8.5 seconds). This image is then broadcast by the radio station and picked up by 16 cable systems operating throughout the Michigan Upper Peninsula area. The cable systems feed the picture on a regular channel, and conventional television sets are used at the schools to display the picture. No motion can be shown on slow-scan television, of course, but the system is expected to bring math and music instruction—and eventually science teaching—to about 2,500 children in 15 school districts at a production cost of perhaps $100 an hour.

Recession casualties

One of the major private-brand names in television and stereo has disappeared—Bradford, the name under which W. T. Grant sold its consumer electronic products through some 1,100 outlets. Bradford color and monochrome TV sets have been made by General Electric, Matsushita (Panasonic) and Wells-Gardner. Its stereos have come from a variety of sources, including the big Japanese trading company C. Itoh, Lloyd's and Major Electronics.

Meanwhile ,the largest supplier of glass bulbs for TV pix tubes, Corning Glass Works, has dropped out of the monochrome business after unsuccessfully trying to pass along cost increases—leaving the future of American black-and-white tube business in doubt. Corning shut down its last remaining monochrome plant, in Albion, MI. This still leaves two monochrome pix bulb manufacturers, Owens-Illinois and Lancaster Glass Co. But Owens is known to be re-evaluating its black-and-white business and Lancaster makes only relatively expensive small pix tubes. There are two black-and-white tube manufacturers left in the United States—Sylvania and Clinton Electronics. If they drop production of monochrome tubes, or if they are forced to price too high, the end of black-and-white television set production in the United States could be in sight. Of course, monochrome sets will continue to be sold under American brand names, but they'll come from Japan, Taiwan and other Far Eastern countries, as many already do.

CB spectrum crisis

The greater the success of Citizens band radio, the less valuable it is to CB users. The fact is that CB's burgeoning boom has resulted in such overcrowding on the 23 channels that in some localities it's difficult to get a word in edgewise. Recently, a group of 36 CB equipment manufacturers, distributors, dealers and user organizations petitioned the FCC to get moving on its plan to reallocate 40 more channels for FM Citizens-band use in the 224—225-MHz band. This proposal has been opposed by amateur radio operators, who currently occupy these frequencies along with government services.

The CB proponents told the FCC that the situation had reached "emergency proportions" and predicted a "public outcry of unsatisfied and disgruntled citizens" unless the FCC took action soon. The FCC says it can't do anything until it receives reaction and data from Mexico and Canada, required by treaty. The Commission is particularly anxious not to arouse the ire of amateur radio operators, who have performed great emergency services for the nation—and also happen to have a very effective lobby. As an alternative to the 224—225-MHz band, the FCC is known to be looking into the 216—218-MHz band that is used for low-powered telemetering. The FCC believes that this band could be shared between CB operators and telemetering service without any major interference problems. But don't look for any rapid resolution to the situation—FCC allocation proceedings are always slow affairs at best.

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR

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Circle 4 on reader service card

new & timely

Raymond F. Guy dies at age 76; was early amateur, broadcaster

One of the first holders of an amateur radio license as well as one of the first persons to operate a broadcast station, Raymond F. Guy, died July 12 at Boca Raton, Florida. Born in 1899, he received the ham call 2ANC in 1911 and his commercial radiotelegraphy license in 1916. He worked as "Sparks" on several ships before enlisting in the U.S. Army in 1918, where he served in the Signal Corps. After his discharge he attended Pratt Institute in Brooklyn, receiving his E.E. degree in 1921.

On the opening of WJZ, the country's second broadcast station in the same year, he accepted a position that included the work of engineer, announcer and such other functions as might be necessary. In 1924 he was transferred to the RCA research laboratory at Van Cortlandt Park, New York, doing development and research work. This included (in 1927) some of RCA's earliest television developments.

He joined the National Broadcasting Co., (NBC) in 1929, remaining until his retirement in 1961 as Senior Executive Engineer, responsible for all of NBC and its networks, transmitters and frequency allocations.

Mr. Guy was an active member of more than a dozen professional organizations, plus a number of amateur and other associations. He was a prolific writer, coauthor of *Fundamentals of Radio and Electronics*, published by Prof. W. L. Everett, and of more than 150 engineering papers, as well as numbers of magazine articles, some of which appeared in **Radio-Craft** and **Radio-Electronics.** His numerous awards include recognitions from the Veteran Wireless Operators Association, Broadcast Pioneers, National Association of Broadcasters and RCA Corp.

He is survived by his wife, a sister, a daughter (Mrs. Helen Guy Winget of Mahwah, NJ) and two grandchildren.

Thomas Waye and Stephen Meredith are Gernsback Award winners

Latest winner of the Hugo Gernsback Scholarship Award—a grant of $150 given annually to an outstanding student in each of eight leading home study electronics schools—is M/Sgt Thomas A. Waye, CET, of Elgin Air Force Base, Florida. A Crew Chief Radar Maintenance Supervisor, M/Sgt Waye is responsible for the operation and maintenance of the AN/FPS-85 Phased Array Spacetrack Radar (valued, his colonel says, at more than $100 million). The radar is used to detect and track satellites. His duties also include guiding the workload of a large number of technicians who perform essential functions for the organization.

Married and with two children, M/Sgt Waye expects to retire from military service this year after 20 years of service (he is 37) and hopes to obtain a research or development oriented job.

M/SGT THOMAS A. WAYE

He has completed two courses at the Capitol Radio Institute, and has taken a number of military and civilian courses in various phases of electronics. His future educational goal: to earn a BSEE degree. The February, 1975 issue of the ISCET (International Society of Certified Electronic Technicians) magazine reports that M/Sgt Waye is the only CET who has ever passed all five of the available CET examination options.

STEPHEN H. MEREDITH

Winner of the second-place award, an RCA WV-529A service special VOM donated each month by RCA, is Stephen H. Meredith. Born in Corning, Iowa, he graduated from the Bedford Community High School in May 1970 and attended Southwestern Community College in Creston, Iowa, majoring in Electronics Technology until June, 1972. In September of that year he entered the Air Force and attended the Precision Measuring Equipment Specialist School at Lowrey Air Force Base, graduating with special honors at the top of his class.

He is now at Offut Air Force Base in Nebraska, where he was selected as Maintenance Man of the Month in December 1974. He is continuing his CREI studies, maintaining an "A" average while progressing rapidly. In February 1975 he passed his examinations for the First Class Radiotelephone license.

Acoustooptical light deflection opens up new techniques

Before the laser, the only practical methods of deflecting light beams were mechanical. Acoustooptical methods made possible by laser technology have greatly increased scanning speeds, moving deflection up from the low speeds of the mechanical techniques into the order of microseconds.

RESOLUTION IS HIGH from acoustooptical printer. Letter on right was made with new printer, letter on left was made with a conventional mechanical printer.

In an acoustooptical scanning system, ultrasonic waves are generated and made to travel through a suitable deflecting medium (crystal or liquid). The resulting variations in pressure traveling down the reflecting medium alter its refractive index (the amount it will bend a beam of light) so that a laser beam passing through the medium at right angles to the direction of the ultrasonic waves is deflected as if by a diffraction grating.

An important application of such techniques is in nonmechanical high-speed printers where, in addition to the high scanning speed, wear is reduced almost to zero because of the absence of moving parts. Siemens Laboratories have demonstrated such a printer, in which the switching time (the time required to deflect the beam from one end of its scan to the other) is between 5 and 10 microseconds. Printing speeds of more than 10,000 lines a minute are possible. The acoustic frequency used is approximately 150 MHz.

(Continued on page 12)

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GLIDE-PATH?®
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Model
Shown: STA-225

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

NRI pays no salesmen. We buy no outside "hobby kits" for our experiments or training kits. NRI designs its own instruments and TV sets... to give you great performance plus real training that you can put to practical use. The result is low tuition rates without the penalty of exorbitant interest charges for time payments. We pass the savings on to you.

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Home study isn't a sideline with NRI. We've been its innovating leader for 60 years. More than one million students have enrolled in our many career courses. NRI is one of the few home study schools with a full-time staff of engineers, authors and editors to help you with any problem. NRI graduates will tell you: you can pay more, but you can't buy better training.

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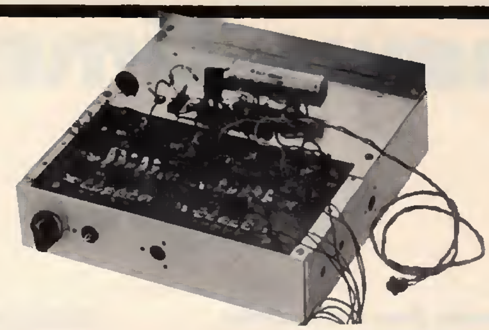

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This Master course combines theory with practice in fascinating laboratory units. Unlike "hobby kits", the NRI color TV was designed with exclusive "discovery" stages for experimentation and learning. Building the set will give you the confidence and ability to service any color TV set on the market. And you'll have a magnificent set for years of trouble free performance.

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new & timely

(Continued from page 6)

Smokey Bear and truckers unite for greater safety

Truckers and highway police have often been at odds, with truckers using CB radio (now almost universal on large road rigs) to warn of speed traps. Some groups have even proposed making CB radio illegal on trucks.

Such organizations as REACT (Radio Emergency Citizens Radio Teams) maintain that CB increases highway safety tremendously.

The US Department of Transportation appointed a committee to study the pros and cons, particularly from the viewpoint of interstate trucking use. The report of this committee backs up the citizen user of CB with the opening statement: "CB has value for transportation safety by providing means for the citizen to request assistance, report hazards and problems and receive safety information," and recommends "Support and encourage use of CB Channel 9 as a national emergency and motorist-aid contact channel."

Traffic police organizations tend to agree with the D.O.T. No one is more interested in highway safety than the driver of a large truck, and where State Police have CB radio, the response to accidents—reported largely by truckers—has been speeded up and apprehension of drunken and wrong-way drivers and other menaces to safety has increased greatly. The trucker, of course, still uses his radio to warn of "Smokey Bear" and speed traps, but the superintendent of the Missouri State Highway Patrol, Colonel Sam Smith, predicts that such warnings would diminish in scope if all enforcement officers were equipped with CB.

Colonel Smith further points out that the greatest benefit of CB is that it makes the traveling public and the police partners in maintaining highway safety. "We consider the use of CB radios the most revolutionary idea to occur in law enforcement in the century," he says. "It not only has the potential of providing upgraded services to the public, but will also provide means whereby the citizen can become involved in law enforcement."

Sale of instant-on TV's banned in New York State

Passed as an energy conservation measure, a new State law forbids the sale of sets in which a small continuous current flows at all times, keeping tube elements hot and permitting the set to go into action immediately when it is turned on.

The new law has been before the legislature a number of years, but passed only recently. It takes effect January 1, 1976.

Scientists believe they've found magnets with only one pole

Scientists of the University of California and the University of Houston (TX) join in announcing that they have discovered the track of what may be the basic unit of magnetism, a unit that plays the same part in magnetism that the electron does in electricity. The track of the assumed magnetic particle was found in a multi-layer "blanket" that was hung from a balloon over Iowa two years ago, in a search for superheavy elements in cosmic rays. It contained 33 layers of a special plastic plus several layers of emulsions and photographic film designed to record the tracks of high-speed particles.

The track is of a particle far heavier than any previously recorded, and the scientists believe it can only be a monopole, or one-pole magnetic particle.

Researchers have long suspected that a one-pole magnetic unit might exist, and in 1931 the famed physicist P. A. M. Dirac listed some specifications for it. He said that the magnetic monopole should carry a basic unit of manetism comparable to the basic unit of charge on an electron. It would be 68.5 times as strong as the electric unit, or a multiple of that figure. (The present particle appears to have the strength figure of 137, predicted as a possibility by Dirac.)

In 1943 the controversial Austrian scientist, Professor Felix Ehrenhaft, reported that he believed he had observed such particles in an apparatus of his own devising. His work was described in two articles in the predecessor of this magazine, **Radio-Craft**, March and November 1944. One of the articles states: "Dr. Ehrenhaft believes that small particles may have one polarity—may be magnetically charged North or South." The professor's results were inconclusive.

Other scientists have looked favorably on the idea of magnetic monopoles, partly because electric theory almost requires such units. The existence of magnetic monopoles "would lead to such symmetry in electrical and magnetic phenomena" as to cause scientists to suspect their existence. Says Dr. Goldhaber of the State University of New York: "No one would have believed in the existence of monopoles from one observation, if they were not already convinced."

The possibilities of isolating or using monopoles seem remote, but dramatic statements have been made about the uses to which they might be put. These range from new therapies and small but powerful motors to "putting a few monopoles in a ship and having the Earth's magnetic field tug it across the ocean."

(Continued on page 14)

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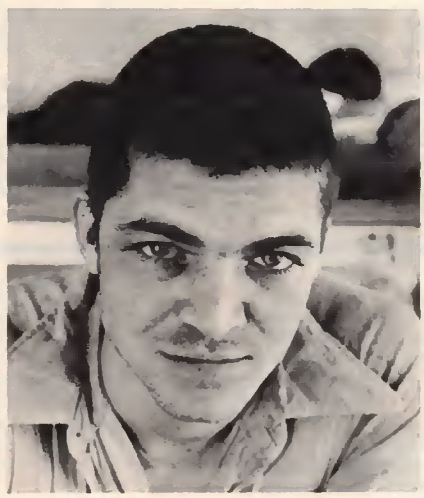
new & timely

(Continued from page 12)

Lamont Whitlock, Donald Thorne awarded Gernsback scholarships

The fourth 1975-76 winner of the Hugo Gernsback Scholarship Award, a prize of $150 given annually to a deserving student in each of eight leading home study electronics schools, is Lamont C. Whitlock. Winner of a WV-529A special service VOM donated monthly by RCA to the student who scores second highest in the contest is Donald Thorne, Sr.

Born in 1951 in Mayfield, KY, Lamont C. Whitlock enlisted in the Marine Corps in the spring of 1970. His interest in electronics began with his in-service training as a radio-telecommunications maintenance man. Having left high school in a dispute over classes a month before graduation, he also acquired his High School GED certificate—with a score of 95—while in the Marines.



LAMONT C. WHITLOCK

Arrested in November 1974 while on a deer hunting trip, Lamont was convicted of carrying a concealed weapon without proper license and was sentenced to 10 months in the county jail. Deciding to put his time to good use, he enrolled for the NRI Master TV/Audio Servicing course while working as instructor for the inmates weight-training course, High School-GED program, and English and Math study programs.

Donald J. Thorne, Sr., age 40, had to leave school at age 15 to help support his family. During his working years he became increasingly aware of the importance of radio and electronics to many industries.

He took a course with NRI, and in 1961 graduated as an appliance service technician. At present he is taking the Complete Communications Course, which he has almost completed. He has also en-

DONALD J. THORNE, SR.

rolled in the American School's High School course and has completed nine of the 18 units required for graduation.

Electronics firms unlikely to take over digital watch sales

Sales of digital watches will continue with watch companies rather than go into the hands of electronics marketeers as was the case with electronic calculators. This is the opinion of W. K. Weakland of Hughes Aircraft Company's microelectronics products division, probably the nation's largest producer of digital watch modules.

"The watch business," said Weakland, "has a long-established and successful merchandising pattern that watch companies know and electronics companies don't." Calculators, on the other hand, were a brand new product with no existing marketing channels.

THE NEW GEMINI II DIGITAL WATCH, has a digital display which shows the time clearly under all light conditions from noonday sun to absolute darkness. Retal price is $395.

The comments were made at the first public showing of the Longines Wittnauer Gemini II, for which Hughes makes the module. The new watch features a unique dual-display design, using both light-emitting diodes and liquid crystal display. The reflecting liquid crystal is most highly visible in brightest light; the LED display is activated in dim light or darkness.

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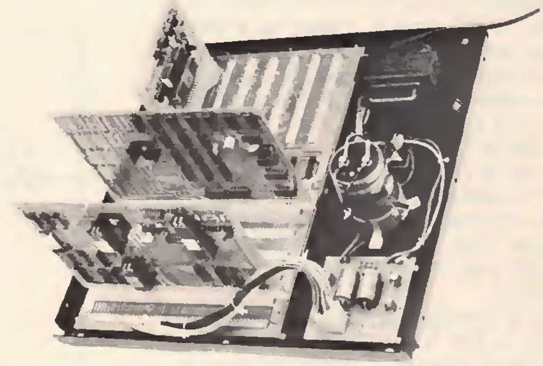

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In addition to the outstanding hardware system, the Motorola 6800 has without question the most complete set of documentation yet made available for a microprocessor system. The 714 page Applications Manual for example contains material on programming techniques, system organization, input/output techniques, and more. Also available is the Programmers Manual which details the various types of software available for the system and provides instructions for the programming and use of the unique interface system that is part of the 6800 design. The M6800 system minimizes the number of required components and support parts, provides extremely simple interfacing to external devices and has outstanding documentation.

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letters

RECTIFICATION

Regarding your article, "Audio Signals You Never Bargained For" in the April 1975 issue of **Radio-Electronics,** I felt compelled to write to you regarding detection of RF signals. I work as a technician for the Canadian Broadcasting Corporation here in Toronto and our radio studios are about 100 yards from:

CH 5 TV transmitter
CH 19 TV transmitter
CH 25 TV transmitter
FM station at 94.1 MHz

We originally had considerable interference from these transmitters and I thought you might be interested in our solutions.

For a transistor stage, the solution is shown in Fig. 1. The 1000-ohm resistor and 200-pF capacitor should be as physically close to the transistor as possible —preferably on the leads of the transistor itself. The 1000-ohm resistor is after the biasing network.

The rectification is normally *in the 1st stage* of the mike, phono or tape preamp but the same method should be applied to later stages if required. The 200-pF capacitor with ¼-in. leads has a series resonance of about 80 MHz but its very

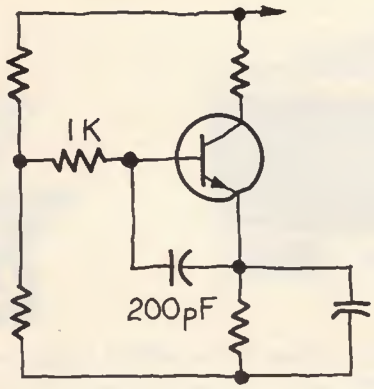

FIG. 1

broad and will cover TV channels 4 through 6 and FM band. I don't recommend going above 500 pF as the transistor could oscillate.

For AM band, change the 1000-ohm resistor to a 1-mH RF choke and the capacitor to 470 pF.

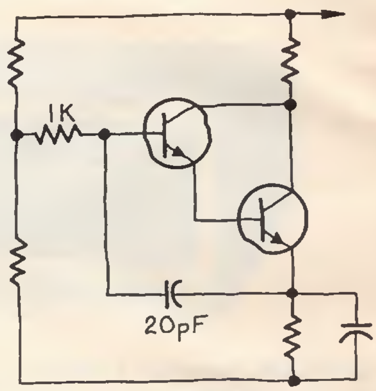

FIG. 2

For 30 MHz; leave the resistor at 1000 ohms (although a 20 μH RF choke may work as well) and change the capacitor

(continued on page 22)

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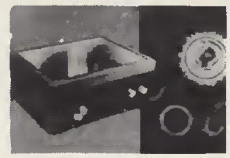

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(continued from page 16)

to 470 pF.

For UHF TV interference; try a ferrite bead in place of the 1000-ohm resistor and change the capacitor to a 10 pF ceramic.

For Darlington input stage—same method. (See Fig. 2.)

Now for the theory behind this. Consider a detector (base-emitter junction) and an antenna (See Fig. 3). If a capacitor

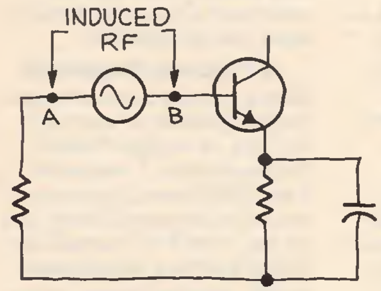

FIG. 3

is placed between point A and ground, the source is effectively shorted out as far as RF is concerned. This applies more RF to the base-emitter junction and makes matters worse! Connecting a capacitor to point B (close to transistor) and to ground is not doing the job either. The reactance of the emitter capacitor is very high to RF, so the emitter resistor is in series with the capacitor across the base-emitter junction (see Fig. 4). Obviously, the best solution is to put the capacitor directly across the detector (base-emitter junction). The resistor in series with the detector gives a further improvement.

It has not been my experience that the base-collector junction detects. Possibly

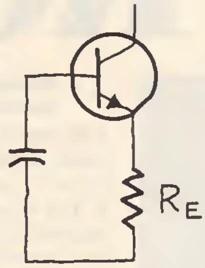

FIG. 4

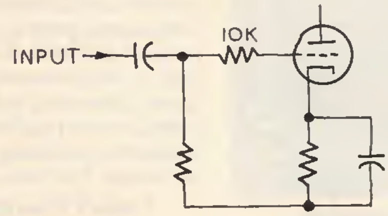

FIG. 5

because of the high reverse-bias. Old germanium transistors never give any trouble due to their high base-to-emitter capacitance (low high-frequency response).

For tubes, a 10,000-ohm resistor in the grid circuit once again, as close as possible to socket, usually works best. NO CAPACITOR. (See Fig. 5.)

The solution for integrated circuits is shown in Fig. 6. IC's are the hardest to

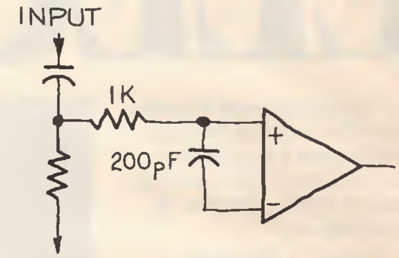

FIG. 6

debugg primarily because its not generally possible to get across the base-emitter junctions.

T. R. BURNS
Toronto, CANADA

In your April 1975 issue, you published an article by Len Feldman entitled "Audio Signals You Never Bargained For." The article came at an appropriate time as I was having this type of trouble and could not determine what was causing it.

I do quite a bit of tape recording of records as a retirement hobby. I recently constructed a single-channel 9-octave audio equalizer which I wanted to use while taping records.

I have a small Sony 8FS-50W stereo

(continued on page 28)

This automatic transistor tester works in-circuit when others can't.

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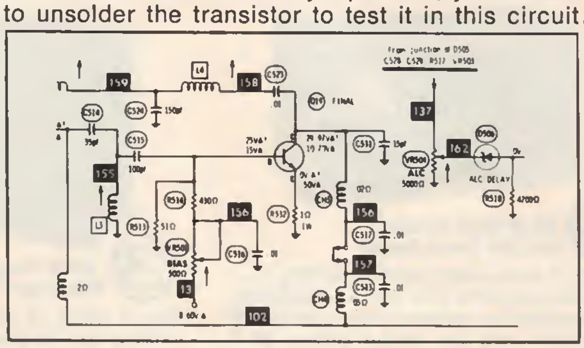

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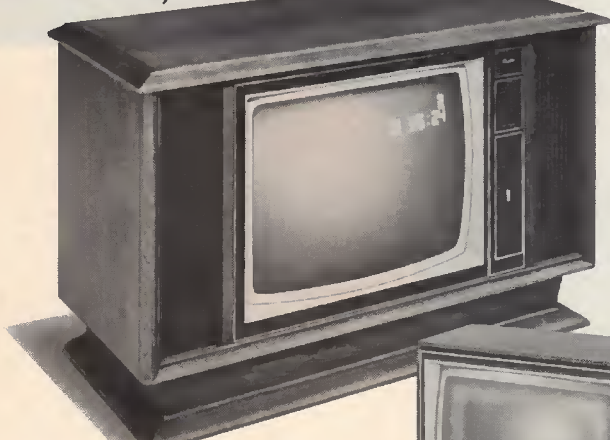

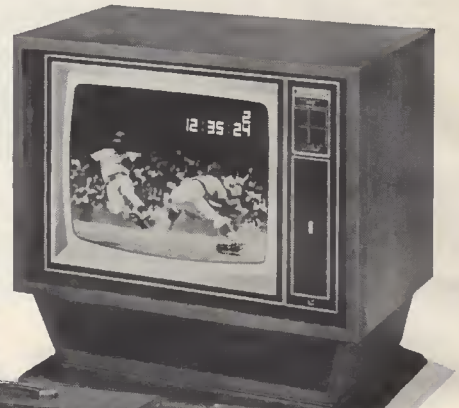

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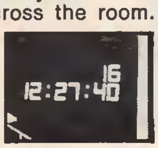

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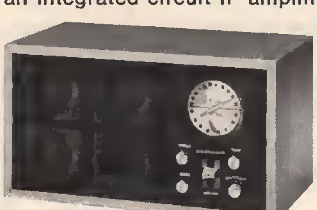

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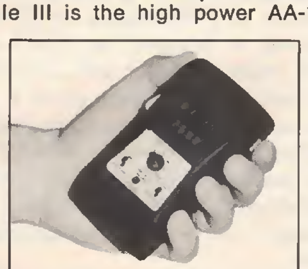

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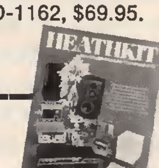

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PIONEERS OF RADIO

by FRED SHUNAMAN

ELIHU THOMSON

EDWIN HOUSTON

THE EFFECTS OF RADIO WAVES WERE probably first noted by Professor Edwin Houston of Philadelphia, in 1871. Attempting to improve the 6-inch spark from a new induction coil, he attached one end of the secondary to a water pipe and the other to a large insulated conductor, in this case a metal still. This made the spark stronger, though a little shorter. Houston called it a "condensing" (we would say capacitance) effect.

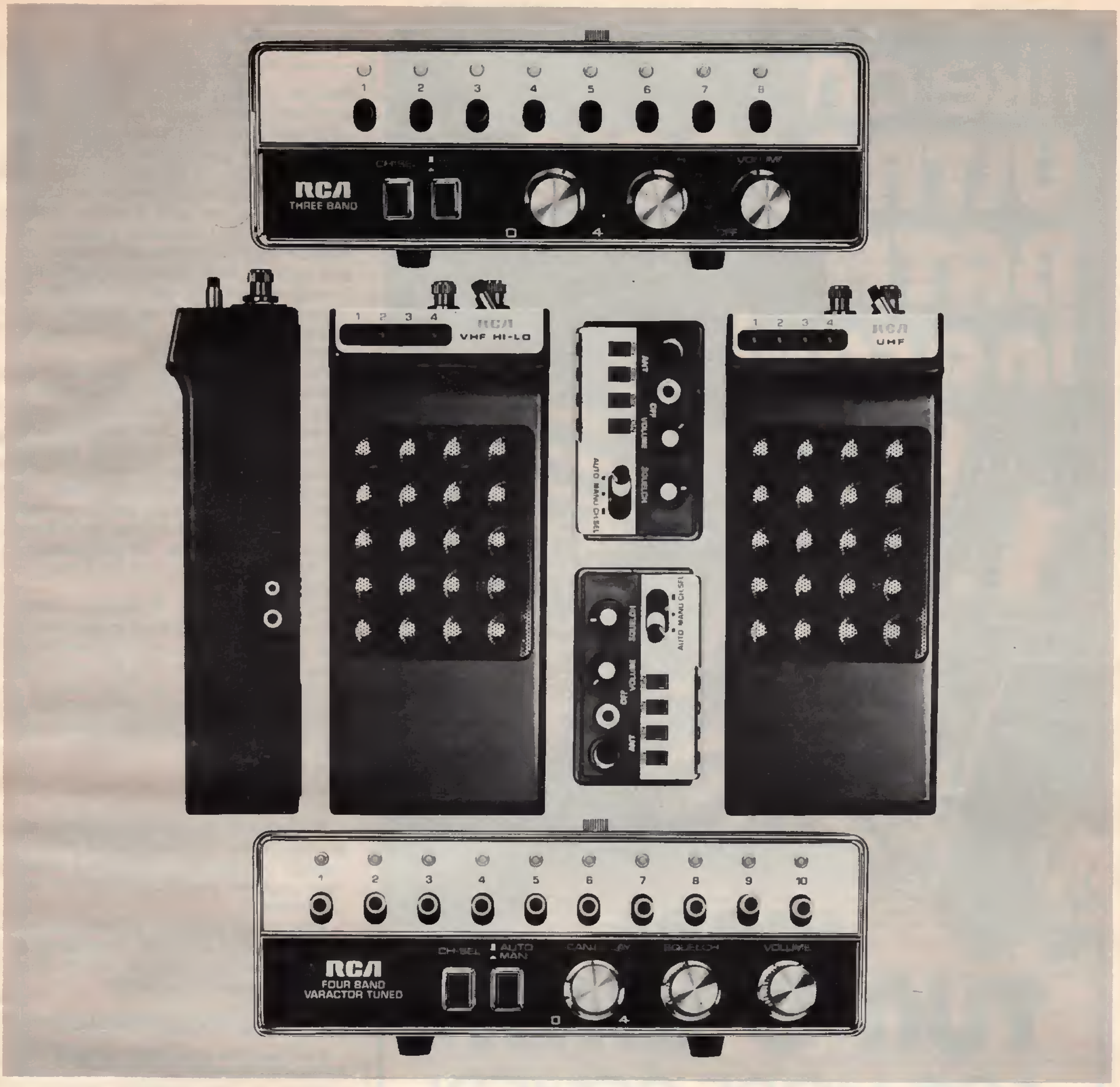
He noted that when the coil was so connected, sparks could be drawn from metal objects in the room, especially grounded ones, and that he could light the gas with the spark that jumped when he brought a finger close to the metal gas jet. He did not understand the effect and referred to it as electrical losses.

Four years later, Edison announced his discovery of "etheric force." He did not believe it was electrical, because it could not be detected with a galvanometer and did not affect the gold-leaf plates of an electroscope.

Houston and his associate Elihu Thomson, chemistry professor at Philadelphia's Central High School, discussed the new force. Thomson decided: "This is not a new force–it is electrical, in the form of sudden impulses reversed rapidly, as it might be termed." Rigging up the 1871 equipment (with a smaller spark coil) they set out to prove the new force was electrical in nature. Professor Thomson was able to draw sparks from doorknobs with a short, sharp lead pencil, first in the same room as the coil and then on succeedingly higher floors till he drew sparks from the observatory library doorknob on the sixth floor, about 100 feet from the "transmitter."

Houston and Thomson debated Edison's conclusions in the *Journal of the Franklin Institute* and in the *Scientific American Supplement*. They explained that the reason Edison's "force" did not act like ordinary (direct current) electricity was that each impulse that produced a spark was succeeded by a reverse impulse, an "inverse current" as they called it. This neutralized any effect the first current would have had on an instrument, if indeed the first current lasted long enough to have produced any effect at all. (If they had known that the first two were followed by a series of "direct" and "inverse" currents of decreasing amplitude, they would have had a complete theoretical explanation.)

Unfortunately for radio, Thomson's great talents led him in other directions. He left teaching and with his friend and associate Houston started designing and manufacturing electric generators and motors, and arc lighting and resistance welding equipment. Their company combined with Edison's in 1892 to form General Electric, though the Thomson-Houston firm name still exists and is important in a number of foreign countries. R-E



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LETTERS

(continued from page 22)

AM/FM receiver thru which I can play and tape records but it is not equipped with tape monitor in and out circuit, so I constructed a separate phono preamp using an LM381 IC. Now when I connect the record player thru the preamp, then equalizer, to the tape recorder (Sony model TC-353), I can tape a record and monitor the taped result on my speakers. But at times while taping I'd hear interference—sometimes music, sometimes voices. Checking this out I found I was hearing an FM station and at times an Amateur would be heard.

As suggested by Mr. Feldman, I put a 250 pF capacitor across the input of the preamp and that helped considerably. I tried the capacitor and inductor setup suggested using first a 1.5 μH inductor and then a 5.6 μH, but it didn't seem to improve things. I was told that the shielded cables normally used are made with a spiral shield instead of braided shield. I had some single-conductor braided shield cable and tried that but it didn't help.

Mr. Feldman said if enough interest was shown he would have more information on this subject. Are more articles coming up? I would like to get all information available on this subject. I wrote to the local FCC but they were of no help. I am writing to EIA to see what they will do.

A. A. HOLLIGER
Los Angeles, CA

Mr. Feldman is patiently awaiting reader responses to determine if there is enough interest for a follow-up article. Your response has been taken into consideration.

How about the rest of our readers? If you know of any other sources of information on rectification, let us know so we can pass it on—Editor.

CLEARING HOUSE FOR SECURITY

I've been an avid reader of your publication for many years. I particularly look forward to the excellent articles on security systems and I am presently attempting to write a book on the subject. In reviewing the many articles you have presented over the years, I noted that a gentleman volunteered to act as a "clearing house" for your TV Typewriter. I would like to avail myself as a "clearing house" for security systems. Readers that would like to participate in exchanging ideas, approaches and problems can write to me at the following address: Don Johanson, 1860 Polk St., Concord, CA 94521. In turn I will compile the information and distribute it to those interested. (A self-addressed, stamped envelope will help.)

My book, when completed, will cover fire/intrusion detection, controls and alarms with sections on do-it-yourself circuits and low-cost measures that can be taken to reinforce areas of entry.

Keep the security articles coming—in these times we need them.

DONALD P. JOHANSON
Concord, CA. R-E

TV games are great fun to play. But they are also exciting examples of how to use modern electronics. Come along and see how they work

by LARRY STECKLER
EDITOR

TV Games At Home

FOR A CONSIDERABLE NUMBER OF YEARS, we sat in front of our TV sets and let them entertain us with moving pictures on that little screen. In the time that we've enjoyed TV, the screen has gotten larger and is still growing, and we've gone from back and white pictures to full living color. And now there are even some experiments with stereophonic sound.

Yet there is a new kind of entertainment being offered on that home TV screen—it's a Ping-Pong game, a soccer field, a shooting gallery and others and you, who until now have been a passive viewer get to control the action.

By now, we've all been exposed to the coin-operated games in hotel lobbies and "penny" arcades, but those games have finally moved into the livingroom. You just take the little black box with two or four knobs on the top, connect it to your TV receiver and instantaneously convert that set into a home game center—a center that lets you play any one of several games, keep score and includes sound effects too.

The first of these games to reach the home was the Magnavox Odyssey. In its original form, it offered no sound, but did permit the user to play a multitude of games by placing printed plastic overlays on the screen of the set to form the gameboard. Now Magnavox has gone one step better. They've added sound effects along with scoring and pattern generation, to create the field upon which you play and produce the sound effects that add realism.

We've all seen the games, but the real question is do we know how they work. Thanks to an awful lot of cooperation from the Magnavox engineering staff in Fort Wayne, Indiana, we are able to bring you details on how their system functions.

Odyssey 200

The 200 is a self-contained unit that connects to the antenna terminals of any TV set. It is powered by either six "C" cells or an external 9-volt DC power supply. Three games are offered—Hockey, Tennis and Smash. Either two or four players can play.

The unit connects to the TV receiver and delivers its signal via a 50 ohm coaxial cable through an antenna switchbox to the set's VHF antenna terminals. The switch selects either the game or an external VHF signal. Since this unit is a Class 1 TV device, it meets all of the required FCC regulations. The switch box prevents game signals from being fed into the antenna system.

Before we look at how the unit works, let's briefly describe the three games that can be played. First is Hockey, which can be played with either two or four players, a ball, a left wall and a right wall on the screen. In the 4-player mode, each opponent has vertical position control of two players (both move vertically by means of one control) and horizontal control of one player (the other player is fixed horizontally). The two walls have openings (goals) at the center. As the ball moves across the screen and contacts one of the walls, it reverses direction.

If the ball is moving to the right and contacts the right opponent's player, it reverses direction to the left and the right opponent has ball control. If the ball is moving to the right and touches the left opponent's player (it may have rebounded off the left wall), it continues to the right, but the vertical ball control is now in the possession of the left opponent. The ball cannot go off the top or the bottom because black rebound walls return the ball to the playing field with a bounce. A score is made for the left opponent when the ball passes through the right goal regardless of who has ball control. The right opponent scores when the ball passes out through the left goal.

The second game is Tennis, and again there can be either two or four players, a ball and a center wall. The ball does not rebound from the center wall. The opponents attempt to make each other miss the ball as it moves across the screen. A score is made for the left opponent when the ball passes out the right side of the screen and a score is made for the right opponent when the ball passes out the left side of the screen. Just as in Hockey, the ball will not go off the top or the bottom because black rebound walls return the ball to the playing field with a bounce.

The third game is Smash and there can be only two players, a ball and a left wall. The ball rebounds to the right off the wall and to the left off the players. Opponents attempt to make each other miss the ball. A score is made for the opponent who last had ball control when the ball passes out the right side of the screen. Just as in Hockey and Tennis, the ball will not go off the top or bottom because black rebound walls return the ball to the playing field with a bounce. The ball is reset by touching the wall with a player.

How it works

Signal from the unit is fed into the TV set on either channel 3 or channel 4. The choice is up to the user and the active channels in his area. The heart of the unit is a network of six integrated circuits (see block diagram in Fig. 1), IC1 contains the regulated power supply, right-wall generator, syc generator, and rebound circuitry.

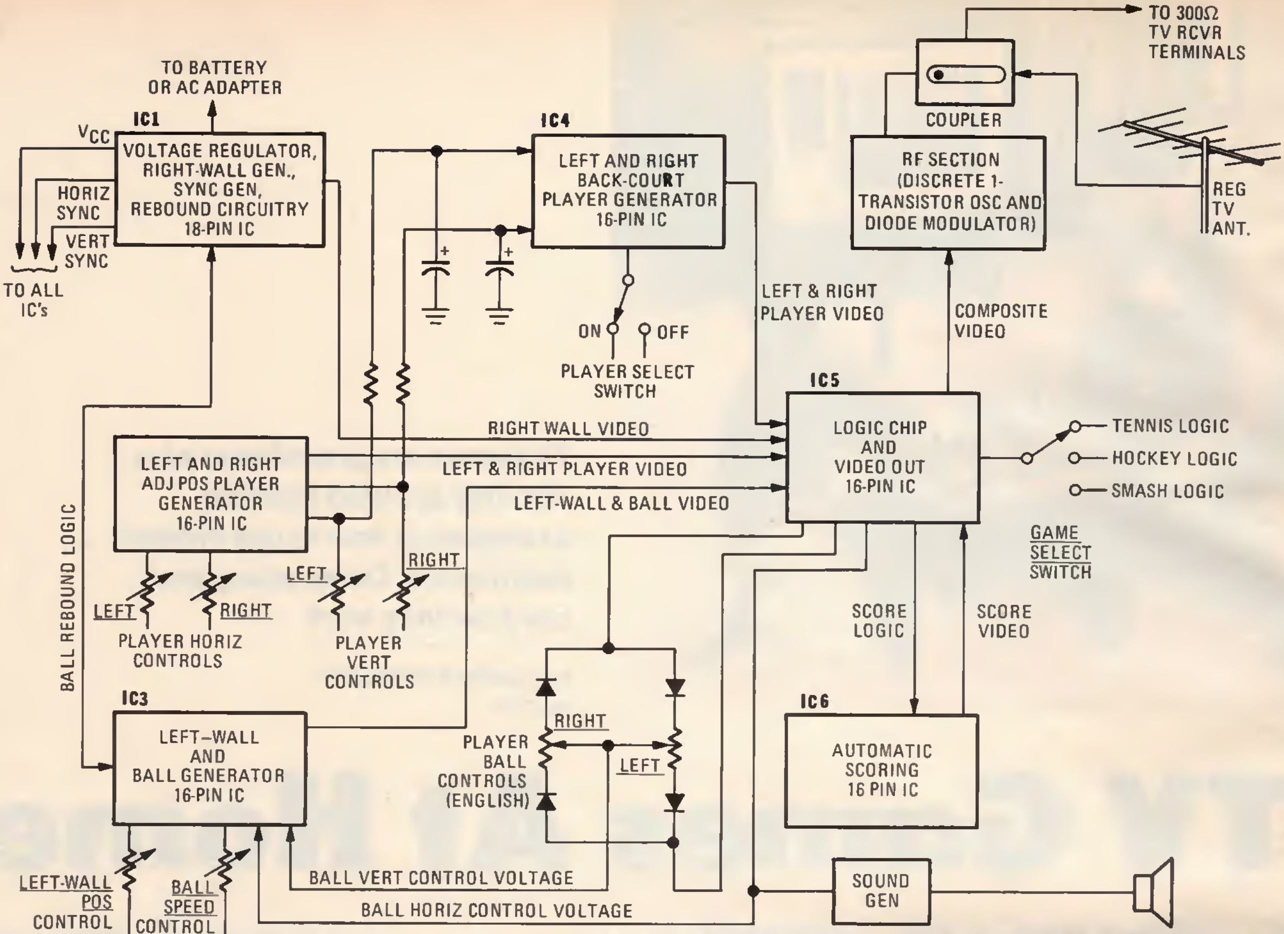


FIG. 1—TOTAL SYSTEM OF MAGNAVOX ODYSSEY shown in block diagram form.

Another, IC2 contains two user adjustable (horizontal and vertical position) player generators. IC3 contains the ball generator, the left-wall generator and the wall gate on-off. IC4, like IC2 has two operator adjustable (vertical position only) player generators. IC5 contains the game select logic, video summer, serving delay, horizontal video blanking, ball horizontal direction and ball vertical control selection flipflops. IC6 contains the circuitry for on-screen bar scorekeeping.

Spot generator

Figure 2 is a block diagram of a spot generator, the basic building block of the Odyssey system. All video spots are generated using this system and varying the size and polarity of the vertical pulse. The vertical and horizontal sections both operate in the same manner so we need only describe one of them here. Vertical sync is used to control the switching that transfers the position control voltage to the timing capacitor. Constant-current source I_1 begins to discharge the timing capacitor. When the voltage reaches the first trip point, voltage comparator 1 output goes high (see timing diagram in Figure 2-b). Since the output of the comparator 2 is still low and the output of inverter 1 is high, the output of AND gate 1 goes high too. This high level turns I_2 on increasing the discharge rate of the timing capacitor.

When the timing voltage reaches the second trip point, the output of comparator 2 goes high, causing the output of AND gate 1 to go low, I_2 turns off and the timing capacitor continues to discharge at

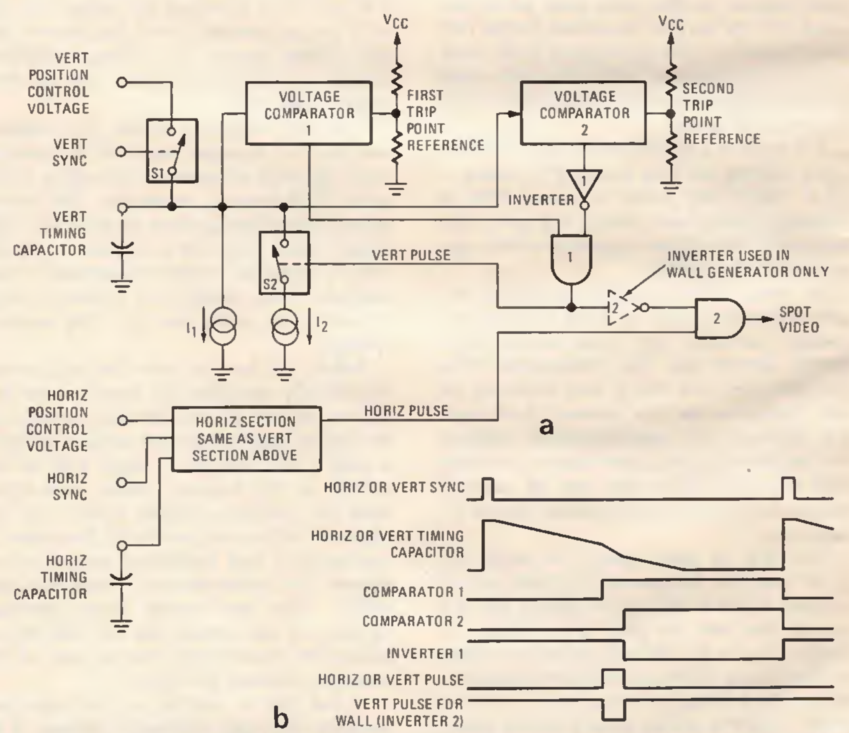


FIG. 2—THE SPOT GENERATOR is the basic building block of the Odyssey system. It creates all the spots on the game field.

the lower rate. The width (height) of the spot is determined by the size of the capacitor and I_2 since I_2 is much larger than I_1. The position of the spot is determined by the capacitor, I_1 and the position control voltage.

To produce the video spot, the output of the vertical section is combined with the output of the horizontal section in an AND gate. In the case of a wall, the output of the vertical section is first inverted. This produces a goal for the hockey game. In tennis and smash, the vertical section is turned off.

Video summer-logic

IC5 (Fig. 3) has three distinct sections, the video summer, coincidence circuits (which operate ball and vertical ball control flip flops) and logic control systems.

The video summer is a 5-input OR gate with horizontal and vertical sync added to the output of the gate through an EXCLUSIVE-OR gate.

The purpose of the coincidence gate is to detect coincidence of the ball with the players or walls, depending on which game is being played. The proper coincidence will immediately operate the ball and vertical ball control flip flops. Vertical ball control flip flop controls polarity of the voltage applied to the player control and thus determines who has control over the vertical direction of the ball. In the tennis game, the flip flop output is also used to determine horizontal direction of the ball, since in this game ball direction change and vertical ball control must occur at the same time.

The ball flip-flop output operates the sound beeper and in hockey and handball it also controls ball horizontal direction. The sound beeper, by the way, is simply a ceramic transducer that produces a sound output each time the ball strikes the side of the game or one of the paddles (players).

Logic-control circuitry is connected to the GAME SELECT switch. When this switch is on, as in the handball (SMASH) position,

(Continued on page 71)

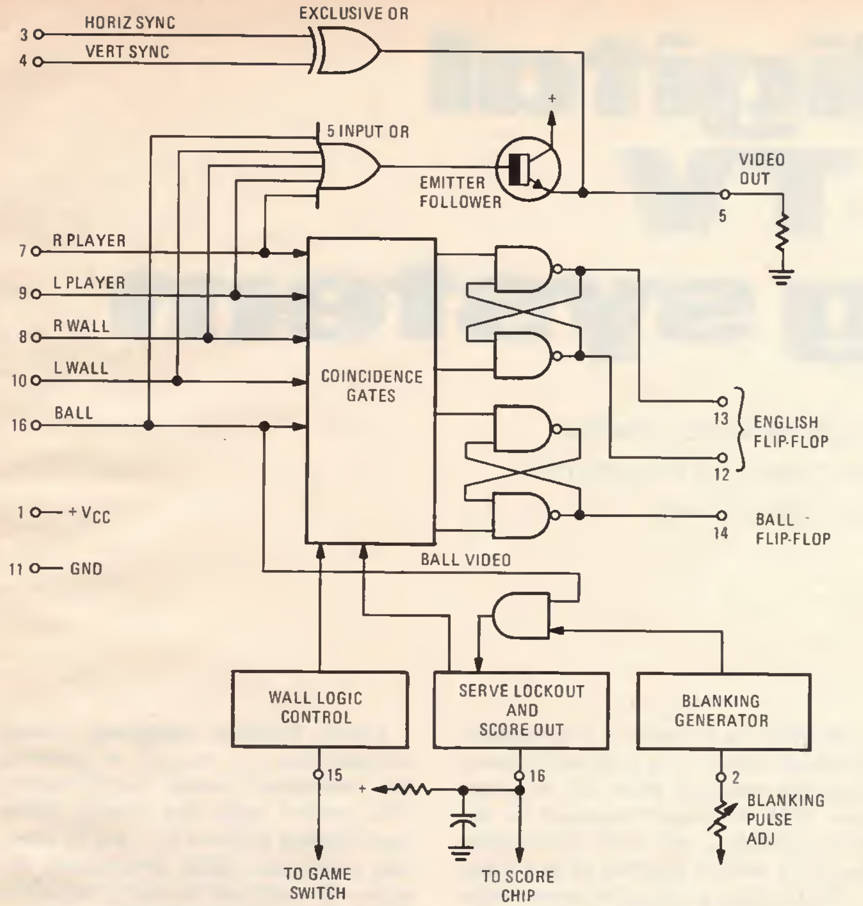


FIG. 3—THERE ARE THREE DISTINCT PARTS to this IC; the video summer, coincidence controls, and a logic control system.

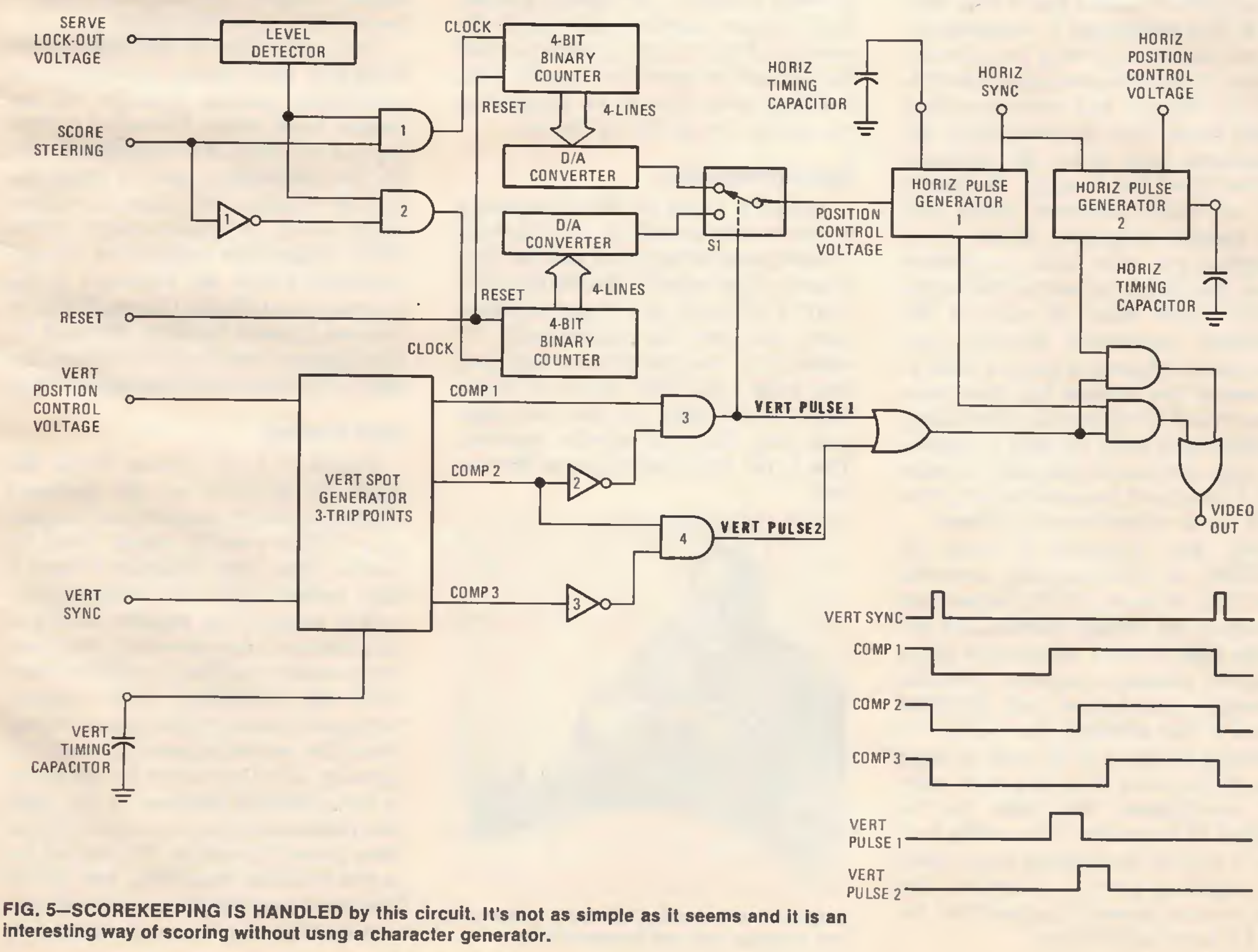


FIG. 5—SCOREKEEPING IS HANDLED by this circuit. It's not as simple as it seems and it is an interesting way of scoring without usng a character generator.

new digital color TV tuning system

General Instrument's Omega system features channel selection via a keyboard and a new memory that stores channel information for ten years without power.

by KARL SAVON
SEMICONDUCTOR EDITOR

THE SMELL OF ADVANCED WORK BEING done on new convenience oriented TV tuning systems is in the air. A number of systems are already being sold. The best of them use varactor tuners. Complete elimination of mechanical switching is the recognized goal.

People want to be able to select and scan stations with the same ease as they dial telephones with a touch-tone keyboard. The technology is available today but has been given a low priority because of the unencouraging sales history of deluxe and remote-control tuners. Brand new semiconductor developments have given set designers updated food for thought. Hopefully they can build improved, nearly perfect, systems. Hopefully as the device processes get into high production swing the system prices will fall significantly below those of some of the unreliable mechanical monsters that have come and gone in the last decade.

General Instruments has done their research and development painstakingly. They have come up with a calculator type keyboard-controlled system with a couple of unusual features that put it in the technological forefront.

First and foremost it uses an EAROM, an *E*lectronically *A*lterable *R*ead *O*nly *M*emory. NCR Corporation developed the unique memory and put it into high volume production in its electronic business machines. What the seemingly paradoxical tag EAROM means is that although the memory is primarily designed to be used to store data that is used over and over without modification, the data can be changed if necessary. The rewrite process is slow so the memory is not good for a general purpose computer. But high memory speed is unimportant for the TV tuner application.

Second, the memory is non-volatile. The data stored in its cells will remain there for years, as much as ten years *even with no power supplied to the device.* There is no need for standby power or battery supplies of any type.

Third, there are none of those banks of pots that so many designs use to store the channel information by their mechanical positions. All tuning information is stored electronically inside the memory. There is only a single pot that can be used to reset the memory cells, but may never have to be touched by the viewer for the life of the set.

System elements

Figure 1 shows all the components of the system except for the relatively few interconnecting wires and the rarely used setup controls. On the left is the UHF-VHF tuner pair. General Instruments has been the major world TV supplier for this component. Last year they even sold UHF tuners to Japan. Next on the right are the four chips including the non-volatile memory. This is the heart and brain of the system.

PROTOTYPE of Omega system is 4-feet long and contains over 400 standard IC's.

Three different integrated circuit technologies are merged to optimize the individual circuit requirements. The control logic and display driver and channel address IC's are N-channel, metal-gate MOS, ion-implant circuits. The digital-to-analog converter is CMOS, and the memory uses the silicon nitride process. It has but a single transistor per bit of storage, a space and cost saving factor.

Over one more to the right is the keyboard that allows non-sequential completely random selection of any station. Each station is selected by keying in a two-digit channel number. For the low channels, a zero is keyed before the number– for channel two you punch in 02. A system design option allows single digit selection of favorite channels. Below the keyboard is the seven-segment display that reads out the selected channel number. Planned future options include direct screen display of the addressed channel number.

How it works

Figure 2 is the system block diagram. It all starts at the keyboard where the switch contacts are scanned at a 10-kHz rate by signals from the control logic chip. Scanning is used in logic systems where the data rate flow is slow enough that parallel sensing of information is not necessary. Borrowed from similar calculator keyboard scanners, the technique saves valuable terminals and simplifies system wiring. From the operators point of view, recognition of a key closure by the circuit is instantaneous because of the mere few milliseconds it takes to scan all possible control functions. The system has a five-function capability, but all the functions may not be used in any one system. The functions are channel se-

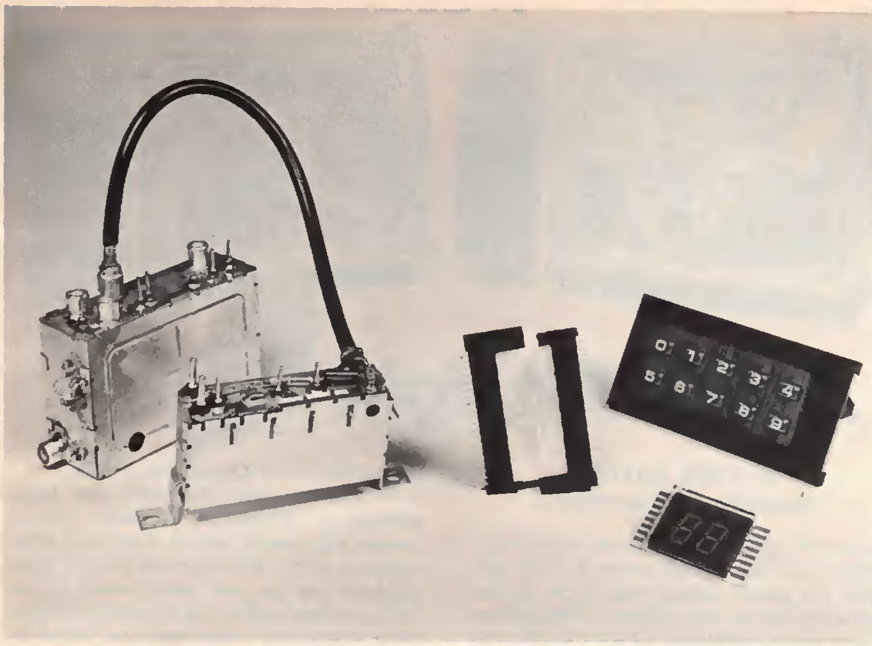


FIG. 1—COMPONENTS that make up General Instrument's Omega system.

lection, channel stepping by units or tens, coarse tuning, fine tuning, and up and down searching.

When a channel is selected by the viewer, the control logic generates 20 bits of information to be acted upon by the rest of the system. Each of the two channel digits is converted to a one-out-of-ten code. No, 10 binary-bits is not optimal coding. Theoretically it only takes 7 bits to encode the 98-channel system capability. However, it's much simpler to encode in this way, particularly because of the way the data is generated by two separate keystroke operations. It also turns out to be very convenient for the channel display decoding, memory addressing, and memory incrementing. Besides, nothing is lost; optimal coding is not really of any concern since this is far from a highly loaded data transmission system. There is plenty of time to transmit the very limited amount of data.

Having received the channel information from the keyboard, the control logic chip addresses the memory to secure the vital tuning data. This is a drastically different concept from those systems that mechanically or even electronically pick off the voltage from selected potentiometers. The non-volatile memory is the thing that makes this approach practical. The 20 address bits from the control logic are sent serially one after the other down a single wire to the EAROM. A total of 1400 binary cells are arranged as 100 14-bit words. Ninety-eight of these are used to store tuning information for the 70 UHF and 12 VHF stations. Sixteen words are reserved for optional services such as closed circuit or CATV hookups. The two remaining words store the channel number of the last selected program. You can think of these as the two slots which would hold the tuning data for channels 00 and 01 if they had been assigned stations. They actually hold a channel address between 02 and 99. This is one of the outstanding features of the Project Omega design. Without any need for standby energy, the power supply can be sensed during set turn-on to automatically interrogate the memory. Start-up will then be on the station it was tuned to when it was last shut down. Without this particular memory and in the absence of a mechanical tuner, continuing from where you were last is a tough act to duplicate.

Information to the control logic can also originate from a remote control receiver. Again an encoded random-channel selection can be shifted into the chip through special terminals. In the signal-search tune mode, the tuner steps in numerical order up or down until an active channel is found.

Normally the system requires no customer set-up of any kind, but it is sufficiently adaptable to tune to a transmitter channel-frequency with an error of 2 MHz or such as encountered in some CATV systems.

Each of the 98 14-bit data words in the memory have 10-bits dedicated to an encoded representation of the coarse tuning voltage. Ten bits divide a reference voltage into 2^{10} or 1024 equal segments. The other four bits are the fine tuning data representing 15 signal levels.

Now when the memory is interrogated by the 20-bit address code, the address is first stored in address registers and the data in the selected channel word then transferred out over the same single bidirectional lead connecting to the control logic chip. A 3-bit parallel code again conserving wires and pins, commands the memory into one of its seven operating modes—input address, input data, erase, write, read, data out, and standby. Only seven pins are tied up resulting in a small and inexpensive package—the package is a large part of the total IC cost.

The digital-to-analog converter chip resolves the data word into the DC voltage needed to find the channel being addressed. The DC voltage changes the capacitance of the varactor diodes used in the tuner. Pulse-width modulation is used to convert the 10-bit coarse tuning data into the coarse-tuning voltage. The average voltage of a sequence of pulses is proportional to the area under its envelope. With the pulse amplitude determined by a precision regulated reference voltage, changing the widths of a pulse group changes the average DC value. A constant-width pulse is used to convert the 4-bit fine tuning portion of the tuning data into the fine-tuning voltage. The amplitude of a single coarse-data pulse is adjusted to one of the 15 fine-tuning voltage levels. A low-pass filter extracts the DC tuning voltage from the combined pulse-width modulated pulse train and fine tuning pulse. The filter integrates the area under both component waveforms. The modulator-filter converter keeps the tuning voltage ripple below 100 microvolts, and the settling time is about 200 ms. Maximum clock rate is 1 MHz which gives an overall resolution of one part in

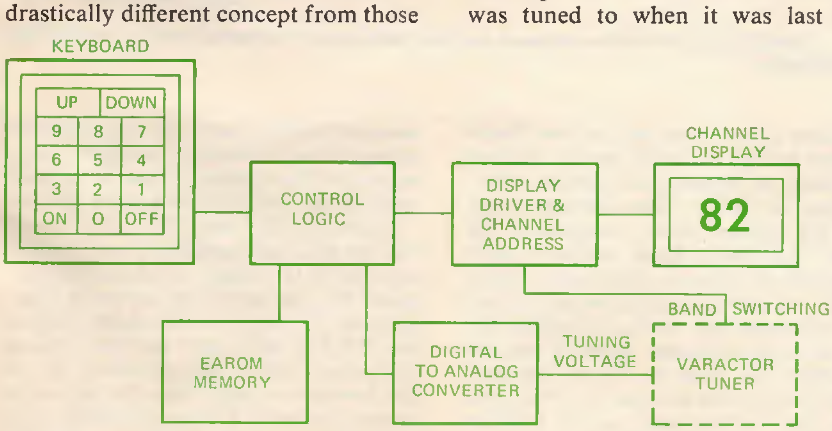


FIG. 2—OMEGA SYSTEM has keyboard channel selection.

16,000 of the reference voltage. CMOS technology is used for the pulse-width modulator because it is the best way of time gating the precision reference voltage into the filter to recreate the analog tuning voltage with minimal effects from component and environmental drifts.

The display driver and channel address chip performs the remaining chores. It also receives the serially transmitted code from the control logic and stores it. Decoding the channel number determines what bandswitching configuration the system must adopt and an appropriate switching voltage is sent to the tuner. The chip also supplies the two digit seven-segment display signals to operate the channel display indicator on the front panel of the receiver.

Though tuning is preset at the factory and can be lumped with general alignment procedures, there are occasions when the mode switch and tuning pot may have to be juggled to revise the systems stored data. It is a mandatory procedure when the tuner has been replaced or repaired or when the varactor tuning characteristics have been modified. Don't get worried–the adjustment is simple. After punching in the channel number, the serviceman or viewer presses the coarse-tune switch and turns the pot until the channel is tuned in. As labelled, this is a coarse adjustment and is made to the limited resolution of the single turn of the pot. Its setting determines the most significant 10-bits of the data word to be stored in the memory slot. Marking the pot dial with approximate channel numbers speeds up the alignment operation. When the coarse button is released, the actual rewriting of memory with the new data word is carried out. Calling up that data word later by punching in the same channel number calls on the system to synthesize the voltage from the binary bits with the minimum error possible. Frequency resolution of 25 kHz is the capability of the system, which is more than enough for just about any situation that may be encountered.

Fine tuning is taken care of in the same basic way but the pot is not used. The tuning is stepped by the control logic itself, controlled by fine-tune up and down switches. Release of the button again rewrites the data into the addressed channel memory slot. Rocker switches are ideal so you can jiggle the tuning back and forth easily correcting for overshoot.

Additional chip development is under way for full random-access remote control via a keyboard, digital clock and channel number information display on the face of the picture tube, and preprogramming of an entire week of TV viewing. **R-E**

ZOOM in tight

by KARL SAVON
SEMICONDUCTOR EDITOR

SHADES OF YESTERYEAR! DO YOU REMEMBER those black-and-white round pix TV sets with the magic button that blew up the center of the screen? (Enlarged the picture —not exploded the pix tube.) Yup, they're back again in today's much improved nearly rectangular deluxe color sets. Zenith's revived "Zoom" is a relay activated system that uses three transistors and a dozen or so other parts. One 19-inch and all 25-inch models are being equipped with the electronic magnifier as part of the Space Command 1000 remote control option.

the vertical output amplifier harder.

So far so good. But when the same amount of picture is stretched over a greater expanse of picture tube area, contrast and color saturation are diluted. That accounts for the two leads routed to the low level luminance and chroma modules. Both video and color gain are hiked in the Zoom mode.

There's still one more problem to be straightened out—overscan. Expanding the picture beyond the screen edges without any further precautions would produce a hazy backlighting effect that wouldn't do the picture much good. Blanking the video during the overscan intervals solves this problem. Horizontal pulses and vertical

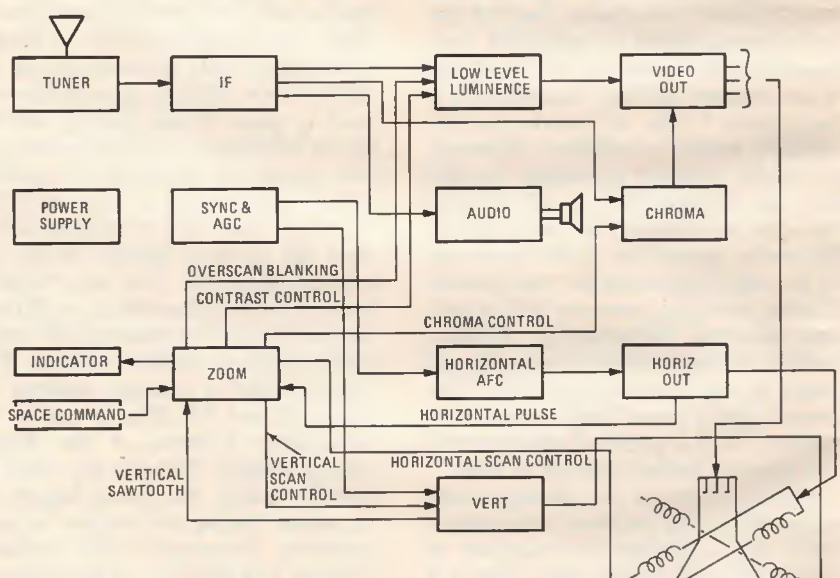


FIG. 1—ZENITH'S ZOOM feature expands both the vertical and horizontal scans to provide the magnification.

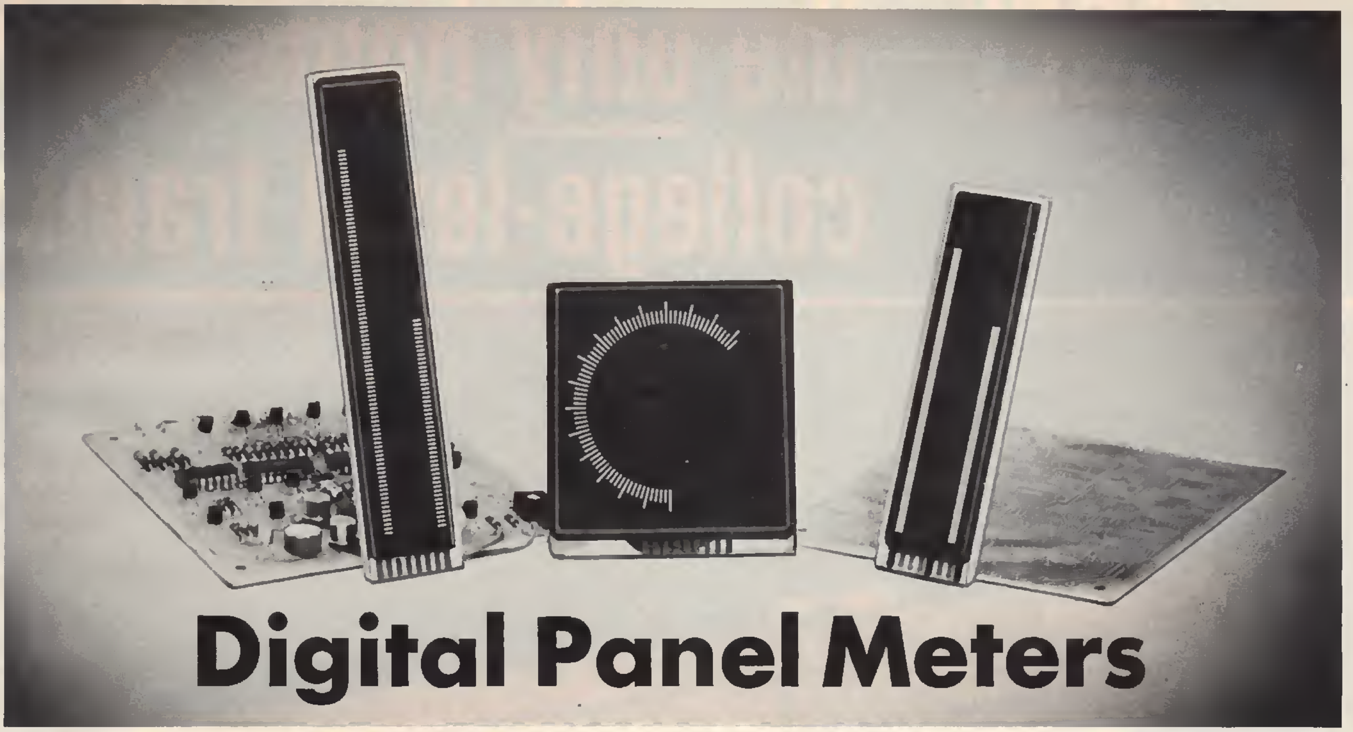
Figure 1 shows the way the new Zoom module reaches out to the related receiver functions to expand the picture 50%. Pushing the ZOOM switch fills the screen with the original center two-thirds of the image. The front panel indicator lamp lights and the system springs into action.

First the scan must be expanded in both the horizontal and vertical directions for the basic magnification effect. A connection from the Zoom module to the horizontal yoke circuit steps up the horizontal scan. The vertical scan control lead increases the vertical deflection by driving

sawtooth signals fed to the Zoom module are processed to form an overscan blanking signal. The blanking is inserted into the video in the low level luminance circuits.

You'll find the detailed circuit ins and outs in Fig. 2. Grounding Zoom module terminal W13 triggers the circuit by energizing K1. The relay is shown in the Zoom position. The upper double-throw contacts add R313 in series with the lower end of the contrast control. R312 bypasses part of the luminance signal from the top of the contrast control. The overall effect is an

(Continued on page 66)



Digital Panel Meters

The DPM is the state-of-the-art answer to the D'Arsonval meter movement. Here's a roundup of who makes what and how they work.

by JACK DARR
SERVICE EDITOR

THE DIGITAL PANEL-METER (DPM) HAS been getting more popular of late. They have advantages over the conventional types. For one, better readability at a distance. Unlike bench meters, the panel-meters must often be read at some distance. They also take up less room. Though there doesn't seem to be a standard size yet, the typical unit is approximately 4-inches wide and 2-inches high. They're approximately 4.5-inches deep behind the panel.

Most of them use the 7-segment LED display, in various sizes. The most popular LED size is 0.5-inch high, give or take a fraction.

The basic DPM uses an analog-to-digital converter to convert any analog input to a corresponding digital value. This is fed to the stock decoder/latch/driver and then to the display. Figure 1 shows a block diagram of this, as used in several of the Simpson DPM's.

Like its predecessor the milliammeter, the DPM can be made to read any desired electrical quantity by adding multipliers, rectifiers, shunts and so on. Another development that makes this easier is the new resistor networks. These are made a lot like IC's in that they're encapsulated. Networks of high precision can be made with this technology and they'll hold the initial accuracy for a long time. Speaking of accuracy, this type of digital circuit is inherently very accurate. Accuracy of 1% on all readings is common. In many units, such as the Simpson 2850 Series shown in Fig. 2, accuracy of 0.1% on all ranges is standard. Since this is a 3½-digit readout, an accuracy of "±0.1% of reading ± 1 digit" means that a reading of 122.9 volts as shown would be accurate to within ±0.123 V. For a reading of 1.229 volts, it would be accurate to within ±1.23 mV.

Other very desirable features are easy to get, without adding much of anything to the basic circuitry. Automatic polarity indication, for one. Automatic zeroing for another, as in the Datel model DM-4000 shown in Fig. 3. The input impedance is very high; a 10-megohm input is easy, and some go to 100 megohms. With high sensitivity and low loading, the output of small sensors and transducers can be fed directly into the instrument.

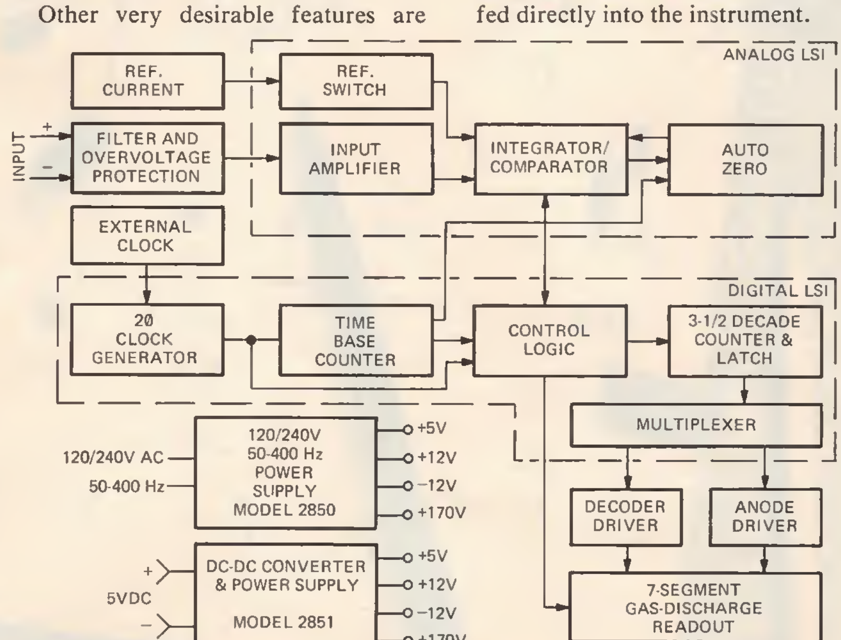


FIG. 1—SIMPSON MODELS 2850 and 2851 digital panel meters, block diagram.

Stability is very good. Most DPM's incorporate elaborate temperature-compensating circuitry, and some have crystal-controlled clock circuits, as in the Datel DM-4000.

The displays are flicker-free due to the high sampling rate used—several times per second. Changes of reading are rapid and easy to follow. For over-range indication, the entire display blinks on and off to attract attention. Several models use separate LED's as over-range and overflow indicators. The decimal point switches automatically with the range switch, if used.

There are several novel applications of these readouts. One good example is the Simpson model 7527 shown in Fig. 4. It looks like a standard linear-scale meter; the meter needle is a row of dots, each one being a red LED. In Fig. 4, it's showing a reading of 0.6 microamperes. This type of display makes it a bit easier to do things like peaking and dipping of adjustments.

The Burroughs Self-Scan display

The Burroughs Corporation has come up with a novel type of display unit. These are flat panel analog-type indicators; they use digital techniques to drive them. Figure 5 shows one of these. This is a dual bar-graph type, equivalent to two meter-needles. The length of each bar indicates the value of the reading; the two bars are independent of each other. There are two types, one with 100 separate elements for a 1% accuracy, and the other with 200 elements for an 0.5% accuracy. A third, shown in Fig. 6, has a circular scale with 120 elements.

Figure 7 shows a block diagram of the electronics. The voltage (or quantity) to be read is compared to a reference voltage. The circuitry scans the display from the bottom up, lighting each bar as it goes. When the input voltage reaches coincidence with the reference voltage, the display from there on does not light. The scan continues, and resets when it reaches the top. Scanned at 70 Hz, the display does not flicker but displays an apparently solid bar of light.

How it works

Each bar-graph panel is made up of a rear substrate, a spacer, and a glass front-plate (see Fig. 8.) The desired segment pattern is screened onto the substrate with conducting ink. A black dielectric mask is also used to give a light-absorbing background and increase contrast. Two transparent conducting anodes are screened onto the front glass, as well as the anode contacts. The spacer establishes the distance between front and back panels. The whole assembly is then sealed and filled with neon gas. Electrical connections are made by a connector unit that slides between the front and back panels, on the end.

The display segments are lit up on the glow-transfer principle. The glow is established at the reset cathode, then transferred sequentially to the desired segment of the panel at a 70 Hz rate. Figure 9 shows the construction of the panel and the circuitry inside. When the panel is energized, the +250-volt potential between the keep-alive anode and cathode establishes a glow-dis-

FIG. 2—SIMPSON MODEL 2850

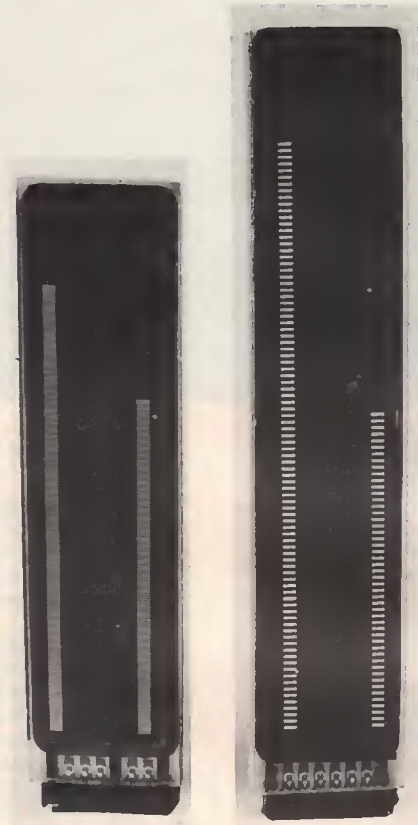


FIG. 5—BURROUGHS SELF-SCAN linear bar-graph displays.

FIG. 6—BURROUGHS SELF-SCAN circular bar-graph display.

FIG. 3—DATEL MODEL DM-4000

FIG. 4—SIMPSON MODEL 7527

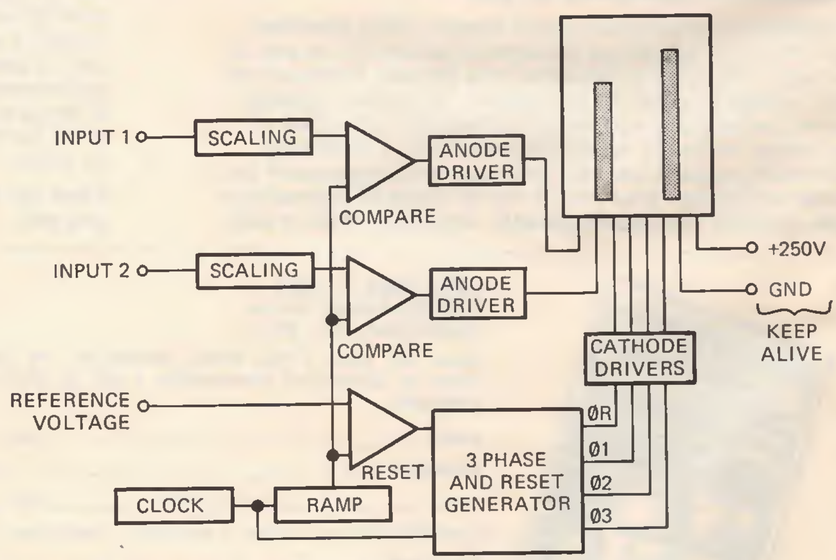


FIG. 7—DRIVE CIRCUITRY of the Burroughs Self-Scan display.

charge in this area. The phase generator controls the transferral of the glow along the bar.

To start a scan, the reset transistor Q1 is turned on, grounding the reset cathode. The reset and phase-drive anodes are connected to the +250-volt source through limiting resistors. When the reset cathode is grounded, the neon gas ionizes at this one cathode. The counter advances on the next clock pulse and transistor Q2 is turned on, while the reset cathode is returned to the off condition.
(NOTE: This description is written for the dual linear bar-graph. The circular graph operates much like this, though it uses 5 phases, and the 5th phase is held on for two clock pulses).

Transistor Q2, grounds every third cathode; ionization rapidly transfers on the surface of the phase-1 cathode. At the same time, ionization is no longer supported at the reset cathode. The glow will occur only at the adjacent or nearest grounded cathode. Once ionization occurs at this cathode, the anode voltage drops, due to current flow, to a level high enough to support ionization at the desired cathode but too low to cause ionization at any other grounded cathode.

The next clock pulse turns Q2 off and turns Q3 on. This removes the ground from the phase-1 cathodes and at the same time grounds the phase-2 cathode bus, transferring the glow to the second cathode. The next clock pulse removes the ground from the phase-2 cathode bus and grounds the phase-3 cathode bus.

As the counter advances, the cathode busses are sequentially grounded, causing the glow to transfer along the panel.

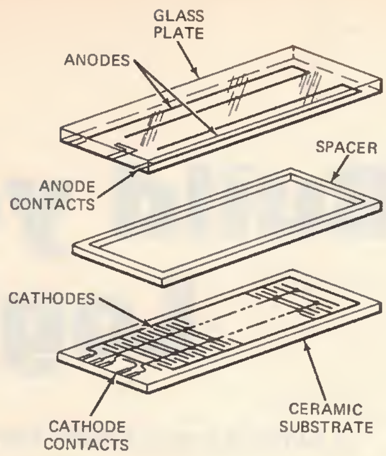


FIG. 8—CONSTRUCTION of the Self-Scan display.

When the counter determines that a sufficient number of clock pulses have been generated to scan every cathode element, the reset pulse generator is enabled. This grounds the reset transistor Q1, and the scan cycle starts over.

Since the phase-1 bus is connected to cathodes 1, 4, 7 etc., whenever cathode-1 is grounded, so are cathodes 4 and 7. However, the glow appears only at cathode 1. When cathode-1 is turned off, the glow transfers to cathode 2, and ionization at cathode-1 begins to decay. When cathodes 1 and 4 are grounded once more, (only two clock-pulses later), the ionization decays below a point where a glow will again form on cathode 1. So, if a different scan-rate is selected, the period that each cathode must remain off before that bus is grounded again will be between 100 and 150 microseconds.

The length of the glowing bar, in either the linear or circular types, is determined by terminating the glow after the desired number of clock pulses. This is accomplished by turning the anode driver on at the beginning of the reset period and turning it off again at the desired count. This point is determined by the input voltage in the comparator circuit. **R-E**

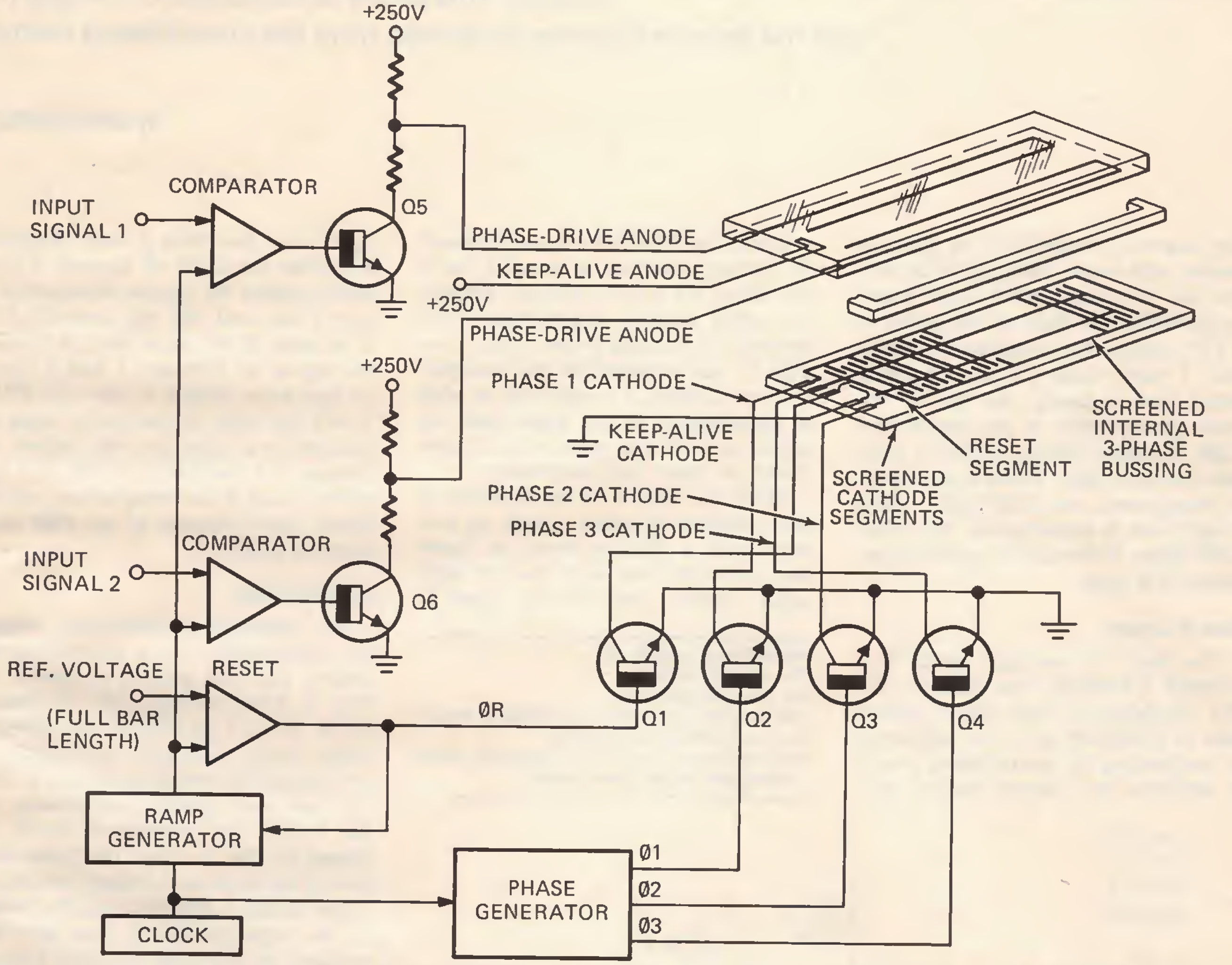


FIG. 9—CONSTRUCTION AND CIRCUITRY of the Self-Scan display.

Build your own Logic Probe

A simple logic probe like the one described in this article can save hours of time when troubleshooting TTL logic circuits. This probe is built around a single IC and the source of power is derived from the circuit being tested

by DON LINGLE

THE SERVICE TECHNICIAN OR EXPERIMENTER who works with digital circuits can use this economical logic probe to determine the state of any point in a TTL circuit. By powering the probe with 5 volts from the circuit being tested and touching the tip of the probe to any point in the circuit, two Light Emitting Diodes (LED's) indicate the logic state. When a logic high is encountered, one LED lights; when a logic low is encountered, the other LED lights. If there is an open circuit, neither will light.

How it works

The heart of the logic probe is a CD4009 COSMOS hex inverter IC. The characteristic high input impedance of COSMOS gives the advantage of not loading the circuit being tested. In addition, the output current capability of the CD4009 can be increased by placing inverters in parallel, so it can drive the LED's directly without any other current amplification. The inverters in the logic probe circuit (See Fig. 1) are arranged to give complementary outputs if a logic low or high is encountered at the input and no output at all if the input is at an open circuit or other high impedance.

Since the output of the inverters is not specified at either a high or low level with a floating input, an input bias network produces lows at both input inverter pairs if the input is open or at less than 2 volts. Resistor R3 holds the input of inverter 3 low which makes the output of inverters 4 and 5 low and will not permit LED 2 to light. At the same time, R1 holds the inputs of inverters 1 and 2 high, so that their output is low and LED 1 will not light. If the probe input is touched to a logic low, the output of inverter 3 is held high by R3 and inverter 1 and 2 are brought low, which causes their outputs to go high and turns on LED 1.

All resistors 1/8 watt, 5%
R1—150,000 ohms
R2, R3—100,000 ohms
LED 1, LED 2—Monsanto MV 5020 or equal
IC—RCA CD4009 hex inverter
Misc.—marking pen, wire, alligator clips, safety pin, epoxy, cork, solder

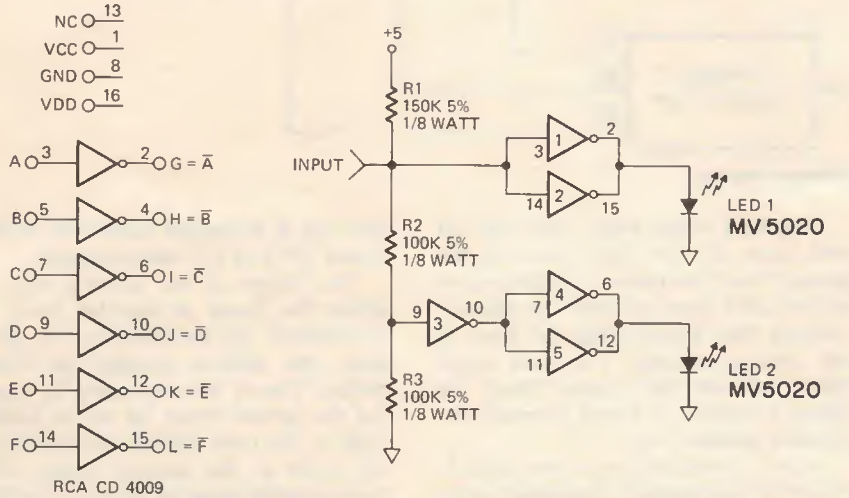


FIG. 1—LOGIC PROBE schematic using five of the six CD4009 inverters. The basing diagram of the CD4009 is also shown.

Construction

For compact construction, mount the components on a printed-circuit board. The foil pattern is shown in Fig. 2. After etching, trim the board to ½ in. x 3 in. Solder the jumper wires where indicated and attach a 4-ft length of twisted pair lead to the +5 volt and ground connections of the board. The component layout is shown in Fig. 3. Tape the front section of the leads to the board for strain relief. Solder a sufficient length of wire to the input so that it can later be soldered to the probe tip. Use a large felt-tipped pen of sufficient size to contain the PC board for the probe housing. Pry the bottom off the marking pen cylinder with a screwdriver. Remove the packing inside and clean it out with solvent. Drill a .18 inch diameter hole in the bottom of the tube for the 5-volt leads and 2 holes .18 inch diameter and .18 inch apart in the front of the tube for the LED's.

After guiding the input lead wire through the probe tip, insert the circuit board into the tube by pushing it through the rear of the tube. Adjust

the board in the tube so the LED's fit through the holes drilled in the top of the case. Press the plastic down around the two LED's. This is a close enough fit to fix the board in position, but if you want to, secure the board with a dab or two of epoxy along the rear inside of the cylinder.

For the probe tip, snip a ¾" length off a safety pin. A heavy gauge straight pin could also be used. Solder the blunt end of the pin to the input lead coming from pin 3 of the CD4009. The pin can now be fixed in the tip of the probe with epoxy. Before you put the epoxy in, grease the inside of the probe tip so after the epoxy sets it will form a plug that can be pulled out of the probe tip if necessary. Use a cork to hold the pin so when the tube is placed horizontally the cork keeps the pin centered until the epoxy hardens. Drill a small hole in the rear cap of the cylinder. Fit the power leads through the hole and snap the cap back onto the end of the probe. Solder two alligator clips on the ends of the power leads and mark them so that the positive and negative leads cannot be confused.

Test the probe by hooking it up to a 5-volt supply and touching the probe tip alternately to the high and ground pins. LED 2 should light when you touch the positive pin; LED 1 should light when you touch the negative pin. If the probe is not contacting anything both LED's should remain off. **R-E**

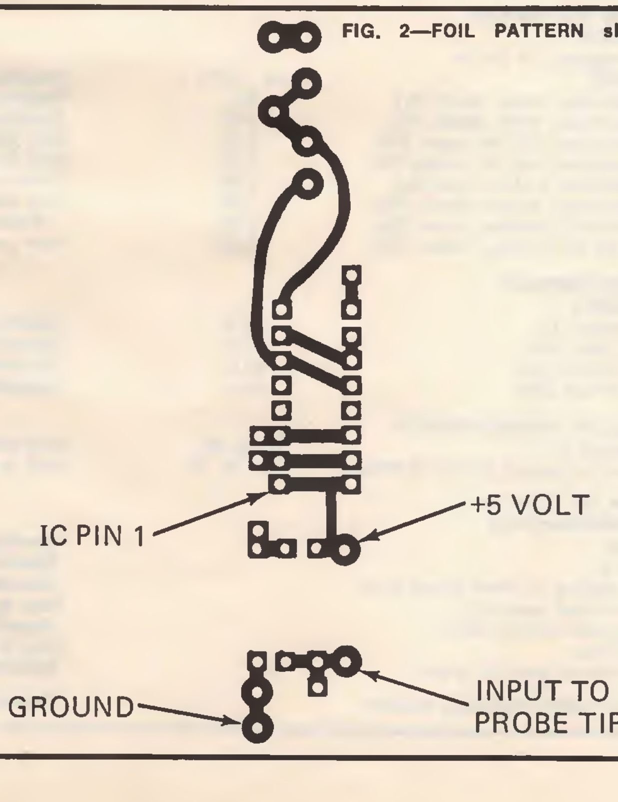


FIG. 2—FOIL PATTERN shown full-size.

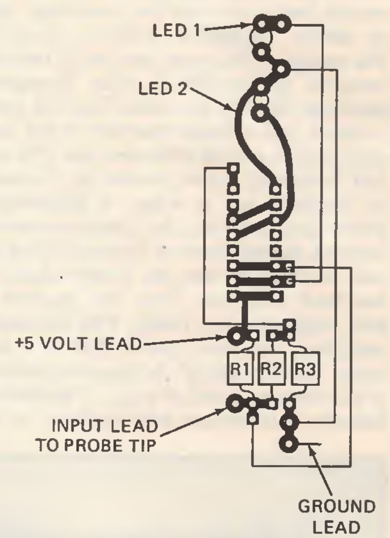
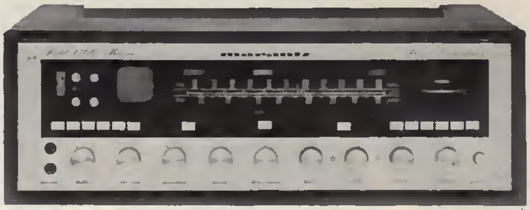


FIG. 3—COMPONENT LAYOUT shown from the component side of the PC board.



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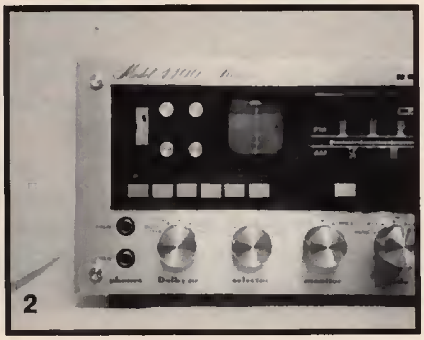
Radio-Electronics® Tests Marantz Model 4400

by LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

THE MARANTZ MODEL 4400 IS THAT COMPANY'S most expensive receiver. If you consider power output alone (as, unfortunately, so many uninformed buyers do) you might well wonder what right the company has to charge upwards of $1200 for this 4-channel/2-channel unit. This only goes to prove that there is more in front and behind a front panel than watts of audio power and elegant styling. Marantz has styled this impressive unit in keeping with the family tradition of that famous brand of components, as can be seen in the front panel view of Fig. 1. There is edge-flywheel tuning (which they call Gyro-touch tuning), a feature that we still feel makes for the smoothest type of station frequency selection possible. The center of the upper portion of the dial becomes illuminated in blue frequency markings for FM and AM. The FM scale is linear and a supplementary 0-100 logging scale is provided between the FM and AM frequency scales. Above the frequency markings are a series of illuminated words that indicate the program source selected, the presence of a stereo broadcast and whether or not the Dolby circuitry has been activated. Yes, the receiver is fully equipped for Dolby FM broadcast reception, but more about that in a moment. The left end of the panel is pictured in the close-up detail of Fig. 2. The famous Marantz oscilloscope tube is there, an ongoing reminder of the venerated Marantz 10B tuner where it first made its appearance many years ago. Four pushbuttons just below select one of the three uses of the scope display (audio display for stereo or 4-channel, tuning, and multipath, plus a button to turn the scope feature on and off).



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This sort of scope display, when properly calibrated, is, in our opinion, still the most useful and accurate way to tune FM. To the left of the scope display are four tiny level controls, two for calibrating Dolby record level and two for calibrating Dolby playback level (yes, you can use the built-in Dolby with your open-reel or cassette tape deck, if either or both of these units does not already have the Dolby feature built in). A tiny meter at the extreme left of the panel assists in these calibration procedures. The remaining two buttons in this area of the panel serve to introduce a built-in 400-Hz tone for calibration purposes and to select left- or right-channel connection of the level meter.

The central section of the front panel contains three slide controls that handle

TABLE I

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Marantz** Model: **4400**

FM PERFORMANCE MEASUREMENTS

SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE	R-E Measurement	R-E Evaluation
IHF sensitivity, mono: (μV)	2.2	Very good
Sensitivity, stereo (μV)	5.0	Excellent
50 dB quieting signal, mono (μV)	3.1	Very good
50 dB quieting signal, stereo (μV)	50.0	Average
Maximum S/N ratio, mono (dB)	78.0	Superior
Maximum S/N ratio, stereo (dB)	64.0	Good
Capture ratio (dB)	1.2	Very good
AM suppression (dB)	65	Superior
Image rejection (dB)	More than 110	Excellent
IF rejection (dB)	More than 110	Excellent
Spurious rejection (dB)	More than 110	Superior
Alternate channel selectivity (dB)	72	Very good
FIDELITY AND DISTORTION MEASUREMENTS		
Frequency response, 50 Hz to 15 kHz (±dB)	+0, −0.75	Excellent
Harmonic distortion, 1kHz, mono (%)	0.1	Excellent
Harmonic distortion, 1kHz, stereo (%)	0.22	Excellent
Harmonic distortion, 100 Hz, mono (%)	0.15	Very good
Harmonic distortion, 100 Hz, stereo (%)	0.30	Very good
Harmonic distortion, 6 kHz, mono (%)	0.13	Excellent
Harmonic distortion, 6 kHz, stereo (%)	0.50	Very good
Distortion at 50 dB quieting, mono (%)	0.80	Good
Distortion at 50 dB quieting, stereo (%)	0.80	Very good
STEREO PERFORMANCE MEASUREMENTS		
Stereo threshold (μV)	40.0	Excellent
Separation, 1 kHz (dB)	47.0	Superior
Separation, 100 Hz (dB)	40,0	Excellent
Separation, 10 kHz (dB)	34.0	Excellent
MISCELLANEOUS MEASUREMENTS		
Muting threshold (μV)	6.0 to 35	Very good
Dial calibration accuracy (±kHz @ MHz)	−60 @ 90	Very good
EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION		
Control layout		Excellent
Ease of tuning		Excellent
Accuracy of Meters or other tuning aids		Excellent
Usefulness of other controls		Very good
Construction and internal layout		Superior
Ease of servicing		Very good
Evaluation of extra features, if any		Excellent
OVERALL FM PERFORMANCE RATING		Excellent

TABLE II

Manufacturer: **Marantz** Model: **4400**

AMPLIFIER PERFORMANCE MEASUREMENTS

POWER OUTPUT CAPABILITY	R-E Measurement	R-E Evaluation
RMS power/channel, 8-ohms, 1 kHz (watts)	59/180	Excellent
RMS power/channel, 8-ohms, 20 Hz (watts)	58/178	Superior
RMS power/channel, 8-ohms, 20 kHz (watts)	56/163	Excellent
RMS power/channel, 4-ohms, 1 kHz (watts)	90	Superior
RMS power/channel, 4-ohms, 20 Hz (watts)	78	Excellent
RMS power/channel, 4-ohms, 20 kHz (watts)	80	Excellent
Frequency limits for rated output (Hz-kHz)	15-30	Very Good
DISTORTION MEASUREMENTS		
Harmonic distortion at rated output, 1 kHz (%)	0.007	Excellent
Intermodulation distortion, rated output (%)	0.012	Excellent
Harmonic distortion at 1 watt output, 1 kHz (%)	0.02	Very Good
Intermodulation distortion at 1 watt output (%)	0.016	Very Good
DAMPING FACTOR, AT 8 OHMS	65	Excellent
PHONO PREAMPLIFIER MEASUREMENTS		
Frequency response (RIAA ± dB)	0.4	Very Good
Maximum input before overload (mV)	120	Good
Hum/noise referred to full output (dB) (at rated input sensitivity)	66	Very Good
HIGH LEVEL INPUT MEASUREMENTS		
Frequency response (Hz-kHz, ± dB)	10—30, 0.2 dB	Very Good
Hum/noise referred to full output (dB)	90	Excellent
Residual hum/noise (min. volume) (dB)	94	Very Good
TONAL COMPENSATION MEASUREMENTS		
Action of bass and treble controls	See Fig. 7	Very Good
Action of secondary tone controls	See Fig. 8	Excellent
Action of low frequency filter(s)	See Fig. 9	Excellent
Action of high frequency filter(s)	See Fig. 9	Excellent
COMPONENT MATCHING MEASUREMENTS		
Input sensitivity, phono 1/phono 2 (mV)	2.0	
Input sensitivity, auxiliary input(s) (mV)	190	
Input sensitivity, tape input(s) (mV)	190	
Output level, tape output(s) (mV)	190	
Output level, headphone jack(s) (V or mW)	0.5 V	
EVALUATION OF CONTROLS, CONSTRUCTION AND DESIGN		
Adequacy of program source and monitor switching		Very Good
Adequacy of input facilities		Very Good
Arrangement of controls (panel layout)		Excellent
Action of controls and switches		Very Good
Design and construction		Excellent
Ease of servicing		Very Good
OVERALL AMPLIFIER PERFORMANCE RATING		Excellent

Marantz Model 4400 4-Channel/2-Channel Receiver
SUMMARY OF MANUFACTURER'S PUBLISHED SPECIFICATIONS:

TUNER SECTION (FM)

Quieting Slope: 1.8 μV for 30 dB; 5 μV for 55 dB; 10 μV for 60 dB. **Ultimate S/N:** 70 dB. **Selectivity:** 75 dB. **Capture Ratio:** 1.5 dB. **Image Rejection:** Better than 90 dB. **IF Rejection:** Better than 100 dB. **Spurious Rejection:** Better than 95 dB. **AM Suppression:** Better than 60 dB. **THD:** (Mono): Less than 0.2%; (Stereo): Less than 0.3%. **Frequency Response:** 30 Hz to 15 kHz ±1 dB. **Muting Threshold:** Variable from 8 μV to 35 μV. **Stereo Separation:** 42 dB at 1 kHz; 27 dB at 15 kHz.

TUNER SECTION (AM)

AM Sensitivity: 20 μV. **Selectivity:** Better than 30 dB. **AM Bandwidth:** 7 kHz (for −6 dB). **Image Rejection:** Better than 70 dB.

AUDIO AMPLIFIER SECTION:

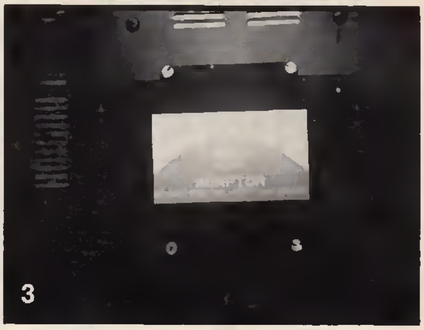
Power output: 125 watts-per-channel in stereo, 50 watts-per-channel in quadriphonic, minimum continuous power into 8 ohms at no more than 0.15% total harmonic distortion. **IM Distortion:** 0.15%. **Power Bandwidth (FTC):** 20 Hz to 20 kHz. **Damping Factor:** 50. **Input Sensitivity:** Phono: 1.8 mV; High Level: 180 mV. **Frequency Response:** Phono: RIAA ± 1 dB. **Preamp-output Level:** 1.0 volt. **S/N Aux:** 80 dB. **Phono Dynamic Range:** 96 dB above 1.5 μV equivalent noise input. **Tone Control Range:** Bass: ±10 dB at 50 Hz; Treble ±10 dB at 15 kHz; Mid-Range: ±7 dB at 700 Hz. **Filter Cut-off Points:** Low: 50 Hz (12 dB/octave); High: 9 kHz (12 dB per octave).

GENERAL SPECIFICATIONS:

Power Requirements: 120 VAC, 60 Hz, 690 watts maximum (65 watts minimum). **Dimensions:** 19-19/64" wide × 5¾" high × 15-13/64" deep. **Net Weight:** 51.6 lbs. **Suggested Retail Price:** $1250 (SQA-2B Decoder $79.95 extra).

front left-to-right balance, front-rear balance and rear left-to-right balance. Six more symmetrically positioned pushbuttons at the right, under the tuning wheel, activate loudness control, FM muting, low and high cut filters and select main or remote pairs or quartets of speaker systems. The lower portion of the panel is equipped with nine gold colored metal turned knobs, a POWER on/off pushbutton switch and a pair of headphone jacks for connection of front and rear plugs of a quadraphonic headphone. The knobs are master VOLUME, TREBLE, BASS, MID-RANGE, a DIMENSION control that is associated with the built-in matrix decoder circuit, a MODE switch, tape MONITOR switch (that selects source or one of two tape-monitor circuits), program SELECTOR switch and a DOLBY selector switch (with settings for Dolby FM, Dolby playback, settings for recording non-Dolby or Dolby programs and an off position).

In the specifications as supplied by the manufacturer, we noted that an optional SQ decoder costs $79.95. That was not meant to imply that this 4-channel receiver comes without matrix decoding facilities. It does. In fact, the built-in matrix docoder has a DIMENSION control that varies the decoding parameters over a wide range. It is, however, what the industry has come to call a "basic" matrix decoder. That is, it contains no logic circuitry and therefore provides only minimal channel separation when listening to matrix encoded records. For this reason, Marantz very wisely chose to provide a "pocket" under the receiver into which can be popped SQ decoders of increased sophistication as they become available. There are two advantages to this approach. If you find that the built-in decoder gives you all the 4-channel effects you would want, leave well enough alone. If, however, you seek the ultimate in 4-channel SQ reproduction, add Marantz's latest full-logic decoder (which, at the moment, is their model SQA-2B which was included in our sample) for another $80.00 or so. A view of how the module fits in under the chassis is shown in Fig. 3 and the whole idea is also designed to



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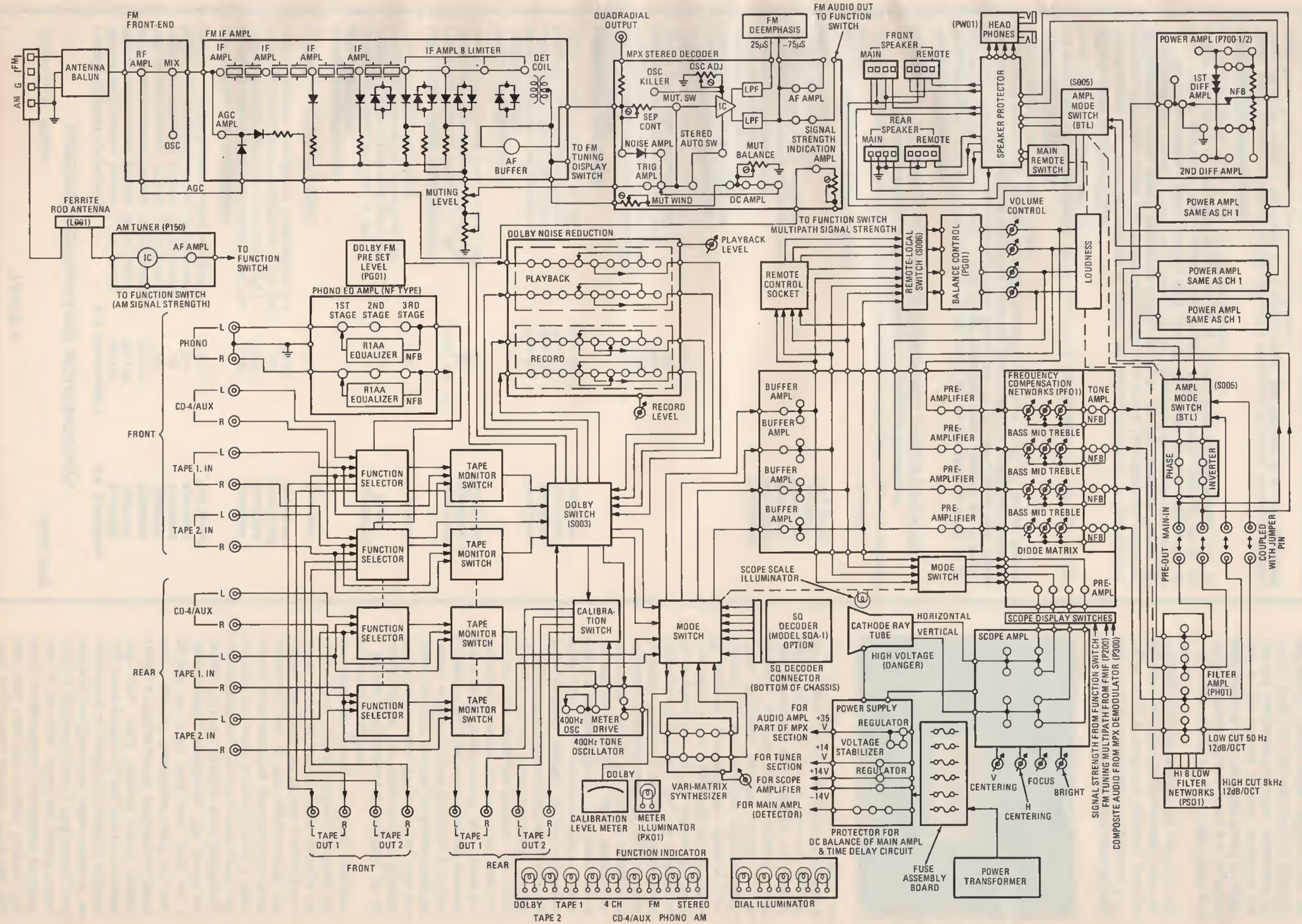
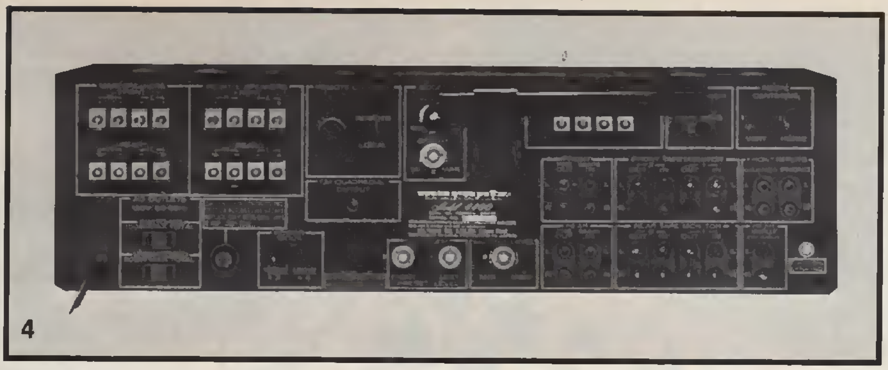
prevent obsolescence as more sophisticated logic circuits are developed. Instead of having to scrap a $1250.00 receiver, you can buy an even better logic decoder later on, assuming improvements are made in the future.

The rear panel of the Model 4400 will elicit as much delight from the seasoned audiophile as will the front panel. In addition to the sixteen speaker terminals for two full quartets of speakers (main and remote), there are the usual tape in, tape out and phono inputs, scope controls that po-



FM FRONT-END
RF AMPL
MIX
OSC
ANTENNA BALUN
AM G FM
FM IF AMPL
IF AMPL
IF AMPL & LIMITER
DET COIL
AGC AMPL
AGC
AF BUFFER
MUTING LEVEL
TO FM TUNING DISPLAY SWITCH
QUADRADIAL OUTPUT
MPX STEREO DECODER
OSC KILLER
OSC ADJ
MUT. SW
SEP CONT
NOISE AMPL
STEREO AUTO SW
TRIG AMPL
MUT BALANCE
MUT WIND
DC AMPL
LPF
FM DEEMPHASIS
25μS -75μS
AF AMPL
SIGNAL STRENGTH INDICATION AMPL
FM AUDIO OUT TO FUNCTION SWITCH
TO FUNCTION SWITCH MULTIPATH SIGNAL STRENGTH
FERRITE ROD ANTENNA (L001)
AM TUNER (P150)
IC
TO FUNCTION SWITCH
TO FUNCTION SWITCH (AM SIGNAL STRENGTH)
DOLBY FM PRE SET LEVEL (PG01)
PHONO EQ AMPL (NF TYPE)
1ST STAGE 2ND STAGE 3RD STAGE
RIAA EQUALIZER
NFB
PHONO
CD-4/AUX
TAPE 1. IN
TAPE 2. IN
FRONT
REAR
FUNCTION SELECTOR
TAPE MONITOR SWITCH
DOLBY NOISE REDUCTION
PLAYBACK
RECORD
PLAYBACK LEVEL
RECORD LEVEL
DOLBY SWITCH (S003)
CALIBRATION SWITCH
MODE SWITCH
400Hz OSC
METER DRIVE
400Hz TONE OSCILLATOR
DOLBY
CALIBRATION LEVEL METER
METER ILLUMINATOR (PX01)
VARI-MATRIX SYNTHESIZER
TAPE OUT 1
TAPE OUT 2
FUNCTION INDICATOR
DOLBY TAPE 1 4 CH FM STEREO
TAPE 2 CD-4/AUX PHONO AM
DIAL ILLUMINATOR
SQ DECODER (MODEL SQA-1) OPTION
SQ DECODER CONNECTOR (BOTTOM OF CHASSIS)
SCOPE SCALE ILLUMINATOR
CATHODE RAY TUBE
HORIZONTAL
VERTICAL
HIGH VOLTAGE (DANGER)
POWER SUPPLY
REGULATOR
VOLTAGE STABILIZER
FOR AUDIO AMPL PART OF MPX SECTION
FOR TUNER SECTION
FOR SCOPE AMPLIFIER
FOR MAIN AMPL (DETECTOR)
+35 V
+14 V
+14V
-14V
PROTECTOR FOR DC BALANCE OF MAIN AMPL & TIME DELAY CIRCUIT
FUSE ASSEMBLY BOARD
POWER TRANSFORMER
SCOPE AMPL
V CENTERING
H CENTERING
FOCUS
BRIGHT
SCOPE DISPLAY SWITCHES
SIGNAL STRENGTH FROM FUNCTION SWITCH
FM TUNING MULTIPATH FROM FMIF (P200)
COMPOSITE AUDIO FROM MPX DEMODULATOR (P300)
REMOTE CONTROL SOCKET
REMOTE-LOCAL SWITCH (S006)
BALANCE CONTROL (PG01)
VOLUME CONTROL
LOUDNESS
BUFFER AMPL
PRE-AMPLIFIER
FREQUENCY COMPENSATION NETWORKS (PF01)
TONE AMPL
BASS MID TREBLE
DIODE MATRIX
PRE-AMPL
AMPL MODE SWITCH (BTL)
(S005)
PHASE
INVERTER
PRE-OUT MAIN-IN
COUPLED WITH JUMPER PIN
FILTER AMPL (PH01)
LOW CUT 50 Hz 12dB/OCT
HI & LOW FILTER NETWORKS (PS01)
HIGH CUT 9kHz 12dB/OCT
HEAD PHONES
(PW01)
FRONT SPEAKER
MAIN
REMOTE
REAR SPEAKER
SPEAKER PROTECTOR
MAIN REMOTE SWITCH
POWER AMPL (P700-1/2)
1ST DIFF AMPL
2ND DIFF AMPL
POWER AMPL SAME AS CH 1



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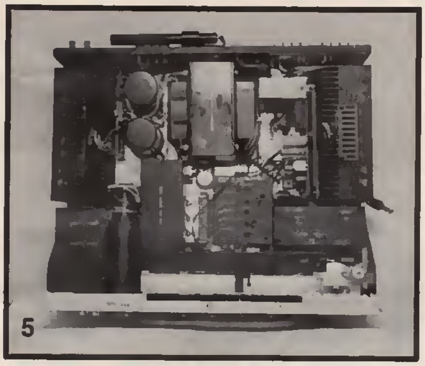
sition the scope trace and adjust focus and intensity, a variable FM mutting control, an FM deemphasis switch (Dolby broadcasts use 25 microsecond deemphasis instead of the usual 75 microseconds), a remote control switch (that permits connection to an adjacent receptacle of a remote control attachment), Dolby FM preset level controls, a detector output jack, jumpers to connect the preamp output to the main amplifier input, a power mode switch that selects higher powered 2 channel operation or 50-watt-per-channel quadraphonic operation, a pair of convenience AC receptacles, a line fuse, a pivotable AM ferrite bar antenna, and a chassis ground terminal. A view of the complete rear panel is shown in Fig. 4.



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We removed the metal enclosure (a wooden cabinet is also available) to get a better look at the insides of this circuit-packed receiver and found that major assemblies are individually shielded with black metal covers, as can be seen in Fig. 5. A better idea of the complexity of this receiver can be had by consulting the overall block diagram shown in Fig. 6.

Circuit Description

Field-effect transistors are used for both the RF amplifier and the mixer in the FM front-end of this unit. The IF section consists of six transistors and four stages of dual ceramic filters. Limiter circuitry consists of gold bond hot-carrier diodes and an IF limiter amplifier and the output of the FM detector feeds a buffer amplifier that is followed by the FET muting circuit. The signal then goes to a phase-locked-loop IC stereo decoder circuit. The muting circuit consists of a two-transistor noise amplifier and a three-transistor switching circuit.

The AM tuner section consists of a single IC, a transistor amplifier that follows AM detection and a three-section variable capacitor. A ceramic filter is also used in the AM circuitry and the AM IF amplifier incorporates an automatic gain control circiut (AGC). Tone control amplifiers use a two-stage direct coupled NPN-PNP in/out configuration followed by an R-C feedback network. The power amplifier sections consist of four direct-coupled differential amplifiers and silicon output transistors are arranged in a full complementary Darlington format. The driver stage uses a pair of push-pull complementary symmetry transistors. The elaborate electronic protection circuitry consisting of three transistors and four diodes for each channel, senses peak output current and limits the current to the drivers to a safe maximum value.

The oscilloscope display circuit consists of two deflection amplifiers and a cathode-ray tube. Each signal to be displayed is selected by the appropriate front panel push button switch and 4-channel signals are matrixed into the oscilloscope display circuits.

FM performance

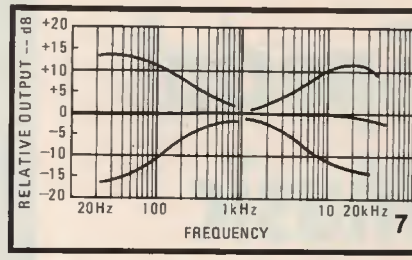
Of those specifications that are supplied by Marantz, every single one was exceeded by a wide margin in our test measurements, as can be seen in the results shown in Table I. Note that Marantz does not publish an IHF sensitivity figure, but prefers to quote only the more meaningful quieting slope results. In the case of our sample, 50 dB of quieting in mono was achieved with a signal input of only 3.1 μV (Marantz claims 5 μV for 55 dB of quieting). Ultimate S/N measured 78 dB in mono (far better than the 70 dB claimed) and a satisfactory 64 dB in stereo. All distortion figures were notably better than claimed, and even at 6 kHz in stereo (for which no figures were given by the manufacturer) THD remained low, at 0.5%. Other results, ranging from very good to superior, can be seen in Table I.

While we do not normally make extensive laboratory measurements of AM performance, we did measure usable sensitivity for the AM section of this receiver and found it to be 17μV for mid-band frequencies using an external antenna and 420 μV when using the built-in ferrite bar antenna.

Amplifier performance

Our amplifier measurements are listed in Table II and can be compared with manufacturer's ratings. Even at the difficult frequency extremes, the power amplifier delivered 58 watts-per-channel (at 20 Hz) in the 4-channel mode and 180 watts-per-channel in the stereo "strapped" mode. In 4-channel operation, only 8-ohm loads are recommended and our measurements reflect this limitation. Overall, power ratings as stated are extremely conservative and, at the rated 50 watts-per-channel (in 4-channel mode), the actual distortion for mid-frequencies measured a mere 0.007% compared with the rated THD of 0.15%. Damping factor measured 65 which is excellent and all hum and noise figures are substantially better than claimed.

Action of the BASS and TREBLE controls is shown in the graphs of Fig. 7. It should



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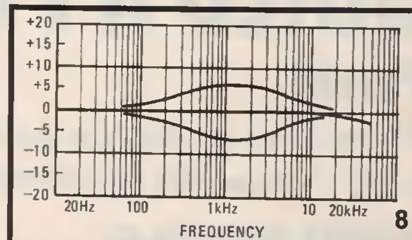
be noted that the knobs used on these controls, though equal in depth to those used for switches, are in reality two half-depth knobs mounted on dual concentric shafts for individual tonal control of front and rear channels. The same holds true for the MID-RANGE control. The response and range of the mid-range control is shown in Fig. 8. High- and low-cut filter responses are shown in Fig. 9.



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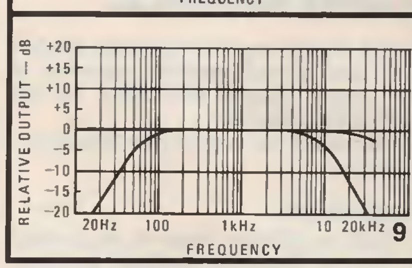

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Phono overload occurred at 120 millivolts as against 100 mV claimed, a high enough figure for most modern recordings played with typical magnetic cartridges, but not as high as some we have measured on a few stereo receivers in the high price category.

SQ decoding

Since our unit came equipped with the add-on SQ decoder previously mentioned, much of our listening concerned itself with SQ source material. We were impressed with the added dimensional realism afforded by the full-logic circuitry of the decoder and decided to measure separation, using a CBS supplied SQ test record and a Shure V15 Type III phono cartridge. We played a left-channel-only SQ encoded signal at various frequencies through the entire system and came up with the results shown in Fig. 10. Note that no graph is provided for the right-front channel under these test conditions, because in the SQ system, separation from left- front to right-front is theoretically infinite (or at least

(continued on page 64)

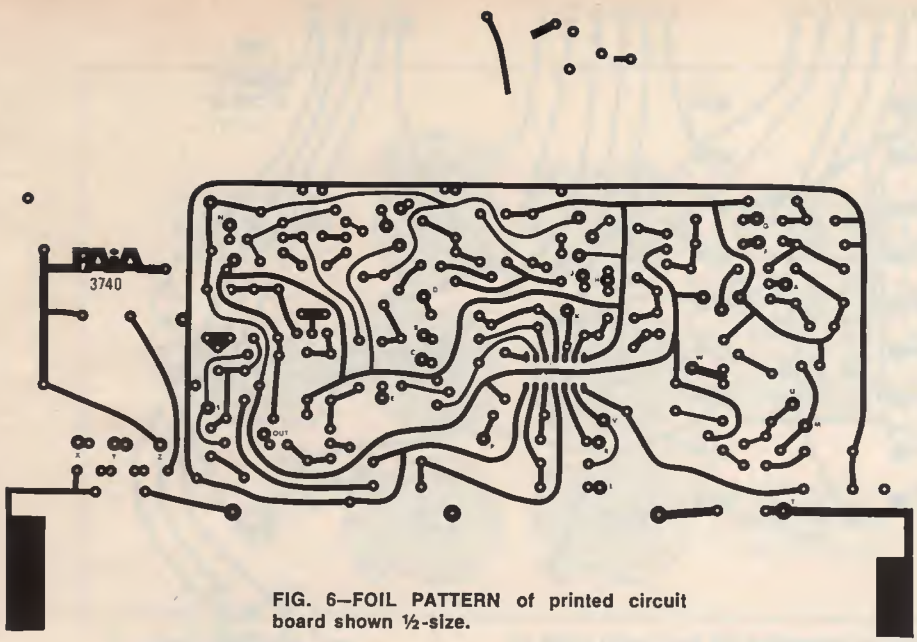

FIG. 6—FOIL PATTERN of printed circuit board shown ½-size.

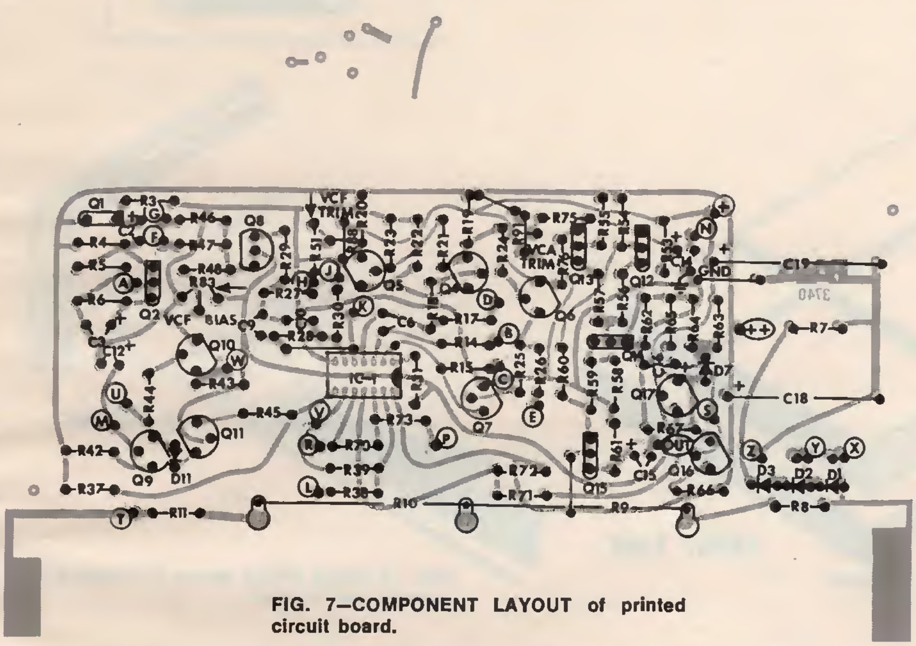

FIG. 7—COMPONENT LAYOUT of printed circuit board.

ments that will need to be made to the GNOME. These adjustments are; balance for the VCA and bias and trim for VCF. The rest of this procedure will be involved with testing the various sections of the GNOME to verify their proper operation.

Snap a pair of heavy-duty 9-volt transistor radio batteries (Eveready #1222 or equivalent) into the battery connectors and use a jumper cable to connect the rear panel output jack of the Gnome to the musical instrument or hi-fi amplifier that you intend using. On most hi-fi amplifiers, either the "aux." or "mag phono" inputs are appropriate.

Before beginning the calibration procedure, set the controls as follows:

Controller section. Rotate the RANGE control fully counter clockwise to the minimum setting. Set the VCO switch to the off position (opposite direction of arrow in schematic is in all cases considered to be off), VCF switch off.

Noise section. Rotate the NOISE LEVEL control to the minimum position.

VCO section. Rotate SKEW control fully clockwise (CW), RANGE control to minimum, TRIANGLE LEVEL to minimum, SQUARE WAVE to minimum.

VCF section. Set IN-OUT switch to out position, REPEAT switch to off, SUSTAIN switch to off, RANGE control to minimum, FREQ/Q control fully CCW, ATTACK control to minimum, DECAY control to minimum.

VCA section. Set SUSTAIN switch to off, ATTACK control to minimum, DECAY control to minimum.

Turn the external amplifier that you are using on and select the proper input channel. Turn the GNOME on by sliding the front-lip mounted power switch to the on position.

Testing the VCA

Rapidly and repeatedly press the TRIGGER button. You should hear a thump from the amplifier that indicates that the GNOME's VCA is working but needs to

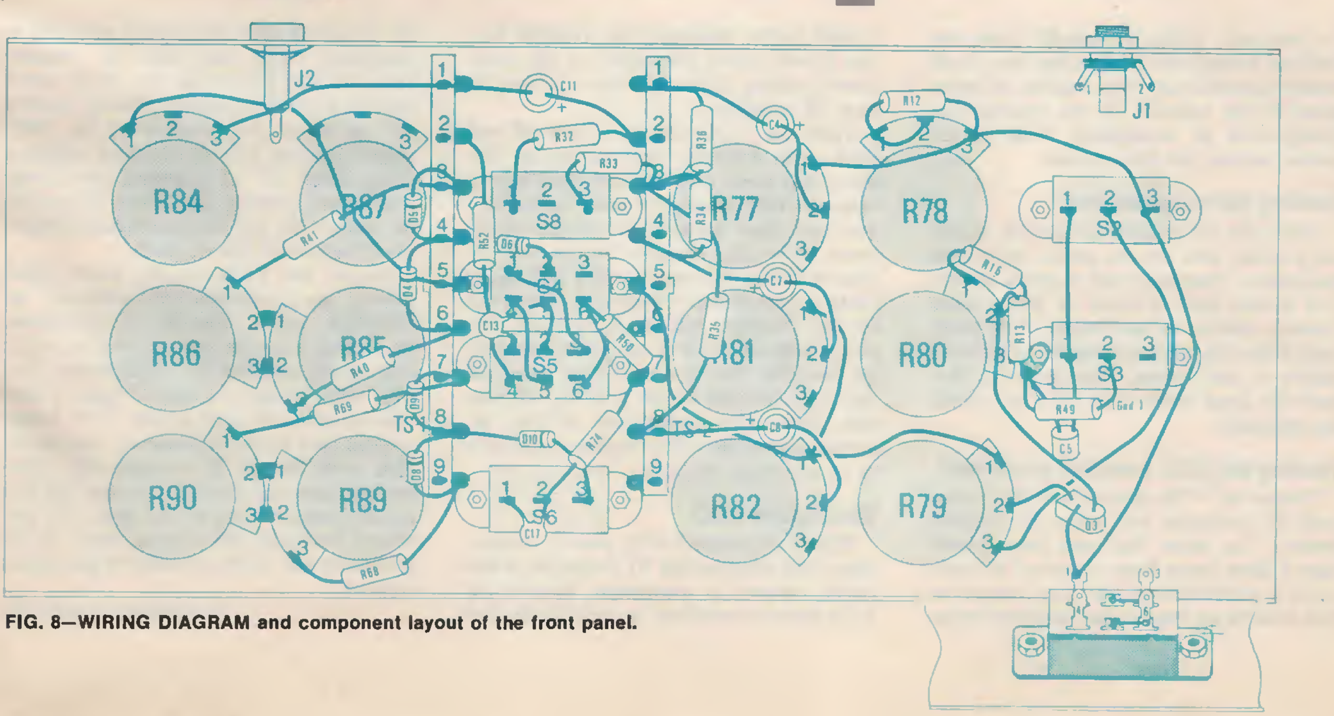

FIG. 8—WIRING DIAGRAM and component layout of the front panel.

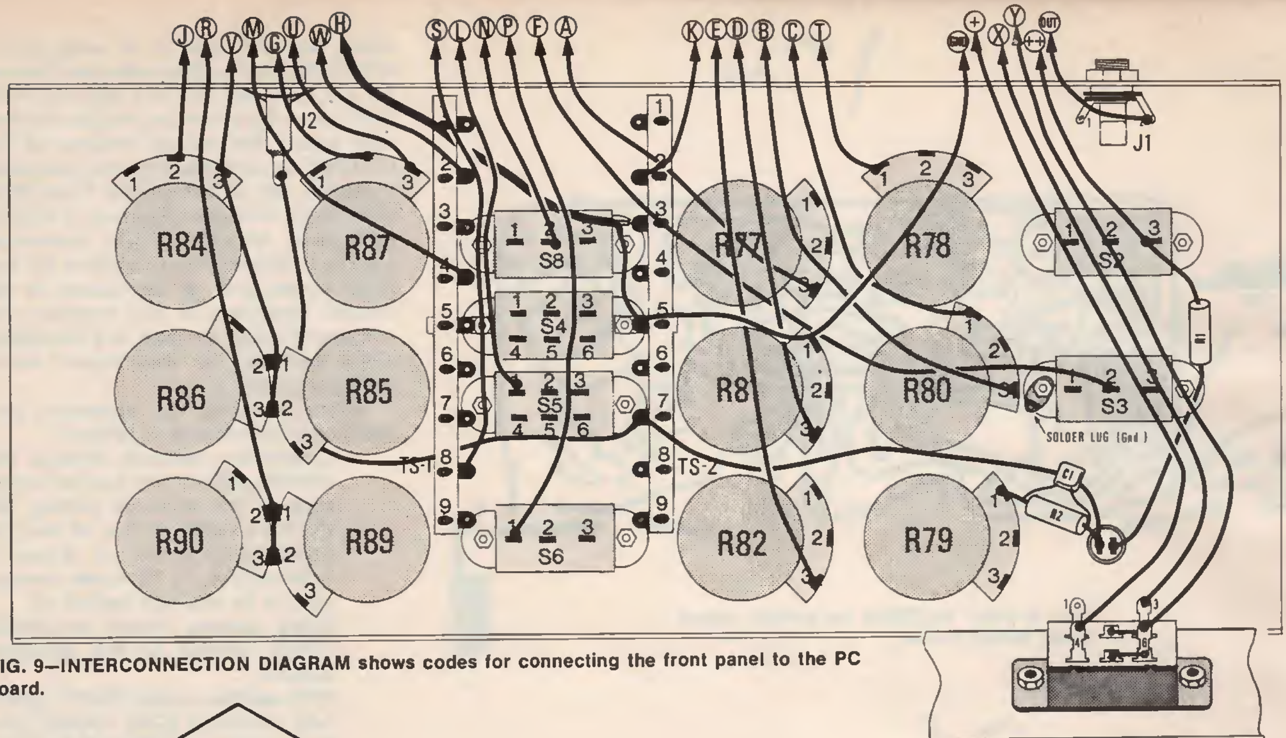

FIG. 9—INTERCONNECTION DIAGRAM shows codes for connecting the front panel to the PC board.

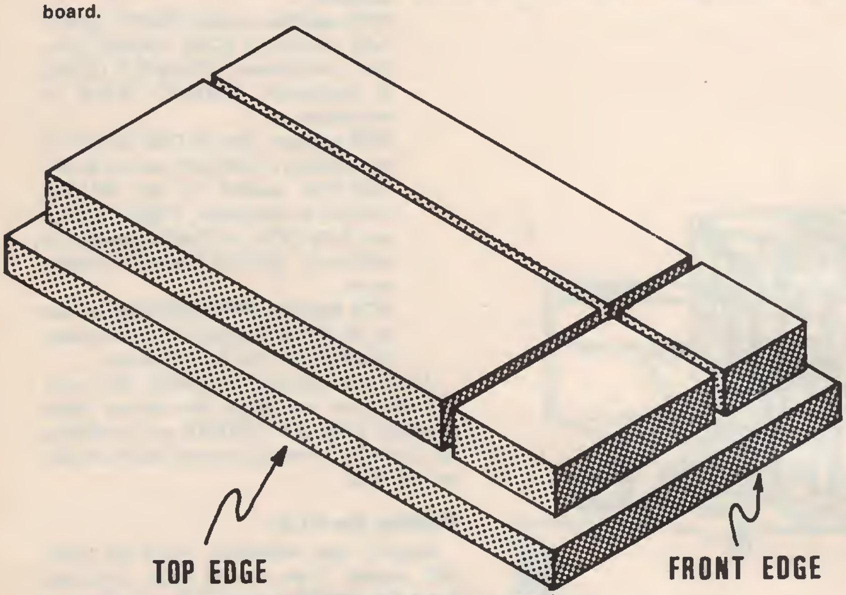

FIG. 10—EDGE PIECES for the GNOME are formed as shown.

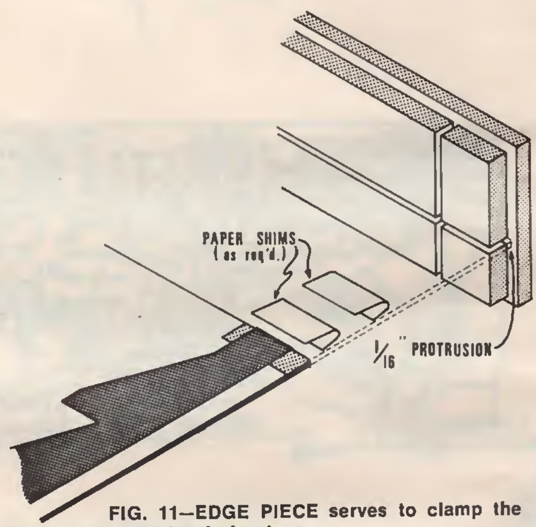

FIG. 11—EDGE PIECE serves to clamp the control strip in place.

be balanced. Again repeatedly press the TRIGGER button while adjusting the circuit board mounted VCA TRIM control. At some point in the rotation of the control, the thump will be minimized. This is the proper setting for this control.

Testing the noise source

Turn the VCA SUSTAIN switch to the on position and set the NOISE control to maximum. Now press the TRIGGER button, you should hear a burst of white noise (hissing similar to inter-station FM radio static) that stays on as long as the TRIGGER button is held down. This indicates that both the noise source and VCA are working properly.

Testing the VCA function generator

Rotate the VCA ATTACK and DECAY controls to maximum and press the TRIGGER button. The noise that you hear should take a little more than a second to build up to a peak volume and then remain at that volume as long as the TRIGGER button is held down. Releasing the TRIGGER button should allow the noise to die away slowly, taking approximately a second to turn off completely.

Turn the VCA SUSTAIN switch off and once again press the TRIGGER button. Observe that now, even though the TRIGGER button is held down, the noise builds to a peak and then immediately begins to die away. Press the TRIGGER button and release it before the entire attack and decay cycle is completed. Observe that as soon as the TRIGGER button is released the sound goes off. This is an automatic muting function that is operational any time the VCA SUSTAIN switch is in the off position. Successful completion of this sequence shows the VCA function generator to be operating properly.

Testing the VCO

Return the NOISE LEVEL control to minimum and advance the VCO SQUARE WAVE LEVEL control to maximum. Return the VCA SUSTAIN switch to its on position and the VCA ATTACK and DECAY controls to minimum. Press and hold the TRIGGER button while advancing the VCO RANGE control toward maximum. During the first 30° or so of the rotation of the VCO RANGE control you should hear nothing. After about 30° of rotation, you should hear a low pitched tone from the amplifier and as the control is advanced further the tone should rise in pitch.

Return the VCO SQUARE WAVE LEVEL control to minimum and advance the TRIANGLE LEVEL control to maximum. Press and hold the TRIGGER button while once again rotating the VCO RANGE control. Once again you should hear a tone that increases in pitch as the VCO Range control goes from minimum to maximum. This tone should be considerably more mellow than the square wave but the frequency range should be the same and you should have the same "dead zone" at the minimum end of the rotation of the RANGE control.

(continued on page 86)

BOOKSHELF SPEAKERS

Part III

How To Buy

Understanding the specifications is the first step. But there's more. Knowing how to conduct listening tests, speaker placement and room acoustics are just as important.

by ARTHUR KLEIMAN
ASSOCIATE EDITOR

THE FIRST TWO PARTS OF THIS ARTICLE DIScussed the speaker sepecifications and presented manufacturer's specifications for several systems. At this point, you should have narrowed down the number of available choices to just a few based on the specifications.

This concluding section will show you how to make a final choice based on listening tests. In addition, we will discuss room acoustics, speaker placement and speaker set-up.

Listening tests

Speaker systems should not be choosen purely on the basis of specifications. Auditioning the speaker system is the final and possibly the most important step in determining the quality of sound that a speaker system will produce. There is no better test instrument available to judge this than the human ear. Especially since it is the human ear that must ultimately be satisfied.

Throughout this article we have been mentioning the accuracy of reproduction —the ability of a hi-fi system to reproduce original sounds. However, most people in today's society are accustomed to "canned" music—music that has been reproduced. The term "original" music has no meaning for them. Therefore, the first step in conducting listening tests would be to purchase a ticket to a concert. It is this "live" music that the final judgment in sound quality must be made against. Listening tests are done on a comparative basis—comparing one speaker system against another. When making a judgment, it is necessary to choose the speaker system that sounds the most natural. It is impossible to make this judgment if you have never heard natural live sound.

Program material

Most audio showrooms allow you to bring in your own program material for conducting listening tests. Choose a record that is plentiful in bass notes (a bass drum is good for judging transient bass response), string instruments, horns, and high-frequency sounds such as bells. Sift through your record collection and choose an album that has most, if not all, of these sounds. One of my favorite records that has its fair share of these sounds is *Carmina Burana*, Columbia Records, MQX-33172. In addition, it would be a good idea to bring along a test record, such as Project 3, PR401-SQ. These test records have frequency sweeps, transient response tests, pink-noise tests, etc. Plus musical passages that make it easier to judge speaker systems.

You should be familiar with the musical passage you choose to conduct the listening tests with. It would be ideal if you heard it performed at a concert too. In this way, you can become aware of how the musical passage should sound. You will have an idea of what is actually on the record and whether the speaker system is reproducing it accurately or not.

Avoid program material that includes "electrified" instruments. The reason for this is simple. No one has ever heard these instruments except through another speaker system. There is no way of knowing what the natural sound of these instruments are. Modern "rock" music is typical of this. In addition, many rock performers intentionally add sound effects in the form of large amounts of distortion. When listening to this type of music, it's difficult to tell whether the speaker system itself is distorting or whether the distortion is part of the music.

Auditioning speaker systems

Listening tests are conducted on a comparative basis. The idea is to *compare* the sound quality of two speaker systems and choose the better of the two. Speaker systems will not sound the same in the audio showroom as they would in your home environment. In most cases, they will sound better in the showroom. Most audio showrooms are acoustically treated so that they more closely approach an ideal listening room. In addition, the physical layout of most audio showrooms are such that one wall is full of speaker systems. One speaker system is played while the rest remain passive. Those passive speaker systems contain resonant cones that affect the overall sound quality that you hear. So, don't select a speaker system on the basis of sound quality alone without comparing it to another system.

The ability of the human mind to remember sound quality is astonishingly poor. For this reason, you should not compare more than two speaker systems at any one time. Needless to say, you should never attempt to compare speaker systems in different showrooms. If you are interested in three speaker systems in the same showroom, select the better system of two and then compare it to the third.

Audio showrooms do not carry all of the speaker systems that are available; they can't, there are just too many different systems. If you are lucky, you will find one that carries all the systems you are interested in. If not, you will have to go from showroom to showroom. Don't forget the poor ability of the human mind to remember sound quality. Choose the best speaker system in the first showroom and the best system in the second showroom. Now you will have to find a third showroom that has both these speaker systems so you can make the final choice.

Once in the showroom, insist that the program material you brought with you be played. In addition, insist that all the speaker systems you are comparing be driven from the same amplifier-turntable-cartridge combination. This will eliminate any effect that different combinations might have on the sound quality. Most audio showrooms are equipped with a switching panel that facilitates this easily. Also, it is a good idea to listen to only one speaker of a particular model at a time instead of a stereo pair. Switch the amplifier to the mono mode and switch off all other speaker systems.

Finally, it is very important that the speaker systems you are comparing be driven to the same output level. Due to psycho-acoustical effects, a louder speaker system usually sounds better. A poor speaker system often sounds better than a good speaker system if it is driven to a louder output level, even if you are not consciously aware of the difference in volume levels. Therefore, *carefully* adjust the volume control on the amplifier so that the speaker systems you are comparing are driven to the same output level.

Remember, efficiencies vary from speaker system to speaker system, so this does not necessarily mean the same volume control setting for all speaker systems. Also, make sure the tone controls on the amplifier are in their "flat" position. Otherwise you will be judging the combined effects of the amplifier-speaker combination and not just the speaker system itself. And don't forget to check the crossover control on the rear of the speaker enclosure. It can have a tremendous effect on the sound reproduction and if set incorrectly can downgrade the performance of a first-rate system.

Judging speaker systems

Play the program material you brought with you and listen to the bass sounds.

These notes should be a subtle enhancement to the music passage. They should not "boom" and you should not be overly aware of their presence. They should simply be there. Try to pick out the beats of a bass drum. These beats should be distinct and clear. The bass drum should sound like a bass drum. Of course, if you've never heard a live bass drum, this explanation is meaningless. This brings us back to that preliminary ticket to a live concert.

Another deficiency among speaker systems is an overall weakness in the bass frequency range (the relative output level of the woofer is lower than the mid-range and tweeter.) This weakness is not necessarily accompanied by a limited bass frequency response (the speaker system will still be able to produce an audible output down to say 30 Hz.) As a result, you will be able to hear the low-frequency bass notes, but not in the proper balance with the rest of the music passage. In addition, the attack portion of the bass note will be exaggerated due to the better mid-range response. A bass note reproduced through this type of speaker system will sound unnaturally sharp, unnaturally crisp. As a result, you will be overly aware of the presence of the bass notes.

The sound of string instruments as well as some female voices are another good basis for judging speaker systems. Normally, strings have a very subtle resinous quality. Speaker systems that have their mid-range response emphasized (this is usually accompanied by an increase in distortion) will exaggerate the resinous quality of the strings. The strings will sound unnaturally harsh. In extreme cases, the instruments will sound as if they are equipped with metal strings and were being played by metal bows. Violins are excellent instruments to judge this quality by.

A good speaker system should sound transparent. Poor speaker systems can sound as if a cloth screen has been placed between the musical instruments and your ear. The reproduced sound takes on a sort of muffled quality.

High-pitched bells should sound distinct and clear. In addition, poor speaker systems can impart a nasal quality to the sound. Nasal quality in orchestral music is difficult to define because of the natural nasal quality of some of the instruments. The only way to separate the natural nasal quality of the instruments from the nasal quality added by the speaker system is to be reasonably familiar with the original music. However, when comparing speaker systems, it is easier to spot this quality in human voices. Singers reproduced through speaker systems of this type sound as if they have a head cold.

Dispersion is another important quality in speaker systems. Poor dispersion results in the music sounding as if it is coming from a confined source. Good dispersion results in a sense of spaciousness—a quality that is common in live music. The reproduced music will also sound dull and lacking in high-frequency sounds from any normal listening position in the room.

In the final analysis, an ideal speaker system will sound as if the musical instruments are in the same room with you. It will reproduce the original music exactly as it was played. How closely the actual speaker system approaches this ideal determines how good it is.

The listening room

Listening rooms should be acoustically treated to obtain the best performance from a speaker system. This includes the consideration of such factors as absorption, reverberation, room resonance and standing waves. Unfortunately, this type of treatment is very expensive and most often out of the reach of most hi-fi listeners. For example, room resonance and standing waves are controlled by, among other things, the room dimensions. There is an ideal set of room dimensions that will optimise these factors. However, not many hi-fi listeners would be willing or able to go through the expense of building a listening room from the foundation on up.

A simpler acoustical treatment consists of controlling the reverberation time. Reverberation time is a measure of how quickly a sound decays after it has been produced. It is defined as the time required for the sound energy to decay 60 dB from its original intensity. It varies with frequency too. Low-frequency reverb time is dependent on room volume. Figure 10 shows a reverberation-time curve for a typical listening room. If the surfaces within the room are acoustically reflective (that is, they reflect the majority of the sound energy that is incident upon them), the sound will bounce back and forth (see Fig. 11) and take a long time to die out.

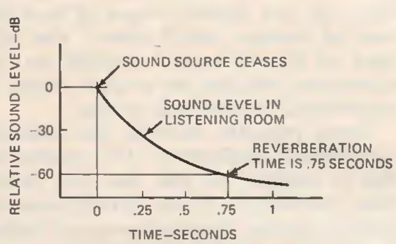

FIG. 10—REVERBERATION TIME curve of a typical listening room. The 0-dB reference level is the steady-state output level of the sound source.

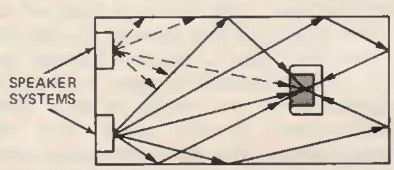

FIG. 11—SOUND ENERGY reaches the listener from many directions.

The problem with this situation is that the speaker system will continue to produce sounds even though the time period isn't long enough to allow the prior sounds to sufficiently subside. The result will be that the listener will hear several sounds simultaneously. If the reverberation time is too great, the listeners ears will become confused and the sound will lose its clarity.

The human ear has become accustomed to reverberations. It exists in normal everyday situations. The concert hall is characterized by the many reflections reaching the listener from different directions. As a result, the ear tends to "pick out" the direct sound and ignore the reverberations. However, a listening room that is devoid of all reverberations (anechoic chamber) would sound unnatural. It would be lacking in the qualities that the ear associates with live music.

The ideal listening room lies somewhere between a 100% reverberant room and an anechoic chamber. Just how much reverberation time is desirable is open to controversy and numerous philosophies exist. A further discussion of this is best left for the psycho-acousticians.

Reverberation time is controlled by the room dimensions and the type of materials that comprise the room. Controlling room dimensions, as already pointed out, is impractical. The materials that comprise the listening room can, however, be changed. Hard materials reflect sound (increasing reverberation time) and soft materials absorb sound (decreasing reverberation time.) There is a procedure for calculating the reverberation time in a listening room (Sabine's formula.) However, the procedure is tedious and must be carried out for several frequencies. In addition, the problem of defining the ideal reverberation time would still remain. So, this procedure is not described in this article.

A few generalized hints regarding room furnishings can be given. The furnishings should consist of enough soft material (carpeting, upholstered furniture, drapes, etc.) to partially absorb the sound energy. There should also be enough hard material (exposed walls, glass windows, etc.) to provide the reflections necessary to give the sound the liveliness that is common in concert halls. Figure 12 shows a possible acoustical treatment of the listening room shown in Fig. 11. Large areas of glass, such as picture windows, should be covered with thick drapes. Large bare walls should be treated in a similar manner, but they should not be completely covered. Covering the entire floor with thick carpeting should be avoided. It is better to cover tiled floors with several thick scatter rugs. Acoustical ceiling tiles generally prove ineffective in reducing reverberation time as the majority of the reflections are from the walls and floor, not the ceiling. Upholstered furniture should be scattered around the room, but not directly against the walls.

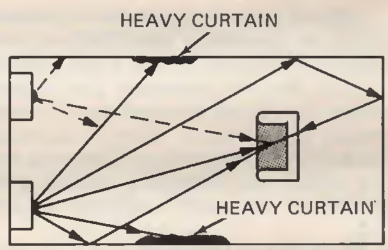

FIG. 12—REVERBERATION TIME can be reduced by covering the reflective surfaces with soft sound-absorptive materials.

Speaker position

Speaker placement within the listening room is an integral part of the room acoustics. It affects the overall tonal balance of the speaker system as well as the primary listening area.

Bookshelf speaker systems, as the name implies, are mounted against a wall. The bass response is affected by the relative position of the speaker with respect to two adjacent surfaces. Minimum bass-frequency output is obtained by placing the speaker system in the center of a wall. By positioning the speaker system closer to either of the side walls, the bass output is increased. This effect can be further increased by positioning the speaker system closer to either the ceiling or floor. Maximum bass output occurs with the speaker system placed in a corner. The best response, however, is usually obtained by placing the speaker system at ear level height. The bass response is controlled by maintaining this height and moving the speaker system either closer or farther away from the side wall (See Fig. 13).

The speaker system can be oriented

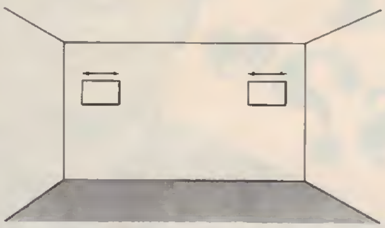

FIG. 13—SPEAKER SYSTEMS are usually placed at ear-level so the listener receives enough direct high-frequency sound energy. The bass output is adjusted by moving the speaker system relative to the side wall.

either horizontally or vertically. As stated earlier, depending upon the type of tweeter used in the speaker system, dispersion may not be symmetrical for both the vertical and horizontal axis. If the dispersion is not symmetrical, then the orientation of the speaker system will affect the high-frequency reverberant field in the listening room. The speaker system should be oriented so that maximum dispersion occurs horizontally.

The bass frequency response depends upon how close the *woofer* is placed against an adjacent surface. To increase the bass output with a vertical orientation when the speaker system is placed against the floor, it should be positioned upside up. Similarly, when the speaker system is placed against the ceiling, it should be placed upside down. To increase the bass output for a horizontal orientation, the bottom of the speaker system should be placed against the side wall. Figure 14 shows the proper orientations for obtaining maximum bass output in the corner locations.

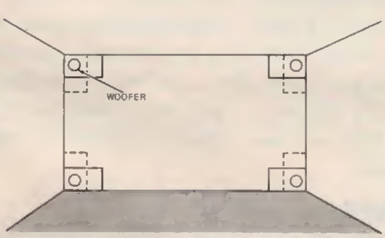

FIG. 14—MAXIMUM BASS OUTPUT occurs when the woofer is placed closest to the corner.

The best location and orientation in a particular listening room is found through experimentation. Try various positions and locations in your listening room and stick to the one that produces the best sound quality. Manufacturers know the particular characteristics of their speaker systems. Therefore, **Radio-Electronics** asked each manufacturer for their recommendations. These recommendations ap-

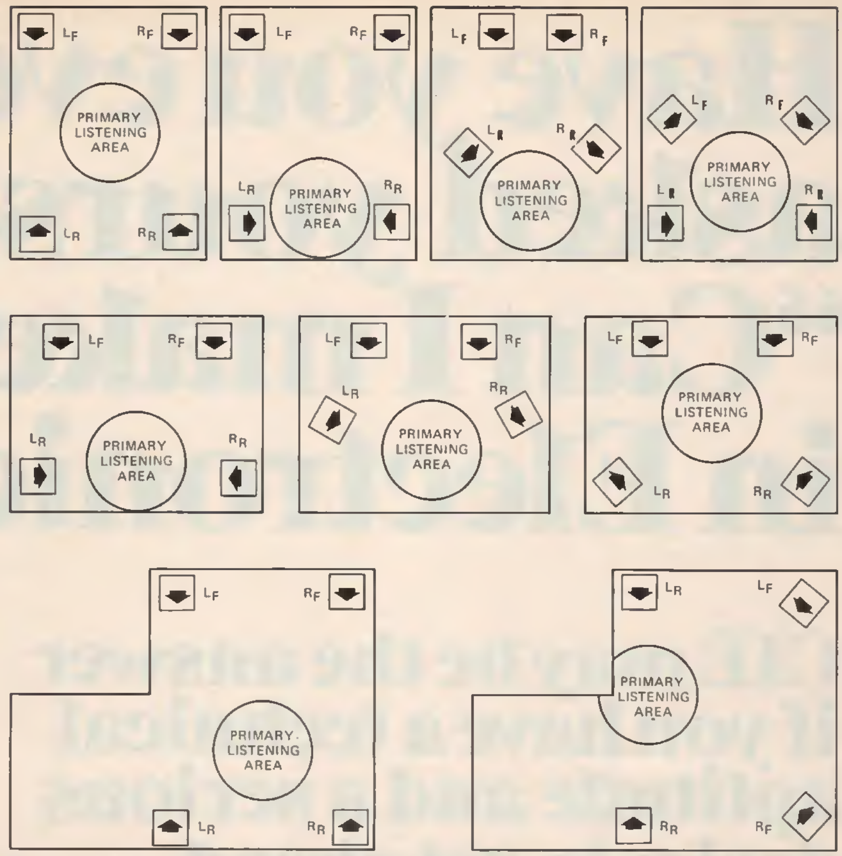

FIG. 15—SPEAKER POSITION AND DIRECTION affects the location of the primary listening area. Some typical listening room shapes are shown. (Courtesy of Marantz.)

pear in the chart (see November 1975 issue) and should only be regarded as a starting point. Experimentation will still be necessary.

Speaker location will also affect the location of the primary listening area. This will also be affected by tilting and pointing the speaker system. Figure 15 shows various listening room shapes and the affect of speaker system position and direction on the location of the primary listening area in a quadriphonic system.

Mid-range and tweeter controls

Most bookshelf speaker systems have mid-range and tweeter controls that set the relative output of their respective drivers. A control is not provided for the woofer as its relative output remains constant. Unlike the tone controls on the preamplifier that introduces a slope at the extremes of the frequency response curve, these controls change their entire respective sections of the spectrum equally. If these controls are misadjusted, the frequency response curve appears stepped. The controls are provided to compensate for production variations and room acoustics.

Contrary to common belief, setting these controls to the center of their rotation does not necessarily correspond to a flat frequency response. To properly set these controls, the speaker system should be placed in the final position you have selected for it in the listening room. The hi-fi system is turned-on and program music that you are familiar with is played. Better yet, if your hi-fi system is equipped with an FM tuner, tune to interstation hiss. The balance controls on the preamplifier are adjusted for minimum output from the other speaker systems. The tone controls on the preamplifier are adjusted to their nominally flat positions. Both controls on the speaker system are set to their minimum positions.

Get close to the speaker system. Your ear should be about one-foot away. Slowly turn-up the midrange control on the speaker system. At one point in its rotation, the sound will seem to be coming from one driver instead of the two (woofer and mid-range) that it actually is. The sound will appear to be coming from a point mid-way between the two drivers. Leave the control in this position. The same procedure is repeated for the tweeter control.

The speaker system is now set-up properly. Some very *minor* adjustments of the controls might be necessary depending upon the room acoustics and the particular taste of the listener. Repeat the procedure for the other speaker systems in the listening room. **R-E**

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Power FET for Audio

The controversy between tube and solid-state audio power amplifiers has taken a new twist with the development of the power FET and its introduction in the Yamaha B-1 amplifier.

by LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

ALMOST SINCE THE VERY FIRST SOLID-state hi-fi audio amplifier appeared in audio shops some twenty years ago, there has been a raging argument between proponents of "tube sound" and those who favored "transistor sound." It took several years for engineers to thoroughly analyze why the sound of a transistor amplifier whose power output and overall distortion specifications were identical to those of a tube-type amplifier "sounded" different.

Today it is generally conceded that two characteristics of bipolar output transistors are responsible for the audible differences between tube amplifiers and transistorized amplifiers. The manner in which a bipolar transistor operates leads to the generation of high-order odd harmonics even at signal levels below clipping, as shown in the diagram of Fig. 1. It is generally

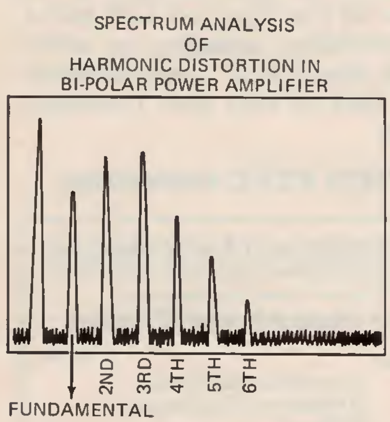


FIG. 1—SPECTRAL GRAPH showing harmonic distortion in bipolar transistor amplifiers.

conceded that the presence of such high-order harmonics is more disturbing to listeners than low-order harmonics which might add up to the same total harmonic distortion expressed as a simple, single percentage figure. In other words, 1% total harmonic distortion in an amplifier, when that distortion consists primarily of second and third harmonics, is apt to be less subjectively annoying than 1% total harmonic distortion which is made up of high-order (4th, 5th, 6th, 7th, etc.) harmonics of the fundamental. Besides generating high-order harmonics over their so-called linear operating characteristic, the manner in which bipolar transistorized output circuits "clip," or overload (because of saturation and cut-off) leads to the generation of sharp, squared-off signals, as Fig. 2 illustrates. Such waveforms also

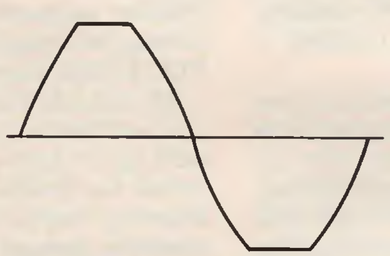


FIG. 2—CLIPPING in class-B bipolar transistor amplifiers.

contain large amounts of high-order harmonic distortion which are more irritating to the listener's ears.

The second significant difference between tube and bipolar transistor amplifiers is thought to relate to the transient response capability of each. Conventional transistors exhibit a carrier-storage effect. This effect can best be described in terms of an analogy. Think of a bipolar transistor as a series of storage tanks of unequal capacity, with a valve to shut-off the flow. Output flow is regulated by the valve. Even if the valve is fully closed, isolating tank 1 from tank 2, output current will continue to flow until tank 2 is fully drained into tank 3. It is this carrier-storage effect (not present in tubes or FET's) that limits rise (and fall) time of high-frequency transient signals in a transistorized amplifier circuit. Thus, even though the bandwidth of the circuit may extend to well beyond the highest audio frequency to be handled, square-wave response at high frequencies may be distorted, as Fig. 3 shows,

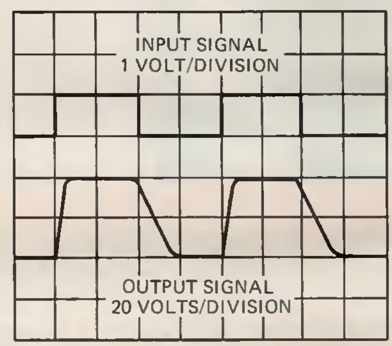


FIG. 3. SQUARE-WAVE RESPONSE of bipolar transistor amplifier at 20 kHz. Note poor transient response at trailing edge of square wave.

because of the carrier-storage effect.

Carrier-storage time is the interval between the beginning of the turn-off signal applied to the base of a saturated transistor and the instant that the collector voltage starts to rise toward the supply voltage.

Merits of the FET as a power amplifier

Bipolar devices (transistors) use input *current* to control output current. The FET, on the other hand, uses a change in input *voltage* to control output current. The FET may be thought of as a kind of large hour-glass-on-edge storage tank, where the diameter of the constriction can be controlled by the applied input voltage. The merits of using voltage to control output current would make the FET a more suitable device for use in audio amplifiers if it could be made to produce high output current. Until recently, though, the ordinary FET was unable to handle high currents. When the regulating input voltage is high (constricting the narrow section of the analogous "hour glass"), output current is limited and the device exhibits cut-off. So until recently, FET's have been confined to voltage amplifying circuits (RF amplifiers and low-level audio preamplifier stages) where current flow was measured in milliamperes. In 1971, Professor Nishizawa of Tohoku

YAMAHA MODEL B-1 amplifier

University solved the problem of obtaining high output currents from the FET by drastically changing its internal structure. Although passage of current is still controlled by a voltage applied to the "gate," Professor Nishizawa changed the "shape" of the constriction to allow high current output even under high voltage input. In effect, current passage can take an infinite number of "paths" instead of just the single path of our hour glass analogy.

(Figure 4 compares the construction of the small-signal FET with its lateral or horizontal current flow in Fig. 4-a with the new vertical power FET in Fig. 4-b. The vertical FET or V-FET permits current to flow vertically from source to drain. The vertical current path has a far greater current capacity and provides for a low output resistance. Current is controlled by the voltage applied to the grid-like P+ gates.

The chip of a typical V-FET is 3 mm square and contains approximately 1500 rectangular source areas connected by metal jumpers. The chip for a small-signal FET is only about 0.7 mm square.—*Editor*)

Another form of distortion often encountered in bipolar transistor amplifier designs is called "notch distortion." The effect is illustrated in the waveform of Fig. 5. While improper biasing of conventional class "B" transistor circuits can cause high levels of notch distortion, even correctly biased output stages may exhibit varying amounts of this form of distortion because of the carrier-storage effect. Since notch distortion is present at *all* power output levels, it is even more audibly objectionable at low listening levels—where it constitutes a greater percentage of the total reproduced signal—than at higher listening levels. The newly-developed "vertical" power FET, devoid of any carrier-storage effect, might correctly be expected to eliminate this very audible form of distortion as well. The device itself is inherently linear; therefore high-order odd harmonics that are most audibly irritating are minimized or eliminated. In addition, the linearity of vertical power FET's means that only small amounts of negative feedback need be applied for wideband frequency response and a higher degree of stability.

Temperature stability

The FET exhibits an inverse relationship between temperature and current flow. As a result, there is an inherent and automatic self-protecting aspect to the use of power FET's in an audio amplifier. As the temperature of the device increases, the current passing through it decreases, causing a decrease in operating temperature. This is a direct contrast to the performance of bipolar transistors which, unless properly protected, are susceptible to thermal runaway.

Triode-like performance

The FET shows no saturation in high-current operation. As voltage in-

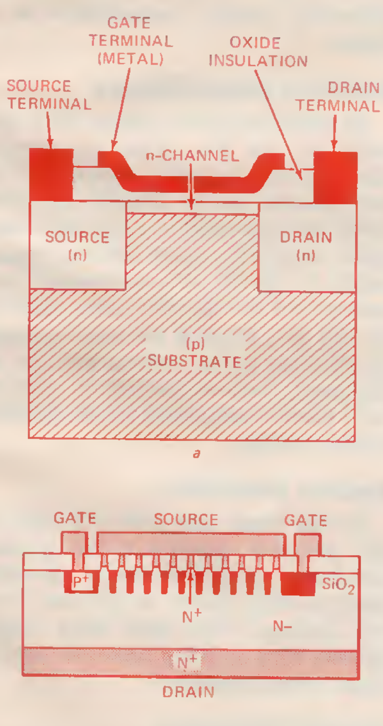


FIG. 4—A COMPARISON of the cross-section of a small-signal FET (a) with that of a vertical FET (b). Note the comb-like construction of the gate.

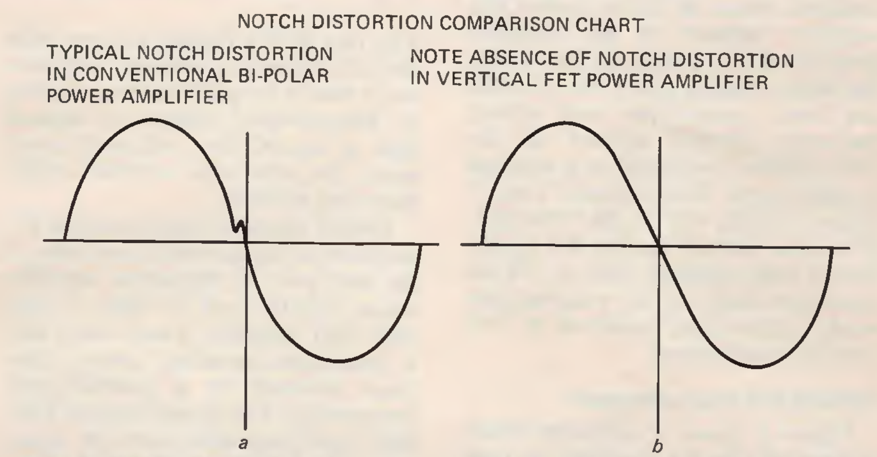


FIG. 5—COMPARISON of notch distortion. Conventional bipolar transistor amplifier is shown in a. Vertical FET is shown in b.

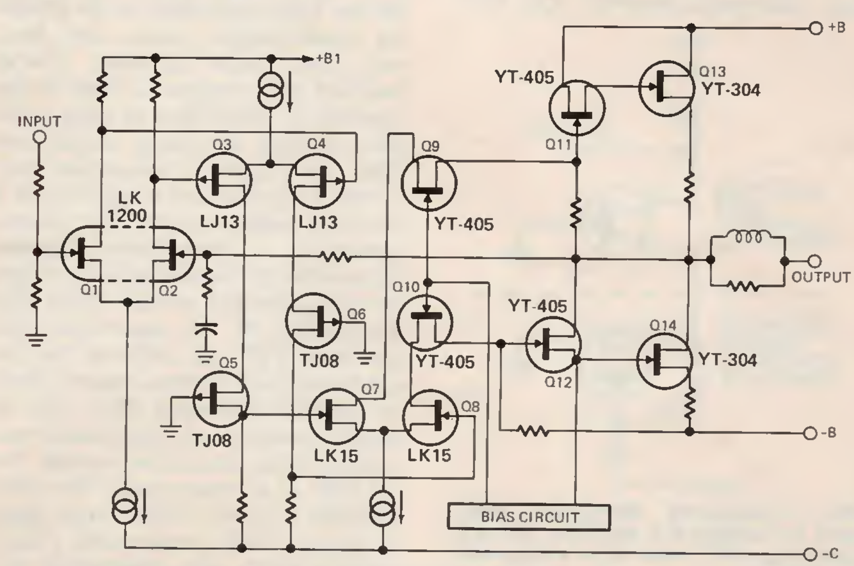


FIG. 6—BLOCK DIAGRAM, Yamaha model B-1 amplifier.

creases, output current also increases, similar to the action that takes place in a triode tube circuit and in contrast to the action of conventional bipolar transistors where an increase in voltage beyond a given level produces no further increase in output current—a condition of saturation.

An all-FET amplifier

With the availability of vertical power FET's, it was natural that an all-FET power amplifier should be designed. One such design already making its way to the audio market is Yamaha's new B-1 basic stereo power amplifier. This unit delivers at least 150 watts-per-channel of continuous power at any frequency from 20 Hz to 20,000 Hz, with no more than 0.1% total harmonic or intermodulation distortion when driving 8-ohm or 4-ohm loads.

Interestingly, at low output-power levels (where notch distortion often tends to produce higher relative percentages of distortion), both harmonic and intermodulation distortion are considerably lower, decreasing to a maximum of 0.04% at 1 watt output. Although lower than usual negative feedback (about 40 dB) is used in this amplifier because of the inherent linearity of the power FET's, damping factor remains high (100 at 1 kHz and lower frequencies) and overall frequency response claimed for the new amplifier, measured at a nominal 1 watt output level, extends from 5 Hz to 100 kHz, +0, −1 dB. Other specifications claimed for the B-1 amplifier are hum and noise ratio of 110 dB (measured using an "A" weighing network) and an input sensitivity of .775 volts for rated output.

Yamaha B-1 block diagram

Figure 6 shows a simplified block diagram of the B-1 amplifier. A type LK-1200 dual FET serves as a first stage differential amplifier (Q1, Q2).

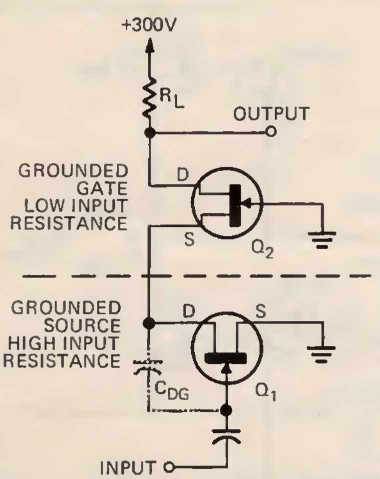


FIG. 7—CASCODE AMPLIFIER stage used in Yamaha B-1 amplifier. Q1 is a low-voltage FET while Q2 is a high-voltage FET.

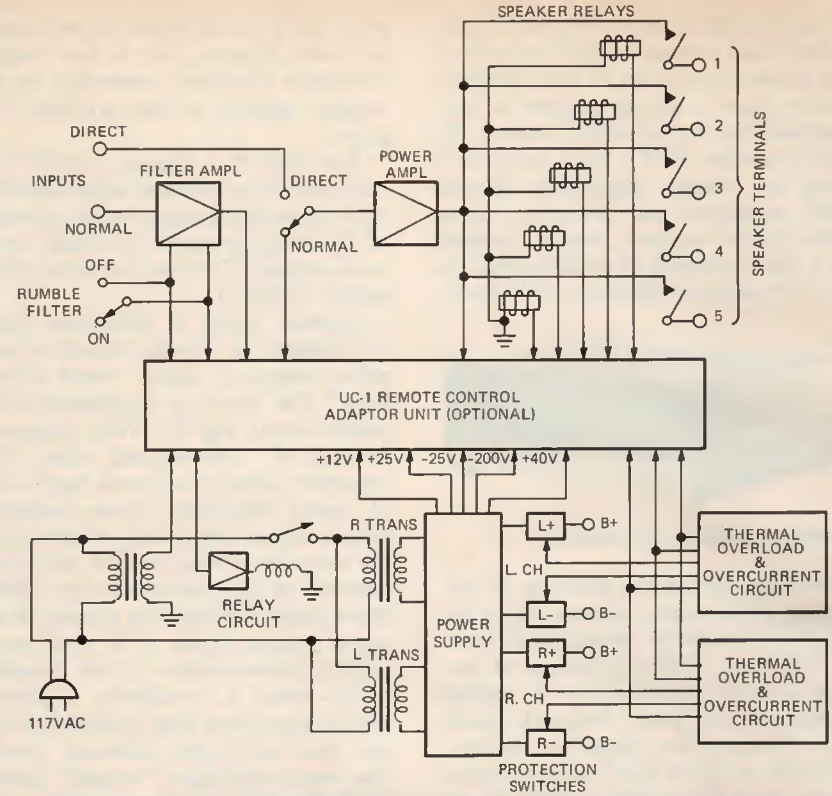


FIG. 8—OVERALL BLOCK DIAGRAM showing power supply, protection, rumble filter, and remote control connection points of Yamaha B-1 amplifier.

The two FET's formed on one chip are well balanced electrically and thermaly. One of the problems encountered in direct-coupled designs is thermal drift of the DC-zero balanced output point. The differential amplifier eliminates this problem.

One of the novel features of the B-1 amplifier is the cascode connection of the next pair of differential amplifier stages (Q3-Q4 and Q5-Q6). A cascode FET amplifier is one which uses a neutralized grounded source input stage followed by a grounded-gate output stage. The circuit has high gain, high input-impedance and low noise. As detailed in Fig. 7, the load of the source-grounded amplifier consists of the low input-impedance of the following grounded-gate stage, and feedback from output to input. Overall feedback from output to input of the amplifier is lower than in most solid-state designs, increasing overall stability. In a cascode connection such as this, gain is almost as great as in a grounded source circuit, but reverse admittance is low, further improving stability. In the case of these stages, the gate-grounded vertical FET's load the outputs of the source-grounded horizontal FET. In addition, the circuit is equivalent to that obtained from an ordinary horizontal FET with the added advantage of high breakdown-voltage. High breakdown-voltage for the FET is necessary since the entire amplifier is direct coupled from input to output. While conventional ("horizontal") FETs have breakdown voltages of 50 to 60 volts at the most, the newly designed "vertical" FET can sustain voltages as high as 200 volts or more before breakdown occurs. High breakdown-voltage, low output-impedance and excellent linearity—all properties of the familiar triode—apply to the vertical FET as well, and the new device also exhibits the same non-saturating output characteristic as a triode.

Additional design features

In addition to the unique FET circuitry of the B-1, there are several other design features worth noting. Independent power supplies are provided for powering left and right amplifier channels. Total filtering capacitance is 30,000 μF-per-channel, and each power transformer has a capacity of 500 VA. Despite the basic reliability ascribed to the vertical FET by its designers, various protection circuits have been incorporated in the finished product design.

Speaker protection

In the event that over ±2 volts of DC potential appears at the speaker terminals, an electronically operated speaker relay opens to prevent voice coil damage. This same relay delays speaker turn-on when power is first applied to the amplifier.

Overload protection

In the event of a short across the speaker terminals, or the application

(continued on page 65)

R-E's Service Clinic

Four Cases—One Cause

Four Different Troubles With The Same Cause

by **JACK DARR**
SERVICE EDITOR

This column is for your service problems–TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge 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 Ave. South, N.Y. 10003.

LET'S TAKE A LOOK AT SOME APPARently unrelated troubles and see if we can tie them together. These troubles all have a common cause. See if you can guess what it is before we get to the explaining of the inexplicable and the unscrewing of the inscrutable. This really shouldn't be a *guess*, there is a good logical reason. (Of course, it's only taken me about 4 years to put these all together and see it!) Once you get it, this should be very helpful in avoiding similar difficulties in the future.

Case 1: This one occurred quite a few years ago. Good-sized transistor hi-fi amplifier. Problem; the output transistors blew out while making standard tests on the amplifier. It had been working very well up to then.

Case 2: Small RCA solid-state B/W TV set. Problem; the circuit breaker tripped almost as soon as it was turned on. All DC power supply circuits checked. Both sweep transistors, damper and high-voltage rectifier, also checked. No defects. This was one of the early solid-state RCA's.

Case 3: Solid-state RCA XL-100 chassis. Horizontal output transistor blows. No apparent cause. All DC power supply and associated circuits check out good.

Case 4: RCA CTC-38 tube-type chassis. Problem: 6LQ6 cathode current far too high, about 280 mA. All load circuits on flyback checked, tubes substituted; no results.

There you are. Can you find the common cause? It's in there. Four "mysterious" cases of trouble in four entirely different TV sets. Yet, the actual cause of the defect is exactly the same in every one! If you have run into any one of them in the past and cleared it up, now you know what the problem is in the other three.

Basically, this is a "drive" problem. At times I'm not too fond of transistors because of some of their characteristics, such as catastrophic failure. However, I'll say this; they're willing little beasts. If you push one, it will cheerfully drive itself to destruction trying to handle the load you're putting on it (sort of an electronic shmoo). The worst part of this is that it does it so blooming quick!

OK; now let's go back and look at a few basics. Notice that we hung in one tube-type set? Same thing applies. When we feed a signal to the input of a device, we cause it to draw a certain amount of current. The average current through the thing is directly proportional to the *time* that it is kept turned on. The currently-popular output-transformerless Class-B transistor output stages are a perfect example of this. With no signal input, they draw a very small current. At full output, they may take 50 or 75 times as much, simply because they are turned on for longer periods of time. So, our *average* current goes skyrocketing.

Figure 1 shows this graphically. This is the key to the whole thing. In Fig. 1-a, there are two pulses. Let's say that each pulse is 10 milliseconds wide. So, during time T, the transistor is drawing current for only 20 ms. Now look at Fig. 1-b. The pulses are the

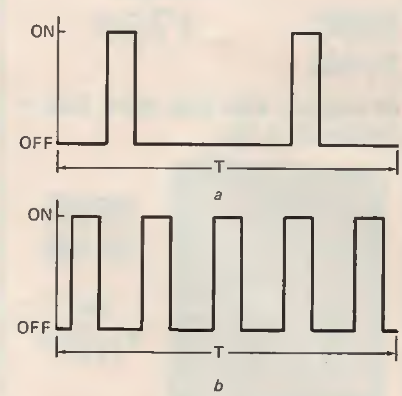


Fig. 1

same width, but now there are 5 of them. So, what happens to our average current during time T? It goes away up; 2.5 times greater.

What did we do? We changed the *frequency* of the driving pulses. These can be flat-top pulses or one half of a sinewave; makes no difference. The end result comes out the same. If we feed *more* pulses into the transistor during the same time, we raise the *average* current clear out of the ball park!

Let's stop for a moment and clear up something. While I suspect that this could apply to all transistor stages, in this case it is meant to apply only to power-amplifier stages which work at high currents. These are the ones that cause the trouble.

Now let's go back and fill in a few

details. In Case 1, the transistor amplifier *was in* good condition. What blew the output transistors was feeding in a sustained sinewave signal at 15 kHz during a frequency-response test! In a music signal, it reproduced the high frequencies very well because they occurred only at very short and irregular intervals. However, trying to drive the amplifier to full power with a single-frequency, *high-frequency* signal overloaded the stage. This was a characteristic of the early transistor amplifiers; later models have been designed so that this doesn't happen.

In Case 2, the trouble turned out to be *very* simple (after we found it!) The vertical oscillator was running far too fast! The hold control had been turned all the way to the high frequency end. Since the receiver didn't stay on long enough for us to see a raster, it was hard to tell what was causing the problem. Frankly, we found it by accident by putting the scope on the wrong place. Readjusting the vertical hold control cleared up the whole problem.

Case 3 in the XL-100 chassis was exactly the same thing, but this time it was the horizontal hold control that had been turned too far toward high-frequency.

Case 4 in the tube type set was also the same thing. We had turned the brightness down to see if this would reduce the current. When we finally looked at the raster, we saw nothing but very thin horizontal lines, showing that the horizontal oscillator was far above normal frequency. Readjusting this, we saw to our amazement that the current had dropped to normal! The high frequency was simply turning the horizontal output tube on *too often*, thus raising the average current.

So there it is. If you run into a case of mysterious fuse blowing or breaker tripping and none of the stock remedies help, check up on the *drive* frequencies. You can do this easily in practically all solid-state sets by taking the output transistor out and reading the frequency of the drive on the base terminal. In tube sets, you can take the tube out if the heater string is connected in parallel. Tubes will withstand overloads longer than transistors, so that you can let it "run up" to get an idea of what's going on.

In some of the older tube power amplifiers, it was possible to blow the output tubes or the output transformer by running it at high power with the speaker terminals open. In some of them, you would see an ultrasonic oscillation develop in the output stage that caused the thing to develop large voltage peaks. In other equipment, a failure of a filter capacitor, etc., could let the output stage go into a violent ultrasonic oscillation, and here we go again. The scope is the best weapon for catching these things. You may not be able to hear this oscillation, but you can very definitely *see* it on a scope! This is the only instrument that will give you the data you need about the P-P voltage and the frequency of the drive signal. R-E

reader questions

BLUE WON'T WORK!

Here's a convergence problem for you! The red and green will overlap nicely, but I can't get the blue to move. What the heck's going on?—G.D., Overland Park, KS.

Offhand, I'd say nothing. Blue should be the easiest of all to converge. You can go in all directions, because it has two magnets. If these will not move the blue lines in the proper direction, they're out of place. That is, if the blue lateral makes the blue move in a diagonal, like the red and green; the magnet isn't set in the proper place on the neck. Move it until it will make the blue move horizontally as it should.

If they won't make the blue move at all, the magnets must be demagnetized. Replace them, or remagnetize them.

OLD SCOPE FOR COLOR TV?

I've got an old scope, in good working order, a 1957 kit model. Do you think it will do for color TV work? Don't know what it will do up around 4-5 MHz.—J.T., Commodore, PA.

I'd say yes. Get a working color TV set, feed a color-bar pattern into it, and check the critical patterns. Compare these to the ones shown on the schematic. They don't have to be identical, but as long as you know what they look like, fine!

These critical patterns would be: Red, green and blue grids on picture tube; output of burst amplifier; output of 3.58-MHz oscillator, and output of bandpass amplifiers (through detector probe). If you can see a "bar" on the 3.58-MHz oscillator, you do *not* have to be able to see individual cycles. All you need to know is the p-p voltage. If you can get a good clean pattern at the video detector output, at horizontal frequency, it should do nicely.

INTERMITTENT BRIGHTNESS

The brightness level jumps up and down on this CTC-25X RCA. When this happens, the picture blurs and loses focus. I can rap the chassis and make it come back. The voltages on the picture tube vary when this trouble shows up. High voltage goes down. I suspected a bad picture tube, but I tried an isolation brightener and it didn't help—so, I need

yours!—A.G., Westminster, CA.

If this is a "jar intermittent," you can find it much more easily. Most likely cause is a bad solder joint somewhere on the PC board. Take a new lead pencil, and tap *lightly* around at different points. Find out where the most sensitive place is; where you can just barely tap it and make the problem appear. When you get here, start moving various parts gently; if you can find one that makes the picture cut out when you move it, OK. One end of it is probably intermittent.

Some parts which could cause this would be the common cathode resistor of the color-difference amplifiers; the B+ or boost feed to the screen controls, and so on. Check the horizontal *blanker* stage, especially the 0.22-μF coupling capacitor to the difference amplifiers. If this is opening intermittently, it will upset the bias on these three tubes.

INTERMITTENT VERTICAL SWEEP

I had intermittent vertical sweep in a Motorola TS-915 Quasar. Finally went out, to a single thin horizontal line. Thought it was the vertical output transistor, but it wasn't. Then tried the convergence (H) panel. No. Finally checked the schematic, and found that the vertical oscillator, pulse shaper and vertical driver are on the *Video Amplifier Panel* (E).

A short blast of spray-coolant on Q11-e (Vertical Driver) transistor brought the vertical sweep back; touching the case with a hot iron killed it. Replacing this cured the whole problem. (Thanks to Paul Galluzzi, Box 352, Beverly, MA. for this one!)

INTERMITTENT OPERATION

This Roberts 50508 tape-recorder doesn't work properly. Sometimes the relays will stay in, but most of the time they close then drop out. All of the relays seem to be good. This is a pretty complicated switching circuit, and I get lost in it. Can you help?—H.L., Florence, KY.

I hope so! Since all of the relays seem to be afflicted with the same trouble, look for something *common* to all of them, meaning the DC power supply! Something seems to be cutting down the *current* output, so that the relays can't hold-in as they should.

Check that "filter resistor" in the low-voltage supply; it's marked 182W on the schematic, which I translated as 18 ohms, 2 watts. You may find that this has gone up in value, causing too much drop in the voltage on the relays.

HV PROBLEM

First problem on this Magnavox T939 was no high voltage; the raster would come on for a couple of seconds, then disappear. Second problem was no sound or video. New 6HB7 mixer-oscillator tube cured the last one, but the high-voltage problem is still there.

Tried new tubes, checked grid drive on horizontal output, which was fine, 200 volts peak-to-peak. Boost voltage comes up to about +400 volts, then drops to about +220 volts. High-voltage regulator circuit seems OK. Cathode current of output tube rises to about 160 mA, then drops to about 130. Any suggestions?—J.B., Littleton, CO.

From the symptoms and the readings, especially the cathode current of the output tube, you shouldn't be looking for a *short*. Check all of the electrolytic *filter* capacitors, with the scope. This sounds very much like feedback due to an *open* capacitor, which is cancelling the output. Try bridging new ones across any suspected units. **R-E**

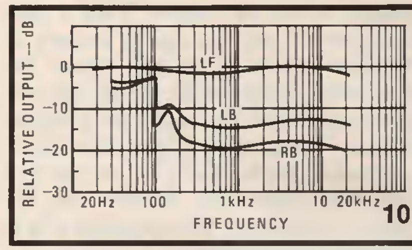
R-E TESTS MARANTZ 4400

(continued from page 47)

stereo cartridge). At frequencies below 100 Hz, the logic circuitry does not improve separation to a great degree beyond the 3 dB inherent in the SQ system. It should be noted, however, that separation at very low frequencies is not an important requirement for the enjoyment of multichannel musical reproduction. Above 100 Hz, cross-talk into both related channels (left-back and right back) is reduced to values ranging between 15 dB and 20 dB, providing very effective quadriphonic listening. The SQ adaptor module in question, though quite small, contains three IC's (two from Motorola, the other a Sony SQ IC) and more parts than we cared to count. To give you an idea of the complexity of this little module (and why Marantz asks just under $80.00 for it), we photographed the inside of the module, as shown in Fig. 11.

Utilization and listening tests

It took us several hours just to try out all the many features of the Marantz 4400. It is, indeed, an audio purist's dream in that its designers have not overlooked any feature that might prove worthwhile in



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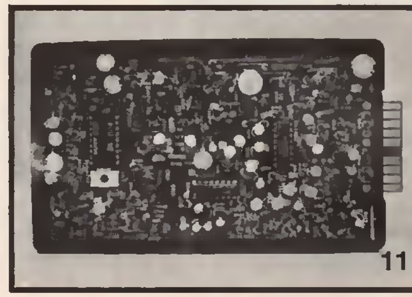


11

TABLE III

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Marantz** — Model: **4400**

OVERALL PRODUCT ANALYSIS

Retail price	**$1250. (SQ Full Logic Decoder optional, extra)**
Price category	**High**
Price/performance ratio	**Very Good**
Styling and appearance	**Superior**
Sound quality	**Excellent**
Mechanical performance	**Excellent**
Comments:	The Marantz model 4400 receiver is, from any viewpoint, a receiver designed for the quadriphonic enthusiast, providing that he or she installs an SQA-2B SQ decoder in that under-the-chassis pocket, and providing the user is willing to invest in a separate CD-4 demodulator circuit such as Marantz's CD-400B. If these two "extras" are included in your system, you end up with one of the most powerful and flexible 4-channel receivers ever offered to consumers. While it may be argued that the paralleling or "strapping" feature of the receiver makes it a worthwhile purchase for the stereo enthusiast as well, we would tend to disagree, since, for over $1200.00, one could purchase some fairly sophisticated separate components (tuner and amplifier) that would outperform this all-in-one both in power capability and versatility of controls. This would be true even if one stayed with Marantz in choosing such separates. Looking at it another way, if all you wanted was a 100 watts plus per channel *stereo* receiver, you can find one at about $500 less than you must pay for the 4400. The emphasis, therefore, is on 4-channel—whether you want it now or plan to convert to it later (in which case the "strapping" feature of the 4400 lets you enjoy full-powered use of the receiver until you buy that extra pair of speakers plus the necessary add-in SQ decoder and add-on CD-4 demodulator). While we strongly suggest staying with Marantz's own SQ module because of its being able to be tucked into the main receiver's underside, such restriction need not be placed on your choice of CD-4 demodulators. Any one of good recent design will work effectively with this receiver (we tried two others from Technics and JVC in our tests and all did well). The demodulator will remain "outboard" regardless of whose version you use. Aside from these provisos, the Marantz 4400, in its basic functions (FM reception, controls, tuning, etc.) is typical of Marantz's traditionally superb styling and internal design.

stereo or 4-channel use. As we said earlier, the built-in matrix decoder is not nearly as effective in reproducing matrixed 4-channel discs with full dimensional realism as compared with the results obtained from the optional SQA-2B module. It is a pity that Marantz was not able to include a CD-4 module option (in another possible pocket under the chassis) so that all 4-channel facilities could be self-contained, but we could understand the problem when we later examined their separate well engineered Model 400B outboard demodulator accessory.

As for FM reception—it was flawless, limited in quality only by the station's transmission practices. Since our lab is equipped with a rotator that controls the orientation of our outdoor 5-element directional FM antenna, we were able to watch the multipath problems disappear on the scope display as we leaned on the rotator control. To use anything but this arrangement with a set of this kind is to do its display features an injustice, for you can literally "tune" your antenna for best reception of each station as you watch that clever scope presentation. Then, when all was right, we switched over to the audio display and permitted those four radiating traces to mesmerize us as we listened to our favorite stations and records. Certainly, the scope display adds a considerable percentage to the final cost of this well equipped receiver, but after a few hours of use, it all seemed worthwhile.

Our summary comments will be found along with our overall product analysis ratings in Table III. **R-E**

POWER FET

(continuel from page 60)

of a load impedance of much less than 4 ohms, the power supply to the power-FET circuit is automatically shut down to protect both output circuitry and the power supply itself. Once the overload condition is removed, the circuit recovers automatically.

Since absence of negative bias at the gate of a FET would cause excessive current flow, the current supply to the output FET's will automatically be shut off if the gate bias circuit fails.

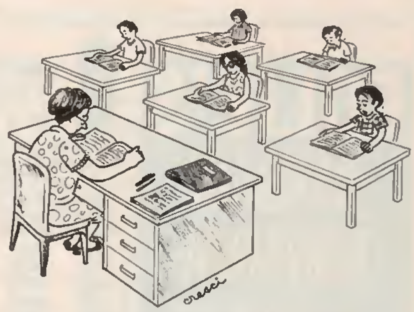
Thermal protection

If abnormal heating of the output FET occurs, base current supply is also temporarily shut off. A thermal detector is mounted on the amplifier heat sink and is activated at a temperature of 100° C. In case of thermal problems, both the thermal and overload indicators on the front panel will light. In other cases of circuit protection activation, only the overload indicator light is illuminated.

An overall block diagram (Fig. 8) illustrates the interconnection of some of the features just discussed. Also shown in this diagram is a block representing a rumble filter which has a cut-off frequency of 10 Hz and a slope of −12 dB/octave.

Does it sound better?

We have had only a brief listening session with the new Yamaha B-1 amplifier, but can attest to the fact that it sounds as clean as any amplifier (tube or transistor) we have heard in many years. In the future, we hope to do an R-E test report on this unique unit, at which time we shall be able to compare its sound with that of conventional high-powered amplifiers and conduct our own test measurements. In the meantime, the Yamaha B-1 and other "power FET" amplifiers that are sure to follow offer an alternative for the purist who never could get used to "transistor" sound. **R-E**



"'Any disturbance in a parallel-tuned circuit starts a current oscillating through the coil,' said Dick. 'But the oscillation dies out unless properly timed energy is fed into it,' said Jane. 'Bow-wow,' barked spot."

ZOOM IN TIGHT

(continued from page 34)

increase in contrast due to the shift in the contrast circuit attenuation.

Next down from the top are the color enhance contacts. Chroma gain in Zenith's receivers is DC controlled. As the voltage on pin 6 of chroma amplifier-demodulator IC1001 decreases, chroma gain increases. Activating the Zoom function loads the center of the color level pot to ground with R311. The voltage at the control slider is reduced and the color level is raised. The lower contact in the transfer set disables the transistor circuitry below. More about this later.

The third set of contacts expands the horizontal scan by changing the size of the horizontal yoke series capacitor. In the normal non-Zoom connection, C250 is paralleled with C242 to form a 0.37 μF capacitor. Switched to Zoom only the 0.1 μF is in the circuit and the picture widens.

The last set of contacts picks up the 130-volt DC supply. The Zoom indicator is fed through R235. R233 and CR200 parallel the 330K resistor increasing the charging current to the 0.47 μF vertical capacitor. Vertical sawtooth amplitude and picture height are stepped up by the reduced RC time constant.

Horizontal flyback pulses are integrated and full wave rectified by a pair of diodes and the three-transistor amplifier to synthesize the horizontal blanking voltage. Low-pass filter R303-R304-C301 shapes the positive going flyback pulse into a sawtooth by the accumulating effect of the RC network. The positive portion of the horizontal sawtooth is conducted through CR305 to the base of Q301. Hooked up as a common-emitter inverting amplifier, the collector of Q301 swings downward during this interval. The negative swing of the integrated pulse bypasses the amplifier by going through CR304 right to the transistor collector terminal.

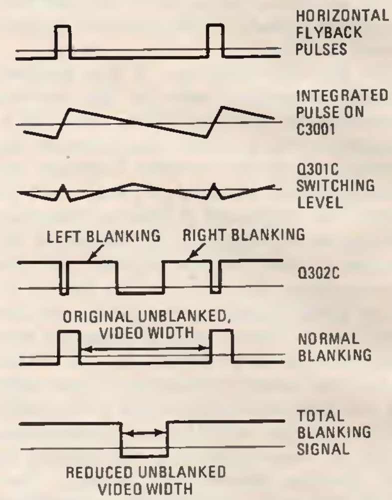


FIG. 3—SIGNAL processing sequence for Zoom blanking.

Twice each horizontal line the summed collector signal swings negative. Full-wave rectification generally doubles the signal frequency by its non-linear switching characteristic. Q302 inverts and squares up the signal transitions to a sharply defined positive going blanking signal. Buffered by follower Q303 the signal then is added into the luminance channel where the video is blanked both by this uniquely processed signal and the conventional horizontal retrace blanking pulse. The blanking information now extends into the video at the left and right picture edges.

The total width of the blanked horizontal screen region is adjusted by R303. It controls the amplitude of the horizontal sawtooth formed on C301 and the exact points of the end of the left blanking and the beginning of the right pulse.

Figure 3 shows the signal processing sequence. Note the way the normal blanking pulse covers over the negative gap between the left and right synthesized pulses to produce a continuous single pulse. The remaining gap is the reduced unblanked video segment that just fills the screen.

Vertical overscan blanking works with the same mechanism. The transistor circuitry is shared by both blanking signals. During the wider vertical blanking period the two signals are ORed by the circuit. This is perfectly normal and is what conventionally happens between standard horizontal and vertical blanking pulses. Two more diodes CR301 and CR302 do full-wave vertical rectification. The vertical signal is already integrated in the vertical module and this sawtooth feeds the Zoom circuits through terminal W1 without any intermediate integration. R301 is the vertical overscan blanking adjustment. As in the horizontal circuit it varies the sawtooth amplitude.

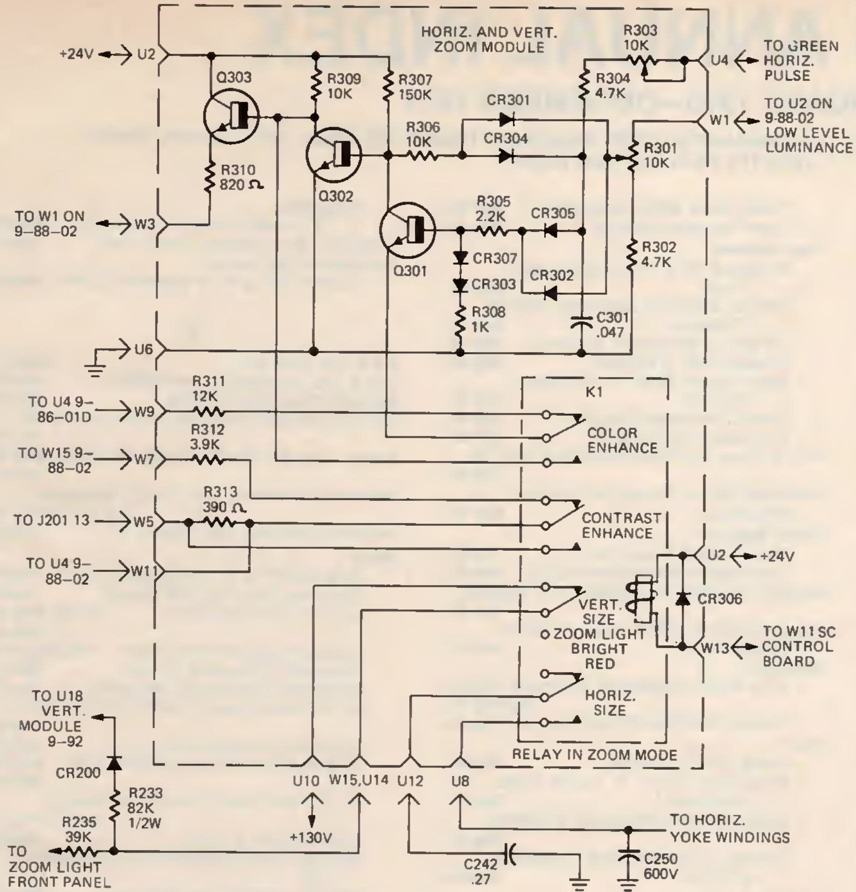


FIG. 2—HORIZONTAL and vertical Zoom module contains relay switching and related circuitry.

Now for that borrowed color-enhance contact. In the non-Zoom mode the relay armature is returned by its spring grounding the base of Q303. Q303 is cut off and the residual luminance signals on its emitter see the high impedance of the reverse biased emitter-base junction. Normal blanking takes over.

Two jumpers must be connected to operate the set with the Zoom module removed. One between terminal U2 and U8 maintains horizontal deflection. The other goes between W5 and W11 in the contrast control circuit.

There it is—a great gadget for TV viewers who like to feel like active participants in the production of their favorite shows. At their own discretion they can zoom in on close or instant replays. Resolution remains fixed of course, you can't create information that's not there. But there are practical aspects for the viewer—such as blowing up text located at or near the center of the screen. **R-E**

MISSING TUBE

A little guitar amplifier just came in. It has four tubes. One of these is missing. No number on socket, no schematic. The three that are left are 35W4, 12AU6 and a 12AT6. Can you tell what the missing one is?—F.S., Bowling Green, OH.

I'll make you a heck of a close guess; try a 50B5. You have the rectifier (35W4), a preamp and the tremolo oscillator. All you need is a power-output tube, and this is the one used mostly with the other types.

HALF COLOR, HALF B/W?

There's a weird symptom in this CTC-36. The screen is half in color, half in B/W! Divided vertically in the middle. What is this?—J.C., Philadelphia, PA.

The crystal ball says that something is wrong in or around the blanking. You seem to be getting a distorted blanking-pulse which is cutting off the color during that half of the scan. Try scoping all bypass capacitors around the color circuits; bandpass amplifier, demodulator, etc. If you see any signal at a point which should have none, that bypass is probably open. Try connecting a good one across it.

(Field feedback: it was C707, .047 μF, in the grid circuit of the bandpass amplifier!)

TRANSISTOR SUBSTITUTION

I can't find a substitute for a horizontal output transistor, 297VO69C01. Used in model V-2483. Do you know of any I could use?—C.M., Brooklyn, NY.

Should be several. The original is in a TO-3 case, as nearly as I can tell. Something like G-E's GE-36 should have plenty of voltage and current rating. **R-E**

1975 ANNUAL INDEX

JANUARY 1975—DECEMBER 1975

Abbreviations: (AC) Appliance Clinic; (C) Construction; (ER) Equipment Report; (F) Filler; (SC) Service Clinic; (HFLTR) Hi-Fi Lab Test Report

A

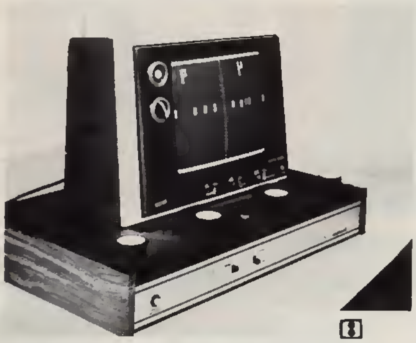
B

TV GAMES

(continued from page 31)

the logic circuitry enables the coincidence gates to detect ball coincidence with the back side of the left player. In handball, the ball must bounce off either player and reverse its direction back towards the wall which is always on the far left of the TV screen.

The serve lockout and score output on this IC provide a score indication pulse for the score IC and also through discharging of an external capacitor prevents the ball from re-entering the playing field once a score has been made until that score has been registered by the score IC (IC6). This capacitor allows approximately 1.5 seconds delay before the ball can be returned to play. Since the ball reset is accomplished by the player who lost the score touching his player to a wall, the delay prevents cheating.



BROADMOOR 4-PLAY combines monochrome TV and game chassis. Game signal is video and is fed directly to video circuitry.

The blanking generator provides a logic pulse slightly wider than the horizontal sync and is centered, timewise, about horizontal sync. Coincidence of the ball and this pulse enables the score output and

PONG BY ATARI is available at Sears stores now. It plays only the one game.

initiates the serve lockout circuitry. This blanking pulse is needed to prevent the ball from travelling into and disappearing in the horizontal sync. If this were allowed to happen, the ball video would not be generated to operate the logic or coincidence gates.

(continued on page 90)

The better the training the better you'll

(Simulated TV Reception)

As an NTS student you'll acquire the know-how that comes with first-hand training on NTS professional equipment. **Equipment you'll build and keep.** Our courses include equipment like the **NTS/Heath Digital GR-2000 Solid State color TV** with first-ever features like silent varactor diode tuning; digital channel selection, (with optional digital clock), and big 315 sq. in. ultra-rectangular screen.

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

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new products

More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card inside the back cover.

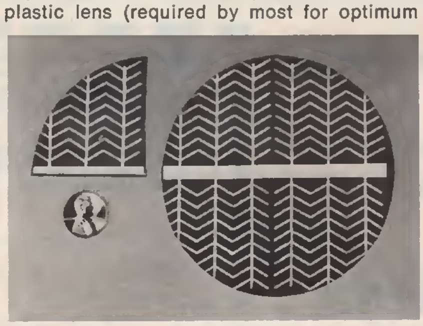
RF WIDE-BAND SIGNAL GENERATOR, the *LSG-16* is said to be ideal for service, hobby, education or industrial use. It features an FET oscillator circuitry for high-stability performance plus an accurately calibrated frequency dial. Frequency range is 100 kHz to 100 MHz; and up to 300 MHz on harmonics. Internal modulation is 1 kHz at 30% or higher while external modulation is 50 Hz-20 kHz at less than 1 RMS.

The *LSG-16* can function as a marker-generator when used in conjunction with a sweep generator and will check and align RF and IF circuits in TV, FM and communication-type receivers and transmitters. Use of the product is further extended by provisions to accommodate a 1—15 MHz crystal.

The *LSG-16* offers a 115/230V; 50/60 Hz; 3VA approx. power supply. It measures 6 × 10 × 5 inches and weighs 5.5 lbs. $109.95—**Leader Instruments Corp.,** 151 Dupont Street, Plainview, NY 11803.

Circle 31 on reader service card

FOUR-INCH SILICON SOLAR CELL is capable of putting out 1 full watt of electricity and over 2 amps of current at 0.45 volt. It is ideal for designers researching the efficiency of solar energy. Each cell is double tested at intensities equivalent to sunlight at 25°C (±3°). Operating range is −65° to ±125°C. The cell is rated at 100 mW/cm² light intensity at 0.45 V. It can be operated without a plastic lens (required by most for optimum



efficiency) and comes with tab leads, allowing any number of parallel or series configurations to attain desired voltage or amperage level.

This 4-inch solar cell, stock No. 42,314 is $29.95 postpaid.—**Edmund Scientific Co.,** 380 Edscorp Bldg., Barrington, NJ 08007.

Circle 32 on reader service card

AUDIO ANALYZER. The *LAV-190*, combines an audio generator, attenuator and AC millivolt meter which will provide performance checking of all audio equipment.

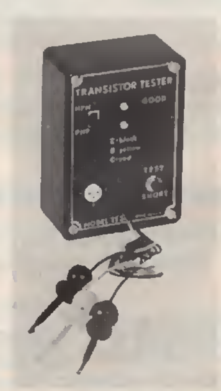
It consumes only 7 VA during testing. Offers a switchable, dual-impedance network of either 6 or 600 ohms. The audio generator frequency range is 10 Hz to 1 MHz sinewave with output of more than 2.5 VRMS into 600

ohms at low harmonic distortion. There is a continuously variable attenuator; a 150 μV—500 VAC millivolt meter scale across 12 ranges with an overall input impedance of 10 megohms.

The *LAV 190* comes with 2 miniplugs and cables, plus a cable with a pin tip. It has a 115/230 V, 50/60 Hz power supply and measures 8.5 × 12 × 7.3 inches. Approximately 8¾ lbs. $499.95.—**Leader Instruments Corp.,** 151 Dupont Street, Plainview, NY 11803.

Circle 33 on reader service card

NEW IN/OUT OF CIRCUIT TRANSISTOR TESTER, *model TT26EZ,* features 3-in-one testing capabilities. It tests transistors, and diodes and also checks continuity. Other features include a gold-plated socket for extra reliability; tests transistors in less than 5



seconds; uses a standard 9V battery; has capability of testing a minimum of 8000 transistors. The TT26EZ measures a compact 3-15/16″ × 1-7/16″ ×2⅞″, priced at $12.55

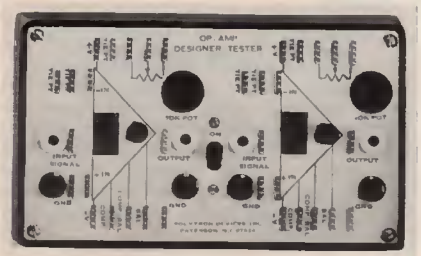
pp. in kit form with E-Z hooks. This unit is also available completely assembled at extra cost. It can be ordered direct from Tokyo Electronics, and will be shipped within 48 hours. **Tokyo Electronics, Inc.,** 1467 48th Street, Brooklyn, NY 11219.

Circle 34 on reader service card

COMPACT CIRCUIT-DESIGN TOOL, the *Dual Op-Amp Designer Tester,* designed to aid both the beginner and experienced user to set-up and test circuits containing one or two op-amps is available with internal ±15 VDC @ 100 mA regulated power supply (*model 202*) or ±9 VDC batteries (*model 201*). This rugged self-powered instrument is also useful to test the performance and electrical specifications of op-amps in any particular test circuit.

No soldering is necessary; just insert components such as resistors, capacitors, diodes, IC's, etc. . . . and your circuit is built.

Other leading features of the *Dual Op-Amp Designer-Tester* include the following:



Solderless tie points. . . . No special patch cords are needed because solid No. 22 gauge wire is used for interconnecting tie points. No soldering is necessary; just insert components.

Internal ±15 VDC @ 100 mA regulated power supply featuring: short-circuit protection, 0.1% line and load regulation, 1 mV RMS maximum ripple and noise, input isolation—50 megohms, warm up drift—35 mV.

On-off switch with provision to use external power, two 10K potentiometers, four pairs of binding posts for input and output connections, four IC sockets (two for each op-amp circuit) with provision for the 8-lead metal can, 14-pin dip or 8-pin mini-dip. Three wire 6-ft. line cord and 0.5 amp fuse.

Physical dimensions: 6.25" × 3.75" × 2".

Model 201, $33.00, (includes ±9 V batteries), *model 202,* $55.00 (includes ±15 VDC @ 100 mA regulated power supply).—**Polytron Devices, Inc.,** PO Box 398, River Street Station, Paterson, NJ 07524.

Circle 35 on reader service card

SCREWDRIVERS for driving slotted, hex or multiple-spline socket screws, or any of six

other types including metric, and available in a wide size range of professional fixed-handle and interchangeable blade models. The line also includes a variety of pouch and roll kits, compact bench stand sets of miniatures with Xcelite's "piggyback" torque amplifier handle, *series 99* individual and kit reversible blades and handles, four metric hex socket sets, and the availability of plastic-dip-insulated blades on fixed-handle drivers.—**Weller-Xcelite Electronics Div.,** The Copper Group, Apex, NC 27502.

Circle 36 on reader service card

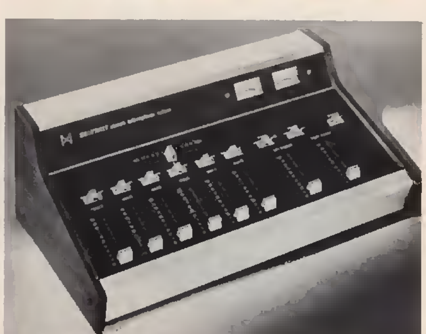
FRONT-LOAD STEREO CASSETTE DECK, the *KX-620,* cuts wow and flutter to less than 0.09%, increases signal-to-noise to better than 61 dB, and offers greater recording headroom to improve the quality of home-recorded cassettes. The unit's precision drive system holds vibration and speed irregularities to negligible levels to achieve 0.09% wow and flutter performance. The design uses an extra-large, critical-tolerance capstan and an electronically controlled DC servo motor. The capstan shaft is polished to a roundness tolerance of less than 0.2 micron. The DC servo motor utilizes a unique feedback circuit to control speed fluctuations. With the motor achieving uniform and

unwavering rotation and the capstan in perfect round, the tape movement of the *KX-620* is smooth, unvarying and precise; and wow and flutter are thus held to a minimum. An automatic stop mechanism complements the precision drive system, disengaging the capstan drive and turning off the drive motor within three seconds after tape motion has stopped.

The *KX-620* incorporates the Dolby noise-reduction system, as well as a low-noise preamp section, to bring the signal-to-noise ratio up to 61 dB with cromium dioxide tapes. For a significant improvement in the quality of recordings, the *KX-620* utilizes a 0-VU recording level of 160 pwb/mm—fully four dB lower than in conventional systems. This lower level provides a full 10 dB of headroom above the 0-VU reading of the meter before tape saturation begins, this eliminating one of the major causes of poor quality recordings. $219.95—**Kenwood,** Dept. P., 15777 South Broadway, Gardena, CA 90248.

Circle 37 on reader service card

STEREO MIKE MIXER, *Heathkit TM-1626,* is a low-cost, high fidelity mixing console for serious tape recording and PA use. It provides a number of professional features including stereo outputs, four high/low impedance mike inputs (one with pan control),



two auxiliary inputs, lighted level meters plus adjustable LED peak indicators and much

Circle 30 on reader service card

more.

Slide controls let you visually balance the relative level of the inputs and outputs. Switches above each input control let you assign that channel to the left or right output or switch the input off. The pan control adjusts the apparent location of the fourth mike from left to right or anywhere in between. Since the pan is a slide control, it's easy to visualize what the final mix-down will sound like. If six inputs aren't enough for you, mixer bus jacks let you parallel any number of TM-1626's.

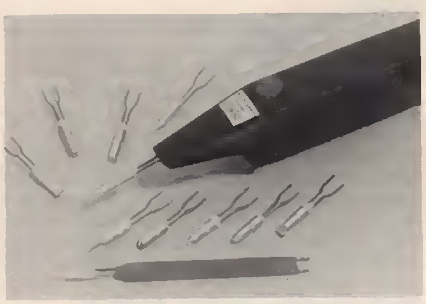
The *TM-1626*'s exceptional output monitoring system is particularly useful for tape recording. A pair of lighted VU meters continuously monitor the output in two switch-selected ranges: +4 or +10 dB. Ordinary meters can't respond to instantaneous peaks quickly enough to prevent tape saturation and increased distortion. To solve that problem, the device uses a pair of LED's which respond to peaks faster than any meter. A pair of controls on the rear panel set the level at which the LED's light, so you can optimize performance with any tape recorder or sound system.

Frequency response extends from 40—20,000 Hz, ±1 dB with less than 0.5% total harmonic distortion up to 6.5 volts output. Hum and noise are extremely low and the inputs are resistant to overload (aux: 3.0 V; mike: 900 mV (hi-Z), 60 mV (lo-Z).

TM-1626 is a kit even a beginner can build. Most of the parts mount on a single printed-circuit board and there's almost no point-to-point wiring. A fully-illustrated manual guides you step by step—even teaches you how to solder.—**Heath Company,** Benton Harbor, MI 49022.

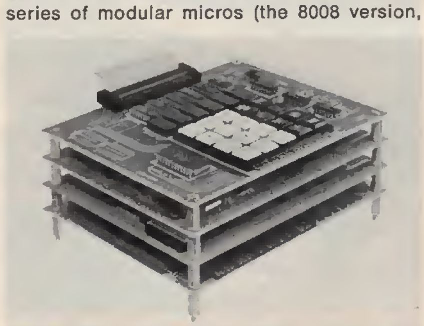
Circle 100 on reader service card

SIX NEW SOLDERING TIPS for the *Iso-Tip* cordless soldering iron. The new tips are: *No. 7569* V-tip to send heat under a circuit-board wire; *No. 7572* blunt tip and *No. 7577* chisel tip for general heating applications; *No. 7573* tinning tip, grooved to coat wire surfaces; *No. 7574* concave centering tip for work on the reverse side of the board; and *No. 7596* knife tip for stripping insulation without marring wire. The knife tip is also handy for cutting nylon rope since it seals as it cuts, preventing unravelling.—**Wahl Clipper Corp.,** Sterling, IL 61081.



Circle 38 on reader service card

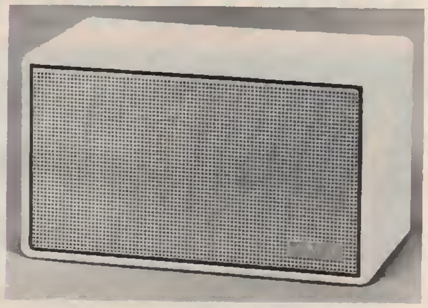
MODULAR MICROCOMPUTERS. A new series of modular micros (the 8008 version, *Mike 2*, and the 8080-based *Mike 3*) features



a bus structure compatible with various standard eight-bit microprocessors. Computers include a calculator-type keyboard, six large LED digits, and a monitor program stored in PROM, for easy program loading and debugging. Assembled on 5.5 by 7.0-inch PC boards, a number of accessory modules are offered. In kit form, computers start at $275.00; assembled and tested versions, and boards suitable for OEM use, are also listed. As an introduction, the *Mike 2 Manual* sells for $25.00.—**Martin Research,** 3336 Commercial Avenue, Northbrook, IL 60062.

Circle 39 on reader service card

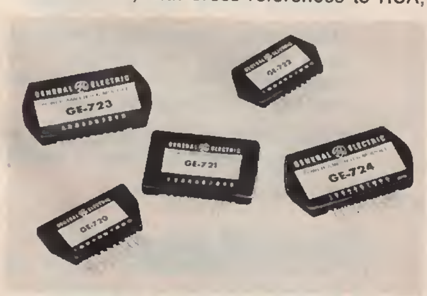
MINIATURIZED ACOUSTIC SUSPENSION SPEAKER SYSTEM, the *model 400* is housed in a reinforced polystyrene cabinet measuring just 6⅝ inches by 11 inches by 6 inches deep. It is intended for use as a second speaker for the Advent *model 400* FM receiving system. In addition, its combination of compact size, high performance, low price, and moderate power requirement makes it ideal for complete music systems of moderate cost; for extending the sound of an existing component system to other rooms where space is at a premium and extremely high acoustic output is not required; and for use with better-quality automobile tape and radio systems.



The single acoustic-suspension driver used in the *model 400* loudspeaker has a cone area, excursion capability, and magnetic structure sufficient to provide solid bass at surprisingly high levels. At the same time, the driver's cone is small enough to provide extended and well-dispersed treble response. In addition, what sets it apart from previous very small single driver systems is the use of an LCR network carefully designed to tailor the octave-to-octave tonal balance, and to provide the system with its audible family relationship to the larger and more elaborate Advent Speaker systems.

Impedance is 8 ohms, and the loudspeaker requires only 4 to 6 watts of power for ample levels in most small- to medium-size rooms. The suggested retail price is $32.00.—**Advent Corporation,** 195 Albany Street, Cambridge, MA 02139.

REPLACEMENT POWER AMPLIFIERS. Five solid-state power amplifier modules primarily for replacement use in domestic and imported stereo components cover a range of power outputs from 8 to 25-watts. They are included in GE's *1975 Replacement Semiconductor Guide*, with cross references to RCA,



Sylvania and original equipment part numbers. This initial offering of solid-state de-

Circle 62 on reader service card

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Circle 64 on reader service card

vices is to be expanded in the near future to make it easier for electronic technicians to service audio equipment.—**General Electric,** 2100 Gardiner Lane, Louisville, KY 40205.

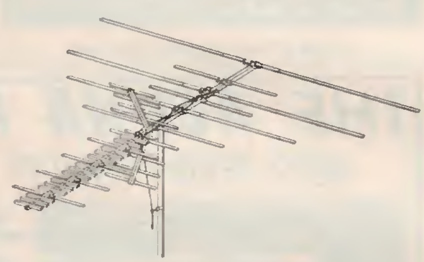
Circle 40 on reader service card

INDUSTRIAL STRENGTH ADHESIVE, *Instant-Weld* is now available in five formulas in a six-pack kit of 1-ounce dispensers. The five formulas are classified by the colors of the labels—red, blue, yellow, green and white.

Red label sets the fastest of all the formulas. It bonds a number of materials in about 3 seconds and is designed for use on plastics, rubber, ceramic or glass. The assortment sells for $49.95, postpaid.—**Oneida Electronic Mfg., Inc.,** Meadville, PA 16335.

Circle 41 on reader service card

TV-FM ANTENNA. The *model 1776* is a 37-element VHF-UHF-FM antenna on a rugged 1 inch square bottom 111⅛ inches long. The multiple drive VHF section with reflector elements for both low-band and hi-band assures



high gain and excellent features of a broadband Yagi-type array and a corner-reflector type array for flat response and high gain across the entire range of UHF channels. A behind-the-set signal splitter is in each carton.—**The Finney Company,** 34 West Interstate, Bedford, OH 44146.

Circle 42 on reader service card

14 HOURS ON A STANDARD CASSETTE. The model *LP5A* long-play professional machine will enable the user to extend by almost five times the normal recording time of any high quality standard cassette used.

An incredibly slow tape speed of ⅜ inches per second and the newly developed micro "Magnapulse" energized recording head combine to enable this cassette recorder to record 14 hours on a standard C-180 high energy cassette.

Applications for the *LP5* include: Voice recording, court reporting, data recording, telephone recording, medical or physiological information storage, automatic sales order storage, security and interrogation storage, or any long-term recording with unattended service. Features include 115-volt or battery operation. Cue control—Audible scanning in fast-forward or reverse mode. Tape-footage counter, automatic stop at end of tape.

An automatic voice actuator is offered as an option. A 75-millisecond start-up time thru voice actuation ends "syllable loss" normally associated with voice actuation. Basic *LP5* $249.00 sample quantities; $144.00 2-5 units; $125.00 each for 6 units.—**The Answerline Associates, Inc.,** 124 W. Lincoln Ave., Mt. Vernon, NY 10550.

Circle 43 on reader service card

new lit

All booklets, catalogs, charts, data sheets and other literature listed here with a Reader Service number are free. Use the Reader Service Card inside the back cover.

LOW-COST ELECTRONIC COMPONENTS are listed in a new 12-page catalog for the experimenter, constructor and service technician. Among those items listed are tools and supplies, chassis boxes, probes, adaptors, drafting supplies, antennas, RF chokes, knobs and hardware.—**WOAS Electronics,** PO Box 2637, El Cajon, CA 92021.

Circle 44 on reader service card

DESOLDERING FOR ANY BUDGET is the title of a 4-page bulletin describing four Ped-A-Vac desoldering systems. The systems feature a foot-controlled vacuum generator that uses available shop air, adjustable vacuum and tip temperatures, and permits placing of both soldering and desoldering tools at your fingertips. Does not generate electrical spikes so it can be used with all sensitive circuit devices.—**PACE Inc.,** 9329 Fraser St., Silver Spring, MD 20910.

Circle 45 on reader service card

SCHOOL BULLETIN describes the degree programs offered by Grantham School of Engineering, a college-level home-study institution specializing in teaching electronics, computer science and supporting subjects. The curriculum in the Electronics Engineering program permits the student to reach any one of three levels of advancement. These are ASET (Associate in Science in Engineering Technology), BSET (Bachelor of Science in Engineering Technology) and BSEE (Bachelor of Science in Electronics Engineering).—**Grantham School of Engineering,** 1505 N. Western Avenue, Hollywood, CA 90027.

Circle 46 on reader service card

RADIO SHACK CATALOG. Everything in electronics for home entertainment, hobbyists and experimenters is illustrated in the new 164-page 1976 catalog. It has 100 full-color pages and describes the company's complete line of products. Among the many new products being introduced for the first time in this catalog are a special limited-edition Bicentennial radio, a 23-channel Citizens band two-way radio with a telephone-type handset, an all-new line of *Radio Shack* pocket calculators priced from $16.95, a digital multimeter, a precision belt-drive manual turntable, an all-new line of *Realistic* stereo cassette recorders and other items.

In addition, the new catalog lists hundreds of specialized electronics items, parts and accessories, tools, tubes and transistors, wire and cable, home security products, intercoms, microphones, timers, batteries and a complete library of *Radio Shack*'s own books on electronics and related subjects.

Also included in the catalog is a coupon good for the purchase of a $1.00 value Radio Shack metric slide-rule for only 25¢.

The 1976 Electronics Catalog *No. 263* is available free, on request from any Radio Shack store or Authorized Sales Center, or from **Radio Shack,** Dept. R-19, 2617 W. Seventh Street, Fort Worth, TX 76107.

Circle 47 on reader service card

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Simulated TV test pattern.

II. HOME ENTERTAINMENT ELECTRONICS

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You'll probe into the digital technology behind all electronic tuning and channel numbers that appear on the screen. An on-screen digital clock that shows the time to the second. You'll also gain a better understanding of the exceptional color clarity of the Black Matrix picture tube, as well as a working knowledge of "state-of-the-art" integrated circuitry and the 100% solid-state chassis.

As you build this remarkable, new generation color TV, you'll not only learn how advanced integrated circuitry works, but how to detect and troubleshoot problems in any area.

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Next, in step-by-step fashion, you'll assemble Bell & Howell's exclusive Electro-Lab® electronics training system. It includes a special design console that enables you to assemble test circuits. A digital multimeter for accurately measuring voltage, current and resistance. And a solid-state "triggered sweep" oscilloscope which will allow you to analyze the functioning of tiny integrated circuits. Putting these instruments together will give you experience in wiring, soldering and assembling. Then, further on, you'll use the lab equipment for experience in electronic testing, troubleshooting and circuit analyzing.

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various times throughout the year. There you can talk shop with fellow students and receive additional help from instructors. These personalized programs cannot guarantee you a job in electronics, but do equip you with important occupational skills. The knowledge you pick up will help you look for a job—or advance in the one you already have.

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MUSIC SYNTHESIZER

(continued from page 50)

Leave the VCO RANGE control at some intermediate position so that a steady tone is coming from the amplifier and rotate the SKEW control in a counter clockwise (CCW) direction from the triangle position toward the ramp position. The frequency will increase slightly as the SKEW control is rotated but it should not vary more than a couple of semi-tones. Notice that with the SKEW control set toward the ramp position, the tone is considerably "sharper" than the triangle wave tone.

Set the TRIANGLE LEVEL control to minimum and the SQUARE WAVE LEVEL control to maximum and verify that the resultant tone is the sharpest of all. Successful completion of this sequence verifies the proper operation of the voltage-controlled oscillator.

Testing the VCF

Return the VCO SQUARE WAVE LEVEL control to minimum and the RANGE control to minimum. Slide the VCF switch to the IN position and advance the NOISE LEVEL control to maximum. Set the filter SUSTAIN switch to on. Set the VCF BIAS trimmer R83 fully counter-clockwise as viewed from the *rear* edge of the circuit board (opposite the direction of the arrow) and rotate the VCF TRIM trimmer R88 fully toward you as you look at the circuit board from the rear (opposite direction of arrow). Make sure that the VCF RANGE control is set to minimum and press and hold the TRIGGER button. While listening to the noise, rotate the VCF TRIM trimmer R88 in the direction of the arrow. You should hear the apparent pitch of the noise increase as the passband of the filter sweeps upwards in frequency. Set the VCF TRIM trimmer to the point at which the pitch of the noise just begins to increase.

Rotate the VCF RANGE control to maximum and observe that the pitch of the noise once again increases. Now rotate the VCF BIAS trimmer R83 in a clockwise direction as viewed from the back of the board (in the direction of the arrow) and observe that at some point the pitch of the noise begins to decrease. Leave the VCF BIAS trimmer set at the point at which the pitch of the noise just begins to decrease.

Return the VCF RANGE control to minimum and once again advance the VCF TRIM trimmer in the direction of the arrow until the point is reached at which the pitch of the noise just begins to increase.

Testing the VCF function generator

Set the VCF RANGE control to about half of its rotation and the NOISE LEVEL control to maximum. Slide the VCF REPEAT switch to the ON position and press and hold the TRIGGER button. This setting of the VCF function generator controls (SUSTAIN on, REPEAT on) causes the function generator to trigger itself producing a cyclic sweep of the filter. In this case, the sound produced should be a "swishing" as the filter sweeps up and down over the frequency content of the noise. Observe that the "depth" of this effect increases as the VCF RANGE control is rotated from minimum to maximum.

Note: At this maximum repetition rate (VCF ATTACK and DECAY both minimum) there will probably be some "thumping" from the GNOME. This transfer of the control voltage into the audio channel can be eliminated by reducing the setting of the VCF RANGE control or by slowing the Attack and/or Decay of the VCF function generator.

Observe that as the FREQ/Q control is rotated in a clockwise direction, the overall pitch of the noise increases.

Return the VCF FREQ/Q control to its fully counter clockwise position and the RANGE control to maximum. While holding down the TRIGGER button, advance the VCF ATTACK control to maximum and observe that the pitch of the noise slowly builds up to a peak and then quickly resets and that this effect occurs cyclicly. Return the VCF ATTACK control to minimum and advance the DECAY control to maximum. Observe that now the pitch of the noise goes to a high value and then slowly slides back down scale until again it resets to the high level. Set the VCF ATTACK control to maximum and observe that the filter slowly sweeps up and down scale. **Note:** The VCF RANGE control is designed to have greater effect than is actually needed. If, during this last test, the pitch of the noise seems to increase to a plateau and then hold momentarily before sliding back down scale, it indicates that the RANGE control is too far advanced. Back off on this control slightly and note that the "plateau" is no longer present. Successful completion of this test sequence indicates that both the filter and function generator are operating properly. We will now test the triggering functions associated with the VCF.

Set the VCF controls as follows: RANGE to maximum FREQ/Q fully counter clockwise, VCF switch to the IN position. REPEAT switch off, SUSTAIN switch off, ATTACK control to minimum, DECAY control to maximum. Press and hold the TRIGGER button. You should hear the noise apparently starting at a high pitch and decaying back to a low pitch, it should not repeat but rather should simply stay at the low pitch until the TRIGGER button is released and pressed again. Set the ATTACK control to maximum and the DECAY control to minimum. Pressing the TRIGGER button should produce a noise that increases in pitch over a period of a second or so followed by a rapid step back to a low pitch. Once again, this pattern should not repeat until the TRIGGER button is released and pressed again. Set the DECAY control to maximum and observe that the pitch of the noise slowly sweeps up and back down each time the TRIGGER button is pressed. Set the VCA DECAY control to maximum, VCF DECAY control to minimum and slide the VCF SUSTAIN switch to its ON position. Press and hold the TRIGGER button. Observe that the pitch of the noise always sweeps up to a high level and remains there until the TRIGGER is released.

Successful completion of these test sequences indicate that the GNOME is working properly.

Next month the article concludes with a short tutorial on synthesizers and the operation of the GNOME synthesizer.

(continued next month)

next month

JANUARY 1976

■ CB Roundup

The new equipment for today's CB enthusiast. There are synthesizers, SSB, and a whole flock of other new and necessary features to learn about.

■ Antennas For CB

R-E's Technical Editor describes the pros and cons of the many different types of CB antennas. It tells where and how to use what.

■ Build A Portable Computer Terminal

Handy pocket device that lets you talk to a remote computer. It's easy to build, fun to use, and darned practical too.

■ Turntable Drive Systems

See the circuits that make these discs go round. They're a lot more complicated than you think they are.

■ R-E's Lab Test Hi-Fi Reports

This month we're going to look at a $1000 stereo integrated amplifier. The LUX L-100.

■ State-Of-Solid-State

Get the low down on new solid-state devices—how they work and how you can use them.

SERVICE NOTES

NO RED

Here's a real weirdo! I have no red in the picture on this Curtis-Mathes CMC-33. Color bar pattern shows 6 blue bars and 3 green. Tint control and color control works. There is a normal waveform on the blue grid. The waveform on the red grid looks something like a distorted green waveform, at very low amplitude. All DC voltages around the demodulator and R—Y amplifier tube are very close to normal. In other words, everything's all right, it just won't work. HELP! —B.R., Umpire, AR.

Check that little choke, L705 in the factory schematic; this is between the red demodulator output and the R—Y amplifier grid. If this is open, these are the symptoms you'll get. Warning! Do NOT use a sharp-pointed test-prod to check the little pins coming out of the top of that choke. If you do, you can break the wire. I know. I won't say how, but believe me.

RASTER PULLS IN, DARK SCENES

On a dark scene, the sides of the raster pull in and weave on this Zenith 25CC50. Same thing when you turn the contrast control down. Can't find anything out of order.—P.P., Brooklyn, NY.

There are two little neon lamps in the high-voltage regulator circuit; these have been known to cause this trouble. Check them. If they're bad, replace with exact duplicates.

(Feedback: reader says "I checked the neon lamps and they were all right. However, the VDR *connected to them* was burned in two! That fixed it. Thanks." Oh, well; I was close!)

R-E

(continued from page 71)

Regulator sync generator

The regulator/sync generator IC (ICI) contains a fairly conventional 5-volt short-circuit protected active regulator, vertical and horizontal sync generators. Fig. 4 shows only the sync generator, right-wall generator and ball-rebound circuitry.

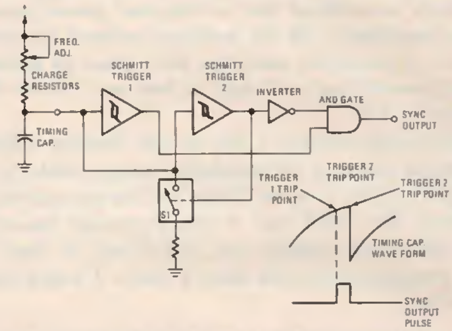

FIG. 4—SYNC GENERATOR is the vertical/horizontal sync generator shown, plus right-wall and ball-rebound circuits that are not shown here.

The sync generators are nearly identical and only the horizontal generator will be described. The oscillator consists of two Schmitt triggers, whose inputs are both connected to a common timing capacitor. As this capacitor charges towards V_{CC}, the voltage across it passes the trip point of Schmitt trigger 1. The output of trigger 1 goes high and is ANDed together with the inverted low from trigger 2 to give a positive output at the sync output.

As the timing capacitor continues to charge, trigger 2 trip point is reached and its output goes high, activating switch 1 which discharges the timing capacitor. Trigger 2's high output is inverted and puts a low at ANDgate 1, thus turning off the sync output. As soon as the timing capacitor discharges to a voltage level low enough to turn trigger 2 off, the switch opens and the capacitor begins charging all over again.

Operation of the top and bottom rebound circuitry is as follows: Two voltage caparators with the same reference voltage are used to detect whether a high- or a low-voltage condition exists on the ball vertical control line. Ball vertical position on the screen is determined by the voltage on this control line. This voltage is controlled by the setting of the player's ENGLISH control. If the ball reaches a pre-determined point on the screen near the top or bottom the appropriate comparator transfers a voltage high to the damping capacitor on its output. The high remains on the capacitor long enough to turn one of the switching transistors full on. When it does turn on, a voltage high (or low) is applied to the ball's vertical control line which counteracts the voltage already there and causes the ball to reverse its vertical direction or bounce away from the rebound wall (both switching are normally off when the ball is at or near the center of the playing field).

As the ball continues in its direction away from the rebound wall, the comparator that supplied the voltage high to the damping capacitor now switches off. However, the capacitor discharges slowly through a 100,000-ohm resistor until the appropriate switching transistor turns off. When the switching transistor turns off, the ball control voltage is no longer being opposed and the control voltage line then assumes whatever voltage is being applied to it by the player ENGLISH control. If the player having ENGLISH control is forcing the ball into an extreme upward (or downward) direction, the ball will return to the rebound wall and the comparator recharges the damping capacitor and the switching transistor again forces counter-acting voltage onto the ball vertical control line.

If the player leaves his ENGLISH control in this extreme position long enough, the ball bounce will eventually decay down until the ball remains at the rebound line. This happens because the damping capacitor requires less and less current to restore its charge each time and the switching transistor remains on all the time.

Scorekeeping

When the ball leaves the screen, the reset-lockout voltage begins to rise. This is detected by the level detector (see Fig. 5 on page 31). This sends a pulse to a counter steered by the score steering logic. This increments the 4-bit binary counter of the player who scores a point. Each counter stores the score of the appropriate player. The output of the counters is converted to analog voltages by digital-to-analog converters.

The horizontal portion of the score index mark is generated by horizontal pulse generator No. 1. The position is controlled by the analog voltage from one of the two digital-to-analog converters selected by switch S1. S1 is controlled by vertical pulse 1.

The vertical portion of the score is generated by a spot generator section with three comparators. The outputs of these comparators are gated together to generate two consecutive vertical pulses. The first pulse controls which counter is selected.

The end-mark horizontal position is generated by a separate generator. Its position is set to coincide with the position of the index mark when the counter is at binary state 1111 (15). And there you have a detailed description of how the Odyssey game works.

Other games

Odyssey is not the only TV game available today. Broadmoor Industries also makes a TV game. Theirs consists of a console and a TV set. The game unit itself cannot be used with any TV set, but must be used with the one Broadmoor supplies. The reason is theirs connects the game signa, into the video circuitry of the TV receiver. Their game offers two different versions, hockey and tennis, for either two or four players. It is complete with sound and digital scoring. After each player scores a point, the score appears on the screen. Details of this circuit's operation were not available at the time this article was prepared and therefore, we can give you only this brief description and a couple of photographs of the unit.

Another game called Pong, is made available through Sears-Roebuck stores. It's made by a company called Atari, the same people who make the game Pong that you find in hotel lobbies. Pong is an electronic adaption of table tennis in which two players manipulate dials on a control console to move computerized panels and hit a ball of light back and forth across a video display screen. The home version of Pong can be played on any size color or black-and-white TV set. The unit connects to the antenna terminals of any TV set and like Odyssey, can be used on either channel 3 or channel 4. It too is battery powered or can be powered by a 9 volt DC power supply. The game sells for approximately $100.00.

Atari also makes fifteen different coin operated computer video games designed around sports such as table tennis, soccer, volley ball, hunting and auto racing. Newer models challenging players to maneuver tanks or airplanes have been developed using some of the most sophisticated computer technology available for electronic games. We can be sure that this is just the beginning of a whole new industry and many of these games will be available in the months and years to come for home entertainment use.

R-E

WE RAN OUT OF ROOM

In this issue we had planned on describing a new remote control system made by RCA. Its a very special system in that there are no controls, that's right NO CONTROLS on the TV itself. Also, there is a special digital clock built in, and the channel number you have selected appears on the screen. Since we ran out of room in this issue and could not include this story, we have been forced to delay its publication until January 1976. Our apologies for not delivering what we promised, and please do look for this story next month.


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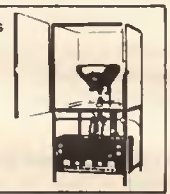

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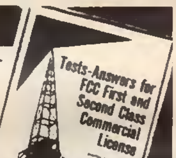

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74LS05	.47	74LS132	1.58
74LS08	.42	74LS136	.68
74LS09	.42	74LS138	1.94
74LS10	.42	74LS139	1.94
74LS11	.42	74LS145	1.58
74LS12	.42	74LS151	1.58
74LS13	.84	74LS153	1.94
74LS14	2.22	74LS155	1.94
74LS15	.42	74LS156	1.94
74LS20	.42	74LS157	1.58
74LS21	.42	74LS158	1.58
74LS22	.42	74LS164	2.27
74LS26	.54	74LS170	5.36
74LS27	.47	74LS174	2.27
74LS28	.54	74LS175	2.27
74LS30	.42	74LS181	6.30
74LS32	.47	74LS190	2.87
74LS33	.54	74LS191	2.87
74LS37	.54	74LS192	2.87
74LS38	.54	74LS193	2.87
74LS40	.54	74LS194A	2.27
74LS42	1.25	74LS195A	2.27
74LS48	1.25	74LS196	2.27
74LS49	1.25	74LS197	2.27
74LS51	.42	74LS221	1.41
74LS54	.42	74LS247	1.25
74LS55	.42	74LS248	1.25
74LS73	.68	74LS249	1.25
74LS74	.68	74LS251	1.94
74LS75	.84	74LS253	2.27
74LS76	.68	74LS257	1.94
74LS78	.68	74LS258	1.94
74LS85	2.27	74LS261	5.36
74LS585	2.88	74LS266	.68
74LS86	.68	74LS279	.84
74LS90	1.25	74LS283	2.27
74LS91	1.25	74LS290	1.25
74LS92	1.25	74LS293	1.25
74LS93	1.25	74LS295A	2.27
74LS95A	2.27	74LS365	.68
74LS96	1.94	74LS366	.68
74LS107	.68	74LS367	.68
74LS109	.68	74LS368	.68
74LS112	.68	74LS375	.84
74LS113	.68	74LS386	.68
		74LS670	6.30

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LM741 mini	Op Amp	(mini dip)	.28
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2N3564	.15
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2N3568	.15
2N3569	.15
2N3640	.15
2N3641	.15
2N3643	.15
2N3702	.17
2N3703	.17
2N3704	.17
2N3705	.17
2N3706	.17
2N3707	.17
2N3708	.17
2N3709	.17
2N3710	.17
2N3711	.17
2N3819	.29
2N3820	.35
2N3903	.15
2N3904	.15
2N3905	.15
2N3906	.15
2N4058	.17
2N4059	.17
2N4060	.17
2N4061	.17
2N4062	.17
2N4123	.15
2N4124	.15
2N4125	.15
2N4126	.15
2N4250	.15
2N4275	.15
2N4401	.15
2N4403	.15
2N5400	.22
2N5447	.16
2N5449	.16
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TIS43	.39

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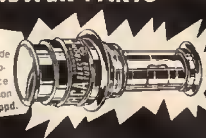

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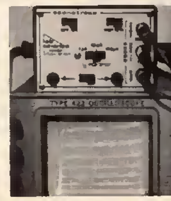

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7405	.19	7470	.30	74161	1.25
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7407	.35	7473	.35	74163	1.39
7408	.18	7474	.35	74164	1.59
7409	.19	7475	.57	74165	1.59
7410	.16	7476	.39	74166	1.49
7411	.25	7483	.79	74170	2.30
7413	.55	7485	1.10	74173	1.49
7416	.35	7486	.40	74174	1.62
7417	.35	7489	2.48	74175	1.39
7420	.16	7490	.59	74176	.89
7422	.26	7491	.97	74177	.84
7423	.29	7492	.71	74180	.90
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7427	.29	7495	.79	74184	2.29
7430	.20	7496	.79	74185	2.29
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7438	.35	74107	.40	74191	1.35
7440	.17	74121	.42	74192	1.25
7441	.98	74122	.45	74193	1.19
7442	.77	74123	.85	74194	1.25
7443	.87	74125	.54	74195	.89
7444	.87	74126	.63	74196	1.25
7445	.89	74141	1.04	74197	.89
7446	.93	74145	1.04	74198	1.79
7447	.89	74150	.97	74199	1.79
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74H10	.25	74H50	.25	74H72	.39
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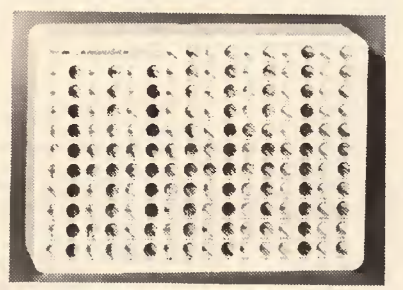

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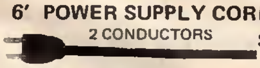

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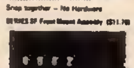

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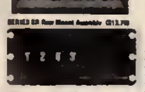

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MM5316N	6 Digit Alarm	3.95
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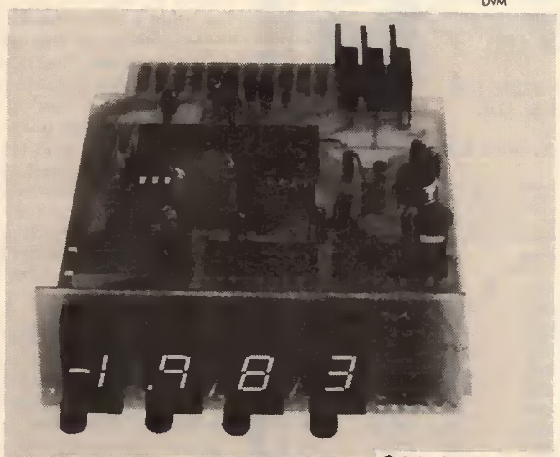
MM5736N	6 Digit-4 Funt.	1.95
MM5738N	8 Digit-5 Funt.	2.95

26 Awg RIBBON CABLE

1 Ft. Minimum	1-9 ft.	10 ft.
4 Cond.	.29 ft.	.25 ft.
8 Cond.	.59 ft.	.49 ft.
16 Cond.	.89 ft.	.79 ft.
32 Cond.	1.89 ft.	1.69 ft.

DIGITAL VOLTMETER

JE801
DVM



$39.99 Per Kit
SINGLE UNIT

GENERAL DESCRIPTION

The JE801 is a three and one half digit, auto polarity digital voltmeter, in a kit form. It features several options not available in any commercial digital voltmeter. Its low cost is perhaps the most important feature, which is achieved by offering it in a kit form. A kit allows the unit to be used by small OEM's where cost effectiveness is an important factor, and by the hobbyist who has to be concerned with cost. The unit also features on card regulators, allowing it to be operated off a single plus and minus fifteen volt, unregulated power supply. The unit has a small size of three inches width, three and three quarters of an inch length, and one and a quarter inch height.

DISPLAY LEDS

FND70	Com. Cath.	.250	.59
MAN 1	Com. Ano.	.270	$1.95
MAN 2	5x7 Matrix	.300	3.95
MAN 3	Com. Cath.	.125	.39
MAN 4	Com. Cath.	.187	1.95
MAN 7	Com. Ano.	.30	1.50
DL33	Com. Cath.	.125	1.95
DL747	Com. Ano.	.625	1.95

DISCRETE LEDS

MV 10	Red	5/$1.00
MV 50	Red	6/$1.00
MV 5024	Red	5/$1.00
MV 5024	Green	4/$1.00
MV 5024	Yellow	4/$1.00
MV 5024	Orange	4/$1.00
MV 50*	Red 1¼" Leads	5/$1.00

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	.36	.37	.36				

SOLDERTAIL STANDARD (GOLD)

8 pin	$.30	.27	.24	24 pin	$.70	.63	.57
14 pin	.35	.32	.29	28 pin	1.10	1.00	.90
16 pin	.38	.35	.32	36 pin	1.55	1.40	1.26
18 pin	.52	.47	.43	40 pin	1.75	1.59	1.45

WIRE WRAP SOCKETS (GOLD) LEVEL #3

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

50 PCS. RESISTOR ASSORTMENTS $1.75 per assort.
Each assortment contains 50 pcs. of ¼ watt, 5% resistors

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

14 PCS. POTENTIOMETER ASSORTMENTS $9.95
Each assortment contains 14 pcs of 10 turn pots.

ASST. A 2 ea: 10 OHM-20 OHM-50 OHM-100 OHM-160 OHM 200 OHM-250 OHM-500 OHM
ASST. B 2 ea: 1K, 2K, 2.5K, 10K, 20K, 25K, 50K
ASST. C 2 ea: 50K, 100K, 200K, 250K, 500K, 1M, 2M

All pots are available in single unit quantities. $.99 ea.

DPST C & K ROCKER SWITCH

They are rated at 125 Vac @ 5A.
They are excellent in application such as Microcomputer Panel Switches
$0.69
Dim: 1"x1"x¼"

PRIME INTEGRATED CIRCUIT ASSORTMENTS

ASST. 8	3 ea.	SN7400 SN7410	7401 7430	7402 7438	7403 7440	7404 7472	SSI/TTL	$5.95 ASST.
ASST. 9	2 ea.	SN7447 SN74145	7490 74175	7491 74180	74100 74191	74121 74193	MSI/TTL	$9.95 ASST.
ASST. 10	2 ea.	CD4001 CD4016	4002 4017	4011 4019	4012 4023	4013 4030	CMOS	$7.95 ASST
ASST. 11	2 ea.	LM301T LM311T	301N 565T	302T 567T	307T 741T	309K 741N	LINEAR	$10.95 ASST.

Satisfaction Guaranteed. $5.00 Min. Order. U.S. Funds.
California Residents — Add 6% Sales Tax
Write for FREE 1976 Catalog — Data Sheets .25¢ each

JAMES

P.O. BOX 822, BELMONT, CA. 94002
PHONE ORDERS — (415) 592-8097

MICROPROCESSOR COMPONENTS

8008 – $19.95 **2102 – $2.95**

	CPU'S			RAM'S		
8008	8 bit CPU	$19.95	1101	256x1	Static	$ 2.25
8080	8 bit Super 8008	149.95	1103	1Kx1	Dynamic	2.95
4040	4 bit 8080	39.95	2102	1Kx1	Static	2.95
	UARTS		2107	4Kx1	Dynamic	19.95
AY – 5 - 1013		6.95	7010	1Kx1	Mnmos	29.95
	PROM'S		7489	16x4	Static	2.49
8223	32x8 Prom	3.00	8101	1Kx1	Static	7.95
1702A	2K E Prom	15.95	8111	1Kx1	Static	7.95
5203Q	2K E Prom	14.95	8599	16x4	Tristate	3.49
74S287	1Kx1 Prom	7.95	91L02	1Kx1	Low Power	3.95
	SR'S		74200	256x1	Static	6.95
2401	2K DSR	9.95	74LS670	4x4	Register	3.95
2533	1K SSR	7.95	93410	256x1	Static	2.95

91L02 1K Static RAM Direct Replacement for 2102-1 with 40% Less Current Drawn. **2.49**

Vector General Purpose Logic CARD Board 14.95
*Very High Noise Immunity * Holds 12 ea. 14 pin DIPS
*44 pin Edge Connection

THE KILOBYTE RAM CARD Per Kit **$49.95**
*Complete 1Kx8 Memory * High Noise Immunity Components
*Single 5v supply *500NS Access Time & Kit includes sockets, ICS & Board

4 PDT SWITCHES, HIGH QUALITY P.B. TYPES .69

KITS EXAR ICS

XR-2206KA SPECIAL $17.95
Includes monolithic function generator IC, PC board, and assembly instruction manual.

XR-2206KB SPECIAL $27.95
Same as XR-2206KA above and includes external components for PC board.

TIMERS

XR-555CP	SPECIAL	$ .69
XR-320P		1.55
XR-556CP		1.85
XR-2556CP		3.20
XR-2240CP	SPECIAL	3.25

PHASE LOCKED LOOPS

XR-210		5.20
XR-215		6.60
XR-567CP		1.95
XR-2567CP	SPECIAL	2.99

STEREO DECODERS

XR-1310P		$3.20
XR-1310EP		3.20
XR-1800P		3.20

WAVEFORM GENERATORS

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

MISCELLANEOUS

XR-2211CP	6.70
XR-2261	3.79

Special Requested Items

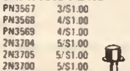
RC4194	Dual Track V Reg	$5.95	N8T97	$3.00	2533	$7.95
RC4195	±15V Track Reg	3.25	4024P	2.25	8263	5.95
F9368	Decoder	3.95	2513	11.00	8267	2.75
LD110/111	DVM Chip Set	28.00	2518	7.00	8288	1.15
CA3130	Super CMOS Op Amp	1.49	2524	3.50	8826	3.00
MC1408L7	A/D	9.95	2525	6.00	8880	1.35
F3341	FIFO	8.95	2527	5.00	7497	5.00

ZENERS—DIODES—RECTIFIERS

TYPE	VOLTS	W	PRICE	TYPE	VOLTS	W	PRICE
IN746	3.3	400m	4/1.00	IN4003	200 PIV	1 AMP	.10
IN751A	5.1	400m	4/1.00	IN4004	400 PIV	1 AMP	.10
IN752	5.6	400m	4/1.00	IN3600	50	200m	6/1.00
IN753	6.2	400m	4/1.00	IN4148	75	10m	15/1.00
IN754	6.8	400m	4/1.00	IN4154	35	10m	12/1.00
IN965B	15	400m	4/1.00	IN4734	5.6	1w	.28
IN5232	5.6	500m	.28	IN4735	6.2	1w	.28
IN5234	6.2	500m	.28	IN4736	6.8	1w	.28
IN5235	6.8	500m	.28	IN4738	8.2	1w	.28
IN5236	7.5	500m	.28	IN4742	12	1w	.28
IN456	25	40m	6/1.00	IN4744	15	1w	.28
IN458	150	7m	6/1.00	IN1183	50 PIV	35 AMP	1.60
IN485A	180	10m	5/1.00	IN1184	100 PIV	35 AMP	1.70
IN4001	50 PIV	1 AMP	.09	IN1186	200 PIV	35 AMP	1.80
IN4002	100 PIV	1 AMP	.10	IN1188	400 PIV	35 AMP	3.00

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	PN3569	4/$1.00	2N4401	4/$1.00
2N2222A	5/$1.00	2N3704	5/$1.00	2N4402	4/$1.00
2N2369	5/$1.00	2N3705	5/$1.00	2N4403	4/$1.00
2N2369A	4/$1.00	2N3706	5/$1.00	2N4409	5/$1.00
FN2415	5/$1.00	2N3707	5/$1.00	2N5086	4/$1.00
2N2484	4/$1.00	2N3711	5/$1.00	2N5087	4/$1.00
2N2906A	4/$1.00	2N3724	$.65	2N5088	4/$1.00
2N2907A	5/$1.00	2N3725	$1.00	2N5089	4/$1.00
2N2925	5/$1.00	2N3903	5/$1.00	2N5129	5/$1.00
2N3053	2/$1.00	2N3904	4/$1.00	2N5138	5/$1.00
2N3055	$.89	2N3905	4/$1.00	2N5139	5/$1.00
MJE3055	$.89	2N3906	4/$1.00	2N5209	5/$1.00
2N3392	5/$1.00	2N4013	3/$1.00	2N5951	5/$1.00
2N3398	5/$1.00	2N4014	3/$1.00	C106B1 SCR	2/$1.00



CAPACITOR CORNER

50 VOLT CERAMIC DISC CAPACITORS

	1-9	10-49	50-100		1-9	10-49	50-100
10pf	.05	.04	.03	.001	.05	.04	.035
22 pf	.05	.04	.03	.0047	.05	.04	.035
47 pf	.05	.04	.03	.01	.05	.04	.035
100 pf	.05	.04	.03	.022	.06	.05	.04
220 pf	.05	.04	.03	.047	.06	.05	.04
470 pf	.05	.04	.035	.1	.12	.09	.075

100 VOLT MYLAR FILM CAPACITORS

.001mf	.12	.10	.07	.022mf	.13	.11	.08
.0022	.12	.10	.07	.047mf	.21	.17	.13
.0047mf	.12	.10	.07	.1mf	.27	.23	.17
.01mf	.12	.10	.07	.22mf	.33	.27	.22

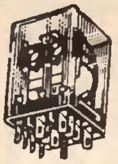
± 20% DIPPED TANTALUMS (SOLID) CAPACITORS

.1	35V	.28	.23	.17	1.5 35V	.30	.26	.21
.15	35V	.28	.23	.17	2.2 25V	.31	.27	.22
.22	35V	.28	.23	.17	3.3 25V	.31	.27	.22
.33	35V	.28	.23	.17	4.7 25V	.32	.28	.23
.47	35V	.28	.23	.17	6.8 25V	.36	.31	.25
.68	35V	.28	.23	.17	10 25V	.40	.35	.29
1.0	35V	.28	.23	.17	15 25V	.63	.50	.40

MINIATURE ALUMINUM ELECTROLYTIC CAPACITORS

Axial Lead					Radial Lead				
.47	50	.15	.13	.10	.47	25	.15	.13	.10
1	50	.16	.14	.11	.47	50	.16	.14	.11
3.3	50	.15	.13	.10	1	16	.15	.13	.10
4.7	25	.16	.14	.12	1	25	.16	.14	.11
10	25	.15	.13	.10	1	50	.16	.14	.11
10	50	.16	.14	.12	4.7	16	.15	.13	.10
22	25	.17	.15	.12	4.7	25	.15	.13	.10
22	50	.24	.20	.18	4.7	50	.16	.14	.11
47	25	.19	.17	.15	10	16	.14	.12	.09
47	50	.25	.21	.19	10	25	.15	.13	.10
100	25	.24	.20	.18	10	50	.16	.14	.12
100	50	.35	.30	.28	47	50	.24	.21	.19
220	25	.32	.28	.25	100	16	.19	.15	.14
220	50	.45	.41	.38	100	25	.24	.20	.18
470	25	.33	.29	.27	100	50	.35	.30	.28
1000	16	.55	.50	.45	220	16	.23	.17	.16
2200	16	.70	.62	.55	470	25	.31	.28	.26

Circle 91 on reader service card



POTTER BRUMFIELD

Type KHP Relay
4 PDT 3A Contacts

24 VDC (650 coil) $1.50 Ea.
120 VAC (10.5 MA coil) $1.75 Ea.

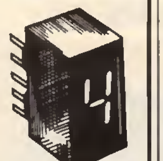
RCA 2010

Numitron Digital Display Tube Incandescent 5-volt 7-segment with .6" high numeral visible from 30 ft., standard 9-pin base (solderable), and left hand decimal point.
EACH $5.00 5 FOR $20.00

CMOS

CD4000	$ .29	CD4016	$ .69
CD4001	.29	CD4019	.69
CD4002	.29	CD4023	.29
CD4007	.29	CD4024	1.50
CD4008	1.98	CD4025	.34
CD4009	.59	CD4030	.65
CD4010	.59	74C20	.65
CD4011	.29	74C42	2.00
CD4012	.29	74C157	2.50
CD4013	.69	74C161	3.00
CD4015	1.98	74C195	2.00

Numeric Display ¼" Single Digit GaAsP LED



SUPER SPECIAL $ .59
TEN for $4.95

COMMON CATHODE WITH RH DECIMAL ACTUAL SIZE

Compact - 10 digits in 3" panel width
Highly legible - bright red ¼" character easily read within 10 feet over a wide viewing angle (140°)
Low power - 125 mW per digit at typical brightness

2102-2 MOS 1024 BIT MEMORY (DIP)

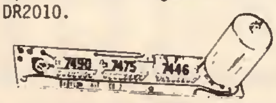
FULLY DECODED STATIC RANDOM ACCESS MEMORY
DIRECTLY TTL COMPATIBLE INPUTS AND OUTPUT
SINGLE 5V SUPPLY - - NO CLOCKS OR REFRESH
$4.00 EA. 8 FOR $27.95

NEW!

FULL WAVE BRIDGE RECTIFIERS
25 AMP 500 PIV
EACH $2.00 10 FOR $16.50

CD-2 COUNTER KIT

Unit includes board, 7490, 7475, quad latch, 7447 seven-segment driver, and RCA DR2010.



COMPLETE KIT $10.95
FULLY ASSEMBLED $15.00
Boards can be supplied separately at $2.50 per digit.

NPN TO3 POWER TRANSISTORS

410 (RCA) 200V - 10A
2N3772 70V - 30A (max.)
Each $1.75 10 for $15.00

2N3055 Transistor (power): PD-115W
VCE-60V; HFE-50; FT-30K; Case TO-3
Each $1.15 10 pak $6.95

See the bargains at our YEAR-END SALE!

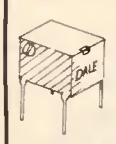
FREE!! CT5001
With $25.00 prepaid order
4 Function, 12 Digit Calculator IC
With Data

TTL

7400	$ .20	7453	$ .15
74H00	.25	7454	.20
7401	.30	74L54	.25
74H01	.25	74L55	.25
7402	.25	7460	.16
7403	.25	74L71	.25
7404	.25	7472	.40
74H04	.30	74L72	.60
7405	.30	7473	.25
7406	.40	74L73	.75
7408	.30	7474	.45
7410	.15	74H74	.75
7413	.75	7475	.80
7417	.40	7476	.55
7420	.20	74L78	.70
74L20	.30	7480	.50
74H20	.30	7483	.70
74H22	.30	7489	3.00
7430	.15	7490	1.00
74H30	.30	7492	.45
74L30	.30	7493	1.00
7440	.20	7495	.65
74H40	.30	74L95	1.00
7442	1.00	74107	.25
7447	1.50	74145	1.25
7450	.15	74180	1.00
74H50	.30	74193	1.50
7451	.20	74195	.65
74H51	.25		

Specials

DIP TRIMMER

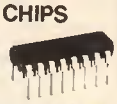


-12 turn trimpots which plug into a DIP socket
-5K and 200K
-¼" x ¼" x ¼"
-4 leads spaced .3" x .2"

Each $.65 10 for $4.95

MEMORY CHIPS

8223 PROM
8 BIT-32 WORD MEMORY



$3.00 EACH 10 FOR $29.00
WE PROGRAM FOR $5.00 EACH

82S129 SIGNETIC
1024 BIT-256/4
FIELD PROGRAMMABLE
(WE WILL NOT PROGRAM)
EACH $5.00 8 FOR $34.95

TRANSISTOR

2N3904 - HEP736
TO92 PLASTIC - NPN
300 MW - 60V - β100-300
NEW - FAIRCHILD - MARKED

EACH $ .15 10 FOR $1.00

All IC's are new and fully-tested. Leads are plated with gold or solder. Orders for $5 or more will be shipped prepaid. Add 55¢ for handling and postage for smaller orders; residents of California add sales tax. IC orders are shipped within 2 workdays--kits are shipped within 10 days of receipt of order. $10 minimum on C.O.D.'s

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BABYLON ELECTRONICS

MONEY BACK GUARANTEE ON ALL GOODS!
SEND FOR FREE FLYER LISTING 100's OF MONEY-SAVING BARGAINS!

Circle 90 on reader service card

8800 SOFTWARE!

Ever dream of just turning on your computer and having its full power available instantly? The **ALS-8 Firmware Module** gives you that kind of "turn on the switch" system with 4K of PROM's pre-programmed with a greatly **expanded** version of our Software Package No. 1.

This powerful file oriented package is the finest Resident Assembly Language Operating System available today. 8080 assembly language programs can be stored as named files (5 letter names) and called at will to be assembled, edited, or listed by line number. Six files can reside in memory at once, or, they can be stored in either source or object code on paper tape, cassette or any other form of storage medium for re-input at a later time. Assembly of the source file can take place from a memory file or from any input device you choose.

If you are new to computers, the manual included with each module not only explains how to use the program (with examples), but goes on to explain each routine of the System and how to call these routines from other programs.

The ALS-8 Firmware comes complete with a module with all components capable of holding 8K of TURN ON THE SWITCH program. So why 8K? Because we wrote this system to be upward compatible with future software developments and the first of these, an interpretive simulator, is up and running now!

INTERPRETIVE SIMULATOR??? Yes, an interpretive simulator that runs 8080 programs, in an interpretive mode, on the same 8080 that contains the Simulator. This isn't just a debug program, because the program thinks it's an 8080! That's right, all registers, flags, program counter, and stack are SIMULATED! The **SIM-1 Simulator Expansion Firmware** comes pre-programmed and ready to plug into the ALS-8 module. The ALS-8 is an integral part of the simulator and must be available for its operation.

Write for more details on these and other 8800 plug in compatible modules.

Processor Technology
2465 Fourth Street
Berkeley, Ca. 94710

Circle 92 on reader service card

COMPLETE STEREO AMPLIFIER CHASSIS

This complete stereo amplifier has 2 push button selected inputs, with indicator lights, and one has adjustable sensitivity. It has a transformer power supply, 15 watts per channel, and seperate Volume, Bass, Treble, & Balance controls with knobs. Rugged steel chassis 11" wide, 8½" deep, 3½" high. Just needs 115v AC and speakers. Shipping weight 7 lbs.
STOCK NO. R5286 Complete stereo amplifier $19.95

ULTRASONIC TRANSDUCERS

We have had many requests for ultrasonic transducers, of the type used in burglar alarms, remote control devices, etc. We now have 2 types, one operating at 23 Khz, the other at 41.5 Khz. Each can operate as a transmitter or receiver. We supply basic alarm circuits and data with each one.
STOCK NO. R9272 23 Khz Transducer $2.00 ea. 4/7.00
STOCK NO. R6000 41.5 Khz Transducer $3.00 ea. 2/5.00

AUTOTRANSFORMERS

120v to 240v step-up or 240v to 120v step-down autotransformer, 150 watts. 3 lbs. STOCK NO. R9844 $3.50 each, 3/9.00

2 KVA autotransformer. Taps at 105, 110, 115, 120, & 125 volts. Ideal for boosting voltage during brown-outs for TVs, etc.
STOCK NO. R9861 11 lbs. $8.95 each, 2/16.00

HEAVY DUTY TRANSFORMER with 64 volt, center tapped, 4 amp winding, with taps at 32v, CT. Also 17 volt, CT, 7 amp and 380volt, CT, 400 ma. Ideal for 250 watt amplifier. True value over $50! STOCK NO. R9905 10 lbs. $11.95 ea, 2/22

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XM-338 Reg. 2.29 **1.20**
DG8R Numerical Indicator Tube
Direct heating cathode 22 mA @ 1.3VAC. 100-ft. lamberts. With specs: ¼ lb.

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Nixie Readout Tube
"Miniature" numeric display of digits 1-9. Min. voltage: 170 VDC. Numeral: 5/16, 5/8". Tube. 1 3/4 x 9/16" 10 pin

3-Digit LED Readout Display
DI-049 Reg. 3.00 **1.50**
Magnifying bubble, high luminance, 7 segment gallium arsonide phosphide indicators. Limited quantity. ¼ lb.

LED 7-Segment Readout
.3" Tall For Easy Reading
1.20 ea. XM-341. Green. SM-370. Red. XM-342. Yellow.
IC Compatible, low forward current VH-1.9V @ 10 mA. Com. anode, left decimal. Specs. Shpg. wt. ¼ lb.

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Hamlin 3½ Digit Liquid Crystal Display
Featured fully reflectorized back glass plate. .200 x .100" size. .020" width. Series 3302. With specs. ¼ lb.

XM-399 **1.40** Reg. 3.00
9-Digit Readout Display
- *Sperry #425-09*
- *For Multiplex Operation*

Designed for direct interfacing with MOS/LSI. Cathode segments internally bussed. .25" high. Display supply. 180 VDC. 300 μA. 3 x 1¼". With specs. ¼ lb.

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Pocket Calculator Keyboard
- *Designed for Handheld Units*

18 feather touch keys, on-off switch and multiplexed for chip CT-5001-2 or mostek 5010-12. Wt. 1 lb.
20 Keyboard. Matches XM-364 IC Below.
XM-339. Wt. 1 lb. 4.00

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45¢ Reg. 89¢ TR-422
IC Pkg. Pkg./10 integrated circuits: dual inlines, TO-5's, etc. Marked with mfr's no. Wt. ¼ lb.

TR-293 **25¢** Reg. 79¢
Integrated CIRCUITS
IC's. Similar to Fairchild 703. For 10.7 MHz. RF or IF amps. Untested. Wt. ¼ lb.

TR-296 **50¢** Reg. 1.00
Integrated CIRCUITS
Fairchild UL-915-291C's. 10 — lead TO-77 case. ¼ lbs.

TR-294 **30¢** Reg. 49¢
Integrated CIRCUITS
IC's. Like Fairchild 717. Linear amp. 100 kHz to 50 MHz. 1—15V. Eight leads. Untested. ¼ lb.

TR-297 **60¢** Reg. 1.00
Integrated CIRCUITS
Fairchild 914 Integrated Circuit. Pkg/2 Dual 2-input. NOR gate. TO-99 case. Wt. ¼ lb.

TR-295 **60¢** Reg. 1.00
Integrated CIRCUITS
General Industries 200-Bit Shift Register IC. Pkg. of 5 8-lead TO-77. Limited quantity.

RE-131 **80¢** Reg. 1.49
Integrated CIRCUITS
709 IC High-Gain OP Amp. High input imped., swing under load. Temp. stability. 18V. Wt. ¼ lb.

WESTERN DIGITAL **XM-364** **$10** Reg. 15.00
ER-1422B ER-1432B
8-Digit Calculator Chip
Complete circuit on two matched 40-pin IC's. Has algebraic key sequence, constant multiplier/divisor, floating decimal, overflow display, leading zero suppression accessible memory. With specs.

Capacitor KIT **CD-407** **2.70** Reg. 5.00
Pkg. of 50 axial & radial lead types. Low voltage, high capacity types.

DUAL IN-LINE IC'S
LOW AS **29¢**
Made in U.S. These IC's are guaranteed against defects. With diagram. Shpg. wt. ¼ lb.

Type 7400 Quad 2-Input Pos. NAND Gate. High speed, diode-clamped inputs.
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Type 7473 Dual J-K Master / Slave Flip-Flop.
TR-436. Reg. 1.19. **Sale 39c**
Type 7474 Dual D-Type Edge Triggered Flip-Flop.
TR-438. Reg. 69c. **Sale 39c**
Type 7475 4-Bit Latch. Temp stores binary coded info.
TR-437. Reg. 1.89. **Sale 79c**
Type 7490 Decode Counter. Binary coded decimal counter with symmetrical divide.
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4.99 6 VDC alkaline rated @ 5 amp/hr. Max. current 1.25 amp Eveready #565 4 lbs.
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BIG 1 LB. Resistor Kit
99¢ Over 400 pieces of ¼, ½, 1 watt sizes. All color coded. 2½ lbs.
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For almost any type of printed circuit or wiring project. 2 lbs.
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PNP Transistors
Big 10 pc kit. For general, lo & hi-gain & audio. Germanium types Untested ¼ lb
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Pkg./ 3 quality cassette recording tapes. 60 min. each. ½ lb.
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40-pin DIP single CAL-Tech #CT-5001 7 - seg decoded display output. overflow lockout. Specs Incl
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Famous manufacturer's high quality low priced tapes. ½ lb.
89¢ Reg. 1.19
TA-854. 40-Min. 89c
TA-855. 80-Min. 99c

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Polarity is unmarked but easily identified with ohm meter. 200 PIV rated. ½ lb.
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Silicon Rectifiers
- *1 Amp Epoxy Type Pkg./5. 4 oz.*

			Reg	Sale
DI-028	50 PIV	IN4001	89c	39c
DI-029	100 PIV	IN4002	99c	39c
DI-030	200 PIV	IN4003	1.19	39c
DI-031	400 PIV	IN4004	1.39	39c

Pkg. of 10
Switching Diodes
Pkg / 10 1N4148 for low current applications. 10 mA-75 PIV. ¼ lb.
59¢ Reg. 1.29 XM-382. Sale 59c

Pkg of 5
LED'S 2V 10 mA
Gallium phosphide Large red, high quality LED. Wt. ¼ lb. Pkg/5.
59¢ Reg. 1.19 PL-233. Sale 59c

Power Rectifier KIT TR-443
- *Pkg. of 3*

60¢ Reg. 1.00
Asst. 6 - 12 amps. Up to 50 PIV. Stud mount. Untested. ¼ lb.

SCR Assortment
Reg. 2.69 **99¢** TR-446
Pkg. of 25
"Hobby Pak" of asst. values & case types. Pkg. of 25. Untested. Wt. 1 lb.

Cadmium Photocell
Pkg. of 2 TR-091 **59¢**
200 ohms — 1 meg. Sen. 500-600 Angstroms. VDC: 150 Max. 75 mW. 1" leads. ⅛ lb.

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7 amp power transistor SI NPN similar to SK-3054. 90V. 90 W.	1.49
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PRV	1A	3A	12A	50A
100	.06	.14	.30	.80
200	.07	.20	.35	1.15
400	.09	.25	.50	1.40
600	.11	.30	.70	1.80
800	.15	.35	.90	2.30
1000	.20	.45	1.10	2.75

TRIACS

PRV	1A	10A	25A
100	.40	.70	1.30
200	.70	1.10	1.75
400	1.10	1.60	2.60
600	1.70	2.30	3.00

SCRs

PRV	1.5A	6A	35A
100	.40	.50	1.20
200	.60	.70	1.60
400	1.00	1.20	2.20
600	—	—	3.00

LINEAR OP AMPS

LM 703CN	.45
LM 709H	.29
LM 709N	.29
LM 710N	.79
LM 711N	.39
LM 723N	.55
LM 723H	.55
RCA	
CA-3013	1.70
CA-3023	2.15
CA-3055	2.25
CA-3039	1.35
CA-3046	1.15
CA-3059	2.46
CA-3060	2.80
CA-3080	.85
CA-3083	1.60
CA-3086	.59
CA-3089	3.25
CA-3091	8.25
CA-3123	1.85
CA-3600	2.75

TR-195 **1.49**
7 AMP POWER TRANSISTOR
Si NPN Similar to SK-3054 90V. 90W

Capacitors

50¢ Pkg. of 10 Reg. 98¢ CD-413 — 1 mfd. @ 600V. Leads fit PC board. 3/4 x 3/4 x 7/16".

60¢ Pkg. of 2 Reg. 1.29 CD-414 — 50 mfd. @ 100V electrolytics. Insulated with full length leads.

50¢ Pkg. of 10 Reg. 98¢ CD-415 — .047 mfd. @ 100V. Leads fit PC board. 3/8 x 5/8 x 3/16".

1.19
LM 309K
TO-3 Case. 1 Amp. 5V DC Voltage Regulator. Brand New By National.

HIGH POWER SCRs

PRV	100 AMPS
50	2.25
100	2.99
200	3.95
400	5.95
600	7.95
800	8.98
1000	10.95

5 AMP GLASS AMP SILICON RECTIFIER
AS LOW AS **22¢**

PIV	
200	.22
400	.39
600	.51
800	.69

SILICON POWER STUD. RECTIFIERS

PIV	12A	55A
50	.29	.69
100	.36	.89
200	.45	1.25
400	.61	1.49
600	.79	1.80
800	.90	2.30
1000	1.15	2.75

ME-205 **90¢** Reg. 1.80
Mini 0-200 μA Meter
- *Edge Type Mounting*

For tuning meter in compact portable equipment. Two color scales. 1⁵⁄₁₆ x ⅜ x 1". ¼ lb.

ME-204 **90¢** Reg. 1.80
Mini 0-150 μA Meter
- *Two Color Scales*

Dial scale registers -10 to +3 for tuning meter applications. 1 x 1 x ⅞". ¼ lb.

ME-203 **1.00** Reg. 2.00
Mini 100-0-100 μA Meter
- *For Easy Panel Mounting*

No current needle position is centered and indicates polarity by direction of movement. 1 x 1 x ⅞". Meter forearea: ⅞ x ¾". Standard 100 μA range. ¼ lb.

ME-182 **1.00** Reg. 1.49
0-1 mA Panel Meter
100 ohms/volt sensitivity. 18k ohms internal resistance. For VU & dB measurements. 1⅜" mtg hole. Wt. 1 lb. Removed from equipment.

ME-201 **1.10** Reg. 2.39
Tuning Meter
- *100-0-100 mA*

Can read FM or AM signals. Use as strength or tuning meter. 1¾ x 1⅝ x ⅞". 1 lb.

Free

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features sine, triangle and square wave; THD 0.5% typ.; AM/FM capability

XR-2206KA — SPECIAL $16.95
Includes monolithic function generator IC, PC board, and assembly instruction manual.

XR-2206KB — SPECIAL $26.95
Same as XR-2206KA above and includes external components for PC board.

TIMERS			
XR-555CP	Monolithic Timer	SPECIAL $	.68
XR-320P	Precision Timer		1.50
XR-556CP	Dual-555 Timer		1.70
XR-2556CP	Dual Timing Circuit		3.10
XR-2240CP	Programmable Counter/Timer	SPECIAL	3.20
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XR-210	FSK Demodulator		5.10
XR-215	High Frequency PLL		6.50
XR-567CP	Tone Decoder (mini DIP)		1.90
XR-567CT	Tone Decoder (TO-5)	SPECIAL	.99
STEREO DECODERS			
XR-1310P	PLL Stereo Decoder		3.10
XR-1310EP	PLL Stereo Decoder		3.10
XR-1800P	PLL Stereo Decoder		3.10
WAVEFORM GENERATORS			
XR-205	Waveform Generator		8.30
XR-2206CP	Monolithic Function Generator	SPECIAL	4.39
XR-2207CP	Voltage-Controlled Oscillator		3.75
OTHER EXAR IC'S			
XR-1468CN	Dual + 15V Tracking Regulator	SPECIAL	2.90
XR-1488N	Quad Line Driver		5.70
XR-1489AN	Quad Line Receiver		4.70
XR-2208CP	Operational Multiplier		5.10
XR-2211CP	FSK Demodulator/Tone Decoder		6.60
XR-2261	Monolithic Proportional Servo IC System w/4 ea. Driver Transistor		3.70

7400N TTL

7400N	$.13	7443N	.95	74104N	1.20	74165N	1.30
7401N	.16	7444N	.72	74105N	.50	74166N	1.30
7402N	.14	7445N	.90	74107N	.30	74170N	2.50
7403N	.16	7446N	.90	74109N	.90	74173N	1.50
7404N	.19	7447N	.77	74110N	.72	74174N	1.10
7405N	.20	7448N	.80	74114N	.93	74175N	1.20
7406N	.29	7450N	.16	74118N	1.52	74176N	1.25
7407N	.29	7451N	.16	74121N	.45	74177N	1.40
7408N	.18	7453N	.16	74122N	.45	74180N	.73
7409N	.20	7454N	.16	74123N	.70	74181N	3.00
7410N	.18	7460N	.16	74125N	.50	74182N	.70
7411N	.26	7470N	.30	74126N	.50	74184N	2.00
7412N	.33	7472N	.30	74128N	.90	71185N	2.20
7413N	.58	7473N	.37	74132N	1.00	74188N	4.80
7414N	1.05	7474N	.32	74136N	.95	74190N	1.20
7416N	.28	7475N	.50	74141N	1.20	74191N	1.20
7417N	.33	7476N	.32	74145N	1.00	74192N	1.10
7420N	.17	7480N	.59	74147N	2.40	74193N	1.00
7421N	.33	7481N	1.18	74148N	1.80	74194N	1.15
7422N	.50	7482N	.89	74150N	1.00	74195N	.80
7423N	.50	7483N	.65	74151N	.80	74196N	1.70
7425N	.34	7484N	3.00	74152N	1.40	74197N	.80
7426N	.25	7485N	1.20	74153N	1.00	74198N	1.75
7427N	.31	7486N	.35	74154N	1.40	74199N	1.40
7428N	.50	7489N	2.25	74155N	1.00	74200N	5.60
7430N	.20	7490N	.48	74156N	1.18	74221N	1.70
7432N	.24	7491N	.90	74157N	1.00	74251N	2.00
7433N	.60	7492N	.55	74158N	1.20	74278N	2.95
7437N	.35	7493N	.58	74160N	1.30	74279N	.90
7438N	.33	7494N	.80	74161N	1.20	74293N	1.00
7439N	.38	7495N	.80	74162N	1.40	74298N	2.20
7440N	.16	7496N	.78	74163N	1.40		
7441N	.95	74100N	1.00	74164N	1.30		
7442N	.50						

HIGH SPEED TTL

74H00N	$.33	74H20N	.33	74H53N	.36	74H73N	.90
74H01N	.25	74H21N	.33	74H54N	.36	74H74N	.87
74H02N	.30	74H22N	.33	74H55N	.36	74H76N	.90
74H04N	.33	74H30N	.33	74H60N	.36	74H101N	.80
74H05N	.33	74H40N	.30	74H61N	.36	74H102N	.80
74H08N	.40	74H50N	.36	74H62N	.36	74H103N	1.10
74H10N	.33	74H51N	.36	74H71N	.80	74H106N	.95
74H11N	.33	74H52N	.36	74H72N	.74		

LOW POWER TTL

74L00N	$.31	74L10N	.33	74L51N	.34	74L90N	1.62
74L02N	.33	74L20N	.33	74L73N	.69	74L93N	1.74
74L03N	.39	74L42N	1.49	74L74N	.90	74L95N	1.62
74L04N	.33						

74LS

74LS00	.46	74LS27	.50	74LS112	.58	74LS170	5.80
74LS01	.58	74LS30	.46	74LS113	.92	74LS174	2.20
74LS02	.46	74LS32	.50	74LS138	2.06	74LS175	2.42
74LS03	.50	74LS38	.46	74LS139	2.06	74LS181	7.00
74LS04	.50	74LS51	.50	74LS151	1.92	74LS194	2.40
74LS08	.46	74LS54	.48	74LS153	1.92	74LS195A	2.40
74LS09	.58	74LS55	.58	74LS157	1.68	74LS196	2.76
74LS10	.46	74LS73	.58	74LS158	1.68	74LS251	2.06
74LS11	.46	74LS74	.58	74LS 75110N;		74LS253	2.42
74LS15	.58	74LS76	.92	74LS161	3.06	74LS257	2.06
74LS20	.46	74LS78	.92	74LS162	3.06	74LS258	2.06
74LS21	.58	74LS107	.92	74LS163	2.90	74LS260	.58
74LS22	.58	74LS109	.92				

SCHOTTKY TTL

74S00N	$.44	74S51N	.80	74S140N	.80	74S189N	4.40
74S02N	.60	74S64N	.80	74S151N	2.20	74S194N	3.30
74S03N	.75	74S74N	1.20	74S153N	3.40	74S195N	3.30
74S04N	.55	74S85N	6.10	74S157N	2.40	74S251N	2.20
74S08N	.80	74S86N	2.50	74S158N	2.20	74S253N	2.40
74S10N	.55	74S112N	1.00	74S160N	3.90	74S257N	2.40
74S11N	.65	74S113N	1.50	74S161N	4.70	74S258N	2.40
74S20N	.65	74S132N	3.60	74S174N	3.30	74S260N	1.20
74S30N	.80	74S133N	.80	74S175N	2.90	74S280N	5.70
74S32N	.80	74S138N	2.20	74S181N	8.40	74S289N	4.00
74S40N	.65	74S139N	2.20				

9300 SERIES

9300PC	$1.00	9318PC	2.30	9366PC	1.75	93L18	3.50
9301PC	1.20	9321PC	1.20	93L00	1.50	93L21	1.50
9304PC	1.50	9322PC	1.30	93L01	1.60	93L22	1.80
9306PC	6.90	9324PC	2.00	93L08	3.20	93L24	2.80
9308PC	2.50	9328PC	2.50	93L09	1.80	93L28	3.70
9309PC	1.60	9334PC	2.95	93L10	2.80	93L34	4.00
9310PC	1.50	9338PC	3.30	93L11	4.20	93L38	4.20
9311PC	2.30	9340PC	5.00	93L12	1.80	93L40	6.50
9312PC	1.20	9341PC	4.10	93L14	1.70	93L41	6.50
9314PC	1.30	9342PC	1.15	93L16	3.20	93L60	3.00
9316PC	1.50	9360PC	1.75	93L18	3.50	93L66	2.70

AUDIO AMPS

TYPE	V	W	Ω	PRICE
LM352	6-15	1.15	8	1.60
TAA611B12	6-15	1.15	8	1.60
TAA621A12	6-27	1.40	8	2.00
TAA641B11	6-18	2.20	4	3.00
TBA800	5-30	4.70	8	2.20
TBA810AS	4-20	2.50	4	3.00
TBA820	3-16	0.75	4	1.70
TCA830	5-20	2.00	4	2.20
TCA940	6-24	6.50	8	4.40

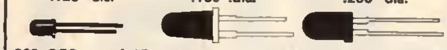
IC SOCKETS

SOLDER-TIN DIP PIN	1-24	25	100	WIRE-WRAP GOLD PIN	1-24	25	100
8	.21	.19	.17	14	.45	.41	.37
14	.25	.22	.20	16	.54	.49	.44
16	.28	.25	.23	**SOLDER - GOLD**			
24	.67	.61	.55				
28	.88	.80	.72				
36	1.09	.98	.89	14	.34	.28	
40	1.24	1.12	.92	16	.37	.31	

TEFLON TO-5

3 PIN	.55 EA
4 PIN	.65 EA
6 PIN	.90 EA
8 PIN	1.10 EA
10 PIN	1.40 EA

LEDs



.125" dia.		.160" dia.		.200" dia.	
209 RED	$.25	216 RED	$.25	220 RED	$.25
209 YELLOW	.35	216 YELLOW	.30	220 YELLOW	.30
209 GREEN	.35	216 GREEN	.30	220 GREEN	.30

LOW PROFILE

226 RED	$.25	5053 RED	$.35	MV50 RED	$.30
226 YELLOW	.30	5053 YELLOW	.40		
226 GREEN	.30	5053 GREEN	.40	*216 = MV5024*	
226 ORANGE	.30	5053 ORANGE	.40	*5053 = MV5053*	

DISPLAYS

LITRONIX

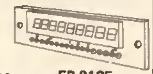
DL80	RED	6.00
DL81	RED	6.00
DL10	RED	6.00
DL10A	RED	4.00
DL101	RED	4.90
DL57	RED	9.90
DL61	RED	12.00
DL33	RED	4.00
DL44	RED	6.00
DL402	RED	4.00
DL701	RED	3.40
DL704	RED	2.25
DL707	RED	2.35
DL747	RED	2.50
DL747	1-9	10up
RED	2.50	2.40

OPCOA

SLA1 RED	2.25
SLA11 GREEN	3.50

XCITON

XAN72 RED	2.00
XAN52 GREEN	2.00



EP 9125 9-DIGIT DISPLAY $7.90
1/8" Character Ht. Compact, Thin PC Pkg., Wide Viewing Angle

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1-24	$21.00
25	16.80
100	14.00
EA 1500ASJ	
1-24	$16.00
25	14.40
100	12.00

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MONSANTO		LITRONIX			
		IL1	1.30	IL74	1.35
MCT2	1.35	IL12	1.40	ILD74	1.75
		IL16	1.80	ILQ74	3.40

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75108BN	2.30
75109N	2.20
75110N	2.20
75115N	2.25
75138N	2.95
75150N	3.10
75154N	4.10
75208N	2.70
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75451N	1.00
75452N	1.00
75453N	1.00
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1404AN	2.90
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1602	33.00
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P2101-2	4.90
P2111	5.80
P2111-1	6.00
P2111-2	5.90
P2112	5.00
P2112-2	5.90
P2401	9.90
P2405	9.70
2505K	3.30
2512K	4.00
2521V	2.50
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7552	4.95
7552-1	5.40
7552-2	5.50
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MM550H	5.90
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P-2102	2.85
C2102-1	5.00
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C2102-2	6.00
P-2102-2	3.00
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LM301AH	.50	LM312H	2.50	LM715CD	4.60
LM301AM	.80	LM318H	1.49	LM723CH	.60
LM301AN	1.10	LM318M	2.40	LM723CN	.65
LM301M	.90	LM324N	1.90	LM723N	.70
LM301H	.90	LM331N	2.20	LM725CH	2.00
LM302D	3.50	LM339N	2.90	LM725CD	5.00
LM302N	1.30	LM320-5K	2.90	LM733CH	1.40
LM302H	1.40	LM320-5T	2.50	LM733CD	3.50
LM304H	1.20	LM320-12K	2.90	LM733CN	1.30
LM305H	.85	LM320-12T	2.50	LM741CH	.40
LM305AH	1.05	LM336K	2.40	LM741CD	1.25
LM305N	1.00	LM340-05K	2.60	LM741CM	.39
LM306H	.95	LM340-06K	2.60	LM741CN	.70
LM307H	.60	LM340-08K	2.60	LM747CH	.70
LM307M	.95	LM340-12K	2.60	LM747CN	.90
LM307N	1.50	LM340-15K	2.60	LM747CD	2.50
LM308H	.85	LM340-18K	2.60	LM748CM	.55
LM308AH	5.00	LM340-24K	2.60	LM748CN	.55
LM308D	2.00	LM555CM	.70	LM777CH	2.15
LM308M	1.20	LM556CM	1.30	LM777CM	2.10
LM309H	1.75	LM567CM	1.70	LM3046CN	.95
LM309K	1.50	LM709CH	.45	LM3054CN	1.50
LM310H	1.50	LM709CN	.45	SG4501T	2.40
LM310M	1.80	LM710CH	.90	SG4501N	2.40
LM311H	1.20	LM710CN	.90	LM5000K	7.50

C-MOS

	1-9	10up		1-9	10up		1-9	10up
4000AE	.26	.22	4022AE	1.11	1.00	4051AE	1.34	1.13
4001AE	.26	.22	4023AE	.26	.22	4052AE	1.34	1.33
4002AE	.26	.22	4024AE	.90	.88	4053AE	1.34	1.33
4004AE	5.83	5.82	4025AE	.26	.22	4055AE	2.68	2.00
4006AE	1.35	1.34	4026AE	3.72	3.70	4056AE	2.43	1.86
4007AE	.26	.22	4027AE	.60	.50	4060AE	1.50	1.25
4008AE	1.79	1.78	4028AE	.98	.90	4066AE	.90	.72
4009AE	.60	.50	4029AE	1.27	1.16	4069AE	.38	.34
4010AE	.59	.50	4030AE	.44	.37	4071AE	.26	.22
4011AE	.26	.22	4033AE	3.01	3.00	4076AE	1.68	1.48
4012AE	.26	.22	4035AE	1.27	1.16	4081AE	.26	.25
4013AE	.47	.40	4040AE	1.49	1.25	4508AE	2.30	2.20
4014AE	1.49	1.25	4041AE	4.06	4.05	4510AE	1.98	1.46
4015AE	1.26	.90	4042AE	.75	.64	4516AE	1.98	1.46
4016AE	.56	.45	4043AE	.60	.50	4518AE	1.28	.98
4017AE	1.20	1.00	4044AE	.60	.50	4520AE	1.28	.98
4018AE	1.49	1.25	4047AE	3.54	3.53	4528AE	2.30	2.20
4019AE	.52	.44	4048AE	1.43	1.42	4901AE	.43	.36
4020AE	1.49	1.25	4049AE	.52	.50	4911AE	.43	.36
4021AE	1.34	1.25	4050AE	.52	.50			

MICROPROCESSORS

	1-9	10 up		
8008	23.90	22.90	1702	17.00
8080	**59.00**	**39.90**	P8101	5.50
MC6800	89.00	79.00	P8101-2	6.00
P11C1A	2.20	2.10	P8102	4.00
P1101A1	3.50	3.30	P8102-2	4.00
P2102-1	3.90	3.00	P8111	5.60
91L02	3.90	3.20	P8111-2	6.00
91L02-1	3.90	3.20	9102PC	4.00

SPDT MINIATURE TOGGLE SWITCH

115V, 5A Rating — Model 105D — .95

WAVEFORM GENERATOR KITS

EXAR XR205K $25.00

Here's a highly versatile lab instrument at a fraction of the cost of conventional unit. Kit includes 2 XR205 IC's, data & applications, PC board (etched and drilled, ready for assembly) and detailed instructions.

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For simultaneous sine, square and triangular waveforms <.001 Hz to 1MHz.

Part No.	1-9	10 up
8038CCPD	$3.90	$3.70

1-AMP RECTIFIERS

	10	100	1000
1N4001	1.00	7.00	60.00
1N4002	1.10	8.00	70.00
1N4003	1.20	9.00	80.00
1N4004	1.30	10.00	90.00
1N4005	1.40	11.00	100.00
1N4006	1.50	12.00	110.00
1N4007	1.60	13.00	120.00

HYBRID POWER AMPLIFIERS

SI-1010G	10W	$6.40
SI-1020G	20W	9.90
SI-1030G	30W	18.70
SI-1050E	50W	24.90
SI-1050G	50W	24.90

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BU204	3A	1300V	$4.14
BU205	3A	1500V	4.95
BU206	3A	1700V	5.94
BU207	6A	1300V	5.85
BU208	6A	1500V	6.93
BU209	6A	1700V	8.64

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THE SMALLEST AC/DC POWER SUPPLY EVER!
Only 1.70"x1.00" x 0.85", output preset ±5%, 9 models:

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10	100
12	90
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18	50
20	35
22	25
24	15

$39.80 each

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Model No.	Output Vdc	Output Amps	1-4	5 up
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APS12-1.6	12	1.6		
APS15-1.5	15	1.5		
APS24-1	24	1.0		
APS28-0.8	28	0.8		
APS5-6	5	6	$48.45	$46.05
APS12-4	12	4		
APS15-3	15	3		
APS24-2.2	24	2.2		
APS28-2	28	2		
APS5-10	5	10	$72.25	$68.65
APS12-7	12	7		
APS15-6	15	6		
APS24-5	24	5		
APS28-4	28	4		

STANDARD MICROSYSTEMS

	1-9	10 up
COM2502	$13.20	$10.60
COM2502P	8.00	6.85
COM2017	13.20	10.60
COM2017P	8.00	6.85
COM2502H	25.00	20.00
COM2017H	25.00	20.00
COM2601	30.00	24.00
COM5016	12.00	9.60
KR2376-ST	20.00	17.50
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NMX5010	12.00	9.60
CAL1022	60.00	52.00

Minimum order: $10.00. Add $1.00 to cover postage and handling. California residents add 6% sales tax.

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State of SOLID STATE

by KARL SAVON
SEMICONDUCTOR EDITOR

I KEEP TALKING ABOUT ONE OF THE most important virtues of integrated circuits—the closely matched thermal environment. I've run across a good clear-cut demonstration of this IC technique in an application note by Precision Monolithics. They've taken a couple of their monolithic (IC) products and built a practical, accurate, remote electronic thermometer. A matched pair of transistors is the temperature sensor Compared to thermistor, sensistor (silicon resistor), single diode or transistor sensors, the technique demonstrates advantages you can put your finger on.

All in all it's an excellent example of how two IC matched transistors use their intrinsic construction to do a relatively simple, but non-trivial job in a better way.

Precision monolithics temperature meter

The base-to-emitter voltage of a transistor is a logarithmic function of the current through it, and a more complicated function of the temperature of the junction: $V_{be} = \frac{KT}{q} \ln \frac{i_c}{i_s}$.

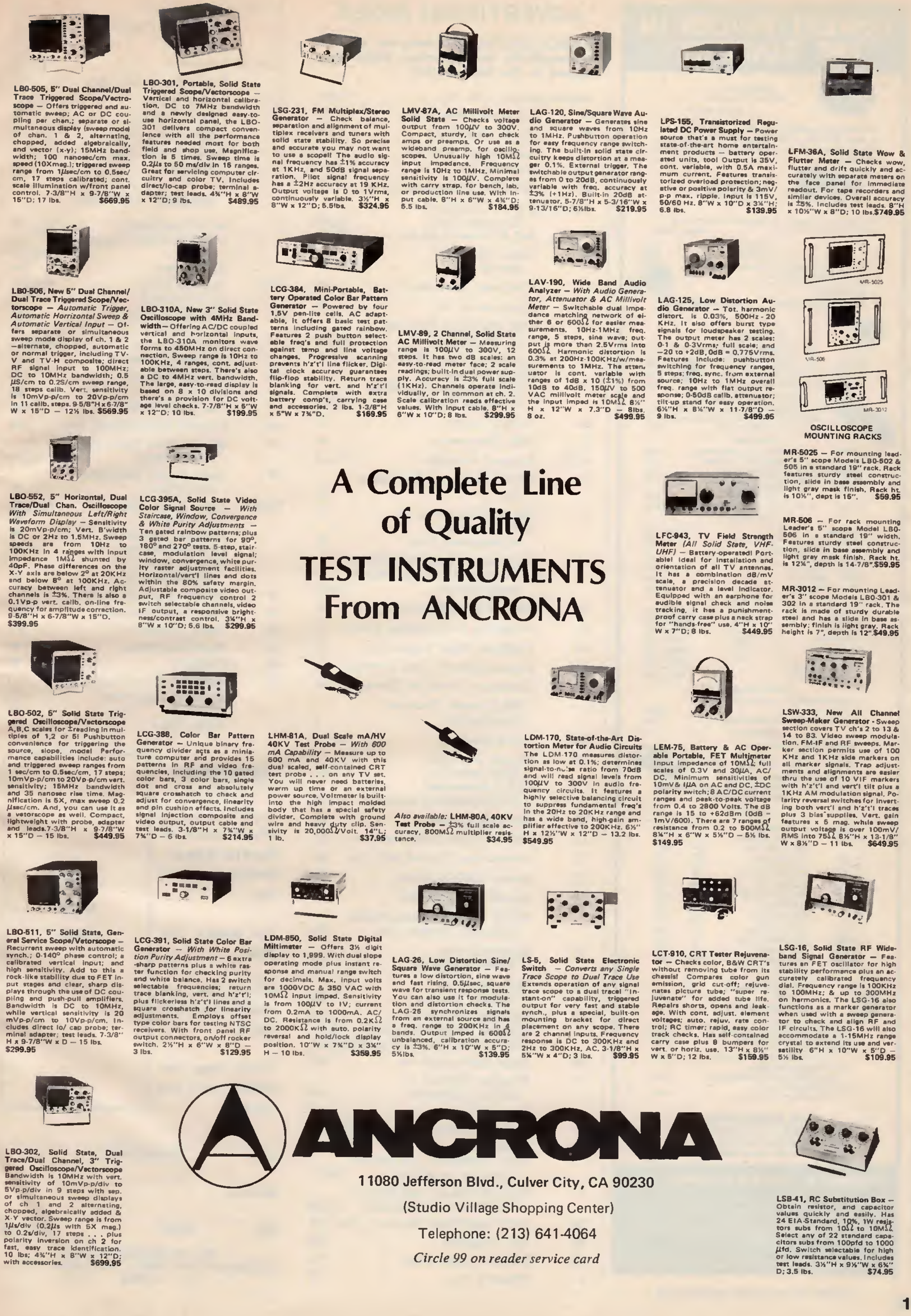
The K is Boltzmann's constant, T the absolute temperature, and q the charge of an electron. The saturation current, I_s, is itself dependent upon temperature.

What's needed is a more dependable mechanism. Somehow the annoying poorly behaved saturation current term must be eliminated. Instead of a single junction, PMI uses the difference between two junction-voltages. If the currents in the two transistors are the same, they will have equal junction voltages and the difference is zero—hardly usable. But if the current in the two transistors are forced to be different, say in a 2 to 1 ratio, a differential voltage is produced. At room temperature it is about 18 millivolts.

Figure 1 is the schematic of the thermometer circuit. IC1 is the sensor device. The transistors are diode connected by tying their bases and collectors together. Grounding these four elements results in a differential sensor output developed between the two emitters.

Fabricating two transistors on the same chip makes their saturation current nearly identical. This cancels the effects of the saturation current. The output is smaller than the 2 mV/°C of the single junction and will need amplification, but it is highly predictable.

(continued on page 109)



LBO-505, 5" Dual Channel/Dual Trace Triggered Scope/Vectroscope — Offers triggered and automatic sweep; AC or DC coupling per chan.; separate or simultaneous display (sweep mode) of chan. 1 & 2, alternating, chopped, added algebraically, and vector (x-y); 15MHz bandwidth; 100 nanosec/cm max. speed (10Xmag.); triggered sweep range from 1μsec/cm to 0.5sec/cm, 17 steps calibrated; cont. scale illumination w/front panel control. 7-3/8"H x 9-7/8"W x 15"D; 17 lbs. $669.95
LBO-301, Portable, Solid State Triggered Scope/Vectorscope — Vertical and horizontal calibration. DC to 7MHz bandwidth and a newly designed easy-to-use horizontal panel, the LBO-301 delivers compact convenience with all the performance features needed most for both field and shop use. Magnification is 5 times. Sweep time is 0.2μs to 50 ms/div in 18 ranges. Great for servicing computer circuitry and color TV. Includes direct/lo-cap probe; terminal adapter; test leads. 4¾"H x 8"W x 12"D; 9 lbs. $489.95
LSG-231, FM Multiplex/Stereo Generator — Check balance, separation and alignment of multiplex receivers and tuners with solid state stability. So precise and accurate you may not want to use a scope!! The audio signal frequency has ±1% accuracy at 1KHz, and 50dB signal separation. Pilot signal frequency has a ±2Hz accuracy at 19 KHz. Output voltage is 0 to 1Vrms, continuously variable. 3½"H x 8"W x 12"D; 5.5lbs. $324.95
LMV-87A, AC Millivolt Meter Solid State — Checks voltage output from 100μV to 300V. Compact, sturdy, it can check amps or preamps. Or use as a wideband preamp. for oscilloscopes. Unusually high 10MΩ input impedance. Frequency range is 10Hz to 1MHz. Minimal sensitivity is 100μV. Complete with carry strap, for bench, lab. or production line use. With input cable. 8"H x 6"W x 4¾"D; 5.5 lbs. $184.95
LAG-120, Sine/Square Wave Audio Generator — Generates sine and square waves from 10Hz to 1MHz. Pushbutton operation for easy frequency range switching. The built-in solid state circuitry keeps distortion at a meager 0.1%. External trigger. The switchable output generator ranges from 0 to 20dB, continuously variable with freq. accuracy at ±3% (+1Hz). Built-in 20dB attenuator. 5-7/8"H x 5-3/16"W x 9-13/16"D; 6½lbs. $219.95
LPS-155, Transistorized Regulated DC Power Supply — Power source that's a must for testing state-of-the-art home entertainment products — battery operated units, too! Output is 35V, cont. variable, with 0.5A maximum current. Features transistorized overload protection; negative or positive polarity & 3mV/p-p max. ripple. Input is 115V, 50/60 Hz. 8"W x 10"D x 3¾"H; 6.8 lbs. $139.95
LFM-36A, Solid State Wow & Flutter Meter — Checks wow, flutter and drift quickly and accurately with separate meters on the face panel for immediate readout. For tape recorders and similar devices. Overall accuracy is ±5%. Includes test leads. 8"H x 10½"W x 8"D; 10 lbs.$749.95
LBO-506, New 5" Dual Channel/Dual Trace Triggered Scope/Vectorscope — Automatic Trigger, Automatic Horizontal Sweep & Automatic Vertical Input — Offers separate or simultaneous sweep mode display of ch. 1 & 2 —alternate, chopped, automatic or normal trigger, including TV-V and TV-H composite; direct RF signal input to 100MHz; DC to 10MHz bandwidth; 0.5 μS/cm to 0.2S/cm sweep range, 18 steps calib. Vert. sensitivity is 10mVp-p/cm to 20Vp-p/cm in 11 calib. steps. 9-5/8"H x 6-7/8" W x 15"D — 12½ lbs. $569.95
LBO-310A, New 3" Solid State Oscilloscope with 4MHz Bandwidth — Offering AC/DC coupled vertical and horizontal inputs, the LBO-310A monitors wave forms to 450MHz on direct connection. Sweep range is 10Hz to 100KHz, 4 ranges, cont. adjustable between steps. There's also a DC to 4MHz vert. bandwidth. The large, easy-to-read display is based on 8 x 10 divisions and there's a provision for DC voltage level checks. 7-7/8"H x 5"W x 12"D; 10 lbs. $199.95
LCG-384, Mini-Portable, Battery Operated Color Bar Pattern Generator — Powered by four 1.5V pen-lite cells. AC adaptable, it offers 8 basic test patterns including gated rainbow. Features 2 push button selectable freq's and full protection against temp and line voltage changes. Progressive scanning prevents h'z't'l line flicker. Digital clock accuracy guarantees flip-flop stability. Return trace blanking for vert. and h'z't'l signals. Complete with extra battery comp't, carrying case and accessories. 2 lbs. 1-3/8"H x 5"W x 7¾"D. $169.95
LMV-89, 2 Channel, Solid State AC Millivolt Meter — Measuring range is 100μV to 300V, 12 steps. It has two dB scales: an easy-to-read meter face; 2 scale readings; built-in dual power supply. Accuracy is ±3% full scale (1KHz). Channels operate individually, or in common at ch. 2. Scale calibration reads effective values. With input cable. 8"H x 6"W x 10"D; 8 lbs. $299.95
LAV-190, Wide Band Audio Analyzer — With Audio Generator, Attenuator & AC Millivolt Meter — Switchable dual impedance matching network of either 6 or 600Ω for easier measurements. 10Hz-1MHz freq. range, 5 steps, sine wave; output is more than 2.5Vrms into 600Ω. Harmonic distortion is 0.3% at 200Hz-100KHz/w/measurements to 1MHz. The attenuator is cont. variable with ranges of 1dB x 10 (±1%) from 10dB to 40dB, 150μV to 500 VAC millivolt meter scale and the input imped is 10MΩ. 8½"H x 12"W x 7.3"D — 8lbs. 8 oz. $499.95
LAG-125, Low Distortion Audio Generator — Tot. harmonic distort. is 0.03%, 500Hz - 20 KHz. It also offers burst type signals for loudspeaker testing. The output meter has 2 scales: 0-1 & 0-3Vrms; full scale; and −20 to +2dB, 0dB = 0.775Vrms. Features include: pushbutton switching for frequency ranges, 5 steps; freq. sync. from external source; 10Hz to 1MHz overall freq. range with flat output response; 0-50dB calib. attenuator; tilt-up stand for easy operation. 6¾"H x 8¾"W x 11-7/8"D — 9 lbs. $499.95
MR-5025
MR-506
MR-3012
OSCILLOSCOPE MOUNTING RACKS
MR-5025 — For mounting leader's 5" scope Models LBO-502 & 505 in a standard 19" rack. Rack features sturdy steel construction, slide in base assembly and light gray mask finish. Rack ht. is 10½", dept is 15". $59.95
MR-506 — For rack mounting Leader's 5" scope Model LBO-506 in a standard 19" width. Features sturdy steel construction, slide in base assembly and light gray mask finish. Rack ht. is 12¾", depth is 14-7/8".$59.95
MR-3012 — For mounting Leader's 3" scope Models LBO-301 & 302 in a standard 19" rack. The rack is made of sturdy durable steel and has a slide in base assembly; finish is light gray. Rack height is 7", depth is 12".$49.95
LBO-552, 5" Horizontal, Dual Trace/Dual Chan. Oscilloscope With Simultaneous Left/Right Waveform Display — Sensitivity is 20mVp-p/cm; Vert. B'width is DC or 2Hz to 1.5MHz. Sweep speeds are from 10Hz to 100KHz in 4 ranges with input impedance 1MΩ shunted by 40pF. Phase differences on the X-Y axis are below 2° at 20KHz and below 8° at 100KHz. Accuracy between left and right channels is ±3%. There is also a 0.1Vp-p vert. calib. on-line frequency for amplitude correction. 9-5/8"H x 6-7/8"W x 15"D. $399.95
LCG-395A, Solid State Video Color Signal Source — With Staircase, Window, Convergence & White Purity Adjustments — Ten gated rainbow patterns; plus 3 gated bar patterns for 90°, 180° and 270° tests. 5-step, staircase, modulation level signal; window, convergence, white purity raster adjustment facilities. Horizontal/vert'l lines and dots within the 80% safety margin. Adjustable composite video output, RF frequency control 2 switch selectable channels, video IF output, a responsive brightness/contrast control. 3¼"H x 8"W x 10"D; 5.6 lbs. $299.95
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LBO-502, 5" Solid State Triggered Oscilloscope/Vectorscope A,B,C scales for ±reading in multiples of 1,2 or 5! Pushbutton convenience for triggering the source, slope, model Performance capabilities include: auto and triggered sweep ranges from 1 sec/cm to 0.5sec/cm, 17 steps; 10mVp-p/cm to 20Vp-p/cm vert. sensitivity; 15MHz bandwidth and 35 nanosec rise time. Magnification is 5X, max sweep 0.2 μsec/cm. And, you can use it as a vetorscope as well. Compact, lightweight with probe, adapter and leads. 7-3/8"H x 9-7/8"W x 15"D — 15 lbs. $449.95
LCG-388, Color Bar Pattern Generator — Unique binary frequency divider acts as a miniature computer and provides 15 patterns in RF and video frequencies, including the 10 gated color bars, 3 color bars, single dot and cross and absolutely square crosshatch to check and adjust for convergence, linearity and pin cushion effects. Includes signal injection composite and video output, output cable and test leads. 3-1/8"H x 7¾"W x 7¾"D — 6 lbs. $214.95
LHM-81A, Dual Scale mA/HV 40KV Test Probe — With 600 mA Capability — Measure up to 600 mA and 40KV with this dual scaled, self-contained CRT test probe . . . on any TV set. You will never need batteries, warm up time or an external power source. Voltmeter is built-into the high impact molded body that has a special safety divider. Complete with ground wire and heavy duty clip. Sensivity is 20,000Ω/Volt. 14"L; 1 lb. $37.95
Also available: LHM-80A, 40KV Test Probe — ±3% full scale accuracy, 800MΩ multiplier resistance. $34.95
LDM-170, State-of-the-Art Distortion Meter for Audio Circuits The LDM-170 measures distortion as low at 0.1%; determines signal-to-noise ratio from 70dB and will read signal levels from 100μV to 300V in audio frequency circuits. It features a highly selective balancing circuit to suppress fundamental freq's in the 20Hz to 20KHz range and has a wide band, high-gain amplifier effective to 200KHz. 6½" H x 12½"W x 12"D — 13.2 lbs. $549.95
LEM-75, Battery & AC Operable Portable, FET Multimeter Input impedance of 10MΩ; full scales of 0.3V and 30μA, AC/DC. Minimum sensitivities of 10mV& 1μA on AC and DC. ±DC polarity switch; 8 AC/DC current ranges and peak-to-peak voltage from 0.4 to 2800 Volts. The dB range is 15 to +62dBm (0dB = 1mV/600). There are 7 ranges of resistance from 0.2 to 500MΩ. 8¼"H x 6"W x 5½"D — 5½ lbs. $149.95
LSW-333, New All Channel Sweep-Maker Generator - Sweep section covers TV ch's 2 to 13 & 14 to 83. Video sweep modulation, FM-IF and RF sweeps. Marker section permits use of 100 KHz and 1KHz side markers on all marker signals. Trap adjustments and alignments are easier thru the use of 10 VIF markers with h'z't'l and vert'l tilt plus a 1KHz AM modulation signal. Polarity reversal switches for inverting both vert'l and h'z't'l traces plus 3 bias supplies. Vert. gain features x 5 mag. while sweep output voltage is over 100mV/RMS into 75Ω. 8½"H x 13-1/8" W x 8½"D — 11 lbs. $649.95
LBO-511, 5" Solid State, General Service Scope/Vetorscope — Recurrent sweep with automatic synch.; 0-140° phase control; a calibrated vertical input; and high sensitivity. Add to this a rock-like stability due to FET input stages and clear, sharp displays through the use of DC coupling and push-pull amplifiers. Bandwidth is DC to 10MHz, while vertical sensitivity is 20 mVp-p/cm to 10Vp-p/cm. Includes direct lo/ cap probe; terminal adapter; test leads. 7-3/8" H x 9-7/8"W x D — 15 lbs. $299.95
LCG-391, Solid State Color Bar Generator — With White Position Purity Adjustment — 6 extra -sharp patterns plus a white raster function for checking purity and white balance. Has 2 switch selectable frequencies; return trace blanking, vert. and h'z't'l; plus flickerless h'z't'l lines and a square crosshatch ,for linearity adjustments. Employs offset type color bars for testing NTSC receivers. With front panel RF output connectors, on/off rocker switch. 2½"H x 6"W x 8"D — 3 lbs. $129.95
LDM-850, Solid State Digital Miltimeter — Offers 3½ digit display to 1,999. With dual slope operating mode plus instant response and manual range switch for decimals. Max. input volts are 1000VDC & 350 VAC with 10MΩ input imped. Sensitivity is from 100μV to 1V; current from 0.2mA to 1000mA. AC/DC. Resistance is from 0.2KΩ to 2000KΩ with auto. polarity reversal and hold/lock display position. 10"W x 7¾"D x 3¾" H — 10 lbs. $359.95
LAG-26, Low Distortion Sine/Square Wave Generator — Features a low distortion, sine wave and fast rising, 0.5μsec, square wave for transient response tests. You can also use it for modulation and distortion checks. The LAG-26 synchronizes signals from an external source and has a freq. range to 200KHz in 4 bands. Output imped is 600Ω unbalanced, calibration accuracy is ±3%. 6"H x 10"W x 5"D; 5½lbs. $139.95
LS-5, Solid State Electronic Switch — Converts any Single Trace Scope to Dual Trace Use Extends operation of any signal trace scope to a dual tracel "Instant-on" capability, triggered output for very fast and stable synch., plus a special, built-on mounting bracket for direct placement on any scope. There are 2 channel inputs. Frequency response is DC to 300KHz and 2Hz to 300KHz, AC. 3-1/8"H x 5¾"W x 4"D; 3 lbs. $99.95
LCT-910, CRT Tester Rejuvenator — Checks color, B&W CRT's without removing tube from its chassis! Compares color gun emission, grid cut-off; rejuvenates picture tube; "super rejuvenate" for added tube life. Repairs shorts, opens and leakage. With cont. adjust. element voltages; auto. rejuv. rate control; RC timer; rapid, easy color track checks. Has self-contained carry case plus 8 bumpers for vert. or horiz. use. 13"H x 8½" W x 5"D; 12 lbs. $159.95
LSG-16, Solid State RF Wideband Signal Generator — Features an FET oscillator for high stability performance plus an accurately calibrated frequency dial. Frequency range is 100KHz to 100MHz; & up to 300MHz on harmonics. The LSG-16 also functions as a marker generator when used with a sweep generator to check and align RF and IF circuits. The LSG-16 will also accommodate a 1-15MHz range crystal to extend its use and versatility 6"H x 10"W x 5"D — 5½ lbs. $109.95
LBO-302, Solid State, Dual Trace/Dual Channel, 3" Triggered Oscilloscope/Vectorscope Bandwidth is 10MHz with vert. sensitivity of 10mVp-p/div to 5Vp-p/div in 9 steps with sep. or simultaneous sweep displays of ch 1 and 2 alternating, chopped, algebraically added & X-Y vector. Sweep range is from 1μs/div (0.2μs with 5X mag.) to 0.2s/div, 17 steps . . . plus polarity inversion on ch 2 for fast, easy trace identification. 10 lbs; 4¾"H x 8"W x 12"D; with accessories. $699.95
ANCRONA
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(Studio Village Shopping Center)
Telephone: (213) 641-4064
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LSB-41, RC Substitution Box — Obtain resistor, and capacitor values quickly and easily. Has 24 EIA-Standard, 10%, 1W resistors subs from 10Ω to 10MΩ. Select any of 22 standard capacitors subs from 100pfd to 1000 μfd. Switch selectable for high or low resistance values. Includes test leads. 3¼"H x 9½"W x 6¾" D; 3.5 lbs. $74.95

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STATE OF SOLID STATE
(continued from page 106)

Back to the schematic. The system has four main components; the temperature sensor, the current sources, the differential amplifier and the output meter. The remote sensor connects to the rest of the circuit through a shielded cable less than 100 feet long. Maximum cable length is determined by the error that can be tolerated from the drop across its resistance and by the allowable noise pickup.

Voltage divided R8–R9 biases the base of Q3 and Q4 at about —13.5 volts and the emitters at 0.5 volt lower or —14 volts. One volt across R5 sets up a current of 10 microamps in Q3, and R7 is adjusted for 5 microamps in Q4 for the 2:1 ratio.

Proportioning the system for a 10 mV/°C coefficient at the output gives a direct temperature readout on a 10-volt full-scale 3-digit digital voltmeter or panel meter. The least significant digit of the readout represents hundredths-of-a-volt which will show degrees. To end up with this temperature relationship, the differential output of ICI must be amplified by 10,000/59.73 = 167.4.

Take two instrumentation amplifiers and put them together right and you have a high input-impedance, accurately controlled gain, differential amplifier. The dual monoOP-10CY hooked up as shown has a common-mode rejection specification of 117 dB. Long term stable .01%-resistors in the amplified feedback network make gain trimming unnecessary. With .01% resistors the gain tolerance is .04%.

Calibration is easy and the adjustment is made at only one temperature in the meter range. The obvious calibration point is room or outdoor temperature. The meter is simply adjusted to coincide with a conventional mercury thermometer. One preliminary amplifier offset adjustment is made by shorting the sensor and turning the offset potentiometer until the output reads zero. This is a real convenience after calibrating other types with both high and low range adjustments. The instructions often suggest such fun as jumping back and forth between boiling water and a cup of ice cubes.

A well regulated power-supply should be used since the output will change at about one degree-per-volt. When you're all finished, accuracy is better than ± 1 degree over a —55 to 125°C temperature range. And the long term stability is very good. For those who want to read Fahrenheit recall the conversion formula $°F = \frac{9}{5}°C + 32$; the gain of the amplifier will have to be boosted 1.8 times. Economics may sway you to try a conventional meter movement. The best bet will be an expanded-scale type to cover a useful range.

Based on 100 quantities, all parts minus the supply and readout meter can be purchased for $34.63. The most expensive of the thirteen components is the monoOP-10CY amplifier at $16.

Precision Monolithics Incorporated at 1500 Space Park Drive, Santa Clara, CA 95050 publishes application note AN-12. A number of other applications including temperature controllers are shown. **R-E**

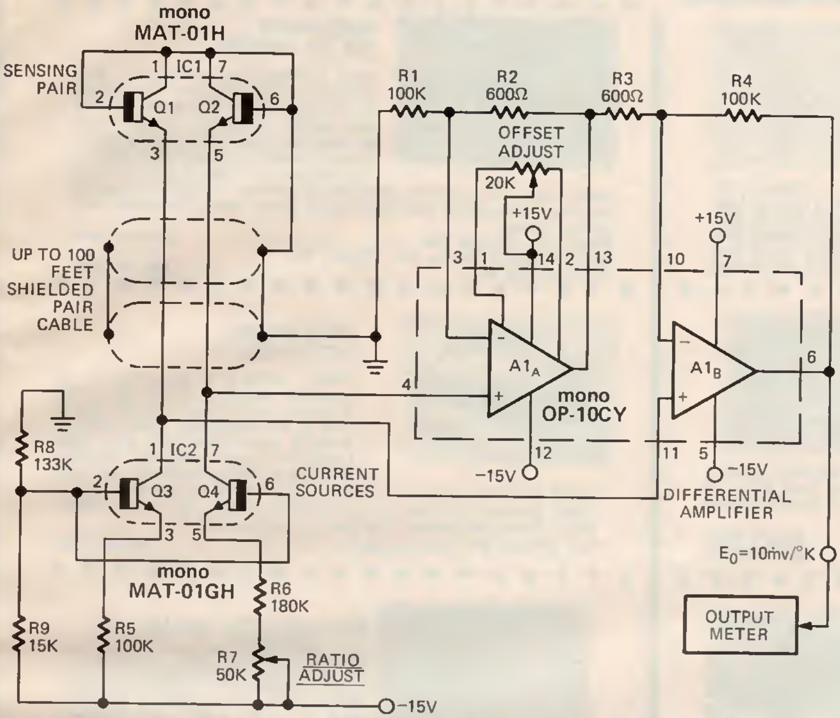

FIG. 1—PRECISION MONOLITHICS temperature meter using new temperature sensor.

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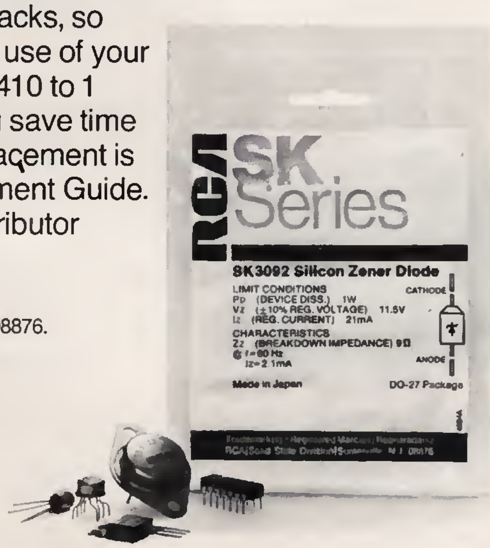

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