Radio-Electronics

INDUSTRIAL TEST EQUIPMENT—METERS

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Radio-Electronics

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

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With Simple IC Add On

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It's Made To Work Wrong

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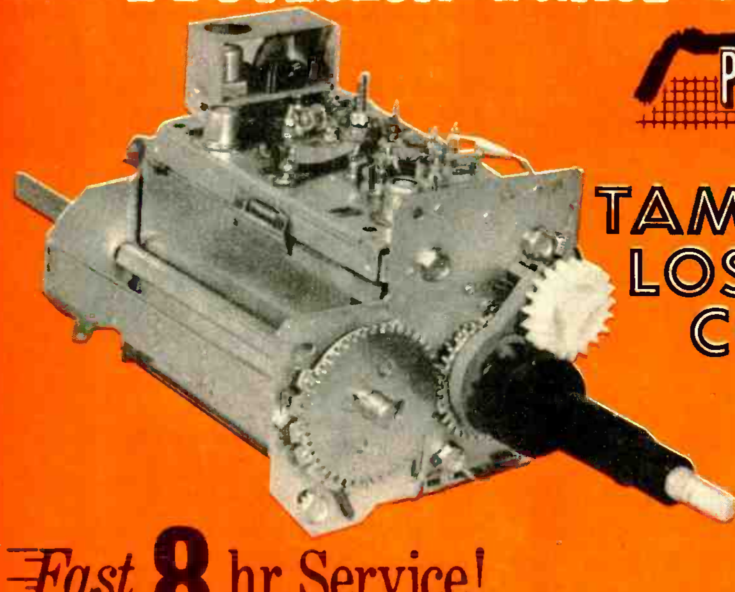
Precision Tuner Service



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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).

Total Price: $544 (Retail price: Altair $439, Memory $97, Postage and handling $8—total $544)

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4,096 Byte Dynamic Memory Card	$264 kit and $338 assembled
Full Parallel Interface Card	$92 kit and $114 assembled
Serial Interface Card RS232)	$119 kit and $138 assembled
Serial Interface Card (TTL or Teletype)	$124 kit and $146 assembled
Audio Cassette Record Interface	$128 kit and $174 assembled
COMTER II*	$780 kit and $920 assembled

*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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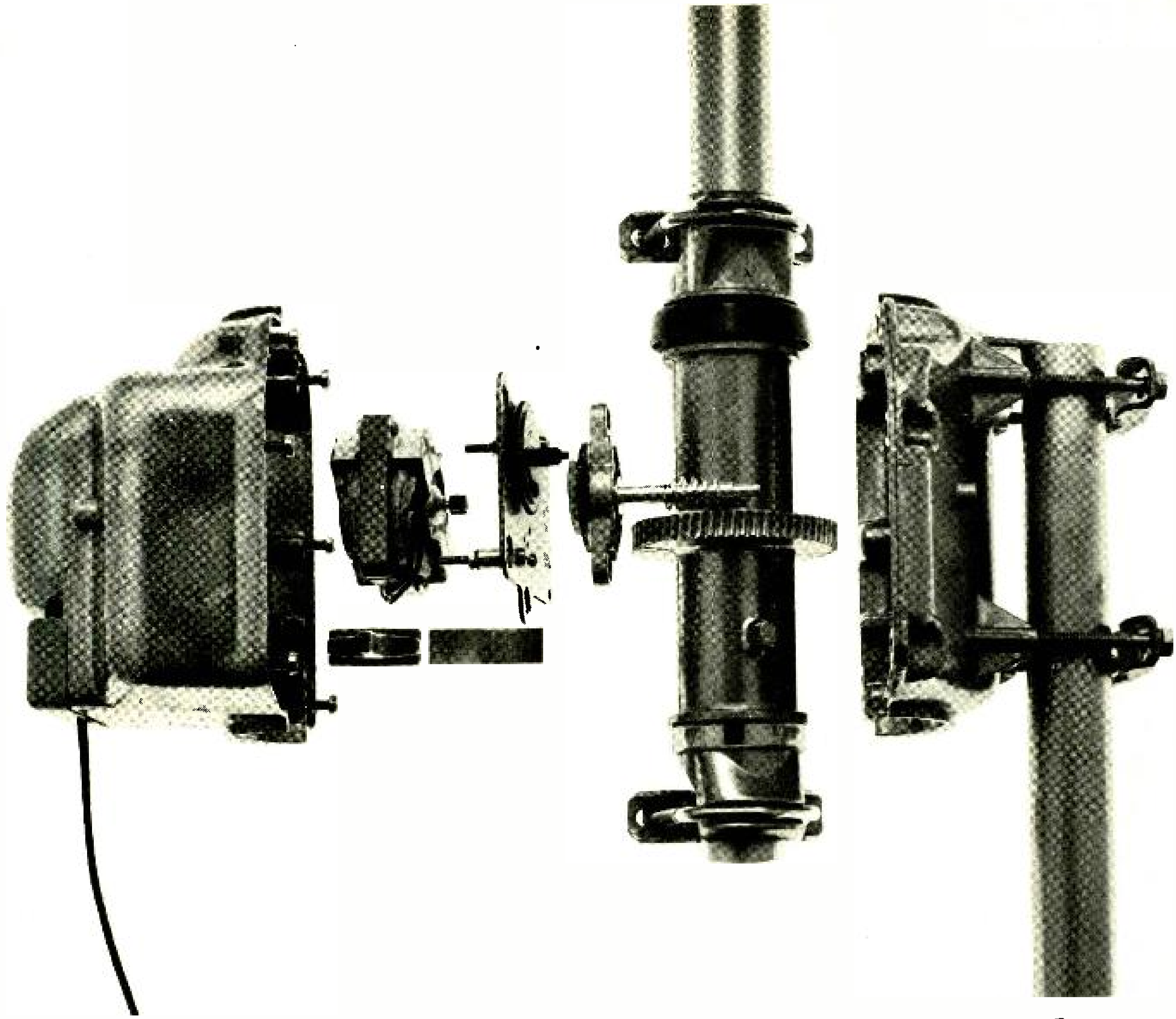
NOTE: Personal checks take 2-3 weeks for clearance. For immediate processing send money order or use charge card.

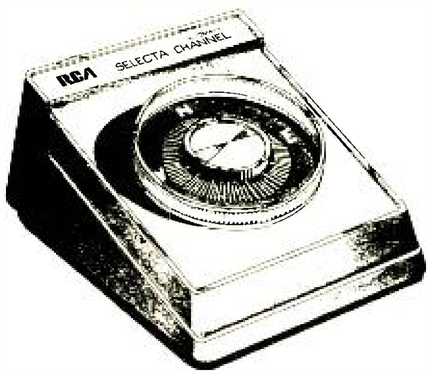
Circle 2 on reader service card



"RCA warrants this product against defects in materials and workmanship for a period of two years from date of purchase..."

RCA's Selecta-Channel Automatic Rotator carries the only 2-year warranty from a major company.

The Drive Unit for model 10W606 (shown above) features an easily removable high-tensile aluminum alloy housing. Inside, a powerful high efficiency motor. Permanently lubricated oversize stainless steel bearings — no external thrust bearings are required. Quick-connect pressure terminals. A new mast mounting that won't snag lead-in wires. Premounted hardware, and a reinforced shaft.



The Control Unit is an attractive chrome-trimmed beige, with cushioned base. The transparent "direct select" control knob has a moving direction indicator light showing the antenna's exact position. And, it's quiet: no click-clack sound.

For more information on the 10W606 or the deluxe Automatic Rotator 10W707, call your RCA Distributor. Or contact RCA Distributor and Special Products Division, Building 206-2, Cherry Hill Offices, Camden, New Jersey 08101.

RCA
Rotators

Radio-Electronics®

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

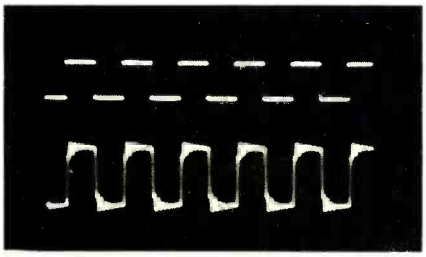
Electronics publishers since 1908

NOVEMBER 1975 Vol. 46 No. 11

ON THE COVER

Floating on that sea of Mylar and a sky of blue paper is a portable music synthesizer that produces effects that border on magic. Find out how you can build your own. Turn to page 37 now.

NEED A STOPWATCH? Just take a calculator, add an IC and a few other components and you'll have one—inexpensive and accurate . . . see page 43.



SQUAREWAVES ARE A KEY element in testing hi-fi gear. Learn how to use them effectively . . . see page 52.

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looking ahead

New CB rules

The FCC has relaxed Citizens band rules to legalize some practices that many CB operators have been doing for years. It discontinued its prohibition against hobbyist use of the band. It dropped restrictions against contacts between stations, eliminating the general requirement that conversations must be between units of the same station. It established Channel 11 as a nationwide calling channel—for use in establishing first contact and arranging to move to another channel. Call letters must now be given only at the beginning and end of each conversation, with "handles"—or nicknames—permitted as supplementary identification.

Crowding of the band could be relieved somewhat by two new rules: Conversations are limited to five minutes maximum, with a minute of silence between conversations. Receiving antenna heights are limited, as well as transmitting antennas. Still pending before FCC are proposals to allocate more frequencies to CB, to switch much of the band to single-sideband use, to lower the licensing age to 16 from 18 and to give the Commission direct engineering jurisdiction over antenna design through a type-acceptance program.

TV's future

Everybody's peering into the future of television. This month it's New York ad agency Needham, Harper & Steers, which studied how television will be in 1985. Here are the forecasts: (1) Cable will be "the dominant TV industry of the 1980's." Some 38,800,000 homes, or 45.7% of all homes that have television will be connected to cable by January 1, 1975. (2) Pay-TV will feed 15.5% of these 38,800,000 cable homes. (3) The average home will have about 2.6 television sets, up from 1.8 today. (4) There will be 85,000,000 homes that have television, and more than 98% of these will have color. (5) Videodiscs—forget it. Only 750,000 homes will have videoplayer systems, less than 1% of all TV-equipped homes, because of the cost of players and discs and compatibility problems.

Microwave pay TV

The initial success of Pay-TV via cable, as opposed to its inability to get moving via broadcast stations, has raised a new question: Why not eliminate the cable and beam programs directly to homes by microwave? This is exactly what is being attempted now in several cities, using Multipoint Distribution Service (MDS), a common-carrier super high frequency (2150—2160 MHz) service authorized by the FCC to transmit specialized material to specific locations.

Microband National System, a national MDS marketing organization, plans to start non-cable Pay-TV immediately in Atlanta, moving to Pittsburgh, Minneapolis and Indianapolis by February, and eventually to Hartford, Cleveland, Akron, Milwaukee, Denver, Seattle and Portland, OR by early next year. MDS is useful for Pay-TV when there are large concentrations of people living in apartment buildings. The signal is beamed selectively to special directional receiving antennas on apartment buildings or hotels and then converted to an unused VHF channel (or special VHF channel to be fed to set-top Pay-TV converter) and funneled into the MATV system. This system is claimed to be more economical than cable for cities with large apartment-building concentrations, and also makes closed-circuit Pay TV available in areas without cable and to people who wish only Pay TV and not cable service as well. In many areas served by cable Pay-TV, the customer must pay eight or nine dollars a month for cable service and another six to nine dollars for Pay TV. Under the MDS system, the customer would pay $6.50 to $8.50 monthly for Pay-TV only and continue to pick up off-the-air broadcasts.

Magnavox factory service

Joining RCA, G-E and Sylvania in providing factory service for its products is Magnavox. At least, Magnavox is dipping its toes tentatively into the captive-service waters. Magnavox is opening its own consumer electronics repair center in Torrance, CA, to service Magnavox products only. Magnavox says only that it wants to get first-hand information on "product performance, reliability and user satisfaction." This undoubtedly is true but it may also be true that Magnavox's new parent organization, profit-minded North American Philips, has studied the situation and found what some others have learned—that servicing can be more profitable than sales.

Console comeback

A funny thing happened on the way to the funeral of the color TV console: Console-TV sales actually have turned around and increased their share of the color-TV market in the first half of 1975 for the first time in history. Ever since the introduction of table models and portables, the share occupied by consoles (including TV-radio-phono combinations) has been decreasing at an accelerating pace. But during January 1975 through June 1975, consoles and combinations actually represented nearly 33% of the American color-TV market, up from 29% one year earlier.

Most experts cite the growing replacement market as the primary reason. Pioneer color-TV buyers generally bought consoles—not only because they represented an affluent group, but because many of them bought color-TV in the days when smaller-screen sets were rare or even non-existent. Now they're coming back for seconds—and presumably many don't want to trade down to smaller-screen sets, or to leave that big space in the home vacant (where the old console was).

Tighter UHF specs

A group of broadcasters' associations led by the Council for UHF Broadcasting (CUB) has petitioned the FCC to order a progressive tightening of permissible noise-figures in UHF tuners. The present upper limit is 18-dB, and CUB wants the FCC to reduce this to 14-dB in six months, 12-dB in 18 months and 10-dB in 30 months. In addition, the CUB urged the FCC to require that an "effective" indoor UHF antenna must be affixed to any TV set that is sold with a VHF antenna attached. The CUB cited recent tests that indicated the average noise figure of American UHF tuners was 12.7-dB, while the VHF tuner had only 6.9-dB.

CUB maintains that changes in receivers could be made at minimal charge, perhaps a nine-dollar increase at retail. As spokesman for receiver makers, EIA replies that price increases would be far higher with minimal benefits. The EIA also considers the proposed rules retrogressive since the television industry is now concentrating its energies on developing all-electronic varactor tuners while the decreases in noise, if decreed by FCC, would make it go back and concentrate on improvements in the current mechanical tuners. Some set makers say improvements in noise figures could increase susceptibility to interference, thereby worsening rather than improving UHF performance.

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR

publisher's memo

R-E Earns Awards

NESDA, the nation's largest organization of independent service technicians and dealers, recently held their 1975 National Convention in Winston Salem, North Carolina.

During the convention, NESDA honored Larry Steckler, Editor of RADIO-ELECTRONICS Magazine, by giving him their Man Of The Year Award. This award is presented annually to the person whom the NESDA membership determines has done the most for the independent electronic service industry in the previous year.

The award is in the form of an engraved plaque (see photo) which states: "In Appreciation For Personal Efforts And Leadership To Achieve The Goals Of N.E.S.D.A. And To Further The Interest Of The Nation's Independent Electronic Service Dealers And Technicians."

The NESDA membership made a second award to RADIO-ELECTRONICS Magazine in the form of a Recognition Certificate: "For the use of their editor [Larry Steckler] as ISCET chairman and their support of the yearbook and convention activities at the convention."

Steckler was re-elected chairman of ISCET (the International Society of Certified Electronic Technicians) for 1975-76.

RADIO-ELECTRONICS is honored to receive these awards and takes this opportunity to thank the NESDA's membership for them. Editor Steckler has devoted a great deal of time and effort to the NESDA and ISCET because he and we believe in the importance of a strong independent service movement.

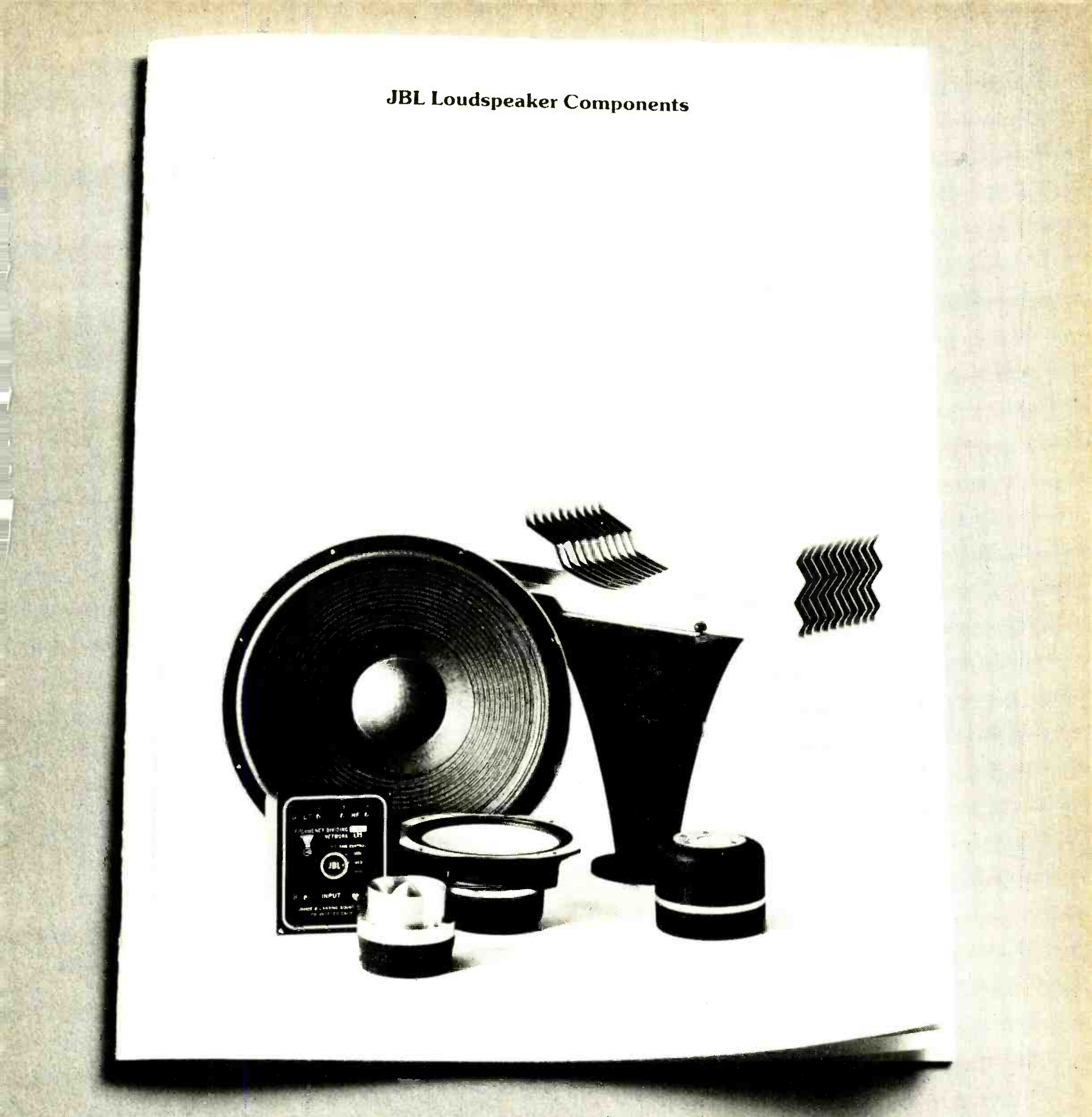
Although RADIO-ELECTRONICS Magazine is not a "service-only" magazine, it has always been strongly service oriented editorially and repeated readership studies have shown that a majority of its readers are engaged in service activities.

We will continue on this editorial path and redouble our efforts to support the service industry and justify its faith in us.

We also take this opportunity to congratulate Larry Steckler for NESDA's recognition of his efforts.

M. Harvey Gernsback

M. Harvey Gernsback,
Editor-In-Chief and Publisher



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Color TV repair is another big opportunity field right now and NRI can train you at home to service and repair any color or black & white TV, hi-fi equipment, AM-FM radios, and sound systems. You can choose from 5 courses, starting with a basic servicing course with 65 lessons . . . up to a Master Color TV course, complete with 25" diagonal solid state color TV in handsome woodgrain cabinet. No other school offers so many choices or so much value.

All courses are available with low down payment and convenient monthly payments to fit your budget. And all courses provide professional tools and equipment along with NRI-designed kits for hands-on training. With the Master Course, for instance, you receive your own 5" wide-band triggered sweep solid state oscilloscope, TV pattern generator, 3½ digit digital multimeter and a NRI 25" diagonal solid state television receiver expressly designed for color TV training.

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new & timely

Zenith co-founder dies at 79

Karl E. Hassel, radio industry pioneer and one of the founders of Zenith Radio Corp., died July 7 in Evanston, IL. His age was 79.

A radio amateur since 1912, Hassel and a friend, R.H.G. Mathews, both Navy radio operators, started the Chicago Radio Laboratory when they left the Navy in 1918. Using a kitchen table as a workbench and a soldering iron that had to be heated over a gas burner, the "laboratory" manufactured amateur radio receivers, at the rate of about one a week. They operated a ham station with the call letters 9ZN, from which came the name "Zenith."

KARL E. HASSEL

The late Commander E. F. McDonald joined the young organization and became general manager and Zenith's founder-president. The assets and business of the Chicago Radio Laboratory were purchased by Zenith Radio Corp. in 1923. Mr. Hassel was active in the reorganized corporation and was a director of Zenith until his retirement in 1973.

Broadcast type resolution in solid-state TV camera

"The first solid-state TV camera that meets the resolution requirements for commercial broadcast use," is what Bell Labs scientists claim for their latest device, an experimental camera that measures only 2.5 x 2.5 x 6 inches. In spite of its lack of size, its imaging area is designed to be equivalent to the scanning area of a 1-inch diameter TV camera of the type used in conventional TV work.

The solid-state imaging unit is a Charge Coupled Device (CCD) in which the light falling on each scan line is converted into a series of charges on tiny plates. At the end of each field, the lines are all shifted to corresponding lines in a storage area, from which a line at a time is stepped out to form a regular television signal while the next field is being imaged.

THE CHARGE-COUPLED IMAGE SENSOR is a single chip of silicon covered with an array of more than 235,000 electrodes.

The CCD in this camera contains nearly a quarter of a million sensing elements—a significant improvement in resolution over older solid-state imagers. It has 496 vertical interlaced scan lines as well as the 475 horizontal picture elements.

To fabricate this extremely large (16 x 20 mm) device, Bell Labs engineers used an electron beam exposure system, similar to the one developed at the Labs for making large-scale integrated circuits.

Audiomen get Debby awards

The Society of Audio Consultants, at its fourth annual Debby Awards dinner-dance held in Chicago in early summer, gave Debby awards to several individuals who have been foremost in the recent improvement and development of audio techniques. (The name Debby is a true audio term, derived from decibel.)

Foremost among those awarded Debby's for technical achievement was Ben Bauer of CBS Labs. With him were cited Ryosuke Ito and Susumu Takahashi of Sansui Electronics. All three were honored for their work in 4-channel recording and reproduction.

A special Debby was given to Leonard Feldman, who among his other activities is Instruction Chairman of the Society. He was cited for educational work and development of IHF (Institute of High Fidelity) standards. John Koss of Koss Corp. was awarded a special Debby for being first to introduce high-fidelity headphones and for maintaining world leadership through continuous research and development.

A number of other Debby's were awarded to consultants, manufacturers, managers and dealers in the audio field.

SOUND-VISION

AUSTRALIAN SOUND-VISION SYSTEM has a combination disc and film cassette, with the film cassette in the center of the disc. Cassette thickness can be reduced to 3-mm (about the thickness of some old-time 78-rpm discs). Sound is on the disc, vision on the film cassette. Inventor, Czech-born Rudolph Stepanek, says the sound is excellent but image at present is not as sharp as a videotape picture. The new device has been named a Poly Gramo-Vision.

Gernsback Scholarship awards to Waylin Goodman, Marvin Baker

This month's Hugo Gernsback Scholarship award, a prize of $150 given each month to a student in one of eight leading home study electronics schools, goes to Waylin Goodman, Grand Island, NE. Nominated by his school, ICS (International Correspondence Schools) he is an electronic technician employed by the FCC and is owner of his own part-time business, Waylin's Color TV Service. He writes:

"After being separated from the Navy, I planned to go into broadcasting. I had experience in programming but no working knowledge of electronics, so I took a beginning course to improve my chances. I was surprised to find that I liked working on the equipment.

I worked on the lessons every second I could spare, and soon converted a large walk-in closet into a TV repair shop. I was really enjoying my endeavors for the

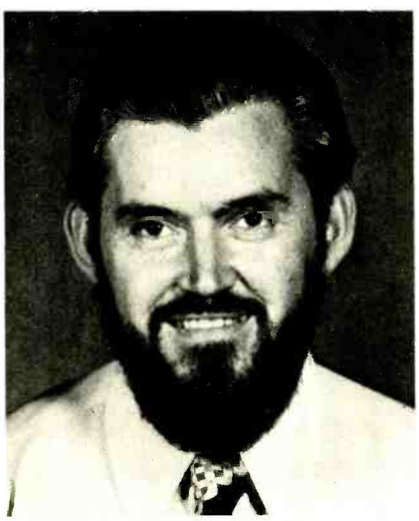
(continued on page 14)

 (continued from page 12)

first time in years, and was making money within a month after I started.

I am an electronics technician with the Federal Communications Commission, and by using the training from ICS and the training the FCC is giving me, I have a good career going. I am repairing radio and television part-time and hope to open my own television sales and service center. I was recently accepted as a warranty repair center by Quasar and General Electric companies.

WAYLIN O. GOODMAN



MARVIN R. BAKER

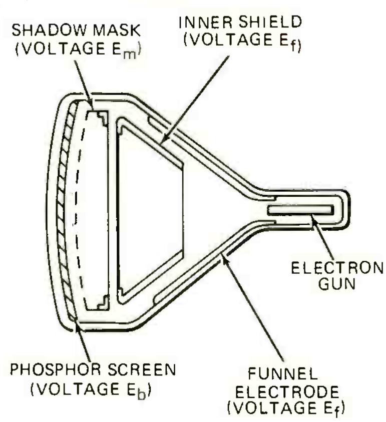
In addition to my career with the FCC, I am becoming known as a good, reliable television technician. These two endeavors are in pursuit of a career in electronics and I love it! I owe a great deal to electronics and the ICS."

Marvin R. Baker of Greenville, OH, is the winner of the second-place award, a WV-529A service VOM donated monthly by RCA to the second most deserving student. Mr. Baker is employed by Inland Steel Container Co. He writes:

"The most important benefits received from my course in Industrial Electronics are capability to service photoelectric eyes and industrial electronic welders as used by Inland Steel Container in their Greenville plant."

Newest Hitachi picture tube has post-deflection focusing

A new "mask-focusing" color television picture tube by Hitachi claims a picture 50% brighter than that of conventional picture tubes. The increased brightness, Hitachi reports, is produced by maintaining the mask at a lower voltage than the phosphor screen; thus accelerating and focusing the electrons as they proceed from mask to screen; and by absorbing secondary electrons with an intermediate voltage applied to a special funnel electrode in the tube (see sketch). The mask-focusing makes it possible to use a mask with slightly larger holes, giving it twice the transparency of a conventional mask.



MASK-FOCUSING PIX TUBE provides a 50% increase in brightness.

The voltage ratios between the electrodes must be maintained very closely for maximum brightness, and much of the work of designing the new tube was in determining and setting those ratios. To improve voltage stability, a special rectifying and adding circuit is used for the funnel electrode. The primary-winding pulse of the feedback transformer is rectified to obtain 0.7 kV. This is added to the shadow mask voltage of 12.1 kV, bringing the funnel electrode voltage up a little higher than that of the shadow mask to better absorb secondary electrons. The voltages on the elements are thus: screen, 25 kV; shadow mask, 12.1 kV; funnel electrode, 12.8 kV. **R-E**

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Circle 5 on reader service card

letters

AM VS. FM

In a recent issue of your fine publication I noted a review of a receiver marketed by Sansui. The review was conducted by, I believe, Len Feldman of your staff.

This review contained detailed analysis of the receiver's FM reception section, as well as the amplifier section, However, no review of the AM section was included.

I cannot help but feel that your exclusion of the AM section does your many readers a disservice. The state-of-the-art is helped greatly by comparative analysis in publications such as yours, as the consumer tends toward those products that achieve excellence in reviews.

You might wish to note that FCC figures as of May 31st, 1975, indicated that commercial AM stations far outnumber commercial FM stations. In fact, there are presently 4,414 AM stations, compared to 2,630 commercial FM operations in this country.

We are not unaware of the trait toward enthusiasts listening on the FM bands, largely because of the specialization in music available there. However, the preponderance of listening is still with the broadcaster who uses amplitude modulation, and there are advances to be made in the quality of receivers used in that service.

As you may—or may not—know, the AM broadcaster is capable of *transmitting* a signal of comparable fidelity to that found on the FM band. Directing your attention toward the broadcast equipment presently in use, you would find very little difference in the frequency response characteristics. RCA, which supplies the great part of transmitters currently in use, has published figures indicating the great similarity between AM and FM transmitters of equal output power. The frequency response specifications and distortion specifications are very very close in comparing two 5,000 watt transmitters, a common output power in the industry.

Some of the belief that AM is a low-fidelity only medium certainly dates back to the past, when most AM broadcasters could achieve a bandpass of only 5,000 Hz—poor by today's standards. A quick check of the modern proof-of-performance standards indicates that the situation has changed. You will note that the RCA "Ampliphase" AM transmitters achieve an audio bandpass of 30—15,000 Hz ± 1.5 dB (BTA-5L1 5,000 watts) at less than 2% distortion. The FM BTF-5E1 RCA transmitter (5,000 watts) achieves an audio bandpass of 50—15,000 Hz ± 1.0 dB at less than .5% distortion.

The AM band is an important part of broadcasting, and I believe that you would do your readers a service by including specifications of the AM sections of receivers reviewed.

NELSON E. DAHL
Dahl Broadcasting Co.
North Platte, NE

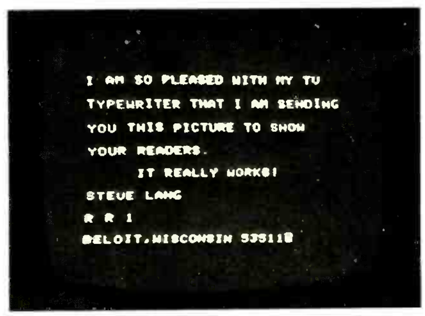
SHOCK HAZARD IN LCD CLOCK

I am very upset about the shock hazard that exists in the LCD clock featured in the August 1975 issue. The clock has a unique construction and because of this, many readers are likely to copy its construction right down to the grain in the wood. This same uniqueness can cause people to handle it with possible fatal results.

I urge you to publish a warning regarding this hazard and suggest that the readers that construct this project install a 1:1 isolation transformer.

DAVID LUNNEY
Greenville, NC

TV TYPEWRITER



OOOOPS!

Please note that there is a misprint contained in the article "All About Oscilloscopes, Part Three," by Charles Gilmore, appearing on page 54 of the August issue. The equation given for phase-angle measurement in Figure 23 should read:

$$\theta = \text{ARC SIN}\,\frac{B}{A}$$

GEOFFREY M. LANGDON
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Now, enjoy the super performance of Digital-Design TV in 5 picture sizes — 25, 21, 19, 17, 15.

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Big, bright, white numbers you can see from any angle, even across the room. Adjustable in brightness. Positionable anywhere on the screen. Adjustable for time duration of up to 1½ minutes or they can remain on all the time, at your option. The numbers change as you change channels. No other channel readout is as convenient.

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Here's a $29.95 option that's a marvel of convenience, too. Big ¾" numbers appearing just below the channel numbers tell you the exact time every time you change channels. Right down to the second, if you wish. And it displays in 12 or 24-hour format.

Fixed-Filter for Best Pictures Longer
Unique. Exclusive. Heath-designed circuitry incorporates a fixed L-C type filter with an integrated-circuit IF amplifier to produce an ideally shaped bandpass. That means you not only get less adjacent channel interference, but also consistently excellent color pictures year after year because it never needs periodic instrument alignment. These Heathkit Color TVs always look better.

100% Solid-State
And more integrated circuits than any. The only tube in these sets is the picture tube. This sophisticated circuitry gives you less interference, truer colors, more precise, reliable tints, improved sensitivity, greater noise immunity, and better picture definition. Solid long-life performance.

The Differences
Tuning. In the 25v and 21v sizes, you get Total Electronic Touch Tuning. Silent varactor tuners, no moving parts. A programmable digital counter controls the tuning — sweeping up or down the 16 preselected channels. And remote control of all functions is just $89.95. In the small screen sizes, the tuning is all-channel detent type.

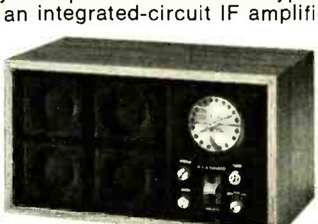
One-Button Picture Control in the three smaller sets restores brightness, contrast, color and tint to pre-set levels at the touch of a button. Child-proof performance.

Latest-design Picture Tubes. In the two larger sets you enjoy brighter pictures with greater contrast thanks to the deluxe Black (negative) Matrix tubes. The three table models use picture tubes with the new precision in-line gun and slotted shadow mask for greater light output and picture realism.

Easier to build and service.
Plug-in circuit modules and wiring harnesses make these sets the easiest to build of all. And the new digital-design Dot Generator, slide-out Service Drawer and Test Meter make self-service easier.

Compare the value.
Send for your free Heathkit catalog, choose the model you prefer. Then compare it with any brand — we think you'll agree you get more for your money with Heathkit Digital-Design Color TV.

For as low as $399.95, you can enjoy Heathkit Digital Design Color TV.



② NEW High Fidelity AM/FM Table Radio

At last, a table radio worth listening to... one that performs like hi-fi components. *5 µV sensitivity;* ceramic filters for *60 dB selectivity;* and an output power of *5 watts,* minimum rms, at less than 1% total harmonic distortion, from 60 to 15,000 Hz into its 8 ohm full range high compliance speaker. The closed cabinet features a teak wood grain vinyl covering and black, molded double-knit jersey front panel. Kit GR-1085, $99.95

③ NEW Programmable Electronic "Doorbell"

Put a song at your doorstep with this unique kit. Program it to play your favorite song. C through C' "keyboard" with plug-in leads for up to 16 notes. Change your tune when you wish to celebrate a season, anniversary, birthday, or special party. One watt sound power; controls for tuning, volume, speed, and decay characteristics. Kit TD-1089, $44.95

④ NEW versatile, low cost 5-digit counter

Measures frequency from 5 Hz to 30 MHz, period to 99.999 seconds, counts events to 99,999, and it will operate on 120 VAC or 12 VDC. As a freq. counter it will resolve to 1 Hz; sensitivity is 15 mV above 50 Hz, 50 mV below 50 Hz. In the period mode, it will resolve to 1 msec. Has Overrange indicator; gate lamp; 3-position input attenuator; 10 MHz time base. Kit IM-4100, $129.95

⑤ MODULUS™

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Heath proudly introduces MODULUS. The totally modular music system that enables you to make of it what you will, change it when you like. With complete freedom. Without obsolescence.

As you like it.

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Your MODULUS custom music system begins with Module I, the AN-2016 Digital AM/FM Tuner/Preamplifier. A superb FM tuner with sophisticated circuitry and exceptional specifications (four ½" LEDs display frequencies; dual JFET, 4-gang tuner with 1.7 μV sensitivity; digital discriminator; LC IF filter with over 100 dB selectivity; phase-locked loop multiplex with over 40 dB separation). AM you'll really enjoy hearing (dual-gate MOSFET tuner and mixer stages; computer-designed 9-pole LC IF filter for no alignment; shielded loop antenna). A superlative preamplifier that functions in stereo or 4-channel modes with specifications unlike any component we've ever offered. Distortion below 0.05% even at full output. Hum and noise are 80 dB below a 0.25 v. input even in the high-level section. A phono preamp with over 94 dB dynamic range — better than most records! Versatile control center. Special speaker protecting circuitry. Four lighted output meters with 40 dB dynamic range. Separate bass, treble, and level controls for front and back channels. Master volume control. 21 pushbutton switches that light when activated. They include: output; inputs (stereo phono, CD-4, aux., tape, tape monitor, dubbing AM and FM); mode (mono, stereo front channels, stereo 4 channels, SQ, and discrete 4-channel); high filter; low filter; loudness; tone flat; squelch defeat; FM Dolby; and power. Use it as a tuner only, as a driver for your present power amps, as a control center for taping, so good you can even use it as a broadcast station monitor. Kit AN-2016, $599.95

Expand your MODULUS system with your choice of stereo power amplifiers. Module II is the medium power AA-1505. Module III is the high power AA-1506. 35 or 60 watts, min. RMS, per channel into 8 ohms at less than 0.1% distortion from 20-20,000 Hz. Styled to match the Module I tuner/preamp. Add one of either power level for a stereo receiver; add two for a 4-channel receiver. Kit AA-1505, $159.95; AA-1506, $179.95

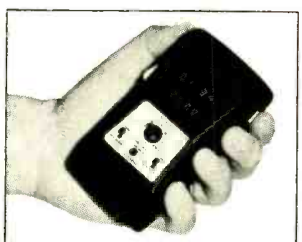
Choose your mode and input. Module IV is the FM Dolby module AD-1504 for reduced noise and greater dynamic broadcast range ($39.95). Module V is the CD-4 Demodulator for the spacious sound of CD-4 discrete 4-channel records ($79.95). Module VI is the SQ Decoder for quadraphonic separation of matrixed material; full logic and variable blend ($49.95). All are housed inside the tuner/preamp module.

A "Living" music system.

MODULUS is designed for you — the way you live — today and tomorrow. It can grow with you, adapt to your changing life style, flex with changing technology. Whatever your desires in music systems, now and later, MODULUS.

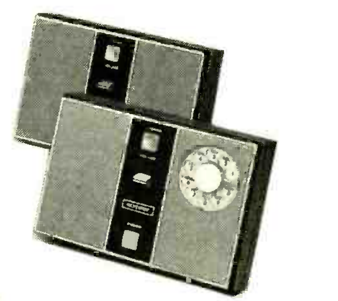
⑥ NEW 3-Way Speaker

Looks and sounds like it should cost $100 more! High performance 3-way system has a 10" woofer, 4½" mid-range, 1" dome tweeter. Drives with 10 watts, yet a super-power amp reveals its unusual dynamic range and high power handling capabilities. Enclosure has walnut veneer on all sides and front for use without the black foam grille. Tweeter and front-mounted switch plate are interchangeable for optimum imaging in horizontal or vertical position. Kit AS-1373, $149.95



⑦ NEW Digital Stopwatch

Programmable — for the time of your sporting life. You program in a time (up to 9 hours, 59 min., 59 secs.) and it will count *up* to that time or *down* from it to zero. Or it will count 99 hours, 59 mins., 59:99 secs. in the five other functions which include: Start/Stop Elapsed; Sequential; Total Activity; Split; & Start/Stop Activity. 8 digits & 2 IC counters with accuracy to ±0.003% & resolution to 1/100th second. Jacks for external trigger and alarm. Includes nickel-cad. batteries & charger. Kit GB-1201, $99.95



⑧ NEW 2-Way Telephone Amps

Amplified "talk" and amplified "listen", with or without dialer. Real hands-free convenience — use from 10' away. VOX control silently switches from built-in microphone to speaker without clipped words or feedback squeals. GD-1112 works with regular phone. GD-1162 with built-in dial and electronic ringer works like an extension phone. Easy to build, convenient for use at home or office. Kit GD-1112, $49.95; Kit GD-1162, $69.95.

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Circle 100 on reader service card

State of SOLID STATE

by KARL SAVON
SEMICONDUCTOR EDITOR

THAT NEW ELECTRONIC CASH REGISTER at the downtown department store has a heart of silicon. Microcomputers are taking over the number shuffling and inventory tasks at the checkout counter. Hidden by familiar equipment, the microcomputer also controls some of those "smart" multiple-way traffic signals. They flex with changing traffic

(continued on page 26)

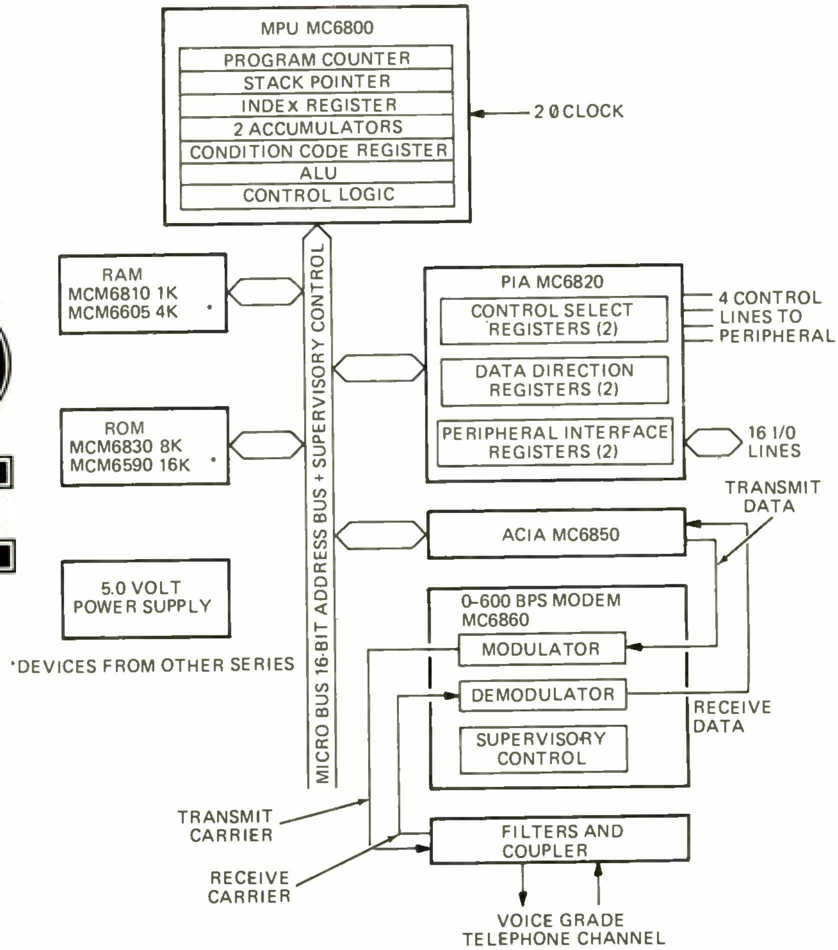
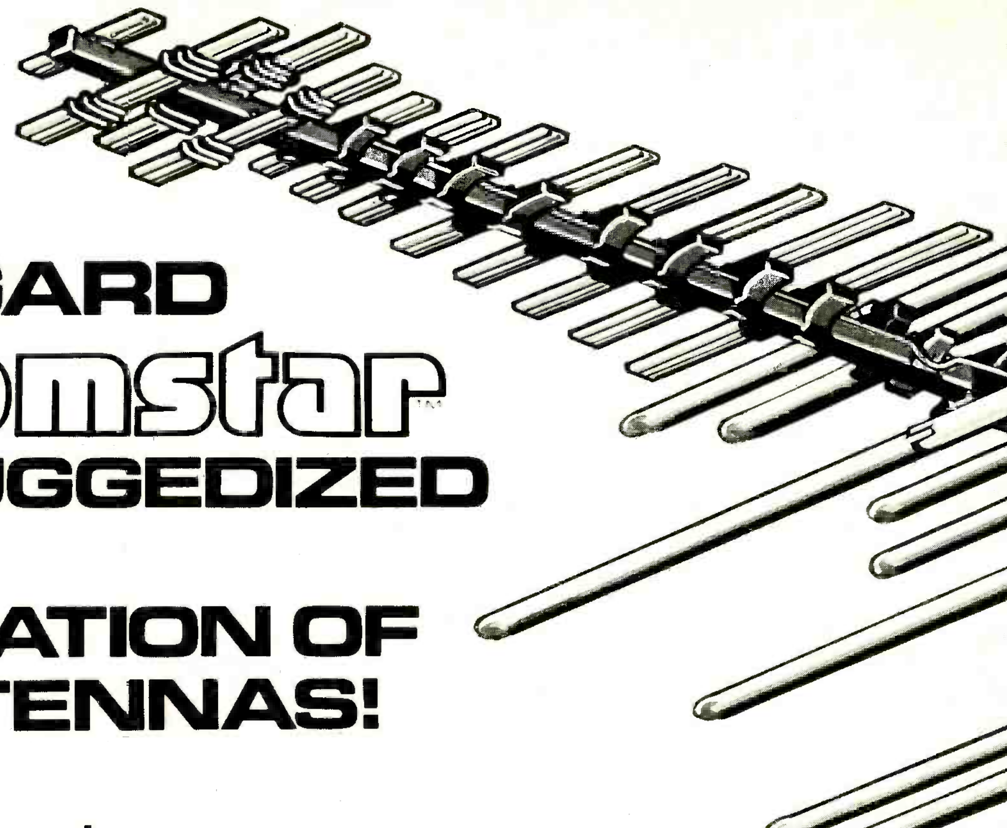


FIG. 1—MOTOROLA'S M6800 microcomputer system.



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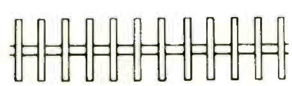
NEW TRI-LINEAR UHF DIRECTOR SYSTEM*

Increases Gain up to 30%!
Provides broader signal capture area in a more compact configuration.

ORDINARY UHF Director System.

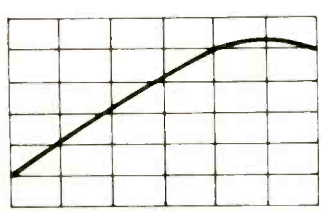
5½"

Uses half-wave directors approximately 5¼" long which respond primarily to the high end of the band, with very little gain on the low end.



55"

Boom length required for 12 directors

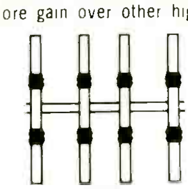


Typical gain curve with ordinary UHF directors. Note low response on low end of band.

WINEGARD High Gain Tri-Linear* Directors

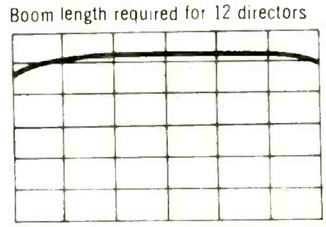
15¾"

Act as 3 half-wave directors on the high end of the band, and re-resonate as a loaded half-wave director on the low end of the band. This results in high linear gain on all UHF channels, giving the antenna sharper directivity and up to 30% more gain over other high gain UHF antennas.



10"

Boom length required for 12 directors



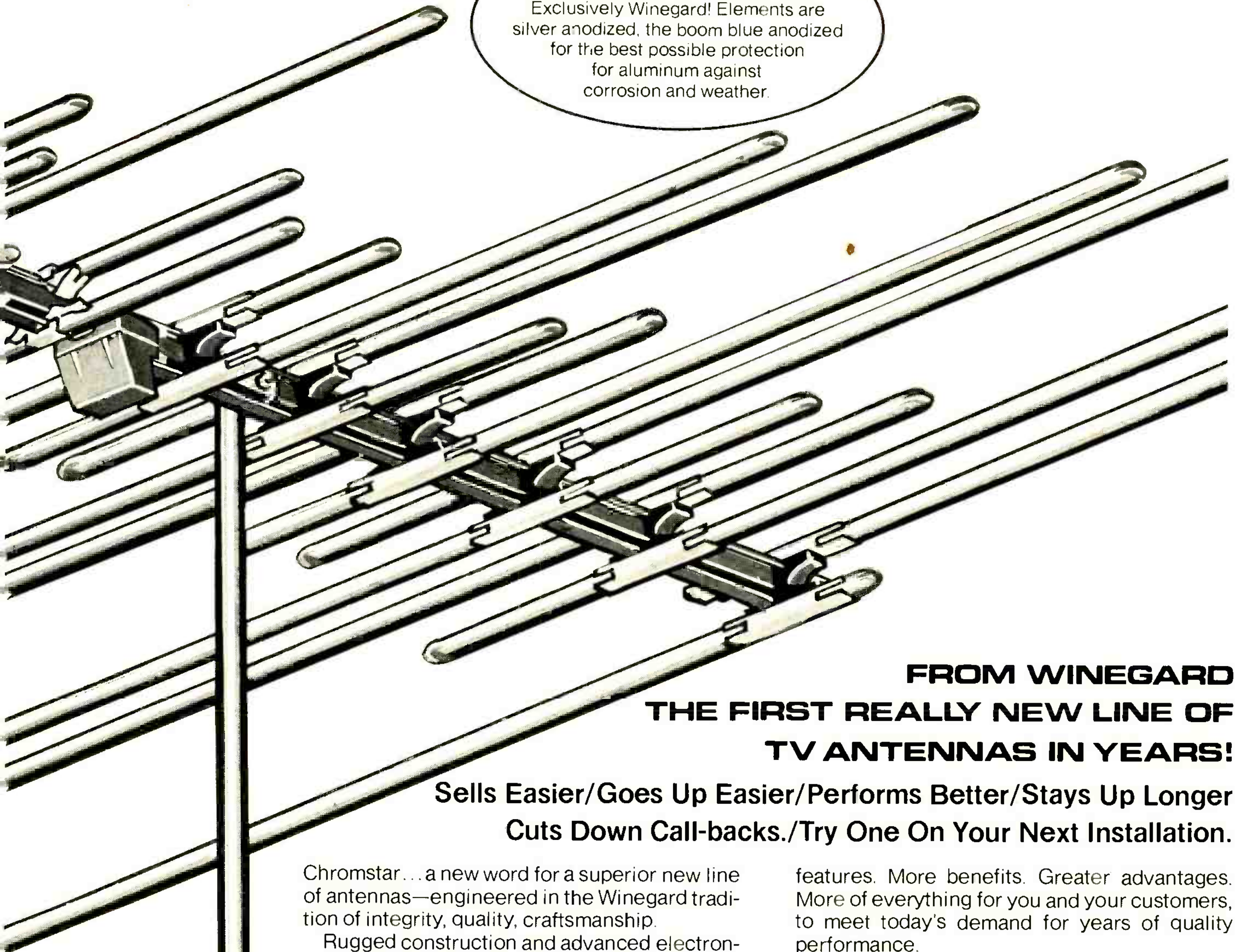
Typical gain curve with Winegard Tri-Linear directors. Note high uniform gain across entire band.

WINEGARD
TELEVISION SYSTEMS

3000 KIRKWOOD
BURLINGTON, IOWA 52601

ANODIZED!

Exclusively Winegard! Elements are silver anodized, the boom blue anodized for the best possible protection for aluminum against corrosion and weather.



FROM WINEGARD THE FIRST REALLY NEW LINE OF TV ANTENNAS IN YEARS!

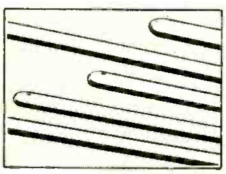
Sells Easier/Goes Up Easier/Performs Better/Stays Up Longer Cuts Down Call-backs./Try One On Your Next Installation.

Chromstar . . . a new word for a superior new line of antennas—engineered in the Winegard tradition of integrity, quality, craftsmanship.

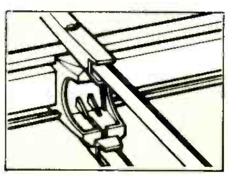
Rugged construction and advanced electronics move this new line even farther ahead of other antennas. More powerful performance all down the line. New Tri-Linear director system gives sharper directivity and up to 30% more gain over other high gain UHF antennas. New features. More benefits. Greater advantages. More of everything for you and your customers, to meet today's demand for years of quality performance.

GET ALL THE FACTS FROM YOUR WINEGARD DISTRIBUTOR, PLUS FREE SPEC CHARTS ON ALL MODELS. Try Chromstar on your next installation and see the *big* difference.

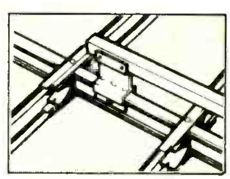
RUGGEDIZED! Chromstar antennas are designed to defy weather and wear—are engineered for *extra* strength at all points of stress. You can actually see the difference in the rugged construction.



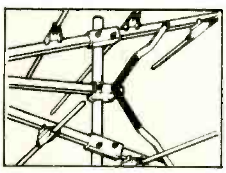
Exclusive 7⁄16" diameter aluminum tubing for 30% greater strength, better performance, longer life. Winegard is the first and only manufacturer to use this larger diameter.



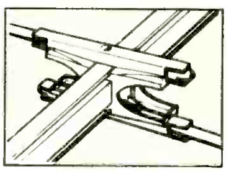
New truss-type phasing bars, top and bottom, with more conductive surface, give maximum transfer of signal. Truss-type "bridge" construction more than doubles boom strength.



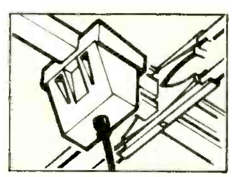
Double boom on longer flat line models for extra strength & rigidity.



New scissors - type struts between upper and lower booms and center boom on wedge models, for extra support, easier installation.



High-impact girder design support insulators are moulded of super-tough Noryl G-E plastic. Four positive locks give maximum support and permanent alignment.



Critical-point weather protection! *New compact weatherproof cartridge housing for downlead, preamplifiers and filter modules. New printed circuit downlead module with both twin lead and 75 ohm coax connections. No separate matching transformer required.

TV ANTENNAS MORE PEOPLE LOOK UP TO

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STATE-OF-SOLID-STATE

(continued from page 22)

patterns and shorten the wait on secondary roads when the traffic permits.

But the real potential of the "computer on a chip" is just beginning to be realized. "Micro" may tell something about the size of the machine, but some of the best things come in small packages. Microcomputers are replacing conventional logic designs. Chip count of complex logic systems can often be reduced ten fold or more. And microcomputers are starting to show up in general purpose minicomputers. This time the prefix "mini" is misleading since many minicomputers outflank their big brothers of a few years ago in both price and performance. The general purpose computer, no matter what its prefix, will probably be a common household fixture in about ten years. Even sooner, dedicated microcomputer systems will control home heating and automotive systems.

So you see, microcomputers fall into two basic user categories—dedicated preprogrammed controllers, and more general user programmed types. Many of the specially programmed units do not operate at high speeds. On the other hand, high speed is a definite advantage in the general purpose computer. If you've spent any time with scientific calculators you know that the calculation time for trigonometric and logarithmic functions can run into seconds. Iterative series evaluation of algorithms proceed step after step until the calculation error falls below a preset level. In a computer, thousands of steps transpire during relatively simple procedures.

Motorola has a microcomputer system with an architecture aimed at both these categories. It runs towards the higher end of the speed range and is relatively easy to program.

Motorola M6800 microcomputer system

Like some other microcomputer systems, the M6800 is actually a series of IC's: the MC6800, MCM6810, MC6820, MCM6830, MC6850, and the MC6860. Motorola has chosen not just to build a single microprocessor chip but to support an entire complementary system. Five of the circuits are already available and the sixth should be on the market about the time you read this. The circuits fit together in the neat organizational plan shown in Fig. 1. The whole computer works from a single 5 volt power supply for economy, pin utilization, and compatibility with TTL and CMOS logic. There are also some preexisting 5 volt static memories. MOS N-Channel Silicon Gate processing is used throughout.

(continued on page 32)

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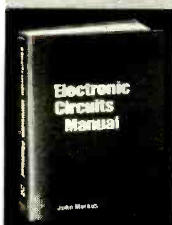

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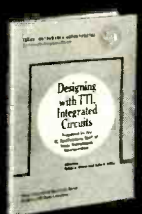

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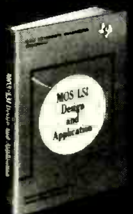

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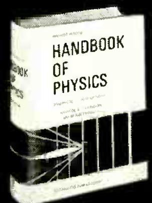

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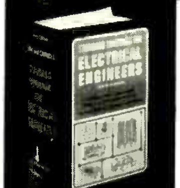

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(continued from page 26)

Motorola's Micro Bus is a universal bus system where all communications between system components takes place over the same set of wires. It is an approach being used by a number of the minicomputer manufacturers with success. The M6800 strongly resembles Digital Equipment's well known PDP-11 minicomputer. Input and output functions are similar to memory instructions. Peripheral devices are addressed as part of a total 65K word address space.

Computer systems are designed around a CPU (Central Processing Unit). The CPU for the M6800 is the MC6800 chip. It contains the control logic to sequentially fetch instructions from memory and decode each of a set of 72 instructions. Each instruction can either be 1, 2 or 3 bytes long. One byte is an 8-bit word. The CPU generates control signals to carry out logic, shift, memory reference, skip, and arithmetic instructions.

MOTOROLA MC6800 CPU

Arithmetic operations are carried out in two's complement or decimal formats. Two's complement is a binary number system widely adopted by the computer industry partly because of the ease of converting to negative numbers. A positive number that is complemented simply by changing all zeros to ones and ones to zeros, and then incremented by 1 becomes a negative number. There are also interrupt instructions that peripherals can use to direct the computer to jump to programmed service routines.

Interrupt programming lets the computer to continue with its business during the time it takes a printing device such as a teletype to print a character. "Push-down" and "pop-up" instructions take care of an assigned portion of memory called a stack where return addresses are stored and reclaimed during execution of nested subroutines.

CPU's use registers to keep track of things and help do arithmetic. The MC6800 has six. A 2-byte (16-bit) program counter increments its contents to select the next instruction from the program stored in memory. The increments are unity except when multiple word instructions or jump instructions are used. A jump instruction inserts the calculated address portion of the instruction into the program counter causing the next instruction to come from the "jumped to" address. Another two-byte register holds the stack pointer, the address of the next available location in the stack. The third two-byte register is the index register used to index or add to the address in a memory reference instruction. This addressing mode is useful in list processing. The remaining three registers are a single-byte in length. Two are accumulators that operate with the ALU (Arithmetic and Logical Unit) portion of the CPU. A condition code register holds sign and overflow information used for conditional branching decisions.

Addressing modes are an important consideration in overall programming. Beginning programmers may be surprised at the large program segments used to calculate addresses. The number of instructions alone is a poor guide to programming ease and efficiency. A better indicator is the number of steps required to carry out benchmark procedures. The MC6800 has a wide assortment of addressing modes, seven in all—direct, relative, immediate, indexed, extended, implied, and accumulator.

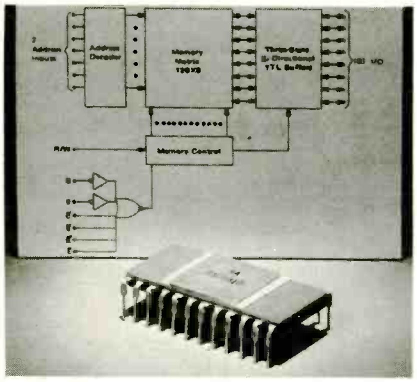
Memory is an essential part of any computer system. Both the data and program steps are stored in memory.

(continued on page 34)

STATE-OF-SOLID-STATE

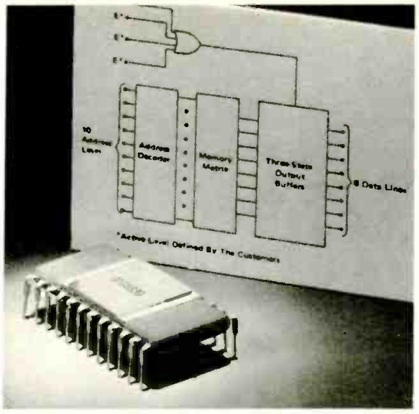
(continued from page 32)

Random-access memory, read-only memory, or a combination of both are used in any one system. RAM's are the most versatile but are more expensive and often slower than ROM's. The MC6800 series includes the MCM6810 128 × 8 bit static-RAM and the



MOTOROLA MC6810 128 × 8 BIT RAM

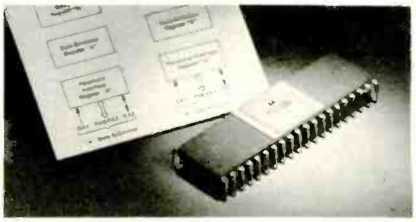
MCM6830 1024- × 8-bit ROM. General purpose machines have a large amount of random-access memory since they must handle any conceivable program that the user wants to store. In contrast, the task dedicated machine often only has to follow a single pro-



MOTOROLA MC6830 8K ROM

gram permanently stored in its ROM. The MCM6830 8K static ROM does not have clock or refresh inputs. Maximum read-access-time is 575 nanoseconds. The MCM6810 1K RAM is also a static memory and is neither clocked nor refreshed. The MCM6810 is available in two versions; the L unit has a maximum access-time of 1 microsecond and the L-1, 600 nanoseconds. Larger sized RAM's are predominantly dynamic and slower since the stored bit charges leak off with time and must be systematically rewritten. Both memory chips have three-state outputs. They can be paralleled and then enabled one at a time by select inputs.

Motorola calls the MC6820 Peripheral Interface Adapter (PIA) the articulate interface. The PIA eliminates much ancillary logic when interfacing many peripherals. By making the pe-



MOTOROLA MC6820 PERIPHERAL INTERFACE ADAPTER

ripherals addressable like memory, the device can be programmed by the user to meet a wide range on input and output applications. The MC6820 is a 16-bit parallel interface that lets the computer interconnect with devices such as keyboards, magnetic disks, and cartridges, CRT displays and terminals, numerical control equipment—anything you want the computer to control or be controlled by. The bus connections between the CPU and any PIA is 8-bits and bi-directional. Peripherals connect to the PIA on two 8-bit bi-directional busses. Any of the 16 lines can be programmed as an input or output of the adapter. There are four addi-

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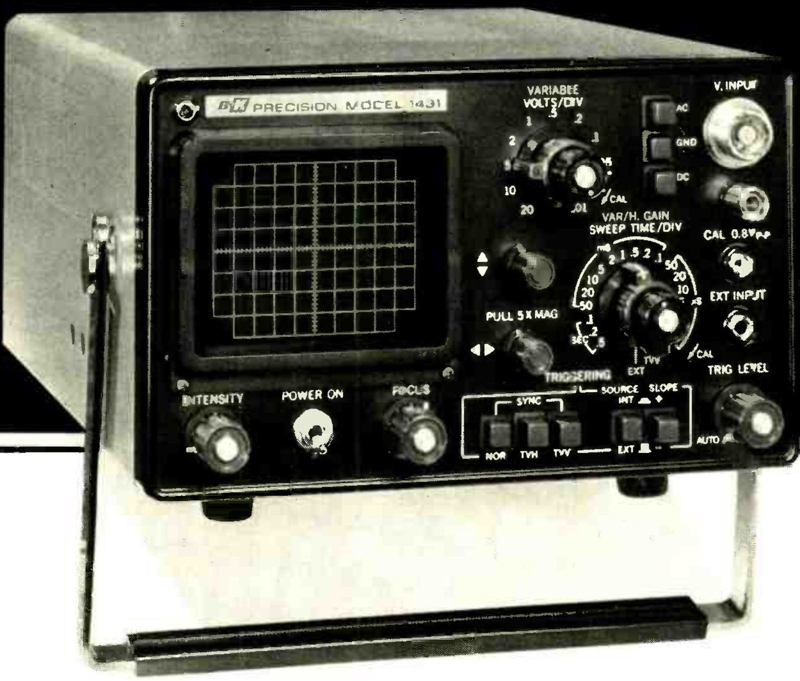

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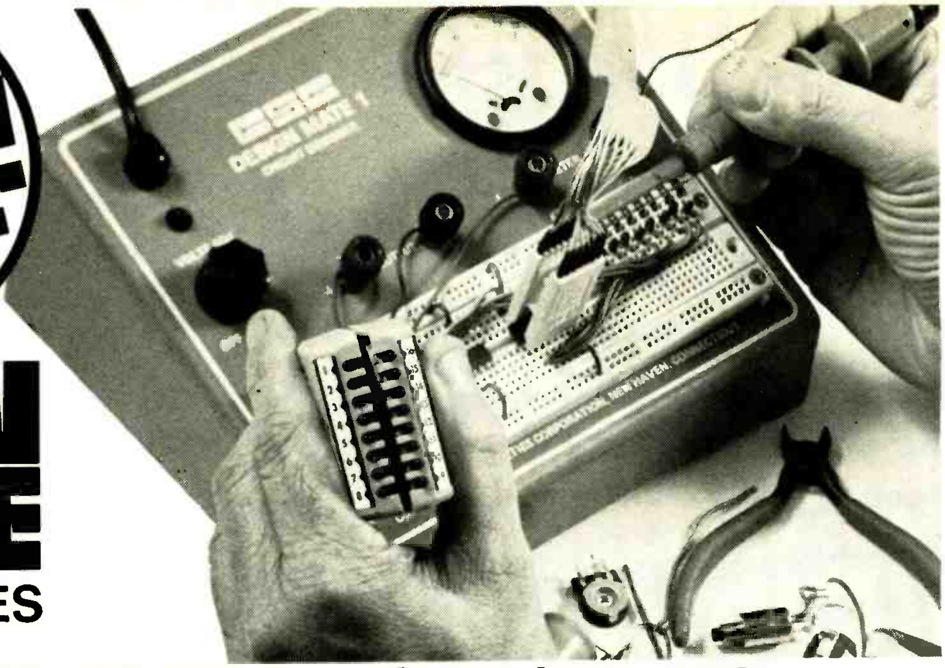

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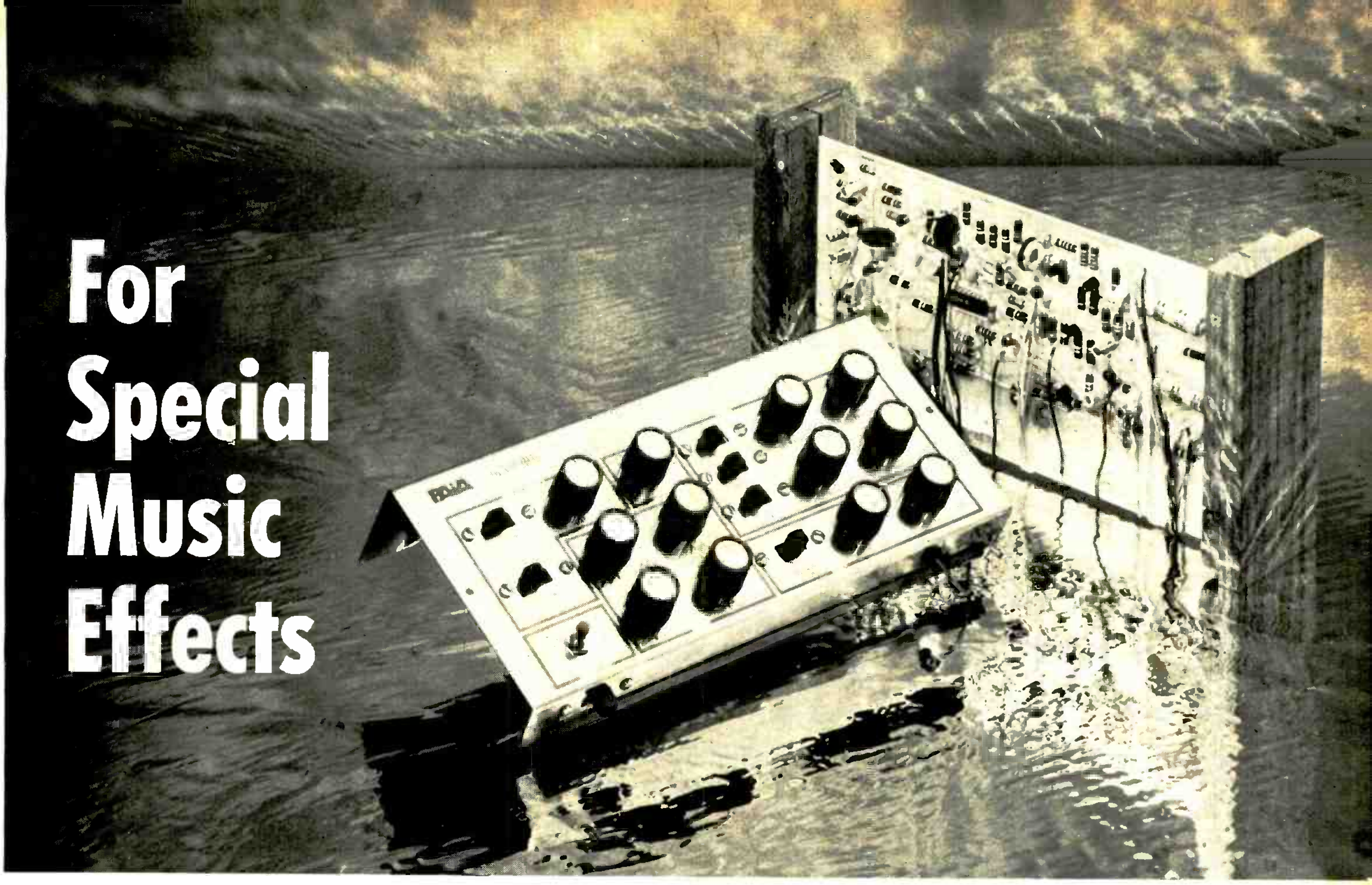

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by JOHN S. SIMONTON, JR.

IF THE TERM "ELECTRONIC MUSIC SYNTHEsizer" calls to your mind a picture of Walter Carlos wandering glassy eyed among a room full of equipment festooned with thousands of knobs and switches and draped with miles of cable, you're a little out of touch.

After years of patching together the amplifiers, oscillator, filters and other individual modules of the early day synthesizers, an interesting pattern began to emerge. Manufacturers and users alike discovered that most of the useful sounds that the equipment could produce were obtainable with a handfull of different patching arrangements. That was the beginning of the "normalized" performing synthesizer.

Basically a normalized synthesizer is one in which the separate elements are pre-arranged in a specific configuration (oscillators feeding amplifiers feeding filters feeding the output, ordinarily) with front panel controls to select various oscillator waveforms and set the level of audio and control signals. Except in studio, University or hobby machines, patch cords are rare and sounds are changed simply by turning a knob or flipping a switch.

To show how normalization works, and to give you a really low cost introduction to synthesis generally, we present the GNOME. The GNOME is a micro-synthesizer that employs the same voltage control techniques that give synthesizers their almost unlimited versatility while featuring controls that are so simple to operate even children can pick out sounds and tunes in the first few minutes.

What's a synthesizer?

The currently fashionable way of thinking of synthesizers is in terms of analog computers. This has the double advantage of giving the electronics technician lacking a musical background a starting point closer to his home stomping ground. It also gives the musician an equivalency between electronic elements and the mechanical counterparts that he already knows. For example, the oscillator of a synthesizer corresponds to the vibrating strings, reeds, or whatever of a musical instrument. The filters correspond to the resonant properties of the body of the instrument. The instrument dynamics (attack and decay) correspond to the voltage-controlled amplifier/function generator combination in the synthesizer.

Once a synthesizer is viewed in these terms, it becomes immediately apparent what the real strengths of the equipment are. It would be difficult to build a mechanical instrument that combined the harmonic structure of a vibrating string with the resonant characteristics of a slide trombone. But with the electronic equivalents of these elements such strange "cross-breeding" is relatively simple.

The GNOME

A block diagram of the normalization scheme is shown in Fig. 1. The built-in controller (a simple voltage divider) provides a control voltage that is proportional to the position of the wiper probe along the strip of conductive elastomer. The front-panel switches routes this control voltage to either the voltage controlled oscillator (VCO) or voltage controlled filter (VCF).

The VCO has two basic output waveforms; a triangle and a square wave. A SKEW control on the input of the oscillator changes the triangular-waveform output to a ramp while the square-wave changes to a short duration pulse, giving the user the option of four waveforms from a low-cost oscillator. Individual level controls on the oscillator's two outputs allow for selecting or mixing the desired waveforms.

The outputs of the oscillator feed a common audio bus as does the output of the GNOME's internal noise source, also with its own level control. The audio bus always drives the GNOME's VCF, but a switch at the input of the voltage-controlled amplifier (VCA) allows the user to bypass the action of the filter if desired.

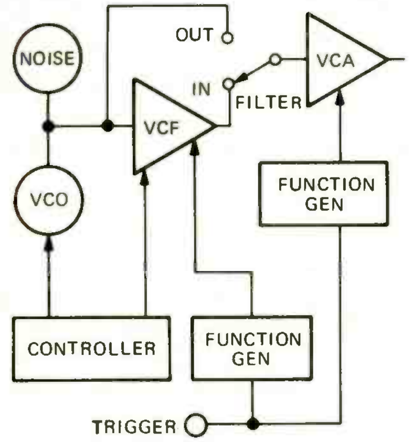


FIG. 1—NORMALIZATION SCHEME of the GNOME.

There are two internal function generators, one dedicated to providing a control voltage for the VCF and the other dedicated to the VCA. Each of these function generators provide for either percussion or sustained envelopes and the VCF's function generator has the added feature of a REPEAT switch that allows it to serve as its own trigger source for low speed cyclic effects similar to tremolo. Both function generators are normally triggered from a front panel TRIGGER button but provision has also been made for external trigger sources such as foot switches or sequencers.

There are many other features to the circuits of the GNOME but these will be covered in the individual circuit discriptions.

Controller

The schematic diagram of the controller, noise source, trigger and power supply is shown in Fig. 2. The "sawtooth" geometry of the conductive elastomer that forms the control strip of the GNOME combines with the paralleling resistors R8 through R11 to produce an exponential voltage distribution along the surface of the strip. The RANGE potentiometer R78 is in series with the effective resistance of the control strip forming a voltage divider. Increasing the resistance of R78 decreases the voltage that appears across the length of the strip.

The wiper probe of the control strip is decoupled by an emitter follower in the VCO to prevent loading of the controller. This probe picks a voltage from the strip that is proportional to the position of the probe along the length of the strip. Switches S2 and S3 allow this voltage to be routed either to the VCO, VCF or both simultaneously.

The diodes at the bottom end of the control strip provide a constant voltage drop of approximately 1.5 volts insuring that there will be sufficient voltage on the strip to drive the VCO regardless of the setting of R78.

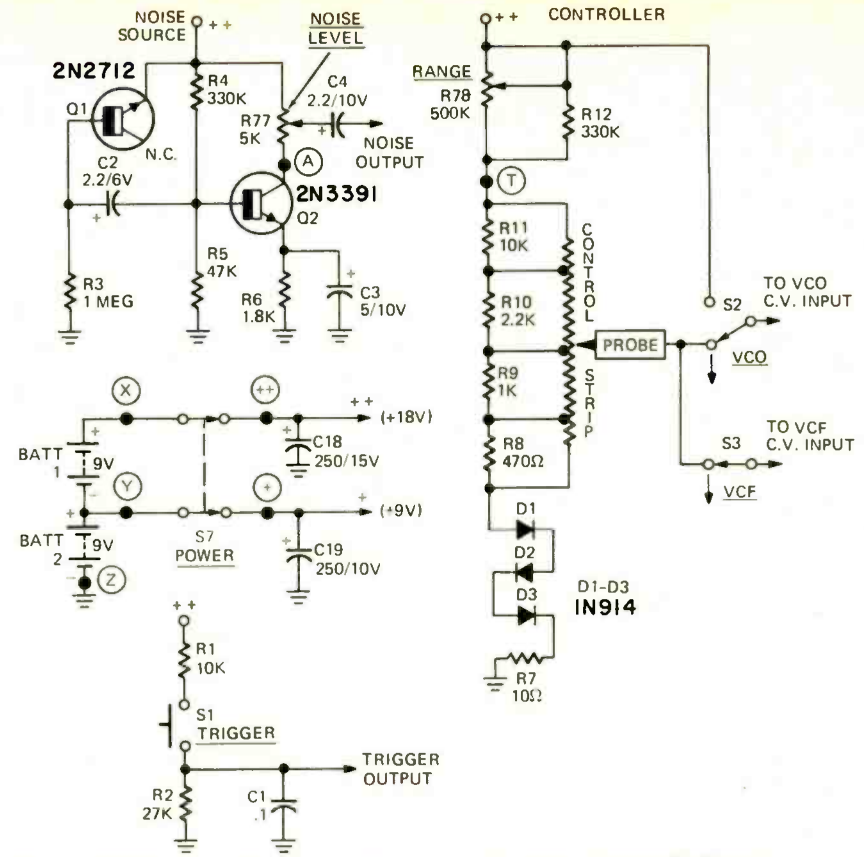


FIG. 2—CONTROLLER, noise source, trigger and power supply schematic diagram.

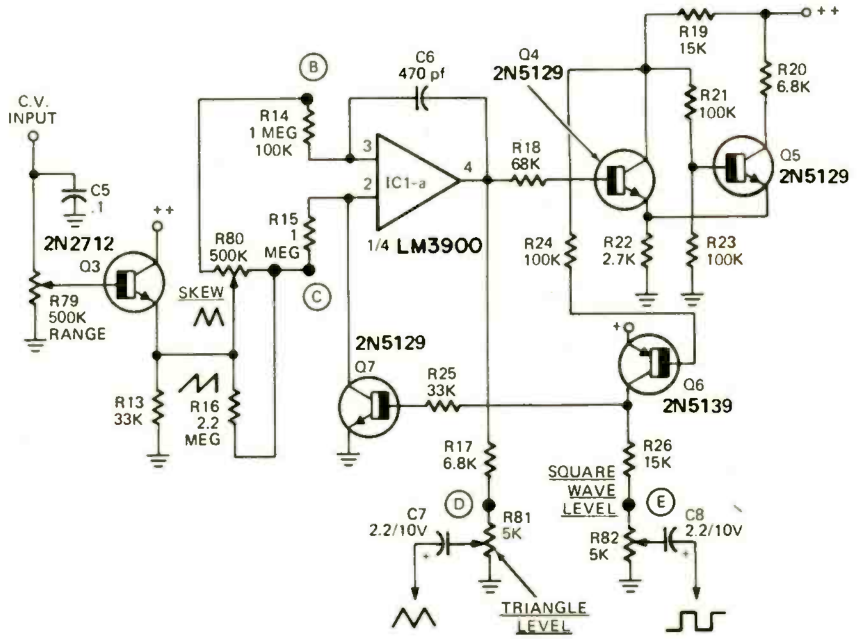


FIG. 3—VOLTAGE-CONTROLLED OSCILLATOR schematic diagram.

Noise source and trigger

The GNOME's noise source (see Fig. 2) is a standard design employing the shot-noise that results from the avalanching process of the reverse-biased base-emitter junction of transistor Q1. The noise appears across resistor R3 and is coupled by capacitor C2 to the single-stage amplifier comprising Q2, R4, R5 and R6. Potentiometer R77 is the level control for the noise source and as the wiper of this control is moved toward the collector of Q2, the amount of noise introduced in to the common audio bus is increased.

The TRIGGER push-button S1 (see Fig. 2) connects the +18-volt supply line to the trigger bus through R1. Capacitor C1 bypasses contact-bounce impulses to ground.

VCO

The schematic diagram of the VCO is shown in Fig. 3. Control voltages are applied to the oscillator at the point marked "c.v. input". Capacitor C5 bypasses to

Parts List

All resistors ½-watt, 10% unless noted.

R1,R11,R34,R36,R40,R41,R61,R69—10,000 ohms
R2—27,000 ohms
R3,R14,R28,R31,R37,R48,R63,R64,R72—1 megohm
R4,R12—333,000 ohms
R5,R35,R51—47,000 ohms
R6,R33—1800 ohms
R7—10 ohms
R8—470 ohms
R9,R53,R76—1000 ohms
R10,R68—2200 ohms
R13,R25,R38,R55,R54,R67,R73,R75—33,000 ohms
R15,R21,R23,R24,R45,R44,R59,R71—100,000 ohms
R16,R46,R49—2.2 megohms
R17,R20,R27,R50,R52,R74—6800 ohms
R18—68,000 ohms
R19,R26,R32,R58—15,000 ohms
R22—2700 ohms
R29,R56,R57—100 ohms
R30,R60—150,000 ohms
R39,R70—470,000 ohms
R42,R66—4700 ohms
R43—22,000 ohms
R47—3.9 megohms
R62—220,000 ohms
R65—680,000 ohms
R77,R81,R82,R84—5000 ohm linear taper potentiometer
R78,R79,R80,R85,R86,R87,R89.R90—500,000 ohm linear taper potentiometer
R83,R88,R91—50,000 ohm linear taper trimmer pot.
C1,C5—.1μF Mylar
C2—2.2 μF 6V electrolytic
C3—5 μF 10V electrolytic
C4,C7,C8,C12,C14,C15,C16—2.2 μF 10V electrolytic
C6—470 pF ceramic disk
C9,C10—.001 μF ceramic disk
C11—33 μF 10V electrolytic
C13,C17—.005 μF ceramic disk
C18—220 μF 15V electrolytic
C19—220 μF 10V electrolytic
D1-D11—1N914 diode
IC1—LM3900 quad current differential amp
Q1—2N2712 selected low noise transistor
Q2,Q12,Q13—2N3391 transistor
Q3,Q14,Q15—2N2712 transistor
Q4,Q5,Q7,Q9,Q10,Q16—2N5129 transistor
Q6,Q11,Q17—2N5139 transistor
Q8—MPF-102 transistor
S1—SPST normally-open push-button
S2,S3,S6,S8—SPDT slide switch
S4,S5,S7—DPDT slide switch
BATT 1,2—9-Volt transistor battery (NEDA 1604 or equal)
MISC.—9-lug terminal strips (2), pin jack, pin plug, miniature phone jack, circuit board, control strip, battery snaps, ¼-in. grommet, knobs (12), wire, solder, hardware, etc.

NOTE—The following are available from
PAIA Electronics, Inc.
1020 W. Wilshire Blvd.
Okla. City OK 73116
Circuit board and control strip
Order #3740-P—$8.50 postpaid
Complete kit of all parts except batteries
Order #3740-K—$48.95 plus postage and insurance for 4 lbs.

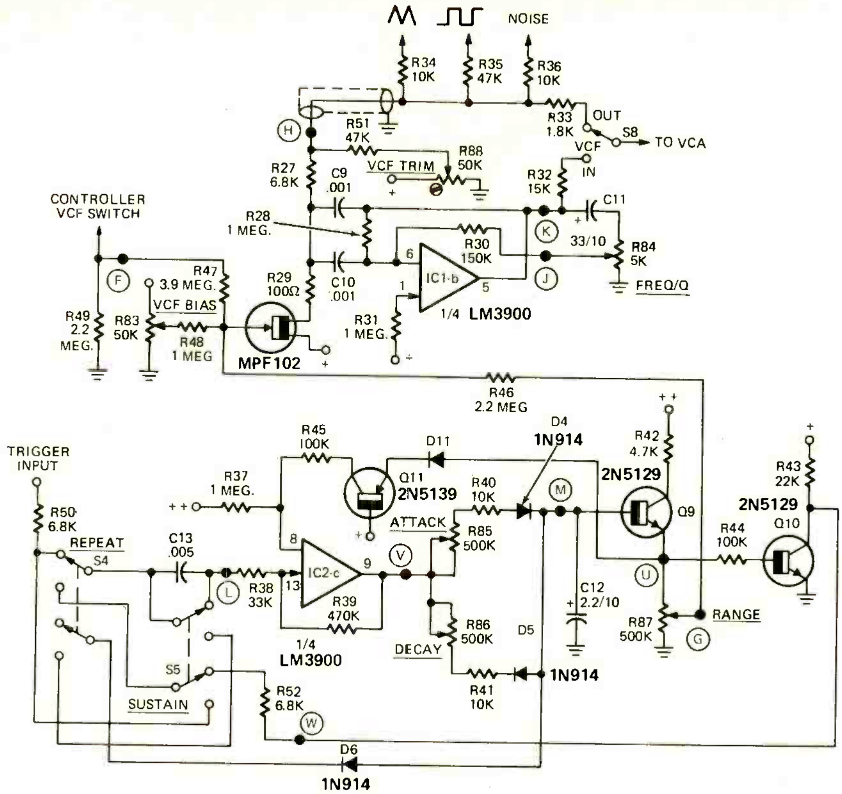


FIG. 4—VOLTAGE-CONTROLLED FILTER schematic diagram.

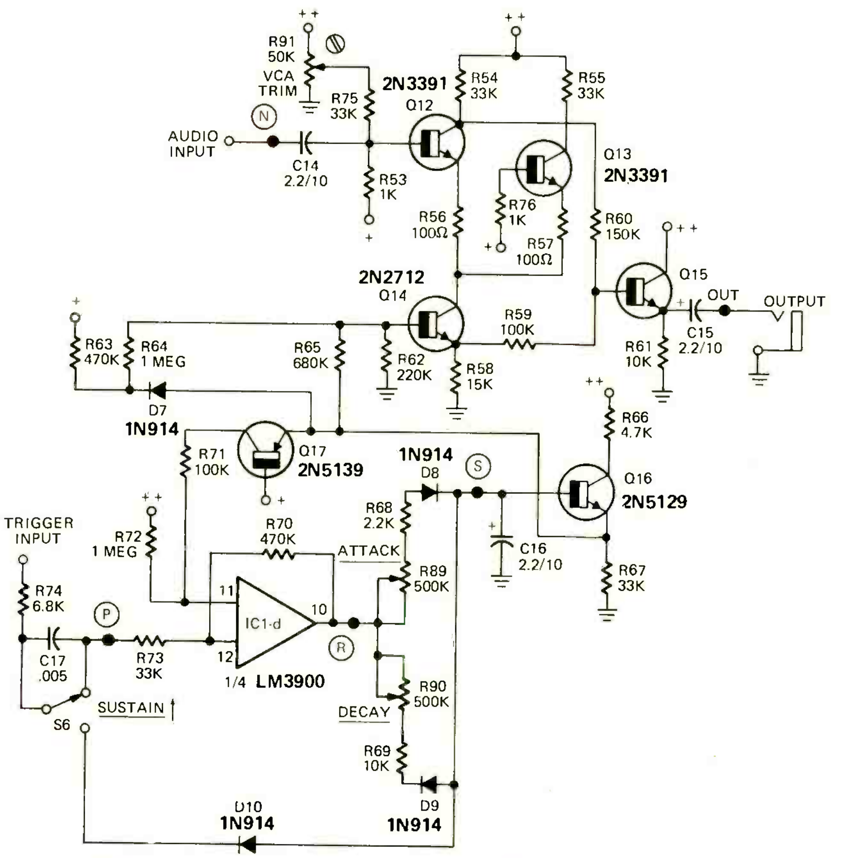


FIG. 5—VOLTAGE-CONTROLLED AMPLIFIER schematic diagram.

ground contact-noise originating at the control strip. The control voltage is then applied to the VCO RANGE control R79 which serves as an attenuator on the control-voltage line. Emitter-follower Q3 serves as an impedance-matching device between the control-voltage input and the oscillator circuitry.

The oscillator is a relatively common type consisting of an integrator (IC1-a) and a Schmitt-trigger comprising discrete transistors Q4 and Q5 and associated components.

(continued on page 100)

Test Equipment for Industrial Servicing

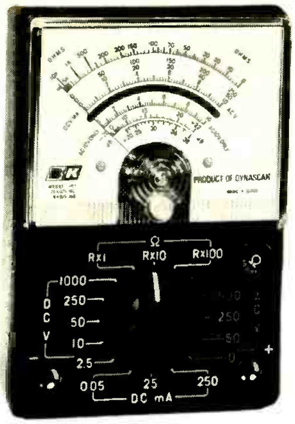


FIG. 1—B & K VOM's. Model 101 is shown above. Model 102 is shown at right.

Specialized servicing requires specialized test equipment. Here's a round-up article on industrial test equipment.

by JACK DARR
SERVICE EDITOR

"INDUSTRIAL ELECTRONICS" IS A SHORT phrase that covers many different things. Here, it means *control.* The machine does the work, and the electronics tell it what to do. Electronic controls tell it when to start and stop, and if it isn't doing something right, they shut down the whole process. These controls come in a great variety of sizes and shapes, all the way from a simple SCR and a few resistors up to large arrays of IC's and logic.

TV viewers may have the impression that complicated electronic machinery is made up of big panels full of flashing lights, which go "a'BEEP'm, a'BEEP'm" all the time. Fortunately, this isn't true. When the crisis occurs, great arcs and sparks fly, and clouds of smoke boil out. Evidently the designers of this complicated electronic machinery never heard of fuses or circuit breakers.

Real life electronic controls are not noisy, and are much better protected. They do not go "a'BEEP'm"; when something happens, they just click quietly and stop the machine. They have two major functions; control of operations, and protection against damage. Monotonous operations can be broken down into a series of simple steps, each with its own set of electronic control units.

As briefly as possible, such a system starts with a "transducer". This is a device that detects quantities; movement, heat, pressure, flow, or any thing else that will provide the information needed. The transducer converts this into an electrical signal. This goes to an amplifier, where it is processed into signals needed to do the actual controlling. If the transducer reading shows that the machine is out of tolerance, or doing something wrong, it actuates a circuit to stop the machine. This can be a relay (usually called a "contactor" if it's big enough) or solid-state switches. Every known form of electronic reaction is used in transducers; resistance, voltage, current, magnetic fields, capacitance, inductance, photoelectric, thermoelectric and piezoelectric reactions, and even radioactivity. There are a lot of these; one reference work lists 1250 different types.

The name of the game is "downtime": this must be avoided, or reduced to an absolute minimum. Most electronic control systems are designed so that they can be serviced quickly and easily, to get the machine back on-line as soon as possible. In one real machine, an electronically controlled lathe, there are ten steps in its process. Each one is controlled by a small PC board ("card") that plugs into a rack in the control cabinet. If the machine goes to step 8 and stops, the technician starts testing by pulling card 8 and trying a new one. If this clears the trouble, the bad card is taken back to the bench and checked out. In quite a few machines like this, the cards are all the same which makes servicing much faster.

Power supplies for the control units are well overrated for cool running, and protected by fuses and circuit breakers. Plug-in rectifier cards, and similar devices are also used to speed testing. The cards themselves are comparatively simple, with "switching" done by circuit-conductors, and control functions by SCR's, switching transistors and diodes, and so on. They may be tested and repaired with very little trouble.

Specially-built test gear

Industrial electronics work, therefore, requires test equipment that can be used to check out all parts of the system quickly and accurately. This may require checking high voltage AC or DC, currents, as well as reading lower voltages used on transistors and other solid-state devices. The test equipment is an essential part of the whole system. It must be versatile, to cover the wide range of quantities to be measured, and rugged, to withstand the normal wear and tear of daily work. It must also maintain its accuracy over long periods.

The test instrument that will do all of these things; read AC or DC voltages and currents over a wide range, resistances, and make continuity tests, is the good old volt-ohmmeter (VOM). Later on in this series, we'll get to some highly specialized and complex instruments. However, at the "primary level", most of the load is carried by the VOM.

There are a great many of these. The ones you'll see here are mainly the units designed to do this type of work. They're well-built, rugged, and protected against accidental physical damage from dropping, and from electrical damage from accidental overloads. All are high-quality test instruments; they will last longer and cost far less. The "$9.95 wonders" just won't hack it. One fall off the bench, or one instant contact with high voltage, and all you have left is a little black box making ominous noises and leaking foul-smelling smoke, all full of tiny bits of carbon.

All of the high-quality industrial VOM's will have very close to the same vital statistics. The size and shape will differ, but the essential functions will be there. This reads something like this: sensitivity, 20,000 ohms-per-volt (or more); AC and DC voltage and current reading from a very low range up to perhaps 1000 volts; ohmmeter ranges from a very low range up to ×10K scale; DC current from a few microamperes up to several amperes, and DC millivolt ranges to an astonishingly low level.

Physically, most of them are built in high-impact plastic cases, with the meter face and control knows recessed for safety. Electrically, most have protective diodes across the meter movement to protect against overloads. Very small valve fast-acting fuses are used, together with fast-acting relays and circuit breakers. Quite a few of these are used in the ohmmeter ranges, for those embarrassing moments when we try to read the AC line voltage on the R×10 scale. Spare fuses are provided inside the case.

Many accessories are available that in-

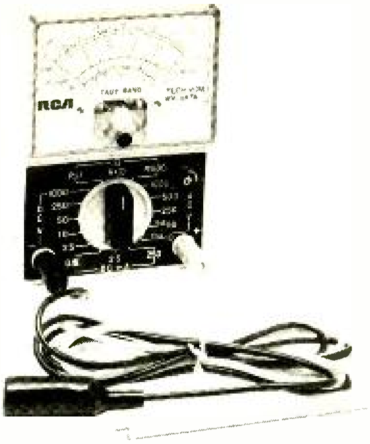


FIG. 2—RCA model WV-547A.

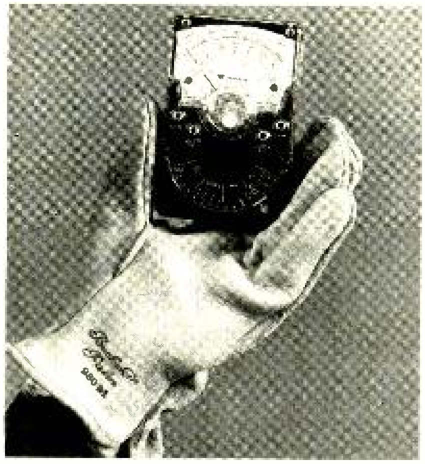


FIG. 3—TRIPLETT model 310.

crease the usefulness of the basic VOM. High voltage probes let you take readings up to 50 kV; heavy shunts let you read direct currents up to many amperes; clamp-on units allow reading alternating currents up to hundreds of amperes. There are other special accessories, that will be dealt with as we get to them. Special carrying cases protect the VOM, and have storage space for test leads, probes and other accessories.

About test leads

Speaking of test leads; this is one point that has been almost overlooked in the past. Not any more. The test leads are light, flexible, and made with long, thin tips so you can get into tight places. Slip-on clips let you hook the test leads in place and leave your hands free; the cases often come with straps or handles so that the VOM can be hung on the machine.

Now let's look at a few good examples of the typical industrial VOM, from the country's leading test equipment makers. The listing is in alphabetical order; these are all "good ones", and will give you your money's worth in long service.

For convenience, I've divided them into three groups, by physical size. First is the "shirt-pocket" types, then a bunch that could be called mediums, and last the full-sized VOM.

Shirt-pocket types

Alphabetically, first come the B&K *101*

FIG. 4—B&K model 120P.

FIG. 5—RCA WV-520A.

and 102. These are compact types, 20,000 ohms per volt, with AC and DC volts, ohms and current. The difference between them is that the *101* has a top voltage range of 1000 volts, AC or DC, and the *102* goes on up to 5000 volts with a special panel jack. No external multiplier probe is needed. Figure 1 shows both of them. They will also go down to a full-scale reading of 250 mV.

RCA's entry in the small-meter field is their *Tech-VOM, Model WV-547A* (Fig. 2). Up to 1000 volts AC or DC, with a 500-mV range. Resistance readings from 2 ohms to 1.0 megohm, and DC current up to 250 mA. Compact, and rugged; taut-band meter suspension and high impact plastic case.

The Simpson Electric Co. of Elgin, IL also has a line of *Micro-Testers*, in this size case. There are eight of these little fellows, AC/DC VOM's, AC ammeter, DC milliammeter, battery tester, low-range ohmmeter, and so on.

Next in the alphabet is a "mini" that's been around a long time, and is still going. This is the Triplett *310*, Fig. 3. This is the latest ruggedized version, with normal the ranges as well as special jacks for reading up to 1200 volts AC or DC. The tip of the negative test lead can be taken out, and plugged into a jack on the end of the case; this gives you one-hand operation. The case is a drop-resistant type, with special finger-tread design on the sides to make it easier to hold.

Next come the medium-sized units, about halfway between the shirt-pocket types and the old "standard-size VOM's". Alphabetically again, here is the B&K

FIG. 6—SIMPSON model 160.

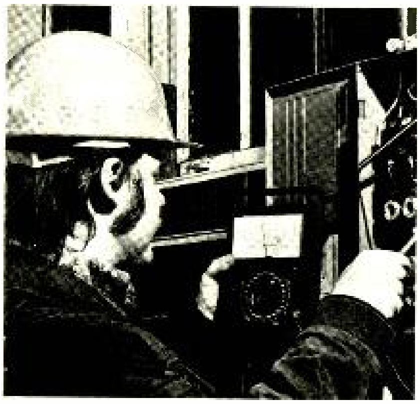


FIG. 7—TRIPLETT model 60.

120P. Standard VOM ranges, and fully protected against electrical overload by a built-in electronic system. When there's an overload, the red RESET button pops up; it can't be reset until the overload has been removed. You can see this in Fig. 4.

RCA's *WV-520A* is another general purpose VOM, this one with a 100,000 ohms per volt movement, and a scale for reading 0-15 MA. A polarity-reversing switch is provided. The meter is protected by diodes. Top voltage ranges are 1500 volts AC or DC, and an 0-5 ampere range can be used for high current (Fig. 5). A similar model is the *WV-532A*, which has a special fast-acting relay circuit to protect the instrument against damage from overloads.

Next, the Simpson *160* (Fig. 6). All of the standard ranges, including a 50-μA (250 mV), which we will take up later, with polarity reversing switch, and protective diodes across the meter.

Figure 7 shows the latest Triplett *Tough Guy*, the *model 60*. This has a very rugged plastic case, taut-band meter suspension, for drop-proofing. Electrically, the *model 60* is well protected, too. Diodes across the meter movement, and two separate fuses, 1/8-A and 10.0-A help with normal overloads. (Spare fuses inside the case.) For a really bad one, a special 2A 1-kV fuse is provided. This protects against those cases when you make accidental contact with the kind of high voltage that could cause explosive arcs inside the case. It has no exposed metal parts, for protection against shock hazards.

Now we get to the "full-sized" types. Figure 8 shows the familiar Simpson *260*. This new model is fully protected against electrical overload, and ruggedized to take hard service. The same bunch of plug-in adapters can be used with this.

FIG. 8—SIMPSON model 260.

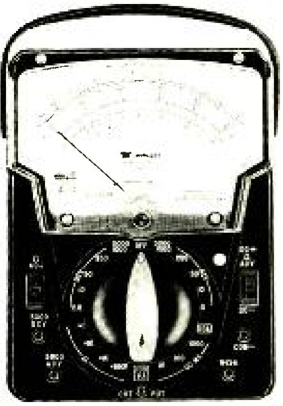


FIG. 9—TRIPLETT model 630-PLK.

Figure 9 shows another familiar "face", the Triplett *630 PLK*. "PLK" in the model number means that the complete meter is protected by a solid-state switching circuit, on all ranges. It is driven by the ohmmeter battery, and draws so little current that battery life is shelf life. The relay instantly opens the input circuits when there is an overload equal to about 3 times normal full-scale reading. Fuses are also used, just in case.

Next we come to something new: this is the specialized industrial VOM. These instruments have all of the features of the preceding ones, and special ranges, functions and accessories to make them more useful in industrial electronic and electrical work. The most compact of these is RCA's *WV-531A*, in Fig. 10. Some of the accessory test leads and probes are seen. One novel feature of this instrument is an LED Probe which can be used to make continuity tests without having to look at the meter. The carrying case holds the meter and all test leads.

The Triplett Co. has a specialized Industrial VOM in their *model 615* (Fig. 11). Quite a few special functions and tests are "built-in"; three thermocouples can be plugged into sockets on the panel, and any one read by moving the switch. Three different temperatures can be read and compared. There are three millivolt ranges, 60, 300 and 1500. A plug-in AC ammeter clamp-on can be used; Fig. 12 shows this with a *model 630*. Figure 13 shows the *model 615* in its very well-padded carrying case with space for the various adapters.

FIG. 10—RCA model WV-531A.

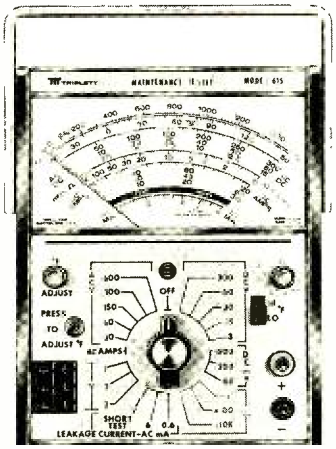


FIG. 11—TRIPLETT model 615.

Figure 14 shows the new *model 60* in its carrying case, with the adapters.

Now that you've seen the instruments, what can you do with them? The answer to this is limited only by the ingenuity of the technician. With one of these VOM's, and a good instruction manual, you can check an amazing number of things. A great many of the transducers can be checked for operation.

Thermocouple testing

You'll find quite a few thermocouples. They're used in special transducers, as thermometers, and also as both the control and source of power in many systems. These are called the "millivolt" systems. The output is very low. It will run from the 10 mV output of a platinum/platinum-rhodium thermocouple used for very high temperature testing, to about 30 mV for the common iron-Constantan types, and up to 70 mV from a Chromel-Constantan type.

Here's where we can use the millivolt ranges mentioned before. Many of the VOM's have a 50-μA range that can be used as an 0–250-mV voltmeter. Others provide several millivolt ranges. Check the instruction book with your VOM; this will give you the exact value of the millivolt ranges. There is a small difference.

Since the DC output of a thermocouple is so low, the μV range can be connected right across the output of a thermocouple. The actual voltage depends on the temperature of the thermocouple junction. In the millivolt control systems, the junction should be in the flame of the pilot light, and have a certain minimum output; usually about 70 mV. For precise tests such as transducers and thermometers, you'll need a calibrated source of heat, and an accurate standard thermometer.

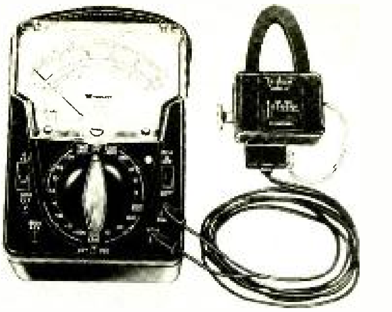


FIG. 12—TRIPLETT models 630 and 10.

FIG. 13—TRIPLETT model 615.

FIG. 14—TRIPLETT model 60.

Photoelectric cell tests

Photoelectric controls are used in several applications. Counting, start-stop on certain operations (the work-piece must be in a certain place before the process can start), indication of the presence of pilot flame on heavy-duty gas boilers, and so on.

There are two main types of photocells; "photovoltaic" meaning those which generate a voltage when exposed to light, and "photoresistive"; these change resistance when illuminated. The original photocells were vacuum tubes, which were photoresistive. They have to have a fairly high voltage supply before they can work. However, these can be tested with an ohmmeter. Connect the meter across the cell, on a high range, with the cell covered. Note the resistance reading. Now uncover the cell, and shine a light on it. A penlight is very handy for this. Note the change in resistance. If there is no change, the cell is probably defective. The reading will usually be very high, but there will be a definite change with light.

(continued on page 113)

BUILD THIS ELECTRONIC STOPWATCH

Simple circuit adds elapsed time measurement feature to basic calculator circuit without affecting calculator operation.

by TOMMY N. TYLER

WITHIN THE PAST YEAR SEVERAL 6-DIGIT hand-held calculators have appeared on the market, often retailing for less than $15. These units are fairly limited in their calculating abilities. They are fine for adding up the grocery bill or balancing the check book, but they do not have a floating decimal point and operate with whole numbers only. Nevertheless, considering the functions they perform, these little calculators are a marvel of simplicity as well as a bargain source of components for digital display projects. With less than $10 worth of additional parts you can modify one of them to provide a handy digital stopwatch as well as a calculator. This is not only a fun and useful project, but also a chance to learn more about the techniques of keyboard scanning and display multiplexing used in many current calculators.

The best calculator to use is the Minuteman-6 manufactured by Commodore Business Machines, although the National Semiconductor Model 600, or the Model 650 "Mathbox" manufactured by the Novus Division of National Semiconductor are essentially equivalent except for styling and keyboard construction. These units use a National Semiconductor type MM5736 calculator chip which features an automatic constant on all four functions. The automatic constant enables the calculator to perform as a counter by entering a "1" and then pressing the "ADD" key repetitively, each operation adding 1 to the previous total. By operating the ADD key electronically with a precision oscillator which is gated on and off, we can measure elapsed time quite effectively. The 6-digit display counts up to 9999.99 seconds, which is over 2¾ hours. If you would prefer to build just the stopwatch alone, the MM5736 calculator chip is being offered at under $4 (check the advertisements in the back of this issue.)

Basic calculator operation

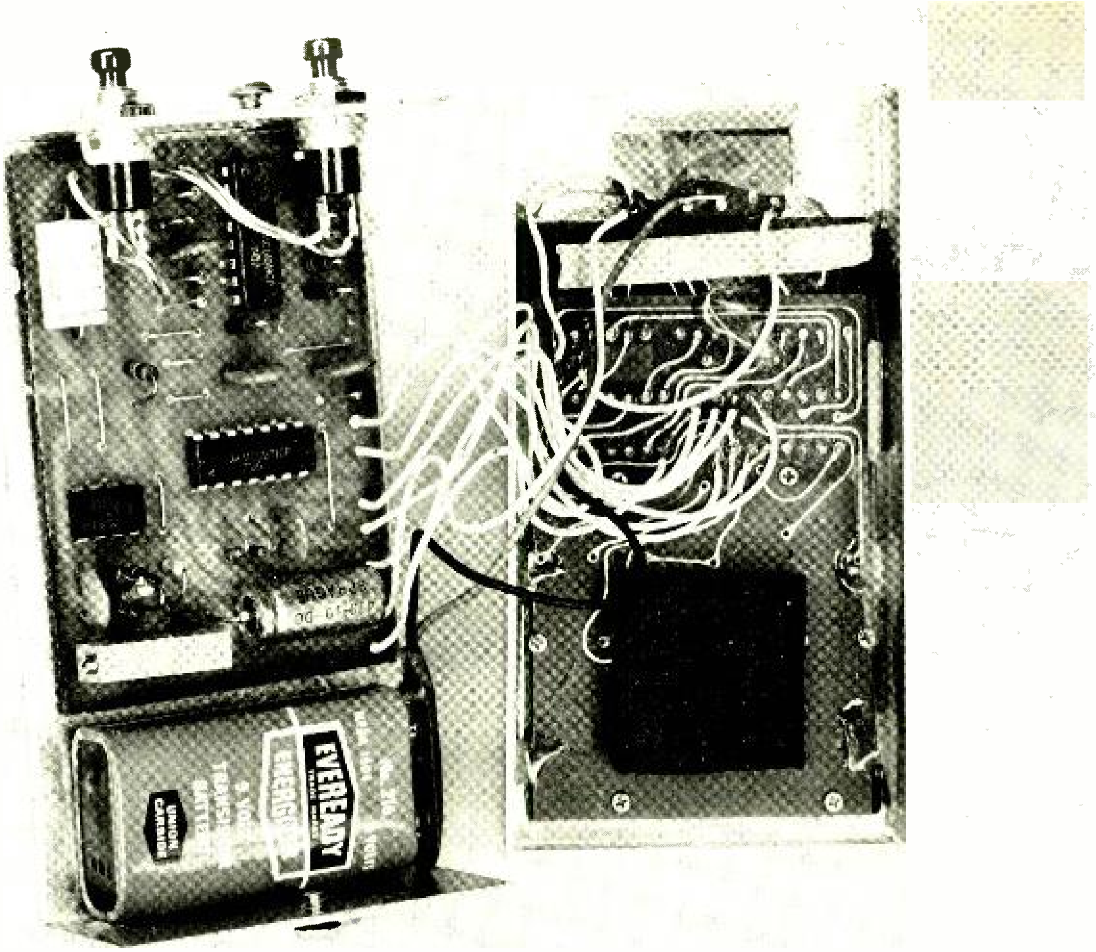
Figure 1 shows a schematic diagram of a typical calculator. The MM5736 calculator chip has three inputs (K1, K2, and K3) and two sets of outputs. One set of outputs (digits 1 through 6) drives the 6-digit display in multiplex fashion, using a 75492 digit driver IC. The other set of outputs (*a* through *g*) provides a 7-segment coded output of the calculator's display register. It is also multiplexed so that the segments for digit 1 appear during digit-time 1, the segments for digit 2 appear during digit-time 2, and so on. Both the digit and segment drive signals return to zero momentarily between digits to prevent ghosting or smear. This is referred to as interdigit blanking. Figure 2 shows a timing diagram of the digit and segment outputs for a display reading of "654321." Digit 1 is at the far right of the display, and the digits are scanned from right to left.

Numbers or functions are entered into the calculator by connecting one of the strobed digit outputs to one of the three inputs. The digit outputs are therefore performing double duty by scanning the keyboard and display simultaneously. It's tricks like this that enable the chip manufacturer to put the entire calculator into a DIP package with only 18 pins.

Battery B1 is an ordinary 9 volt transistor radio battery. An alkaline battery will power the calculator for about 10 to 20 hours, depending on how it is used. Adding the stopwatch reduces this by only a few hours. Note that the artificial decimal point on these calculators is merely a single LED between the second and third digits which is driven through resistor R1. This fixed decimal point is in just the right place for our stopwatch.

Keyboard debounce

Keyboard debounce refers to an operation performed in the calculator chip to discriminate against noisy key contacts which might otherwise cause multiple entries. It is both a blessing and a curse in that it allows the calculator to operate reliably with "cheap and dirty" keyboards, but it also limits the speed of operation in a way that affects our stopwatch. Debounce is accomplished by requiring that one of the digit outputs remain connected to one of the three inputs for at least 8 consecutive keyboard scan cycles before the entry is executed in the chip. Before another entry can be made, at



STOPWATCH printed circuit board (left) is added to basic calculator circuit (right). Both the calculator printed circuit board and display remains intact.

least 8 consecutive scan cycles must elapse during which *none* of the digit outputs are connected to any of the K inputs. When using the calculator as a counter, the counting speed is limited by this requirement for a minimum of 16 scan cycles per count.

Figure 3 shows a block diagram of the stopwatch. Pressing the RESET switch clears the calculator and then enters a "1." Pressing the START/STOP switch turns on the oscillator, which electronically "presses" the "+" key 100 times per second. The first timing pulse to the ADD circuit merely transfers the original "1" to the accumulator register. The second pulse adds another 1, giving a total of 2. The third pulse brings the total to 3, and so on. The calculator is, in effect, counting time in hundredths of a second.

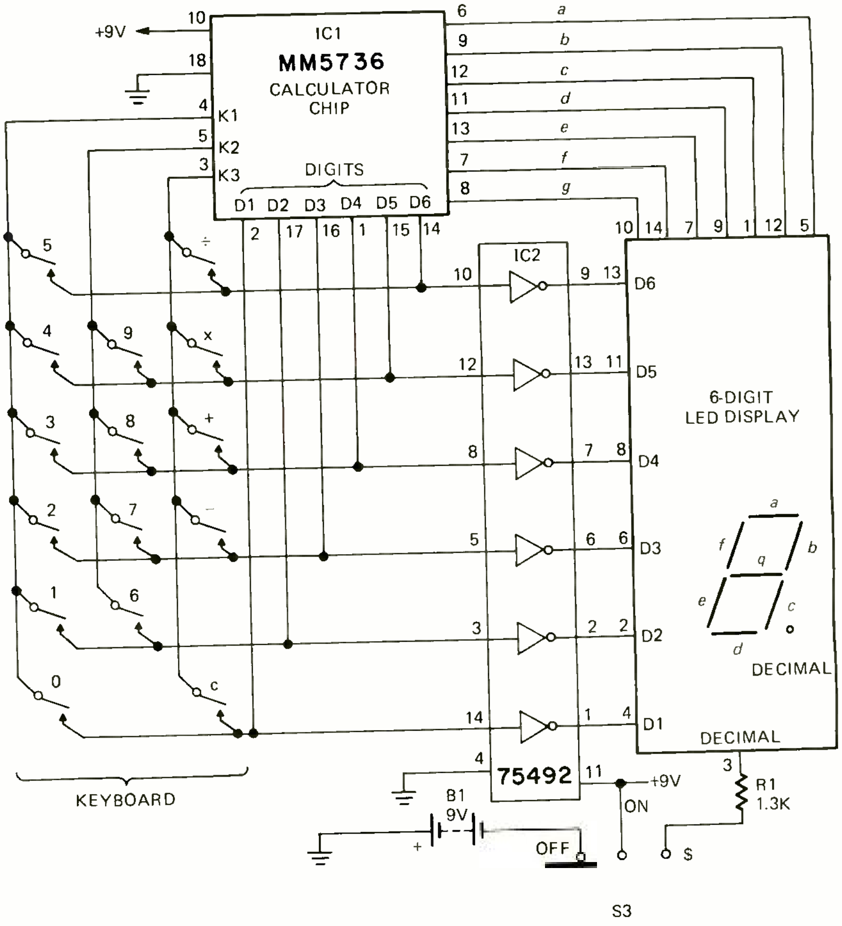


FIG. 1—BASIC CALCULATOR consists of two IC's, keyboard, display and switched DC power source. The keyboard and display are multiplexed.

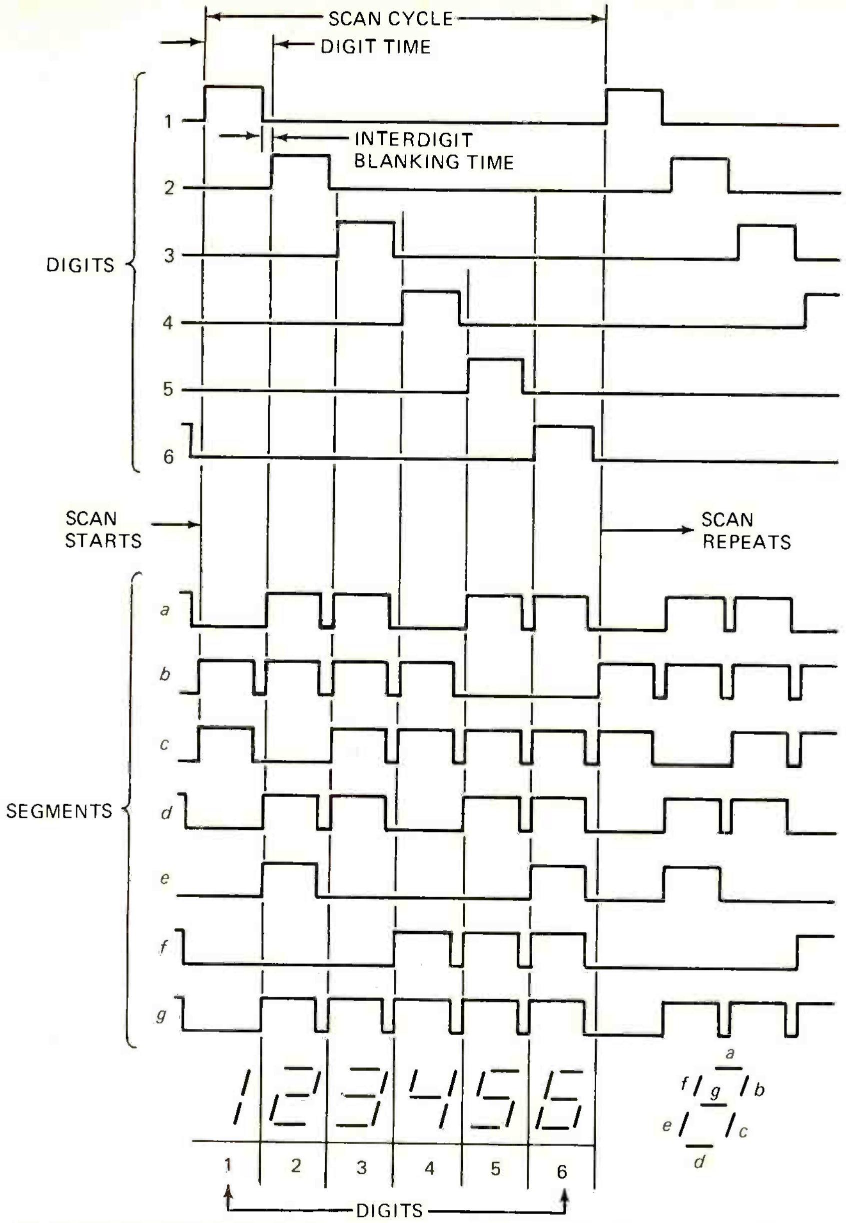


FIG. 2—TIMING DIAGRAM showing digit and segment output waveforms from the calculator chip. The display appears as "654321" because of right to left scanning provided by the calculator chip.

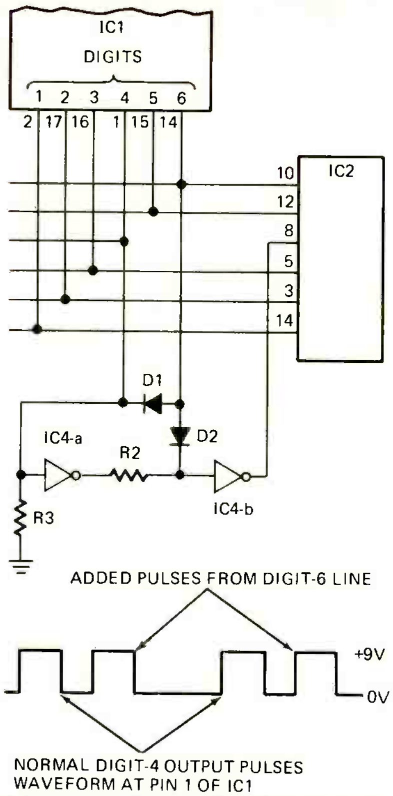


FIG. 4—ADDED COMPONENTS fool calculator into cycling at double speed. The components are only for those calculator chips that will not count at the 100-Hz speed.

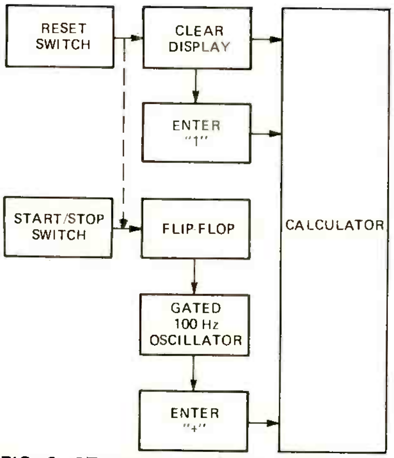


FIG. 3—STOPWATCH circuitry automatically enters a "1" when the reset button is depressed. The gated 100 Hz oscillator then enters "+" repeatedly.

Counting speed

The MM5736 calculator chip has a built-in clock oscillator which provides a typical keyboard scanning rate of 1 kHz, with some running as slow as 700 Hz and some faster than 2 kHz due to inherent variations in chip parameters during manufacture. If we satisfy the debounce requirement of 8 scans closed and 8 scans open per count, our maximum counting speed is typically 60 Hz, with some as slow as 40 Hz or as fast as 150 Hz.

Fortunately there is a way to speed up the counting rate by using the circuit shown in Figure 4. The maximum counting rate attainable with this circuit will depend on the particular chip used, but will run from about 80 Hz up to about 300 Hz. The increase in counting rate is obtained by feeding the digit-6 output pulse back to the digit-4 line, through diode D1. This fools some internal logic in the chip so that the debounce requirement is satisfied whenever a key remains closed at least 4 scan-cycles, followed by at least 4 scan-cycles during which no key is closed. The other components are necessary to prevent the double pulse from appearing on the digit-4 display driver input, which would cause digit-4 to display a ghost image of digit 6. During digit-4 time, the output pulse from digit-4 line is fed through inverters IC4-a and IC4-b to the driver input, lighting digit 4. During digit-6 time, the digit-4 line is again driven high through D1, but this time D2 conducts and the digit-6 pulse holds the input of IC4-b high to prevent digit 4 from being lighted at the same time as digit 6.

Most chips will count at 100 Hz after the addition of the speedup circuit. For those that don't, the stopwatch can still be built to measure time to the nearest 1/50 second. Referring to Fig. 3, this is done by arranging the RESET switch to enter a "2" instead of a "1," and slowing the oscillator to 50 Hz.

Next month, the article will continue with the schematic and the parts list. The foil pattern, component placement, construction details and operation and calibration procedures will also appear next month. **R-E**

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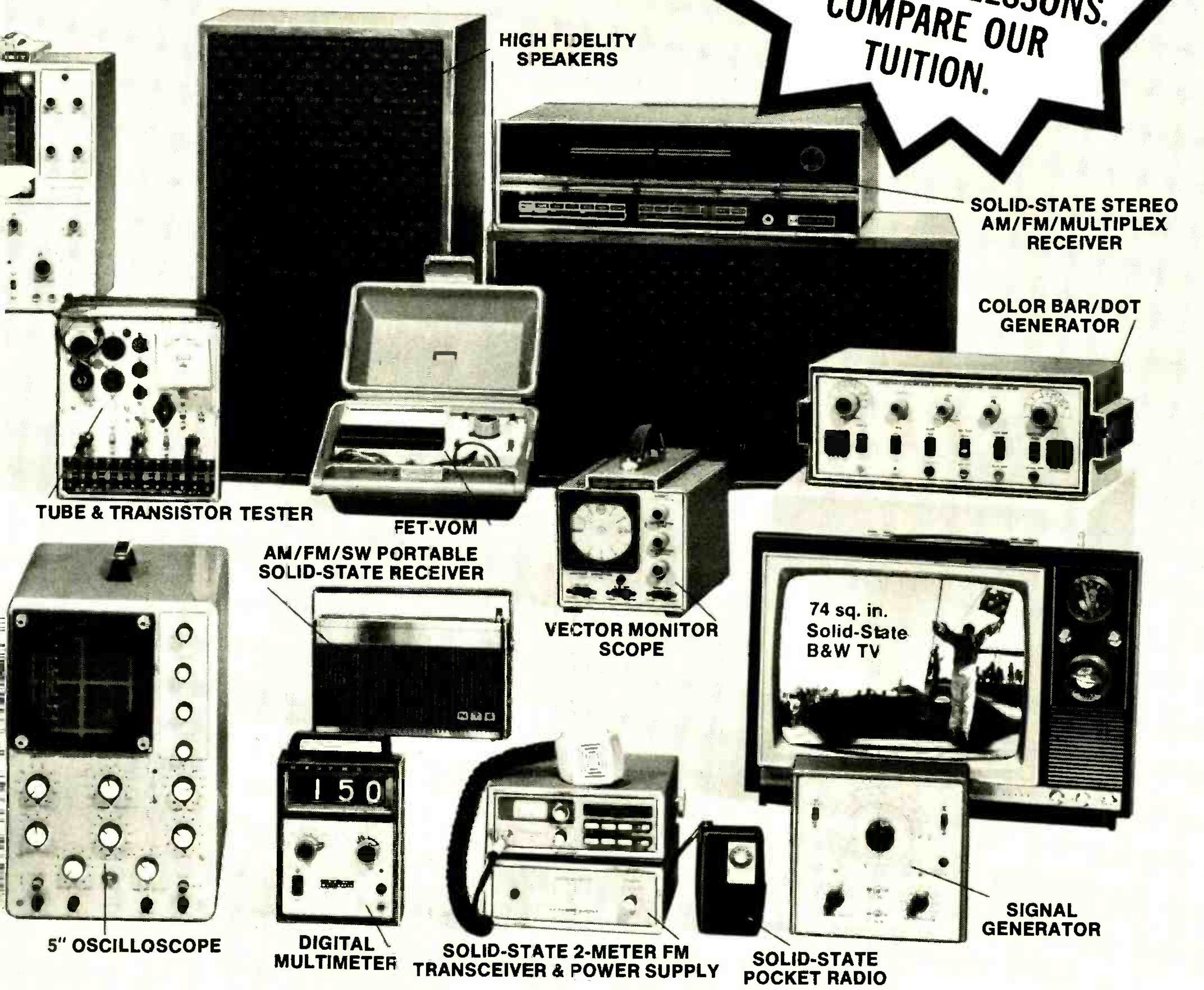

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TV Typewriter II manual cursor board

Add this optional plug-in board to the TV Typewriter II and you can manually position the cursor anywhere on the TV screen.

by ED COLLE

IF YOU HAVE BUILT THE TV TYPEWRITER II that has recently appeared in **Radio Electronics** (see Feb. 1975 issue), you've probably been waiting for the manual cursor plug-in option. This board allows you to manually, with pushbutton switches, move the cursor one space left, right, up or down as well as home-up, erase to end of line (EOL) and erase to end of frame (EOF). The last three options, home-up, erase EOL and erase EOF do not require the cursor board but it is recommended.

The circuitry provides the switch debouncing necessary to prevent multiple cursor counting thus insuring the cursor jumps only one position each time a directional button is depressed. The control switches themselves are SPST normally open pushbutton switches that should be mounted on an aluminum strip just in front of the keyboard. The debouncing delay provided is 100 milliseconds, but longer delays can be achieved by increasing the capacitance of C1 (see Fig. 1). The entire circuit is built on a 3-1/16 in. x 4-1/2 in. fiberglass circuit board that plugs into the main board of the TV Typewriter II on connector strips J3 and J4 just behind the memory board. Switch connections to the cursor board are provided on the nine pin connector attached to the circuit board.

How it works

Since all of the pushbutton control switches are normally open, the switch inputs are all tied high with resistors R1-R7. The input commands are directed to the output NAND gates (IC1, IC5-a, IC5-b and IC5-c) through inverters IC4 and IC5. Note that none of the control switches affect the output gates unless the logic signal from pin 5 of IC2-b is high. IC3 monitors the control switches and its output goes high when any one of the seven switches are depressed. This forces the $\overline{Q}$ output of IC2-a low where it will remain for approximately 100 ms. After the 100-ms delay, the $\overline{Q}$ output of IC2-a goes high again. This triggers IC2-b forcing its $\overline{Q}$ output high for 1 μs. This gates the appropriate control command into the TV Typewriter II circuitry.

Assembly and use

It's not very difficult to assemble the unit, just be sure to orient the integrated circuits, diode, electrolytic capacitor,

PARTS LIST

All resistors are ¼ watt, 10%, unless noted.

R1–R7, R10, R12, R13—1000 ohms
R8, R9—5600 ohms
R11—2200 ohms
C1—33-μF, 6 volts, electrolytic
C2, C3—100-pF polystyrene
C4—0.1-μF, 12 volts
D1—1N914 silicon diode
IC1, IC5—7403 quad NAND gate
IC2—74123 dual one-shot multivibrator
IC3—7430 eight-input NAND gate
IC4—7404 hex inverter
Q1—2N5129 transistor.

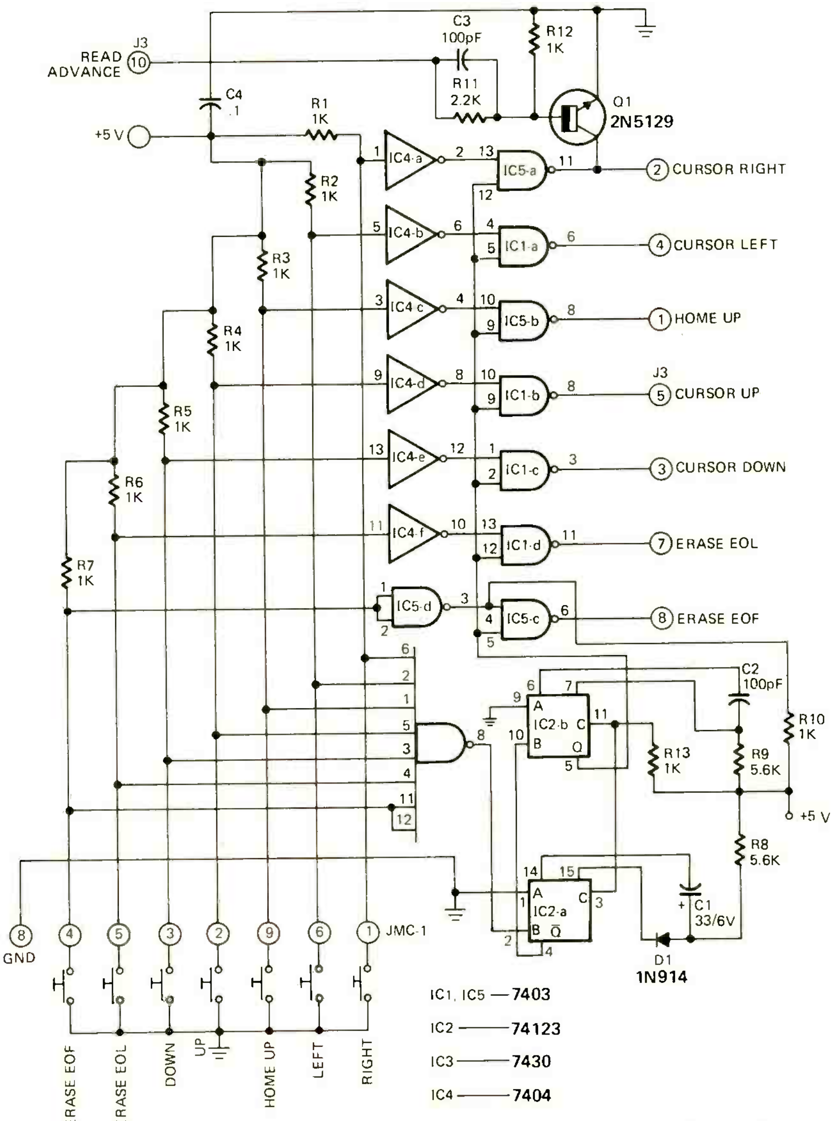


FIG. 1—MANUAL CURSOR BOARD schematic.

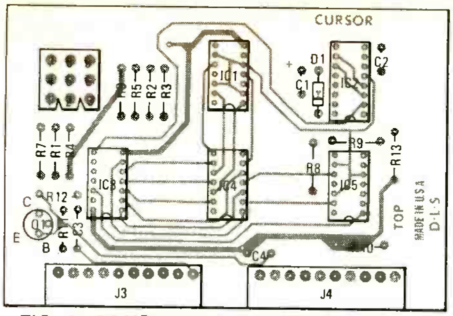
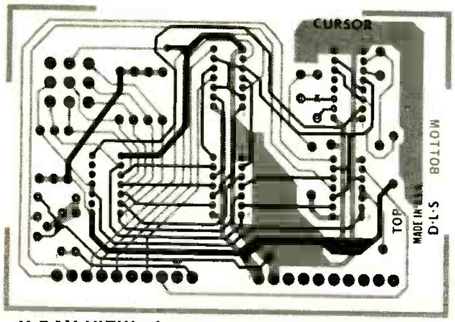


FIG. 2—COMPONENT PLACEMENT diagram.



X-RAY VIEW of the double-sided printed circuit board.

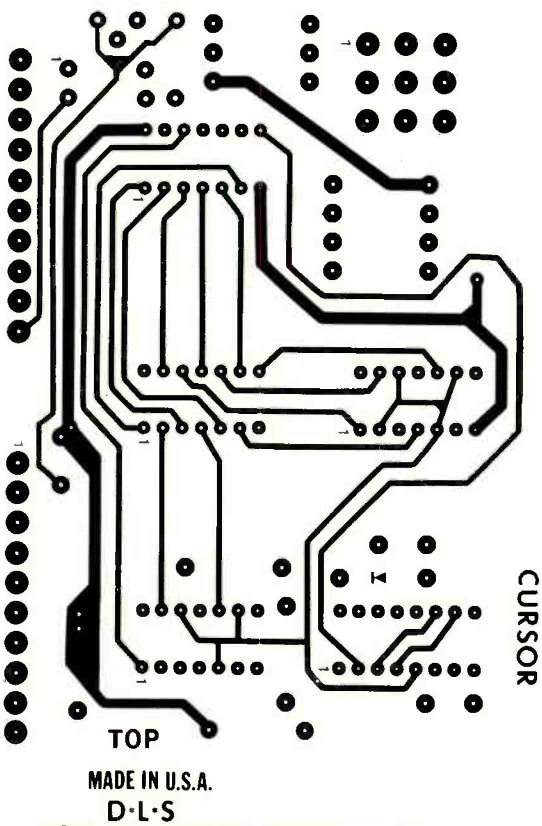


FIG. 3—FOIL PATTERN of component side of double-sided board shown full size.

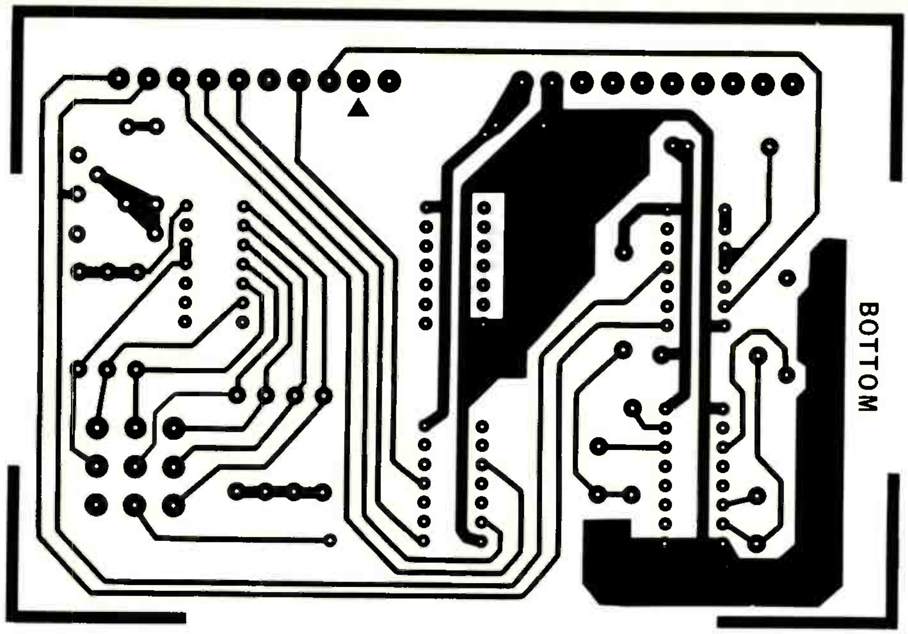


FIG. 4—FOIL PATTERN of foil side of double-sided board shown full size.

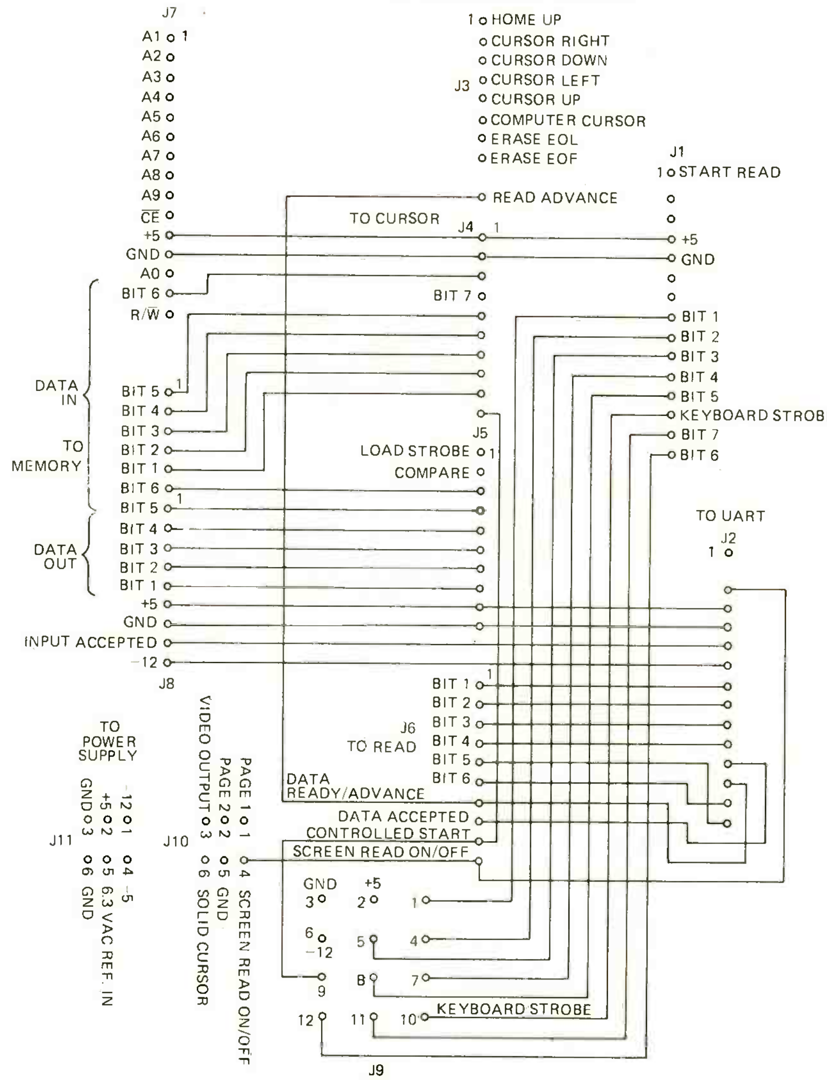


FIG. 5—JACK INTERCONNECTION DIAGRAM of TV Typewriter II.

transistor and connector correctly. Figure 2 shows the component layout. The connector is notched and must be installed exactly as shown in the component side of the foil pattern (Fig. 3). There is a provision for an indexing key on the mounting connectors, J3 and J4, so after soldering the connectors insert a nylon plug in J3 pin 9. This pin is marked with an arrow on the foil side of the board (See Fig. 4). If you have any problems, check to see if the cursor board is working correctly by checking it with a voltmeter and scope. If your TV Typewriter II has never been used, be sure to check it out first without the cursor board. The cursor board should not be plugged in until the main board has been thoroughly checked out. The jack interconnection diagram of TV Typewriter II is shown in Fig. 5. **R-E**

SQUAREWAVES and Audio Performance

Square waves can quickly identify amplifier limitations. Here are some interesting facts regarding the use of square wave testing and interpretation of the results.

by LEN FELDMAN

DESPITE THE STRIDES THAT HAVE BEEN made in recent years in improving audio amplifier performance, there are still many vague areas left in attempting to define *all* the desirable qualities of an audio amplifier. Why, for example, can two amplifiers with indentical power output ratings, frequency response and low distortion (harmonic as well as intermodulation) "sound" different when auditioned on and A-B basis? For that matter, why is it possible to detect differences in "amplifier sounds" when, in fact, distortion produced by speaker systems is far greater than the almost unmeasurable percentages of distortion produced by the amplifiers that are used to drive those speakers?

These and other subjects which might be classified as "audio philosophy" occupied an entire afternoon, recently, when a group of editors and audio journalists attended a round-table discussion at the offices of Harman-Kardon Company, in Plainview, Long Island. Readers who have followed the literature on audio over the last decade will know that Harman-Kardon is a staunch supporter of the "wideband" school of thought when it comes to amplifier design. That is, they firmly believe that an amplifier must have uniform frequency and phase response from well below the lowest frequency we can hear to as high as five-times the arbitrary 20 kHz frequency that is normally considered to be the high-end of human hearing.

Countering this point of view are such well-known companies as Bose Corporation (they deliberately restrict their amplifier's response), who maintain that phase shift of complex waveforms above certain frequencies are inaudible. Taking a middle-of-the road view, the makers of the Accuphase line of components (distributed by Teac Corporation of America) maintain that a frequency response range from 20 Hz to 20 kHz is sufficient. But, in a statement of basic engineering policy they go on to say, "What is more important as far as frequencies beyond human hearing are concerned, is "phase characteristic", to prevent overshoot distortion and vibration with input pulses within the audible range. This problem extends to several hundred kHz, so we cannot be content with a flat frequency response that is only wide."

While we do not propose to "take sides" in this never-ending controversy, some interesting facts regarding the use of square wave testing and interpretation came to light as we were discussing Harman-Kardon's new *Citation 16* power amplifier, shown in Fig. 1. This amplifier boasts a square wave rise time of better than 3 microseconds and the choice of output devices and low-level amplifying transistors used in the amplifier result in an overall slew-rate of 30 volts-per-microsecond. The significance of both of these specifications will become clear shortly.

Square waves and music

Music is composed predominantly of of sine waves, but these are rarely heard as *separate* sine waves. A sound produced by a musical instrument (or a voice) is a combination of sine waves at different frequencies. The fundamental frequency identifies the basic pitch of the sound while the harmonics, generally of lower amplitude, determine its timbre. It is clear that a musical sound, even in its simplest form, is much more complex than the pure sound waves audio engineers and technicians use to measure power output, distortion and frequency response of an amplifier. The people at Harman-Kardon (and engineers from many other audio firms) feel that the square wave is a more useful signal for measuring amplifier performance. It is constant, periodic and repeatable like a sine wave, but its added usefulness is a direct function of its similarity to a musical sound. Square waves, too, are composed of fundamental frequencies and harmonics. The harmonics are arranged in a specific amplitude relationship to one another and are further related with respect to time—all harmonics being "in phase" with each other. The slightest change of amplitude or phase of any of the harmonic components of a square wave will alter its shape. Testing audio products with square waves can therefore illustrate such characteristics as phase response. transient response, frequency response and certain forms of instability if one understands the output waveforms displayed on an oscilloscope.

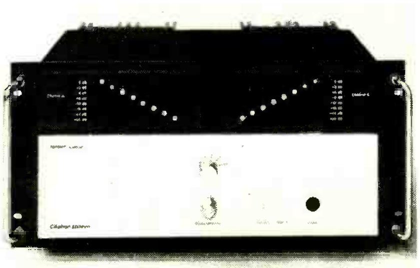


FIG. 1—HARMAN-KARDON CITATION 16 power amplifier. Design emphasis was on wide-bandwidth and linear phase response.

Transient intermodulation distortion

A new form of distortion has recently been given much attention in analyzing the performance of audio amplifiers. It is called transient intermodulation distortion and many experts now feel that it is responsible for much of the stridency that critical lis-

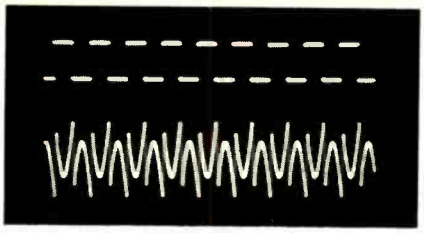


Fig. 2—20-Hz SQUARE WAVE with fundamental frequency filtered out is shown in lower trace.

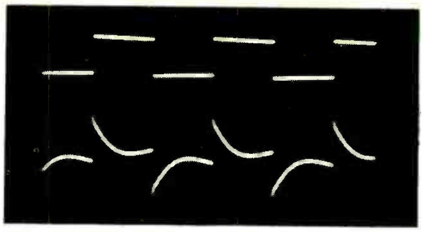


FIG. 3—ROLL-OFF at sub-sonic frequencies distorts 20-Hz square wave.

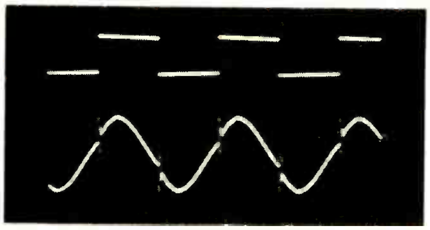


FIG. 4—A 20-Hz SQUARE WAVE contains frequencies at or beyond the high-frequency limits of human hearing.

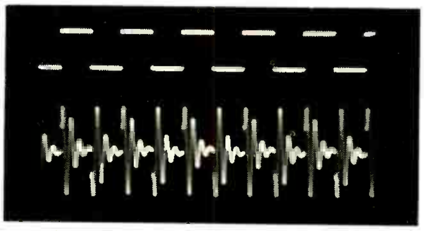


FIG. 5—FILTERING out the fundamental and third harmonic from this 1-kHz square wave makes the waveform look remarkably like "musical" waveforms often seen on monitoring scopes.

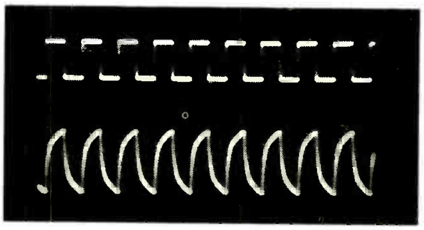


FIG. 6—ROUNDING of leading and trailing edges of 10-kHz square wave results when the bandwidth of the amplifier is limited.

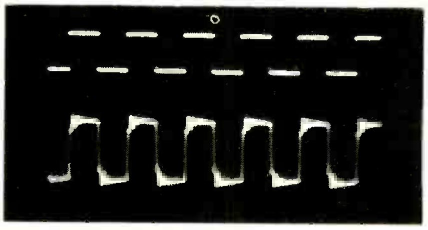


FIG. 7—HIGH-FREQUENCY square waves are useful in detecting amplifier instability with reactive loads.

teners have sometimes associated with solid-state amplifiers. All semiconductors have a limitation in their ability to follow very rapid signal fluctuations or transient pulses. Unlike vacuum tubes that, in theory at least, are controllable at speeds approaching the speed of light (or the speed of the electron flow in a vacuum), solid-state transistors have a fixed slew-rate that determines the length of time an amplifier will be in saturation when a transient waveform is applied to it. This saturation and its associated hysteresis are considered to be the prime factors in the generation of transient intermodulation distortion.

An audio amplifier possessing feedback is driven by the difference signal that results from the combination of the original input waveform and the portion of the output waveform used for negative feedback. If the slew-rate of an amplifier is less than that called for by a steep transient input signal, the output will lag behind the input, and the difference between the feedback and input signals may then exceed the dynamic range of the input stage. A period of input-stage saturation will result during which the amplifier's output will no longer be identical in shape to its input. The condition will continue until the amplifier's output "catches up" to the input signal. This sort of amplifier limitation can also be readily perceived in examining high-frequency square waves.

Square wave analysis

The square wave photos that appear in this article were not taken by comparing input and output waveshapes from any audio power amplifier, for no single audio amplifier could possibly produce all the waveform distortions we hoped to demonstrate. Instead, we availed ourselves of the Soundcraftsmen model RP-2212 audio equalizer that permitted us to alter frequency response drastically to create the effects we wished to analyze. For example, we could apply a square wave of known frequency and attenuate only that frequency so that the output waveform would contain all the harmonics of the squarewave minus the fundamental. Such a waveform is shown in Fig. 2. In this and all subsequent photos, the upper waveform is the input signal while the lower waveform is the output signal. No actual amplifier is likely to produce the waveform of Fig. 2, since frequency-response non-linearity in an audio amplifier occurs gradually rather than as an abrupt "notch" which was used to produce this effect.

The waveform shown in Fig. 3 is more typical of what may be encountered, to varying degrees, with an amplifier that has a limited low-frequency response below 20 Hz. The frequency of the input signal was also 20 Hz. This is an extreme case where the "slope" or "tilt" of the normally horizontal portion of the square wave is severe and the square wave begins to look like an interrupted sinewave. Until recently, the response of an amplifier to a 20-Hz square wave input signal was considered unimportant by most audio designers. With the advent of DC-coupled amplifier designs, it became possible to extend low-frequency response all the way down to DC, if desired, and many astute listeners maintain that flat subsonic response *does* make a difference when listening to bass content of music. Harman-Kardon believes that phase-shift is an audible form of distortion that masks and muddies music. Excessive phase-shift at low frequencies, they claim, muddies the music and causes bass and mid-bass sounds to lose their clarity and transparency and to become dull and boomy.

Just to convince ourselves (and you) that even a 20 Hz square wave contains very high frequencies, we adjusted our filters on the equalizer so that all frequencies but the 20 Hz fundamental and the very highest octave (10 kHz and above) were attenuated, while the two frequency regions of interest were boosted as much as the controls would permit. The results are shown in Fig. 4. As expected, we see the fundamental 20-Hz signal represented almost as a pure sine wave. We can also clearly see tiny bursts of a very high-frequency signal. This high-frequency signal shows a frequency content in the output signal above 10 kHz!

At mid-frequencies and above, phase-shift and low-frequency loss in an amplifier are rarely a problem. Nevertheless, to illustrate the similarity between mid-frequency square waves and musical tones, we eliminated the fundamental and the third harmonic of a 1 kHz square-wave. The output waveform, shown in the lower trace of Fig. 5, strikes a familiar note (pardon the pun) for anyone who has watched musical waveforms displayed on a scope for any length of time. What we see are all the higher-order harmonics of the square wave, clearly visible now that the fundamental and third harmonic contributions are eliminated from the signal.

High-frequency square waves are used to quickly determine the upper limits of bandwidth in an amplifier. To accurately reproduce 10-kHz square waves through an amplifier, the amplifier must be capable of handling at least the eleventh harmonic of that fundamental frequency (110 kHz) in the correct phase and amplitude relation-

(continued on page 115)

1

Radio-Electronics® Tests Radio Shack Model QTA-770

by LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

THE REALISTIC LINE OF HIGH-FIDELITY COMponents (and other electronic products) is manufactured for the Radio Shack chain of electronic stores located throughout the United States. Such products are commonly referred to in the trade as "private label" components, as opposed to "name brand" components which are manufactured by well known firms around the world who sell to a variety of retail outlets. Radio Shack sells only its own Realistic brand of merchandise in this category.

An overall view of the front panel of this quadriphonic receiver is shown in Fig. 1. The panel is equipped with the now familiar slide-rule blacked-out dial area with calibrated FM and AM scales plus a "0 to 100" logging scale for convenient pin-pointing of stations. The single tuning meter at the right of the dial scale is normally illuminated in white, but if the useful AUTO-M (for Auto-Magic) pushbutton is depressed, lighting changes to light green when a station is locked-in, indicating proper center-tuning. This novel automatic frequency-control circuit is deactivated by simply touching the tuning knob at the right. When the Auto-Magic feature is used, the words "Auto Magic" appear near the tuning meter and meter illumination changes to white so long as the user is tuning or touching the knob. When the signal strength meter indicates best tuning, releasing the knob causes the AFC circuit to "pull in" for best tuning and the meter color changes to green. Further use of colored illumination is made by having the illuminated dial pointer change to a bright red color whenever a stereo station is tuned to. A closeup view of this area of the panel is shown in Fig. 2.

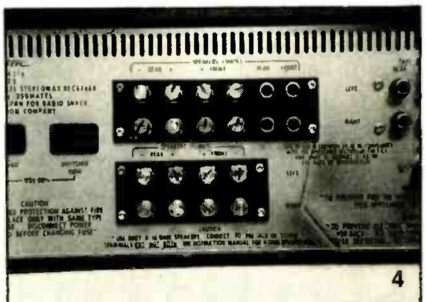
Along the center portion of the front panel are pushbuttons for power on/off, main and remote speaker system selection, high and low filter selection. loudness circuit activation, FM interstation muting, tape monitor circuit and the aforementioned AUTO-M switch. A pair of lights indicate the playing of a discrete CD-4 recording and also of stereo (or matrix 4-channel) discs. At the extreme right of the panel are two slide controls for adjusting front and rear channel volume.

2

3

Other controls located along the lower edge of the panel include BASS, MIDRANGE and TREBLE tone controls, program SELECTOR switch, front channel and rear channel BALANCE controls (left-right), a MODE switch and a four position control that Radio Shack calls Audiorotor. The AUDIOROTOR control permits the listener to shift channel locations in 90 degree increments —all around the listening room. The MODE switch has positions for discrete 4-channel listening, matrix SQ decoding, stereo listening (in which front and rear speakers reproduce the same program information). a QUATRAVOX position that synthesizes 4-channel sound from 2-channel program sources and a MONO position. A closeup view of the tone control area of the panel is shown in Fig. 3.

The speaker connection arrangement on the rear panel, shown in Fig. 4, permits connection of two quartets of speakers for main and remote quadriphonic listening. Main speakers can be connected either by stripping cable ends in the usual manner or by equipping cable ends with standard phono-tip pin plugs. The latter method has the advantage of "permanent" reconnection of speakers in proper phase, once that correct phase has been established.



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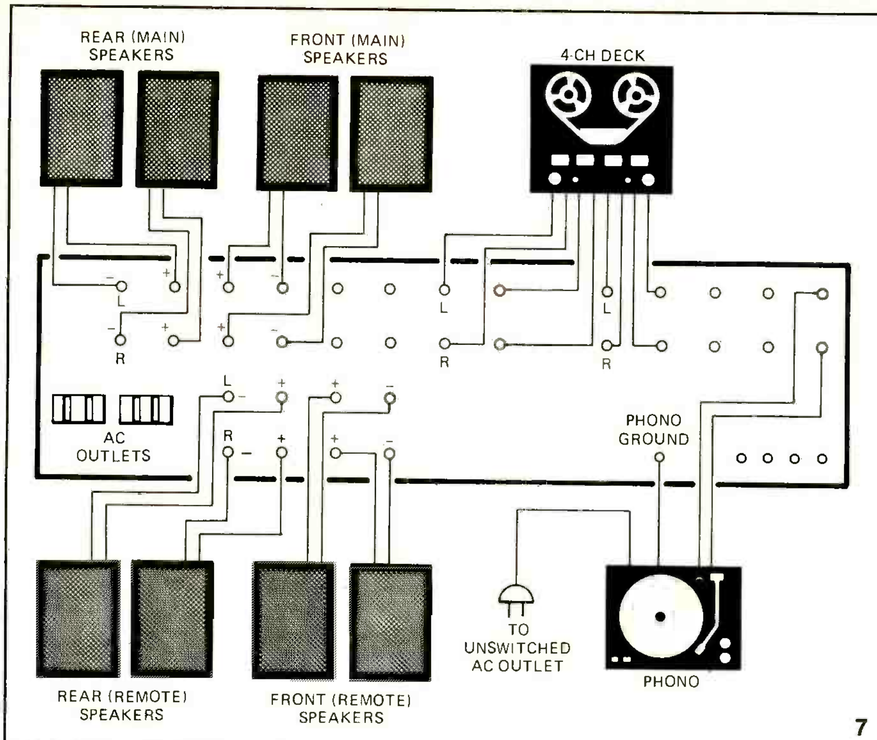
SUMMARY OF MANUFACTURER'S SPECIFICATIONS:

TUNER SECTION: (FM)
IHF Sensitivity: 1.9 μV. **S/N Ratio:** 60 dB. **Selectivity:** 60 dB. **Capture Ratio:** 1.5 dB. **Harmonic Distortion:** (Mono): 0.8% or better; (Stereo): 1.0% or better. **Image Rejection:** 60 dB or better. **Stereo Separation:** 35 dB at 1 kHz.

TUNER SECTION: (AM)
Sensitivity: 250 μV/meter. **Image Rejection:** 50 dB.

AUDIO AMPLIFIER SECTION:
Continuous Power Output: (4-channels driven, 8 ohm loads, 20 Hz to 20 kHz): 25 watts per channel. **Rated Harmonic Distortion:** 1.0%. **Rated IM Distortion:** 1.0% **Frequency Response:** 20 Hz to 20,000 Hz. **Signal-to-Noise Ratio:** (Phono) 60 dB; (Aux.): 70 dB.

GENERAL SPECIFICATIONS:
Power Requirements: 120 VAC, 60 Hz. **Dimensions** (measured by R-E): 19¼" wide by 6" high by 14" deep. **Suggested retail price:** $600.00



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ratio detector. The multiplex stereo decoder contains a phase-locked-loop IC circuit that requires no tuning coils. The CD-4 demodulator board is perhaps the most elaborate circuit of all containing no less than 31 bipolar transistors, 4 FET's and 2 IC's. The SQ decoding function is performed primarily by the familiar Motorola MC-1312P chip designed for that purpose. No logic enhancement circuits are included, and the matrix parameters are changed to provide the stereo-to-4-channel synthesis feature.

Tone control circuitry is of the popular feedback type. Power amplifiers have differential amplifier input stages and are direct coupled to speakers, using ±33-VDC supply voltage derived from a full-wave bridge rectifier with primary filtering accomplished by 8000 μF capacitors. Protective circuitry includes a thermal switch that turns off all power to the receiver in the event of a thermal overload. An internal view of the chassis is shown in Fig. 6. A diagram of possible interconnection of additional components is shown in Fig. 7.

FM tuner section measurements

Results of our FM performance measurements are listed in Table I. Radio

Antenna connections are provided for 300-ohm and 75-ohm FM and external AM. TAPE IN and TAPE OUT jacks, AUX input jacks and PHONO inputs are logically arranged on the rear panel along with an output jack for future use with FM 4-channel decoders and a pair of CD-4 separation adjustment controls that come capped to prevent accidental altering of optimum control settings. While there is only one pair of phono inputs, a slide switch adjusts input sensitivity to match low- and high-output cartridges. This section of the rear panel is shown in Fig. 5, in which the phono ground terminal is also clearly seen. The rear panel is also fitted with a pivotable AM ferrite bar antenna and switched and unswitched AC receptacles.

Circuit configuration and features

There are five major circuit board modules in the QTA-770, all of them well supported mechanically. The eight output power transistors seem adequately heatsinked with fin-type heat sinks running the full width of the chassis. The front end of the receiver uses a dual-gate MOS-FET transistor and a four-gang variable capacitor. The FM IF section uses ceramic filters between stages and contains three IC's plus two bipolar transistors. FM detection is accomplished by a conventional

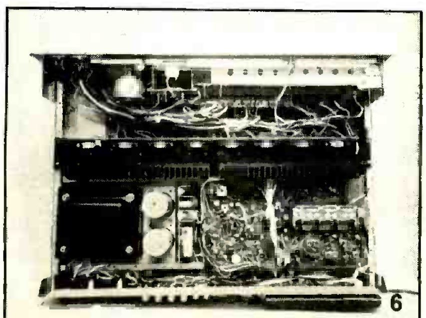
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TABLE I

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Realistic (Radio Shack)** Model: **QTA-770**

FM PERFORMANCE MEASUREMENTS

	R-E MEASUREMENT	R-E EVALUATION
SENSITIVITY, NOISE AND FREEDOM FROM INTERFERENCE		
IHF sensitivity, Mono: (μV)	2.5	Acceptable
Sensitivity, Stereo (μV)	11.0	Acceptable
50 dB quieting signal, Mono (μV)	3.5	Very good
50 dB quieting signal, Stereo (μV)	50.0	Acceptable
Maximum S/N ratio, Mono (dB)	74	Excellent
Maximum S/N ratio, Stereo (dB)	61	Very good
Capture ratio (dB)	1.5 dB	Very good
AM suppression (dB)	50	Good
Image rejection (dB)	70	Very good
IF rejection (dB)	80	Very good
Spurious rejection (dB)	85	Very good
Alternate channel selectivity (dB)	60	Good
FIDELITY AND DISTORTION MEASUREMENTS		
Frequency response, 50 Hz to 15 kHz (±dB)	0.8	Very good
Harmonic distortion, 1 kHz, Mono (%)	0.18	Excellent
Harmonic distortion, 1 kHz, Stereo (%)	0.38	Very good
Harmonic distortion, 100 Hz, Mono (%)	0.12	Excellent
Harmonic distortion, 100 Hz, Stereo (%)	0.21	Excellent
Harmonic distortion, 6 kHz, Mono (%)	0.24	Very good
Harmonic distortion, 6 kHz, Stereo (%)	1.4	Acceptable
Distortion at 50 dB quieting, Mono (%)	0.65	Very good
Distortion at 50 dB quieting, Stereo (%)	0.58	Very good
STEREO PERFORMANCE MEASUREMENTS		
Stereo threshold (μV)	11	Good
Separation, 1 kHz (dB)	39	Very good
Separation, 100 Hz (dB)	42	Excellent
Separation, 10 kHz (dB)	23	Good
MISCELLANEOUS MEASUREMENTS		
Muting threshold (μV)	12	Fair
Dial calibration accuracy (±kHz @ mHz)	—200, 88	Fair
EVALUATION OF CONTROLS, DESIGN, CONSTRUCTION		
Control layout		Good
Ease of tuning		Excellent
Accuracy of meters or other tuning aids		Fair
Usefulness of other controls		Good
Construction and internal layout		Very good
Ease of servicing		Good
Evaluation of extra features, if any		Very good
OVERALL FM PERFORMANCE RATING		**Good**

"Electro-Lab®" is a registered trademark of the Bell & Howell Company.

Simulated TV test pattern.

Shack chooses to list very few operating specifications in their owner's manual, but a few comparisons between published and measured results are possible. While the tuner section did not meet its 1.9 μV sensitivity figure, the 2.5 μV figure obtained is deemed adequate in this price range and the 3.5-μV 50-db quieting point is very good. Ultimate S/N at high signal-levels was excellent for mono and very good for stereo. Distortion levels are quite low for both mono and stereo and, while we generally are suspicious of AFC circuits (they often add distortion and, being first-order closed loop feedback circuits, usually "tune" somewhat off-center) we must admit that the AFC circuit as incorporated in the Auto-Magic feature of the QTA-770 tuned so close to perfect center-of-channel that we could not improve upon observed distortion figures by tuning manually (with the feature defeated). Muting threshold might have been set a bit lower, in our view, so that weaker stations could be received without having to defeat the convenience of silent interstation tuning.

Amplifier performance measurements

Basic amplifier and preamplifier performance measurements are listed in Table II. It should be noted that in the STEREOMAX position of the front panel MODE switch, the rear and front pairs of channels are paralleled or "strapped" together to provide approximately double the output power available from each channel in the 4-channel mode. We checked this feature at mid-frequencies only and found that in the "strapped" setting, the QTA-770 delivered 55 watts per channel at rated distortion. In the more commonly used 4-channel configuration, at mid-band frequencies, power output exceeded claims by a wide margin and met claims nearly exactly at the low frequency (20 Hz) extreme. At lower output power levels, THD and IM tend to rise slightly but remain below the rated 1.0% figure all the way down to 250 milliwatts, as required in the new Federal Trade Commission standards on amplifier power and distortion ratings. Very little increase in power capability was noted with 4-ohm loads, so a user might just as well select 8-ohm speakers for use with this instrument to insure output-circuit protection when using either a single or double set of speakers.

A serious failing of the phono preamplifier section is its inability to accept high levels of input signals from the phono cartridge without first-stage overload distortion. Even in the low sensitivity setting, overload occurs at an input signal level of 25 mV—a level which is too low in terms of today's dynamically recorded discs. Users should choose a low output cartridge and possibly operate the receiver in the low-sensitivity position besides. Hum and noise in phono, on the other hand, was quite good—better than claimed. The one saving grace about the overload problem discussed is the fact that when used with a CD-4 cartridge and when playing CD-4 records, the phono input level is likely to be on the low side and less difficulty will be encountered.

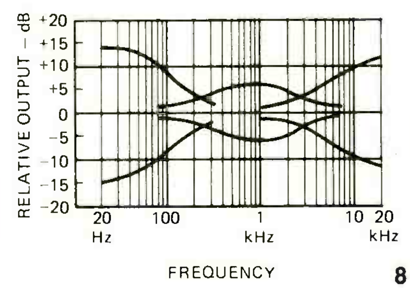
Tone controls operated well and symmetrically. Response of the tone controls are shown in Fig. 8. The MID-RANGE tone control acts effectively as a presence control and is a useful addition. High and low filter response is shown in Fig. 9 and crossover or cut-off points for both these circuits were ideally set.

TABLE II
RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Realistic (Radio Shack)** Model: **QTA-770**

AMPLIFIER PERFORMANCE MEASUREMENTS

	R-E MEASUREMENT	R-E EVALUATION
POWER OUTPUT CAPABILITY		
RMS power/channel, 8-ohms, 1 kHz (watts)	33	**Very good**
RMS power/channel, 8-ohms, 20 Hz (watts)	25.5	**Acceptable**
RMS power/channel, 8-ohms, 20 kHz (watts)	33	**Very good**
RMS power/channel, 4-ohms, 1 kHz (watts)	34	**Good**
RMS power/channel, 4-ohms, 20 Hz (watts)	27	**Good**
RMS power/channel, 4-ohms, 20 kHz (watts)	34	**Very good**
Frequency limits for rated output (Hz-kHz)	19-44	**Very good**
DISTORTION MEASUREMENTS		
Harmonic distortion at rated output, 1 kHz (%)	0.1	**Good**
Intermodulation distortion, rated output (%)	0.03	**Excellent**
Harmonic distortion at 1 watt output, 1 kHz (%)	0.5	**Acceptable**
Intermodulation distortion at 1 watt output (%)	0.06	**Excellent**
DAMPING FACTOR, AT 8 OHMS	20	**Good**
PHONO PREAMPLIFIER MEASUREMENTS		
Frequency response (RIAA± ___dB)	1	**Good**
Maximum input before overload (mV)	25/16	**Poor**
Hum/noise referred to full output (dB) (at rated input sensitivity)	67/62	**Very good**
HIGH LEVEL INPUT MEASUREMENTS		
Frequency response (Hz-kHz, ± ___dB)	20-20, 1	**Good**
Hum/noise referred to full output (dB)	86	**Excellent**
Residual hum/noise (min. volume) (dB)	94	**Excellent**
TONAL COMPENSATION MEASUREMENTS		
Action of bass and treble controls	See Fig. 8	**Very good**
Action of secondary tone controls	See Fig. 8	**Excellent**
Action of low frequency filter(s)	See Fig. 9	**Very good**
Action of high frequency filter(s)	See Fig. 9	**Very good**
COMPONENT MATCHING MEASUREMENTS		
Input sensitivity, phono 1/phono 2 (mV)	2.5/1.5	
Input sensitivity, auxiliary input(s) (mV)	250	
Input sensitivity, tape input(s) (mV)	250	
Output level, tape output(s) (mV)	620	
Output level, headphone jack(s) (V or mV)	1.5V	
EVALUATION OF CONTROLS, CONSTRUCTION AND DESIGN		
Adequacy of program source and monitor switching		**Acceptable**
Adequacy of input facilities		**Good**
Arrangement of controls (panel layout)		**Good**
Action of controls and switches		**Good**
Design and construction		**Good**
Ease of servicing		**Good**
OVERALL AMPLIFIER PERFORMANCE RATING		**Very good**



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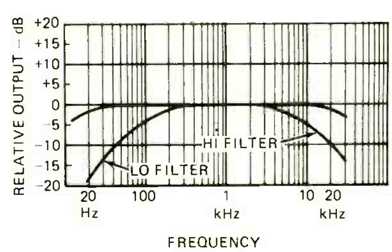

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Utilization and listening tests

Most of our listening tests were confined to FM stereo and CD-4. We did play a few SQ and QS matrix records, but as expected, separation is minimal and the listening position becomes quite critical

TABLE III

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer: **Realistic (Radio Shack)** Model: **QTA-770**

OVERALL PRODUCT ANALYSIS

Retail price	**$599.95**
Price category	**Low-medium**
Price/performance ratio	**Acceptable**
Styling and appearance	**Good**
Sound quality	**Good**
Mechanical performance	**Very good**
Comments:	Not every hi-fi enthusiast is willing to spend upwards of $700.00 for a "state of the art" quadriphonic receiver with sophisticated logic circuitry and a host of extra control features. The Radio Shack QTA-770 offers a reasonable alternative for under $600. Power output is excellent for the price category. The rotating sound field control (Audiorotor) seems like an unnecessary frill to us. Even the control-happy audiophile would tire of it after a few moments, and design effort might well have been expended in beefing up the preamplifier input stage. Overall sound quality is good, and the receiver seems reliably built and designed. For better SQ decoding, we would add an external SQ decoder (several good ones are available), since 4-channel emphasis was placed on "discrete" reproduction rather than matrix formats. If you are interested only in a stereo receiver, better value can be had at the price, even considering the stereo strapping feature. But, if you long for quadriphonics at a non-inhibiting price, the QTA-770 may be worth auditioning.

because of the limited separation capability. SQ image placement is particularly ambiguous with this "basic" matrix decoder. CD-4 record reproduction was much better, but we had to experiment with several cartridges to find the one that works best with the receiver. Among those that did well were the Empire 4000/III and the Audio-Technica AT-15S. Our Bang and Olufsen MMC-6000, while an excellent CD-4 pickup when used with other demodulators, did not put out enough 30 kHz carrier signal to properly activate the built-in demodulator of the QTA-770.

FM reception was good and stereo switching was noiseless. We recommend using the Auto-Magic AFC feature for most accurate tuning since the single signal-strength meter is of little help in pinpointing exact center-of-channel tuning. Power output was adequate for our medium-to-low efficiency bookshelf air-suspension speakers. Our capsule summary, along with overall comments, is listed in Table III. **R-E**

1

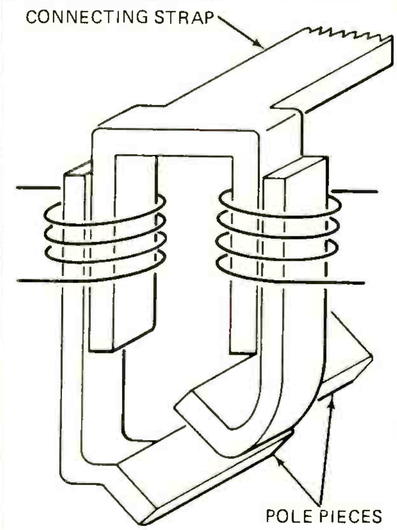
Radio-Electronics® Tests Shure Model M95ED

by LEN FELDMAN
CONTRIBUTING HI-FI EDITOR

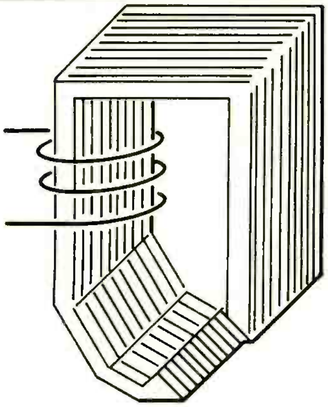
THE SHURE PEOPLE DESCRIBE THIS NEW cartridge as their "number two" unit in their well accepted line of phono pickups. The implication, of course, is that its performance is second only to their top-of-the-line model V15 Type III which has a suggested retail price of $72.00. A close-up photo of the cartridge, shown in Fig. 1, confirms a similarity in outer construction between the two cartridges, down to the pivotable stylus guard. Unlike the more expensive model, long screws are required to mount the cartridge, since these screws traverse the entire depth of the cartridge body. Of course, an assortment of screws and other hardware is supplied in the package, including four tiny terminal connectors (just in case your pickup arm shell is equipped only with loose wires). The easily replaced stylus assembly is color coded in yellow and carries a suggested retail price of $27.00. A spherical stylus assembly, designated as N95-3, and color coded

SUMMARY OF MANUFACTURER'S PUBLISHED SPECIFICATIONS:

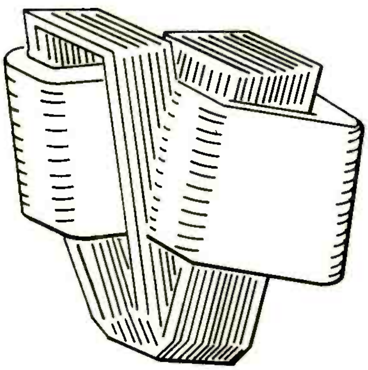
Frequency Response: 20 Hz to 20,000 Hz. **Tracking Force Range:** 0.75 to 1.5 grams. **Output Voltage:** 4.7 mV per channel at 1 kHz, at 5.0 cm/s peak velocity. **Channel Separation:** 25 dB at 1 kHz. **Channel Balance:** within 2 dB. **Trackability:** 24 cm/s at 400 Hz; 33 cm/s at 1kHz, 28 cm/s at 5 kHz; 19 cm/s at 10 kHz. **Optimum Load:** 47000 ohms in parallel with 400 to 500 pF capacitance per channel. **Stylus Type and Dimensions:** elliptical "nude" diamond tip, .0007" × .0002". **Resistance:** 1550 ohms. **Inductance:** 650 mH. **Weight:** 6 grams. **Mounting Centers:** 0.5 inch. **Suggested Retail Price:** $59.95.



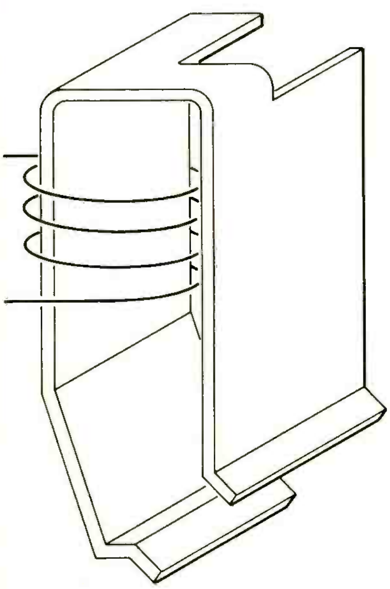
CONVENTIONAL POLE PIECE STRUCTURE (ONE CHANNEL SHOWN ONLY) 2



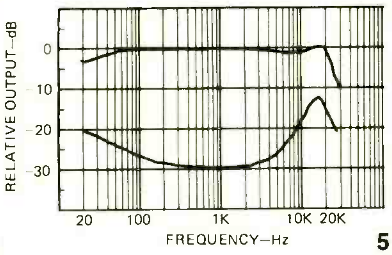
LAMINATED "POLE PIECE STACK"



"POLE PIECE STACK" ASSEMBLY AS USED IN SHURE V15III 3



POLE PIECE – SINGLE CHANNEL, AS DEVELOPED FOR SHURE M95ED 4



5

TABLE I

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer **Shure Bros., Inc.** Model **M95ED**

PHONOGRAPH CARTRIDGE MEASUREMENTS

	R-E Measurements	R-E Evaluation
FREQUENCY RESPONSE (Hz-kHz, ± — dB)	20, −20, ±2.5 See Fig. 5	Excellent
STEREO SEPARATION		
Separation, 1 kHz (dB)	28	Very good
Separation, 10 kHz (dB)	16	Good
Separation, 30 kHz (dB)	Not applicable	....
CHANNEL BALANCE, 1 kHz (dB)	1.8 dB	Good
TRACKABILITY MEASUREMENTS		
Stylus Velocity at 1 kHz (cm/s)	30	Excellent
Stylus Velocity at 10 kHz (cm/s)	18	Very good
COMPONENT MATCHING CHARACTERISTICS		
Output Level, 1 kHz, 3.54 cm/s (mV)	4.5	
Optimum Load Impedance (Ohms)	47,000	
Tracking Force Range (— to — grams)	¾-1½	
Cartridge Weight (grams)	6	
OVERALL PHONO CARTRIDGE RATING		Very good

TABLE II

RADIO-ELECTRONICS PRODUCT TEST REPORT

Manufacturer **Shure Brothers, Inc.** Model **M95ED**

OVERALL PRODUCT ANALYSIS

Retail Price	**$59.95**
Price Category	**Medium-high**
Price/Performance Ratio	**Very good**
Styling and Appearance	**Good**
Sound Quality	**Excellent**
Mechanical Performance	**Very good**

Comments: In one respect, at least, the new Shure M95ED actually offers an advantage over that company's more expensive top-of-the-line V15 Type III phonograph cartridge. It offers approximately 3-dB greater output without an audible sacrifice of fidelity. This can be important if your preamplifier signal-to-noise ratio is marginally acceptable when used with lower output cartridges, since the higher output relates directly to S/N ratio. Since we had access to the more expensive V15 Type III during these tests, we naturally compared listening results between the two models. We could detect virtually no difference in coloration or musical accuracy between the two, despite the slightly better response claimed for the more expensive unit. At equal tracking forces (1 gram), the V15 Type III is able to track somewhat higher recorded velocities, particularly where high-frequency signals are involved, but both units came through Shure's new "obstacle course" test record surprisingly well. Only a rare recording is likely to make greater tracking demands of a cartridge than are within the capability of the new M95ED unit from Shure. We heard no evidence of the high-frequency resonant point of the cartridge, even though it occurs at 19 kHz compared with 23 kHz for the more expensive V15 Type III.

dark green is available for 78 RPM record playing and costs $11.00.

Internal construction

One of the important structural features of the Shure V15 Type III was its laminated pole piece construction. This design eliminated the need for a connecting strap that is usually provided on top of the pole piece structure to provide a path for the magnetic lines of force, as shown in Fig. 2. The continuous-loop pole pieces are laminated together and stacked to form a complete assembly, as used in the V15 Type III is shown in Fig. 3. The M95ED cartridge does *not* have a laminated pole piece but does have a single-piece pole assembly (see Fig. 4). In other words, there is no need for a shorting strap at the top, or a connecting bar. This new magnetic structure arrangement is highly efficient and is, in part, responsible for the higher-than-usual output of the M95ED.

Shure supplied us with a table comparing the effective mass of stylus tips for

(continued on page 121)

BOOKSHELF SPEAKERS

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

LAST MONTH, WE COVERED SUCH CONSIDERations as size and the types of enclosures. We also discussed frequency response and dispersion specifications of many speaker systems.

In this article we will look at more specifications including distortion, linearity, efficiency, power-handling capacity, maximum sound output and impedance.

Distortion is important

There are two types of distortion in speaker systems—harmonic and intermodulation. Both types are directly related to the electromechanical structure of the drivers. In most cases, when one type of distortion is reduced, the other is also reduced. Also, harmonic distortion comprises the majority of the total distortion produced by a speaker system. Therefore, **Radio-Electronics** requested that only a harmonic distortion specification be provided by the manufacturers.

The mechanical sources of distortion affect both halves of the frequency cycle equally. This is similar to a push-pull system. Readers who are familiar with push-pull systems will remember that the even-order components of distortion are cancelled while the odd-order components remain. For this reason, unless the speakers are assembled incorrectly, a speaker system produces the odd-order components only—predominantly the third. Many hi-fi writers insist on referring to this as speaker "doubling". Doubling just doesn't exist. A better term and the correct one is speaker tripling.

Harmonic distortion varies with frequency and amplitude. It increases as the frequency is reduced and the amplitude is increased. It is not unusual for a speaker system to produce as much as 10% or more total harmonic distortion at a frequency of 20 Hz when driven with a 1-watt drive signal. So, don't expect the distortion figures to be preceded by the decimal points and zeros so commonly found in amplifier and tuner specs.

Ideally, distortion should be presented as a frequency versus amplitude graph. Figure 5 shows the harmonic distortion graphs for seven speaker systems manufactured by Acoustical Research, Inc. Figure 6 shows the harmonic distortion graph for a speaker system manufactured by Avid. Unfortunately, space limitations prevent us from presenting the rest of the specifications from the other manufacturers in that form. Instead, **Radio-Electronics** requested that the manufacturers provide the total harmonic distortion produced at 90-, 95-, and 100-dB SPL (Sound Pressure Level) for any frequency in the audio spectrum. Some manufacturers, however, preferred to specify the lower frequency limit. This lower frequency limit appears in the chart for those manufacturers that provided us with it. *(Remember, these are manufacturers specs and we have no way to authenticate their accuracy.)*

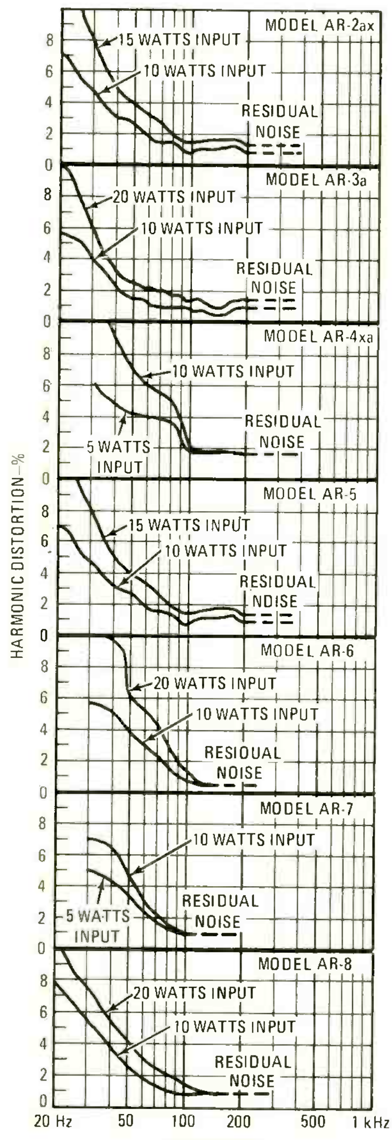


FIG. 5—HARMONIC DISTORTION CURVES for seven speaker systems from Acoustic Research.

If you've ever wondered why a guitar sounds different from a banjo, or a flute sounds different from a trombone, it's the different harmonic content in the musical notes that each instrument produces. Harmonic distortion tends to obscure the musical character. Excessive harmonic distortion garbles reproduced voices. Choose a speaker system with a minimum amount of distortion.

Linearity graphs

A linearity graph is a plot of input power versus output power (constant frequency) of a speaker system. In effect, this is a plot of efficiency (more about efficiency later on). A speaker system with perfect linearity will produce a straight-line plot. A practical nonlinear speaker system will produce a plot that tends to curve downwards (less efficiency) at the low input-power end of the graph. Figure 7 shows linearity graphs of five speaker systems manufactured by H. H. Scott, Inc. The solid line is the plot of the actual speaker system while the dotted line shows the plot that would be obtained if the speaker system had perfect linearity.

Conceivably, it can be argued that nonlinearity of this type can actually increase dynamic range and, therefore, it is good. In effect, it is the compression half of a compression-expansion expansion characteristic. Unfortunately, there is no way to control the amount of nonlinearity and, therefore, the amount of compression that takes place. It would be better to provide compression-expansion through electronic means rather than have it built into the speaker system. Also, some speakers are described as not being able to "open up" unless they are driven to high-output levels. This effect can only be traced to nonlinearity. For these reasons, we treat nonlinearity as a disagreeable effect.

Due to space limitations, the linearity specification is presented as a deviation from the straight-line plot that would be obtained from a speaker system with perfect linearity. It is expressed as a ± dB deviation over a range of input power. When considering linearity, look for a speaker system that offers a minimum deviation over the widest range of input power. *(text continues on page 70)*

MANUFACTURER'S SPECIFICATIONS

MANUFACTURER	MODEL	HARMONIC DISTORTION (%) AT ANY FREQUENCY AT SOUND PRESSURE LEVEL UP TO –			LINEARITY			EFFICIENCY	POWER HANDLING CAPACITY						MANUFACTURER'S RECOMMENDED AMPLIFIER POWER RATING		MAXIMUM OUTPUT
						FROM	TO	dB SPL FOR 1 CONTINUOUS WATT AT 1 kHz MEASURED AT 1 METER ON-AXIS	CONTINUOUS TONE			INTERMITTENT POWER			MIN RATING	MAX RATING	dB SPL AT 1 METER ON-AXIS WITH LESS THAN 3% THD AND IM DISTORTION FROM 100Hz TO 10 kHz
									CONTINUOUS WATTS	AT ANY FREQ BETWEEN		CONTINUOUS WATTS	FOR PERIODS NOT EXCEEDING				
		90dB	95dB	100dB	± dB	CONTINUOUS WATTS	CONTINUOUS WATTS			HERTZ	HERTZ		MINUTES	SECONDS	RMS WATTS	RMS WATTS	
ACOUSTIC RESEARCH	AR-2ax	1	2	4	1	0.1	50		25	20	5K	300	0	2	20	130	110
	AR-5	1	2	4	1	0.1	60		30	20	5K	400	0	2	25	150	112
	AR-6	1	3	8	1	0.1	45		20	20	20K	200	0	2	20	100	106
	AR-7	1	2	6	1	0.1	45		20	20	20K	200	0	2	15	100	106
AUDIOANALYST	A-76X	1.3	1.6	2.8	1	0.5	100	90	32	20	800	450	0	1	10	100	100
	A-100X	1	1.3	1.6	0.5	0.5	100	92	36	20	800	450	0	1	10	100	103
AVID	100	<1	<1	<2	+0 -1	0	75	86	25	65	8K	75*	1	–	15	75	100*
AZTEC BY PMDC CORP.	MINUET							88*							10	50	
	DU LANE II							88*							10	70	
	PICASSO							90*							10	70	
BANG AND OLUFSEN	1702	<2.5	<2.5	<2.5					20	50	20K	40*	–	–	4	20	
	2702	<2	<2	<2					25	45	20K	45*	–	–	3.5	25	
	3702	<1	<1	<1					40	40	20K	75*	–	–	3	40	
	4703	<1	<1	<1					60	30	20K	100*	–	–	4	60	
DYNACO	A-10VW							87	30*	–	–				15	50	
	A-25							90	45*	–	–				20	75	
	A-25XL							92	50*	–	–				20	85	
	A-35							90	45*	–	–				20	75	
ESS	AMT-5	.5 100Hz - 22 kHz	.5 100Hz - 22 kHz	1 100Hz - 22 kHz	3 100 - 22 kHz	1	20	92	30	100	1K				20	60	116
ELECTRO-VOICE	EV-13A			5				89	20	60	1K	100	0	0.1	10	60	103
	EV-14A			5				90	20	50	1K	100	0	0.1	10	60	103
	EV-15A			5				91	20	50	700	100	0	0.1	10	60	103
	EV-16A			5				92	20	40	700	100	0	0.1	10	60	103
	INTERFACE A			5				90	25	32	1500	100	0	0.1	10	60	103
HEATH	AS-48								50*	–	–						
	AS-104								60	30	300				10		
IMF	SUPER COMPACT														20	50	
JENSEN SOUND LABS	OPC-21							89*	40*						10		
	OPC-22							90*	45*						10		
	OPC-23							91*	60*						10		
LAFAYETTE RADIO ELECTRONICS	CRITERION 777	1.9	2.9	4.9				90	64	100	9K	310	0	15	15	80	93
	CRITERION 888	1.8	2.9	4.8				90	73	100	9K	375	0	15	15	100	95
MARANTZ	IMPERIAL 4G			0.9				95	15	40	18K	40	0	30	5	60	105
	IMPERIAL 5G			0.7				92	15	35	20K	40	0	30	5	60	103
PIONEER	CS-44G							91.5									
	CS-66G							92.5									
	CS-500G							94									
	R-300							92									
	R-500B							91									
	PROJECT 60																
	PROJECT 80																
	PROJECT 100																
QUADRA FLEX	RS-3				1	.01	20		20	20	1K	25	0	10	10	50	
	RS-4				1	.01	20		25	20	1K	25	0	10	10	75	
RTR	EXP-8	1	2	3	1	1	20	90	50	40	1K	100	2	0	20	60	100
H. H. SCOTT	S-110	0.8 @ 100Hz	0.7 @ 100Hz	0.65 @ 100Hz	0.1	0.55	50	76.7	20	30	20K	60	1	0	10	60	101.5 1.5% THD @ 100 Hz
	S-15	0.8 @ 100Hz	0.8 @ 100Hz	1.5 @ 100Hz	0.1	0.5	25	78.2	20	40	18K	60	1	0	7	50	101 2.0% THD @ 100 Hz
	S-42	0.8 @ 100Hz	1.0 @ 100Hz	2.2 @ 100Hz	0.1	0.4	35	81.5	15	40	20K	35	1	0	10	35	100 2.2% THD @ 100 Hz
	S-52	0.7 @ 100Hz	0.7 @ 100Hz	0.7 @ 100Hz	0.2	0.5	55	83	20	20	18K	60	1	0	18	60	101 1.2% THD @ 100 Hz
	S-61	0.7 @ 100Hz	0.7 @ 100Hz	0.7 @ 100Hz	0.2	0.5	45	79.5	25	20	20K	75	1	0	18	75	101 1.2% THD @ 100 Hz
SOUND CELL	SC-100								4.0	15	40K				.065	4.5	

NOTES:
*SPECIFICATION NOT MEASURED PER SPECIFIED CONDITIONS
**PRICE SLIGHTLY HIGHER ON WEST COAST
†PRICE INCLUDES EQUALIZER
††KIT FORM
BLANK SPACES INDICATE SPECIFICATIONS NOT PROVIDED BY MANUFACTURER.

IMPEDANCE					WOOFERS			MID-RANGE			TWEETERS			OPERATING PRINCIPLE	MANUFACTURER'S RECOMMENDED ORIENTATION (HORIZONTAL, VERTICAL)	MANUFACTURER'S RECOMMENDED POSITION	SIZE (INCHES)			WHT (LBS)	PRICE
NOMINAL	MIN		MAX																		
OHMS	OHMS	Hz	OHMS	Hz	TOTAL NO.	SIZE	TYPE	TOTAL NO.	SIZE	TYPE	TOTAL NO.	SIZE	TYPE				H	W	D		
8					1	254 mm	CONE	1	89 mm	CONE DAMPED	1	19 mm	DOME	ACOUSTIC SUSPENSION	EITHER	CTR MID-WALL	$13\frac{1}{2}$	24	$11\frac{1}{2}$	$36\frac{1}{2}$	$165.00 EACH
8					1	754 mm	CONE	1	38 mm	DOME	1	19 mm	DOME	ACOUSTIC SUSPENSION	EITHER	CTR MID-WALL	13	24	$11\frac{1}{2}$	39	$215.00 EACH
8					1	203 mm	CONE	0	–	–	1	32 mm	CONE	ACOUSTIC SUSPENSION	EITHER	CTR MID-WALL	12	$19\frac{1}{2}$	7	20	$99.00 EACH
8					1	203 mm	CONE	0	–	–	1	32 mm	CONE	ACOUSTIC SUSPENSION	EITHER	CTR MID-WALL	$9\frac{3}{4}$	$15\frac{3}{4}$	$6\frac{1}{4}$	11	$75.00 EACH
8	6	140	18	52	1	10 in.	CONE	0	–	–	1	2 in.	RING	ACOUSTIC SUSPENSION	EITHER	MID-WALL	$12\frac{1}{4}$	21	$10\frac{1}{2}$	30	$94.00 EACH
8	6.5	115	25	48	1	10 in.	CONE	1	2 in.	RING	1	$1\frac{1}{2}$ in.	DOME	ACOUSTIC SUSPENSION	EITHER	MID-WALL WOOFER AT EAR LEVEL	$13\frac{3}{4}$	24	12	37	$138.00 EACH
8	8.8	200	21	60	1	8 in.	CONE	0	–	–	1	$1\frac{3}{4}$ in.	CONE	AIR SUSPENSION	EITHER	MID-WALL	$12\frac{3}{4}$	21	$8\frac{1}{2}$	22	$85.00 EACH
8	6	150	26	65	1	8 in.	CONE	0	–	–	1	3 in.	RING	ACOUSTIC SUSPENSION	NOT CRITICAL	NOT CRITICAL	18	11	$9\frac{3}{8}$	19	$75.00 EACH
8	5	50	15	23	1	10 in.	CONE	0	–	–	1	3 in.	RING	ADJUSTABLE DISTRIBUTED BASS-REFLEX PORTED	NOT CRITICAL	NOT CRITICAL	23	$13\frac{1}{2}$	$9\frac{3}{8}$	30	$109.00 EACH
8	7	55	30	20	1	10 in.	CONE	1	6 in.	CONE	1	$3\frac{1}{2}$ in.	HORN	ADJUSTABLE DISTRIBUTED BASS-REFLEX PORTED	NOT CRITICAL	NOT CRITICAL	$23\frac{7}{8}$	$13\frac{1}{2}$	$11\frac{3}{4}$	38	$149.00 EACH
4					1	6 in.	–	0	–	–	1	1 in.	DOME	PRESSURE CHAMBER	EITHER	EAR LEVEL IN CORNERS	13	7	7	9	$170.00 PAIR
4					1	7 in.	–	0	–	–	1	$1\frac{1}{2}$ in.	DOME	PRESSURE CHAMBER	EITHER	EAR LEVEL CLOSE TO CORNER	$16\frac{1}{8}$	$8\frac{1}{16}$	$8\frac{1}{16}$	12	$200.00 PAIR
4					1	8 in.	–	1	$3\frac{3}{8}$ in.	–	1	1 in.	DOME	PRESSURE CHAMBER	EITHER	EAR LEVEL IN CORNERS	$19\frac{3}{4}$	$9\frac{7}{8}$	$9\frac{7}{8}$	20	$250.00 PAIR
4					2	7 in.	–	1	5 in.		1	1 in.	DOME	PRESSURE CHAMBER	EITHER	EAR LEVEL IN CORNERS	$22\frac{7}{8}$	$11\frac{7}{16}$	$11\frac{7}{16}$	28	$440.00 PAIR
8	7	200	24	1200	1	$6\frac{1}{2}$ in.	–	0	–		1	$1\frac{1}{2}$ in.	DOME	APERIODIC ACOUSTIC SLOT	VERTICAL	MID-WALL	15	$8\frac{1}{2}$	8	15	$110.00 PAIR
8	8	150	24	1800	1	10 in.	–	0	–	–	1	$1\frac{1}{2}$ in.	DOME	APERIODIC ACOUSTIC SLOT	VERTICAL	MID-WALL	20	$11\frac{1}{2}$	10	24	$92.00 EACH
8	6.5	10K	20	1200	1	10 in.	–	0	–	–	1	1 in.	DOME	APERIODIC ACOUSTIC SLOT	VERTICAL	MID-WALL	20	$11\frac{1}{2}$	10	25	$109.00 EACH
8	6.5	5K	14	70	1	10 in.	–	0	–	–	1	$1\frac{1}{2}$ in.	DOME	APERIODIC DUAL CHAMBER	VERTICAL	MID-WALL	$22\frac{1}{2}$	$12\frac{1}{2}$	10	30	$129.00 EACH
5	4	120	26	55	1	12 in.	–	0	–	–	1	HEIL AIR-MOTION TRANSFORMER		ACOUSTIC SUSPENSION	HORIZONTAL	FLOOR	24	$14\frac{1}{2}$	$11\frac{7}{8}$	45	$159.00 EACH
8	5.5	150	20	75	1	8 in.	CONE	0	–	–	1	2 in.	CONE	SEALED SYSTEM	EITHER	MID-WALL	10	19	$8\frac{1}{2}$	15	$69.95 EACH
8	6	150	20	60	1	10 in.	CONE	0	–	–	1	2 in.	CONE	SEALED SYSTEM	EITHER	MID-WALL	$13\frac{1}{2}$	24	$11\frac{3}{4}$	36	$109.95 EACH
8	5	1500	20	60	1	10 in.	CONE	1	5 in.	CONE	1	$2\frac{1}{4}$ in.	CONE	SEALED SYSTEM	EITHER	MID-WALL	$13\frac{1}{2}$	24	$11\frac{3}{4}$	44	$129.95 EACH
8	5	1500	30	50	1	12 in.	CONE	1	5 in.	CONE	1	$2\frac{1}{2}$ in.	CONE	SEALED SYSTEM	EITHER	MID-WALL	$14\frac{1}{2}$	25	$13\frac{3}{4}$	46	$149.95 EACH
8	5	32 & 150	23	1500	1	8 in.	CONE	0	–	–	2	$2\frac{1}{2}$ in.	CONE	EQUALIZED VENTED SYSTEM	EITHER	MID-WALL	14	22	$7\frac{3}{4}$	27	$450.00 PAIR†
8					1	14 in.	–	0	–	–	1	2 in.	–	TUNED PORT, DAMPED REFLEX	EITHER	MID-WALL	14	$23\frac{1}{2}$	12	42	$249.95 EACH††
8	6				1	10 in.	–	1	$4\frac{1}{2}$ in.		1	$3\frac{1}{2}$ in.	–	INFININTE BAFFLE	EITHER	MID-WALL	24	$13\frac{1}{2}$	$11\frac{1}{2}$	36	$109.95 EACH††
8	7	200	12	55	1	8 in.	CONE	1	5 in.	CONE	1	1 in.	DOME	RESISTIVE TUNNEL/ TRANSMISSION LINE	VERTICAL	ON STAND, AWAY FROM CORNERS	18	$11\frac{3}{4}$	11	20	$200.00 EACH
8	6	200	14	3000	1	8 in.		0	–	–	1	2 in.	CONE	ACOUSTIC SUSPENSION	EITHER		$18\frac{1}{4}$	11	$8\frac{3}{8}$		$69.00 EA **
8	6	200	14	3000	1	10 in.		0	–	–	1	2 in.	CONE	ACOUSTIC SUSPENSION	EITHER		$22\frac{1}{2}$	$12\frac{1}{4}$	$10\frac{3}{4}$		$99.00 EA **
8	6	3000	11	600	1	10 in.		0	–	–	1	$1\frac{1}{2}$ in.	DOME	ACOUSTIC SUSPENSION	EITHER		24	13	12		$129.00 EA **
8	7	95	22	1500	1	10 in.		1	6 in.		1	2 in.	DOME	ACOUSTIC SUSPENSION	EITHER		23	15	12	36	$119.95 EACH
8	7	100	22	1500	1	12 in.		1 1	6 in. 5 in.		1	2 in.	DOME	ACOUSTIC SUSPENSION	EITHER		24	$15\frac{1}{2}$	12	52	$169.95 EACH
8	6	200	12	75	1	8 in.		0	–	–	1	$1\frac{3}{4}$ in.		ACOUSTIC SUSPENSION	EITHER	MID-WALL	$19\frac{1}{8}$	$11\frac{1}{4}$	$8\frac{1}{2}$	20	$59.95 EACH
8	6	200	16	70	1	8 in.		0	–	–	1	$1\frac{3}{4}$ in.		BASS REFLEX PORTED	EITHER	MID-WALL	23	12	$9\frac{1}{2}$	23.5	$99.95 EACH
8					1	8 in.	CONE	0	–	–	1	$2\frac{9}{16}$ in.	CONE	INFINITE BAFFLE	EITHER	MID-WALL	$17\frac{3}{4}$	11	$10\frac{1}{4}$	19	$79.95 EACH
8					1	10 in.	CONE	1	$6\frac{1}{2}$ in.	CONE	1	3 in.	CONE	INFINITE BAFFLE	EITHER	NEAR CORNER	$21\frac{5}{8}$	$12\frac{1}{2}$	$11\frac{3}{8}$	26	$119.95 EACH
8					1	10 in.	CONE	1	5 in.	CONE	1	3 in.	CONE	INFINITE BAFFLE	EITHER	NEAR CORNER	$22\frac{1}{2}$	$12\frac{3}{4}$	$12\frac{3}{4}$	32	$149.95 EACH
8					1	10 in.	CONE	0	–	–	1	–	HORN	BASS REFLEX	EITHER	NEAR CORNER	$22\frac{15}{32}$	13	$10\frac{9}{16}$	26	$119.95 EACH
8					1	10 in.	CONE	1	5 in.	CONE	1	–	HORN	BASS REFLEX	EITHER	NEAR CORNER	$24\frac{1}{32}$	$13\frac{25}{32}$	$12\frac{1}{16}$	38	$169.95 EACH
8					1	8 in.	CONE	0	–	–	1	$2\frac{1}{2}$ in.	HORN	BASS REFLEX	EITHER	NEAR CORNER	$18\frac{1}{2}$	$10\frac{5}{8}$	$8\frac{1}{2}$	11	$79.95 EACH
8					1	10 in.	CONE	0	–	–	1	$1\frac{1}{2}$ in.	DOME	AIR SUSPENSION	EITHER	MID-WALL	$20\frac{3}{4}$	$11\frac{3}{4}$	11	25	$99.95 EACH
8					1	10 in.	CONE	0	–	–	1	$1\frac{1}{2}$ in.	DOME	AIR SUSPENSION	EITHER	MID-WALL	23	13	$10\frac{1}{2}$	40	$129.95 EACH
8	5.3	200	23.5	65	1	8 in.		0	–	–	1	3 in.	CONE	ACOUSTIC SUSPENSION	EITHER	EAR-LEVEL	$21\frac{1}{4}$	$12\frac{3}{8}$	8	25	$59.95 EACH
6	4	200	7	60	1	10 in.		0	–	–	1	3 in.	CONE	ACOUSTIC SUSPENSION	EITHER	EAR-LEVEL	$23\frac{1}{2}$	$13\frac{3}{8}$	11	30	$89.95 EACH
8	6.5	150	10	20K	1	8 in.		0	–	–	1	–	–	ACOUSTIC SUSPENSION	NOT CRITICAL	NOT CRITICAL	$11\frac{1}{4}$	$19\frac{1}{8}$	$8\frac{1}{2}$	25	$89.95 EACH
8	6.5	5K	16	47	1	10 in.		1	$4\frac{1}{2}$ in.	CONE	1	1 in.	DOME	ACOUSTIC SUSPENSION	VERTICAL	4 INCHES ABOVE FLOOR, MID-WALL	24	$14\frac{1}{2}$	$11\frac{1}{4}$	36	$149.95 EACH
8	6.5	3500	25	70	1	10 in.		1	$4\frac{1}{2}$ in.	CONE	1	3 in.	CONE	ACOUSTIC SUSPENSION	VERTICAL	4 INCHES ABOVE FLOOR, MID-WALL	$23\frac{1}{2}$	$11\frac{3}{4}$	9	24	$134.95 EACH
8	6	2K	20	65	1	8 in.		0	–	–	1	1 in.	DOME	ACOUSTIC SUSPENSION	EITHER	10 INCHES ABOVE FLOOR, MID-WALL	22	$11\frac{1}{4}$	$8\frac{1}{2}$	22	$79.95 EACH
8	6	150	25	42	1	10 in.		0	–	–	1	$1\frac{1}{2}$ in.	DOME	ACOUSTIC SUSPENSION	EITHER	4 INCHES ABOVE FLOOR, MID-WALL	24	$14\frac{1}{2}$	$10\frac{1}{2}$	40	$114.95 EACH
8	6	6K	30	45	1	10 in.		1	$4\frac{1}{2}$ in.	CONE	1	1 in.	DOME	ACOUSTIC SUSPENSION	EITHER	4 INCHES ABOVE FLOOR, MID-WALL	25	$14\frac{1}{2}$	$11\frac{1}{2}$	43	$169.95 EACH
8					0	–	–	1			0	–	–	CENTER EXCITED PIPE	HORIZONTAL		$8\frac{3}{4}$	$10\frac{1}{2}$	$8\frac{3}{4}$		$75.00 EACH

(chart continues on page 70)

If you've ever said...

"There must be a better

Send for a free Career Guidance Booklet that could start you on the road to success in a rewarding new career.

It happens to all of us, sooner or later. No matter what kind of job we have.

One day, it suddenly strikes home that we're going to have to work for a living, the rest of our lives. And most of us are horrified at the thought of forever being locked into the jobs we now hold.

"Surely," we tell ourselves, "there must be a way to get more satisfaction out of working. Surely, there must be a way to find a job that's more rewarding."

"Surely," in other words, "there must be a better way to earn a living!"

If you, too, have been thinking these same thoughts, you'll find one of our free Career Guidance Booklets very helpful at this time. We invite you to send for one.

Your free booklet will describe the opportunities for higher income and greater job security you might expect in one of the career fields listed on card or coupon. It will also explain why ICS can prepare you for this new career field...right in your own home...in your spare time...regardless of your education or past experience.

Of course, no school—not even ICS—can guar-

MANUFACTUERER'S SPECIFICATIONS (CONT)

MANUFACTURER	MODEL	HARMONIC DISTORTION (%) AT ANY FREQUENCY AT SOUND PRESSURE LEVEL UP TO –			LINEARITY			EFFICIENCY	POWER HANDLING CAPACITY						MANUFACTURER'S RECOMMENDED AMPLIFIER POWER RATING		MAXIMUM OUTPUT
						FROM:	TO:	dB SPL FOR 1 CONTINUOUS WATT AT 1 kHz MEASURED AT 1 METER ON-AXIS	CONTINUOUS TONE			INTERMITTENT POWER			MIN RATING	MAX RATING	dB SPL AT 1 METER ON-AXIS WITH LESS THAN 3% THD AND IM DISTORTION FROM 100Hz TO 10 kHz
									CONTINUOUS WATTS	AT ANY FREQ. BETWEEN		CONTINUOUS WATTS	FOR PERIODS NOT EXCEEDING				
		90dB	95dB	100dB	±dB	CONTINUOUS WATTS	CONTINUOUS WATTS			HERTZ	HERTZ		MINUTES	SECONDS	RMS WATTS	RMS WATTS	
STR	ALPHA	1 50 Hz-15 kHz	1 50 Hz-15 kHz	3 50 Hz-15 kHz				96	40	20	20K	100	0	10	5	75	100
SUPERSCOPE	S-16A	2	5					95	5	80	17K	15	0	30	2	20	93
	S-26A	3	5					88	5	60	18K	20	0	30	2	20	92
	S-212A	1	2	3				90	50	30	20K	100	0	30	5	100	100
TECHNICS BY PANASONIC	T-200							73.3				40	5	0	10		
	T-300							73.3				50	5	0	10		
TEMPEST	LAB SERIES 2	<.5 100 Hz 22 kHz	<.5 100 Hz 22 kHz	<1 100 Hz 22 kHz	2 100 Hz 22 kHz	1	15	96	30	100	1K				8	40	120
	LAB SERIES 3 & 3E	<.5 100 Hz 22 kHz	<.5 100 Hz 22 kHz	<1 100 Hz 22 kHz	2 100 Hz 22 kHz	1	15	96	30	100	1K				8	40	120
YAMAHA	NS-670														6.3	50	
ZENITH	E9012 ALLEGRO 1000								20	60	15K				3	30	
	E9014 ALLEGRO 2000								20	50	15K				3	40	
	E9018 ALLEGRO 3000								20	40	15K				3	50	

NOTES:
*SPECIFICATION NOT MEASURED PER SPECIFIED CONDITIONS
**PRICE SLIGHTLY HIGHER ON WEST COAST
†PRICE INCLUDES EQUALIZER
††KIT FORM
BLANK SPACES INDICATE SPECIFICATIONS NOT PROVIDED BY MANUFACTURER.

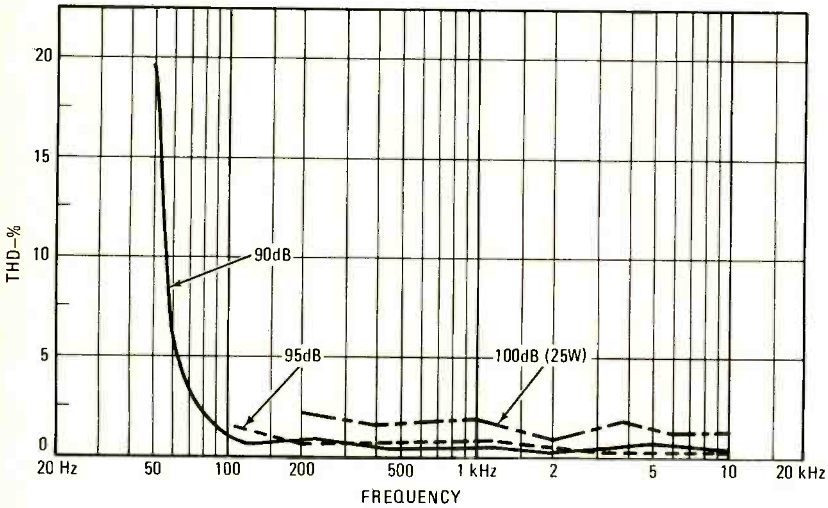


FIG. 6—HARMONIC DISTORTION CURVE of Avid's model 100.

Efficiency and sound levels

Efficiency refers to the ability of a speaker system to convert electrical input power into acoustical power. Not all the power fed to a bookshelf speaker system is converted into acoustical power. The majority of power is dissipated in the form of heat by the individual drivers. A speaker system with a relatively high efficiency will convert more input power into acoustical power and achieve higher sound levels from an amplifier with a given power rating then a low-efficiency system.

To provide realistic sounding reproduction, a hi-fi system must be able to deliver the same sound levels that are produced at a live concert. (Unfortunately, not very many of us live where we can run our systems at these levels without the neighbors running us out of town.) Normal listening levels produced by an orchestra in a concert hall rarely exceed 90-dB as experienced by the audience. At a live rock concert, the sound levels can approach 110—115 dB, and more. To provide a reference level, the threshold of pain for the human ear is 130-dB. Consider the fact that an increase of 10 dB will only *double* the loudness level. This is a ten-fold increase in the power that must be provided by the amplifier.

The average power consumed by a speaker system at normal, not too loud, listening levels is a fraction of one watt. The program material, however, contains transient peaks that can demand from the amplifier as much as 100 times the average power level. To prevent the amplifier from clipping these transient peaks, and thus causing distortion, either the amplifier power rating can be increased or the average power consumed at normal listening levels can be decreased. This latter alternative is done by choosing a speaker system with a high-efficiency rating.

The efficiency specification is presented as the number of dB SPL produced by the speaker system when it is driven with a 1000-Hz, 1-watt drive signal measured at a distance of 1-meter on axis. There is no direct relationship between efficiency and sound quality. However, a more efficient speaker system demands less power from the amplifier. Consider this point (along with power-handling and impedance specifications) when selecting an appropriate amplifier to drive the speaker system. If you already own an amplifier, choose a speaker system that will match the amplifier based on these considerations.

Power handling capacity

A speaker system is rated for the maximum number of watts that it can handle safely. Beyond this point, the speaker system will be destroyed. Excessive power usually results in the voice coil of one of the drivers being melted. So this specification is important when selecting an amplifier that will safely drive the speaker system.

The power handling capacity of a speaker system is dependent upon frequency. Each driver in the speaker system has a different power handling capacity. Normal program material is not made up of equal amounts of power in the bass, mid-range, and treble portions of the audio spectrum. Also, each driver in the speaker system (woofer, mid-range and tweeter) has a different efficiency. As a result, it is not necessary for each driver to handle the same amount of power. For example, in a typical three-way speaker system, the mid-range will be capable of handling 25% of the total system power while the tweeter will be capable of handling 5%. The woofer will be capable of handling 100% of the total system power. For this reason, the first specification for power handling capacity is expressed in continuous watts electrical input signal over a range of input frequencies. In addition, this is a continuous tone specification. The speaker system will be capable of handling this amount of power for an infinite amount of time—forever.

The continuous-tone specification is the average power that the speaker system can handle. This specification coupled with the efficiency and the power delivered by the amplifier will determine the listening levels that will safely be achieved by the speaker system. Normal program material however, is not composed of constant level

MANUFACTURER'S SPECIFICATIONS (CONT)

IMPEDANCE					WOOFERS			MID-RANGE			TWEETERS			OPERATING PRINCIPLE	MANUFACTURER'S RECOMMENDED ORIENTATION (HORIZONTAL, VERTICAL)	MANUFACTURER'S RECOMMENDED POSITION	SIZE (INCHES)			WHT (LBS)	PRICE
NOMINAL	MIN		MAX																		
OHMS	OHMS	Hz	OHMS	Hz	TOTAL NO.	SIZE	TYPE	TOTAL NO.	SIZE	TYPE	TOTAL NO.	SIZE	TYPE				H	W	D		
8	5	140	18	50	1	10 in.		1	12 cm	–	1		PIEZOELECTRIC	TUBE VENTED REFLEX	VERTICAL	2 FT. OFF FLOOR, 2 FT. FROM WALL	$23\frac{7}{8}$	$14\frac{3}{4}$	$12\frac{1}{2}$	45	$139.00 EACH
8	8	500	25	20K	1	6½ IN. FULL RANGE								BASS REFLEX	EITHER	NEAR CORNER	17	$10\frac{1}{2}$	7	7	$69.95 PAIR
8	8	400	15	150	1	$6\frac{1}{2}$ in.		0	–	–	1	2 in.	CONE	BASS REFLEX	EITHER	NEAR CORNER	$19\frac{1}{8}$	$11\frac{1}{4}$	7	9.5	$79.95 PAIR
8	8	150	30	1500	1	12 in.		0	–	–	1	3 in.	–	AIR SUSPENSION	EITHER		$23\frac{1}{2}$	$14\frac{1}{2}$	11	27	$169.95 EACH
8	6.5	200-400			1	10 in.	CONE	0	–	–	1	$1\frac{3}{4}$ in.	RING	ACOUSTIC SUSPENSION	EITHER	MID-WALL	$21\frac{3}{4}$	12	$10\frac{1}{2}$	27	$99.95 EACH
8	6.5	200-400			1	10 in.	CONE	1	3	CONE	1	2 in.	DOME	ACOUSTIC SUSPENSION	EITHER	MID-WALL	$24\frac{3}{8}$	$13\frac{3}{4}$	$12\frac{1}{2}$	33	$179.95 EACH
5	4	150	22	60	1	10 in.		0	–	–	1	HEIL AIR MOTION TRANSFORMER		SHELF PORT REFLEX	HORIZONTAL	FLOOR	$24\frac{1}{4}$	$13\frac{1}{4}$	$13\frac{1}{4}$	40	$169.00 EACH
5	4	170	20	65	1	8 in.		0	–	–	1	HEIL AIR MOTION TRANSFORMER		SHELF PORT REFLEX	HORIZONTAL	FLOOR	22	$12\frac{1}{4}$	$10\frac{5}{8}$	30	$129.00 EACH
8					1	250 mm	CONE	1	60 mm	DOME	1	30 mm	DOME	ACOUSTIC SUSPENSION	HORIZONTAL	FLOOR, NEAR CORNER	$22\frac{3}{4}$	$12\frac{5}{8}$	$10\frac{5}{8}$	42	$460.00 PAIR
8	8	250	48	105	1	$6\frac{1}{2}$ in.		0	–	–	1	$3\frac{1}{2}$ in.		BASS REFLEX PORTED	EITHER		$16\frac{1}{2}$	$10\frac{1}{2}$	$7\frac{1}{2}$	12	$54.95 EACH
16	10	8K	90	90	1	8 in.		0	–	–	1	$3\frac{1}{2}$ in.		BASS REFLEX PORTED	EITHER		$18\frac{5}{8}$	$12\frac{3}{8}$	$7\frac{7}{8}$	17	$64.95 EACH
16	11	8K	100	70	1	10 in.		0	–	–	1	$3\frac{1}{2}$ in.		BASS REFLEX PORTED	EITHER		$22\frac{3}{4}$	$14\frac{1}{4}$	$8\frac{7}{8}$	22	$79.95 EACH

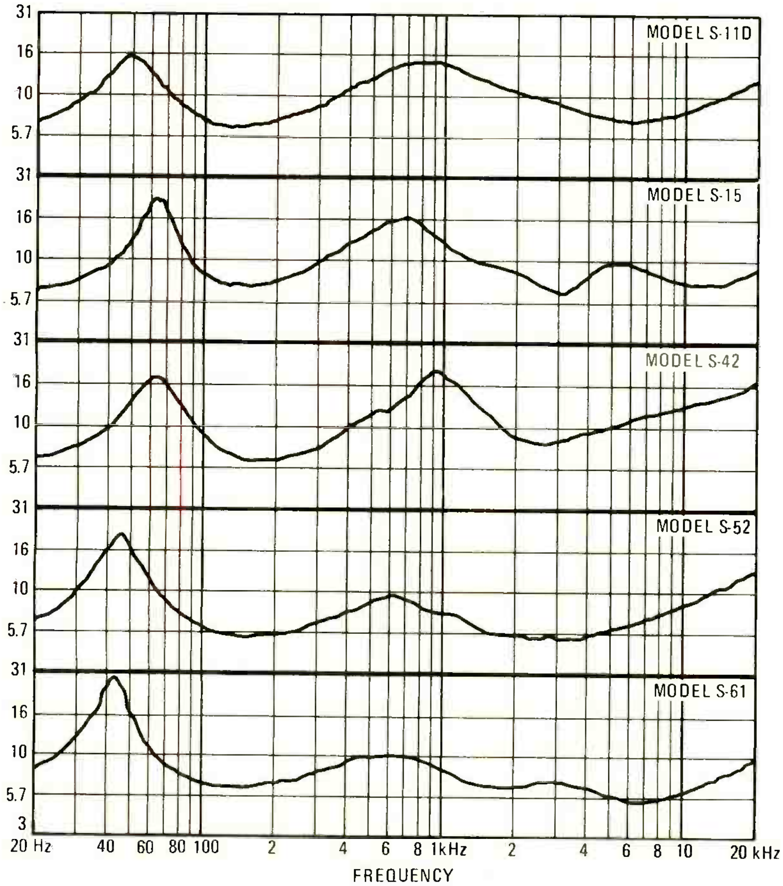


FIG. 8—IMPEDANCE CURVES for acoustic suspension speaker systems from H. H. Scott.

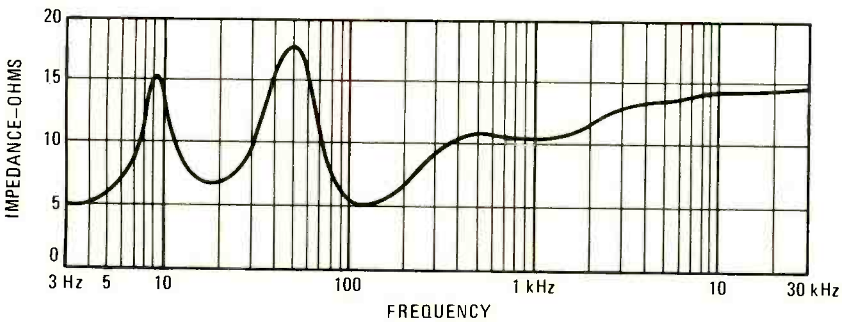


FIG. 9—IMPEDANCE CURVE of STR's model Alpha bass-reflex speaker system.

signals. It is made up of transient peaks. Therefore, the amplifier delivers short bursts of power to the speaker system that are much greater than the average level. For example, suppose an amplifier rated at 100 watts RMS is driving a speaker system. If the volume control was turned up to the point where the peaks of the program material were just being clipped, the average power delivered to the speaker system would only be 15 watts RMS. The power delivered on the program peaks would be 100 watts.

The intermittent power handling specification is referenced to time. The ability of a speaker system to handle short bursts of power is much greater than its ability to handle power for long periods of time.

There is no direct relationship between power handling capacity and the sound quality that a speaker system will produce. However, if the actual input power to a speaker system is quite a bit less than its power handling capacity, the distortion will be less. In addition, this as an important consideration to prevent damage from an amplifier whose maximum output is too powerful for the speaker system. Therefore, choose a speaker system with a large power handling capacity. For the continuous-tone specification this means the largest power rating over the widest range of frequencies. The intermittent specification should be the largest power rating over the longest period of time.

Recommended amplifier power

In addition to the power handling capacity, **Radio-Electronics** requested that the manufacturers provide their recommendations concerning the proper power rating of the amplifier that should drive the speaker system. This recommendation is in two parts—minimum power and maximum power. The recommendation of the maximum power rating of the amplifier is directly related to the maximum power handling capacity of the speaker system. The power rating of the amplifier (RMS) should not exceed this recommendation to avoid possible damage to the speaker system. Otherwise some protective device must be used to protect the speakers

(continued on page 76)

how a PROM works

Programmable Read Only Memories are manufactured using various technologies. This article describes each type of PROM and its advantages and disadvantages.

by ROGER L. SMITH

REMEMBER WHEN SOMEONE MENtioned a PROM, we all thought of a high school dance? Well, in today's age of electronics, a PROM is a *P*rogrammable *R*ead *O*nly *M*emory. Incidentally, PROM is a trademark of Harris Semiconductor Div. of Harris Intertype Co.; however, the word has become generic because of its widespread use in describing all field programmable ROM's.

Speaking of ROM's, let's cover some of the basics of memories and the terms used before going any further. The first memories that were used with computers (and a computer is not a computer without a memory) were ferrite-core memories. These core memories—provided they were properly powered down and up—were non-volatile, meaning the data in them was not lost when power was removed. In a volatile memory, all data is lost in powering down. Most core memories are also classified as DRO, although a few are NRDO. The DRO (*D*estructive *R*ead-*O*ut) uses a read-write cycle to restore data to the cores. An NDRO (*N*on-*D*estructive *R*ead-*O*ut) memory does not require rewriting the data after a read cycle is completed.

With the advent of LSI (*L*arge *S*cale *I*ntegration) techniques and the decreasing cost of semiconductors, the use of semiconductors as memory elements became possible. Various types of semiconductor memories evolved—from simple diodes arranged in a matrix to flip-flops, stored-charge devices and amorphous semiconductors. These new types of memories permitted designers to implement the ROM for cases where the memory was to be used for fixed conditions such as program control.

These ROM's presented logic designers with options not previously available. Now it became possible to replace complex logic circuits with ROM's. You can imagine how difficult it would be to design the logic for a code conversion—a simple job for a ROM. Another unique use for ROM's is in custom waveform generators. A sequential counter feeds the ROM inputs and the outputs go to a digital-to-analog (D-to-A) converter. In another use, the inputs are treated as separate logic inputs and the ROM acts as a Programmable Logic Array (PLA). For more information, refer to the article "What Is A ROM?" in the February, 1974 issue of **Radio-Electronics.**

What PROMs are available?

The simplest PROM's—diode matrices—are available in 14-pin packages (Harris HM1-034-2, a 6 × 8 array) containing diode arrays with fusible links, These diode matrices can be programmed by "burning out" the fusible links and thus can be classified as PROM's. Such memories are used primarily in encoding and decoding functions.

Amorphous semiconductor

An interesting type of memory that is also field-programmable is the amorphous semiconductor memory. This memory consists of amorphous glass semiconductor resistors (called ovonic memory switches by Energy Conversion Devices, Inc.) in series with silicon diodes in a matrix array. The glass semiconductor can exist in either of two phases—amorphous or polycrystalline. The resistors in the amorphous phase show a resistance of about 300K ohms, and in the crystalline phase about 500 ohms. The low-resistance, or set state, is achieved by applying a 15 millisecond pulse to the bit to be set. The high-resistance, or reset state, requires applying 8 to 10 five-microsecond pulses at 80 μs intervals.

These amorphous memories thus have a slow write-cycle time and are called by the manufacturer (Energy Conversion Devices) Ovonic Read-Mostly Memories (RMM). These devices are non-volatile like PROM's but they can also be written into like Random Access Memories (RAM's).

Fusible links

The semiconductor PROM most often used at this time is the bipolar type containing memory elements composed of nichrome fusible-links. Intel is

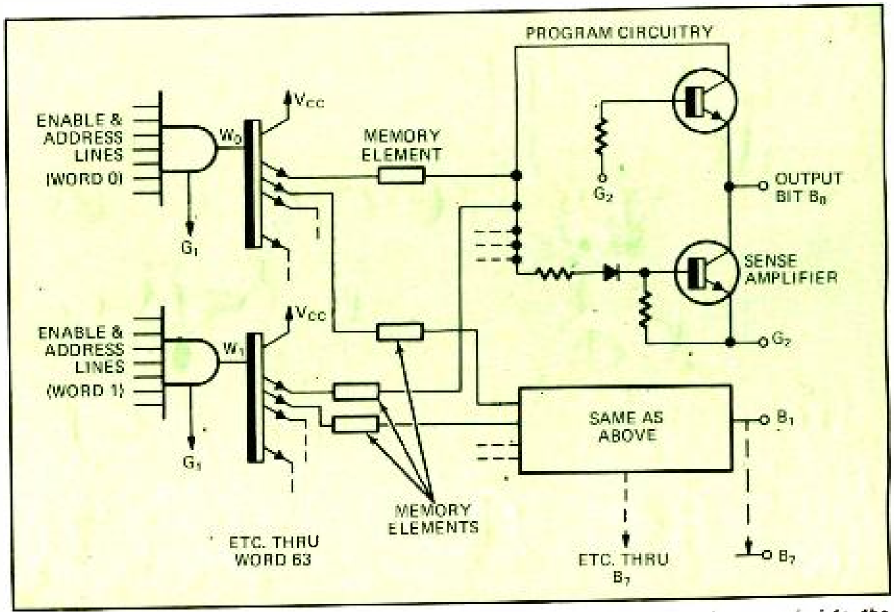


FIG. 1—512-BIT PROM schematic shows the word transistors (64 of them) connected to the sense and program circuits via memory elements.

TABLE 1

Manufacturer	Part No.	Organization	Bits	Supply Voltage Normal	Supply Voltage Program	Memory Element	Special Notes
Advanced Micro Devices	AmS08	32x8	256	+5V	10V to 15V	polysilicon	open col. out. } +2 words
	AmS09	32x8	256	+5V		polysilicon	3 state out. } 9th bit,
Harris Semiconductor	HPROM-0512	64x8	512	+5V	+5V,+15V	nichrome fuse	Program similar to
	HPROM-1256	256x1	256	+5V	+5V,+15V	nichrome fuse	Signetics.
	HPROM-8256	32x8	256	+5V	+5V,+15V	nichrome fuse	
	HPROM-1024/A	256x4	1024	+5V	+5V,+15V	nichrome fuse	3 state out, A=open coll.
	HPROM-2048/A	512x4	2048	+5V	+5V,+15V	nichrome fuse	3 state out, A=open coll.
Intel Co.	1602A/1702A	256x8	2048	+5V-9V	+12V,−45V	FAMOS device	1702A is erasable
	3604	512x8	4096	+5V	+10V,+15V	polysilicon	all outputs norm. high (1)
	8702A	256x8	2048	+5V-9V	+12V,−45V	FAMOS device	3 state out
	3601	256x4	1024	+5V	+10V,+15V	polysilicon	
Intersil	IM5600C/IM5610	32x8	256	+5V	+5V,+28V	"AIM" device	open coll. 5610=3 state
	IM5603A/IM5623	256x4	1024	+5V	+5V,+28V	"AIM" device	special pulse programmer
	IM5604/IM5624	512x4	2048	+5V	+5V,+28V	"AIM" device	
Motorola Semiconductor	MCM5003AL	64x8	512	+5V	+5V,−6V	nichrome	9th bit. Prog. manually
	MCM5004AL	64x8	512	+5V	+5V,−6V	nichrome	has 2K on output
National Semiconductor	MM5202A	256x8	2048	+5V-9V	+12V,−45V	FAMOS device	Q suffix has quartz lid
	MM5203	256x8	2048	+5V-9V	+12V,−45V	FAMOS device	for erasing.
	MM5204	512x8	4096	+5V-9V	+12V,−45V	FAMOS device	
Signetics	8223	32x8	256	+5V	+5V,+12.5V	nichrome	open coll. Prog. manually
	82S23/82S123	32x8	256	+5V	+5V,+12.5V	nichrome	82S123=3 state
	82S26/82S29	256x4	1024	+5V	+5V,+12.5V	nichrome	26=open coll. 29=3 state
Texas Instr.	SN74186	64x8	512	+5V	+5,−5V	nichrome	9th bit & extra word tested
	SN74188A	32x8	256	+5V	+5V,+10V	nichrome	by mfg. Prog. manually.
							open collector output.
							All types are 0° to 75°C

presently making bipolar PROM's (up to 4096 bits) using polycrystalline silicon fuses (instead of nichrome). Advanced Micro Devices also makes 256 bit PROM's with silicon fuses. A look at Fig. 1 will help you to understand the operation of this type of fuse-link PROM. This figure is a block diagram of a 64-word, 8-bit PROM (512 bits). The 6-bit ADDRESS input is buffered and inverted to provide true or complement addresses to each of six inputs on the 64 multiple-emitter AND gates. A seventh input provides the chip enable signal. Since only one of the 64 AND gates will be activated for a particular address, that gate will generate a high level on one of the 64 word lines connected to each gate output. These word lines are connected to the bases of 64 multiple-emitter transistors located in the memory section of the circuit.

The selected (1 of 64) multiple-emitter transistor drives the output transistors thru the eight memory elements. With the proper resistive load connected to their collectors, these transistors will saturate and a low voltage, or logic "0," will appear at the output. Thus the normal output of such a PROM, with the memory elements intact, is a "0." This PROM is programmed by opening the appropriate memory elements and causing a logic "1" to appear at the output for a specific address.

Memory elements of this type (as in the Motorola MCM5003) are fused open by connecting a negative voltage (−6V) to the output collector of the desired bit, applying a voltage (+5V) to Vcc, grounding pin G2, and connecting G1 to a negative voltage (−6V). Then the desired word is addressed (with −6V as a "0" and −4V to +5V as a "1"). Notice in Fig. 1 that this forward biases the program transistor for that bit so that when the address is

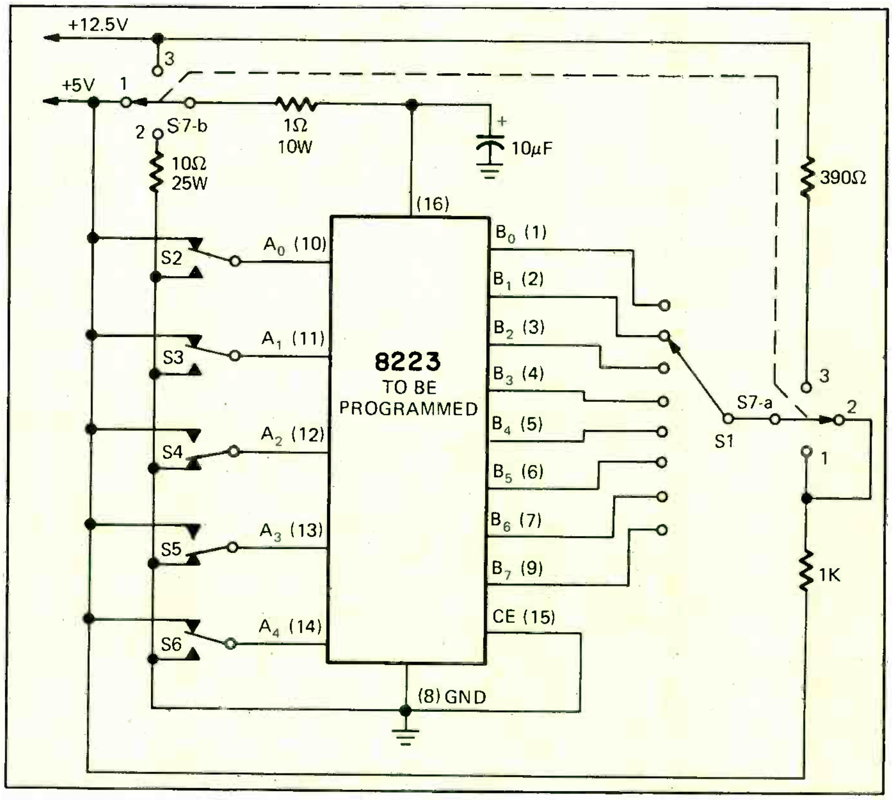


FIG. 2—MANUAL PROGRAMMER schematic. During programming, switch S7 is moved to position 2 long enough to discharge the 10-μF capacitor. Switch S7 should not be in position 3 for longer than one second.

selected, current thru the memory element is increased (to 30 mA). This is sufficient to cause the metal fuse to flow and separate. The current is applied as a ramp and limited to 60-mA maximum to prevent sputtering, metal splatter, or oxide damage.

Programming voltages for other nichrome type PROM's such as Signetics' 8223, vary somewhat. However, the basic idea is to allow a heavy current to pass thru the nichrome "fuse" to a program transistor that is biased into saturation. Figure 2 shows a manual programmer that can be used to program the Signetics 8223. When using this programmer, current should not be applied to a bit for over one second.

Two precautions should be observed when programming this type of PROM. One is to limit the application of programming current to one output at a time. This current passes thru the multiple-emitter "word transistor" whose design doesn't allow it to conduct more current than required to open one element. Another precaution is to maintain the case temperature of the PROM at or below 75°C. This is easy to do if you program manually and remove voltages as soon as the memory element opens. Automatic programming may require a heat sink.

The above description of programming the fuse-link type of PROM illustrated a manual technique. Manual programming is possible with most types of nichrome fuse-link PROM's *provided* that the currents are limited in some manner. Most often, the rise time must be controlled and the duration and amplitude of the programming current must be limited. This is easily done with a pulsing technique. All of this of course, can be accomplished with an automatic programmer that also sequences thru the addresses and bit patterns. Automatic programmers are desirable when more than three or four PROM's are to be programmed, and are required equipment for some of the PROM's to be described next.

AIM

Another type of memory element is used by Intersil in their PROM's. They have patented *A*valanche *I*nduced *M*igration (AIM) programming system. Each memory element in an open-base NPN transistor whose base-emitter junction is shorted out when it is programmed.

A partial schematic of an AIM matrix is shown in Fig. 3. Notice that the matrix is constructed using conventional TTL processes. Collectors on the "X" lines are common and emitters on the "Y" lines are common, allowing for simple fabrication steps. No connection is provided for the bases. To program an element, a high current is forced thru it from emitter to collector. The emitter-base junction is forced beyond normal avalanche and into a second breakdown mode. Aluminum moves into the junction and causes a short. The result is a low-resistance path to the base and a base-collector diode as shown in Fig. 3.

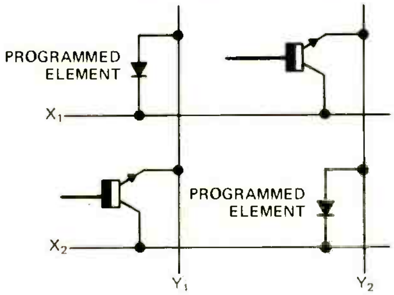


FIG. 3—PARTIAL AIM PROM matrix with two bits programmed as "1".

The programming is done using a 200 mA pulse (at about 32V) of about 2.5 μs duration followed by a 20 mA, 1.5 μs sense pulse. These pulses are repeated a number of times until a change in the bit has been detected. The programmer then moves on to the next bit automatically.

FAMOS

The last type of PROM we will investigate is the stored-charge type made by Intel and National Semiconductor. This type of PROM falls in the same category as the ovonic amorphous semiconductor type mentioned earlier in that it can be *re*-programmed (however, not electrically). The advantage of this type of PROM is obvious. If you make a mistake, or change your bit requirements, you can change your PROM by erasing all bits and programming it over again! Erasure is accomplished with ultraviolet light or X-rays (although X-rays are not recommended).

The memory element consists of a floating-gate avalanche-injection MOS charge-storage device (which has been shortened to FAMOS transistor). Notice in Fig. 4 that the FAMOS transistor is essentially a P-channel silicon gate MOS field-effect transistor in which no contact is provided to the silicon gate. In programming, a voltage pulse in excess of −30 volts is applied to the drain or source PN junction resulting in the injection of high-energy electrons from the PN junction surface avalanche region to the floating silicon gate. This negative charge on the gate results in current flow between source and drain of the P-channel FAMOS transistor.

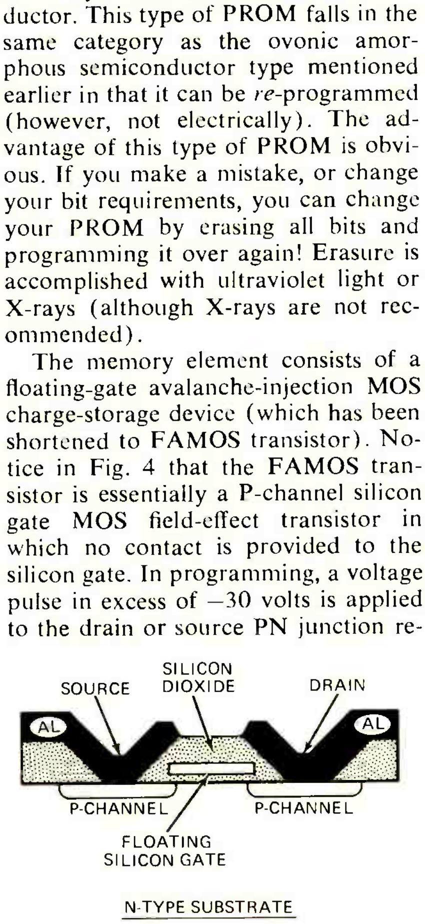


FIG. 4—CROSS-SECTION OF FAMOS structure. Negative charge on floating gate causes conduction between source and drain.

The FAMOS transistors are arranged in a matrix on the silicon chip along with an X and Y decoders, input drivers, output sensors and buffers to form the complete MOS memory device. Programming these PROM's (typically the Intel 1702A, 2048-bit PROM) requires special programmers that pulse the device with a minimum of 32 program pulses for each 8-bit word to be programmed. Note in this PROM that all 8 bits of a word are programmed simultaneously. In addition to the program pulse, voltages V_{GG} and V_{DD} are also pulsed. The Intel Company will furnish you schematics for the MP7-03 PROM Programmer, or of course, you could buy an assembled unit.

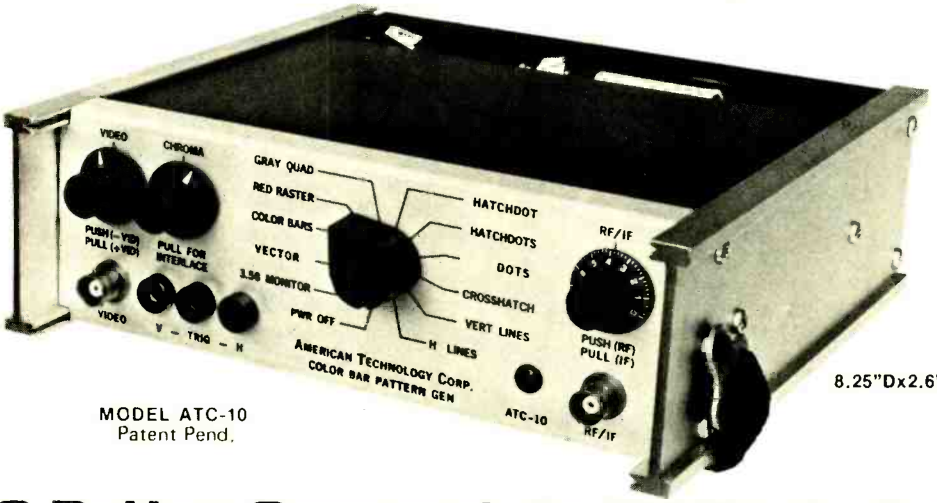
The Intel 1702A PROM comes with a transparent quartz lid which permits you to erase the bit pattern. You can erase a device by exposing it to high intensity ultraviolet light at a wavelength of 2537 A. Just put the 1702A about 1 inch away from the lamp tube for 10 to 20 minutes. Recommended lamps are Models UVS-54 or S-52 ultraviolet lamps manufactured by Ultra-Violet Products Inc., San Gabriel, CA. Physically, the erasing action creates an ionizing effect that causes the excess electrons on the floating gate to flow back to the substrate.

You have no doubt noticed that many of the PROM's we have covered use irreversible memory elements. Aside from the fact that such a PROM cannot be reprogrammed, there is also the problem of testing the PROM initially. If you order a ROM, the manufacturer programs it to your specification and tests it to be sure the bit pattern and output circuits are OK. However, if you buy a PROM, there most likely was no way for the manufacturer to test it so you won't know if it is any good until you program it. Most manufacturers build PROM's with experience and quality control. Several PROM manufacturers have decided that this method is not good enough (Motorola and Advanced Micro Devices among them). They have solved the testing problem by adding a ninth bit to all 8-bit PROM's. Some have even added several extra words to the memory. In the Motorola MCM5003 there are 32 of these ninth bits that have already been programmed to "1s," and the remaining 32 bits may be used by the customer to check out the capabilities of his programming circuitry.

Table 1 has been prepared to help

(continued on page 119)

Introducing... the Money Generator

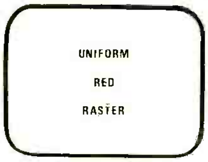


MODEL ATC-10
Patent Pend.

8.25"Dx2.6"Hx8.25"W

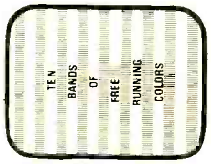
A Better Approach to TV Analyzing

ATC-10's Unique Patterns



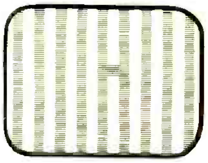
RED RASTER

Check and adjust purity at the flip of a switch without disabling blue and green electron guns.



3.58 MONITOR

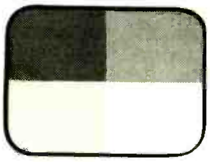
Check and adjust color Sync. OSC. Freq. at the flip of a switch (No need to ground AFPC Test Point.)



COLOR BARS

Sixth bar marked for identification.

Luminance pedestal shows color fit.

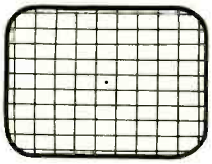


GRAY QUAD

Gray scale tracking checks/adjustments.

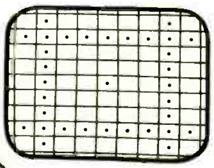
Yoke orientation.

L.F. video response.



HATCHDOT

Composite convergence patterns enable you to complete an entire convergence series with no need to alternately select separate patterns for DC and dynamic convergence.



HATCHDOTS

The hatchdots pattern with its frame-of-dots is also great for size, linearity, centering, and pincushion checks and/or adjustments.

Great Money Generating Features

The ATC-10 offers portability with a variety of new money-generating features for faster in-home servicing. It is also a superior analyzing device for troubleshooting tough dogs in the shop. A sample of its outstanding features include the following.

- CRYSTAL CONTROL AND PHASE LOCK OF ALL CHROMA AND SWEEP FREQUENCIES PROVIDE PATTERNS WITH UNMATCHED CLARITY AND FREEDOM FROM INTERFERENCE — CHROMA WAVEFORMS ARE VIEWED AS STATIONARY SINE WAVES USING H TRIGGER.
- IN-HOME BANDPASS CHECKS AT 1.78 MHz AND 3.58 MHz.
- ALL CRYSTAL-CONTROL / SOLID-STATE / DIGITAL IC DESIGN PROVIDES MAXIMUM RELIABILITY AND COMPLETE FREEDOM FROM VERTICAL LINE WIDTH AND COUNTER STABILITY ADJUSTMENTS.
- EXTRA WIDE RANGE RF/IF OUTPUT ATTENUATOR TESTS RECEIVER SENSITIVITY AND DYNAMIC RANGE.
- IF AND VIDEO INJECTION OUTPUTS WITH "FUSELESS" PROTECTIVE CIRCUITS.
- INTERLACE SELECTABLE FOR H/V COUNTDOWN TV'S.
- SQUARE WAVE PROVIDED FOR VIDEO PEAKING TEST.
- HORIZ. AND VERT. TRIGGER OUTPUTS OPTIMIZED FOR EXPANDED OSCILLOSCOPE PRESENTATIONS.
- 2 YEAR FACTORY WARRANTY AGAINST DEFECTIVE WORKMANSHIP AND MATERIALS.
- 30 DAY MONEY BACK GUARANTEE.

American Technology Corporation
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- ☐ Please send additional information on the MOD. ATC-10.
- ☐ Include a copy of the 2-volume (Home/Shop) ATC-10 Owner's Manual. $1.00 enclosed to cover postage and handling.
- ☐ Please ship________Model ATC-10's at $299.95 with:
  - ☐ Chan. 2 RF CRYSTAL (std.) installed. (NO Chan. 2 transmitter in our area.)
  - ☐ Chan. 3 (optional) crystal installed. (Chan. 2 transmitter in our area.)

Subtotal ________

3% sales tax (Colorado residents only) ________

TOTAL REMITTANCE ENCLOSED ________

Send certified check or M.O. for fastest shipment to American Technology Corp., 225 Main, Dept. 11C, Canon City, CO 81212.

Name ________________

Address ________________

City ________ State ________ Zip ________

Circle 28 on reader service card

BOOKSHELF SPEAKERS

(continued from page 71)

against excessive power.

There are valid reasons however, for using super power (150 watts-per-channel and up) amplifiers. As stated earlier, the amplifier may be called upon to deliver as much as 100 times the average power during the transient peaks. Many audiophiles believe that to reproduce these transients without clipping them, super power amplifiers are necessary. To safely use these amplifiers, you must insure that the intermittent power handling capacity of the speaker system is great enough to handle the transient power that these amplifiers will deliver. In addition, you must insure that the average power delivered by the amplifier does not exceed the continuous-tone power handling capacity of the speaker system. This is especially important in light of the logarithmic response of the human ear. Remember, it requires a ten-fold increase to double the volume level. So, it is possible for you to turn up the volume control to a point where the continuous-tone capacity of the speaker system is exceeded and not hear a substantial increase in the volume level. To prevent this from occurring, the speaker system must be properly fused when using these super-power amplifiers.

There are two reasons for observing the minimum power recommendation. First, there is a definite minimum amount of power that is required to drive the speaker system. If an amplifier with less power is used, the speaker system will not be driven to an adequate listening level and will not produce satisfactory music reproduction.

The second reason concerns possible *damage*. Yes, damage! With the amplifier delivering too little power, it's only natural to turn up the volume control to drive the speaker system to an adequate listening level. If the amplifier is not capable of delivering the necessary power, it will clip the peaks of the program material. This clipping action will produce harmonic distortion with its associated high-frequency components. As a result, the amplifier will deliver substantially more power to the high-frequency end of the spectrum. Remember, the tweeter in most systems can handle only 5% of the total system power. This extra power due to amplifier clipping is over and above the normal high-frequency power delivered as a result of the program material. The result is possible damage to the tweeters.

If you already own an amplifier, choose a speaker system so that the output power of the amplifier falls within the minimum and maximum power recommendations. Should you decide to go the route of the super-power amplifier, make sure the speaker systems are properly fused. If you don't own an amplifier, choose the speaker system first and then choose an amplifier based on these recommendations and the impedance specification (a discussion on impedance is forthcoming). These power recommendations refer to the RMS power-per-channel rating of the amplifier.

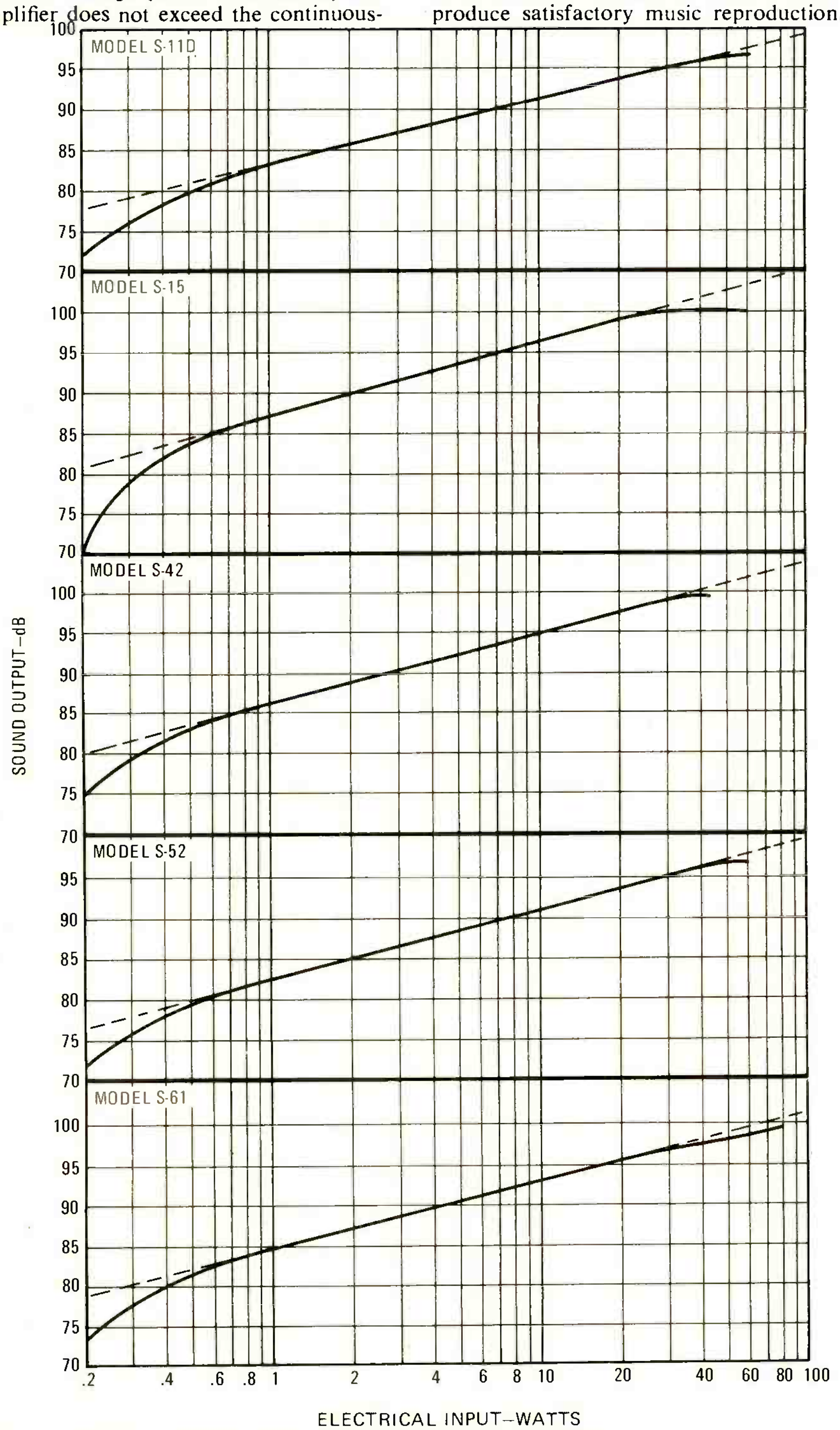


FIG. 7—LINEARITY CURVES for five speaker systems from H. H. Scott

Maximum sound output

This specification is a combination of the distortion, efficiency and power handling specifications. It states the maximum safe output sound level of the speaker system. In addition, the speaker system will not produce more than 3% total harmonic and intermodulation distortion when driven to this output level. Its measured at a distance of 1-meter on-axis over a frequency range of 100-Hz to 10-kHz and stated in so many dB's of sound pressure level.

The speaker system's dynamic range is determined by this specification. Dynamic range refers to the range of output levels that the hi-fi system is able to produce. The total dynamic range of the hi-fi system is determined by the minimum dynamic range of any component in the system. Dynamic range adds to the realism of the reproduced sound, and therefore adds to the accuracy of reproduction. Choose a speaker system that is capable of producing a high output level.

Impedance

The speaker system acts as an electrical load for the amplifier's circuitry. This is a reactive load that varies widely with frequency and it therefore, is termed impedance. The total amount of impedance presented to the amplifier will determine the amount of power that the amplifier delivers to the speaker system. To illustrate the variation in impedance, Fig. 8 shows the impedance graphs of five acoustical suspension speaker systems manufactured by H. H. Scott, Inc. Figure 9 shows an impedance graph of a bass reflex speaker system manufactured by STR, Inc. These graphs are typical of high-quality speaker systems.

The impedance specification is pre-

(continued on page 120)

R-E's Service Clinic

High-voltage shut-down circuits

How they work and how to service them

by JACK DARR
SERVICE EDITOR

THE DEPARTMENT OF HEALTH, EDUCATION and Welfare (HEW) has come up with some interesting requirements for color TV sets. (Some of these may not do too much for our Health or our Welfare but they can certainly be Educational, especially if you don't know they're in there!) One of the best among these is the high-voltage shut-down circuit. The purpose of this circuit is to shut down the set if the high-voltage rises above a preset level to avoid X-Ray radiation.

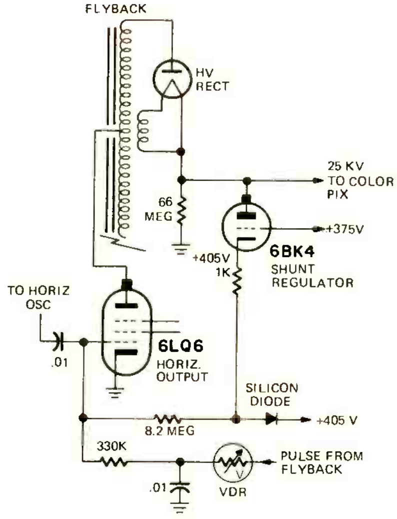


FIG. 1

This isn't really too new. It's been in effect for some time. RCA has a version of it in the CTC-38XP chassis and some others (RCA TV Service Data File No. 1968-T18-S2). Figure 1 shows the basic circuit. A silicon diode is installed in series with the 6BK4 high-voltage regulator tube cathode. The cathode current flows through it from the +405-V source. From the anode end of the diode (on 6BK4 cathode), an 8.2 megohm resistor is connected directly to the 6LQ6 control grid. This serves the same purpose as the familiar 10-megohm resistor to a high positive voltage; it feeds in a small positive voltage to keep the 6LQ6 grid from driving itself too far negative. Beside this, a pulse regulator circuit using a VDR also helps to control the 6LQ6 grid voltage. Normal operating bias on the 6LQ6 grid is about a −55 volts.

Now, if the 6BK4 regulator tube goes out, the diode stops conducting. The normal positive voltage fed to the 6LQ6 is lost and the tube drives itself so far negative that the high-voltage is cut away down. Typical symptoms of this condition are about 100 mA 6LQ6 cathode current (normal 200-220 mA). High-voltage is about 10 kV, and usually no raster or a very dim narrow one appears. The 6LQ6 grid voltage will be about a −70 volts. The key clue here is the −60 volts or so you'll see on the 6KB4 *cathode*, it should be +405 volts. If you find these symptoms, look for a 6KB4 with an open heater.

In other RCA's, especially the solid-state types, the shut-down circuit is designed to upset the horizontal oscillator *frequency*. This reduces the high-voltage. Typical symptom, you can not get the picture to lock in horizontally at all. The shutdown circuit can be disabled for testing, check the service data.

Quasar, Zenith, and others use SCR's in the shut-down circuitry. In some of these, service problems have been encountered. Most of these are due to the SCR being just a little bit too eager; they'll shut off on small transients, sometimes when changing channels. This of course applies in cases where the horizontal oscillator stage, high-voltage, etc., are *not* at fault. Most of them are modular, try a new shut-down module to find out. In others, especially if the SCR is a plug-in type, try a new

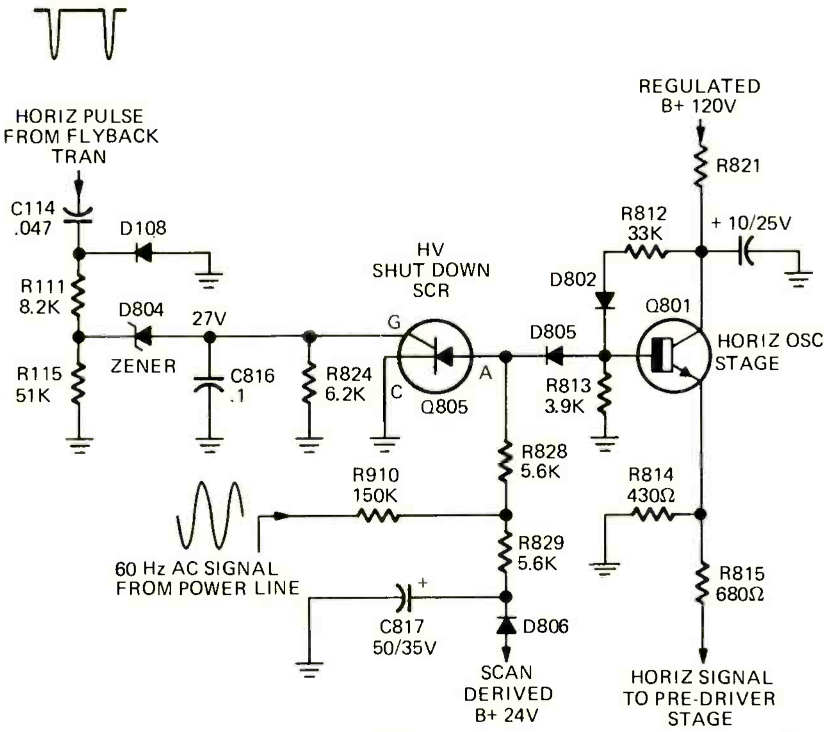
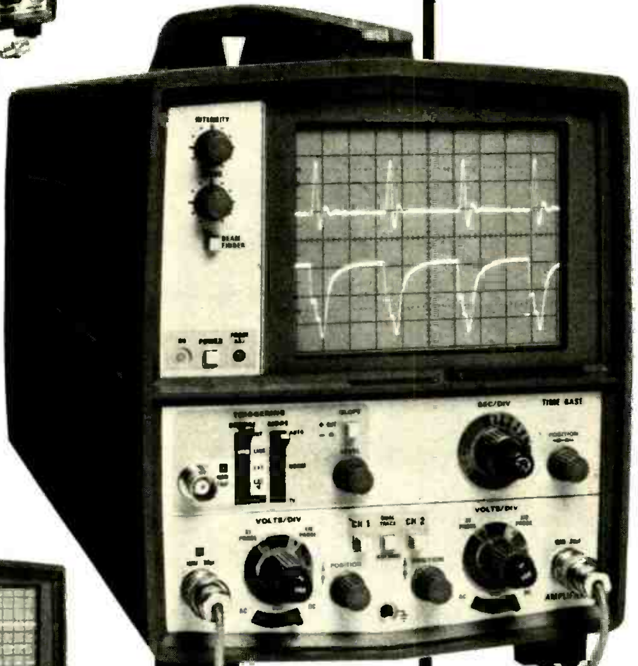


FIG. 2

T921

T912



T922

T935

T932

Circle 30 on reader service card

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Circle 61 on reader service card for demonstration

SERVICE CLINIC
(continued from page 78)

SCR to see if the original is just a little too quick on the trigger.

Admiral's M10 chassis has an SCR shut-down circuit with a highly novel reaction. This one could wipe you out completely if you didn't know about it. Let's look at this and see how it works. Figure 2 shows the *basic* circuitry used.

The SCR is normally turned off. Its anode is connected to the base of the horizontal oscillator transistor through a blocking diode. The cathode of the SCR is grounded. A negative-going pulse from the flyback is fed to a 27-volt Zener diode. A clamp diode, D108, holds the negative peak of this pulse to −0.6 volt below ground. The Zener diode, normally not conducting, is connected to the SCR gate.

If a problem occurs which makes the flyback pulse increase, this makes the *positive* peaks higher. The Zener goes into conduction and turns the SCR on. When this happens, the SCR grounds the base of the horizontal oscillator transistor, killing the oscillator. Since this chassis derives most of its operating DC voltages from the *flyback*, this brings everything to a screeching halt.

Don't go away! We're just getting a good start. This circuit doesn't just turn things off and sit there. Note the connection to the +24 volt DC line on the SCR anode through two resistors and a diode. (Which we carefully haven't mentioned till now.) When things are working, capacitor C817 charges up to the +24 volt line, minus the drop across the diode. When the SCR is gated on, its anode voltage drops to zero; the +24 volt line also goes to zero. The capacitor starts to discharge through the two resistors.

There's more! Note the AC voltage connected to the junction of those two resistors. This is a very small sample AC voltage from the main power supply, about 3.6 volts peak. (Remember the peak.) When the charge on the capacitor has dropped to 3.6 volts, the anode voltage of the SCR will go to zero on the next negative going peak of the AC voltage. (The SCR, having DC on its anode, has stayed on.) When the SCR anode goes to zero, it turns itself off again. The circuit is reset.

This reaction takes about one second. If it was caused by a short transient spike, things will now go on normally. The raster will reappear. However, if the fault is still there, the shutoff cycle will start over again, and it will keep on until the set is turned off!

This gives you the oddball symptoms; the raster will flash on and off at a one-per-second rate, accompanied by a "Poot!" in the sound! As I said, if you didn't know about this circuit, something like this could blow your mind.

There is a quick-check procedure for this circuit. Start by checking the +120 volt regulated line, with a 120 volt AC line voltage. Turn the set to a blank channel and turn the brightness completely off. Next, turn the horizontal oscillator adjustment (T800) counterclockwise until the shutdown circuit triggers. (That is, if it isn't triggering itself.) You'll have to bend the little tab on the can up to allow the core to be turned this far.

Now, disable the shutdown circuit by connecting a jumper across the SCR gate resistor. This is R824, a 6.2K ¼-watt. If everything else is in the ballpark, the horizontal oscillator should start and the raster will appear. If it doesn't, try a new M-700 module. If the raster comes on, the high-voltage should read between 29 kV and 33 kV (zero beam current). If it does, take the jumper off and readjust the horizontal oscillator, on a signal, until it holds sync. Check by changing channels. If the SCR keeps on triggering, check it, and the diodes, resistors, etc. in the circuit. If the 50-μF charging capacitor should open, there would be no time-delay action. If you have other troubles, try turning the horizontal oscillator control shaft clockwise until the raster begins to shrink in at the sides. This should reduce the high-voltage far enough to stop the shut-down circuit from triggering and allow you time for making tests. **R-E**

reader questions

ODD COLOR

I have odd color problems in this G-E KC chassis. I notice that the little neon glow lamp on the chassis goes out. Does this have anything to do with the color? Also, if it does, where can I get a substitute; they call it an 8315AH?—A.A., La Vale, MD.

Does that little neon lamp have anything to do with the color in a KC chassis? Yea, verily, brother! The *burst* goes through it! If this lamp is not glowing, no color, or very odd colors. Check the bulb; if it's blackened, clip it off and replace it. You can use a stock NE-2 or NE-2H. I've used these and it seems to work very well. You replace it from the top of the chassis by clipping off the leads of the old one and tacking the new one in.

THIN VERTICAL LINE?

All I've got on the screen of this G-E D2 TV is a thin, bright vertical line. I changed the deflection yoke; no luck. Any ideas?—R.B., Los Angeles, CA.

(continued on page 82)

Tear 'n Share

Save your RCA entertainment receiving tube carton ends* and color picture tube warranty serial number stickers*... and redeem them for discount certificates or valuable premiums. Just tear and you'll share!

*Save the receiving tube carton end that is solid red reading RCA Electronic Components and the warranty serial number sticker that appears above the warranty envelope on the upper right hand corner of the RCA color picture tube carton. *One* color picture tube warranty serial number sticker is equal in value to *20* receiving tube carton ends.

Your RCA receiving tube carton ends are valuable! So are your RCA color picture tube warranty serial number stickers. Save them. In various quantities, they will bring you:

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RCA Tear 'n Share Headquarters,
P.O. Box 154, Dayton, Ohio 45401.

RCA

Distributor and Special Products Division, Cherry Hill Offices, Camden, N.J. 08101

CLINIC QUESTIONS
(continued from page 80)

A thin bright vertical line shows that you do have high voltage and vertical sweep, but no *horizontal* sweep. If you have high voltage, the horizontal output stage must be working. A good possibility for this would be an open yoke-return capacitor; this is C45, .039 μF. This capacitor completes the *return* circuit from the horizontal winding of the yoke. Try bridging it. (Feedback; that was it!)

NO VERTICAL SWEEP

There's no vertical sweep on this Panasonic CT-26, and I can't find a schematic on it. Can you help?—T.G., Prairie Village, KS.

The service data on this is in Sams Photofacts 1371-1. (That's the accurate part of the answer! Now for the regular stuff.) Check the voltages around that 9AQ8, and the 12FQ7-25HX5; the last two make up the vertical multivibrator. Just for luck, check the service switch for a short on the 25HX5 pin-1 grid. Should show a very high resistance.

(Feedback from reader: that wasn't it! R477, a plate load resistor, was open! Oh, well.)

VERTICAL PROBLEM

This Hitachi CT901 has an odd vertical problem. After two hours or so, it starts to roll, and then shrinks. Vertical height decreases to only 2-3 inches. I checked and changed transistors, etc.; no luck. Then I noticed that the +12-volt supply to this stage was increasing when the trouble started! Finally disconnected it and used a regulated 12-volt external supply. This cured the problem.

Now what? This supply comes from the horizontal output stage. Where do I go from here?—J.S., Montezuma, GA.

I believe that I'd go to that horizontal output stage, and from there back to the regulated DC voltage supply for it. Check the regulated +120 volt supply. It looks as if you have a thermal problem, and very likely in the error-amplifier transistor of the regulator. Check all of the transistors in the regulator circuit while you're at it. (Try spray-cooling them just to see what happens.)

PICTURE TUBE REPLACEMENT

I want to replace the picture tube in my set, a 25AP22, with one of the new black matrix types. Can I do this?—P.J., Baltimore, MD.

Yes, indeed. Just order a Matrix type with the same type number as your original tube. You'll probably see it listed as "25AP22BM" or some kind
(continued on page 88)

SWTPC 6800

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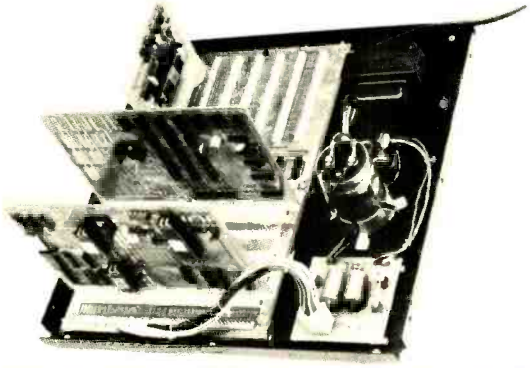

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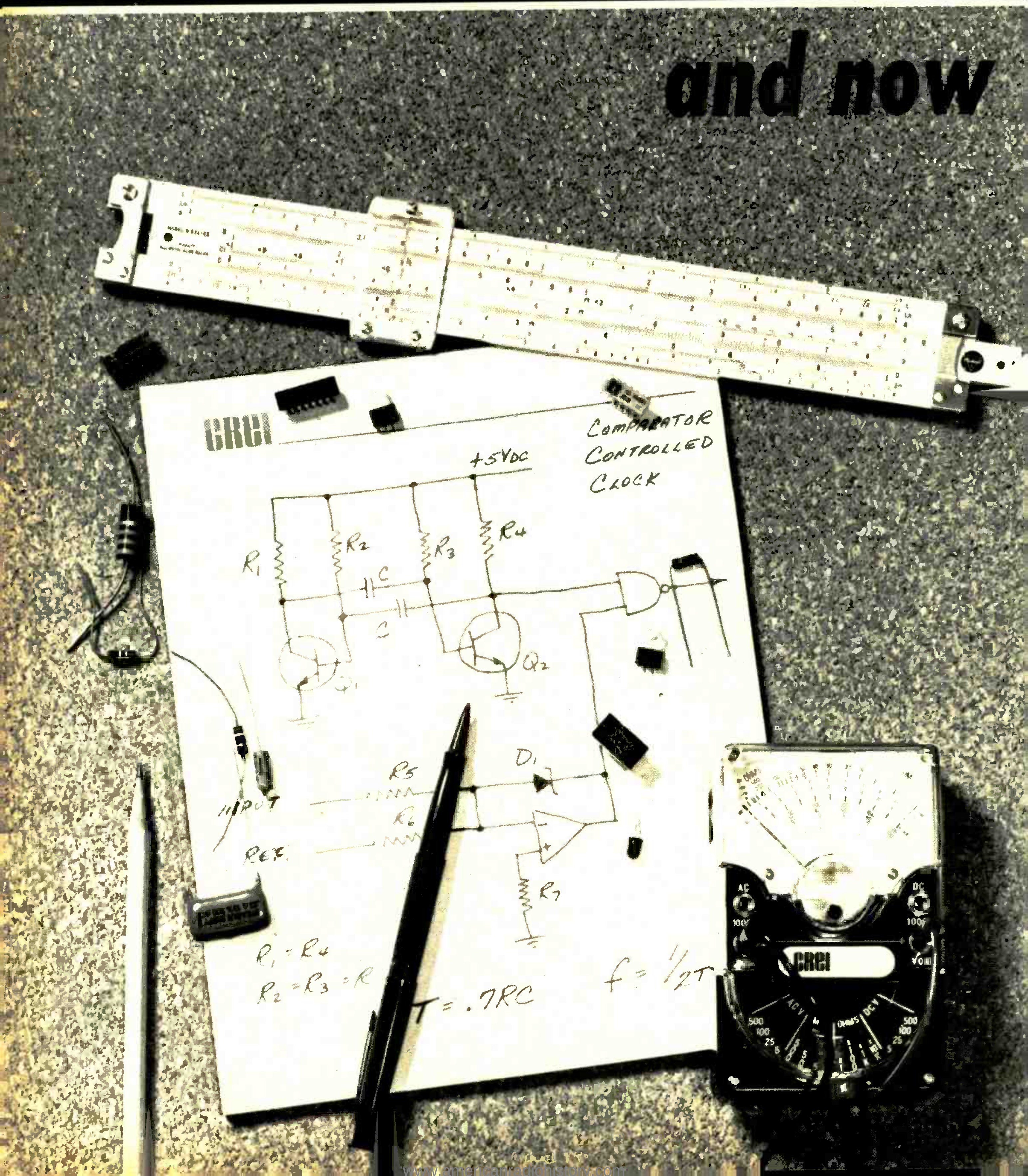

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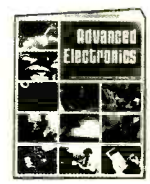

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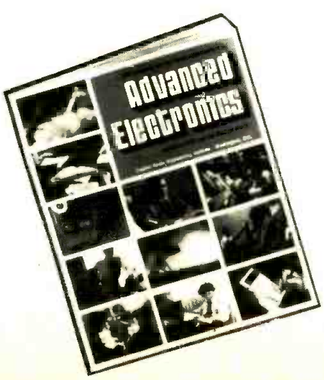

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CLINIC QUESTIONS

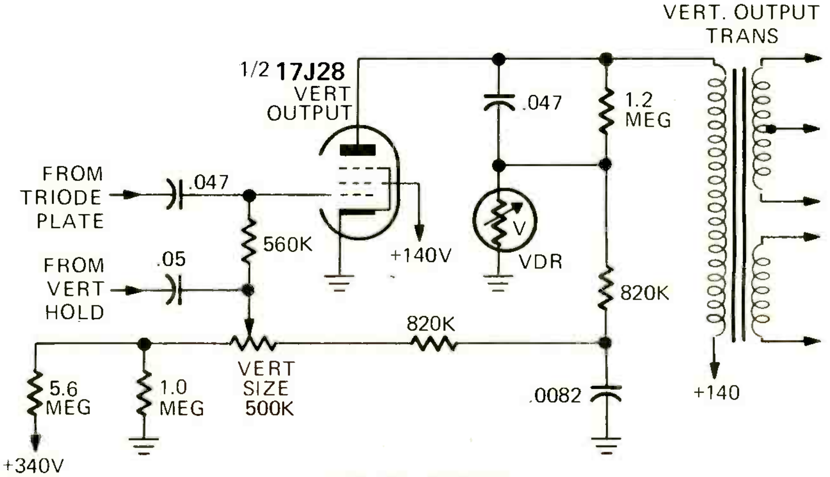
(continued from page 80)

of designation identifying a matrix tube. Incidentally, in the new tube type listings, a 23VALP22 is an exact replacement for your 25AP22.

BAD FOLDOVER

This Philco 15J27 has a massive foldover at the bottom of the screen. Checking capacitors showed nothing. I checked the 5.6-megohm resistor from the VERTICAL SIZE control to the +340-volt boost (see diagram); checked OK out of circuit. I left it disconnected and tried the set. Foldover gone! I don't get it.—H.D., Buffalo, NY.

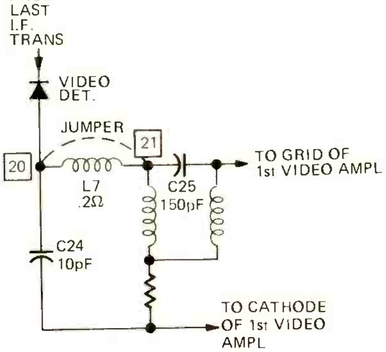
I don't either, but there's something out of pocket in there. The classic answer to questions about foldover is "something is upsetting the grid bias on the vertical output stage." This is apparently true here. Disconnect all of the resistors in the voltage-divider circuit around the vertical size control, and check them. This is quite a bag of worms, and one of them could be off. If that VDR turns out to be defective, try an Oneida GB-808; 1.0 mA at 290-330 volts. This is a replacement for the original Philco part.



BAD FOLDOVER

NO SYNC

After I replaced the picture tube in this RCA CTC-31A, I had no horizontal or vertical sync! Before, both were good. I made several tests with no results, then I found that I could get an audio signal through to the screen from point 21. Nothing came through to the screen from point 20. Tying a jumper across these points, I had good sync. So, I replaced L7 and C24 (see diagram); no luck. Then I put the jumper back and it works nicely. I don't understand this!—M.G., Springfield, NJ.



This happens. When you change a picture tube, quite often some little thing will show up; probably due to moving the chassis, pulling wires and so on. (My pet is pulling a yoke lead out and not noticing it).

You won't do too much harm by leaving the jumper in there. L7 is just a tiny peaking coil. The crystal ball says that the original parts are probably OK and that you have a hairline crack in the PC conductors somewhere between them. Check from the video detector output with an ohmmeter.

HARMONICS OF AM

Broadcast band AM stations aren't supposed to radiate harmonics, are they? Still, I can pick up two or three AM stations on my four-band SW receiver, at double and sometimes triple their carrier frequencies. If these aren't radiating harmonics, then what is going on here?—G.K., Yardley, PA.

You *can* tune in AM broadcast stations at what seems to be their second harmonic, especially if the stations are fairly close, as yours are. However, it is very likely that these "harmonics" are being generated *in your own mixer stage!* This is a non-linear stage. If it weren't, it wouldn't work. So, a very strong RF signal can develop beats and actually harmonics, but it's in this stage and not at the station.

I have made tests on radio stations and found practically no harmonic radiation. Then, the next day, heard this same thing on a SW radio. If you add a sharply tuned RF amplifier stage, this will usually get rid of this kind of a problem. **R-E**

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Do your Christmas shopping before midnight Nov. 30th.

If you've been saving Sylvania tube tabs, your time has come.

Unless your tabs are received at award headquarters by midnight Nov. 30th, all you'll have is a bunch of tabs.

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But before that magic hour you can have anything in the '75 Save-a-Tab catalog.

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Do your Christmas shopping now for everyone (especially yourself) from the catalog available at your Sylvania distributor.

But have your tabs at award headquarters by midnight Nov. 30th.

Nov. 30th, the world.

Dec. 1st, just tabs.

GTE SYLVANIA


SYLVANIA
electronic tube

new products

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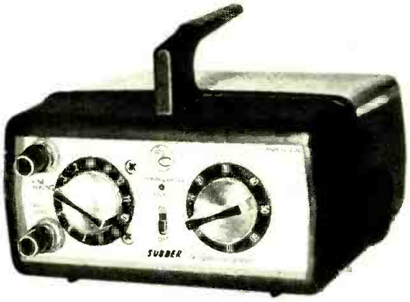
It tunes all 82 VHF and UHF channels for substitution tests of the tuner and the entire IF system of any 40-MHz TV receiver, and permits signal injection after the AGC controlled stages for a high speed AGC system



analyzing procedure. Use it anywhere. Battery or 120-VAC line powered, instrument automatically changes over to internal battery power when AC power is disconnected. The price is $64.95.—**Castle TV Tuner Service, Inc.,** 5710 N. Western Ave., Chicago, IL 60645.

Circle 31 on reader service card

STEREO RECEIVER, *model 540,* features a sensitive tuner and a unconditionally stable amplifier. The tuner section features a 4-gang MOSFET front end combined with a compensated ceramic IF filter, a quadrature FM detector and a phase-locked-loop multiplexer. Specifications include an IHF sensitivity of 1.8 μV, a capture ratio of 1.5 dB and stereo separation of more than 40 dB at 400 Hz and better than 30 dB across the band. The control center of the model 540

has dual concentric bass and treble controls, 12 dB per octive high-filter and volume and balance controls. In addition, there are 2 phono inputs, microphone, headphone and tape jacks on the front panel as well as main and remote speaker switching. The power amplifier section provides 40 watts per channel minimum RMS into 8 ohms from 20 to 20 kHz with no more than 0.3% total harmonic distortion. Rear panel jumpers permits separation of the amplifier and power amplifier sections. The unit measures 5⅛" high × 15" wide × 11½" deep and weighs 30 pounds. The suggested retail price is $419.90.—**Pilot Radio Sales,** 165 West Putnam Avenue, Greenwich, CT 06830.

Circle 32 on reader service card

DIGITAL MULTIMETER, *model 334,* is designed for continuous operation in service, laboratory and testing applications. It has 5 ranges of AC and DC voltage and current and 6 ranges of resistance. Features include 3½-digit resolution, automatic decimal point,

automatic overrange indication, 200-mV AC and DC ranges, fuseless protection on volts and ohms, and fast response. Power input is 105—125-VAC/210—250-VAC, 50—400-Hz. It measures 8½-in W × 4-in. H × 6-in. D and weighs 3½ lbs.—**Hickock Electrical Instrument Co.,** 10514 Dupont Ave., Cleveland, OH 44108.

Circle 33 on reader service card

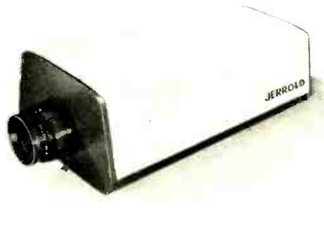
CATV MULTI-TAP, *series 3800,* is for two or four subscriber service. Special features include a cable seizure that does not damage

center conductor or strain the internal circuitry, cast-in labyrinth RFI seal, and collars for direct application of shrink-sleeving to the housing. Specifications include—bandpass, 5 to 300 MHz, return loss, 23-dB minimum; tap-to-tap isolation, 30 dB; hum modulation, −65 dB at 6A tap value for 0 dBmV level.

The 3800 series can be pedestal or aerial mounted. The unit measures 3¼ in. wide × 3¾ in. high × 1¾ in. deep, less connector and mounting hardware. The suggested retail prices are $6.25 each for the two-tap models and $6.50 each for the four-tap models.—**GTE Sylvania,** Marketing Department, 114 S. Oregon St., El Paso, TX 79901 .

Circle 34 on reader service card

CCTV CAMERA, *model TVC-501,* is a solid-state compact closed-circuit TV vidicon camera. The vidicon is a ⅔" separate mesh type with electrostatic focus and magnetic deflection. The position of the vidicon can be easily



adjusted for mechanical focusing and for operation with different lenses. An F/1.6 16mm lens is supplied with the camera. The center resolution of the camera exceeds 550 lines. The output is video, 1.4 volts P-P across 75 ohms. Automatic light compensation is 8000:1. The grey scale includes at least 10 steps. Signal to noise ratio exceeds 40 dB. Suggested retail price is $495.00.—**Jerrold Electronics Corp.,** 200 Witmer Road, Horsham, PA 19044.

Circle 35 on reader service card

CONDENSER MICROPHONE, *model CM-1000,* features a cardioid pick-up pattern and an extended dynamic range. A gold metalized polyester film diaphragm provides exceptional high frequency transient performance. A bat-

tery operated power supply energizes the *model CM-1000,* but it may also be powered directly from a console (45V—50V). Switchable 10-dB and 20-dB altenuator pads and low-frequency rolloff network (−10 dB at

100 Hz) guard against amplifier and input overload.

Specifications include: Frequency response, 2–20,000 Hz ±2.5 dB; output impedance (1 kHz), 600 ohms ±15%; sensitivity, −67 dB ±1.5 dB; signal-to-noise ratio, better than 50 dB; maximum SPL at 3% distortion, 139 dB; current consumption, less than 1.5 mA; operating voltage, 8.5V–9.1V; dynamic range, 115 dB.

An optional pinpoint capsule is also available, *model CP-102,* to convert the microphone to a super-omni-directional pick-up pattern. Suggested retail price is $290.00 including preamplifier, battery power supply, windscreen, connecting cables and swivel stand adaptor. The suggested retail price for the optional *model CP-102* is $100.00.—**Nakamichi Research, Inc.,** 220 Westbury Ave., Carle Place, NY 11514.

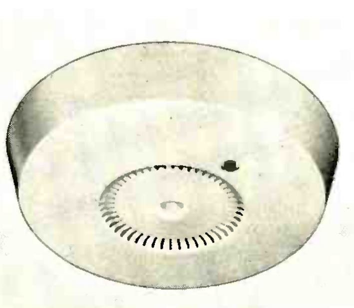
Circle 36 on reader service card

GUTTER CLAMP ANTENNA MOUNT features a high-tension spring that clamps the unit fast to any make vehicle. A special rubber bumper prevents marring the car's finish. Clamp styles are available to fit all popular makes of antennas and complete mounts.

Also, antennas of both the quarter wave type and gain antennas for low, high and VHF bands complete with the clamp are available. Provisions are also made to assure a proper ground plane for maximum radiation efficiency of the antenna.—**Larsen Antennas,** P.O. Box 1696, Vancouver, WA 98663.

Circle 37 on reader service card

COMBUSTION DETECTORS, *models 580 and 600,* operate on the ionization principal, detecting fire at its earliest stage before smoke,



heat and flames develop. Both models contain built-in batteries that are constantly monitored. When battery voltage drops to a preset warning level, a built-in horn will sound, indicating trouble. The battery is easily replaced and will last approximately one year. **Alarm Device Manufacturing Company,** Syosset, NY 11791.

Circle 38 on reader service card

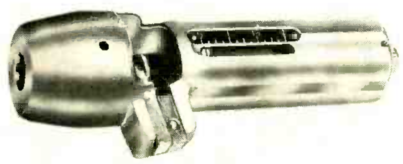
STEREO PREAMPLIFIER, *model SP 5200,* is a linear flat-response preamplifier that has provisions for the connection of external signal processing devices. There is a five-input monitor selector that allows listening to the signal source whether the source is processed by an external device or not.

Operating controls consist of a record source selector, a monitor selector, a mode switch and a pair of volume controls. The volume control consists of a pair of slide potentiometers. The gain of the input preamplifier is adjustable from 27 dB to 55 dB so that it can accommodate any cartridge regardless of its output voltage. Specifications include a frequency response of 20 Hz to 20 kHz ±0.1 dB, total harmonic distortion of 0.05% maximum from 20 Hz to 10 kHz and a

rated signal output of 2.5 volts. At rated output, noise is 95 dB minimum measured from 20 Hz to 20 kHz. Suggested retail price is $489.95.—**Burwen Laboratories,** 209 Middlesex Turnpike, Burlington, MA 01803.

Circle 39 on reader service card

CABLE PREPARATION TOOLS. A new series of coaxial cable stripping tools save time by preparing cables for their connectors in less than 15 seconds. The cut dimensions are accurate to within 20 thousandths of an inch. To use the tool, just insert the cable in one end and rotate it to either expose the center conductor or strip the outer jacket, depending



on the specific tool used. Then insert the cable into the other end of the tool and it is rotated to either remove the outer jacket or to remove the dielectric cable. The cutter blade will not nick the center conductor of the coax nor will it leave loose strands of wire. The tools are available for cable sizes from RG-59 to 0.75-in. aluminum cable. A set of replacement cutting blades is also available for use in the stripping tools.—**Blonder-Tongue Laboratories, Inc.,** Old Bridge, NJ 08857.

Circle 40 on reader service card

CRT RESTORER/ANALYZER, model 467, employs an exclusive test method that tests all three guns of a color CRT simultaneously under actual operating conditions. The guns are tested in sequence, 20 times per second, and the results are displayed simultaneously on three color coded meters. The model 467

tests for true beam current—current that passes through the G1 aperture to the screen.

Restoration is performed with minimal danger of cathode stripping. The model 467 can be used to test and restore any type of color or black-and-white picture tube without calculation or reference to charts. It also provides tube-life indication, finds and removes shorts, and identifies and corrects tracking deficiencies in color CRT's. The price is $279.00.—**B&K-Precision,** Div. of Dynascan Corp., Chicago, IL 60613.

Circle 41 on reader service card

TURNTABLE, *model SR-525,* is a manual single-record direct-drive turntable that is driven by a 20-pole, 30-slot DC brushless motor. The motor is servo-controlled. Two

speeds are available, 33⅓ or 45 RPM, with a fine adjustment for both speeds. Speed control is aided with the help of an illuminated stroboscope with markings on the platter. The platter has a diameter of 12¼-in., is aluminum die-cast and weighs 3.1 lbs. The tonearm is S-shaped, incorporating a special resonance absorber. The unit has bias and lateral balance compensation and a separate lever at the arm base for cueing.—**Sansui Electronics Corp.,** 55-11 Queens Boulevard, Woodside NY 11377.

Circle 42 on reader service card

SOLDERING STATION, *WTCP series,* features an exclusive "closed loop" method of controlling maximum tip temperature. This protects temperature sensitive components.

The complete station includes a low-voltage stainless steel pencil-grip iron, 700° F screwdriver tip, holder, sponge and receptacle, and a three-wire non-burning silicone power cord. *Model WTCP-L* adds a built-in on/off switch and red pilot light.

The 60-watt units control temperatures in three ranges—600°, 700° and 800° F, determined by choice of quick-change, anti-oxidation-coated tips in many configurations and sizes.—**Weller-Xcelite Div., The Cooper Group,** Apex, NC 27502.

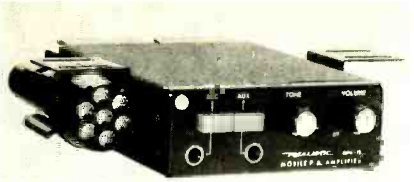
Circle 43 on reader service card

AUDIO GENERATOR, *model LAG-26.* Fast rising square waves for testing transient response and low distortion sine waves are among the features. It has a sine wave output range of 20 Hz—200 kHz at 0-5 VRMS with ± 1-dB flatness and with distortion at less than 0.5% below 20 Hz. Square wave output is 20 Hz–20 kHz in the 0-10V P-P voltage range with 0.5-μs rise time. The generator can synchronize signals from an ex-

ternal source and has a calibration accuracy of ±3%. Output inpedance is 600-ohms unbalanced and the frequency range is in 4 decade-bands. The unit measures 6-in. H × 10-in. W × 5-in. D and weighs 5.5 lbs. The price is $139.95.—**Leader Instruments Corp.**, 151 Dupont St., Plainview, NY 11803.

Circle 44 on reader service card

MOBILE PA AMPLIFIER, *Realistic MPA-10,* is designed for 12-volt operation in cars, trucks, campers or boats. The unit measures 1½ in. × 4⅛ in. × 6½ in. and comes with a dynamic mike and hanger for clipping it to the side of the unit. Separate microphone and auxiliary input jacks allow connection of a tuner, ceramic phono or tape player to the amplifier with pushbutton selection of either or both for paging over music. Output power is 10 watts RMS into 8 ohms. Frequency response is 200 Hz to 10 kHz at full power. A



tone control allows adjustment for best tonal quality. Suggested retail price is $39.95 complete with microphone and mounting hardware.—**Radio Shack,** 2617 West Seventh Street, Fort Worth TX 76107.

Circle 45 on reader service card

"Which one of you fellas is the best TV repairman?"

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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.

SERVICEMAN/TECHNICIAN CATALOG. A 48-page illustrated mail-order catalog which has been specifically designed as a quick reference ordering guide for use by radio/TV servicemen, electronic technicians and hobbyists. Included are tools, service and repair kits, test equipment, tubes, phono cartridges, speakers and microphones, antennas, components and many other servicing aids of various major manufacturers.—**Fordham Radio Supply Co.,** 558 Morris Avenue, Bronx, NY 10451.

Circle 46 on reader service card

ENGINEERING MANUAL & PURCHASING GUIDE. 228-page catalog of electronic components. Included are complete specifications, illustrations and information which describe each product. You'll find wire, cable, solid-state devices, test equipment, timers, connectors, relays, tools, capacitors and other electronic parts for virtually any application.—**Allied Electronics,** Dept. 76, 401 East 8th Street, Fort Worth, TX 76102.

COSMOS CIRCUITS. 246-page catalog and applications manual that describes two lines of CMOS logic circuits—the *54C/74C* and *CD4000 series*. This paperback handbook contains data sheets, specifications, diagrams, charts, graphs, applications information, and a cross reference.—**National Semiconductor Corporation,** 2900 Semiconductor Drive, Santa Clara, CA 95051.

Circle 47 on reader service card

STEREOPHONES. 6-page brochure describes five headphones plus a 4-channel converter. These include two stereo lightweight models, a stereo high-performance model and a Electret model. In addition, there's a 4-channel headphone that uses the Fixler Effect for enhancing separation. A 4-channel converter that is designed to be used with the 4-channel headphone synthesizes the 4-channel effect from existing 2-channel program material. Brochure includes specifications and features.—**Telephonics,** 770 Park Avenue, Huntington, NY 11743.

Circle 48 on reader service card

SPEAKER BROCHURE. 8-page brochure describes six hi-fi speakers incorporating the Heil air-motion transformer. Specifications are listed for each speaker. The brochure also explains the principal behind the Heil air-motion transformer.—**ESS, Inc.,** 9613 Oates Drive, Sacramento, CA 95827.

Circle 49 on reader service card

VOM BROCHURE. 4-page brochure describes the new *model 60 series* VOM's. The brochure lists specifications, features and application data for the *model 60*, *model 60-A* (±1-½% DC accuracy) and the *model 60-K*. These 28-range VOM's feature drop-proof and burnout-proof protection. They can be safely dropped from 5-foot heights and have diode and fuse protection. The brochure includes complete specifications and lists a host of optional accessories.—**Triplett Corp.,** Bluffton, OH 45817. **R-E**

Circle 50 on reader service card

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, Calif.

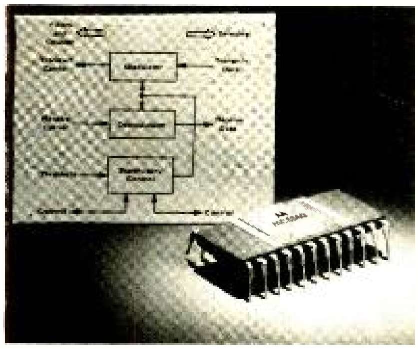
If this is a "jar intermittent", you can find it much more easily. Most likely cause is a bad solder joint somewhere on the PC board. Take a new lead pencil, and tap *lightly* around at different points. Find out where the most sensitive place is; where you can just barely tap it and make the problem 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-mf coupling capacitor to the difference amplifiers. If this is opening intermittently, it will upset the bias on the three difference amplifier tubes and cause some problems.

STATE-OF-SOLID-STATE
(continued from page 34)

tional control lines that are a supervisory link between the CPU and the peripheral. Each PIA has six registers that function like standard memory locations.

The Asynchronous Communications Interface Adapter (ACIA) is a serial output circuit. The output data is in a sequential form one bit after the other.



MOTOROLA MC6860 MODEM

Sequential data is processed and sent out over voice grade telephone lines to remote terminals or other computers. The actual modulator-demodulator job of putting the serial data onto the phone line is done by the remaining circuit type, the MC6860, 0 to 600 bit-per-second MODEM.

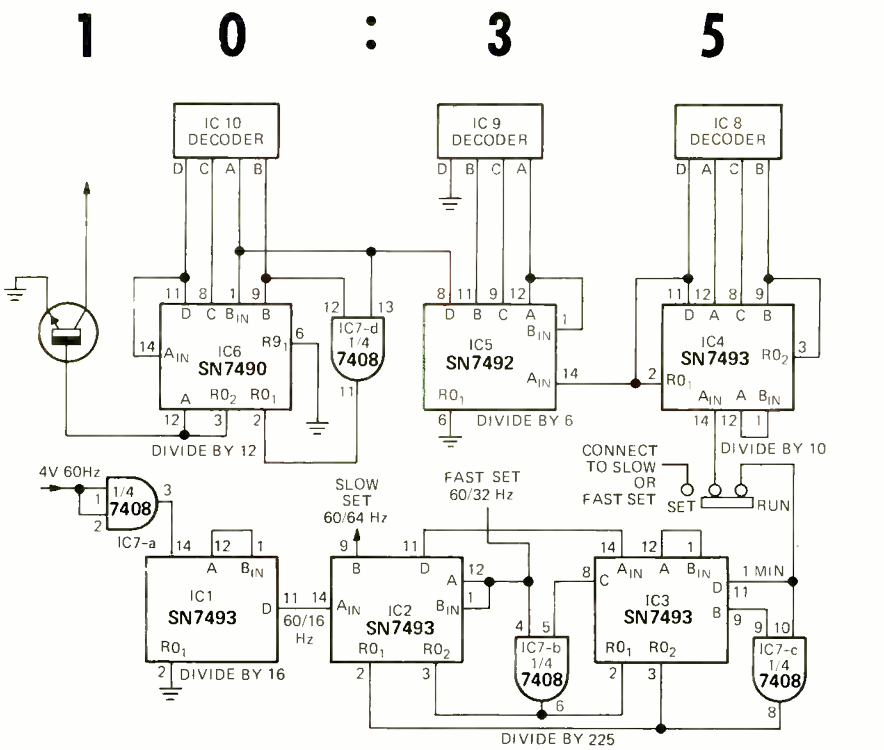


FIG. 2—TTL CLOCK circuit.

Prices of the five available circuit types are: MC6800, $360; MCM6810L, $30.50; MCM6810L-1, $37.50; MCM-6820, $20; MCM6830L, $35; MC6860, $75. All prices are for 1 to 24 quantities. The MC6800 and MC6820 are 40-pin ceramic dual-in-line devices and the others are 24-pin units. Software (programming) support now includes a *(turn page)*

cross-assembler and interactive simulator, with more on the way. American Microsystems Inc. will second-source the microcomputer circuits.

TTL clock circuit

Kenneth Bagnall of Bagnall Electronics sent me a clock circuit (Fig. 2) that is timed by the 60-Hz power-line frequency. The circuit has ten IC's plus some digit driver-transistors, the exact number depending upon the display chosen. Especially interesting are the instructive 7400 TTL counter feedback strategies.

The input to IC7-a, the first section of the SN7408 Quad 2-Input AND Gate

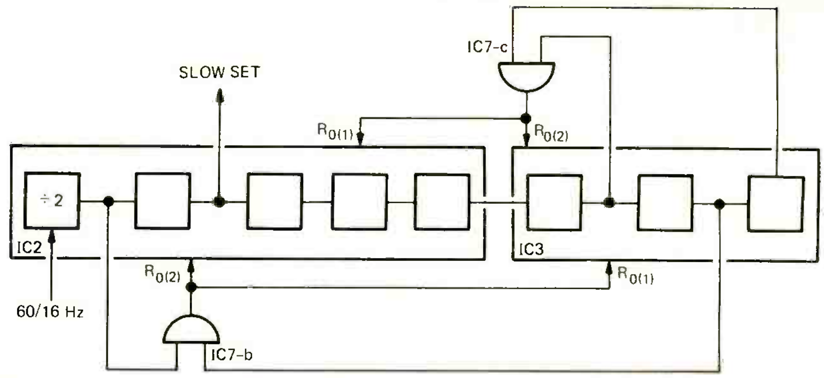


FIG. 3—DIVIDE-BY-225 counter from TTL clock circuit.

is a 4-volt 60-Hz sine wave. The gate converts the sine wave into a square wave that drives an SN7493 4-bit Binary Counter (IC1), the first of 6 counter devices in the clock. IC1 operates as a straight divide-by-sixteen with the four stages cascaded by connecting pins 1 and 12. The output frequency at pin 11 is 60/16 Hz.

The clock displays hours and minutes so the basic frequency needed to drive the display counters is one cycle per minute. After the initial division by 16, another division by 225 gives a combined division of 3600. 60 Hz/3600 = 1/60 Hz or one cycle per minute. The divide-by-225 function is accomplished by two SN7493's with a total of eight series-connected binary dividers. Two gates from the SN7408 IC is used for resetting the binary dividers (See Fig. 3.) The 7493 IC has two reset inputs–R_{01} and R_{02}. The zero in the subscript indicates that the counter is reset to zero when the reset function is activated. An on-the-chip NAND gate requires that both inputs be 1's to reset all the counter stages.

The output of each of the 7408 gates (IC7-b and IC7-c) drives one of the reset inputs on IC2 and IC3. Staggering the AND gate outputs so that each gate controls one reset input to both IC2 and IC3 causes the counters to reset when the four inputs to IC7-b and IC7-c are simultaneously high. The counter state at which the reset condition is satisfied is from left to right 1XXXX111, where the X's are "don't cares" and may be either 0's or 1's. But as the counter steps in binary fashion starting from 0, the first situation that meets the reset pattern is 10000111. From left to right the counter digits represent weights of 1, 2, 4, 8, 16, 32, 64, and 128. Adding the weights of the stages set to 1: 1 + 32 + 64 + 128 = 225. At the 225th pulse the divider resets to zero.

When the set switch is in the RUN position, the 1/60 Hz signal (1 pulse-per-minute) clocks IC4, the SN7493 minute-units display counter. By connecting the B and D (2 weighted and 8 weighted, respectively) outputs to the two reset input terminals, the count is

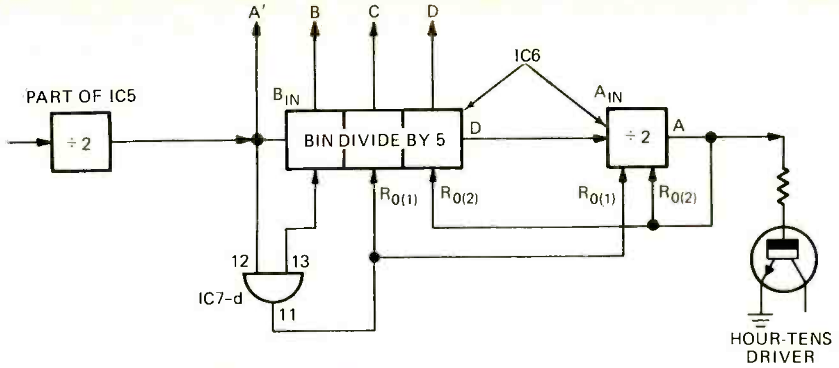
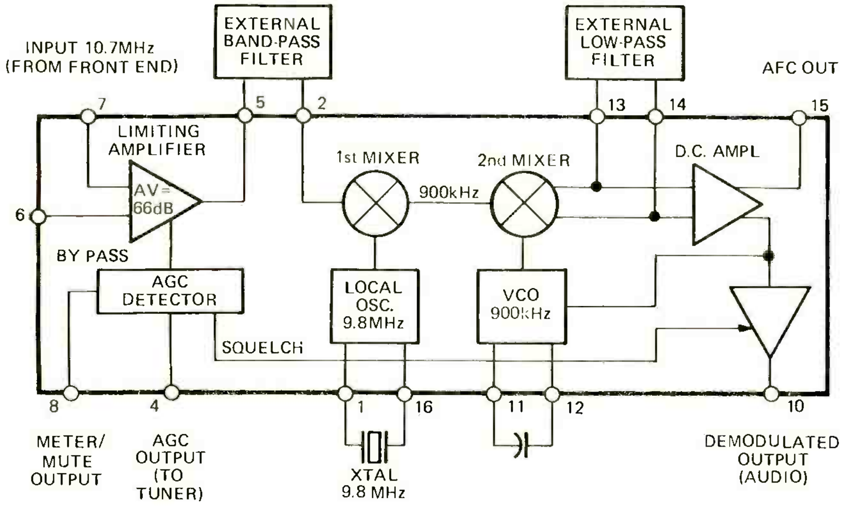


FIG. 4—HOUR COUNTER from TTL clock circuit.



INPUT FREQUENCY TO 2nd MIXER
IS 10.7MHz−9.8MHz = 900kHz

FIG. 5—SIGNETICS' NE563 IC contains ⅓ of an FM stereo receiver.

shortened to 10. No external gating is used because the states of only two stages have to be sensed, and the internal reset-gate on the 7493 IC can handle it. The minute-units digit cycles from 0 through 9 and the A, B, C, D binary coded decimal outputs drive an output decoder.

The minute-tens digit must count from 0 through 5 for 00 through 59 minutes. A divide-by-six counter is necessary. The 7492 is a divide-by-twelve partitioned into a divide-by-two stage and a three stage divide-by-six. The divide-by-six counter stages A, B, and C are used for the minute-tens digit display. The D output is a symmetrical divide-by-twelve that is used by the hour counter. The A, B, and C outputs of IC5 are decoded by IC9. The D input to the decoder is grounded since a count of eight is never reached.

The divide-by-twelve counter is comprised of the last section of IC5, IC6 and IC7-d. Figure 4 shows this arrangement more clearly. The SN7490 (IC6) is a decade counter broken into a divide-by-two stage and a divide-by-five counter. The A, B, C and D outputs sequence through the first 10 hours in a normal binary manner. At 10 o'clock, the A output switches to a 1 turning on the hour-tens digit. In addition, the A output also applies a 1 to the R_{02} reset input. The counter waits for a high output from pin 11 of IC7-d for resetting. Three counts later, at thirteen, the A and B outputs are high and the reset occurs putting the four stages of the 7490 counter at 0. Resetting is very quick, only hindered by the short propagation times through the circuits and the momentary state of 13 is never actually seen on the display.

A wide variety of BCD decoders are available; the choice hinges on the voltage and current demands of the specific indicator that is to be used and its display format.

The SN7441A, 7442, and 7445 are all BCD-to-Decimal decoders. Cold-cathode indicator tubes can be interfaced directly with the SN7441A. If segment displays such as LED's are used, one of the SN7446, SN7447, SN7448, SN7449 BCD-to-Seven-Segment decoders should be used.

For information on a mounting board with silkscreened power supply and readout circuits for this clock circuit write: Bagnall Electronics, 179 May Street, Fairfield, CT 06430. Bagnall proposes a wire wrap method of assembly that does not use soldering or printed circuit boards. Wires are run from pin-to-pin using a specially designed tool.

(continued on page 112)

MUSIC SYNTHESIZER

(continued from page 39)

The configuration of the integrator is such that the amplifier will work to make identical currents flow into its inverting (IC1-a pin 3) and non-inverting (IC1-a pin 2) inputs. Because of the values of resistors R14, R15 and R80, the current into the non-inverting input will always be at least twice the current into the inverting input except when transistor Q7 is turned on. To make up for this difference in current, the output voltage of the amplifier rises linearly to force current through capacitor C6 into the inverting input. At some point, the integrator output voltage exceeds the threshold established by the Schmitt trigger causing the collector voltage of Q4 to switch from essentially +18 volts to approximately +3 volts. Under these conditions, the base-emitter junction of Q6 is forward biased causing the collector of this transistor to rise to approximately +9 volts. The resulting current flow through R25 into the base of Q7 turns this transistor on. This in turn effectively shunts the current that was previously flowing into the non-inverting input of the integrator to ground. The integrator's amplifier now tries to make up for the surplus current flow into the inverting input by linearly decreasing its output voltage to pull current out of this input through C6. When the amplifier's output voltage falls below the threshold level, the Schmitt trigger resets. The collector voltage of Q4 goes high again and turns off Q6 and Q7 and restores the current flow into the integrator's non-inverting input so that the cycle can start over.

The cycle is identical when the SKEW control is rotated toward the RAMP position except that the decreased resistance in the non-inverting input circuit allows a greater current flow. This causes the integrator's output ramp to rise more quickly. Simultaneously, the decreased resistance in the non-inverting input circuit is added to the inverting input to cause the integrator's output to fall more slowly. The combination of increasing rise-time while decreasing fall-time keeps the total period of the waveform approximately constant.

The ramping output of the integrator is applied to resistor R17 and potentiometer R81. The setting of potentiometer R81 determines the level of the triangle/ramp waveform that is applied to the audio bus. Similarly, potentiometer R82 is in the collector circuit of transistor Q6 and this control adjusts the level of the square wave applied to the audio bus.

VCF

The voltage-controlled filter is a common design built around one amplifier section of the LM-3900 and is tuned by varying the effective resistance of field-effect transistor Q8. The schematic diagram of the VCF is shown in Fig. 4.

The three signals applied to the audio bus are mixed together by resistors R34, R35 and R36 and applied to the input of the filter through resistor R27. Switch S8 allows either the filtered or the unfiltered audio bus signal to be applied to the VCA (*V*oltage-*C*ontrolled *A*mplifier).

The control voltage for the filter can originate at either the control strip or the filter's dedicated function generator. Voltages from the control strip appear across resistor R49 and are applied to the gate of FET Q8 through R47 while voltages from the function generator are applied through R46.

The function generator comprises one section of the LM-3900. Trigger voltages that appear at R38 produce a current flow into the amplifier's non-inverting input that switches the output of the amplifier to a high level. This high output voltage charges the timing capacitor C12 through R40, the ATTACK control R85 and the forward biased diode D4. The voltage across C12 is sensed by the high-impedance emitter-follower Q9 with the voltage at the emitter of this transistor being a diode drop less than the voltage across the capacitor.

Once the amplifier is turned on by the trigger signal, it is held on by feedback current through R39 even if the trigger is removed. As long as the voltage at the emitter of Q9 is low, Q11 is off and there is no current flow through R45 into the inverting input of the amplifier. As soon as the voltage at the emitter of Q9 exceeds two diode-drops (D11 and the base-emitter junction of Q11) above the +9-volt reference at the base of Q11, this transistor starts to conduct causing current to flow through R45 into the inverting input of the amplifier. If the triggering signal has been removed by this time, the amplifier's output resets to a low voltage causing the charge on C12 to drain off through R41, the DECAY control R86 and diode D5 which is forward biased under these conditions. If the triggering signal is still present, it provides enough current into the amplifier's non-inverting input to hold the output high for a sustained interval.

Slide switch S5 provides for either sustained or non-sustained outputs from the function generator by allowing either a direct or capacitively coupled input for the trigger signal. Slide switch S4 provides for a repeat function by allowing the trigger signal from the trigger pushbutton to be replaced by the collector voltage of Q10. Transistor Q10 is a simple inverter stage that changes to a high output voltage when the output of the function generator approaches its lowest level.

Diode D6 provides a discharge path from capacitor C12 back into the triggering network wnen a "mute" function is desired from the function generator (SUSTAIN off, REPEAT on).

VCA

The schematic diagram of the voltage-controlled amplifier is shown in Fig. 5. With the deletion of the components that provide for repeat, the operation of the function generator associated with the VCA is identical to that of the VCF's function generator.

The VCA is a common design employing a differential pair (Q12 and Q13) sharing a common constant current sink in their emitter circuits. Since the gain of a transistor is proportional to its collector current, more current flow through the current sink (Q14) increases the gain of the transistors in the differential stage.

In more expensive VCA's, the differential outputs form the collectors of Q12 and Q13 would be applied to the inverting and non-inverting inputs of an operational amplifier so that the DC voltage level changes associated with increasing and decreasing the gain of the pair would be rejected as a common-mode voltage. In this circuit, the DC voltage changes are cancelled out in R59 and R60 and this is based on the fact that as the voltage at the collector of Q12 drops with increased gain, the voltage at the emitter of Q14 rises by a proportional amount because of current flow through R58. The ratio of R59 to R60 cancels the DC level changes while acting only as an attenuator on the audio signal present at the collector of Q12.

Emitter follower Q15 provides a high input-impedance to the output of the VCA while presenting a desirable low output-impedance to drive the power amplifier being used with the GNOME.

The last two parts of this article will cover the construction details including the foil patterns and component placement diagrams. Also, testing and calibration, and operating procedures will be given.

A short tutorial on synthesizers will also be presented to help the readers understand the principles behind synthesizers.

Circle 67 on reader service card

Circle 68 on reader service card

Build this set...

SERVICE

LIGHT GREEN RASTER ON WARMUP

This RCA CTC-24 shows a light green raster on warm up, for 10 minutes (almost exactly), then wham, good picture. All tubes tested and wiggled in sockets. Where to look?—E.G., N. Bellmore, NY.

Could be something intermittent in one of the color-difference amplifier stages. Most likely cause, the G-Y amplifier, with a small thermal leakage or something. Check its plate load resistor connections for solder joint trouble, too.

(Field Feedback; the crystal ball was right on frequency today. It was the 6GH8 tube in the G-Y amp. Even a blind pig gets an acorn once in a while.)

QUESTIONS AND ANSWERS

Q. Will a 19DVP4 picture tube work in place of a 19ECP4 picture tube?
A. Should; base the same, etc.
Q. Doesn't work! Why?
A. Still ought to! Recheck.
Q. Woops! It will work if you put the picture tube socket on *right* instead of turning it halfway around! (Thanks to W. J., San Diego, CA.)

A NEW CAUSE FOR JAIL-BARS!

The original complaint in this Admiral G13 chassis was bars (similar to Jail-Bars) on the left side of the screen. We suggested the stock tests such as blanking diodes, "diodehausen radiation," etc. Later, the reader wrote again. They found that pulling any of the IF tubes would kill the bars, though shorting the IF input to ground had no effect. Blanking diodes were checked, and putting an ion-trap magnet on the horizontal output tube didn't help the situation either.

Finally, they looked into the high-voltage cage and noticed "some sort of leakage into the focus rectifier, coming from a very small crack in the cap of the high-voltage rectifier tube"! Replacing this cap cleared up the problem. Thanks to Albert M. Dryer of the Division of Engineering, and David L. Smith, 2d year Electronics Technician Student, at Lord Fairfax Community College, Winchester, VA, for the feedback and a new cause for jail-bars!

EXCESSIVE BRIGHTNESS

I can't control the brightness on this Admiral 4H12. Too high at all times. The DC voltages seem to be OK, but the 6AF9 (video output) plate voltage is only 180 volts. Normal is 216 volts. Can you tell me where to look for the trouble?—J.V., Scottsdale, AZ.

Right where you are. The video output plate voltage *is* the picture tube cathode voltage. Since this is "too far negative," your picture tube bias is too far toward conduction. This could well be due to incorrect bias on the 6AF9, if the plate load resistors, etc. are all good.

Check the DC voltages on the brightness control. You have a positive voltage fed from the three background controls; this is balanced by a negative voltage developed by a flyback pulse on a diode rectifier. If this diode is bad, the voltage here would be too far positive.

ONE-COLOR SCREEN PROBLEMS

When this Sylvania D-12 was first turned on, the screen was all green. After a warmup, it would work. Then, it started showing all red. Stays until switch is turned on and off sev-

NOTES

eral times. Have you seen a freak like this?—H.S., Milwaukee, WI.

Yep. There are a couple of things that can do this. One is an intermittent heater-cathode short in one gun. However, this can be caught by a picture tube test, and it isn't *likely* that you'd have two. (Possible of course, but unlikely.)

Here's the other. Replace the 6MD8 (color-difference amplifier triple-triode) tube. If this doesn't work, then check the *tube-socket* (same tube) very carefully. I have seen this type of symptom in cases where one of the plate pins of this tube wasn't making contact with the tube-socket, or where there was a "pocket-joint" between the tube socket terminal and the board. (Cold solder joint which looks good from outside!) Plate voltage goes up, and tube flares up.

AUTOMATIC NOISE ELIMINATOR ON AM/FM?

I want to build the Automatic Noise Eliminator (R-E, May 1974). My problem is that my radio is an AM/FM stereo. Should I use two lamps, or one lamp and two photocells?—P.S., Troy, MI.

Your receiver has two complete audio circuits with one section of the volume control in each channel. The lamp in the emitter circuit of Q4 in the noise eliminator will have to excite two photocells—one in each channel. You'll have to pick up electrical audio signals from both channels so you'll need a second audio transformer in series with the secondary of T1.

VIDEO DETECTORS BLOW

I had a very bad picture on this Packard-Bell 23T7. Found that the video detector had very low back-resistance, and replaced it. Found a couple of resistors bad; still no picture. Checked the diode I'd just put in, and it was bad. Put in new Motorola diode. Fine picture.

For two days. Diode blew again. Replaced it with a different one. Two days and poof. I'm getting pretty good at replacing video detectors, but no closer to a solution. What the heck's going on?—E.P., Torrance, CA.

I've seen this before, on other sets, including G-E's, Truetone's, etc. Frankly, I don't know the *cause* (though I made very exhaustive tests on some of them) but I can tell you the *cure*. Replace the diode with a special RCA type, No. 125844. This is a video detector diode with a very high voltage rating, somewhere around 200 volts. These will hold, or at least they have in all the sets I've put them in. **R-E**

NESDA

THIS PAST SUMMER, THE NATIONAL ELECTRONIC SERVICE Dealers Association (NESDA) held its annual convention. Members of the **Radio-Electronics** staff attended and participated in the convention activities (see publisher's memo, page 6 this issue). The convention was held in Winston-Salem, NC and here is a photographic report.

NESDA'S EXECUTIVE COMMITTEE got down to business early during the convention. Here is the scene at that meeting as Mike Horewitch, NESDA's new insurance agent, explained the new casualty and health program for the membership.

THE GIANT TRADE SHOW, the NESDA Electronic Circus was a big success. Here are the Quasar and O. W. Donald Co. booths. Traffic was heavy all day long.

AWARDS CHAIRMAN JACK KELLEY, CET (left), Sage & Sand TV, Litchfield Park, AR presents the runner-up award for the "Technican Of the Year" award presented by ISCET to Clarence Saatkamp, CET; Saatkamp's TV, Milwaukee, WI. To the right of the podium is Gene Jadwin, Host of this breakfast and George Camp.

Convention News

SERVICEABILITY INSPECTIONS were conducted at the convention by ISCET personnel. Seen here is Carl Saffer, CET, Louisville, KY closely examining features of one of the sets checked.

RADIO-ELECTRONICS' EDITOR, Larry Steckler, CET, won the NESDA "Man Of The Year" award. Here Larry (center) receives the award from O. W. Donald of Fort Smith (at podium). O. W. Donald is the sponsor of this award. Seated on the right are Toby Mack, Staff Vice President, Distributor Products Division, EIA, the NEDSA Awards Banquet Speaker and M. F. Finneburgh, Sr., EHF (far right). At the left is Dick Glass, CET the MC.

OUTSTANDING NESDA COMMITTEE CHAIRMAN award plaque went to Jerry Hall, NESDA's membership chairman. Accepting for Jerry is Frank Schroeder (standing right) of the Wisconsin affiliate. Jack Kelly (standing left) made the presentation. (turn page)

SPECIAL RECOGNITION AWARD CERTIFICATES were presented to many individuals and companies. Here is a look at the recipients as they received their certificates at the NESDA Awards Banquet in Winston-Salem. These certificates are presented in recognition of those who made special contributions to the service industry during the past year.

AT THE SPECIAL FTC SEMINAR, Gerry McCann, CET; president of ETA of Louisiana, answers some questions raised by the talk from FTC spokesman John Phelan (seated on the right). Miles Sterling, CET; Electro TV, Garden Grove, CA (seated on the left) chairmaned the seminar.

A PROFITABLE SERVICE-MANAGEMENT SCHOOL was held during the convention that had over 150 attendees. They heard top business leaders show how they make a success of the service business. At the podium is Jesse Leach, CET, owner of Lee's TV in Linthicum, MD., explaining how he takes two months vacation each year, even though he is a one-man shop owner. The Profitable Service Management School is only one of the many ways that NESDA strives to make its members more successful in their chosen profession. It is held in many different places during the year.

FOR RON CROW'S EFFORTS during the past year as Director of ISCET and the CET programs, he was presented a painting of his son and home. The award was made by Radio-Electronics Editor, Larry Steckler, CET; who was re-elected ISCET Chairman.

By any standards, the convention was a rousing success. It was marked by heavy attendance, enthusiastic manufacturer participation, important industry speakers (EIA and FTC) and an atmosphere of something getting done . . . something worth doing. Those who attended, came away with a feeling that solid progress was made on many fronts including professionalism of the technician, strengthening of the association, recognition by industry and a true co-operative effort to continue to enhance the status of the service technician in the United States. R-E

STATE-OF-SOLID-STATE
(continued from page 99)

Signetic's FM microcircuit

Just tacking on a phase-locked-loop to an old limiter design is not Signetic's way of doing things. The NE563 FM IC is new from the ground up. Things begin in an ordinary enough way in Fig. 5 by taking the 10.7 MHz tuner IF output and passing it through a 66-dB limiter.

Signal level sensing by an AGC detector generates control voltages that drives a signal-strength meter, regulates the gain of the tuner to prevent overloading, and squelch the receiver's audio output.

The signal leaves the chip for band limiting by an external ceramic filter and then reenters into the 1st mixer. This second conversion mixes down to 900 kHz by taking the 10.7 − 9.8 MHz difference component and sending it on the IC's second mixer.


SIGNETICS NE563

Crystals, ceramic resonators or LC tanks can tune the local oscillator. What remains on the chip are the three components that make up the PLL. The second mixer is the loop's phase detector. Frequency shifts to either side of the 900 kHz center frequency forces the VCO to track by a corresponding change in its control voltage. Where does the voltage change come from? What happens is the phase difference between the phase detector signal input and the VCO output slips just enough to generate the exact voltage needed. The external low-pass filter separates the DC component from the phase detector output.

During capture when the frequency of the VCO first attempts to match that of the input, the filter smooths the beat note between the two signals. Selection of filter parameters affects the pull-in range and time, and the noise bandwidth of the detector.

The PLL does not have an easily identified tuned circuit like a diode discriminator would. It is there though, and if the NE563 had used an LC tank instead of a capacitator tuned oscillator it would be more conspicuous. The initial tuning of the oscillator by whatever method, defines the equivalent center frequency and the low-pass filter restricts the bandwidth around center.

The recovered audio signal out of the NE563 is 500 mV RMS with 75 kHz deviation. Distortion with 1 kHz modulation frequency is .05% typical and the AM rejection is a respectible 70 dB.

In lots of 100, the NE563 sells for $2.55.

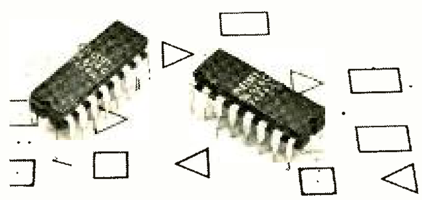
New releases

From time to time I get letters asking about interfacing reader projects with different types of displays. National and Spraque have display driver guides that will be of interest to these readers.

National makes a series of common-cathode and common-anode, segment and digit drivers useful in clock and calculator readout circuits. They've published a single page LED Driver Selection Guide with 23 LED devices. Each IC is grouped according to its output type. The number of outputs and current capabilities are listed. For a copy write to the Marketing Service Department of the National Semiconductor Corp., 2900 Semiconductor Drive, Santa Clara, CA 95051.

The Sprague short form catalogue lists gas discharge and power display drivers. Fourteen devices interface between TTL, CMOS, or PMOS IC's and gas discharge displays as well as relays, solenoids, lamps and LED's. Ask for "Display/Interface and Transistor Arrays for the Digital Decade" from Sprague Electric Co., Technical Literature Service, 81 Marshall St., North Adams, MA 01247.

Plessey Semiconductor's SL624 will demodulate AM, FM or SSB. The circuit works as a synchronous detector


PLESSEY SL624 AM, FM, SSB demodulator.

for AM, a quadrature detector for FM and as a product detector with its own oscillator for SSB. The SL624 is tailored for multi-detection mode receivers. Power supply requirements for the 16 pin ceramic DIP are 9 to 12 volts with 12 mA current drain at the highest voltage. Price is $4.44 in quantities above 100. R-E

INDUSTRIAL TEST EQUIPMENT

(continued from page 42)

The solid-state cells can be of either type. A great many of them are photovoltaic, generating a small DC voltage when illuminated. Here again we can use the millivolt ranges to check the output.

You'll also find LASCR's (*L*ight *A*ctivated *SCR*'s) used for controls in some systems. Tests on these are slightly different, but look for the same basic reaction; a change in the output when the photosensitive surface is illuminated.

AC leakage tests

Many of the "Consumer Safety" regulations deal with possible AC leakage from the line to the frame or case of a unit. This applies not only to appliances, but to industrial machines as well. For production-line testing, safety checking of machines after repair, and on general principles, every AC powered unit should be checked. The standard ANSI (*A*merican *N*ational *S*tandards *I*nstitute) test for this limits the allowable leakage in appliances and other units, with either two-wire line cords or three-wire "safety" cords, to not more than 0.5-mA AC. For non-portable units with three-wire cords, third wire ground, the limit goes up but not much; only 0.75 mA.

There is a standard test for this. A 1500-ohm resistor, shunted by a 0.15-μF capacitor, is connected from the frame of the appliance to a good earth ground. The AC ammeter is connected across this network. Several of the industrial VOM's seen before have this test built in; all you have to do is switch to AC LEAKAGE and hook it up. RCA also has a "dedicated" AC leakage tester, the model WT-540A, in Fig. 15. Dedicated means that this is a special leakage tester only. It will catch shorts and excessive leakage, for example in production line final tests.

MODEL WT-540A LEAKAGE TESTER.

Let's wrap it up

Now you've seen some of the high quality modern test instruments that are available. These are *Ready, Rugged* and *Reliable*; the Three R's of test equipment. Since practically all jobs start with the use of a VOM, we covered these first. In the next article, we'll look at amplified VOM's; the FETVOM units. From there on, we will go into other specialized equipment, for testing any kind of unit used in Industrial Electronics. **R-E**

color TV kit teaches electronics

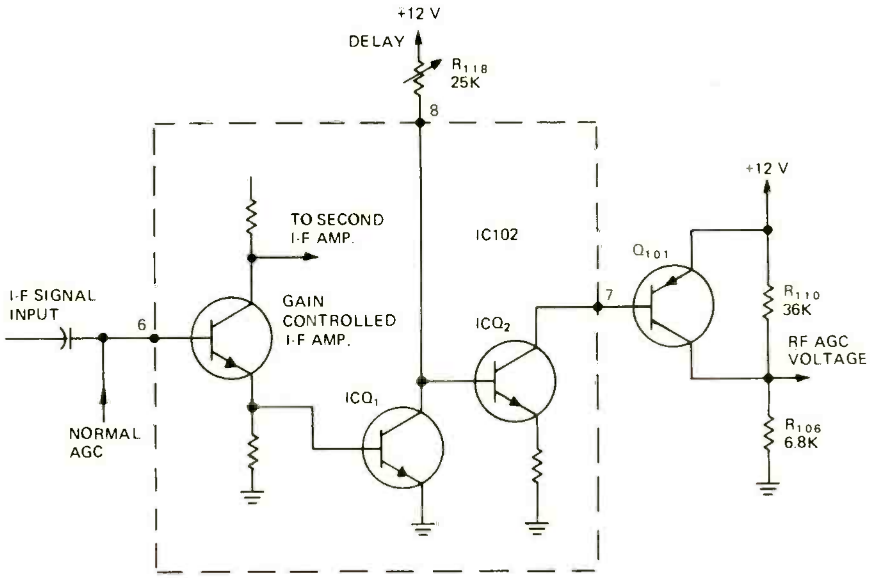
It's a whole new concept in learn at home techniques. Build this color TV and learn electronics even if you build it wrong.

IS WRONG EVER RIGHT? THAT'S A QUESTION that has been debated for ages. But in this new color TV kit, that you build as a part of a television servicing course, wrong is learning.

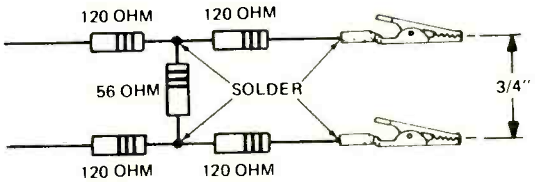
You see, if you build this set wrong, you find out about immediately and learn some important lessons about the kind of electronic circuits used in modern color TV sets at the same time. Here's how it all works.

When you build most kits, you don't different. You build it in sections, (like most other kits) but when you complete a section you submit it to a series of experiments that show whether it is working or not and explain the circuit to you at the same time. In effect, each circuit becomes a laboratory in which you check for proper operation and then learn how that particular circuit works.

First step in this kit is the power supply. There's nothing very special here.



SIMPLIFIED SCHEMATIC of the delayed AGC system as presented in the NRI training kit manual. An example of the way data is presented to students.



THIS H-PAD is built while performing experiments on the tuner of the color set. It's an important part of the experiment program.

ordinarily know whether it will work or not until the entire kit is completed and turned on. But the model 315 from the National Radio Institute is rather You build it onto a circuit board that is part of the basic color TV chassis. The different part starts after you have com-

(continued on page 117)

SQUAREWAVES

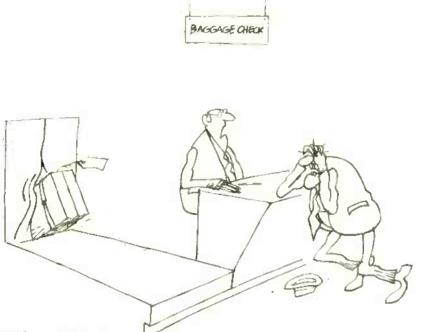
(continued from page 53)

ship with respect to the rest of the frequency content of that waveform. The rounding of the leading and trailing edges of the 10-kHz waveform shown in the lower trace of Fig. 6 indicates either that the system (in this case our equalizer filter) is limited in frequency response above 20 kHz, or is introducing phase distortion. If this system was a power amplifier, the waveform might also indicate a "speed" or transient response limitation in one or more of the transistors used in its circuitry. A 10-kHz waveform has a period of 100 microseconds (1/10,000 second). For a circuit to respond to the eleventh harmonic of such a square wave would require a rise time of 9 microseconds. The Harman-Kardon amplifier shown earlier boasts a square-wave rise-time (to 90% of full amplitude) of only 3 microseconds.

Amplifier instability

High-frequency square waves can be used to determine another problem present in some audio amplifier designs—instability. In Fig. 7 we see a "ringing" effect indicative of such instability. Highly capacitive loads connected to the output terminals of some amplifiers will cause such instability and are part of the reason why some amplifiers cannot be used properly with full-range electrostatic speakers, no matter how powerful they are and no matter how wide their bandwidth may be.

While experts may disagree regarding the need for such ultra-wide bandwidth and phase linearity as has been designed into Harman-Kardon's new Citation 16 amplifier and other products of its kind, it should be obvious that there is a great deal to be learned from examining the square wave response of any amplifier. Since function generators are now available at very moderate cost and can produce square waves as well as more traditional sine waves for testing purposes, there seems to be no reason why audio technicians and engineers should not avail themselves of this useful "tool." **R-E**



Why didn't you tell me it was a mini-computer and I wouldn't have thrown it . . .

Circle 81 on reader service card

Circle 82 on reader service card

Circle 83 on reader service card

Circle 84 on reader service card

equipment reports

B&K-Precision Model 280 DMM

Circle 104 on reader service card

THE B&K-PRECISION TEST EQUIPMENT DIVISION of the Dynascan Corp. has introduced a new digital multimeter. When they say "multimeter", they're not kidding. This compact little instrument measures AC and DC voltages at 10 megohms input impedance, resistance and both AC and DC current. The voltage ranges go from 1,000 millivolts to 1,000 volts. Resistance ranges go from 100 ohms (full-scale!) up to 10 megohms. The current ranges go from 1,000 microamps up to 1,000 milliamps (which is very close to 1.0 ampere). The bad joke about "close to 1.0 ampere" is really true. On the 0–1,000 scale, you'll see 0.999, which *is* pretty close to 1,000 mA. If you can get within 1.0 mA, that's close!

The accuracy of the model 280 is excellent, within ± 1% of full-scale on all ranges except DC volts; this is ±0.5%. When you go over the full-scale value on any range, the whole display blinks at you. Polarity reading is automatic, no setting to "+ volts" or "— volts", etc. If you see a minus sign, the voltage is negative; no minus sign, it's assumed to be positive. There is also a ZERO ADJUST control; just set it to DC volts, short the test leads and turn the control until you see "000" with the minus sign blinking slowly off and on.

The display uses 7-segment LED's with good brightness. Decimal point location is automatic. It's bright enough to read even fairly close to a bright bench-light. They're big enough to be read easily at any reasonable distance.

Overload protection is provided on all ranges. This will protect up to 1,000 volts. Even the low-ohms ranges, 100 and 1,000 ohms, will withstand the full 125 volt AC line voltage continuously. It is not recommended that you read the resistance of the AC line voltage, of course, but if you do, you'll be safe. There is a 1.0-A fuse in the negative jack and a special fusible resistor in the input to the electronics.

The ohms ranges of the model 280 have the new low-voltage ohms feature. Alternate ranges are low-voltage; this is read out by a H or L appearing in a little window just below the range switch. This can be used for in-circuit testing of transistor circuitry or out-of-circuit testing of transistor junctions. Blinking of the display in both polarities means that the junction is open. Zero or very low reading both ways, it's shorted. Overrange one way and an in-range reading the other shows that the junction is good.

A built-in battery test feature is also provided. Set the range switch to 10 volts DC and touch the positive probe to a terminal in a hole on the right side. A reading of .001 or more means that the batteries are good, for standard dry cells. Four size-C cells are used. Rechargeable NiCad batteries may be used; a jack on the top of the case connects the charger. The reading on these should be 090 or more. If you see 090, this means that it's time to recharge. With alkaline batteries, a service life of more than 50 hours of continuous duty is claimed.

The model 280 does all of these tricks with solid-state circuitry, of course. Numerous IC's and transistors are used. In the input, a special dual JFET (two transistors in the same case, so that they will be accurately matched) gives it the very high input-impedance. Even though the instrument is battery-powered, an IC voltage regulator is used in the DC power supply. This gives it very good stability under temperature changes and battery aging. It will hold its accuracy down to a 4-volt level though the battery gives a 6-volt supply.

The model 280 is built into a case of tough Cycolac high-impact plastic. It has a "nubbly" texture to make it easier to hold. There are no exposed metal parts for protection against accidental shock to the user.

One attractive feature of the model 280 is its price. This is less than $100.00. For an instrument with this versatility and accuracy, this is good! Its performance compares well with instruments costing quite a bit more. R-E

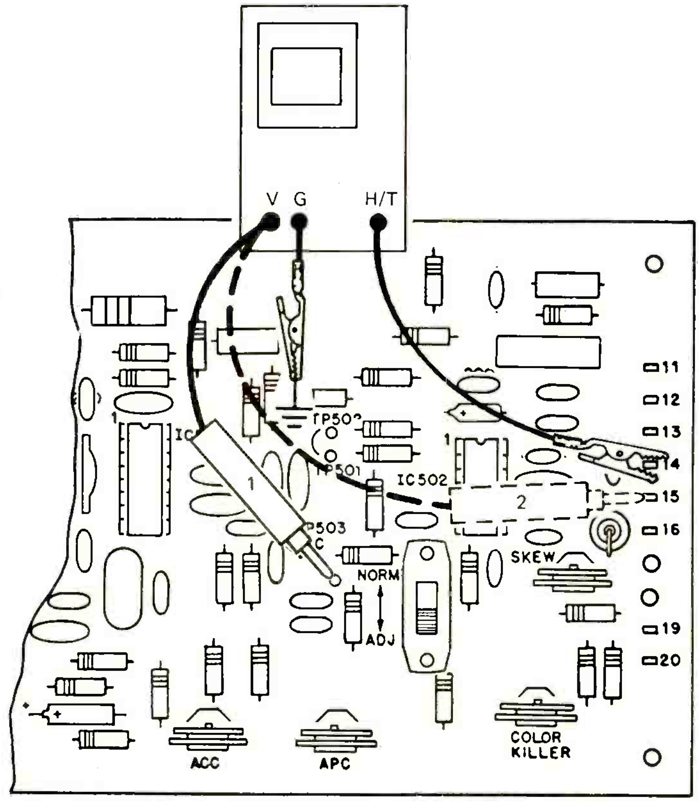
COLOR TV KIT
(continued from page 114)

pleted wiring this section of the TV. For that's when you read through a detailed description of how the circuit works. Then you take a series of measurements with your scope (you built it earlier in the course) that tells you if the power supply regulator is working the way it should. If it isn't, you troubleshoot the regulator and repair the fault. Then you go on to check out another section of the power supply.

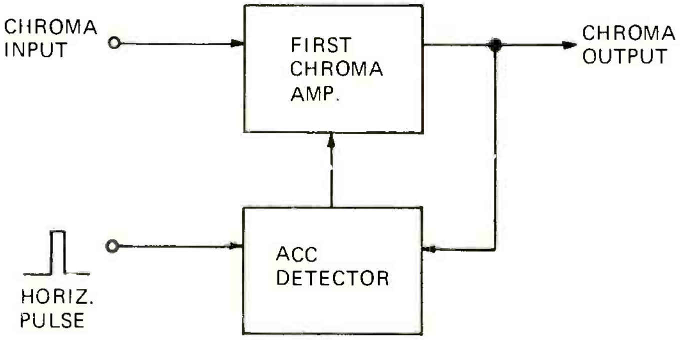
This procedure continues as you assemble each section of the set until you have a complete working color TV. In the process you have learned just how each circuit operates and the part it plays in the performance of the total color set. A hands-on education.

The end result is a large-screen color TV in a console-type cabinet and an excellent working knowledge of color TV circuitry. You've also discovered what the various components that go into a color set look like and how they are wired into place. And you've been working with some of the newest solid-state circuits used in today's equipment.

Remember, this is only one part of the total color television servicing course. The complete course offers a lot more basic theory, construction of test equipment, experiments and necessary data. The total course is a full education in color TV servicing techniques and should be considered as one of the ways you can learn more about electronics. It's certainly well worth looking into. **R-E**



USING THE SCOPE to observe the operation of the automatic color control is another experiment that is performed during the construction of the set.



ANOTHER BLOCK DIAGRAM, this one of the ACC section and where it connects into the video circuitry. It's also a part of the construction manual.

next month

DECEMBER 1975

■ Project Omega

Code name for a new digital color TV varactor tuning system featuring a non-volatile programmable memory. Also, other new color TV circuits including RCA ColorTrak and Zenith zoom.

■ TV Games For Your Living Room

Video games have finally made it into your home, courtesy of Magnavox and Broadmoor. Here's how they work and what they can do.

■ All About Digital Panel Meters

State-of-the-art answer to the D'Arsonval movement. Round-up of who's making what.

■ Vertical FET In Audio Power Amplifiers

A new semiconductor made even newer to take over an old job.

■ Build A Logic Probe

Using an LED indicator to show logic levels, this probe can test digital circuits fast.

■ Radio-Electronics Hi-Fi Lab Tests

In-depth reports on the Marantz model 4400 4-channel receiver and the Marantz CD-4 decoder.

PLUS

State-Of-Solid-State
Jack Darr's Service Clinic
Step-By-Step Troubleshooting Charts

HOW A PROM WORKS

(continued from page 74)

you in selecting a PROM. This table includes most of the presently available PROM's along with the number of bits and the bit organization of each. Also included are voltage requirements for both the read and write (programming) modes. Comments in the special notes column may also be helpful in choosing a PROM that exactly fits your requirements.

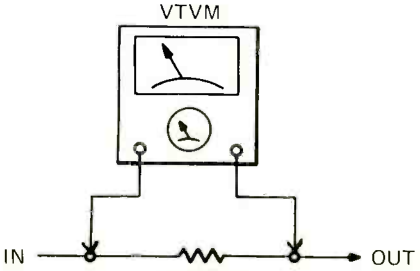
The main thing for you to remember in selecting a PROM is how you are going to program it. Unless you are prepared to spend some extra time and money for automatic or pulsing type programmers, it is advisable to stick with the fuse-link PROM's that can be programmed manually (Signetics 8223, Motorola MCM5003 etc.). Whichever way you go, remember to proceed slowly. Once you decide on your bit pattern (program), set it aside and check it over from the beginning the next day. It's easy to change an error on paper, but impossible in most PROM's.

Another hint for those of you who want to try out some PROM's: several of the PROM's we have mentioned in this article are available from companies advertising in the back pages of **Radio-Electronics.** For instance, the Signetics 8223 was noted in a couple of ads for under $5, and the National Semiconductor MM203 (similar to Intel's 1702A) can be found for around $20. **R-E**

READ CURRENT ON VTVM

I've got an old vtvm without any current ranges. How can I read current with this instrument?—C.B., Bronx, N.Y.

Make up an adapter with a small value, precise resistor. Connect this into the circuit, and read the voltage drop across it. For example, a 1.0-ohm resistor will show 1.0-volt drop if there is 1.0 ampere flowing, and so on.



This will work on AC or DC. If you want to read low currents, in high impedance circuits, use a 1000 ohm resistor. Now, you'll read 1.0 volt for each milliampere of current. This works only in circuits with high resistance, so that the added 1000 ohms won't upset things. **R-E**

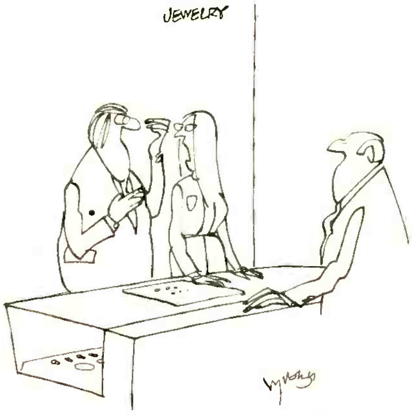
BOOKSHELF SPEAKERS

(continued from page 76)

sented in three parts. The first part is termed nominal impedance and it is usually measured at a frequency of 400 Hz. The speaker industry has standardized the nominal impedance rating so that the speaker systems are either 4, 8, or 16 ohms. This specification does not affect the sound quality of the speaker system but it does affect the total amount of power that the amplifier will deliver. Most speaker systems are 8 ohms. As such the output power of most amplifiers are referenced to 8-ohm loads. There is no problem in using a 16-ohm speaker with a solid-state amplifier rated for an 8-ohm load. However, be aware that the amplifier will deliver less power to the speaker system—approximately half as much. Similarly, the amplifier will deliver approximately twice as much power to a 4-ohm speaker system.

The second impedance specification refers to the minimum amount of impedance that the speaker system will present to the amplifier and it includes the frequency that this minimum impedance will occur at. Caution—impedances of less than 3-ohms can play havoc with some amplifiers. Most speaker systems will not present less than this value to the amplifier. However, you should consider this specification if you plan on using more than one set of speaker systems in your hi-fi system. For example, if you plan on using main and remote speaker systems, the parallel combination of two speaker systems should not present less than 3 ohms to the amplifier at any frequency in the audio spectrum.

The last impedance specification is the maximum impedance that the speaker system presents to the amplifier and it includes the frequency that this impedance occurs at. This maximum impedance usually occurs in the bass frequency range of the audio spectrum. Maximum impedances as high as 25 or 30 ohms are not uncommon in speaker systems. This maximum impedance will decrease the power that the amplifier will deliver. Although the output sound level will also be reduced, this effect has been accounted for in the frequency response curves. Modern amplifiers can handle this increase in impedance fairly well. However, it is still a good idea to choose a speaker system with a minimum amount of impedance variation. *(to be continued)*



Look, we're buying a diamond, forget you're in micro miniatures.

R-E TESTS SHURE M95ED

(continued from page 62)

their various cartridges. The effective mass of the stylus tip of the M95ED is a low 0.5 milligrams compared to 0.33 milligrams for the V15 Type III. For comparison, Shure's well known "work-horse" cartridge, the M3D, has an effective stylus tip mass of 2.2 milligrams and the V15 Type I (ancestor of the V15 Type III) boasted a stylus tip mass of 1.2 milligrams.

Laboratory measurements

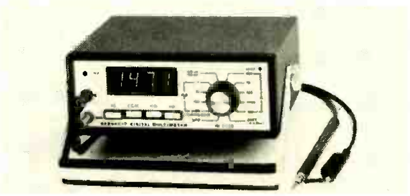
Frequency response of the Shure M95ED is shown in Fig. 5 and extends within ±2 dB from 20 Hz to 20 kHz. Cartridge resonant point is approximately at 19 kHz and the slight dip below that frequency and down to about 10 kHz is hardly significant. Other measured results are listed in Table I. It should be noted that the 400 to 500 pF capacitive loading called for in Shure's published specifications is extremely important to obtain the response shown in Fig. 5. With the recent interest in CD-4 cartridges that require much lower capacitive loading (generally 100 pF or lower), many turntable manufacturers are now supplying low-capacitance audio cables with their products in order to insure their compatibility with the CD-4 cartridges. In our first measurements, we ignored the capacitance requirement and came up with a curve that had nearly a 5 dB peak at the high end. A return to a pair of 4-foot cables of earlier vintage, added to the tonearm wiring capacitance, tamed things down considerably. Alternatively, we could have soldered in a pair of 300 pF fixed capacitors across the phono input terminals of our preamplifier and accomplished the same smoothing of the response curve. The difference is not only plottable, but audible!

Shure invented the term trackability which has almost universally replaced compliance as a meaningful measurement of cartridge capability. Since our lab is equipped with a Shure Cartridge tester and a Shure TTR-103 trackability test record (not to mention a dozen or so other test records including CBS's newly repressed STR-112 tracking and IM test record), it was a simple matter to check out Shure's claims for the trackability of the M95ED. We could not come up to the 33 cm/s velocity at 1 kHz claimed by Shure and had to settle for a very impressive 30 cm/s. The slight difference may well be due to the fact that they specify their own SME pick-up arm for making this measurement whereas we used a different high quality arm that is a part of our reference turntable system.

Separation at mid-frequencies exceeded the 25 dB minimum claimed by 3 dB and tapered off to 16 dB at 10 kHz. An overall product analysis of the M95ED, together with our comments and results of our listening tests, is contained in Table II. When properly loaded, we feel that the M95ED represents very good value in a phono cartridge and find it suitable for use in high quality single-play turntable systems and better automatics. Its low tracking force requirements preclude its use in low-cost record changers where its full potential cannot be realized. **R-E**

equipment report

Heath IM-2202 Portable Digital Multimeter



Circle 100 on reader service card

NOT VERY LONG AGO THE DIGITAL VOLTmeter was a very expensive, laboratory instrument. Recently, the release of a number of revolutionary analog-to-digital conversion IC's have drastically changed the picture. The IM-2202 uses one of these, the MK6013, that contains all of the instrument's logic circuitry. Without it, the 3½-digit auto-polarity indicating meter would be about twice as complicated (and costly). The Heath multimeter measures AC and DC voltage, AC and DC current, and resistance.

The dual-slope analog-to-digital converter scales DC inputs of either 1 volt or 100 millivolts to a full count of 1000. Readings up to 1999 are indicated with the meter's 100% overrange capacity. The decimal point is automatically positioned as the scales are changed. Readings are updated at a 5-per-second rate on the nonblinking display. The main feature of the widely accepted dual-slope method is its high accuracy despite long term drifts of the clock oscillator frequency.

When the instrument is switched to the ohms scale, precise current sources are connected to the unknown external component. The voltage across it is then measured by the converter. This ohmmeter scheme is great for checking semiconductor junctions. On the 1K ohm scale, a test current of 1 mA is passed through the device. In effect you are measuring the forward drop of the junction at 1 mA. In the reverse direction the meter will read overrange. Though some reversed-biased junctions, like the base-to-emitter of silicon NPN's, break down below the 10 volt possible terminal voltage, anything over 1.999 volts is interpreted as an overrange resistance.

Kit construction is a procedure of wiring three tightly packed PC boards, interconnecting them with a wire harness, and installing them in a battery and transformer power supply main chassis. Even with the MK6013, there are still plenty of parts in the analog and display circuitry, so you're kept pretty busy putting it all together. I counted 39 transistors, 26 diodes, and 3 IC's in all. Careful soldering is called for. Closely spaced PC runs are prerequisites for the small 3" × 8¼" × 8" final package. Troubleshooting is not too bad considering the packing density. Removing a few screws and the front panel exposes just about everything.

The IM-2202 has basic accuracies of ±0.2% on DC and ±0.75% on AC when calibrated with laboratory standards. Internal calibration references will bring DC and AC accuracy within ±0.5 and ±1.5% respectively. The ohmmeter scales are calibrated against built-in ±0.1% resistors. Instructions for extra care when mounting these critical components are aimed at preventing heat from affecting their values. I found that on the DC ranges, lab-standard accuracy was approached by interpolating and readjusting the plus and minus potentiometers so an externally applied voltage reads the same magnitude when the test leads are reversed. In general, the amount of improvement using this trick depends on the statistical variation of the two built in Zener diodes. These diodes are pre-measured by Heath with their precise voltages marked on their envelopes.

The digital readout tubes are Sperry gas-discharge types. They have excellent readability because of their large 0.55-in. high digits. Plugging them into the connector pins used for sockets was a bit tricky, but eventually yielded to some gentle pin bending. I'm sure the choice of display was the subject of some discussion over at Heath because of the 170 volt DC supply the gas tubes require. It would have been simpler to use LED's, but they would seriously compromise the convenience of the meter. An extra winding on the DC-to-DC power supply converter is used to generate the 170 volts. The same converter chops the 5-volt primary supply to produce the ±12-volt main voltages.

Four NiCad batteries are used to power the unit and when fully charged will run the multimeter for eight hours of field operation. Differential voltage measurements are eased by disconnecting from the capacitive loading AC power line. A special function position connects the meter to read its own battery voltage. The batteries should not be allowed to fall below 4.6 volts. When the batteries are being checked, the counter latches are disabled. Count accumulation is no longer blanked and all segments of the three right-hand digits are exercised as a readout check.

The digital multimeter is not a replacement for the FET analog meter but rather a complementary instrument. Once you own one, you will probably use the digital meter 90% of the time. But null adjustments or monitoring of changing voltages is usually best done with the analog meter.

The IM-2202 gives more accurate and faster readings than analog meters. Errors in making a measurement such as using the wrong scale or wrong interpolation are minimized. For $179.95 it is a lot of measurement power. **R-E**

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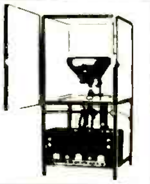

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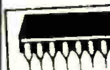

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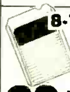

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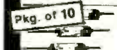

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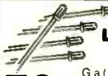

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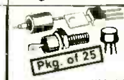

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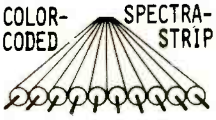

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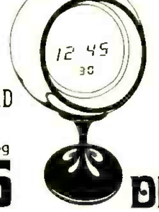
COMPUTER KIT NEWS

This ad is being prepared in mid-August, so all the details aren't nailed down yet; but we've had our system up and running in Berkeley, executing instructions and waiting for its case and panel. Target price: UNDER $600--and this includes cassette I/O, bit serial interface for teletype, editor and assembler, 1K x 16 integral RAM, readouts, keyboard, and more. By the time this ad appears, we'll have a system data package for a nominal fee.

DIGITAL CLOCK KIT



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+2 lbs shpg
$19.95
SIX DIGITS!

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FOR YOUR EDITOR/ASSEMBLER OR WHATEVER. FAST--1 usec, 1 wait. Full 4K needs 5V @ ½A and -12 @ 100 ma; board runs cool, supply doesn't grunt

ALTAIR 8800 OWNERS, TAKE NOTE: ALL ABOVE MEMORY BOARDS ARE **DIRECTLY PLUG-IN COMPATIBLE!** NO JUMPERS, NO RASSLE, NO HASSLE; ALSO ELECTRICALLY COMPATIBLE WITH OTHER 8 BIT MACHINES.

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DS0026	$3.00	DUAL CLOCK DRIVER
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8008	$17.95	POPULAR 8 BIT MICROPROCESSOR---IDEAL FOR PERIPHERAL CONTROL
5204	$24.50	SIMILAR TO 5203 (SEE BELOW), BUT 4K BITS WORTH OF EROM

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Craig Anderton's new book tells you how to build the 19 projects below---even if you've never built anything before. It contains an introduction to basic electronics with emphasis on practical construction techniques, detailed instructions on the projects, how to troubleshoot, and where to find more information. Craig has selected us to provide parts kits for the projects, as we have for his how-to articles in the past. Our kits save you the trouble of locating parts and making circuit boards. Send address & stamp for latest prices, or $6.95 + postage for the book. It contains a record that demonstrates the sounds of the projects, and a forward by Joe Walsh. HAVE FUN!

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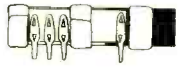
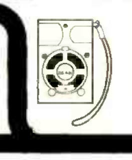


EXPERIMENTERS
Ferrite type; for AM transistor radio.

2" SPEAKER



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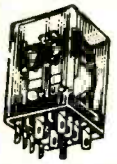

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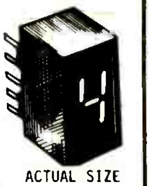

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Highly legible - bright red ¼" character easily read within 10 feet over a wide viewing angle (140°)
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DIRECTLY TTL COMPATIBLE INPUTS AND OUTPUT
SINGLE 5V SUPPLY - - NO CLOCKS OR REFRESH
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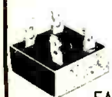

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25 AMP   500 PIV
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74H01	.25	74L55	.25
7402	.25	7460	.16
7403	.25	74L71	.25
7404	.25	7472	.40
74H04	.30	74L72	.60
7405	.30	7473	.25
7406	.40	74L73	.75
7408	.30	7474	.45
7410	.15	74H74	.75
7413	.75	7475	.80
7417	.40	7476	.55
7420	.20	74L78	.70
74L20	.30	7480	.50
74H20	.30	7483	.70
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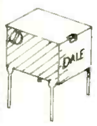

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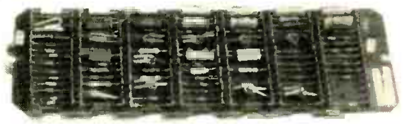
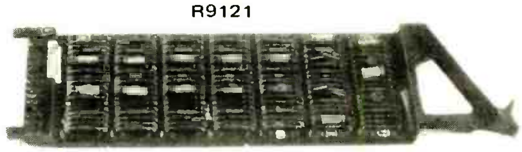


R9121



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7400	$ .14	7453	.17	74155	1.07
7401	.16	7454	.17	74156	1.07
7402	.15	7460	.17	74157	.99
7403	.16	7464	.35	74158	1.79
7404	.19	7465	.35	74160	1.39
7405	.19	7470	.30	74161	1.25
7406	.35	7472	.30	74162	1.49
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
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7425	.27	7493	.60	74181	2.98
7426	.26	7494	.94	74182	.79
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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74L03	.25	74L71	.25	74L93	1.69
74L04	.25	74L72	.39	74L95	1.69
74L06	.25	74L73	.49	74L98	2.79
74L10	.25	74L74	.49	74L164	2.79
74L20	.33	74L78	.79	74L165	2.79
74L30	.33	74L85	1.25		
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74H08	.25	74H40	.25	74H62	.25
74H10	.25	74H50	.25	74H72	.39
74H11	.25	74H52	.25	74H74	.39
74H20	.25	74H53	.25	74H76	.49

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8121	.80	8520	1.16	8830	2.19
8123	1.43	8551	1.39	8831	2.19
8130	1.97	8552	2.19	8836	.25
8200	2.33	8554	2.19	8880	1.19
8210	2.79	8810	.69	8263	5.79
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4000A	$ .26	4017A	1.19	4066A	.89
4001A	.25	4020A	1.49	4068A	.44
4002A	.25	4021A	1.39	4069A	.44
4006A	1.35	4022A	1.10	4071A	.26
4007A	.26	4023A	.25	4072A	.35
4008A	1.79	4024A	.89	4073A	.39
4009A	.57	4025A	.25	4075A	.39
4010A	.54	4027A	.59	4078A	.39
4011A	.29	4028A	.98	4081A	.26
4012A	.25	4030A	.44	4082A	.35
4013A	.45	4035A	1.27	4528A	1.60
4014A	1.49	4042A	1.47	4585A	2.10
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74C02	.26	74C76	1.34	74C163	2.66
74C04	.44	74C107	1.13	74C164	2.66
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74C10	.35	74C154	3.15	74C195	2.66
74C20	.35	74C157	1.76	80C95	1.35
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5261	1024 bit RAM	2.69
5262	2048 bit RAM	5.95
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8223	Programmable ROM	3.69
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MM5738	8 DIG 5 funct K & mem	5.35
MM5739	9 DIG 4 funct (btry sur)	5.35
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MM5312	24 pin 1 pps BCD 4 dig mux	3.95
MM5313	28 pin 1 pps BCD 6 dig mux	4.45
MM5314	24 pin 6 dig mux	4.45
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LED's

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MV5020	Jumbo Vis. Red (Red Dome)	.22
	Jumbo Vis. Red (Clear Dome)	.22
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MAN2	Red alpha num .32"	4.39
MAN4	Red 7 seq. .190"	1.95
MAN5	Green 7 seg. .270"	3.45
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MAN7	Red 7 seq. .270"	1.19
MAN3	Red 7 seg. .127" straight pins	.29
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MAN66	.6" high spaced seq.	3.75
MCT2	Opto-iso transistor	.61

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HP5082 7405	5 digit .11 led magn. lens com. cath	3.49
HP5082 7414	4 digit .11 LED magn. lens comm. cath.	$3.25
FNA37	9 digit 7 seg led RH dec clr. magn. lens	4.95
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936	.15	946	.15	963	.15

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308	Micro Pwr Op Amp	mDIP TO-5	.89
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566	Function Gen	mDIP TO-5	2.25
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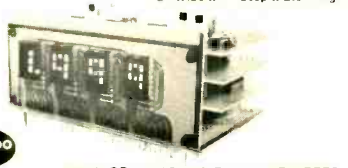

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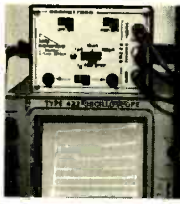

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2SC710	.70	2SC789	1.00	2SC1306	4.75	HEP-S 3001	3.25	2SK30	1.00
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2SA316	.75	2SB235	1.75	2SC460	.70	2SC828	.75	2SC1756	1.25
2SA473	.75	2SB303	.65	2SC478	.80	2SC829	.75		
2SA483	1.95	2SB324	1.00	2SC491	2.50	2SC830	1.60	2SD30	.95
2SA489	.80	2SB337	2.10	2SC497	1.60	2SC839	.85	2SD45	2.00
2SA490	.70	2SB367	1.60	2SC515	.80	2SC945	.65	2SD65	.75
2SA505	.70	2SB370	.65	2SC535	.95	2SC1010	.80	2SD68	.90
2SA564	.50	2SB405	.85	2SC536	.65	2SC1012	.80	2SD72	1.00
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2SA699	1.30	2SB476	1.25	2SC643	3.75	2SC1166	.70	2SD300	2.50
2SA699A	1.75	2SB481	2.10	2SC644	.70	2SC1170	4.00	2SD313	1.10
2SA705	.55	2SB492	1.25	2SC681	2.50	2SC1172B	4.25	2SD315	.75
2SA815	.85	2SB495	.95	2SC684	2.10	2SC1209	.55	2SD318	.95
2SA816	.85	2SB507	.90	2SC687	2.50	2SC1213	.75	2SD341	.95
		2SB511	.70	2SC696	2.35	2SC1226	1.25	2SD350	3.25
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2SB54	.70	2SC206	1.00	2SC713	.70	2SC1293	.85	2SD380	5.70
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2SB135	.95	2SC320	.75	2SC756	2.00	2SC1409	1.25		
2SB152	4.50	2SC352	.75	2SC762	1.90	2SC1410	1.25	C106B1	.50
2SB173	.55	2SC353	.75	2SC783	1.00	2SC1447	1.25		
2SB175	.55	2SC371	.70	2SC784	.70	2SC1448	1.25		
2SB178	1.00	2SC372	.70	2SC785	1.00	2SC1507	1.25		
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		2N967	.50	2N2221A	.30	2N2916A	3.65	2N3772	1.90	2N4403	.20		
2N173	1.75	2N1136	1.35	2N2222	.25	2N3019	.50	2N3773	3.00	2N4409	.20		
2N178	.90	2N1142	2.25	2N2222A	.30	2N3053	.30	2N3819	.32	2N4410	.25		
2N327A	1.15	2N1302	.25	2N2270	.40	2N3054	.70	2N3823	.70	2N4416	.75		
2N334	1.20	2N1305	.30	2N2322	1.00	2N3055	.75	2N3856	.20	2N4441	.85		
2N336	.90	2N1377	.75	2N2323	1.00	2N3227	1.00	2N3866	.85	2N4442	.90		
2N338A	1.05	2N1420	.20	2N2324	1.35	2N3247	3.40	2N3903	.20	2N4443	1.20		
2N398B	.90	2N1483	.95	2N2325	2.00	2N3250	.30	2N3904	.20	2N4852	.55		
2N404	.30	2N1540	.90	2N2326	2.85	2N3375	6.50	2N3905	.20	2N5061	.30		
2N443	1.75	2N1543	2.70	2N2327	3.80	2N3393	.17	2N3906	.25	2N5064	.50		
2N456	1.10	2N1544	.80	2N2328	4.20	2N3394	.17	2N3925	3.75	2N5130	.20		
2N501A	3.00	2N1549	1.25	2N2329	4.75	2N3414	.17	2N3954	3.50	2N5133	.15		
2N508A	.45	2N1551	2.50	2N2368	.25	2N3415	.18	2N3954A	3.75	2N5138	.15		
2N555	.45	2N1552	3.25	2N2369	.25	2N3416	.19	2N3955	2.45	2N5198	3.75		
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2N711	.50	2N1613	.30	2N2904	.25	2N3565	.20	2N4124	.20	2N5369	.20		
2N711B	.60	2N1711	.30	2N2904A	.30	2N3638	.20	2N4126	.20	2N5400	.40		
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2N718A	.30	2N2060	1.85	2N2905A	.30	2N3643	.15	2N4142	.20	2N5457	.35		
2N720A	.50	2N2102	.40	2N2906	.25	2N3645	.15	2N4143	.20	2N5458	.30		
2N918	.35	2N2218	.25	2N2906A	.30	2N3646	.14	2N4220A	.45				
2N930	.25	2N2218A	.30	2N2907	.25	2N3730	1.50	2N4234	.95				
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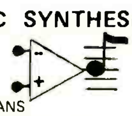

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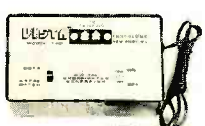

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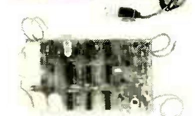

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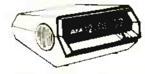

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SN7427N	.37	SN7495N	.91	SN74184N	2 30
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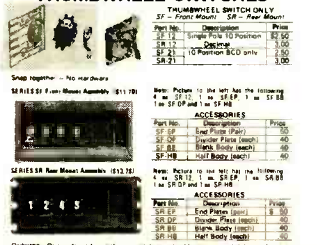

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PARTS SURVEY

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James Electronics	Belmont, CA	7–10 days
Poly Paks	Lynnfield, MA	2–3 weeks (getting better)
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Meshna Electronics	Lynnfield, MA	2–3 weeks
Delta Electronics	Lynnfield, MA	3–4 weeks
Solid State Sales	Somerville, MA	3–4 weeks
Howard W. Sams & Co.	Indianapolis, IN	7 weeks
Altaj Electronics	Dallas, TX	1–1½ months

All the times are from the day I wrote the letter until I received the parts.

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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	23	.22	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 ASST.

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

PRIME INTEGRATED CIRCUIT ASSORTMENTS

ASST. 8	3 ea	SN7400 7401 7402 7403 7404 SN7410 7430 7438 7440 7472	SSI/TTL	$5.95 ASST.
ASST. 9	2 ea	SN7447 7490 7491 74100 74121 SN74145 74175 74180 74191 74193	MSI/TTL	$9.95 ASST.
ASST. 10	2 ea	CD4001 4002 4011 4012 4013 CD4016 4017 4019 4023 4030	CMOS	$2.95 ASST
ASST. 11	2 ea	LM301T 301N 302T 307T 309K LM311T 565T 567T 741T 741N	LINEAR	$10.95 ASST.

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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	17.95	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
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2401	2K DSR	9.95	74LS670	4x4	Register	3.95
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TIMERS			STEREO DECODERS	
XR-555CP SPECIAL	$ .69		XR-1310P	$3.20
XR-320P	1.55		XR-1310EP	3.20
XR-556CP	1.85		XR-1800P	3.20
XR-2556CP	3.20		WAVEFORM GENERATORS	
XR-2240CP SPECIAL	3.25		XR-205	8.40
PHASE LOCKED LOOPS			XR-2206CP SPECIAL	4.49
XR-210	5.20		XR-2207CP	3.85
XR-215	6.60		MISCELLANEOUS	
XR-567CP	1.95		XR-2211CP	6.70
XR-2567CP SPECIAL	2.99		XR-2261	3.79

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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			PN4249	4/$1.00
MPS-A06	5/$1.00	PN3567	3/$1.00	PN4250	4/$1.00
2N2219A	3/$1.00	PN3568	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	2N3700	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 119 on reader service card

Circle 120 on reader service card

Circle 110 on reader service card

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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
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XR-1468CN	Dual + 15V Tracking Regulator	SPECIAL	2.90
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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	1.05	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	.80	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	74185N	2.29
7413N	.58	7473N	.37	74132N	1.00	74188N	4.80
7414N	1.23	7474N	.32	74136N	.95	74190N	1.20
7416N	.28	7475N	.59	74141N	1.20	74191N	1.20
7417N	.33	7476N	.32	74145N	1.00	74192N	1.20
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	2.30	74155N	1.00	74200N	5.60
7430N	.20	7490N	.50	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	1.50	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	.36	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	74LS160	3.06	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				
24	.67	.61	.55	**SOLDER - GOLD**			
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.

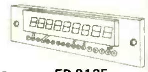
209 RED	$.25	216 RED	$.25	220 RED	$.25
209 YELLOW	.35	216 YELLOW	.30	220 YELLOW	.30
209 GREEN	.35	216 GREEN	.30	220 GREEN	.30

LOW PROFILE

226 RED	$.25	5053 RED	$.35	MV50 RED	$.30
226 YELLOW	.30	5053 YELLOW	.40		
226 GREEN	.30	5053 GREEN	.40		
226 ORANGE	.30	5053 ORANGE	.40		

216 = MV5024
5053 = MV5053

DISPLAYS



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DL704	RED	2.25
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LM301H	.90	LM331N	2.20	LM733CH	1.40
LM302D	3.50	LM339N	2.90	LM733CD	3.50
LM302N	1.30	LM320-5K	2.90	LM733CN	1.30
LM302H	1.40	LM320-5T	2.50	LM741CH	.45
LM304H	1.40	LM320-12K	2.90	LM741CD	1.25
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LM305AH	1.05	LM340-05K	2.60	LM741CN	.70
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	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			

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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
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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		

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2N293	.60	2N984	95	2N2193	44	2N2857	3.00
2N321	50	2N1035	1.90	2N2197	2.40	2N2880	10.90
2N324	.55	2N1132	.30	2N2217	.80	2N2893	9.70
2N336	1.00	2N1136	1.40	2N2218	.25	2N2894	.45
2N338A	1.25	2N1137A	1.90	2N2218A	.28	2N2895	1.00
2N389	9.00	2N1143	1.90	2N2219	.29	2N2903	4.10
2N396A	1.20	2N1168	.65	2N2219A	.36	2N2904	.30
2N397	1.20	2N1204	1.40	2N2221	.24	2N2904A	.34
2N398B	1.00	2N1302	.30	2N2221A	.25	2N2905	.32
2N404	.30	2N1303	80	2N2222	.24	2N2905A	.34
2N404A	.65	2N1305	35	2N2222A	.26	2N2906	.17
2N417	.85	2N1307	.80	2N2259	1.10	2N2906A	.19
2N443	1.15	2N1309	80	2N2270	.40	2N2907	.19
2N456	1.30	2N1377	1 40	2N2289	3.60	2N2907A	.26
2N491	5.10	2N1408	.60	2N2290	5 90	2N2911	21.00
2N508A	.40	2N1420	.50	2N2297	.95	2N2913	.89
2N511A	3.50	2N1485	2.60	2N2323	1.90	2N2925	.20
2N512B	2.90	2N1521	4 80	2N2326	3.30	2N2926	.14
2N525	.90	2N1523	5.00	2N2356	5.90	2N2947	14 40
2N526	.90	2N1534	1.00	2N2356A	6.90	2N2949	5 90
2N527	.90	2N1540	1.05	2N2359	15 90	2N2950	6.40
2N555	.50	2N1543	3.40	2N2368	.29	2N2958	1.90
2N586	1.00	2N1549	1.30	2N2369	.22	2N2969	30 90
2N594	1.50	2N1551	3.90	2N2382	4.40	2N3019	.50
2N630	4 00	2N1552	3.90	2N2440	3 45	2N3022	17 90
2N652	.40	2N1554	1.90	2N2465	7 40	2N3053	.34
2N652A	40	2N1557	1.70	2N2468	1.00	2N3054	.80
2N657A	.40	2N1560	3.20	2N2475	.55	2N3055	.94
2N677C	5.50	2N1613	.40	2N2476	.79	2N3060	2.95
2N683	2.70	2N1671	2.00	2N2483	.28	2N3066A	1.19
2N697	.25	2N1671B	2 10	2N2484	.25	2N3107	.78
2N697A	.50	2N1693	14 90	2N2492	4.00	2N3117	1.50
2N699	.66	2N1711	.40	2N2518	5.90	2N3130	4.90
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2N711	.36	2N1907	4.90	2N2605	.49		
2N711B	.60	2N1921	2.90	2N2605A	.58		
2N718	.28	2N1924	1.25	2N2606	3.50		
2N718B	.40	2N1934	9.30	2N2647	1.30		
2N720A	.50	2N1990	.75	2N2648	3.90		
2N744	.35	2N2060	2.05	2N2658	6.90		
2N829	2.90	2N2080	4.90	2N2708	25		
2N834	.35	2N2081A	2.50	2N2712	.30		
2N917	80	2N2100	2.90	2N2713	.14		
2N918	.40	2N2102	.45	2N2714	.40		
2N929	.26	2N2143	1.50	2N2715	.18		
2N930	.28	2N2147	1.40	2N2716	.18		
2N960	.45	2N2148	68	2N2754	94.00		
2N962	.45	2N2152	3 00	2N2802	9 70		

2N3247	3.80	2N3468	1.85	2N3657	9.90
2N3250	.49	2N3478	2.00	2N3662	.42
2N3307	8.50	2N3501	6.40	2N3663	.44
2N3308	6.50	2N3506	7 40	2N3684	1.20
2N3309	7.10	2N3544	3.90	2N3685	1.35
2N3323	1.15	2N3546	2.90	2N3685A	1.75
2N3324	.80	2N3553	1.80	2N3686	1.50
2N3325	.70	2N3563	.16	2N3687	1.60
2N3368	.80	2N3564	.14	2N3692	.20
2N3375	5.50	2N3565	.18	2N3693	.21
2N3390	.40	2N3567	.19	2N3694	.22
2N3391	.41	2N3569	.19	2N3702	.18
2N3391A	.20	2N3570	5.50	2N3705	.25
2N3392	.20	2N3571	3.90	2N3707	.18
2N3393	.20	2N3572	2.60	2N3708	.22
2N3394	.22	2N3584	1.80	2N3709	.22
2N3395	.24	2N3614	1.10	2N3710	.20
2N3396	.26	2N3616	1 24	2N3711	.18
2N3397	.28	2N3617	2.40	2N3713	1.20
2N3398	.25	2N3634	7.90	2N3721	.22
2N3414	.20	2N3638	.18	2N3725	.36
2N3415	.20	2N3640	.19	2N3730	1.80
2N3416	.20	2N3642	.19	2N3731	2.00
2N3417	.22	2N3643	.16	2N3732	1.95
2N3436	1.60	2N3645	.16	2N3740	1.10
2N3440	.98	2N3646	.10	2N3741	1.60
2N3441	1.70	2N3649	4.70	2N3771	2.20
2N3442	2.15	2N3650	6.10	2N3772	2.30
2N3445	4.90	2N3651	9 20	2N3773	3.30
2N3467	1.45	2N3656	8.50	2N3789	3.00

2N3793	.25	2N4142	.17	2N4988	.95	2N5311	.44	2N5813	.42
2N3796	3.00	2N4143	.16	2N4989	1.40	2N5322	.70	2N5815	.36
2N3799	3.15	2N4220A	1.00	2N4990	.75	2N5323	.66	2N5816	.38
2N3804	8.00	2N4225	3 75	2N4991	.75	2N5354	.30	2N5817	.38
2N3805	10.40	2N4226	3.90	2N4992	1.10	2N5355	.35	2N5818	.40
2N3819	.30	2N4227	.34	2N4993	1.60	2N5365	.40	2N5819	.42
2N3821	1.35	2N4228	.49	2N4994	.25	2N5366	.40	2N5821	.60
2N3822	1.40	2N4235	1.90	2N4995	.26	2N5367	.42	2N5822	.56
2N3823	.69	2N4248	.17	2N5016	12.70	2N5368	.24	2N5823	.66
2N3824	1.00	2N4249	.20	2N5036	1.17	2N5369	.25	2N5824	.24
2N3851	7.40	2N4250	.22	2N5064	.50	2N5370	.26	2N5825	.26
2N3856	.28	2N4256	.28	2N5088	.45	2N5371	.22	2N5826	.28
2N3858	.26	2N4258	.34	2N5089	.80	2N5373	.26	2N5827	.30
2N3859	.28	2N4289	.40	2N5105	3.05	2N5375	.25	2N5828	.32
2N3860	.29	2N4291	.35	2N5109	2.40	2N5380	.50	2N5828A	.38
2N3877	.42	2N4293	.50	2N5127	.16	2N5381	.56	2N6000	.50
2N3900	.38	2N4303	.30	2N5130	.20	2N5382	.50	2N6001	.52
2N3901	.30	2N4341	1.35	2N5131	.20	2N5383	.56	2N6002	54
2N3903	.20	2N4347	1.60	2N5133	.17	2N5397	2.90	2N6004	.54
2N3904	.22	2N4348	2.10	2N5134	.18	2N5407	28.90	2N6010	62
2N3905	.20	2N4352	2.00	2N5135	.16	2N5409	31.90	2N6011	.64
2N3906	.22	2N4395	1 25	2N5137	.26	2N5418	.30	2N6014	.66
2N3909	.80	2N4400	.29	2N5138	.17	2N5419	.34	2N6015	68
2N3924	3.50	2N4401	.33	2N5154	7.05	2N5420	.40	2N6027	50
2N3925	4.75	2N4402	.35	2N5155	3.20	2N5447	.26	2N6028	.64
2N3933	1.30	2N4409	.30	2N5157	9.85	2N5448	.27	2N6076	16
2N3945	.90	2N4416	89	2N5161	2.60	2N5449	26	2N6099	1.00
2N3954	4.40	2N4424	.35	2N5172	.14	2N5450	.24	2N6101	.95
2N3954A	5.80	2N4425	.40	2N5198	4.25	2N5451	.24	2N6103	.98
2N3955	2 70	2N4427	1.30	2N5210	.22	2N5453	5.35	2N6107	1.90
2N3955A	3.20	2N4441	1.00	2N5219	.16	2N5457	.40	2N6109	2.30
2N3956	2.90	2N4443	1.40	2N5220	.28	2N5458	.40	2N6111	2.60
2N3957	1.45	2N4852	.85	2N5221	.30	2N5490	1.40	2N6114	4.50
2N3958	1.45	2N4858	1.10	2N5222	.16	2N5491	.80	2N6115	2.10
2N3964	1.09	2N4859	1.20	2N5223	.16	2N5492	1.45	2N6218	.60
2N3970	1.20	2N4863	5.45	2N5224	.22	2N5494	1.70	2N6219	.59
2N3971	1.00	2N4870	.60	2N5225	.30	2N5496	1.90	2N6220	.58
2N3972	1.39	2N4878	3.85	2N5226	.26	2N5562	12.40	2N6221	.52
2N4012	10.40	2N4890	95	2N5227	.16	2N5563	8.90	2N6222	.28
2N4032	1.90	2N4898	1.10	2N5232	.22	2N5592	1.00	2N6223	.30
2N4037	.70	2N4901	2.70	2N5232A	.24	2N5637	26.90	2N6224	.32
2N4045	1 90	2N4902	3.00	2N5249	.30	2N5644	7.10	2N6225	.34
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2N4060	.25	2N4905	4.10	2N5295	.60	2N5679	1.39	3N83	1.70
2N4061	25	2N4906	4.30	2N5296	.95	2N5742	35.00	3N84	1.68
2N4062	.25	2N4918	1.30	2N5298	1.00	2N5777	.50	3N85	3.30
2N4093	1.05	2N4922	1.00	2N5306	.26	2N5778	.54	3N86	6.10
2N4123	.20	2N4983	.80	2N5306A	.40	2N5779	.80	3N153	1.05
2N4124	.20	2N4984	1.10	2N5307	.40	2N5780	.85	3N189	4.10
2N4125	25	2N4985	1 90	2N5308	.44	2N5810	.34	40290	1.70
2N4126	.25	2N4986	.95	2N5309	.36	2N5811	.38	40319	1.00
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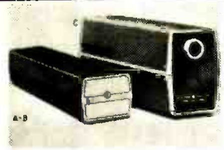

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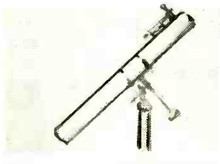

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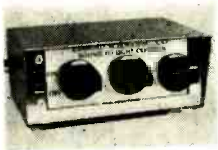

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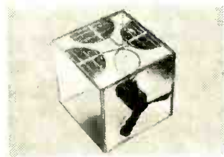

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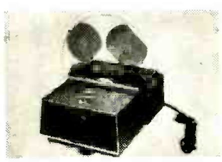

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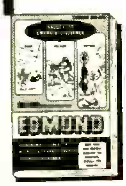

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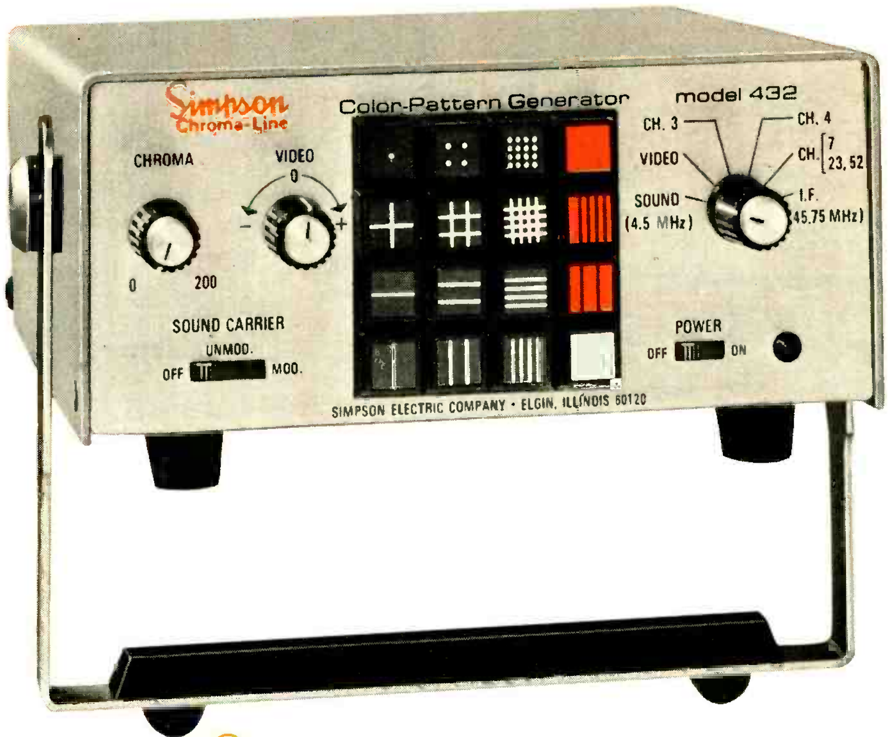

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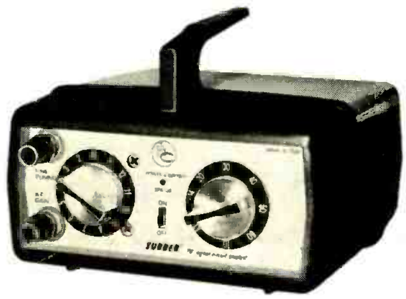

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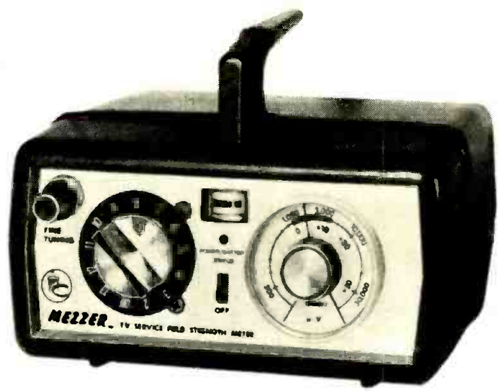

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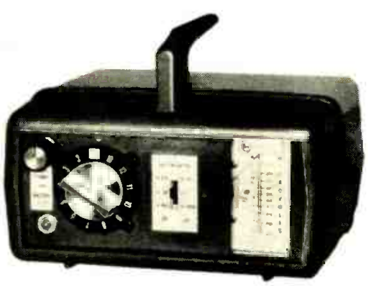

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