

Radio-^{IND}Electronics

60c ■ SEPT. 1973

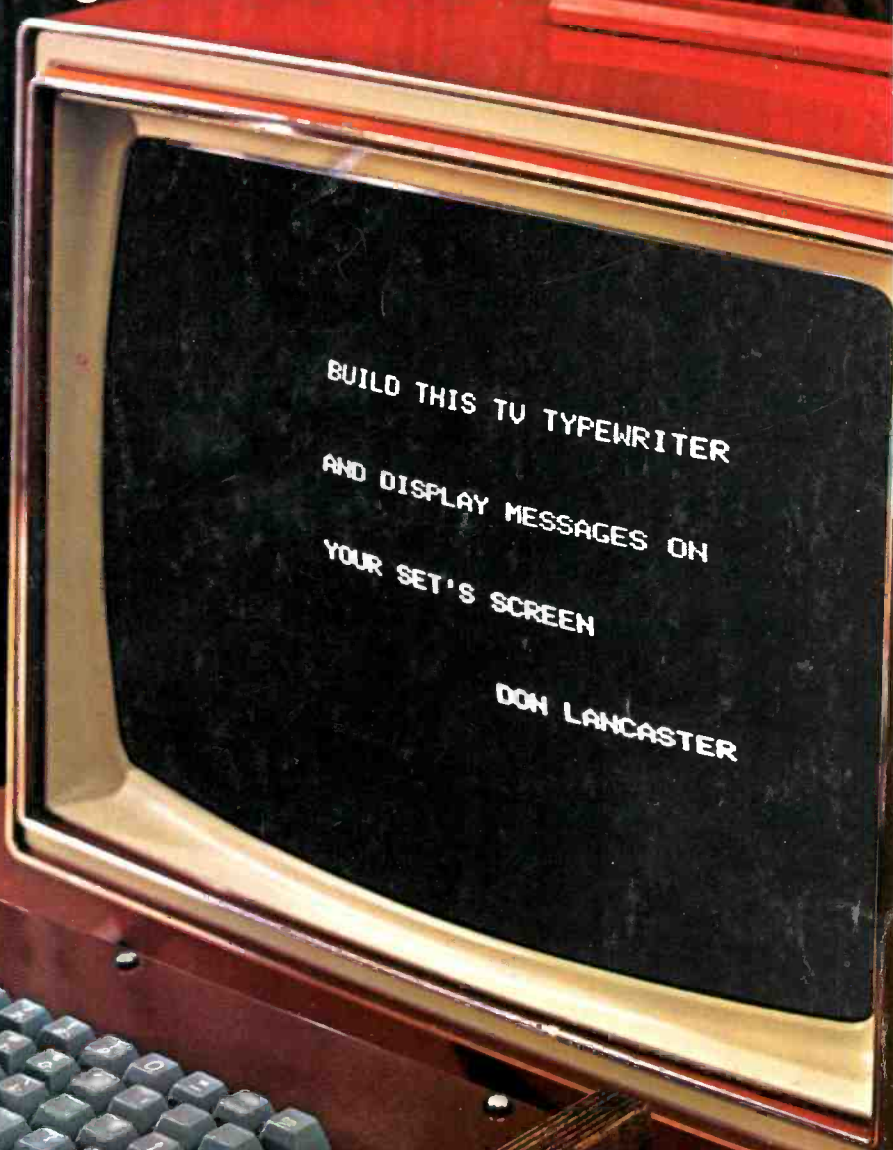
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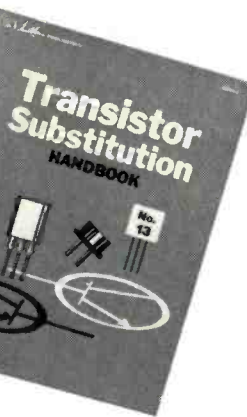
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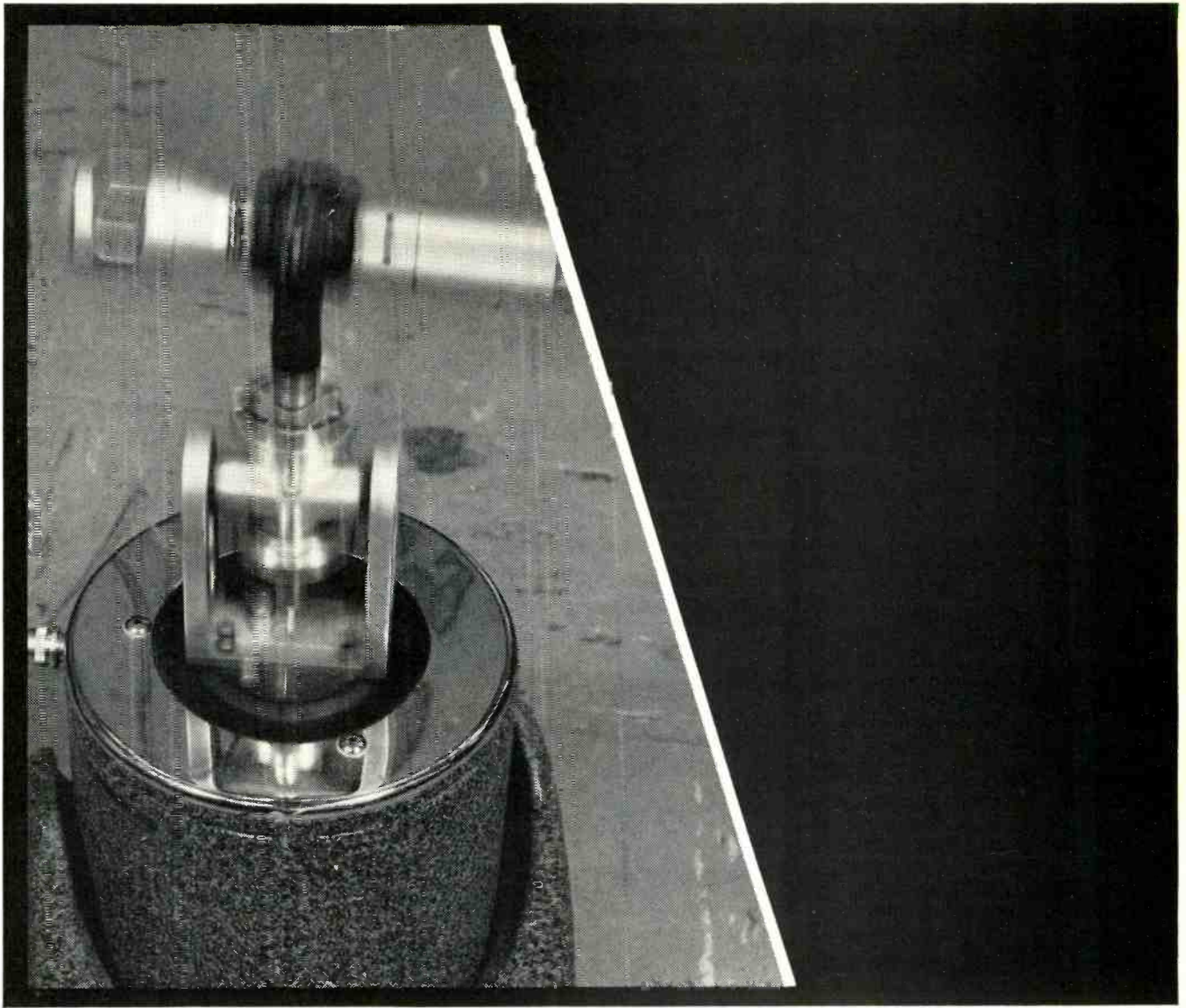
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SEPTEMBER 1973

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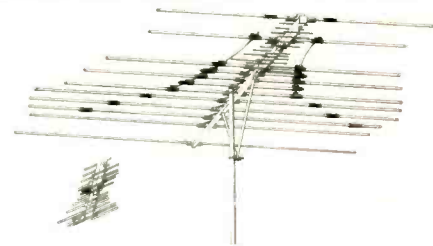
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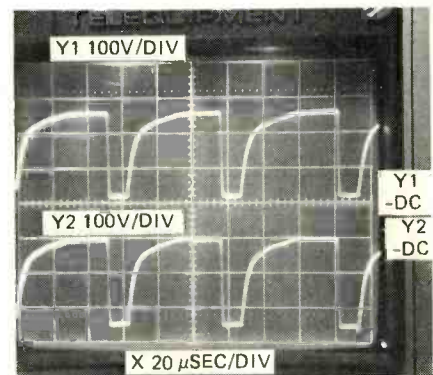
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TV ANTENNA by GC Electronics is just one of many new models to be described in this issue. To bring yourself up to date on the latest antennas **turn to page 40**



STEP-BY-STEP troubleshooting is easier if you use your scope. This is one of the waveforms you'll find while testing sweep circuits. **turn to page 68**

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editorial

MERGER—one association for all

Today there are two great, but separate, associations whose membership is made up of electronic service technicians. Both of these associations are totally dedicated to their membership. Both frequently fight the same battles. Both champion the service technician. Both strive to improve the professional image of the service technician. Both work to make the service technician better trained—better trained as a businessman as well as better trained in his chosen profession.

When these associations raise their voices to pursue a course of action, there are two separate voices—two medium-powered voices. Two voices that separately are, all too often, easily ignored.

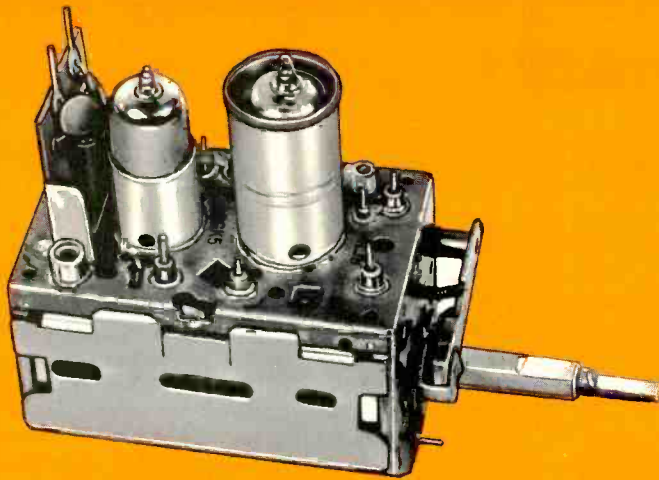
Merger would create one new, large association. It would be a giant. It would speak like a giant and would become a major influence in the betterment of the service technician.

At the joint convention in Kansas City this month (August 21st to August 26th), the membership of the two present associations will be meeting at the Crown Center Hotel. At this meeting, they will be presented with a report by the merger committee—organized one year ago in New Orleans.

I have studied the merger committee report and feel that merger represents the proper action for the membership to take. When the votes are counted, I hope they will add up to MERGER-YES!

If you are a member of NATESA or NEA, attend the convention. Let your voice be heard. Help forge your new association.

—Larry Steckler, CET, Editor.



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looking ahead

Videodisc ready

Montreux, Switzerland—An unscheduled attraction at the biennial International Television Symposium here was a demonstration of the first consumer videodisc system from actual pilot production. The demonstration was held by Telefunken of Germany, Decca of Great Britain and Teldec, their jointly owned phonograph record-producing subsidiary.

As already described in **Radio-Electronics**, the system uses a "pressure pickup" technique. The thin, flexible disc rides on a cushion of air,



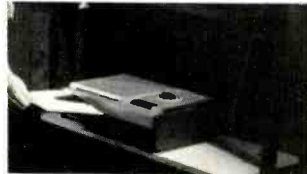
PHILIPS VIDEODISC is brightly silvered optical type used in their laser TV disc system.

and the pickup translates embossed "hill-and-dale" impressions into electrical impulses. The player itself, scheduled for marketing in Germany, is about the size of a component turntable—which it doesn't resemble at all.

The player has three pushbuttons, a timing dial and a slot—everything else is enclosed. The eight-inch videodiscs are enclosed in two paper sleeves. The outer one is removed and the disc inserted in the slot with the inner sleeve still in place. The flexible disc is fed around a roller, the sleeve removed. The disc then is played automatically and is returned to

the operator through the slot, once again in its inner sleeve.

Each disc plays for 10 minutes, in color, revolving at 1,500 rpm (speed for the U.S.



PAPER-JACKETED disc is inserted in slot of compact Telefunken-Decca developed videodisc player.

version will be 1,800 rpm because of the American 60-cycle TV standard). The picture, as displayed on two 25-inch Telefunken TV receivers, was excellent—better than most home sets receive off the air. Some horizontal "dropouts" were occasionally evident in the picture, but not objectionable. On close-up examination, the picture had a "soft" look, not evident at normal viewing distance.

The videodisc player and more than 200 different discs are scheduled to go on the consumer market in Germany shortly after the beginning of next year. Exact prices weren't announced, but the developers said that as a general rule the player would be priced at about half the cost of a large-screen color TV set—on the German market that will work out to about \$375. An automatic-changing version will follow in about a year at between \$500 and \$600.

The initial programming on discs will consist of how-to material (cooking lessons, home handyman instructions, etc.); nature, science and travel; sports; pop music. The entertainment discs, spokesmen said, will be priced about same as audio LP's.

Among the unique features of the system is an "instant replay" button. When depressed, it repeats a one-second segment until re-

leased, or until the scene has been run 15 times. Using the timer knob, the disc may be quickly scanned until any portion is located. During this "search" process, the picture remains in sync at all times.

The developers of the system say that each disc can be played at least 1000 times and that the diamond stylus has a life of 80 hours (it's automatically cleaned and polished each time a record is played). After its debut in Germany, the system will be introduced on the British market. An American version will be demonstrated before this year's end, and Telefunken-Decca spokesmen say they expect at least one U.S. manufacturer to adopt the system. (Zenith has already demonstrated its own version of the system.)

Like other proposed and demonstrated videodisc systems, the Telefunken-Decca unit is for playing recorded material only; unlike videocassette systems, it doesn't permit home recording. At any rate, it now appears that the video phonograph record is about to become a home product. And Telefunken-Decca appear to have at least a one-year lead over competing systems under development by RCA and MCA Disco-Vision in the United States, Philips in Holland and Thomson-GSF in France.

Color from b&w

The International Television Symposium also saw the first prototype showing of a unique color TV system which could lead to an extremely low-cost home color camera and lower the costs of home color recorders and videodisc systems. Called "GX," the system uses a slightly modified black-and-white vidicon camera to produce color pictures, which can be stored by

any monochrome VTR for later playback in color on a standard home color set.

GX makes use of a discovery made a generation ago at Bell Telephone Laboratories that increasing the amount of green seems to sharpen up a color picture significantly, making up for low resolution in the other two colors. As demonstrated here, the system used a low-cost black-and-white industrial TV camera, modified with a transparent glass "light divider" and three side-by-side color filters (red, green and blue) between the lens and the pickup tube.

The vidicon camera produces three black-and-white pictures, one representing red, one green and one blue. These may then be stored on regular monochrome video tape and later fed to a special encoder, or fed directly to the encoder for live color TV showing. The encoder filters out most of the red and blue information, leaving the green intact. It then constructs a line-sequential color signal, consisting of as many green lines as red plus blue, in a sequence of R-G-B-G-R-G-B-G, etc.

The picture demonstrated on a Sony 12-inch color receiver from a half-inch Sony black-and-white VTR showed good colors and a crisp picture. It's too early to say whether GX represents a real cost breakthrough which can lead to a home color camera and low-cost color recording, but several major manufacturers are looking into the system, which was developed in Jaeger's laboratories in Florence, Italy. In mass production—about a million units a year—Jaeger says the camera and encoder should retail for less than \$350. He adds that he is developing a low-cost play-only videodisc.

by **DAVID LACHENBRUCH**
CONTRIBUTING EDITOR

Announcing the RCA MINI-STATE Antenna System



**The profitable new
achievement in antenna technology.**

The Mini-State is brand new from RCA. It's the first true miniaturized rotating antenna system on the market. *It works . . . and works well!*

This system is specifically made for your metropolitan and suburban customers who want the quality reception of an outdoor-type antenna, in a beautifully compact unit suitable for homes and apartments.

Measuring just 21" across and 7" high, the Mini-State is completely enclosed in an attractive sturdy plastic case that's weatherproof and resistant to dust and dirt. It weighs just 6 pounds and can be mounted almost anywhere: rooftop, chimney, window, attic and closet.

The RCA Mini-State's uni-directional pattern, VHF slotted ring and multi-element UHF design, combined with its completely integrated solid state circuitry, provides excellent reception on all channels, and helps avoid interference and ghosts.

Mini-State model 5MS440, with built-in rotator, allows your customers to zero-in for best reception on any chan-

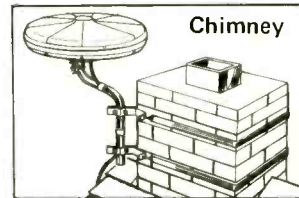
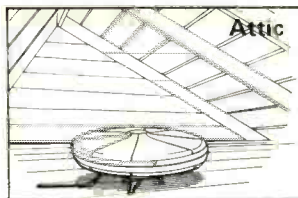
nel. Exclusive direction indicator light on the hand held control unit tells them where the antenna is aimed.

The RCA Mini-State rotating antenna system includes: The antenna with built-in amplifier. Built-in rotator and hand held remote control unit. A 120 volt AC power supply. A VHF-UHF antenna matching transformer. An outdoor mast clamp. Legs which can be snapped in to place for indoor use.

Although regular coaxial and rotator cable may be used, a unique combined coaxial and rotator cable is available in prefabricated lengths for quick, easy installation. (A fixed non-rotating model 5MS330 is also available.)

Yes, this new RCA Mini-State antenna system can mean maxi-profits for you. See your RCA Parts and Accessories distributor today, or contact RCA Parts and Accessories, P.O. Box 100, Deptford, N.J. 08096. Make sure you're in on the ground floor of this profitable new era in TV antenna systems.

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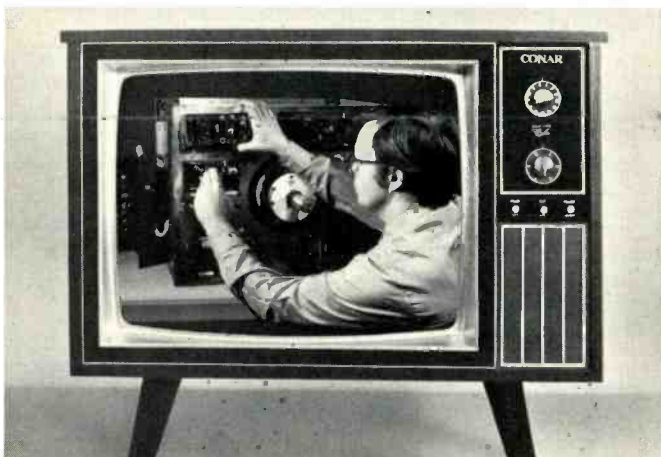
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firsts

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give you priceless
confidence.

Some NRI **firsts** in training equipment



first to give solid state 25" diagonal color TV, 5" wide band oscilloscope, color bar generator and other professional equipment engineered specifically for education. You work directly on the receiver as you build it, discovering the practical aspects of TV servicing as you create a handsome new color console. Only NRI includes an attractive woodgrain cabinet without extra charge.



first to give you a unique, exciting digital computer *with memory* built especially for home training. You learn organization, troubleshooting, operation, programming as you build and use it. Performs the same functions as commercial computers. Lessons stress computer repair. You conduct a hundred experiments, build hundreds of circuits. A solid-state TVOM is included among ten training kits.

NRI's "discovery" method is the result of over half a century of leadership simplifying and dramatizing training at home

The FIRSTS described below are typical of NRI's half century of leadership in Electronics home training. When you enroll as an NRI student, you can be sure of gaining the in-demand technical knowledge and the priceless confidence of "hands-on" experience sought by employers in Communications, Television-Radio Servicing and Industrial and Military Electronics. Everything about NRI training is designed for your education . . . from the much-copied, educator-acclaimed Achievement Kit sent the day you enroll, to "bite-size" well-illustrated, easy to read texts programmed with designed-for-learning training equipment.

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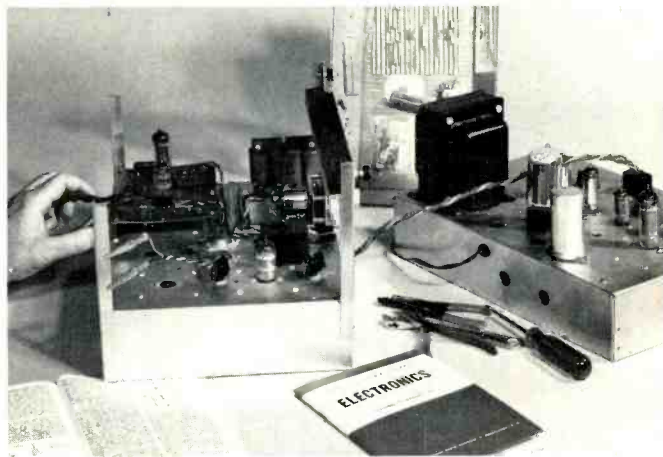
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new & timely

"Music center of the future" demonstrated at Chicago show

A prototype home audio center of the future, as conceived by Zenith engineers, was on exhibit at the Consumer Electronics Show held during the summer in Chicago.

Featuring—among other things—loudspeaker systems that do not need to be connected to the set, the Concept 4X music center can reproduce music in twelve ways, including Zenith's new discrete four-channel FM system (which was linked by cable to a transmitter, since the FCC has not yet approved any four-channel FM system).

Besides the four-channel discrete FM, the instrument receives ordinary FM, stereo FM and AM, plays monophonic, stereophonic and four-channel records, both mono and stereo sound on cassette tape, and mono, stereo and four-channel discrete sound on 8-track tapes.

Two of the instrument's four speakers are connected to the equipment in ordinary fashion. The other two are actuated by infrared light transmission. Another new feature is the touch-type controls, which light on contact and activate

the function, while the light indicate the mode that is operating.

Robert E. Williams is Gernsback Award winner

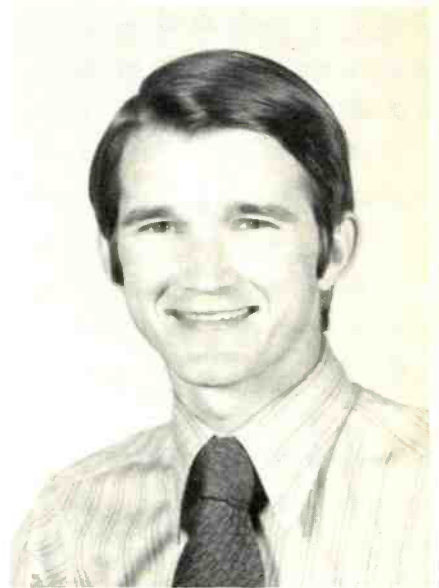
Robert E. Williams of Arlington, Texas, has been selected by National Technical Schools to receive the Hugo Gernsback Scholarship Award for 1973. The award is a \$125 grant given annually to an outstanding scholar in each of nine leading electronics home-study schools.

Mr. Williams is a graduate of the University of Texas, with a degree in Electrical Engineering Technology and certification from the American Society of Certified Engineering Technicians. He writes:

"Even though my major course of study in college was electronics, there was little time for radio and TV. After checking with several friends who had taken the National Technical Schools course, I felt it would do an excellent job of filling in the gaps.

"After getting through the fundamentals, which I might add were quite thorough, I found that the subject sequence,

along with kits supplied with the course, made everything fall into place. I am already doing some part-time work on radio and TV equipment. After completing the course and getting some experience, I hope to open my own shop.



"I am 25 years old and married. My wife, Paula, is an elementary school teacher. I am now employed by Lanier Business Products as an electronics technician. We service a complete line of interoffice communications equipment."

Aeronautical Satellite Program to ensure transatlantic safety

A "quantum jump" in improving communications for ocean air-traffic control will be necessary if international aviation is not to "strangle on its own growth" in the '80's or before. This statement was made by Howard Hawkins, chairman of RCA Global Communications, addressing the Aviation/Space Writers at the opening of their annual conference at Las Vegas.

To meet the threat of strangulation, he said, an experimental program is already being initiated jointly by the United States, Canada and the European Space Research Organization (ESRO). Called the Aeronautical Satellite Program (Aerosat) it proposes to employ two synchronous satellites to relay communications and position data direct between transatlantic aircraft and air traffic control centers in North America and Europe.

(continued on page 14)



HOME AUDIO CENTER OF THE FUTURE, using speakers (seen left, beyond the console) that activate from across the room with signals from Infrared devices. It also uses touch-type electronic controls that light when contacted.

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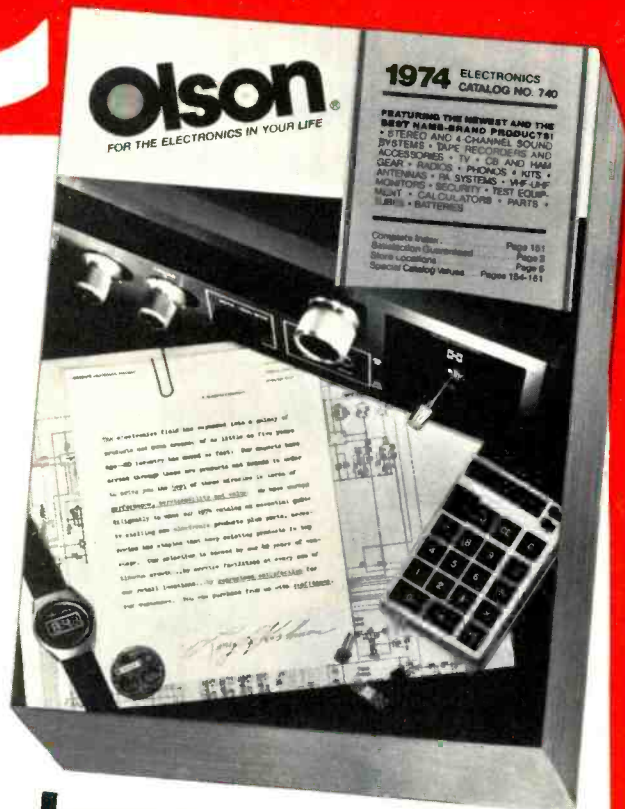
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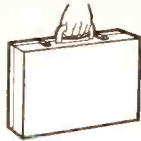
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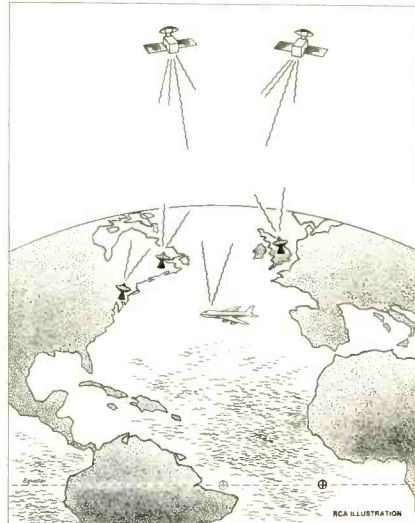
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Circle 6 on reader service card

new & timely (continued from page 12)

The present communications system for the North Atlantic now operates up to 85 per cent of capacity during peak traffic periods, and does not allow direct contact between pilot and air traffic controller during most of a transatlantic flight. Neither can the air-traffic control centers track an aircraft's position directly.



AERONAUTICAL SATELLITE PROGRAM would use two geostationary satellites, working with ground stations to provide exact position information on and direct communication with the aircraft during the whole transatlantic flight.

With air traffic expected to double before 1980 and to increase six times by 1990, obviously present systems would be oversaturated. The greater density of aircraft would also demand closer spacing between planes than at present, which would require the closer direct traffic control that Aerosat could provide.

It is expected that contracts for building the first Aerosat spacecraft will be awarded in 1974, with the first satellite to be orbited in 1976. Using the lessons provided by the experimental program, an operational system would be expected by the early 1980's.

New two-way radio headset reverses bone-conduction unit

Reversing the function of the usual bone-conduction unit, widely used as a transducer in hearing aids, a new personal communication unit has a bone-conductor microphone. It is mounted with the earphone in a hearing-aid type unit and worn behind the ear. A projection on the case makes contact with the

head. Since it is purely a conduction-type unit, the new microphone is claimed by the manufacturer, Dynacomm Corp. of Hicksville, NY, to be particularly effective in high-noise areas, where ambient noise might make conventional microphones ineffective.



PERSONAL COMMUNICATION HEADSET uses a conventional acoustic earphone, with a bone-conduction microphone. The control unit, at left, has a push-to-talk switch and a volume control. Button shown on the ear-phone unit is the microphone contact, which is worn toward the head in use. Lead between the ear unit and control is longer than shown (note cut lead).

The unit is designed to be compatible with practically all portable two-way communicators, and has its own "head" amplifier built into the hearing-aid type case, to adjust microphone output to suit the various pieces of equipment into which it may be plugged.

Two Virginia associations install new officers

Two local chapters of the Virginia Electronics Association, Inc., installed their officers in a joint meeting and Ladies night held early in June. Virginia Electronics Association President John McPherson, CET, came from Yorktown to perform the installation.

VEA-Peninsula's officers, elected at the annual meeting in May, are Terry Woodley, Langley TV, president; Jim Zimmerman, Jim's Radio and TV, vice president; William Crawford, Newmarket Electronics, secretary; Robert Mason, Electronic Service, treasurer. All the firms mentioned are in Hampton.

The officers of VEA-Tidewater are John C. Wood, Jr., Campostella Electronics, Norfolk, president; Clyde Crowe, Crowe's TV, Norfolk, vice president; Richard Ambrose, A & T TV, Portsmouth, secretary; Paul Whosdos, Jr., Atlantic

(continued on page 16)

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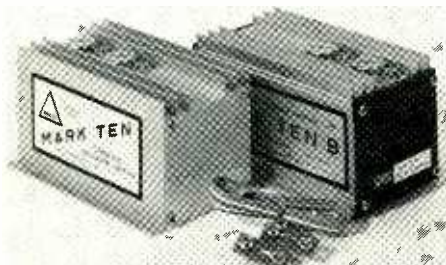
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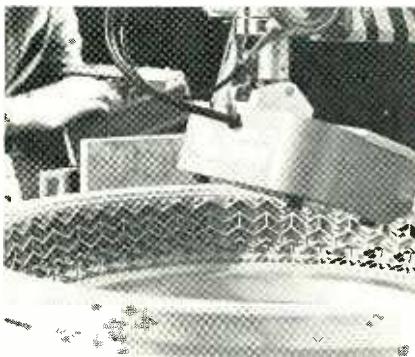
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new & timely (continued from page 14)

TV, Virginia Beach, treasurer.

Dick Ambrose of Portsmouth served as toastmaster for a varied program of short speeches, awards and entertainment. A record crowd of 88 attended. All ladies present received flowers and gifts.



BETTER TIRES PRODUCED BY LASER. A new laser measuring instrument introduced by Siemens checks the accuracy of tire molds with precision heretofore unattainable. Because the dimensional stability of these molds vitally affects the characteristics of the tires that are made from them, the device makes it much simpler to make tires that run round. Measurements are made by a sort of radar principle, the laser beams being bounced from the tire to a reference plane.

Static electricity heals fractures in bones

Encouraging results in experiments on increasing the speed at which bone fractures heal by using static electricity are reported by the Director of the Orthopedic Research Labs at Columbia University. The director, Dr. C. Andrew Bassett, said that studies with rabbits indicate that, by using static electricity, fractures can be healed in half of what is now the normal time.

It is known that applying weak direct currents can speed healing of bone fractures, and has in some cases succeeded on fractures that otherwise would not heal. The present method, still considered experimental, though increasing rapidly in use, is to implant electrodes on either side of the fracture and cause a small current—in the order of microamperes—to flow.

In the static method, the fractured limb is placed in an electric force field maintained by two metal plates that can be mounted in a cast similar to the casts normally used on fractured limbs. Implanting electrodes would become unnecessary. **R-E**

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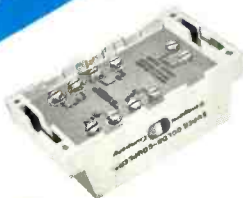
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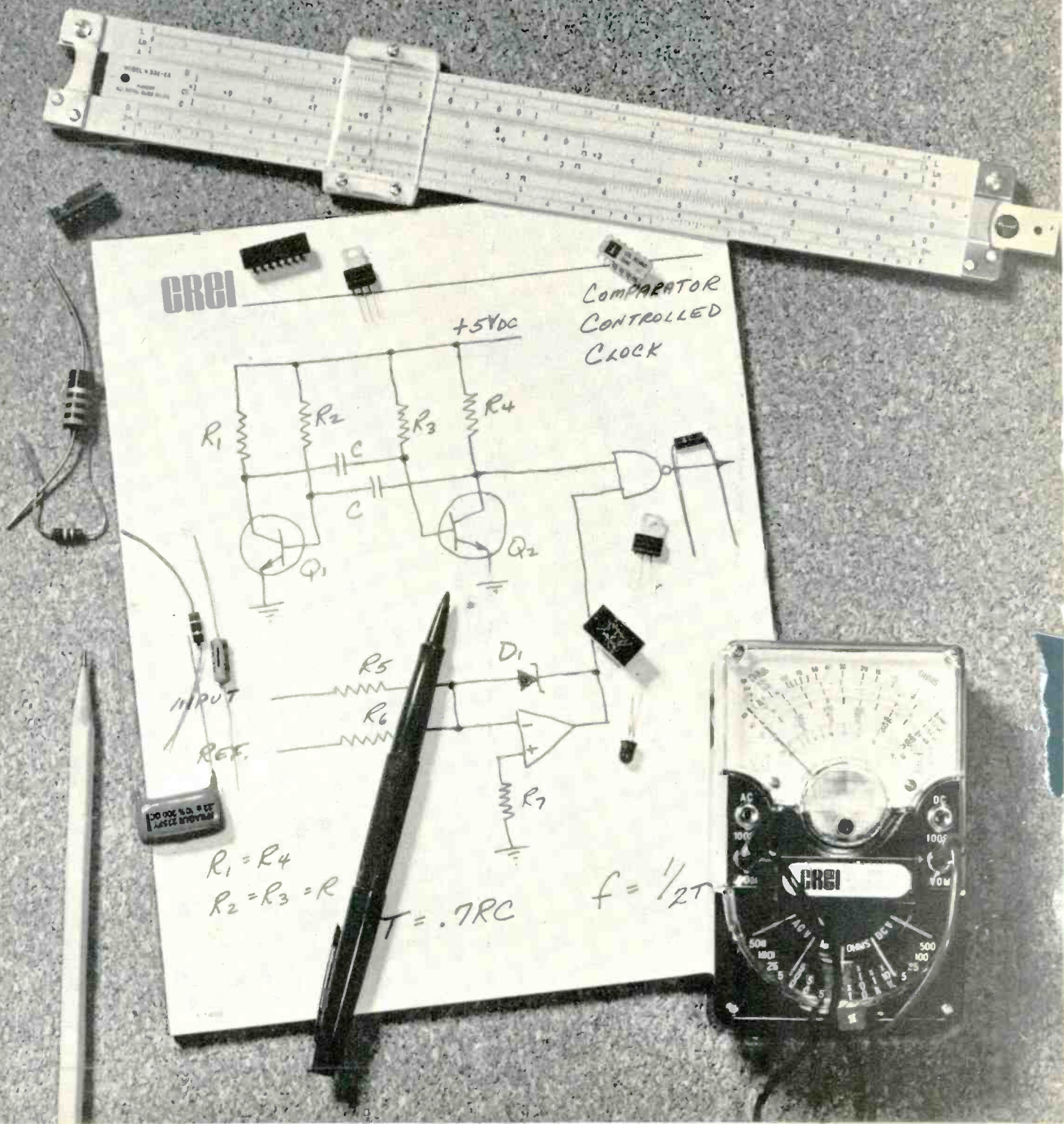
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letters

PHONE SENTRY PROBLEM

I've made some changes in the Phone Sentry I built from your article (June 1973) to provide better operation. First I paralleled T1 and T2 to improve audio quality in both playback and record. Then I added a parallel RC network in series with the secondary of T1, between T1 and the connection to the fixed contact of RY1. (680-ohm resistor in parallel with two 20- μ F, 50V electrolytics wired back to back—positive to positive) Then I added a 150-ohm resistor from the fixed contact of RY1 to ground. Adding these parts improve the matching impedance to the telephone line. They also cause pin 4 of IC2 to go low whenever power is applied to the circuit initially, either by a ring or by pressing the TEST switch.

ROGER E. OUSTERHOUT
Ogdensburg, N.Y.

I have suggested the following

changes to those having trouble with the "Phone Sentry".

1. Parallel the primary (10K) side of T2 with 1800 ohms.
2. Switch locations of C3 & C9 (make C9 = 1 μ F).
3. If the capacitor supplied for C2, in the kit, is marked "Whale 10 μ F/150 volt," replace it—it is probably leaky.
4. The neon should fire at 70 volts dc, if not—replace.
5. Lettering on upper left corner of coverplate (in the kit) should be "EAR" (wire to P1).

The transformer changes suggested by Mr. Ousterhout are OK but adding the 1800-ohm resistor to T2 is simpler. The main thing is to present 500 ohms to the phone line so central office switching relays operate properly.

The change on pin 4 of IC2 would be better if the resistor went to +6V (connect between pins 4 and 8) rather

than to ground. I have used this change and it is more effective than the added capacitor between pins 1 and 8 to suppress turn-on triggering.

I was glad to hear from Mr. Ousterhout and appreciate his comments.

ROGER SMITH
Phoenix, Arizona

WWVB SERVICE IMPROVED

If you are building the WWVB receiver for Superclock (Radio-Electronics, August and September 1973), you'll be interested in this change in WWVB service.

The National Bureau Of Standards will be eliminating all Tuesday maintenance schedules. The time code, therefore, will be continuously broadcast, except for unforeseen maintenance problems or commercial power outages.

DONALD E. LANCASTER

(continued on page 24)

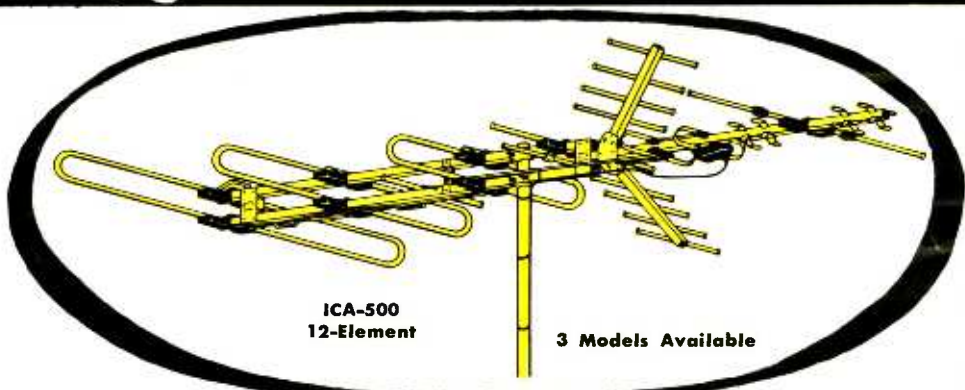
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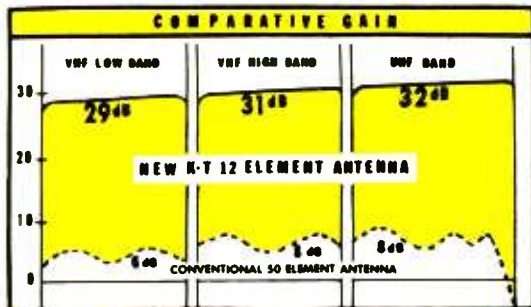


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Most turntables use belts, pulleys, idler wheels to make their turntables spin at the record's speed, instead of the motor's. Look underneath Sony's new PS-2251 and all you'll see is the motor. We don't need all those extras, because our motor's speed is precisely the same as the record's.

Eliminating all those parts also eliminates the wow and flutter and rumble they can cause. So, our rumble figure is a remarkable -58dB (NAB).

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NEW KS-10 TRANSISTOR ASSORTMENT . . . REGULARLY \$34.11



special
introductory
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\$24⁹⁹



THE BROAD-LINE PRODUCER OF ELECTRONIC PARTS

Circle 10 on reader service card

LETTERS

(continued from page 22)

MORE TESTING DATA

I read with great interest your article "8 Ways To Test Hi-Fi Amplifiers" in the July 1973 issue. Can I obtain more information on such tests? Is there a bibliography that could point me toward more data?

JOHN K. KIRKLAND
Chicago, Ill.

There sure is! This article was based heavily on a Sony publication titled "Sony Hi-Fi Test Procedures—Audio Amplifiers" which was prepared by M. J. Salvati, Technical Publications Department, Sony Corporation Of America. The original booklet showed how to perform a complete series of tests on specific Sony equipment. In preparing the article this information was enlarged and generalized to make it adaptable to all makes of hi-fi amplifiers.

MORE AUTOMOTIVE ELECTRONICS

I really enjoyed your article, Electronics For Your Car, in the April 1973 issue, and would like to know more about electronic systems in automobiles. Where can I look?

FRANK MCCORMICK
Los Angeles, Calif.

There is an excellent comprehensive book on automotive electronics in print now. It's titled "Automotive Electronics," written by George Whalen and Rudolph Graff, and published by Howard Sams.

HEAR, HEAR

In the article "Hearing Through The Teeth" (**Radio-Electronics**, June 1973), note is made that Dr. Collard heard the tuning fork via vibrations transmitted through the teeth after it was "not loud enough to be heard by ear." (Presumably it means by holding the tuning fork by the ear.)

If this is so, a visit to an ear specialist (there are many good ones in California) might be of help to him if he has not already done so. His personal observations suggest a conductive hearing loss which may be correctible.

While there is a place for bone conduction hearing aids, at the present time the efficiency of the air conduction reproducers is more than enough to compensate for a conductive hearing loss. Hence bone conduction hearing aids are of limited use.

It may be that Dr. Collard might devise something better than what is currently available in bone conduction hearing aids. If so, this might be of benefit to the many people with hearing problems.

WALTER K.W. YOUNG, M.D.
Honolulu, Hawaii



As you can see, your Sylvania distributor has 200 picture tubes in stock.

And they're all in just five Sylvania cartons.

Because our line of five color bright 85XR® OEM-quality tubes gives maximum coverage of 19V, 21V, and 25V diagonal sets with a minimum of stock.*

It also means faster service because these Sylvania picture tubes are direct replacements. You replace a kimcode with a kimcode, a bonded with a bonded.

And then, there is the biggest advantage of all: You can count all your large-screen color tube needs on the fingers of one hand.

See your local GTE Sylvania distributor for a complete replacement list. With needs that you

can count on one hand, you can bet he has the tube you want in his hands.

Sylvania Electronic Components, 100 First Ave., Waltham, Mass. 02154.

- *XR23VANP22/
- SRE25BGP22 Replaces 53 types
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- SRE25BHP22 Replaces 27 types
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GTE SYLVANIA

**A. Build your own Heathkit
25V Color TV... 599.95*** less cabinet

The GR-900 is the most advanced TV you can build. Yet everything goes together with traditional Heathkit simplicity. And the built-in convergence board and test meter for at-home maintenance add further savings over the life of the set. You preset any 12 UHF channels for positive pushbutton power tuning, and you can scan both UHF and VHF channels in either direction. An ultra-rectangular black matrix tube, voltage controlled varactor UHF tuner, MOSFET VHF tuner and an exclusive angular tint control for better flesh tones combine to produce an absolutely brilliant color picture. Mailing weight, 125 lbs.

**B. Heathkit 18V
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Solid-state modular circuitry spells reliable operation and easy assembly. And the GR-269 comes with a full complement of alignment and self-service equipment — dot generator, convergence board, test meter and troubleshooting book. Factory assembled and aligned AFT module for perfect picture & sound at a touch. VHF tuner with MOSFET circuitry

and UHF tuner with hot-carrier diode design for low noise, high sensitivity. Both tuners & IF assembly factory assembled & aligned "Instant-on", switch-controlled degaussing, hi-fi sound output; 75 & 300 ohm antenna inputs; exclusive Heath Magna-Shield, standard. Mailing weight, 100 lbs.

**C. Heathkit 14V
Color TV... 299.95*** includes cabinet

Set aside about a dozen evenings. Build up 10 circuit boards, prepare the chassis. Install the wiring harness. Result: the Heathkit GR-169, with picture purity at the top of its class. And you keep it that way — with plug-in modular circuit boards, troubleshooting meter and data book to help you fix it right at home. A "big" little TV, the GR-169 has all the secondary controls found in our larger models —

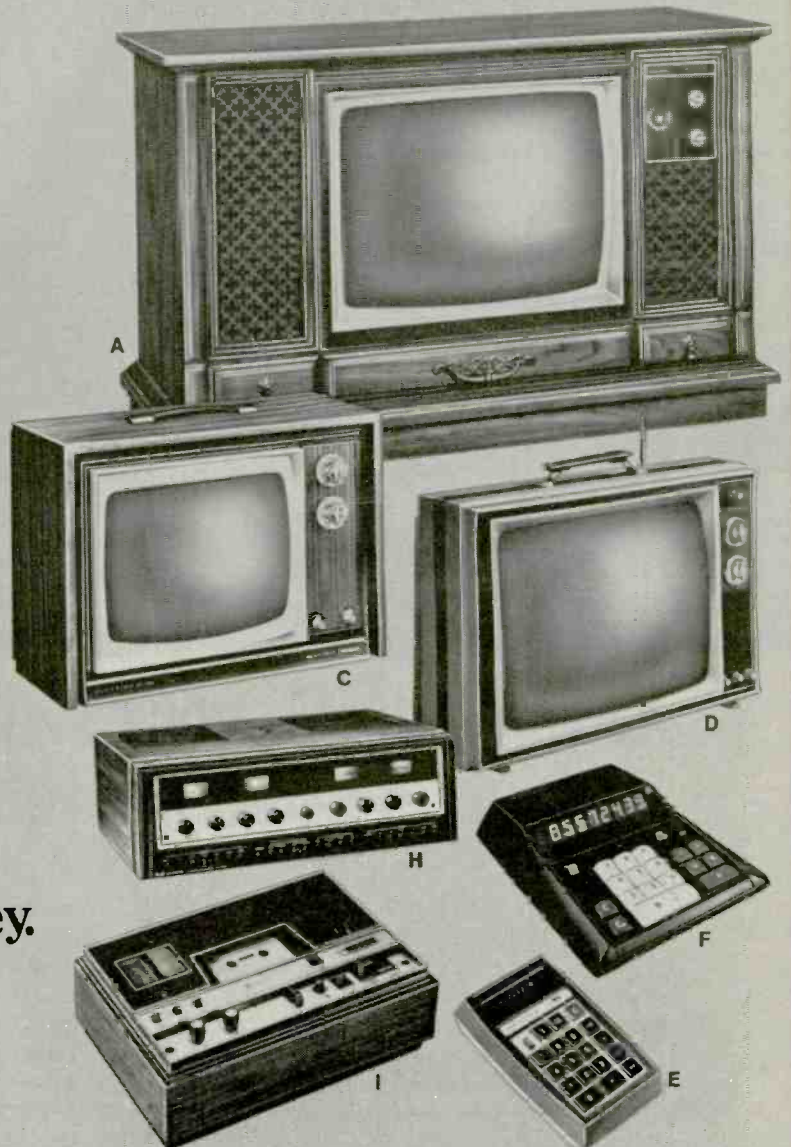
color, tint, contrast, horizontal & vertical hold, height, AGC, color killer, switch-controlled degaussing. Carry it room to room or across the country — this is the portable that bounces back with console-like performance. Mailing weight, 69 lbs.

**D. NEW Heathkit 19V B&W
Portable TV... 179.95*** includes cabinet

The new GR-1900 is like no other B&W portable! With advanced solid-state "modular" design — most circuitry mounts on just 4 plug-in boards. Just 2 tubes; picture & high voltage. Total detent tuning on all 70 UHF channels as well as VHF. "Instant-on." Front panel controls of VHF/UHF fine tuning; brightness; contrast, master on/off; vert. hold; AGC & height. New ultrarectangular tube for a full 184 sq. in. view. Other

Start a Heathkit hobby..

It's fun, easy, and it
saves you money.



"big" set features are Automatic Vertical Linearity; dual-controlled AGC; extra-wide Video Bandwidth; 4-circuit grounded-base VHF tuner. A kit even the novice can build; both tuners come preassembled & aligned; transistors & ICs plug into sockets; and all chassis wiring is color coded. Mailing weight, 56 lbs.

E. NEW Heathkit Pocket Calculator... 92.50*

The new Heathkit IC-2009 is a fully portable calculator with rechargeable nickel-cadmium battery. Or you can leave it connected to the plug-in charger for permanent desk-top use. Weighs just 12 oz. And check over these features: 8-digit capacity. Four arithmetic function. Floating decimal. Constant key. Chain calculation capability. Clear-entry key. Entry & total overflow indicators. Low battery indicator. Battery-saver circuitry. And you can build it in three evenings. Mailing weight, 3 lbs.

F. New Heathkit Desk-top Calculator... 79.95*

The Heathkit IC-2108 — a great looking full-function electronic calculator for home or office. You can assemble it in two spare evenings. Features

include: Addition, subtraction, multiplication and division functions. Floating and fixed decimal. Constant key. Chain calculation capability. Clear display key. Entry and result overflow indicators. Negative answer indicator. 120 or 240 Volt operation. Mailing weight, 4 lbs.

G. New Heathkit Small-engine Tune-up Meter... 39.95*

Kit CM-1045 — for all 2- and 4-cycle engines, 1 to 4 cylinders, with conventional, CD, or transistorized ignitions. Great for motorcycles, snowmobiles, outboard marine engines, etc. Clip-on leads let you check dwell, volts, ohms and continuity without tearing down the engine to get at systems buried beneath the flywheel. A built-in inductive-pickup tachometer works with any number of cylinders. Blue high-impact plastic case stores leads and three "C" batteries for ultimate portability. Mailing weight, 5 lbs.

H. Heathkit 4-Channel Amplifier with decoder... 359.95* less cabinet

You select discrete 4-channel, or switch-in the "Universal" decoder for reproduction of all the matrixed 4-channel discs now on the market, plus "derived" 4-channel from conventional stereo. Four solid-state amplifiers produce 200 watts (4x50 IHF) into 8 ohms, with power bandwidth on all channels from less than 5 Hz to greater than 45 kHz at 0.25% distortion.

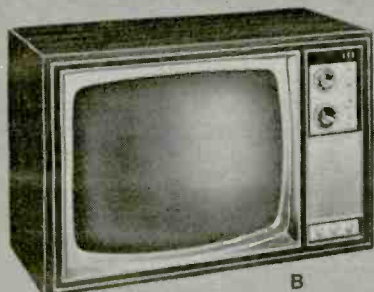
Kit AA-2010, mailing weight, 37 lbs. AAA-2004-1, pecan cabinet 24.95* Mailing weight, 7 lbs.

I. Heathkit Cassette Deck with Dolby circuitry... 249.95* less cabinet

The Heathkit AD-1530 is a kit-form cassette deck utilizing the famous Dolby® noise reduction system. Accommodates the greater fidelity and dynamic range of chromium dioxide cassettes. Independent switches provide Dolby on/off and regular or CrO₂ bias control. Domestic-make tape transport comes preassembled for easy kit building. Mailing weight, 20 lbs.

J. New Heathkit AM Radio... 14.95*

The Heathkit GR-1008 is a smartly styled, great sounding solid-state radio that makes a great introduction to Heathkit building. Eight-transistor circuitry mounts on one printed board, big 3½" speaker mounts in high impact plastic case. If you've never built a kit before you can probably have this one together in one fun evening. Uses 9-volt battery (not supplied). Order the Heathkit GR-1008 for yourself or the kids. Mailing weight, 2 lbs.



HEATHKIT ELECTRONIC CENTERS—ARIZ.: Phoenix; **CALIF.:** Anaheim, El Cerrito, Los Angeles, Pomona, Redwood City, San Diego (La Mesa), Woodland Hills; **COLO.:** Denver; **CONN.:** Hartford (Avon); **FLA.:** Miami (Hialeah); **GA.:** Atlanta; **ILL.:** Chicago, Downers Grove; **IND.:** Indianapolis; **KANSAS:** Kansas City (Mission); **MD.:** Baltimore, Rockville; **MASS.:** Boston (Wellesley); **MICH.:** Detroit; **MINN.:** Minneapolis (Hopkins); **MO.:** St. Louis; **N.J.:** Fair Lawn; **N.Y.:** Buffalo (Amherst), New York City, Jericho; **L.I.:** Rochester; **OHIO:** Cincinnati (Woodlawn), Cleveland; **PA.:** Philadelphia, Pittsburgh; **TEXAS:** Dallas, Houston; **WASH.:** Seattle; **WIS.:** Milwaukee.

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RCA Electronic Components



equipment report

Castle Mark IV Tuner Subber



Circle 85 on reader service card

SUBSTITUTING A TUNER IS NOT A NEW thing; even I have been doing it for years. A Castle Mark IV Tuner Subber is. It'll do all kinds of tricks, all of them very handy. One of them is a brand-new one; I certainly wish I'd thought of it.

The Mark IV is a solid-state, 13-position vhf tuner, with a 40-MHz i.f. output. It also has a 40-MHz input, in the uhf position, for testing uhf tuners. The vhf input and the i.f. output are electrically isolated; the Mark IV can be used with all TV sets; tube, solid-state, modular, hybrid, etc. The 40-MHz i.f. amplifier stage is very stable. This permits the use of two Subbers in cascade, if a very high level i.f. is needed.

In almost all cases, this will be strictly a "plug-in" operation. The coax from the i.f. input to the tuner, in most sets, uses the "RCA phone-plug" type of connector. Just pull this out of the set's tuner, plug it into the jack on the back of the Mark IV, hook up the antenna and away you go. No power connections are needed. This gives you an instant and accurate answer to the old question, "Is it the tuner or something else?"

You can check i.f. stages, too. Hook the antenna to the Mark IV, plug in the cable with clip leads, pull the set's i.f. input cable. Now, connect the 40-MHz i.f. output to the i.f. input. If this doesn't get a signal through, there's another very handy test you can make. (This is the one I wish I'd thought of!)

You can check not only the i.f., but the agc. Just move the output clip to the input of the *last* i.f. stage in the set. Turn up the rf gain control of the Mark IV, and you should see a picture, and hear sound. Now you can "walk out" any i.f. trouble, by moving the clip back toward the i.f. input one stage at a time.

If you move back to an agc controlled stage and lose the picture and sound, you've got two possible causes; a defective i.f. stage, or trouble in the agc. Now comes the cute one. You can check for agc trouble by going back to the last i.f. stage where you can get a picture through. You know that you have the required *signal* on the agc stage, and it's easy to check for the presence of the keying pulse, dc voltages, and so on. The operation of the agc circuit is "normal", and not masked by an agc clamp or override bias. By varying the rf output of the Mark IV, you can check for variation of the agc voltage with signal strength, as it should. Of course, if you do *not* get a signal through from the last i.f. stage, then you know where to go. Back to the video detector, video amplifier and so on.

This is a vhf tuner. It has a uhf position, in which the amplifier stage is automatically switched to an i.f. input, as we said before. To check a uhf tuner, just pull the cable which normally goes to the set's vhf tuner, and plug it into the jack on the Mark IV. Be sure to set the vhf tuner on the TV to uhf, so that the uhf tuner will get its normal B+ supply. Most vhf tuners switch this on only in the uhf position. If the set's tuner works on vhf, and the uhf tuner works when connected through the Mark IV, then this points to some trouble in the set-tuner's uhf position.

The Mark IV comes in a handy, tough plastic case with a handle on top. A full set of hookup cables is included; the plug-in type for vhf, another with alligator clips for the i.f. tests, a uhf interconnecting cable, and even a cable with no termination at all. This is for use with sets having the i.f. coax soldered in. Just lift the hot

(continued on page 30)

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OSCILLOSCOPES**

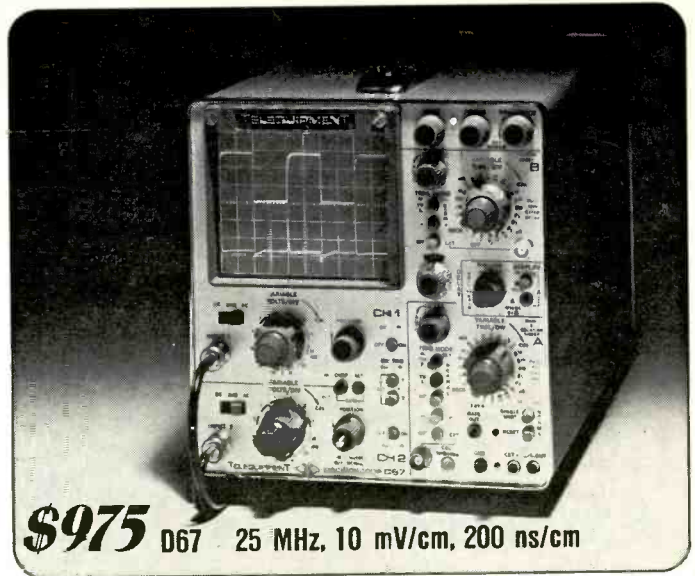


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The Telequipment line is growing . . . and offers you a greater selection for your next dual-trace scope. Take the new **DM64** . . . it offers 25 cm/ms bistable storage with auto erase, 10-MHz conventional operation, alternate or chopped dual-trace displays and convenient single-button X-Y operation. The new **D56** offers 25-MHz dual-trace performance and X-Y. The **D67** offers laboratory performance with delayed sweep, regulated power supplies, and 3% accuracy. The **D54** offers dual-trace convenience at lowest cost. All have triggered sweeps.

All are backed with the same warranty as other **TEKTRONIX** products, and are marketed and supported through an international network of Tektronix Field Offices, Service Centers, Distributors and Representatives. Call your nearest office or write Tektronix, Inc., P.O. Box 500, Beaverton, Oregon 97005.



\$975 D67 25 MHz, 10 mV/cm, 200 ns/cm



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Part of the Telequipment line from Tektronix, Inc.

Circle 82 on reader service card

Are you ready for a REAL



CONTROL CENTER?

If you're a music lover looking for more enjoyment from your music collection, we have a pleasant surprise for you.

Up to now you've enjoyed the few control functions on your tape deck, amp or receiver. But think what you could do with a discrete control center! Not a lo-fi economy model, but the famous CROWN IC150, with a variety of versatile controls unavailable in any other model under \$300, and some models over \$500.

This is the control center praised by that dean of audio, Ed Canby: "This IC150 . . . is the finest and most versatile control unit I have ever used. For the first time I can hook all my equipment together at once. I find many semi-pro operations possible with it that I have never before been able to pull off, including a first-class equalization of old tapes via the smooth and distortionless tone controls. I have rescued some of my earliest broadcast tapes by this means, recopying them to sound better than they ever did before."

The IC150 will do the same for you. You could record from any of seven sources: tuners, turntables, guitars, tape players, microphones, etc. You could also tape with one recorder while listening to a second one. Even run two copies of the same source at once while monitoring each individually. How about using the IC150's exclusive panorama control to improve the stereo separation of poorly produced program material or to correct that ping-pong effect with headphone listening? It's all up to your creativity.

You'll feel perfectly free to copy and recopy through your IC150, since it creates practically no deterioration whatsoever. Cleaner phono and high-level circuits cannot be found anywhere. Harmonic distortion is practically unmeasurable and IM is less than 0.01% (typically 0.002%).

Of course, construction is traditional Crown quality, backed with a three-year warranty. The price is \$299. The enjoyment is unlimited. The opportunity is yours. Visit your local Crown dealer to discover if you are ready for a real control center, the IC150.



CROWN

BOX 1000, ELKHART, INDIANA 46514

Circle 12 on reader service card

EQUIPMENT REPORTS

(continued from page 28)

wire and tack this one in its place.

The Mark IV has a rather "firm" fine-tuning, with a "preset-memory" fine-tuner (which works). I hooked it up to my test set and found that every channel was tuned right on the button, color and all. The fine-tuning does not shift when channels are changed. I tried to jar it off and couldn't.

Being entirely self-contained, and very compact, the Mark IV can be taken along on service calls. With some of the huge stereo theater sets we run into today, this could save a

lot of work. If you could take only the tuner to the shop, it would certainly be easier.

Two standard 9-volt transistor batteries, in series, power the Mark IV. An on-off switch on the front panel, along with what I think is a LED pilot light, helps to conserve them. The rf gain control has a gain reduction of 60 dB. The other things are on the back: the 300-ohm input terminals, and the 40-MHz i.f. input and output jacks.

If I may repeat myself, any piece of test equipment that will pay for itself in time-saving is worth having. The Mark IV Tuner Subber would very definitely fall into that category. **R-E**

Shure VR15-III stereo cartridge



Circle 86 on reader service card

WHILE AMPLIFIERS USED IN HIGH FIDELITY equipment can be designed for near optimum performance across a 20 Hz to 20 kHz spectrum, the transducers—speakers and phono pickups—work well only within a limited frequency range. For example, the pickup designed for optimum low-frequency performance will be less than optimum at the higher frequencies due to tracking problems. We get around the "limited range" problem in speakers by using multiple devices designed for proper operation within a limited spectrum: a *woofer* for the lows, a *tweeter* for the highs and possibly one or two *honkers* for the mid-range (in larger speaker systems).

But we have not yet reached the stage in technology where we can use more than one stylus or bandwidth-sensitive coils in a single phono pickup. Therefore, a phono pickup must be designed for the best possible performance in terms of the *total* high-fidelity spectrum—which is 20 to 20 kHz. Total spectrum performance involves many trade-offs, such as sacrificing some low-frequency performance for cleaner ("shimmering") highs. Alternately, if the pickup is designed for optimum low-frequency performance the highs will be less than optimum. The frequency-vs-performance trade-off is necessary because the stylus compliance (among other aspects) required for optimum high-frequency tracking is not the

same as what is needed for optimum low-frequency tracking.

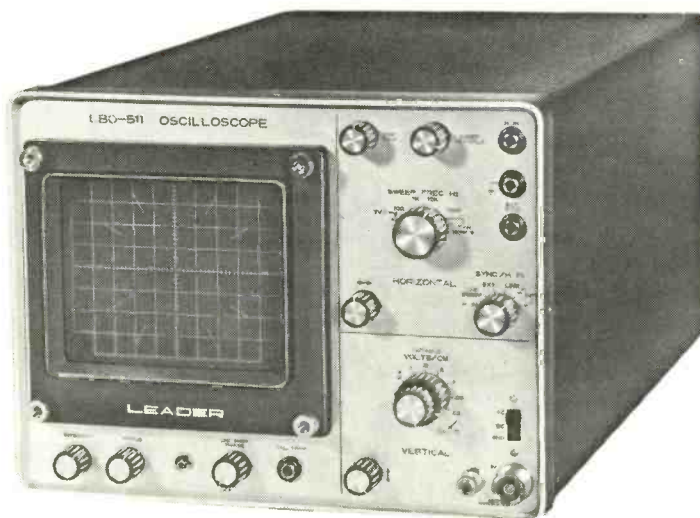
For many years the top-of-the-line Shure pickups—the V15 series—were designed for the best possible compromise in full spectrum tracking, and the V15 was always rated among the finest pickups, with many audiophiles and experts rating it as *the* finest, the reference to which all others were compared. Though the latest product from Shure still retains the V15 series designation, the V15 Type III is a totally new design—almost from the ground up—whose tracking ability considers not just the normal 20-20 kHz frequency range, but also the excessive velocities created by the *warps* inherent in virtually all records. (The stylus designed to track the maximum recorded velocity must also track the excursion which is *added* by a warp(s). If the stylus fails to track both velocity components it must generate distortion which appears as a sound product.)

Another consideration in the Shure V15 Type III pickup is a mechanical resonance above the audible limit of 20 kHz. When the resonance occurs below 20 kHz it will result in a "peaked" electrical response at the resonant frequency. It is, therefore, necessary to design into a pickup electrical attenuation complimentary to the mechanical "peak" so that the overall electrical output is "flat". Unfortunately, it is extremely difficult to design electrical attenuation into the pickup which is the exact complement of the mechanical resonance, and most pickups, even the finest in terms of overall sound quality, have a moderate peak in the order (generally) of 2 dB at some frequency around 15 kHz.

As a result of this peak and its electrical correction there is a broad dip in the frequency response, generally between 3 and 8 kHz, also just a few dB. The whole effect is like a child's teeter-totter. If the dip is elimi-

(continued on page 88)

**WHEN
YOU'VE
GOT**



LBO-511 \$349.⁹⁵

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GENERAL SERVICE

What's more, the LBO-511 delivers calibrated vertical input along with rock-like stability, recurrent sweep and automatic synchronization. This outstanding wide-band oscilloscope/vectorscope is the newest in a series of solid state instruments, Leader developed to give you more for your money. Sweep frequency is in 4 ranges from 10Hz to 100KHz and we've added a versatile phasing control, continuous from 0 to 140°. Overall sensitivity is 20mVp-p/cm to 10Vp-p/cm and vertical input is calibrated. The solid-state stability and distortion-free displays are the result of Leader's exclusive FET input stages plus DC coupling and push-pull amplifiers. Bandwidth is DC to 10MHz. And, there are special inputs to obtain vectored pattern displays for color TV circuit testing. Complete with probe, adapter and test leads, the LBO-511 weighs just 15 lbs. and is unusually compact.

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& TV-H...**

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Circle 13 on reader service card

Here's everything you'd expect from a high-priced portable VOM.

Except a high price.

The VOM is one of the most important tools in your kit—but you needn't pay high prices to get the features and quality you want. Like the high-priced units, the B & K model 120P VOM has features like a front-resettable overload protection circuit, preventing damage to the instrument and components should an overload occur.

The 120P is more accurate than you'd expect—20,000 ohms/volt sensitivity on DC, with 2% accuracy. Plus a total

of 35 ranges, measuring DC volts and current with 0.25 volt and 50 μ A low-range scales; AC RMS volts, output volts, and decibels; and ohms. That makes it one of the most versatile test units ever designed. But it's also one of the most rugged—its meter movement is a taut-band, self-shielding annular type, to withstand damage from shock or vibration.

You'll also appreciate the 120P's easy-access battery and fuse compartment complete

with extra fuse; and the handy TRANSIT position on the range switch.

All considered, the B & K 120P VOM gives you more accuracy, reliability, and versatility for your money than any other battery-powered portable VOM. And that's just what you'd expect from B & K.

Contact your distributor for complete information. Or write Dynascan Corporation.

\$79⁹⁵

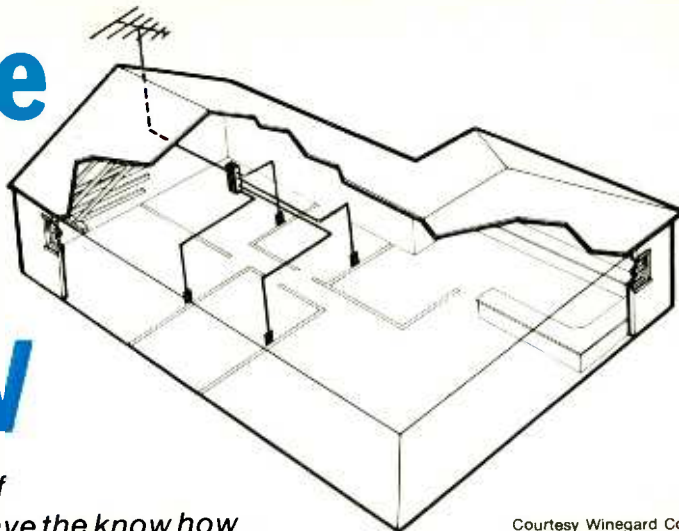


B & K Very good equipment at a very good price.

Product of Dynascan Corporation/1801 W. Belle Plaine Ave., Chicago, Ill. 60613

Circle 14 on reader service card

How To Wire A House for MATV



Courtesy Winegard Co.

Antenna systems are easy to handle if you use the right equipment and have the know how

by EUGENE WALTERS

YOU MAY NOT HAVE A CUSTOMER WHO wants to run 10 TV sets simultaneously, but if his household is fairly typical, he is likely to want to run three TV's and an FM stereo receiver or two—all from one antenna at the same time. Once upon a time, if someone wanted to add a couple of TV sets to the antenna, you just installed a coupler and let it go at that. The 20-dB drop in signal level didn't mean much, since everyone was watching black-and-white, and the picture still looked pretty good.

But today, with color sets abounding, and the stringent signal requirements of the FM stereo buff, a single antenna may have a lot of hardware hanging from it, and the idea is to give each one of these receivers a good signal to work with.

Before you can even start, you have to make a couple of important decisions. Should you install a TV antenna outlet wall-mounted in every room of the house? There may be only three television sets, but if two of them are portables and mobility is desired, suggest the wall jack for each room; it has definite advantages (and disadvantages). Also, decide if a mast-mounted preamp is needed. There are three ways to go with antennas: mast-mounted preamp; no preamp, but using a distribution amplifier; and using

both the preamp and distribution amplifier. Also, you must decide if you are going to provide vhf, vhf/uhf, vhf/FM, or vhf/uhf/FM. Not only do antennas come in all these possible configurations, so do the preamps and distribution amplifiers.

A mast-mounted preamp is a must when the signal level from the antenna is insufficient to drive the distribution amplifier or couplers effectively. The preamp must be located as close to the antenna as possible, and is powered by a low-voltage power supply in the attic or other convenient location near an ac outlet. Power to the preamp is carried from the power supply to the preamp by the antenna lead-in, so a second cable is not needed.

A distribution amplifier performs two functions. It provides broadband amplification of all TV and FM channels (if you're using it in that mode) mainly to overcome the insertion loss effects of using multi-set couplers and tapoffs. It does not correct for a weak signal at the antenna, and using a distribution amplifier without a good, crisp antenna signal can result in severe loss of signal at each antenna tapoff. This will mean lots of noise (snow) in the picture, running colors, interference and other related evils.

Typically, there are several types of amplifiers to choose from. A typical

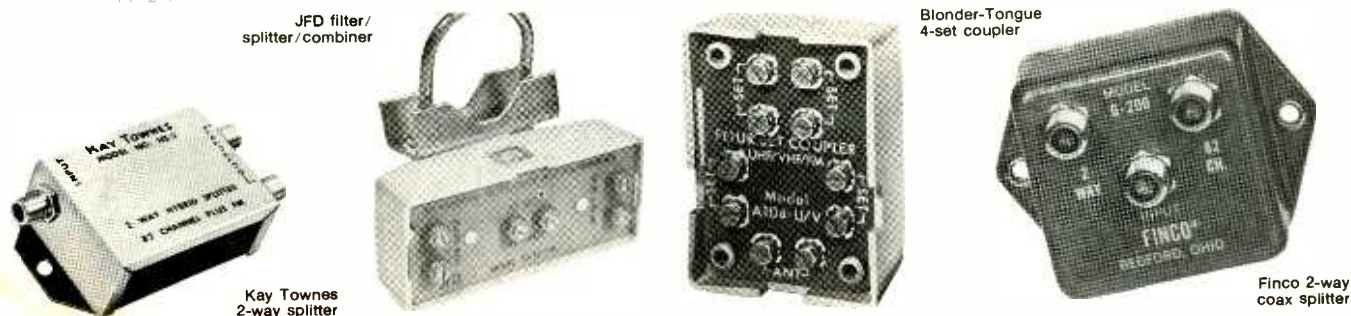
catalog lists some six different models for home use. These are models for: vhf/FM at 300 ohms; vhf/FM at 75 ohms; vhf/uhf/FM at 300 ohms; vhf/uhf/FM at 75 ohms; vhf/uhf at 300 ohms with built-in two-set coupler; vhf/uhf at 75 ohms with built-in two-set coupler. All are designed for continuous 117-volt ac operation. Depending on the model, ac power consumption can be as much as 3.6 watts.

Signal loss

Multi-set couplers, no matter how good, must cause a certain amount of signal loss. This can vary, but a typical figure is 5 to 9 dB for each such coupler. If there is a strong signal at the antenna and only two sets are to be coupled to it, then all other types of hardware may not be necessary. But this is the exception rather than the rule, and certainly in any household with more than two sets operating on a single antenna, some kind of amplification is a must.

Fig. 1 shows a typical setup using all of the available hardware. A two-set coupler is used for the color TV receiver and for the FM stereo rig in the family room. A four-set coupler, which has a higher insertion loss, is used to feed smaller monochrome TV sets and a secondary FM receiver in other rooms.

Equipment is available from a va-



JFD filter/
splitter/combiner

Kay Townes
2-way splitter

Blonder-Tongue
4-set coupler

Finco 2-way
coax splitter

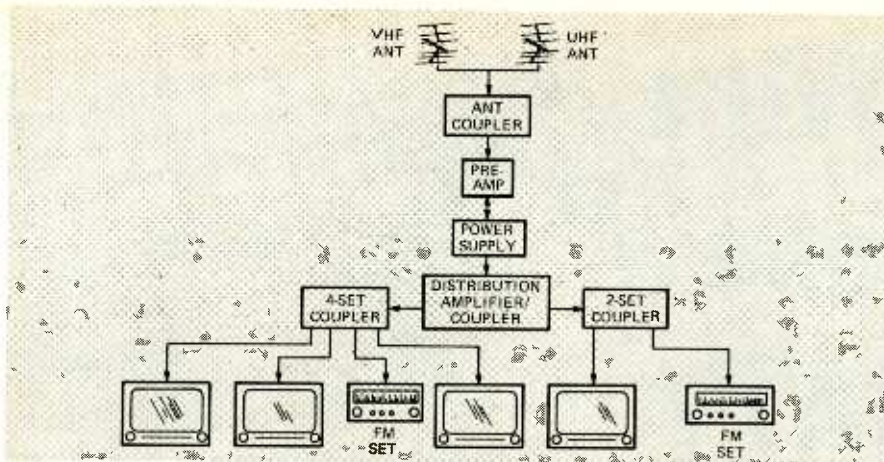


FIG. 1—TYPICAL MATV WIRING SETUP in block diagram form, Remember this is a system for a one-family home and is, therefore, relatively simple.

riety of suppliers (see list at the end of this article) for both 300-ohm twin-lead and for 75-ohm coax. We're not going to discuss the relative merits of twinlead vs coax here, but each cable type has inherent advantages and disadvantages, and each has its staunch adherents. Whichever type of cable you elect to use, there's hardware for it.

In any master antenna system, the chances are good that more than one TV set will be turned on at the same time. If the home is in a signal area with TV stations coming in from different directions, the obvious solution of an antenna rotor won't work here—not if you want to keep freedom of channel selection available at all TV set locations. There's also the FM listener to consider with this setup.

A fairly painless solution to the problem is two antennas mounted on the same mast, pointing in different directions. These can be combined into a single download by using a two-set coupler in the line from the two antennas in reverse order. Fig. 2 shows how this works. The result is that just a single antenna lead-in line feeds all the TV sets, even though you may have two different antennas facing in different directions.

There is a particular hazard in using this setup, though. In a situation where unwanted channels are too strong on the wrong antenna, phase differences can cause some ghosting. In one area of New Jersey, for example, one antenna is pointed at New York, the other at Philadelphia. But

Philadelphia's Channel 3 comes in strong on the New York-facing antenna, and when mixed with the signal from the other antenna, this can create multipath problems.

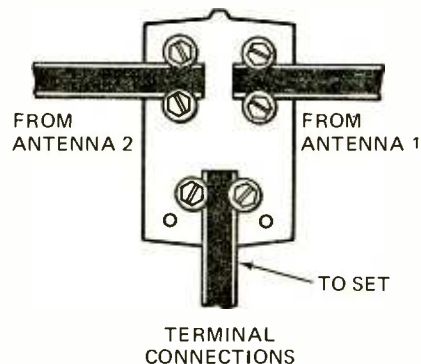


FIG. 2—A TWO-SET COUPLER used backwards combines two antennas.

The solution to this and also for too-strong local TV channels that might swamp the receiver's tuner is to use a selective attenuator in the line. Models are available from several manufacturers for vhf low-band, vhf high-band, and the FM band. Each of the vhf traps can attenuate one, two, or three channels, and has adjustments to set the amount of attenuation. For example, in the New Jersey situation, a low-band trap would be set to attenuate Channel 3 on the New York-facing antenna line only. It would be

installed between the New York antenna and the combiner as shown in Fig. 3.

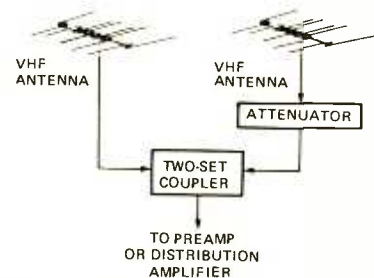


FIG. 3—TWO ANTENNAS are handy when signals come from opposite directions.

Frequency bands splitters can provide a convenient way to avoid multi-set coupler line losses. Splitters, or frequency-band separators of the all-channel variety have three sets of outputs: vhf, uhf and FM. The insertion loss of one of these devices is so low that it's negligible. Yet, using the FM output has the same effect of using a two-set coupler installed for a TV and FM. The coupler has a line loss of 5 or 6 dB; the splitter has almost no loss at all. So where installations might call for another coupler just to install an FM receiver, opt instead for a band-separating splitter; it saves a lot of dB's.

Another important factor is tilt—something that most home-type distribution amplifiers just don't have. Tilt is the uneven amplification of different TV channels; the higher-band channels get more amplification than the lower-frequency channels. This is to overcome the increasing transmission line signal loss at higher channels. Ideally, amplifiers designed to use coaxial cable should have the greatest amount of tilt, because high-band channels are attenuated more in coax than they are in twinlead. Professional amplifiers have an adjustable tilt control; home-type amplifiers have none. The reason for this flat frequency response is because the amount of high-channel loss in the relatively short cable distribution systems in the home don't warrant tilt. Also, tilt *must* be adjustable to compensate for different cable lengths in a commercial system—installations that have so much cable that severe high-channel losses are inevitable.



RMS 8-way splitter



Finco vhf/FM amplifier



RCA preamp

If you opt for a 75-ohm system, consider just where you want to use that coax cable. You may only need it for long antenna-to-distribution amplifier runs, and can possibly use twin-lead for the rest of the system. No matter how you slice it, a 75-ohm system means lots of matching transformers.

The most conventional type of transformer can hang right on the antenna terminals of the TV set. How-

ing plates. They're available in various styles from every major manufacturer as well as from sources that aren't well known at all. Some of these outlet plates already contain the 75/300-ohm matching transformer, which can make life a lot easier when doing the installation.

Frequency selection is an important planning factor. In your particular area, vhf may be all that you have available, so you don't have to go to

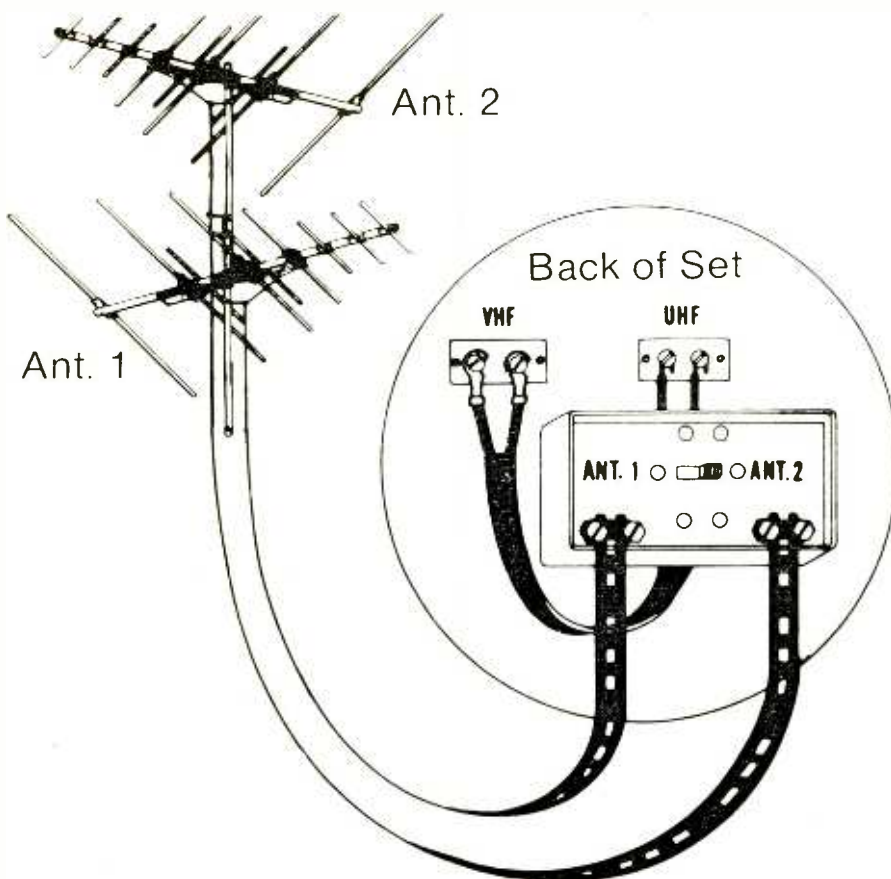
the antenna line. Third, use the FM attenuator switch on the broadband amplifier, if your amplifier is equipped with one. This is a rather drastic step, though, and leaves you with no alternative but to set up a separate FM antenna and run its own cables and distribution. Even more severe measures are necessary when a strong FM station operates at half the frequency of a TV station's video carrier.

Distribution systems for the home are simple and straightforward. Special new accessory items make these systems easy to install and a pleasure to use. Take for example, the combination antenna/rotor wall plate. This lets you hook up an antenna rotor control to the same plug-in wall plate as the antenna.

But it's in the professional system, such as for an apartment or hotel complex that designs get really sophisticated. For a large commercial MATV system, several cut-to-frequency Yagi antennas may be used, with each antenna feeding its own single-channel amplifier. Even where one or two all-channel master antennas are used, individual single-channel amplifiers are called for, since these provide the greatest amount of flexibility, individualized control (such as tilt), and special attenuation (on strong local channels) and other needed features. Interference filters and traps can be wired into the affected channel's amplifier, and coax can be used throughout the system with idealized tilt to compensate for high-band losses.

Tapoffs and downloads are different for commercial systems, too, and setting up something like this calls for some preliminary engineering before even starting.

But in the home MATV areas, much sophisticated technology, developed specifically for the commercial setups, is available at a nominal cost today. And while you're keeping costs in mind, here are a few factors that affect the total: number of antennas installed; number of preamplifiers used; the use of a broadband amplifier or several single-channel units; the type and number of TV and FM outlets; the antenna location; type and amount of download and connecting cable; cable and outlet installation. **R-E**



ANTENNA SWITCH-SPLITTER divides uhf and vhf signals from two separate antennas through a switching network. Photo courtesy Winegard Co.

ever, in these days of uhf and FM, a splitter is also called for. But this minor headache has been relieved with some new sensible designs—a combined balun and splitter all in one. The mini-handfull gadget takes a 75-ohm antenna lead-in, and has the appropriate vhf, uhf and FM outputs for 300-ohm lines.

Easiest place to hang a transformer is in a Gem box behind one of those oh-so-neat antenna wall-mount-

ing plates. They're available in various styles from every major manufacturer as well as from sources that aren't well known at all. Some of these outlet plates already contain the 75/300-ohm matching transformer, which can make life a lot easier when doing the installation.

Then too, FM can be a problem, causing herringbone interference on adjacent TV channels (mainly channels 6 and 7). If there is FM interference present, you can do one of several things. First use a vhf-only antenna. Second, install an FM trap in



Channel Master amplifier



Jerrold amplifier



Winegard amplifier

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By Harry Remmert

AFTER SEVEN YEARS in my present position, I was made painfully aware of the fact that I had gotten just about all the on-the-job training available. When I asked my supervisor for an increase in pay, he said, "In what way are you a more valuable employee now than when you received your last raise?" Fortunately, I did receive the raise that time, but I realized that my pay was approaching the maximum for a person with my limited training.

"Education was the obvious answer, but I had enrolled in three different night school courses over the years and had not completed any of them. I'd be tired, or want to do something else on class night, and would miss so many classes that I'd fall behind, lose interest, and drop out.

The Advantages of Home Study

"Therefore, it was easy to decide that home study was the answer for someone like me, who doesn't want to be tied down. With home study there is no schedule. I am the boss and I set the pace. There is no cramming for exams because I decide when I am ready, and only then do I take the exam. I never miss a point in the lecture because it is right there in print for as many re-readings as I find



Harry Remmert gives his CIE Electronics course much of the credit for starting him on a rewarding career. He tells his own story on these pages.

necessary. If I feel tired, stay late at work, or just feel lazy, I can skip school for a night or two and never fall behind. The total absence of all pressure helps me to learn more than I'd be able to grasp if I were just cramming it in to meet an exam deadline schedule. For me, these points give home study courses an overwhelming advantage over scheduled classroom instruction.

"Having decided on home study, why did I choose CIE? I had catalogs from six different schools offering home study courses. The CIE catalog arrived in less than one week (four days before I received any of the other catalogs). This indicated (correctly) that from CIE I could expect fast service on grades, questions, etc. I eliminated those schools which were slow in sending catalogs.

FCC License Warranty Important

"The First Class FCC Warranty* was also an attractive point. I had seen "Q" and "A" manuals for the FCC exams, and the material had always seemed just a little beyond my grasp. Score another point for CIE.

*CIE backs its courses with this famous Money-Back Warranty: when you complete a CIE license preparation course, you'll be able to pass your FCC exam or be entitled to a full refund of all tuition paid. Warranty is valid during completion time allowed for your course.

"Another thing is that CIE offered a complete package: FCC License and technical school diploma. Completion time was reasonably short, and I could attain something definite without dragging it out over an interminable number of years. Here I eliminated those schools which gave college credits instead of graduation diplomas. I work in the R and D department of a large company and it's been my observation that technical school graduates generally hold better positions than men with a few college credits. A college degree is one thing, but I'm 32 years old, and 10 or 15 years of part-time college just isn't for me. No, I wanted to *graduate* in a year or two, not just *start*.

"When a school offers both resident and correspondence training, it's my feeling that the correspondence men are sort of on the outside of things. I wanted to be a full-fledged student instead of just a tag-a-long, so CIE's exclusive home-study program naturally attracted me.

"Then, too, it's the men who know their theory who are moving ahead where I work. They can read schematics and understand circuit operation. I want to be a good theory man.

"From the foregoing, you can see I did not select CIE in any haphazard fashion. I knew what I was looking for, and only CIE had all the things I wanted.

Two Pay Raises in Less Than a Year

"Only eleven months after I enrolled with CIE, I passed the FCC exams for First Class Radiotelephone License with Radar Endorsement. I had a pay increase even before I got my license and *another* only ten months later.

"These are the tangible results. But just as important are the things I've learned. I am smarter now than I had ever thought I would be. It feels good to know that I know what I know now. Schematics that used to confuse me completely are now easy for me to read and interpret. Yes, it is nice to be smarter, and that's probably the most satisfying result of my CIE experience.

Praise for Student Service

"In closing, I'd like to get in a compliment for my Correspondent Counselor who has faithfully seen to it that my supervisor knows I'm studying. I think the monthly reports to my supervisor and generally flattering commentary have been in large part responsible for my pay increases. My Counselor has given me much more student service than "the contract calls for," and I certainly owe him a sincere debt of gratitude.

"And finally, there is Mr. Tom Duffy, my instructor. I don't believe I've ever had the individual attention in any classroom that I've received from Mr. Duffy. He is clear, authoritative, and spared no time or effort to answer my every question. In Mr. Duffy, I've received everything I could have expected from a full-time private tutor.

"I'm very, very satisfied with the whole CIE experience. Every penny I spent for my course was returned many

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times over, both in increased wages and in personal satisfaction."

Perhaps you too, like Harry Remmert, have realized that to get ahead in Electronics today, you need to know much more than the "screwdriver mechanics." They're limited to "thinking with their hands" . . . learning by taking things apart and putting them back together . . . soldering connections, testing circuits, and replacing components. Understandably, their pay is limited—and their future, too.

But for men like Harry Remmert, who have gotten the training they need in the fundamentals of Electronics, there are no such limitations. He was recently promoted, with a good increase in income, to the salaried position of Senior Engineering Assistant working in the design of systems to silence submarines. For trained technicians, the future is bright. Thousands of men will be needed in virtually every field of Electronics from two-way mobile radio to computer testing and troubleshooting.

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RE 22

INSIDE STORY ON

An unexpurgated report of what it takes to
television or FM multiplex.

by FOREST H. BELT

DEALERS AND TECHNICIANS WHO HAVE to guarantee an acceptable color television picture for customers almost unanimously agree: the set must be fed a reasonably strong, ghost-free signal. They also know the monopole or dipole on the back of the set just can't hack it. Nor can those little uhf loops and bows. Even if signals from all the local stations are strong, rare is the location where a built-in TV antenna accepts every station without reflection or lead-in pickup.

But why such a big antenna? What is it about all those rods, bars, and booms that enables them to select just what the viewer wants sent down the lead-in cable to the receiver? You probably know vaguely that dimensions and spacing are major factors. Some technicians and set-owners feel sure that additional rods and bars always bring greater sensitivity. There's more to it than that. Too, most localities nowadays have both uhf and vhf TV stations; that adds another antenna complication.

Major antenna makers spend a lot of dollars on engineering to come up with something "different" as well as effective. That's why you see so many shapes and sizes. Each year, at least one or two manufacturers bring out improvements of some sort. The next year, it's some other brands. But the changes accumulate. There's now an antenna for just about every conceivable reception situation. In choosing the right one, it helps to know what each detail of antenna design accomplishes.

Advanced, but basic

The fundamental antenna for TV or FM reception has always been the *Yagi*. A dipole, cut precisely to resonate at one-half wavelength of the desired reception frequency, forms the "driven" element. In front of the active element, and cut slightly shorter, are *directors*. Behind, and a bit longer than a half-wavelength, are *reflectors*.

Directors and reflectors are "parasitic" elements; they do not feed the lead-in cable directly. Sometimes they're termed passive, as opposed to active elements. The more directors and reflectors, the narrower the frontal capture pattern—and the greater the array's sensitivity. Yagi antennas cut for single-frequency operation and augmented by many directors and reflectors offer extremely high gain over a simple resonant dipole.

Color television introduces a need for broadband reception. It's fairly important that the entire color television signal be picked up without attenuation of any portion. A Yagi must be treated to broaden its frequency response.

Most reception situations impose an even more stringent need: to pick up several TV channels with one antenna. Here, the plain Yagi fails. Its design is practical for one station only. One alternative lies in stacking several Yagis, one for each desired station. For the ordinary color-TV owner, that's impractical. The accepted approach is through a collection of driven and parasitic elements on one boom. The array resembles Yagi operation but elements combine broadly to pick up all television channels about equally. Most important for color reception, there should be no "dips" or "dropouts" in the overall frequency pickup characteristic.

One antenna that answers to these criteria is illustrated in Fig. 1, the top model in RCA's *Permacolor* series. You may wonder how so complex a design stems from

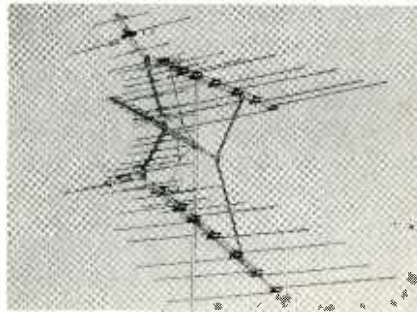


FIG. 1.—FAR-FRINGE RCA PERMACOLOR antenna incorporates Yagi characteristic of lower-gain models.

the simple Yagi. First realize that what you see comprises three arrays. Two are broadband vhf antennas, stacked in a forward-tapered formation. The third is a uhf array consisting of special bowtie driven element, corner reflector, and a set of directors. The bends at the front of the two vhf arrays extend the uhf reflector into a near-parabolic dish that focuses incoming uhf energy on the bowtie.

Consider one of the vhf arrays first. The hindmost element, despite looking like a dipole, is a parasitic reflector. The two rods connect together electrically at the center. It is reflector to all the other elements.

The next element forward is a dipole cut approximately for a half-wavelength at channel 2. The centermost ends of the rods are separated. The left-pointing rod connects to the top phasing bar, the right-pointing one to the bottom bar. (Neither connects to the main boom as the rear reflector does.)

The next element forward is another dipole, this one cut for TV channel 3. Note particularly the center connections, which have been transposed on the phasing bars:

right one to the top, left to the bottom. This phase-transposition is necessary when driven elements for different channels are close together and must feed a common downlead. Another interesting phenomenon contributes to operation. The elements behind, being slightly longer than this driven element, act as reflectors for channel-3 signals. Elements toward the front act as directors, being slightly shorter than the channel-3 dipole. This ability of driven dipoles to resonate at one frequency yet function as parasitics at other frequencies vastly increases the sensitivity and, therefore, the performance of the antenna array.

Adding uhf

If only one vhf array were involved, the uhf antenna would stack right on the front of it. The RCA uhf design consists of a corner reflector with rods long enough and spaced to act as a "sheet reflector"; a bowtie spatially bent to favor the low end of the uhf TV spectrum; and a set of directors to improve response to high uhf channels.

In the front-stacked configuration, the corner-reflector rods add pickup for high vhf channels. The tapered design offers an opportunity to enhance uhf pickup as well as vhf. The forward reflectors and boom of each vhf array are bent—one upward, one downward. The angle creates the effect of a parabolic dish for the uhf bowtie. Placement becomes critical in a design like this; the bowtie must be at the exact focal center of the reflector.

A dropoff of frequencies above channel 70 is considered normal in this model. Those channels cover translators. But, for that reception situation, little tabs on the uhf directors can be snapped off easily. The shorter directors force the uhf antenna then to favor the high end of the uhf TV spectrum, with some sacrifice in the response for channels 50-70.

The antenna in Fig. 1 shuts out FM signals rather abruptly. That's to eliminate interference if a strong FM station operates nearby. But, the installer who wishes to include FM in the pickup band of this antenna can modify it.

The "bugle" directors hold the key. Each one is scored just beyond the loop. The scoring makes it easy to break off the end of each bugle director. The new length extends the low-band spectrum right on up through the FM band. The antenna then responds smoothly to both vhf TV bands, to multiplex FM, and to uhf television.

A network of capacitances and inductances you can't even see isolates the vhf array from the uhf. The FM signals join vhf TV in its trip down the common lead-in. At the set, or at the distribution amplifier, a three-function splitter siphons off

OUTSIDE ANTENNAS

pick up good color

FM and separates vhf from uhf television.

From Yagi to wedge

Other manufacturers produce wide-band color-TV and FM antennas based on the Yagi. Variations abound. Full-fledged Yagi designs flourish most where specific reception problems exist. For example, Winegard offers an "Indianapolis special" to suit the peculiar arrangement of television stations around that city. Channels 6, 13, and 20 are north of town, and a special u/v array points in that direction. A three-element Yagi points east for channel 8. A more sensitive Yagi aims south toward channel 4, about 35 miles away. All three arrays are phased together by a harness and feed a single download.

An older broadband Winegard series, the *Super Colortron*, carries the Yagi prin-

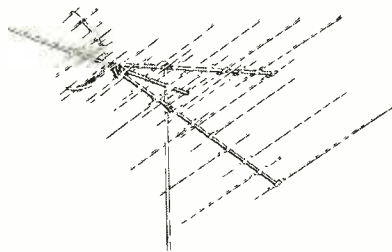


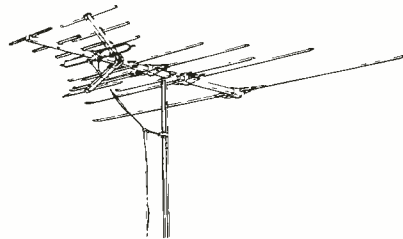
FIG. 2.—UNUSUAL COLOR WEDGE from Winegard departs from Yagi array in several ways, yet adheres to some of the principles.

ciple through the uhf and vhf bands. FM is included. A more recent introduction, the *Color Wedge* (Fig. 2), abandons the in-line dipole arrangement. In fact, this model incorporates several departures from "standard" design.

Possibly the most noticeable variance lies in the off-center and staggered elements. All the dipoles you see in Fig. 2 are active. Each rod connects to a phasing bar. But the phasing bars are not at all typical. The lengths of the elements grow shorter from back to front of the array, just as with Yagi designs, to cover the whole vhf TV band. Dipoles perform as resonant active elements at one frequency, and as passive parasitic elements for other channels.

Here's the kicker: The booms themselves are the phasing bars. They are formed as elliptical rods, dimensions 1/4 by 3/4 inches. The elements connect to them electrically and mechanically (making construction inordinately sturdy). The phasing-bar booms are kept apart at the apex of the wedge by an insulator. The arrangement, spacing, and lengths of the elements, with the low Q of the phasing booms, present a 75-ohm impedance at the point of the wedge. Staggering elements on the booms, one to the left

and the next to the right, introduces the necessary cross-phasing without a criss-cross wiring harness.



THIS 83-CHANNEL ANTENNA from Antenna Corporation of America holds to in-line design for passive elements, but uses now-uncommon folded dipole for driven element. Uhf array front operates mainly in three-half-wave mode, with corner reflector that doubles as vhf high-band director.

The obvious overlapping develops the "cells" that permit the elements to double for both low and high vhf bands. Rods that are part of the semi-parabolic reflector for uhf aid somewhat in this "breakup."

The uhf antenna itself trends more toward a yagi design; but directors of various sizes broaden its bandwidth to accommodate the entire uhf spectrum. The unusual curved reflector concentrates uhf energy efficiently on a special driven element. The latter is longer than you'd expect for a uhf yagi, and its two dipoles are connected in the center by an oddly shaped frequency/impedance correlator.

One other quality of this Winegard series seems worth noting: the close spacing of the elements. This is characteristic of the earlier *Super Colortron* series too. In those models, the short spacing was made pos-

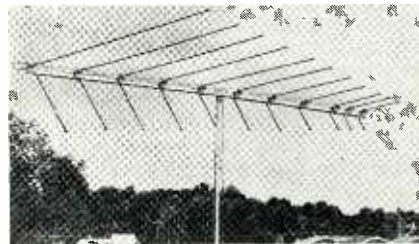


FIG. 3.—THIS JFD ELECTRONICS DESIGN was the first to include the log-periodic principle of element size and spacing.

sible by "corrugated" phasing strips.

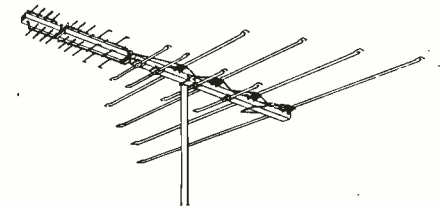
As is common with antennas that don't block out FM frequencies, a three-way splitter at the set end of the download separates uhf, vhf, and FM.

Log-periodic designs

This description, which has been around several years, refers to a particular length-and-spacing relationship among ele-

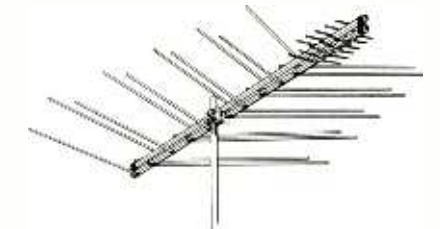
ments. The concept was pioneered by JFD Electronics. Several manufacturers have since borrowed the idea. JFD put the design into a configuration called *log-periodic vee* or just *LPV*. An example appears in Fig. 3.

The lengths of dipoles follows a principle similar to that already described for Yagis. That is, the longest, at the rear, resonates to a half-wavelength of the lowest vhf television channel frequency. Successively shorter elements, proceeding toward the front, resonate at correspondingly higher



ANTENNACRAFT CDX-SERIES of antennas combine some characteristics of Yagi, some of log-periodic. In-line dipoles work at half-wave for low band, at full-wave for high. Channel-2 droop is alleviated by close phasing loop at rear. Transposed phasing harness smooths response across band. Uhf array in front uses twin-boom staggered phasing for dipoles, and in-line directors for response at high end of uhf.

channel frequencies. Phasing is taken care of by a crossed harness, leading from element to element. Dipole length and spacing follow a formula that includes a logarithmic relationship to frequency. A closed stub at the rear helps overcome response "droop" at the channel-2 end of the band.



THE BLONDER-TONGUE PRISMATIC series combines several principles discussed in text. Twin booms with staggered elements at log-periodic spacing contribute smooth channel-to-channel response across vhf band. Forward sweep improves front/back ratio and forward gain. Uhf array is merely continuation of design for vhf, except that dipole elements are not swept forward into vee.

The log-periodic relationship, with the transposed phasing, makes the antenna resemble a helical spiral—a principle incorporated in low-noise broadband antennas for satellite reception. For each television channel, elements toward the rear act as reflectors to the resonant element. Those to the front act as directors. Dipoles that are basi-

cally half-wave at low-band vhf break up into three half-waves for high-band. For vhf television and FM, this "helix" boasts smooth sensitivity across the entire band.

Sloping the dipoles forward into the vee formation narrows the frontal pickup lobe. That raises gain, especially at the higher end of the TV band, and improves front-to-back ratio. Recent versions (Fig. 4) use the twin-boom means of transposing dipole phasing. Two booms hold the dipole rods in a staggered pattern that accomplishes phase transposition. Also, capacitive buttons have been interjected in forward elements to smooth the breakup for high-band reception.



FIG. 4.—MORE ADVANCED LPV ANTENNA for uhf and vhf brings new innovations to the basic log-periodic design.

The uhf antenna appended at the front of the antenna in Fig. 4 uses flat-plane log-periodic driven elements in a wedge formation. The wedge, as for vhf, helps narrow the vertical capture angle in front and combats ghosts that plague uhf reception. A rod-and-disc director system offers very broadband gain to the uhf array.

Uniform periodic

The log-periodic approach nowadays outstrips the Yagi in popularity for all-channel TV and FM antennas. But not all designers adhere to the logarithmic pattern faithfully. For the *Super VU-Finder* line of antennas (Fig. 5), Jerrold Electronics has adopted "uniform periodic" spacing. Whereas the log-periodic arrangement theoretically gives even sensitivity across the

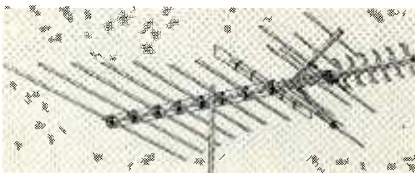


FIG. 5.—ANOTHER MODIFICATION of log-periodic principle, known as uniform-periodic, is typified in this Jerrold all-channel *Super-VU-Finder*.

whole TV band, this slightly altered spacing imparts a rising curve. The antenna shows progressively greater gain as channel frequencies go higher. This partially overcomes the increase in propagation loss from low to high channels.

The new series advances the *Paralog* design that Jerrold offered for several years. Basically a channel-2-through-FM half-wave array, the vhf section converts to full-wave operation for high-band channels. The chief trigger for this dual-mode operation is the trombone-shaped folded-dipole parasitic element up near the front.

Phase transposition takes place in an interesting manner. The dipoles are in-line, separated by disc-shaped insulators. Notice the two straight-line phasing strips, one above and one below the insulators. Phasing connections are imbedded inside each insulator. One carries its right-pointing dipole-half to the top phase strip and its left-pointing dipole-half to the bottom one. The next insulator reverses that order. The third goes the same as the first, and the fourth the same as the second. And so on throughout the array. Phasing is thus criss-crossed without worry of phase-wire interaction and without staggering the dipole elements.

The uhf array sports a special low-Q three-quarter-wave dipole. A corner reflector focuses incoming uhf energy on the driven element. The unusual quarter-wave X-type directors are Yagi-spaced and offer a very narrow, circular horizontal/vertical reception lobe to uhf signals. Their width-versus-length make them broadband across the upper end of the uhf TV band.

"Reverse" spacing

Even with antennas that don't follow the log-periodic formula for spacing, elements at the rear ordinarily spread farther apart than those up front. The antenna in Fig. 6 breaks that tradition. All models in The Finney Co.'s new *80 Series Color Spectrum* line follow a patented spacing principle that the firm tags "frequency Dependent Principle."



FIG. 6.—LATEST FINCO ANTENNA, the 80 Series Color Spectrum, takes an opposite approach to element spacing—almost log-periodic in reverse.

The prime object of the "FDP" is to stagger the gain of the antenna to match and counter propagation loss exhibited by television signals at higher channel numbers. Instead of decreasing dipole separation toward the higher-frequency front of the array, the frequency dependent principle puts them comparatively farther apart. The model shown here carries that idea even into the uhf antenna up front.

Twin booms and staggered dipoles transpose phase. Short elements spaced strategically along each boom help the dipoles operate at three half-wavelengths for high-band vhf. Two high-band directors are part of the corner reflector in the uhf array. They're broken up by insulators so they don't upset the uhf capture pattern. These directors also help isolate uhf from vhf. The uhf driven element is channel-shaped, which Finco engineers find rather broadband, almost like a folded dipole. Channel-aluminum strips make up the uhf directors. As with similar uhf arrays, the directors provide high-end gain and the reflector low-end.

Folded dipole with IC

Adding an amplifier to an outdoor antenna certainly is nothing new. Nor is the folded dipole new, although it doesn't fig-

ure in many antenna designs these days. You might also shrug "so what's new?" about integrated circuits. But Kay-Townes, Inc. has brought these not-so-usual ingredients together in a lone of antennas called the *ICA* series.

The antenna design shows in Fig. 7. Folded dipoles, cut for half-wave operation at low-band vhf, mount on a twin boom. Folded dipoles are somewhat broadband in normal operation, so not many are needed to give reasonably smooth coverage of the low vhf band. High-band passive elements, staggered along the two booms, assure full-wave dipole operation for high-band vhf. A director far up front aids low-band gain, and the uhf corner reflector aids high-band vhf.

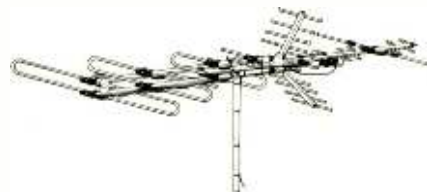


FIG. 7.—INTEGRATED-CIRCUIT AMPLIFIER is standard part of this Kay-Townes model ICA-500.

The uhf portion contains two folded dipoles as broadband driven elements. An array of X-type directors assures response to high uhf channels.

What justifies the Kay-Townes claim to high antenna sensitivity is an integrated-circuit signal amplifier. The usual drawback to antenna amplifiers is noise. The antenna picking up a weak television signal often can't make the signal override the noise level in the amplifier. Hence, no matter how high the amplifier gain, all you see is more snow on the screen. The gimmick here is a low-noise, wideband integrated circuit. Company spokesmen offer no clue to where this special IC comes from, but here are some claimed specs: 20 dB gain, absolutely flat from 50 to 1000 MHz. Most important of all, the noise figure is no more than 4 dB, across the whole spectrum. Compare that with the usual 6 dB for vhf and 8 dB or more for uhf, and you get the notion that this amplification might mean something—given a halfway reasonable signal from the antenna.

Beware of one antenna-preamp problem. Close to stations, the IC amp overloads easily. A gain adjustment on the newest K-T version, labeled "Zoom control," adapts the system to exact signal conditions.

Summing up

So, what does all this technical data on antennas mean to you when you go to choose one? Only that you can evaluate sales literature a bit more intelligently. Some antenna makers still compare "gain" figures or "this many dB's" more signal. Unless you know the specific conditions of measurement, such figures don't mean much.

Study the configurations you think best fit your locality. Need high sensitivity on uhf but ordinary operation on vhf? Pick a model that offers that combination. Need just the opposite? Choose accordingly. At the very least, when a customer asks why a particular antenna does the job it does, you can explain.

R-E

TU TYPEWRITER

This character generator and your TV set form a computer terminal, educational toy or display device. Basic details are here. Full and complete data is yours when you need it.

by DON LANCASTER

This construction project started out as a very low-cost computer terminal for home use, but as it went together, we became aware of the many possible noncomputer uses for such a device, particularly since it is priced right. What can you do with a machine that puts letters and numbers on an ordinary unmodified TV set?

Obviously, it's a computer terminal for timesharing services, schools, and experimental uses. It's a ham radio teletype terminal. Coupled to the right services, it can also display news, stock quotations, time, and weather. It's a communications aide for the deaf. It's a teaching machine, particularly good for helping preschoolers learn the alphabet and words. It also keeps them busy for hours as an educational toy.



GET THE COMPLETE STORY

The TV Typewriter is a very special story. Complete construction information, including full-size circuit-board patterns would require a long, multi-part article in *Radio-Electronics*.

To make it possible for interested readers to get full details of the unit and to immediately start construction, we are making available a special package of additional data, including complete construction details, more data on how it works, troubleshooting tables, connections and other important information. The cost of this 16-page package is \$2.00.

To order your construction details, send \$2.00 to:

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This is the first time that *Radio-Electronics* has presented a construction article in this fashion. We would appreciate your comments on this approach. Remember, by doing this we can offer readers many more construction articles in *Radio-Electronics* without the need to wait for more details in the next issue. Also we can provide full-size printed circuit patterns and overlays.

Use the reader service card in this issue to tell us what you think. If you like this approach, and want to see us use it more often, circle number 132. If you do not like this approach and do not want us to use it again circle 130.

If you don't use the reader service card to register your feelings address your letters and cards to the Editor, *Radio-Electronics*, 200 Park Ave South, New York, N.Y. 1003.

It's a super sales promoter, either locally or on a store-wide basis. It's easily converted to a title machine for a video recorder. It's a message generator or "answer back" unit for advanced two-way cable TV systems. Tied to a cassette recorder, it's an electronic notebook and study aid, or a custom catalog. It's an annunciator for plant, schools, and hospitals that tells not only that someone is needed, but why and where.

And, if all that isn't enough, it's easy to convert into a 12- or 16-place electronic calculator. You can also make a clock out of it, and, with extensive modification, you can even make a 32-register, 16-place serial digital computer out of the beast!

Cost of the project? Around \$120 for the basic unit. This is slightly under two month's normal rental of commercial units that don't do nearly as much, and less than 1/10 the cost of anything commercial you could buy to do the same job. And we feel that this cost is finally low enough that a lot of new uses are now not only possible, but reasonable as well.

The low cost comes about by using the latest available semiconductors, leaving the keyboard and case as flexible options, and working in kit form.

Printed-circuit boards and complete kits are readily available as are any special or hard-to-get-normally parts. A limited quantity of high-quality keyboards are also available from the same source. This is not the sort of thing you'd want to try as a first electronic project, but if you are willing to slowly and methodically work things out and carefully reason out any debugging problems, you shouldn't have an unreasonable amount of trouble getting the thing to work. Once you're past a certain stage early in the construction, the TV set itself becomes a self-testing display that greatly simplifies debugging.

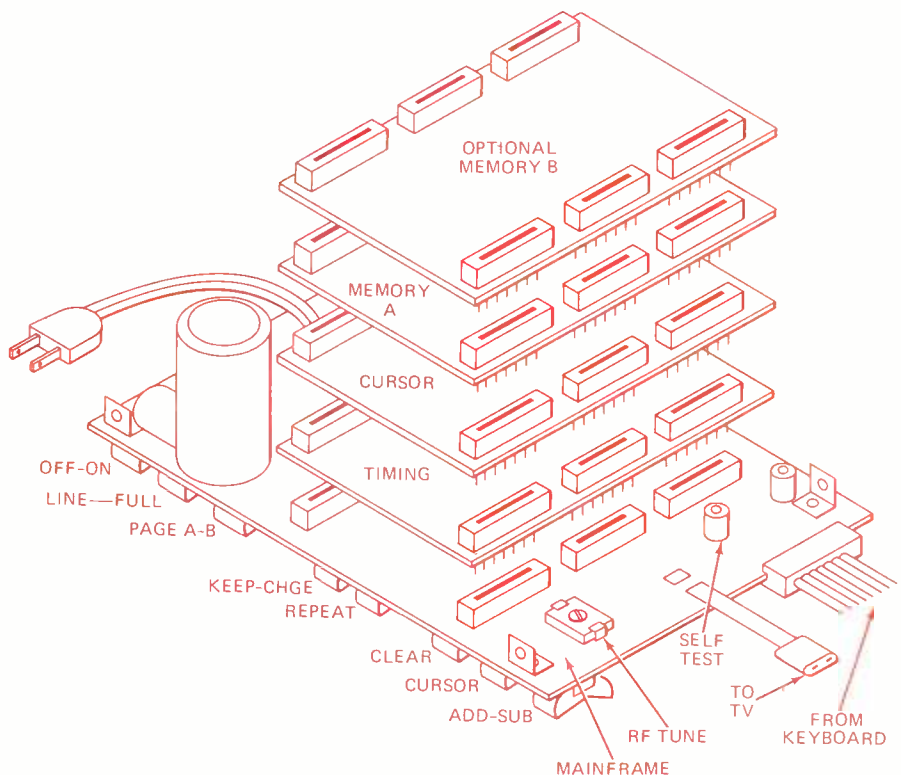
To make things easier, you can get a complete copy of the *entire* story that includes additional design information, how it works, PC patterns, construction details, etc. **DO NOT ATTEMPT CONSTRUCTION WITHOUT THIS ADDITIONAL INFORMATION!**

Construction is done in stages. Once each stage is tested, it is safe to go into the next, progressively working up to a complete unit. The basic machine we'll show you works from a keyboard or a set of six switches and a pushbutton. Thanks to the plug-in construction, low-cost add-on circuit boards can let you talk to a computer or a cassette recorder, or adapt the unit for 12-place calculation. These add-ons will be picked up later if enough readers seem interested. They're not needed for most of the possible applications of this TV Typewriter.

Specs of the unit

Complete specs appear in Table 1. The basic device generates and stores 512 characters, arranged as sixteen lines of 32 characters each. A second page of characters is easily added internally to bring the total up to 1024 characters. For more storage, a C90 cassette can store well over a hundred pages, so the total capability is quite large. The characters available are standard ASCII ones that include the capital letters, numerals, and most punctuation.

The TV Typewriter is self-powered and contains its own miniature TV transmitter which simply clips onto the antenna terminals of an unmodified TV tuned to an unused channel. Several TV's may be driven simultaneously, and a direct video output is also available for industrial and experimental uses. While any TV can be "borrowed" and used with the typewriter, small, high-quality portables give the nicest presentation, and slight size and position



HOW TYPEWRITER ELECTRONICS IS ASSEMBLED within the case. The timing, cursor and memory boards plug into the mainframe and each other, cordwood fashion.



A SURPLUS KEYBOARD is used in this version of the TV typewriter. Unit on cover has a home-made keyboard based on the article in the February Issue.

TABLE I

COMPLETE SPECIFICATIONS—TV TYPEWRITER

STORAGE:	1024 Characters arranged as 2 pages of 16 lines of 32 characters each.
OUTPUTS:	Rf Output tuneable from channel 2 through 5; clips directly to the antenna terminals of one or more unmodified television sets. Optional positive-white video output.
INPUTS:	Parallel, TTL compatible, ASCII character code (Table II) is input with positive logic on six lines; a seventh <i>keypressed</i> line is suddenly brought to ground to input character, Internal debouncing. The full 8-bit ASCII code may also be used as an input. If done, any CTRL input will be interpreted as a combined CARRIAGE RETURN and LINE FEED, CTRL output available for code extension.
FORMAT:	Begins in upper left HOME position and proceeds as in normal typing. Carriage return and linefeed automatic at end of line. At bottom of screen, jumps to upper left HOME position and rewrites over old text.
EDITING:	Winking cursor indicates next character position. Cursor may be blanked and may be independently moved in any direction with or without changing text. One or more letters may be easily changed at any time.
TIMEBASE:	Internal, crystal controlled TTL divider. Basic video clocking rate = 4.562 MHz. 15,840 kHz noninterlaced horizontal scan rate; 60-Hz vertical scan rate. Easily converted to full interlace for Video Recorder titling applications.
MEMORY:	512 word by 6 bit MOS dynamic storage, bus oriented for easy page conversion, optional memory output, and optional extension to calculator, computer, and other functions.
CONTROLS:	Internal: Rf frequency (trimmer capacitor) Position—(Jumpers—4 horiz; 3 vert for 12 possible locations.) EXTERNAL: ON-OFF PAGE OR LINE SCAN KEEP-CHANGE memory protect A or B page select REPEAT or SINGLE character HOME or RUN cursor location CURSOR ON-OFF ADD-SUBTRACT cursor direction
CONSTRUCTION:	Modular mother-daughter boards. Mother board contains power supply, rf modulator, and control switches. Timing board, cursor board and one or two memory boards snap on as a stack. Add-ons such as calculator and MODEM FSK unit snap onto same stack; not included in basic unit. 33 integrated circuits, of which 8 are MOS LS1.
SIZE:	7"x8½"x3", not including keyboard or case.

adjustments can further help the appearance, although they are not needed.

The characters are added one at a time and normally go on the screen just like you were typing. This is done by providing the proper ASCII character code on seven input lines and tripping an eighth "key pressed" line to enter the character. A winking cursor tells you where the next character is to go, but you can turn this off if you want to. Should the screen get filled, the machine starts over again on the top, rewriting over the old message.

Besides the normal operation, you have a complete editing capability. You can move the cursor either direction anywhere you want and then change only the characters or words you wish to, thus editing something you already have on the screen. This nicely handles mistakes without having to start over again. A REPEAT key is available for putting down a group of identical characters or getting to a given position in a hurry. There's a KEEP-CHANGE switch to protect what you have written while you are moving around, and you can home the cursor to the upper left either by itself or erasing the whole picture on the way. Other switches control the direction the cursor goes, which page is being displayed, and optionally whether the mode will be a full screen one for typewriter use or a line scan one for calculator use.

Computer people would call this a parallel input system with off-line editing. A single machine command is available; this is the LINE FEED. Thus, any CTRL key moves you down a line. Other remote commands are easily added, but were left off to hold the cost down. The contents of the memory can be retransmitted with simple circuit modifications, and the whole system is bus-oriented to allow all sorts of add-ons without major circuit rework.

Character input rate is asynchronous and up to 30 characters per second, thus making the beast three times faster and compatible with the industry standard ASR-33 teletype. Hard copy is via cassette recorder or Poloroid® photos.

Organization of the instrument

To keep things as simple as possible, the circuit is arranged like a set of snap-together blocks. This way, the only interconnect wiring consists of the line cord and the 300-ohm twinlead output. Since the interconnect wiring is locked into the board and 60-pin connector system, the biggest single headache and potential error source is eliminated.

Fig. 1 shows the basic blocks. The MAINFRAME contains a power supply of +12, +5, -5, and -12 volts; the control switches; the rf modulator; the internal test system; and connectors for both the keyboard and the other boards in the stack.

There are three other essential boards. The MEMORY board is the most important and the most complex. It contains a dynamic MOS (Metal Oxide Semiconductor) shift register that stores 512 words of 6 bits each. It also holds a single-line memory; a character generator; and an output video register. We'll see later that the single-line memory is needed to get each character back eight times in sequence for eight successive TV scans.

For a page-A memory, you need all of
(continued on page 50)



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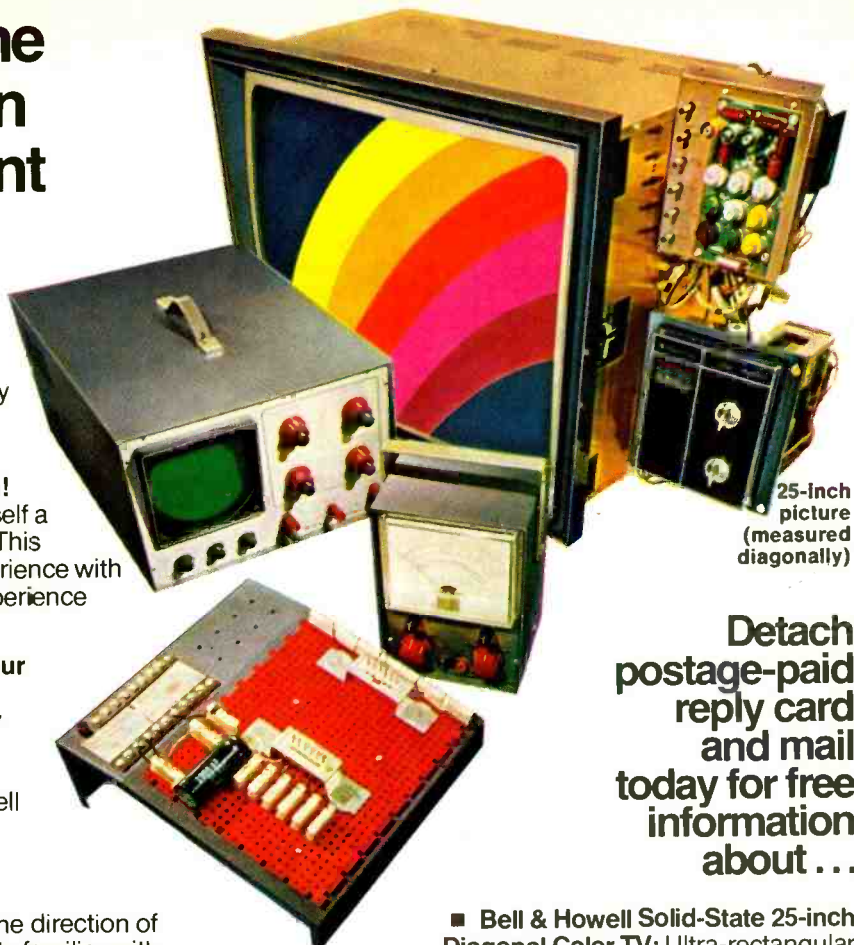
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this board. The additional page-B memory does not need a new single-line memory, character generator, and output video register, as it can borrow the one in the page-A memory when the second page is in use. This is called *bus organization*. The character generator will respond to anything that is enabled on the bus, be it page-A memory, page-B memory, a calculator add-on, or whatever. Of course, we have to be careful to only enable *one* possible source of characters at a time, but this is easy. We can also use the bus optionally to *output* characters to the outside world.

The output of the memory board also contains a video combiner that assembles the character video, sync signals, and the internal test signal into one composite video output. This output may either be used directly or routed to the rf modulator for clip-on operation of an unmodified TV. It can be optionally flashed or blinked.

The **TIMING** board contains a crystal divider and TTL (Transistor Transistor Logic) countdown chain that generates all the needed signals to run the typewriter in proper sequence. It does not normally use interlace, but the timing chain is split so that the somewhat more complex TV full-interlace system can be added if you need this sort of thing for video titling. There are two principal areas to the timing board, the **MAIN** timing, and the **DERIVED** timing. The main timing is the continuous waveforms obtained off the crystal divider, while the derived outputs combine portions of the main timing signals into properly coded signals needed to run the rest of the typewriter. Two examples are the composite sync signal and a blinker used for flashing, cursor winking, and repeat functions.

The third essential board is a **CURSOR** board. Anyone who ever tried to design and debug a simple one of these will easily understand why it is called a cursor board. Anyway, the cursor keeps track of where the next character is to go; runs the winking line that shows the character position; controls entry of the character; and optionally sets up characters for output. It also contains an input conditioner, and debouncer and a detector for CTRL commands that tells the typewriter to carriage return rather than enter a character.

Many cursor systems are extremely complex. This one is relatively simple in that it uses a *phase-shift counting technique*. The cursor has a *continuously running* counter just like the main timing chain does. Its output drops suddenly in some *relative* position, indicating where the next character is to go.

To back the cursor up, we throw in another count pulse. To run it forward, we hold back one normal count pulse. Thus, the *relative* position or phase of the cursor counter advances or backs up with respect to the system timing. Actually, to go forward, we hold back *two* normal system timing pulses and throw in a new one. This buys us a simplification of circuitry, but still ends up with the same result.

An **ADD-SUBTRACT** switch on the main-frame controls the cursor direction for editing. **LINEFEED** is handled by adding and removing the proper number of counts in the proper position in the cursor counter so that the new position is reached. Just like most typewriters, the linefeed always returns to the lefthand side.

In normal operation, each character entry moves the cursor over one character. When it gets to the end of the line, it starts again on the next line. When it gets to the bottom of the page, it starts again at the top. A **CLEAR** or **HOME** override also moves the cursor to the upper lefthand position.

And, this is about all you need for a normal parallel entry type of TV typewriter. One possible optional board is a **MODEM** or frequency-shift-keying interface. This would use a MOS chip and some TTL to convert to or from a serial tone input, suitable for computer or telephone line communication. A cassette recorder will work just as well with the modem for electronic notebook use.

Another possible add-on makes the typewriter into a calculator. This is done by converting the scan from a complete frame to a single line of numerals and would use a surplus calculator chip to provide the familiar calculator functions. If you already have or need the TV typewriter for something else, this add-on is far cheaper than a conventional calculator would be, and its display would be obviously larger and more readable.

Or, you can add most anything else you want onto the machine by tying into the bus-oriented lines (b1 through b6). For instance you can think of the memory as sixteen registers of 32 numbers each, and those numbers are decimal numbers plus, not bits! With six bits per word, you can store 10 possible numerals and 54 machine commands in any word! Or, you can split the registers into 32 registers of 16 decimal numbers each, building your own computer or programmable calculator.

Of course, this computer-add-on is very much an advanced experimenter project, but it really doesn't take much more than a double handful of TTL to pull it off. While such a computer will be relatively slow (around a 33-ms cycle time), it does provide an extremely accurate and very low cost computer approach, particularly when you are working directly with BCD numbers instead of binary.

Some basics

Before we turn to the actual circuitry, some basics of what a character is and how it can get on a TV screen is in order. Lets start with the characters:

If we had six possible binary bits of either 1 or 0, we would have sixty-four different possible combinations ranging from 000000, 000001, 000010, . . . through to 111110 and finally 111111. These 64 different states can represent all the capital letters, all the numbers, a blank, and most punctuation, following the standard ASCII code. In the TV Typewriter, all of the six bits of this code must be presented at once or in *parallel* form, and this is the only code the circuitry shown can use. Other codes can be converted to ASCII before going into the TV Typewriter. A seventh bit is used to separate characters from internal commands.

Our final presented character consists of an array of 5×7 dots. Since it only takes 6 bits to store a coded character and at least 35 bits to store a generated one, its obviously much better and cheaper to generate the characters *after* they are stored, rather than before.

For other keyboards and encoders, the

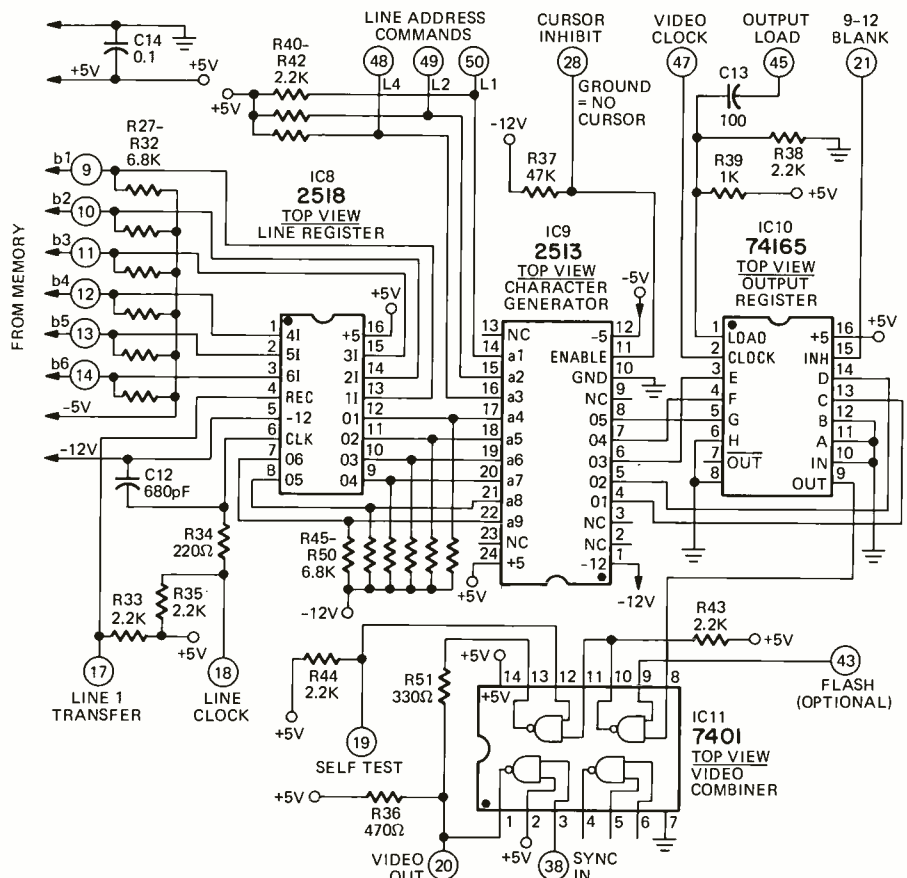
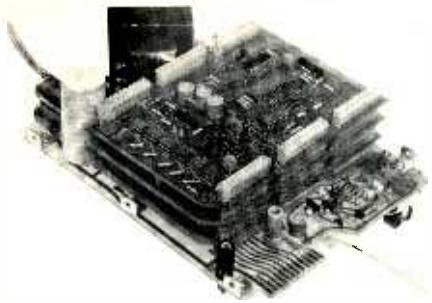


FIG. 2—SCHEMATIC OF THE CHARACTER GENERATOR. The use of integrated circuits greatly reduces circuit complexity and makes possible a very compact device.



INSIDE VIEW SHOWS STACKED BOARDS containing the electronic circuits in the TV typewriter.

typewriter gives you lots of +5 and a choice of +12 or -12 volts at relatively low current. The original **Radio-Electronics** ASCII encoder needs the +12; a mechanically encoded keyboard will only need +5, while a MOS encoded keyboard probably will need +5 and -12 volts.

A limited quantity of suitable keyboards is presently available from the kit source. Other sources of input material include computers, calculators, the phone line, or a cassette recorder. Many of these signals will be in serial or one-bit-at-a-time form and have to be changed to the parallel ASCII code. This takes an add-on board using a MOS terminal-receiver chip. Regardless of the source, your input must be in parallel form when presented to the typewriter, with a "1" near but not exceeding the internal +5 and a "0" near but not going below ground. Internal debouncing is provided on the cursor board for manual keyboard entry.

Interfacing with the TV

To use an unmodified TV, we have to build a miniature transmitter and arrange the signals so they compare as closely as possible to a normal broadcast set of scanning standards. This way, any TV can be driven by the typewriter simply by clipping onto the antenna terminals and tuning to an unused low channel.

A TV starts in the upper lefthand corner and sweeps a dot rapidly to the right and slowly downward, taking around 62 μ s to get across the screen and 33 ms to get to the bottom. It then repeats the process again and again, presenting a series of dots that assemble into a series of still pictures that the tube phosphor and your eye integrate to get the effect of a complete and usually moving picture.

Brightness is changed on each dot by controlling the picture tube's cathode current, which in turn follows the input rf signal seen at the antenna terminals. Very low signal is seen as white. The stronger the signal, the blacker the picture. The sync signals are the strongest of all, or "blacker than black", and are used to synchronize the scanning of the television set to the transmitted signal.

To provide sync, we need one horizontal sync pulse at the beginning of each scan line, and one vertical sync pulse for the beginning of each frame. To keep things simple, we make all the frames identical in the TV Typewriter instead of using interlace. Interlace has no advantage on a stationary message presentation and simply adds parts. If you have to you can easily

add it for video titling or other places where you must superimpose the TV Typewriter's output onto an existing program.

We assign 48 possible character positions across the TV screen, but we only use 32 of them. The remaining 16 allow for retrace and the extreme overscan used on economy TV's. We assign 12 scan lines per row of characters. The uppermost scan line is blank except possibly for a winking cursor that appears as a bar above the next character to get input. The next 7 lines form the character as a series of dots 5 dots wide by 7 dots high, and the final 4 lines are blank. These allow for the space between character lines.

We likewise assign 22 possible character lines but only use 16 of them, this time saving 7 for vertical retrace and overscan. By picking the right timing frequencies, we obtain a horizontal rate that's so close to the normal rate the TV doesn't know the difference, and a vertical rate of exactly 60 Hz. The latter is especially important to keep hum bars out of the display. Since each frame is stationary and ends with a bunch of blanks, Equalizing pulses are neither needed nor used.

Each character takes six bits of storage, arranged as one parallel 6-bit word. The storage is used to hold the character from time of entry until it is no longer needed, which can range from seconds to days. For a single-page memory of 512 characters, we use six 512-bit recirculating MOS shift registers. These go around once each TV frame. The timing and cursor boards together decide *where* in each of the six registers a new character is to go. Once in memory, the character stays in the same relative slot until it is cleared or replaced. The memory is volatile, meaning that you lose the message if power drops for more than a half a second or so.

Note that an ASCII blank is 100000. All 1's is a "?" and all 0's is an "@". This is helpful when troubleshooting, for it's rather difficult to get a totally blank screen by accident. On the other hand, this means we have to be careful when we clear our memory to erase the screen. Here, we purposely have to set up the 100000 code. One way to do this, is to hold down the keyboard's space bar during the clearing process. A better way is to remove the keyboard encoder power (via the UNCLEAR or not-clear line from HOME switch S6) from the encoder to get all 0's out. Then a "1" can be force-fed to the a6 input line to set up the proper code. This gives us a one-button clearing operation. Other schemes can easily be worked out, but the essential thing is that the 100000 code gets set up during the time you want to erase what you have.

We normally put a character into memory and leave it there for a relatively long time. The memory usually is in a *recirculate* mode where its own output is connected internally back to its input. The memory is a *serial* device—the bits take turns coming out one at a time, and 512 pairs of clock pulses are needed to turn the memory over exactly once.

The memory is normally in the *recirculate* mode. We keep it there if we are using the other page or if we have our KEEP-CHANGE switch in the KEEP position. We also force it to recirculate if a CARRIAGE RETURN command (a6 and a7 = 0)

arrives, for, just like a typewriter, we don't want to enter anything while the carriage goes back to the beginning of a line.

The only time we actually enter a character is once when the cursor board tells us it is the right time, then only if we are working on this page, want to change the character, and are not trying to return the carriage.

About keyboards

So where do we get our characters? The simplest and far cheapest source is from six switches and a pushbutton, arranged to get us +5 for a "1" and ground for a "0" and set up so the pushbutton gives you a sudden +5 to ground "Key-pressed" output. This is handy (almost essential) for testing, and can be used for message generation, although it takes quite a bit of practice to get any speed.

A keyboard is the next best bet, such as the low-cost keyboard in the February 1973 issue of **Radio-Electronics**, and its low-cost companion ASCII encoder (April 1973). Many of the surplus keyboards offered in the back pages of **Radio-Electronics** can also be either used directly or readily adapted.

The input code *must* be in ASCII. Any keyboard that consists of one or two make contacts per key *must* be converted in a suitable encoder, again such as the low-cost ASCII encoder described in the March 1973 issue of **Radio-Electronics**. Further, the ASCII output *must never exceed* the internal +5 volt supply of the typewriter, nor should it go below ground, even by a small amount.

Jumpers on the timing band allow for selection of 12 possible display positions so that internal TV adjustments need not be changed.

Character generation

We use raster-scan dot-matrix characters providing an array of 5 dots wide by 7 dots high for each character with one "undot" between characters for spacing. Seven passes of the TV raster are needed to generate each line of characters. This says we must borrow one line's worth of characters (32) from the memory and put it into a *new line register* memory, use it over again at least seven times, and then later on, go get a new line of characters. To do this, we need a line memory, a single IC consisting of six 32-bit recirculating shift registers.

Let's go through a typical scan and see what happens. Most of the circuitry is shown in Fig. 2.

Suppose we just retraced to the upper left hand corner. We're now on line 1 of the top of the characters. On line No. 1, our line register is connected to the memory and it samples the next 32 characters to be presented. The main memory thus fills the line register. For the next twelve scans, the memory is idle, but the line register brings the same characters back over and over again. On scans No. 2 through No. 8, the character is actually generated. The line register drives a character generator.

The character generator is also connected to logic that tells it which part of each character it is working on. The output of the character generator goes to an output register that converts the characters into actual video.

Since line No. 1 is supposed to be all blanks, the character generator is told this and we get all blanks, except possibly for a brief cursor winking bar.

On the second scan line, we again clock the line register 32 times, letting it go once around. The main memory just waits. This time, the character generator is told to work on line No. 2 and please put down the top row of dots on each character. For instance, if a "T" comes up, we get five "I's" in a row. An "S" would be 01110 and so on. As the TV scans across, each top row of dots for each following character is put down.

On the next pass, we again clock the line register 32 times. This time, the second row of dots gets output, with a "T" being a 00100 and an "S" being 10001, and so on. Lines No. 4, 5, 6, 7, and 8 are handled the same way, with the character generator working on the line it is told to and the line register going once around for each line. By the end of the eighth line we have put down all the dots we need for a line of 32 complete dot-matrix characters. The circuitry is blanked for the next four scan lines, providing us with a space between character lines.

On line No. 13 (a new line "1"), our main character memory is once again clocked 32 times and the line register is simultaneously clocked. This fills up the line register with a new set of 32 characters. The same operation repeats for each of the sixteen rows of characters that we want to put down.

Notice that the timing runs in bursts and is not continuous. Thus, the line register runs for 32 counts and waits 16 for retrace and so on. The memory does the same thing, but only on every twelfth line during the active scan. Carefully established internal timing delays take care of settling times between memory, line register, character generator, and the final video generating output register. The output register converts the five parallel outputs of the character generator into serial, high speed video.

About the memory bus

So far, we've assumed that we were using the page-A memory with the page-A character generator. Thanks to the memory bus (b1 through b6) we can connect anything we like to the character generator, including the page-A memory, the page-B memory, or anything else we want to hang on these lines.

To run page-B, we simply disable the page-A memory and enable the page-B memory's output. The handy thing about bus organization is that no complex switching is involved. Whatever is enabled gets connected to the character generator; other things tacked on just sit there. The only restriction is that we have to enable only one character source at a time. We can also use the same memory bus optionally to output characters to a computer, a cassette recorder, or a phone line.

This way, with suitable add-ons we have a choice. We can send one character directly from the keyboard, or we can send an entire page at a time from the keyboard. The latter is faster and more convenient. It has the advantages that you can correct mistakes first and don't tie up the TV for much outside equipment. R-E

PARTS LIST

MAINFRAME

C1—5000- μ F 10-V electrolytic
 C2, C3—1000- μ F 25-V electrolytic
 C4—100- μ F 6-V electrolytic
 C5, C7—470-pF disc for vhf bypassing
 C6—3-30 pF trimmer
 C8—27-pF mica
 C9—47-pF mica
 C10—Gimmick attenuator made of twin lead
 D1 to D6—1N401 or equal
 D7—12-V, 1-W Zener, 1N4742 or equal
 D8—6.8-V, 1-W Zener, 1N4736 or equal
 D9—5.1-V, 1-W Zener, 1N4734 or equal
 D10 to D14—1N914 or equal
 F1—1-A fuse and fuseholder
 IC1—7805 regulator (Fairchild or Motorola)
 J1, J2—Binding posts, one yellow, one black (5 way)
 L1—Coil made from 4" of No. 14 solid wire
 Q1—2N918 transistor in metal can, **do not substitute!**
 R1, R2—47 ohms, 1/2-W
 R3—22 ohms, 1/4-W
 R4, R9, R10—2200 ohms, 1/4-W
 R7—4700 ohms, 1/4-W
 R8—470 ohms, 1/4-W
 S1, S2, S3, S4, S7, S8—dpdt rocker switch
 S5 to S6—dpdt rocker switch, momentary spring return
 SO1 to SO6—connector, Molex 09-52-3103
 SO7—TV lead-in connector
 T1—Power transformer, dual 12-V center tapped secondaries, 1.5-A. Signal 24-1A or equal
 MISC.—PC Board, 8 3/4 x 6 3/4; mounting brackets and hardware (6); switch mounting hardware (8 sets); line cord and cable clamp; hardware for T1; vertical heat sink for IC1; No. 24 jumper wire; sleeving; No. 14 wire for L1; fuse clips and hardware, 300-ohm twin-lead, 18"; PC terminals, optional-2; solder.

MEMORY BOARD

Note: Each system needs one "Memory A" board. Memory "B" boards are optional. These parts are needed for either a Page A or a Page B memory:
 C1, C3, C5, C7—100- μ F 15-V electrolytic
 C2, C4, C6, C8, C9, C10, C11—0.1- μ F disc ceramic
 D1, D4, D5, D6—1N914 or equal
 D2, D3, D7—1R4001 or equal
 IC1 to IC 6—2524 MOS 512-bit recirculating shift register (Signetics)
 IC7—7406 hex driver, TTL
 P1 to P60—Connector pins to fit Molex 09-52-3103 connectors
 Q1, Q2—2N5139
All resistors 1/4-W carbon
 R1 to R6, R25—2200 ohms
 R7, R8, R15—2.7 ohms
 R9, R23—10,000 ohms
 R10, R12—22 ohms
 R11, R13—4700 ohms
 R14, R18, R19, R20—150 ohms
 R16, R17—100 ohms
 R21, R22—1000 ohms
 R24—330 ohms
 R26—470 ohms
These parts are needed ONLY for a page A memory:
 C12—680-pF mica
 C13—100-pF mica

C14—0.1- μ F disc ceramic
 IC8—2518 MOS hex 32-bit recirculating register (Signetics)
 IC9—2513 character generator, MOS (Signetics)
 IC10—74165 TTL 8-bit PISO register
 IC11—7401 TTL open collector NAND gate
 R34—220 ohms
 R33, R35, R38, R40 to R42, R43, R44—2200 ohms
 R27 to R32, R45 to R50—6800 ohms
 R36—470 ohms
 R37—47,000 ohms
 R51—330 ohms
 MISC: PC Board, 4 1/2" x 6 1/2"; #24 wire jumpers; Sleeving; PC Terminals (Optional-2); Solder.

TIMING BOARD

C1 to C4—0.1- μ F 10-V disc ceramic
 C5, C6—160-pF mica
 C7—0.001- μ F disc ceramic
 C8—100- μ F 6-V electrolytic
 C9—33- μ F 6-V electrolytic
 IC1—MC4024 dual astable (Motorola)
 IC2, IC3, IC5—8288 divide by 12 (Signetics)
 IC4—7473 dual JK, TTL
 IC6—8288
 IC7, IC8—7432 quad OR gate, TTL
 IC9, IC12—7402 quad NOR gate, TTL
 IC10, IC11—7410
 P1 to P60—Pins to fit Molex 09-52-3103 connector
 R1—330 ohms 1/4-W
 R2, R3—220 ohms, 1/4-W
 R4—2200 ohms, 1/4-W
 SO1 to SO6—Molex 09-52-3103 socket
 XTAL 1—4561, 920-kHz series-resonant crystal
 MISC: PC Board, 4 1/2" x 6 1/2"; #24 solid wire jumpers; Sleeving; PC Terminals (optional-2); solder.

CURSOR

C1—1200-pF mica
 C2—4300-pF mica
 C3—620-pF mica
 C4—6200-pF mica
 C5—1000-pF mica
 C6 to C9, C12 to C15—0.1- μ F disc ceramic
 C10—100- μ F 6-V electrolytic
 C11, 16—10- μ F 6-V electrolytic
 IC1—7408 quad AND gate, TTL
 IC2, IC4—74197 or 74177 or 8281 or 8291 divide by 16 TTL
 IC3—7473 dual JK TTL
 IC5, IC6—7402 quad NOR gate TTL
 IC7—7474 dual D flip-flop, TTL
 IC8—7400 quad NAND gate, TTL
 IC9—555 timer, Signetics
 P1 to P60—pins to fit Molex 09-52-3103 connector
 Q1—2N5129
 R1, R5, R8, R13, R16, R21—1000 ohms, 1/4-W
 R2, R3, R4, R6, R7, R9, R11, R14, R17, R18, R22—2200 ohms, 1/4-W
 R10, R19—330 ohms, 1/4-W
 R12—100 ohms, 1/4-W
 R15—100,000 ohms, 1/4-W
 R20—150 ohms, 1/4-W
 SO1 to SO6—Molex 09-52-3103 connector
 MISC: PC Board, 4 1/2" x 6 1/2"; No 24 wire jumpers; sleeving; PC terminals (optional-8); solder.

The following items are available from Southwest Technical Products, 219 West Rhapsody, San Antonio, Texas, 78216.

All circuit boards are etched and drilled
Mainframe board: No. TVT-1, \$9.75
Timing board: No. TVT-2, \$5.75
Cursor board: No. TVT-3, \$5.75
Page A or B board: No. TVT-4, \$5.75
High-quality keyboard, custom remanufactured for TV typewriter use (less-encoder) No. TVT-5, \$18.75

A complete or nearly complete kit of parts will also be offered, but pricing depends on semiconductor availability at time of publication. Write for a complete list of available parts and prices for assembled units.

more SYNTHESIZER modules

Part IV: You've built the keyboard and the basic electronic circuits. Here are four modules to enhance your instrument.

by JOHN S. SIMONTON, JR.*

BY NOW YOU SHOULD HAVE A GOOD START on your synthesizer. You've built the VCO, keyboard controller and power supply from articles in May, June and July issues. Now we will finish the basic package by assembling a voltage-controlled amplifier, two types of voltage-controlled filters, a noise source, envelope generator and low-frequency control oscillator.

Rather than go through the same tired old warnings about soldering and component polarity for each module, let's just get them all out of the way at once. These same precautions and assembly details apply to all the modules.

As you might expect, there is nothing critical about the assembly of any of the modules we will look at. There are no

high frequencies involved so other than standard rules of good practice for audio assembly work lead dress and component arrangement are not critical. Keep outputs and inputs separated as much as possible and avoid outrageously long input and output lines.

Any of the standard assembly techniques from perf-board to etched circuits may be used with extra points for professional appearance and ease of assembly going to the etched circuit boards. Boards may be etched at home using the layouts shown or are available commercially.

As with any semiconductor circuit, heat is a major enemy so stick to as small a soldering iron as possible (no larger than 35 watts in any case) and wherever possible

heat sink semiconductor leads while soldering. Do not use a soldering gun. The induced EMF generated when they're turned on and off has crunched more than one previously healthy transistor.

Like electrical assembly, the mechanical assembly techniques used can be adapted from whatever you have available. Our standard module is 2 inches wide by 4 inches high with double and triple modules being 4 and 6 inches wide respectively. Front panels may be made of whatever materials you have handy from sheet aluminum to scrap copper-clad. Paint and mark the panels before installing any controls, jacks, etc. In prototypes the front panels are attached to the circuit boards with 4-40 hardware and small "L" brackets.

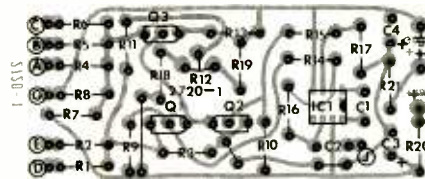
Voltage-controlled amplifier

Most important characteristics of synthesized sounds are their attack times—how fast they build up. Taken together, these two characteristics are ordinarily referred to as envelope or dynamics. In a synthesizer, the envelope is produced by an amplifier whose gain is determined by one or more control voltages. Ordinarily the control voltages are added together and the gain is proportional to the sum so that any control input that is not connected represents zero voltage and does not contribute to the sum.

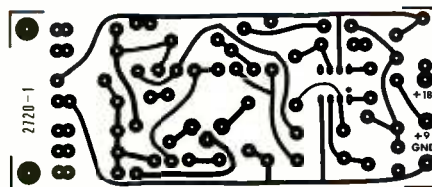
Since many sounds require that the amplifier be switched from an essentially isolating condition to full gain in 2 ms or less, the primary concern in designing a VCA is that none of the control voltage appear as part of the audio output. If it does, the result is at best annoying "pops" and "clicks" and at worst blown loudspeakers. In my VCA (Voltage Controlled Amplifier) this problem is eliminated by using the control voltage to set constant current source (Q3) common to both emitters of a differential pair Q1 and Q2. Since the gain of a transistor is proportional to its collector current, increasing the current increases the gain of the pair.

Increasing the collector current also increases the voltage drop across load resistors R9 and R10. Since these two voltages are equal for matched transistors they ap-

pear as a common mode voltage at the inverting and noninverting inputs of the operational amplifier IC1 and are rejected at the common mode rejection ratio of the amplifier (about 90 dB for the 748 op-amp). The audio signal on the other hand is applied to the base of Q1 and appears 180° out of phase between the two collectors of Q1 and Q2. When these out of phase signals are applied to the inputs of the op-amp they are slightly amplified and appear at the output.



WHERE PARTS ARE LOCATED on the PC board for the voltage-controlled amplifier.



PC BOARD PATTERN for the voltage-controlled amplifier is half-size.

Control voltages are summed using a simple passive summing network (R4, R5 and R6). R1 and R2 allow the VCA to be used as a two-input audio mixer. Circuit values are selected so that when the inputs add up to 5V there is unity gain between the "0 dB" input and the output while there is a 3 dB power gain between the "3 dB" input and the output.

Test the completed module by connecting an audio signal source to one of the inputs and jumpering the output to an amplifier. Apply a variable 0 to 5V supply (such as one of the power supply's bias outputs) to one of the control voltage inputs and observe that varying the control voltage varies the gain. Note that there is no provision for dc isolation of the audio inputs so if a signal source other than the VCO is used in this test, an external isolation capacitor must be provided.

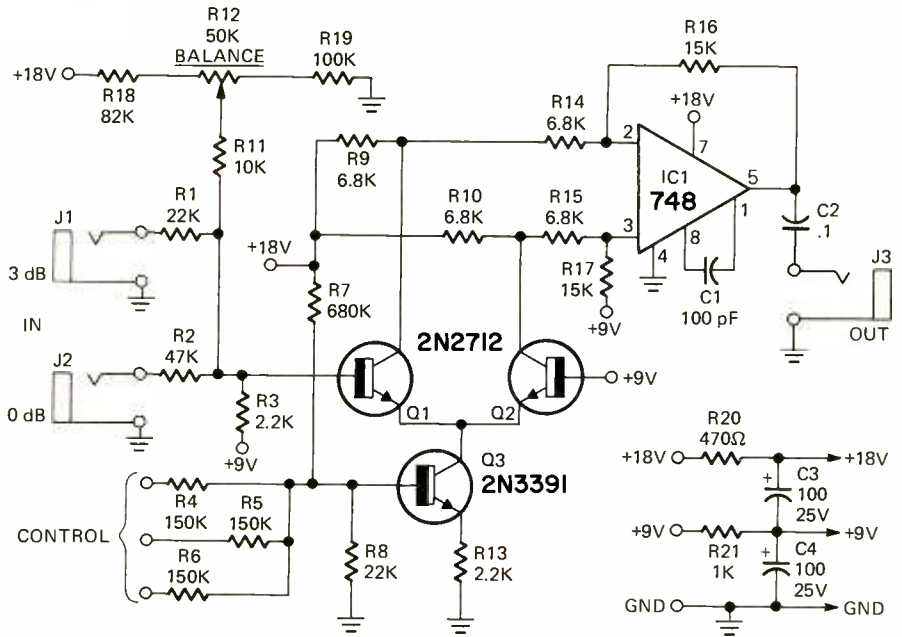
Of the modules described in this article, the VCA is the only one that requires any sort of calibration. Potentiometer R12 must be adjusted so that the characteristics of the differential pair Q1 and Q2 are as nearly identical as possible. The quickest and easiest way to perform this adjustment is to use the output of the control oscillator (described later) as a control voltage input source. With both audio inputs to the VCA open, jumper the 5V peak-to-peak output of the control oscillator to one of the VCA

*President, PAIA Electronics.

control voltage inputs. Jumper the output of the VCA to the input of an amplifier and set the control oscillator for its maximum frequency. At this point you will probably hear a "popping" from the amplifier at the same frequency as the control oscillator signal. This is the control voltage being coupled into the audio channel. Simply adjust R12 for minimum pop, indicating that the two transistors are matched.

All resistors are 1/2W 10% unless noted

- R1, R8—22,000 ohms
- R2—47,000 ohms
- R3, R13—2,200 ohms
- R4, R5, R6—150,000 ohms
- R7—680,000 ohms
- R9, R10, R14, R15—6,800 ohms
- R11—10,000 ohms
- R16, R17—15,000 ohms
- R18—82,000 ohms
- R19—100,000 ohms
- R20—470 ohms
- R21—1,000 ohms
- R12—50,000 ohms, trimmer potentiometer
- C1—100-pF ceramic
- C2—.1-μF disc or mylar
- C3, C4—100-μF 25V electrolytic
- IC-1—748 op-amp
- Q1, Q2—2N2712
- Q3—2N3391



VOLTAGE-CONTROLLED AMPLIFIER uses a differential-pair fed from a constant-current source to drive the IC op-amp. Control voltages are summed in Q3's base circuit.

band-pass filter

Next to dynamics, a sound's most important property is timbre. Everybody has a feeling that timbre in some way relates to the body that a sound has, but in technical discussions this term refers to the constant or time-varying harmonic content of the signal.

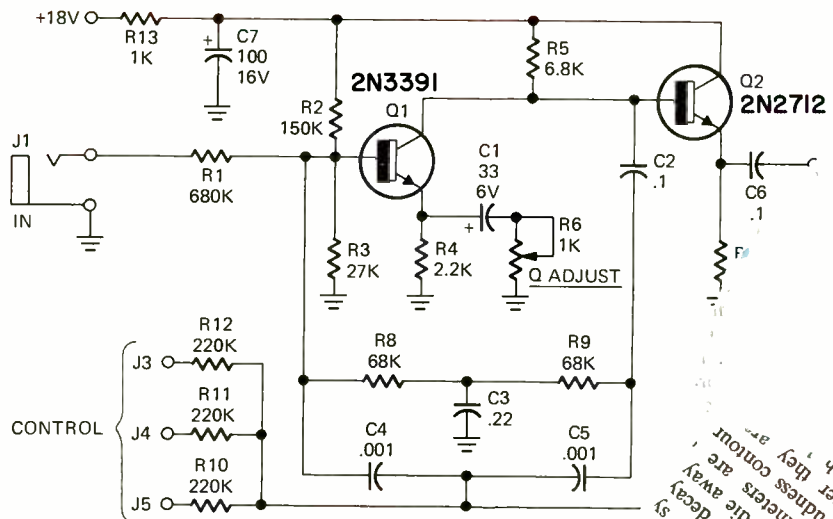
Synthesizers produce various timbral properties using formant synthesist techniques. This is a fancy way of saying that instead of summing together a bunch of sine waves to arrive at a desired sound you start out with a waveform that has more harmonics than you need and use filters to eliminate the ones you don't want.

If the timbre is to be time-varying, as it should be to produce musically interesting sounds, there must be some convenient way to change the characteristics of the filter being used. Once again, voltage control comes to the rescue by allowing us to turn the job of varying the filter parameters over to automatic function generating circuitry.

In our band-pass filter, resistors R8 and R9 in combination with capacitors C3, C4 and C5 and the equivalent impedance of diode D1 form a parallel-T notch filter in the feed-back loop of the common emitter gain stage Q1. The combination of a gain block with a notch filter for negative feed-back produces a band-pass circuit.

Voltages applied to the three control voltage inputs are summed by resistors R10, R11 and R12 and cause a current to flow through diode D1. As the current flow through the diode increases, the diode's equivalent ac impedance decreases (because of the slope of the diode curve) and causes the center frequency of the notch filter to be raised.

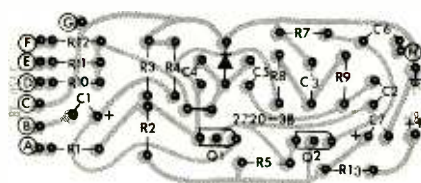
Potentiometer R6 varies Q1's gain by decreasing or increasing the emitter by-pass. As the amplification provided by the gain stage is increased it tends to overcome



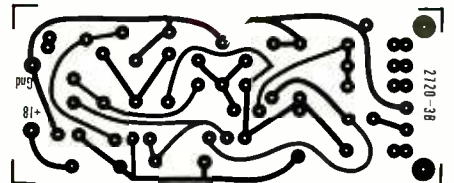
IN THE BAND-PASS FILTER, diode D1 replaces the shunt resistor in a parallel-T notch filter. Voltages vary D1's impedance and modify the filter's center frequency.

All resistors 1/2W 10% unless noted

- R1—680,000 ohms
- R2—150,000 ohms
- R3—27,000 ohms
- R4—2,200 ohms
- R5—6,800 ohms
- R7—4,700 ohms
- R8, R9—68,000 ohms
- R10, R11, R12—220,000 ohms
- R13—1,000 ohms
- R6—1,000 ohms,
- C1—33-μF 6V electrolytic
- C2, C6—.1-μF Mylar
- C3—.22-μF Mylar
- C4, C5—.001-μF ceramic
- C7—100-μF 16V electrolytic
- D1—1N914
- Q1—2N3391
- Q2—2N2712



WATCH TRANSISTOR LEAD PLACEMENT when wiring the band-pass amplifier board.



HALF-SIZE FOIL PATTERN for the active band-pass filter. Direct wiring is OK too.

arrives, for, just like a typewriter, we don't want to enter anything while the carriage goes back to the beginning of a line. The only time we actually enter a character is once when the cursor board tells us it is the right time, then only if we are working on this page, want to change the character, and are not trying to return the carriage.

About keyboards

So where do we get our characters? The simplest and far cheapest source is from six switches and a pushbutton, arranged to get us +5 for a "1" and ground for a "0," and set up so the pushbutton gives you a sudden +5 to ground. "Key-pressed" output. This is handy (almost essential) for testing, and can be used for a bit of practice to get any speed. A keyboard is the next best bet, such as the low-cost keyboard in the February 1973 issue of *Radio-Electronics*, and its low-cost companion ASCII encoder (April 1973). Many of the surplus keyboards offered in the back pages of *Radio-Electronics* can also be either used directly or readily adapted.

The input code *must* be in ASCII. Any keyboard that consists of one or two make contacts per key *must* be converted in a suitable encoder, again such as the low-cost ASCII encoder described in the March 1973 issue of *Radio-Electronics*. Further, the ASCII output *must* never exceed the internal +5 volt supply of the typewriter, nor should it go below ground, even by a small amount.

Jumpers on the timing band allow for selection of 12 possible display positions so that internal TV adjustments need not be changed.

Character generation

We use raster-scan dot-matrix characters providing an array of 5 dots wide by 7 dots high for each character with one "underscore" between characters for spacing. Seven passes of the TV raster are needed to generate each line of characters. This says we must borrow one line's worth of characters from the memory and put it into a new line register memory, use it over again (32) from the memory and put it into a board's space bar during the clearing process. A better way is to remove the key-board encoder power (via the UNCLEAR or not-clear line from HOME switch S6) from the encoder to get all 0's out. Then a "1" can be forced to the 46 input line to set up the proper code. This gives us a one-button clearing operation. Other schemes can easily be worked out, but the essential thing is that the 10000 code gets set up during the time you want to erase what you have.

We normally put a character into memory and leave it there for a relatively long time. The memory usually is in a *recirculate* mode where its own output is connected internally back to its input. The memory is a *serial* device—the bits take turns coming out one at a time, and 512 pairs of clock pulses are needed to turn the memory over exactly once.

The memory is normally in the *recirculate* mode. We keep it there if we are using the other page or if we have out each character it is working on. The output of the character generator goes to an output register that converts the characters into actual video. We also force it to recirculate if a *KEEP-CHANGE* switch in the KEYP position. We also force it to recirculate if a *CR-SPACE RETURN* command (a6 and a7 = 0) add it for video tiling or other places where you must superimpose the TV Typewriter's output onto an existing program. We assign 48 possible character positions across the TV screen, but we only use 32 of them. The remaining 16 allow for trace and the extreme overscan used on economy TV's. We assign 12 scan lines per row of characters. The uppermost scan line is blank except possibly for a winking cursor that appears as a bar above the next character to get input. The next 7 lines form the character as a series of dots 5 dots wide by 7 dots high, and the final 4 lines are blank. These allow for the space between character lines.

We likewise assign 22 possible characters for a "0," and set up so the pushbutton gives you a sudden +5 to ground. "Key-pressed" output. This is handy (almost essential) for testing, and can be used for a bit of practice to get any speed. A keyboard is the next best bet, such as the low-cost keyboard in the February 1973 issue of *Radio-Electronics*, and its low-cost companion ASCII encoder (April 1973). Many of the surplus keyboards offered in the back pages of *Radio-Electronics* can also be either used directly or readily adapted.

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Each character takes six bits of storage, arranged as one parallel 6-bit word. The storage is used to hold the character from time of entry until it is no longer needed, which can range from seconds to days. For a single-page memory of 512 characters, we use six 512-bit recirculating MOS shift registers. These go around once each TV frame. The timing and cursor boards together decide *where* in each of the six registers a new character is to go. Once in memory, the character stays in the same relative slot until it is cleared or replaced. The memory is volatile, meaning that you lose the message if power drops for more than a half a second or so.

Note that an ASCII blank is 10000. All 1's is a "0" and all 0's is an "1." This is helpful when troubleshooting, for its rather difficult to get a totally blank screen by accident. On the other hand, this means we have to be careful when we clear out memory to erase the screen. Here, we purposely have to set up the 10000 code. One way to do this, is to hold down the key-board's space bar during the clearing process. A better way is to remove the key-board encoder power (via the UNCLEAR or not-clear line from HOME switch S6) from the encoder to get all 0's out. Then a "1" can be forced to the 46 input line to set up the proper code. This gives us a one-button clearing operation. Other schemes can easily be worked out, but the essential thing is that the 10000 code gets set up during the time you want to erase what you have.

We normally put a character into memory and leave it there for a relatively long time. The memory usually is in a *recirculate* mode where its own output is connected internally back to its input. The memory is a *serial* device—the bits take turns coming out one at a time, and 512 pairs of clock pulses are needed to turn the memory over exactly once.

The memory is normally in the *recirculate* mode. We keep it there if we are using the other page or if we have out each character it is working on. The output of the character generator goes to an output register that converts the characters into actual video. We also force it to recirculate if a *KEEP-CHANGE* switch in the KEYP position. We also force it to recirculate if a *CR-SPACE RETURN* command (a6 and a7 = 0) add it for video tiling or other places where you must superimpose the TV Typewriter's output onto an existing program. We assign 48 possible character positions across the TV screen, but we only use 32 of them. The remaining 16 allow for trace and the extreme overscan used on economy TV's. We assign 12 scan lines per row of characters. The uppermost scan line is blank except possibly for a winking cursor that appears as a bar above the next character to get input. The next 7 lines form the character as a series of dots 5 dots wide by 7 dots high, and the final 4 lines are blank. These allow for the space between character lines.

We likewise assign 22 possible characters for a "0," and set up so the pushbutton gives you a sudden +5 to ground. "Key-pressed" output. This is handy (almost essential) for testing, and can be used for a bit of practice to get any speed. A keyboard is the next best bet, such as the low-cost keyboard in the February 1973 issue of *Radio-Electronics*, and its low-cost companion ASCII encoder (April 1973). Many of the surplus keyboards offered in the back pages of *Radio-Electronics* can also be either used directly or readily adapted.

The input code *must* be in ASCII. Any keyboard that consists of one or two make contacts per key *must* be converted in a suitable encoder, again such as the low-cost ASCII encoder described in the March 1973 issue of *Radio-Electronics*. Further, the ASCII output *must* never exceed the internal +5 volt supply of the typewriter, nor should it go below ground, even by a small amount.

Each character takes six bits of storage, arranged as one parallel 6-bit word. The storage is used to hold the character from time of entry until it is no longer needed, which can range from seconds to days. For a single-page memory of 512 characters, we use six 512-bit recirculating MOS shift registers. These go around once each TV frame. The timing and cursor boards together decide *where* in each of the six registers a new character is to go. Once in memory, the character stays in the same relative slot until it is cleared or replaced. The memory is volatile, meaning that you lose the message if power drops for more than a half a second or so.

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We normally put a character into memory and leave it there for a relatively long time. The memory usually is in a *recirculate* mode where its own output is connected internally back to its input. The memory is a *serial* device—the bits take turns coming out one at a time, and 512 pairs of clock pulses are needed to turn the memory over exactly once.



INSIDE VIEW SHOWS STACKED BOARDS containing the electronic circuits in the TV typewriter.

PARTS LIST

- MAINFRAME**
 C1-5000-µF 10-V electrolytic
 C2, C3-1000-µF 25-V electrolytic
 C4-100-µF 6-V electrolytic
 C5, C7-470-pF disc for vht bypassing
 C6-30-pF trimmer
 C8-27-pF mica
 C9-47-pF mica
 C10-Gimmick attenuator made of twin lead
 D1 to D6-1N401 or equal
 D7-12-V, 1-W Zener, 1N4742 or equal
 D8-6.8-V, 1-W Zener, 1N4736 or equal
 D9-5.1-V, 1-W Zener, 1N4734 or equal
 D10 to D14-1N914 or equal
 F1-1-A fuse and fuseholder
 IC1-7805 regulator (Fairchild or Motorola)
 J1, J2-Binding posts, one yellow, one black (5 way)
 L1-Coil made from 4" of No. 14 solid wire
 Q1-2N918 transistor in metal can, do not substitute!
 R1, R2-47 ohms, ½-W
 R3-22 ohms, ½-W
 R4, R9, R10-2200 ohms, ¼-W
 R7-470 ohms, ¼-W
 R8-470 ohms, ¼-W
 R9-470 ohms, ¼-W
 S1, S2, S3, S4, S7, S8-dpdt rocker switch
 S5 to S6-dpdt rocker switch, momentary spring return
 SO1 to SO6-connector, Molex 09-52-3103
 SO7-TV lead-in connector
 T1-Power transformer, dual 12-V center tapped secondaries, 1.5-A, Signal 24-1A or equal
 MISC.-PC Board, 8 ½ x 6 ¾; mounting brackets and hardware (6); switch mounting hardware (8 sets); line cord and cable clamp; No. 24 jumper wire; sleeving; No. 14 wire for hardware for T1; vertical heat sink for IC1; fuse clips and hardware, 300-ohm twin-lead, 18"; PC terminals, optional-2; solder.
- CURSOR**
 C1-1200-pF mica
 C2-4300-pF mica
 C3-620-pF mica
 C4-620-pF mica
 C5-1000-pF mica
 C6 to C9, C12 to C15-0.1-µF disc ceramic
 C10-100-µF 6-V electrolytic
 C11, 16-10-µF 6-V electrolytic
 IC1-7408 quad AND gate, TTL
 IC2, IC4-7419 or 7417 or 8281 or 8291 diode by 16 TTL
 IC3-7473 dual JK TTL
 IC5, IC6-7402 quad NOR gate TTL
 IC7-7474 dual D flip-flop, TTL
 IC8-7400 quad NAND gate, TTL
 IC9-555 timer, Signetics
 P1 to P60-pins to fit Molex 09-52-3103 connector
 Q1-2N5129
 R1, R5, R8, R13, R16, R21-1000 ohms, ¼-W
 R2, R3, R4, R6, R7, R9, R11, R14, R17, R18, R22-2200 ohms, ¼-W
 R10, R19-330 ohms, ¼-W
 R12-100 ohms, ¼-W
 R15-100,000 ohms, ¼-W
 R20-150 ohms, ¼-W
 SO1 to SO6-Molex 09-52-3103 connector
 MISC: PC Board, 4 ½" x 6 ¾"; No. 24 wire jumpers; sleeving; PC terminals (optional-8); solder.

MEMORY BOARD
 Note: Each system needs one "Memory A" board. Memory "B" boards are optional. These parts are needed for either a Page A or a Page B memory.
 C1, C3, C5, C7-100-µF 15-V electrolytic
 C2, C4, C6, C8, C9, C10, C11-0.1-µF disc ceramic
 D1, D4, D5, D6-1N914 or equal
 D2, D3, D7-1R401 or equal
 IC1 to IC6-2524 MOS 512-bit recirculating shift register (Signetics)
 IC7-7406 hex driver, TTL
 P1 to P60-Connector pins to fit Molex 09-52-3103 connectors
 Q1, Q2-2N5139
All resistors ¼-W carbon
 R1 to R6, R25-2200 ohms
 R7, R8, R15-2.7 ohms
 R9, R23-10,000 ohms
 R10, R12-22 ohms
 R11, R13-4700 ohms
 R14, R18, R19, R20-150 ohms
 R16, R17-100 ohms
 R21, R22-1000 ohms
 R24-330 ohms
 R26-470 ohms
These parts are needed ONLY for a page A memory:
 C12-680-pF mica
 C13-100-pF mica

Timing board:
 No. TVT-2, \$5.75
Cursor board:
 No. TVT-3, \$5.75
Page A or B board
 No. TVT-4, \$5.75
High-quality keyboard, custom remanufactured for TV typewriter use (less-encoder)
 No. TVT-5, \$18.75

All circuit boards are etched and drilled
 No. TVT-1, \$9.75
Maintenance board:
 No. TVT-2, \$5.75
Timing board:
 No. TVT-3, \$5.75
Cursor board:
 No. TVT-4, \$5.75
Page A or B board
 No. TVT-5, \$18.75
High-quality keyboard, custom remanufactured for TV typewriter use (less-encoder)
 No. TVT-5, \$18.75

The following items are available from Southwest Technical Products, 219 West Rhapsody, San Antonio, Texas, 78216.

A complete or nearly complete kit of parts will also be offered, but pricing depends on semiconductor availability at time of publication. Write for a complete list of available parts and prices for assembled units.

Since line No. 1 is supposed to be all blanks, the character generator is told this and we get all blanks, except possibly for a brief cursor blinking bar.

On the second scan line, we again clock the line register 32 times, letting it go once around. The main memory just waits. This time, the character generator is told to work on line No. 2 and please put down the top row of dots on each character. For instance, if a "T" comes up, we get five "T's" in a row. An "S" would be 01110 and so on. As the TV scans across, each row of dots for each following character is put down.

On the next pass, we again clock the line register 32 times. This time, the second row of dots gets output, with a "T" being a 00100 and an "S" being 10001, and so on. Lines No. 4, 5, 6, 7, and 8 are handled the same way, with the character generator working on the line it is told to and the line register going once around for each line. By the end of the eighth line we have put down all the dots we need for a line of 32 complete dot-matrix characters. The circuitry is blanked for the next four scan lines, providing us with a space between character lines.

On line No. 13 (a new line "1"), our main character memory is once again clocked 32 times and the line register is simultaneously clocked. This fills up the line register with a new set of 32 characters. The same operation repeats for each of the sixteen rows of characters that we want to put down.

Notice that the timing runs in bursts and is not continuous. Thus, the line register runs for 32 counts and waits 16 for retrace and so on. The memory does the same thing, but only on every twelfth line during the active scan. Carefully established internal timing delays take care of settling times between memory, line register, character generator, and the final video generating output register. The output register converts the five parallel outputs of the character generator into serial, high speed video.

So far, we've assumed that we were using the page-A memory with the page-A character generator. Thanks to the memory bus (bl through b6) we can connect anything we like to the character generator, including the page-A memory, the page-B memory, or anything else we want to hang on these lines.

To run page-B, we simply disable the page-A memory and enable the page-B bus organization. The handy thing about bus organization is that no complex switching is involved. Whatever is enabled gets connected to the character generator; other things tacked on just sit there. The only restriction is that we have to enable only one character source at a time. We can also use the same memory bus optionally to output characters to a computer, a cassette recorder, or a phone line.

This way, with suitable add-ons we have a choice. We can send one character at a time directly from the keyboard, or we can send an entire page at a time from the memory. The latter is faster and more complex but has the advantages that you can fix all the mistakes first and don't tie up nearly as much outside equipment.

more SYNTHESIZER modules

Part IV: You've built the keyboard and the basic electronic circuits. Here are four modules to enhance your instrument.

by JOHN S. SIMONTON, JR.*

BY NOW YOU SHOULD HAVE A GOOD START on your synthesizer. You've built the VCO, keyboard controller and power supply from articles in May, June and July issues. Now we will finish the basic package by assembling a voltage-controlled amplifier, two types of voltage-controlled filters, a noise source, envelope generator and low-frequency control oscillator.

Rather than go through the same tired old warnings about soldering and component polarity for each module, let's just get them all out of the way at once. These same precautions and assembly details apply to all the modules.

As you might expect, there is nothing really critical about the assembly of any of the modules we will look at. There are no

high frequencies involved so other than standard rules of good practice for audio assembly work lead dress and component arrangement are not critical. Keep outputs and inputs separated as much as possible and avoid outrageously long input and output lines.

Any of the standard assembly techniques from perf-board to etched circuits may be used with extra points for professional appearance and ease of assembly going to the etched circuit boards. Boards may be etched at home using the layouts shown or are available commercially.

As with any semiconductor circuit, heat is a major enemy so stick to as small a soldering iron as possible (no larger than 35 watts in any case) and wherever possible

heat sink semiconductor leads while soldering. Do not use a soldering gun. The induced EMF generated when they're turned on and off has crunched more than one previously healthy transistor.

Like electrical assembly, the mechanical assembly techniques used can be adapted from whatever you have available. Our standard module is 2 inches wide by 4 inches high with double and triple modules being 4 and 6 inches wide respectively. Front panels may be made of whatever materials you have handy from sheet aluminum to scrap copper-clad. Paint and mark the panels before installing any controls, jacks, etc. In prototypes the front panels are attached to the circuit boards with 4-40 hardware and small "L" brackets.

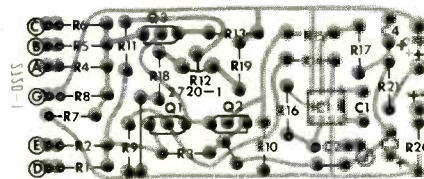
voltage-controlled amplifier

The two most important characteristics of natural or synthesized sounds are their attack and decay times—how fast they build up and die away. Taken together, these two parameters are ordinarily referred to as loudness contour or dynamics. In a synthesizer they are produced by an amplifier which has its gain determined by one or more control voltages. Ordinarily the control voltages are added together and the gain is proportional to the sum so that any control input that is not connected represents zero voltage and does not contribute to the sum.

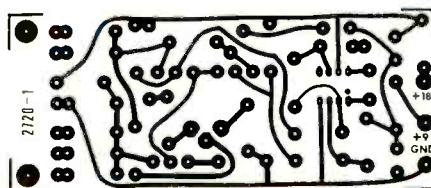
Since many sounds require that the amplifier be switched from an essentially isolating condition to full gain in 2 ms or less, the primary concern in designing a VCA is that none of the control voltage appear as part of the audio output. If it does, the result is at best annoying "pops" and "clicks" and at worst blown loudspeakers. In my VCA (Voltage Controlled Amplifier) this problem is eliminated by using the control voltage to set constant current source (Q3) common to both emitters of a differential pair Q1 and Q2. Since the gain of a transistor is proportional to its collector current, increasing the current increases the gain of the pair.

Increasing the collector current also increases the voltage drop across load resistors R9 and R10. Since these two voltages are equal for matched transistors they ap-

pear as a common mode voltage at the inverting and noninverting inputs of the operational amplifier IC1 and are rejected at the common mode rejection ratio of the amplifier (about 90 dB for the 748 op-amp). The audio signal on the other hand is applied to the base of Q1 and appears 180° out of phase between the two collectors of Q1 and Q2. When these out of phase signals are applied to the inputs of the op-amp they are slightly amplified and appear at the output.



WHERE PARTS ARE LOCATED on the PC board for the voltage-controlled amplifier.



PC BOARD PATTERN for the voltage-controlled amplifier is half-size.

Control voltages are summed using a simple passive summing network (R4, R5 and R6). R1 and R2 allow the VCA to be used as a two-input audio mixer. Circuit values are selected so that when the inputs add up to 5V there is unity gain between the "0 dB" input and the output while there is a 3 dB power gain between the "3 dB" input and the output.

Test the completed module by connecting an audio signal source to one of the inputs and jumpering the output to an amplifier. Apply a variable 0 to 5V supply (such as one of the power supply's bias outputs) to one of the control voltage inputs and observe that varying the control voltage varies the gain. Note that there is no provision for dc isolation of the audio inputs so if a signal source other than the VCO is used in this test, an external isolation capacitor must be provided.

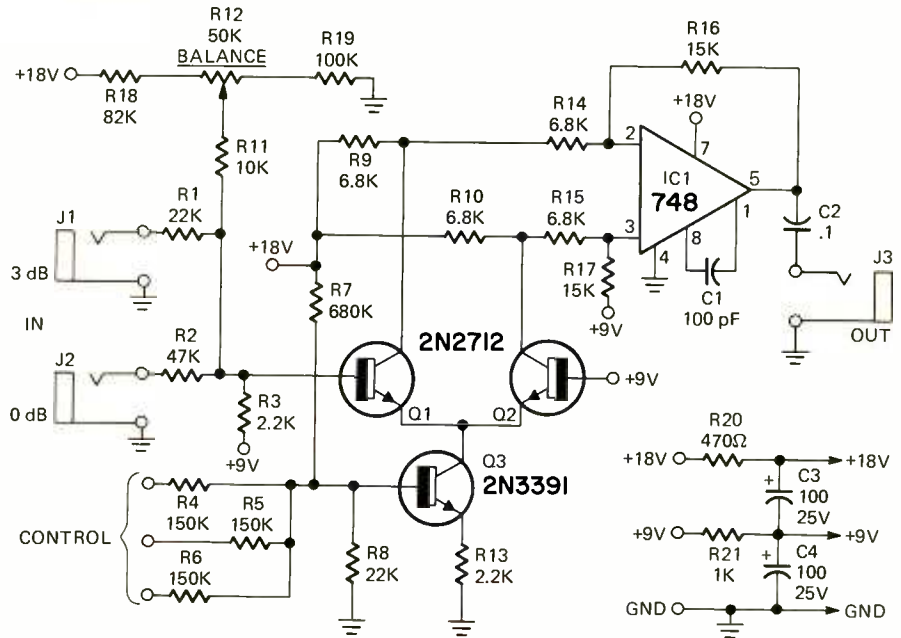
Of the modules described in this article, the VCA is the only one that requires any sort of calibration. Potentiometer R12 must be adjusted so that the characteristics of the differential pair Q1 and Q2 are as nearly identical as possible. The quickest and easiest way to perform this adjustment is to use the output of the control oscillator (described later) as a control voltage input source. With both audio inputs to the VCA open, jumper the 5V peak-to-peak output of the control oscillator to one of the VCA

*President, PAIA Electronics.

control voltage inputs. Jumper the output of the VCA to the input of an amplifier and set the control oscillator for its maximum frequency. At this point you will probably hear a "popping" from the amplifier at the same frequency as the control oscillator signal. This is the control voltage being coupled into the audio channel. Simply adjust R12 for minimum pop, indicating that the two transistors are matched.

All resistors are 1/2W 10% unless noted

- R1, R8—22,000 ohms
- R2—47,000 ohms
- R3, R13—2,200 ohms
- R4, R5, R6—150,000 ohms
- R7—680,000 ohms
- R9, R10, R14, R15—6,800 ohms
- R11—10,000 ohms
- R16, R17—15,000 ohms
- R18—82,000 ohms
- R19—100,000 ohms
- R20—470 ohms
- R21—1,000 ohms
- R12—50,000 ohms, trimmer potentiometer
- C1—100-pF ceramic
- C2—.1- μ F disc or mylar
- C3, C4—100- μ F 25V electrolytic
- IC-1—748 op-amp
- Q1, Q2—2N2712
- Q3—2N3391



VOLTAGE-CONTROLLED AMPLIFIER uses a differential-pair fed from a constant-current source to drive the IC op-amp. Control voltages are summed in Q3's base circuit.

band-pass filter

Next to dynamics, a sound's most important property is timbre. Everybody has a feeling that timbre in some way relates to the body that a sound has, but in technical discussions this term refers to the constant or time-varying harmonic content of the signal.

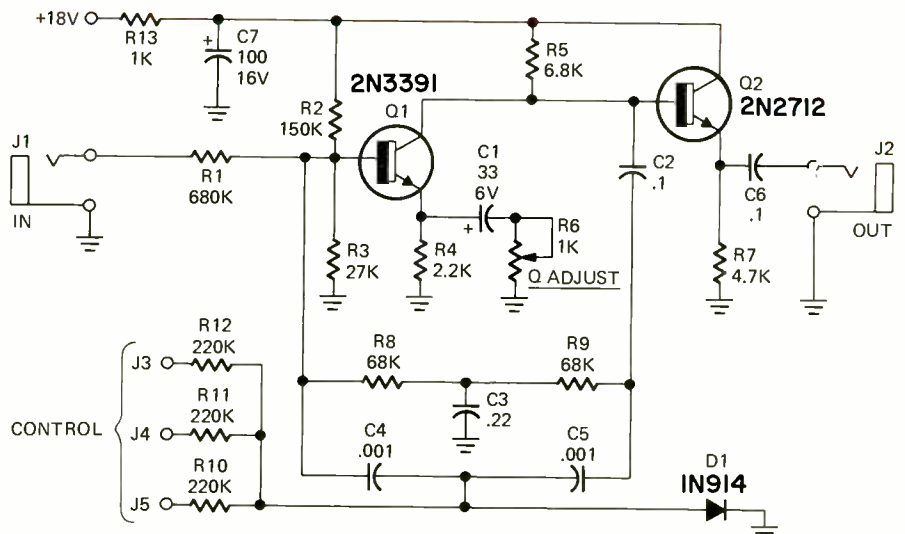
Synthesizers produce various timbral properties using formant synthesis techniques. This is a fancy way of saying that instead of summing together a bunch of sine waves to arrive at a desired sound you start out with a waveform that has more harmonics than you need and use filters to eliminate the ones you don't want.

If the timbre is to be time-varying, as it should be to produce musically interesting sounds, there must be some convenient way to change the characteristics of the filter being used. Once again, voltage control comes to the rescue by allowing us to turn the job of varying the filter parameters over to automatic function generating circuitry.

In our band-pass filter, resistors R8 and R9 in combination with capacitors C3, C4 and C5 and the equivalent impedance of diode D1 form a parallel-T notch filter in the feed-back loop of the common emitter gain stage Q1. The combination of a gain block with a notch filter for negative feed-back produces a band-pass circuit.

Voltages applied to the three control voltage inputs are summed by resistors R10, R11 and R12 and cause a current to flow through diode D1. As the current flow through the diode increases, the diode's equivalent ac impedance decreases (because of the slope of the diode curve) and causes the center frequency of the notch filter to be raised.

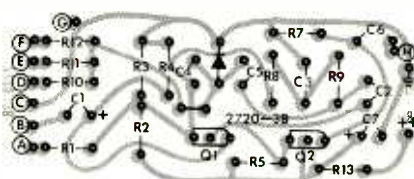
Potentiometer R6 varies Q1's gain by decreasing or increasing the emitter by-pass. As the amplification provided by the gain stage is increased it tends to overcome



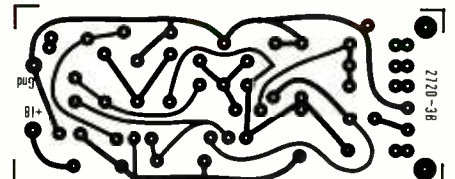
IN THE BAND-PASS FILTER, diode D1 replaces the shunt resistor in the parallel-T filter. Control voltages vary D1's impedance and modify the filter's center frequency.

All resistors 1/2W 10% unless noted

- R1—680,000 ohms
- R2—150,000 ohms
- R3—27,000 ohms
- R4—2,200 ohms
- R5—6,800 ohms
- R7—4,700 ohms
- R8, R9—68,000 ohms
- R10, R11, R12—220,000 ohms
- R13—1,000 ohms
- R6—1,000 ohms, linear taper potentiometer
- C1—33- μ F 6V electrolytic
- C2, C6—.1- μ F Mylar or ceramic
- C3—.22- μ F Mylar
- C4, C5—.001- μ F disc
- C7—100- μ F 16V electrolytic
- D1—IN914
- Q1—2N3391
- Q2—2N2712



WATCH TRANSISTOR LEAD PLACEMENT when wiring the band-pass amplifier board.



HALF-SIZE FOIL PATTERN for the active band-pass filter. Direct wiring is OK too.

more of the losses in the notch filter which has the overall effect of increasing the "Q" of the filter.

The filter is tested by supplying its input with a harmonic rich waveform—the pulse output of the VCO with the duration control at minimum is ideal—and listening to the output as a control voltage variable between 0 and 5 volts is applied to one of

the control inputs. As the control voltage increases you should hear the unmistakable waa-waa of a band-pass filter being swept up and down. Advancing the Q control should make the effect more pronounced. It is one of the peculiarities of this type of filter that as the Q control is advanced the overall gain of the module is also increased but this is not particularly objectionable in

a low-priced unit.

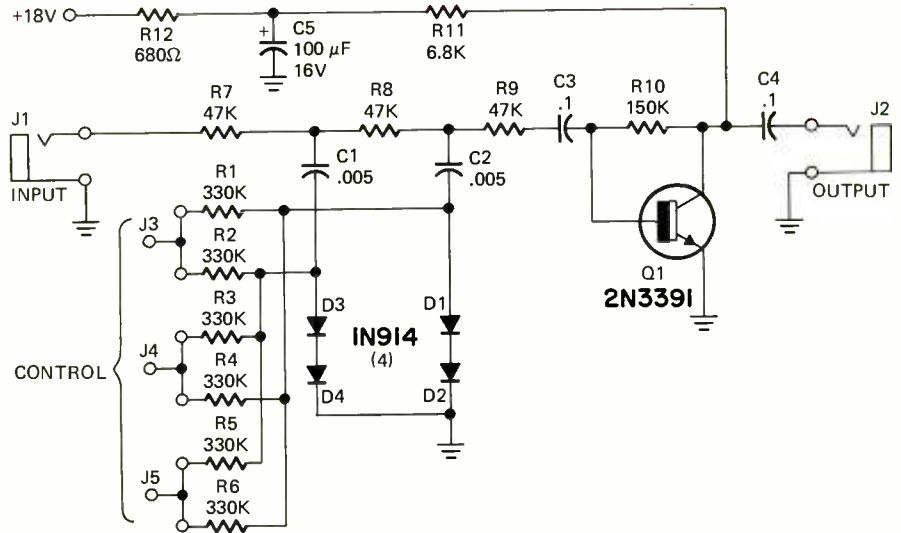
The biggest drawback of this filter is that it will "pop" if the control voltage is stepped very rapidly but you can rationalize this drawback away by reasoning that you really don't ever need to step the control voltage anyway. The nicest thing about the filter is that it's cheap. Several can be built for the cost of the next best design.

low-pass filter

Here we have a rather un-elegant, but low-priced, solution to the filter problem. While the bandpass filter is used to select a particular frequency from a harmonic rich source, the low-pass filter is used to eliminate all frequencies above some cutoff frequency.

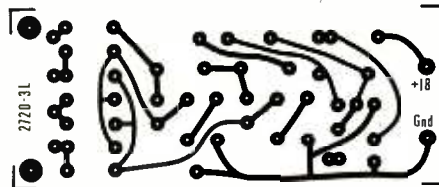
The actual filter part of this circuit is the pi-section composed of resistors R7, R8 and R9, capacitors C1 and C2 and diodes D1 through D4. As with the bandpass filter, the equivalent impedance of the diodes is decreased by increasing the current flow through them. As the impedance of the diodes decreases the cutoff frequency of the filter rolls back. The gain stage Q1 is used to compensate for losses in the filter section.

Like the bandpass filter this module may be tested by supplying it with a harmonic-rich source and listening to the results as the voltage applied to one of the control inputs is increased from 0 to 5V. Unlike the band-pass the sound of this filter will lack the "resonant" quality and be more like the operation of a tone control turned toward accentuated bass.

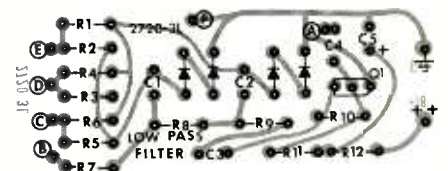


THE LOW-PASS FILTER IS A PI NETWORK feeding the base of Q1. Series diodes tune the filter by varying the impedance of the shunt (capacitive) legs.

All resistors 1/2W 10%
 R1 thru R6—330,000 ohms
 R7, R8, R9—47,000 ohms
 R10—150,000 ohms
 R11—6,800 ohms
 R12—680 ohms
 C1, C2—.005- μ F disc
 C3, C4—.1- μ F ceramic or Mylar
 C5—100- μ F 16V electrolytic
 D1-D4—1N914
 Q1—2N3391



FOIL PATTERN for the low-pass filter. It should be copied twice the size shown.



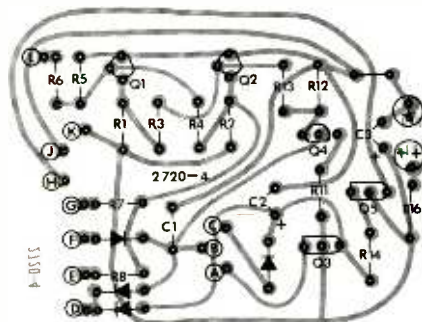
DIODE POLARITY IS IMPORTANT in the low-pass filter. Follow layout carefully.

envelope (function) generator

Now that we have built up a few of the basic synthesizer processing modules we need some way to perform all these automatic control functions we have been talking about.

The primary controller is of course the manual one, the keyboard controlled voltage source that we built last month. But that controller will most often be used to set the pitch of the VCO and what we're after now is producing desired loudness contours and all those terrific time-varying timbral changes.

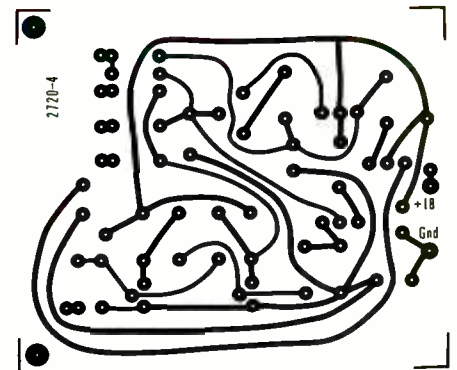
The most important automatic control voltage source is the envelope generator. Essentially this is a module that, on command, produces a voltage that rises to a pre-set level in a pre-determined time, sustains that level for a controllable length of time and then takes a pre-set length of time to decay back to zero. Obviously, this module will generate the attack and decay times required by the VCA to produce dynamics



ENVELOPE GENERATOR parts layout is above. It's half-size foil pattern is at right.

but as we will see it also meets innumerable other needs.

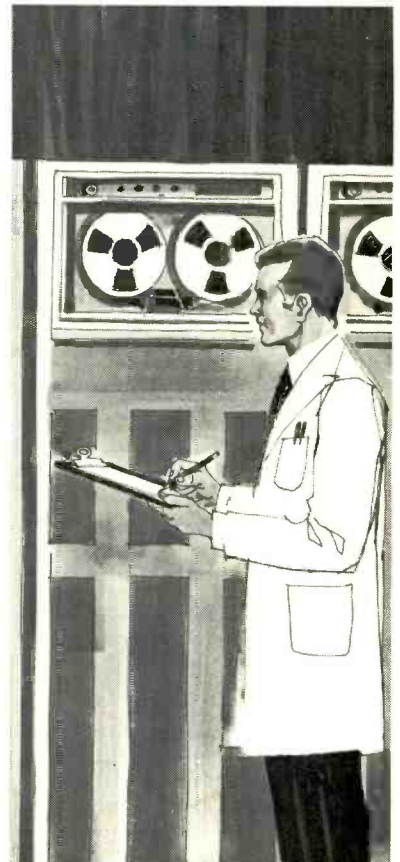
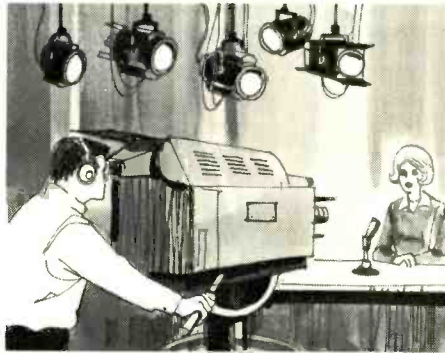
When a short-duration pulse is applied to the input of the circuit shown, it causes bistable Q1 and Q2 to switch so that the collector of Q2 goes high. In this condition



capacitor C1 charges through the "attack" control and forward biases diode D1. When the voltage reaches the triggering threshold of UJT Q4, a pulse appears across R12 which resets the bistable so that C1 dis-

(continued on page 102)

Great careers



Join the high-paid electronics technicians who got their start through NTS Home Training.

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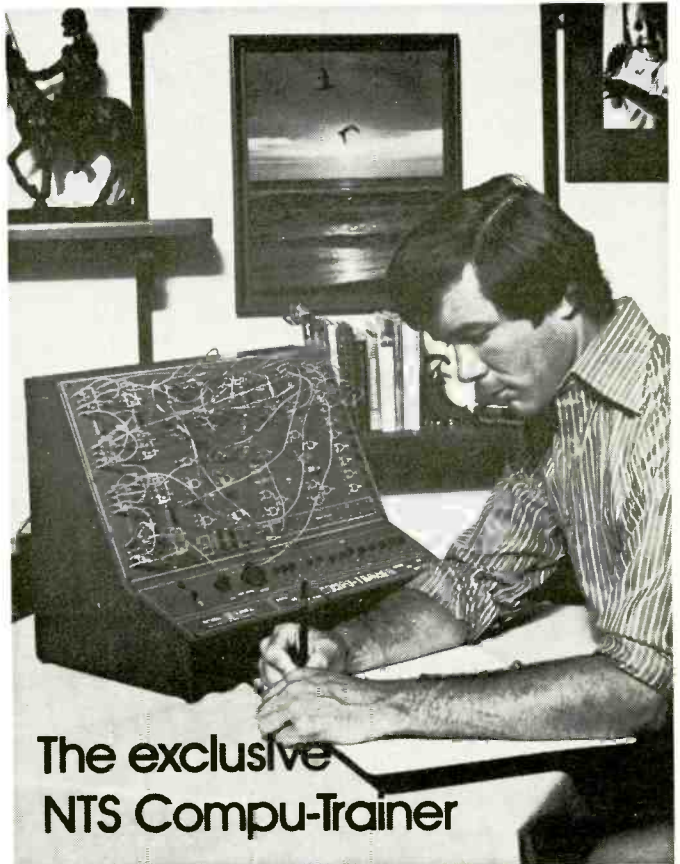
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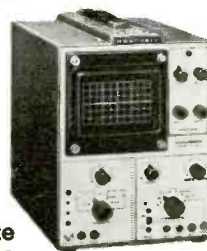
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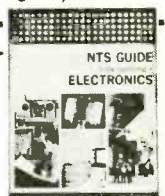
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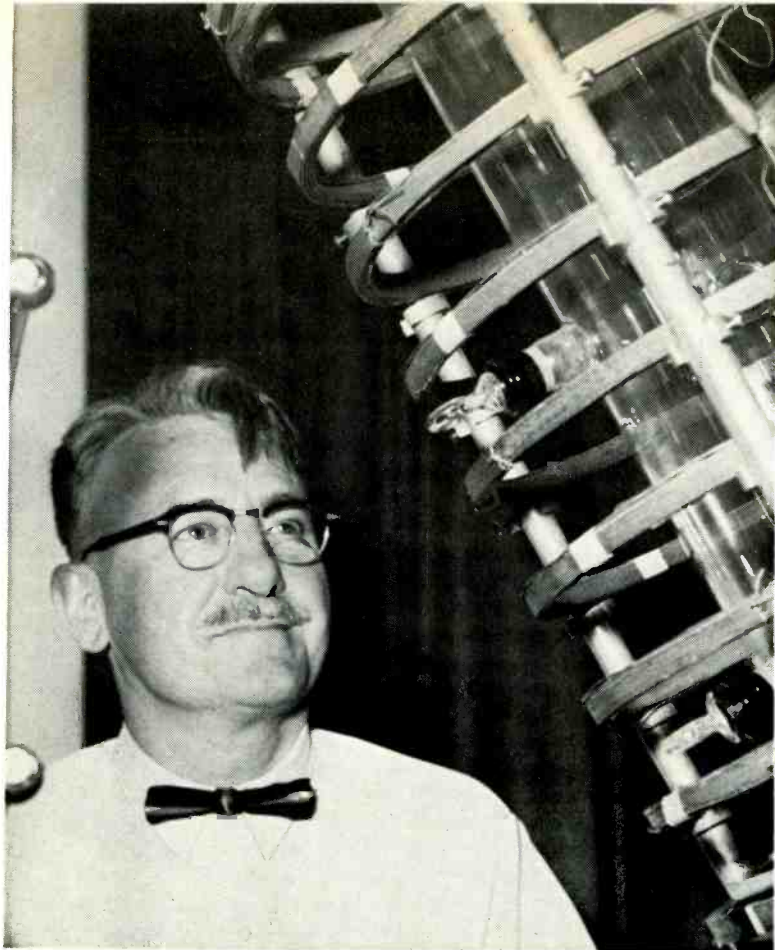
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DR. WILLARD H. BENNETT, PhD. with his experimental magnetic focusing ion plasma tube.

SECRETS OF ION PLASMA TUBES

The electrical conducting coating is "the" vital secret that makes the modern ion plasma tube possible

by JAMES A. GUPTON

"THE GIANT TRANSPARENT TUBE glowed weirdly with angry light, as if the atoms of the gaseous mass were rebelling against the laws of nature. Slowly the plasma began to recede inward as Willard applied power to the multicolored bands ringing the tube. He watched as the plasma condensed into a narrow band of intense energy."

The fantastic potentials of electrical conducting (EC) coatings seem to come from a quotation out of science fiction. Only faint colored fringes give an indication of the presence of the EC coating on glass or quartz, yet this amazing coating provides a conducting path for current and a tough protective shield to the surface. So durable is this coating, once applied it can only be removed with extreme difficulty for it resists all acids.

Electrical conductive coatings have been used for many years. It is a simple process when applied to the surface of flat objects—you just spray it on. The spray process requires a controlled temperature environment to fuse the oxide into the surface. Other than heat, flat coating imposes no special problems. Inside wall coatings have been very difficult to coat with conductive oxides. Not only are uniform coatings virtually impossible to achieve, there is the hazard imposed by volatile mixtures and high temperature.

It was Dr. Willard H. Bennett, Ph.D., Head of Plasma Research at North Carolina State University, who developed a successful process for placing uniform electrical conductive coatings inside tubes. While more involved and complicated than the flat surface method, Dr. Bennett's process provides uniform conductivity throughout the tube and is virtually suitable for cathode ray or plasma tubes since it eliminates the familiar dark gray aquadag coating used for internal conduction of high voltage. Not only do EC coatings provide cleaner tubes, they eliminate possible contamination from aquadag when the electron gun is inserted. By applying a high potential to the EC coating, it would repel plasma in ion laser tubes thus preventing erosion of the tube walls by the plasma. If the EC coating is sectionalized with individual anode connections, it will provide electrostatic focusing or shaping action for plasma or electron beams through the entire length of the tube.

You might have thought that the opening paragraph of this article was from a science-fiction story, instead it was an accurate description of the operation of Dr. Bennett's experimental plasma tube. In this experimental tube EC coatings reveal another feature of importance; they offer no opposition

to magnetic fields or rf energy. Thus a gaseous laser could use EC coatings for beam shaping and still use rf excitation. It is conceivable that the EC coating could be etched into the configuration of an electromagnetic coil to produce magnetic fields but the etch process would destroy the protective shield effect in the etched areas.

In the normal EC coating process, the resistance of the coating is uniform throughout the length of the coating. The resistance can be varied from 20 ohms per square cm to as high as several megohms per square cm. It is possible to produce step-resistance patterns by using a telescoping section of glass to serve as a mask. The mask section is withdrawn during the coating process in gradual steps, depending on the length of step desired. The coating build-up gives each step a certain resistance governed by the number of steps. The last coated section having the higher resistance while the preceding steps run progressively lower in resistance.

To illustrate how EC coatings could be used in plasma control, Fig. 1 shows a cutaway diagram of a demountable plasma tube. The neck-down sections of the tube impose no special problem in applying the EC coating. The sectionalized bands may be masked before coating or etched free after coating. Each segment has a

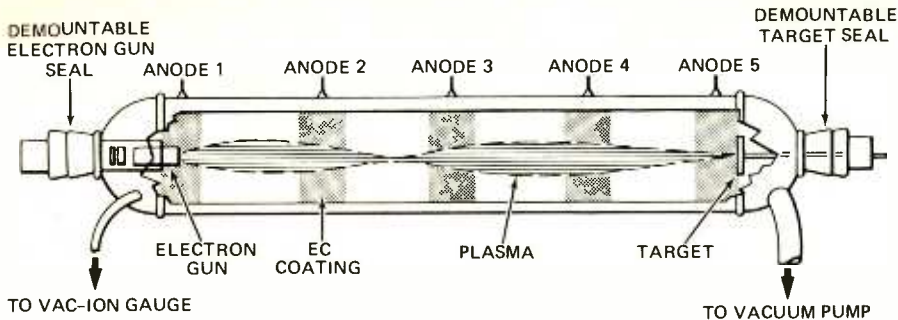
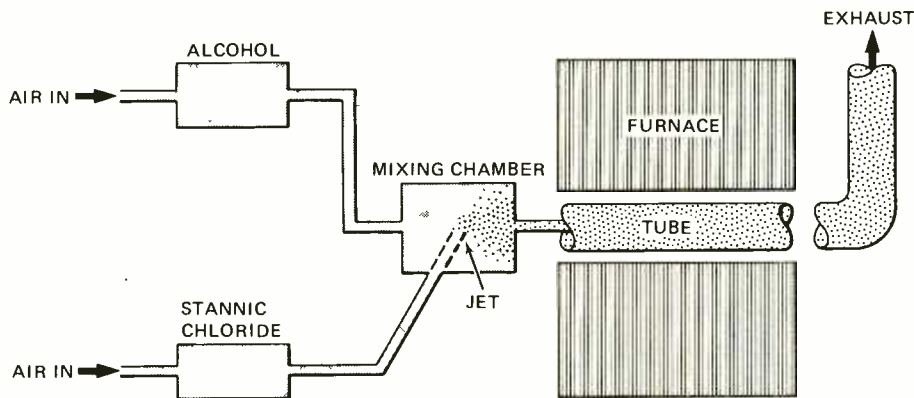


FIG. 1—CUTAWAY VIEW of a demountable plasma tube. Note that each segment has a separate anode connection.



APPLYING EC COATINGS is performed with this kind of equipment setup. Either masking or etching is used to form the anode bands.

separate anode connection to enable different potentials to be applied. The plasma tube, while under constant vacuum pumping, has a pressure of 10^{-3} torr and with an argon atmosphere. (Note: 1 torr = 1 mm mercury;

a reference level used in high-vacuum technology.) The demountable electron gun provides the energy to produce argon ions forming the plasma.

Dr. Bennett theorized that it might be possible to increase the ef-

fective power of gaseous lasers by using EC coating fields to compress the field of excitation by rf energy. The EC coating could pull double duty by providing a static dc potential to shape the field of excitation while simultaneously serving as source of the rf excitation.

For those who detect an apparent discrepancy in the resistivity of the Transparent Electrical Conductive coatings to acid and the "etch" procedure for removing the TEC coating, I have been advised of a newly developed process which etches away the coating without attacking the glass underneath.

The TEC coated glass is placed in hot nitric acid to the point of removal and is slowly withdrawn while a low voltage current is applied to the TEC, as the cathode in an electrolysis process. The removal is so complete that one need only wash away the residue of nitric acid and the glass is ready for use. **R-E**

ACKNOWLEDGMENTS

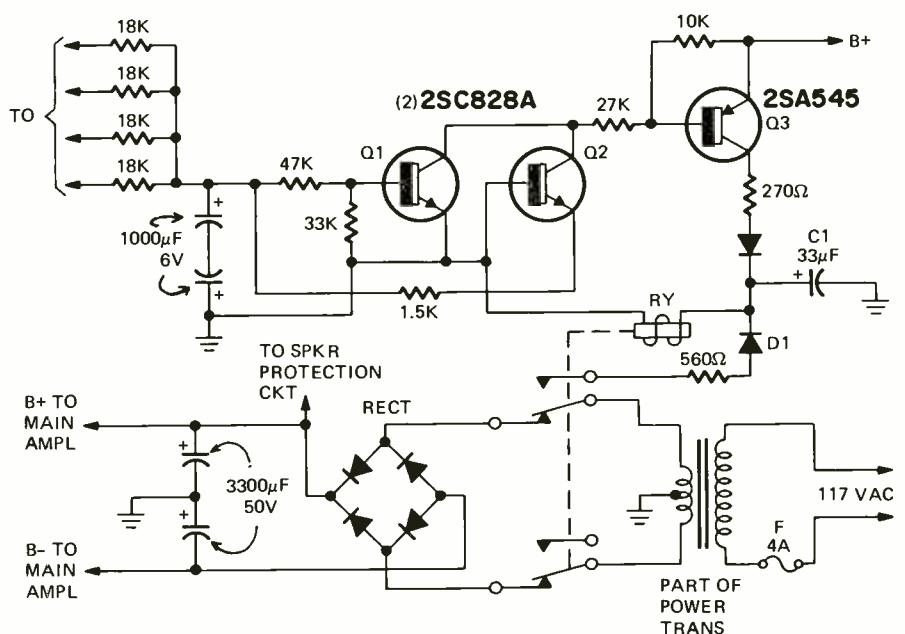
The author wishes to acknowledge the assistance and cooperation of Dr. Bennett in providing the subject material for this article. Dr. Bennett is a Fellow of the American Physical Society, a Fellow of the Washington Academy of Sciences and a Consultant to the Los Alamos Scientific Laboratory. He has authored more than thirty-five major scientific publications and holds over fifty patents. He is listed in *World Who's Who in Science*, in *World Who's Who in Commerce and Industry*, and in *Who's Who in America*.

speaker protection

Electronic circuit protects speakers from damage that might be caused by dc applied because of an amplifier component failure

Loudspeaker protection in Panasonic's model SA-6800X FM/AM 4-channel receiver is provided by this electronic circuit that prevents the speakers from being damaged by dc that might be present at the speaker terminals due to a defect in the output amplifier circuitry. The input to Q1 is bridged across the output terminals of each of the four power amplifiers through 18K-ohm resistors.

A dc voltage present on any of the output terminals is integrated by the 18K-ohm series resistor and the two 1,000- μ F electrolytic capacitors. Q1 turns on if the dc voltage is positive and Q2 turns on when the voltage is negative. Conduction in either Q1 or Q2 turns on Q3 and operates the relay. When the relay pulls in the rectifier bridge is disconnected from the power transformer so the dc supply voltages drop to zero. The relay is then held in by dc supplied by D1 and C1. **R-E**



SPEAKER SPECS

facts and fallacies

Do speaker specs really tell you anything meaningful? Take a look at a spec sheet with Len Feldman and see what he thinks



by **LEN FELDMAN**
CONTRIBUTING HI-FI EDITOR

THERE IS AN OLD TRUISM IN THE HIGH-FIDELITY BUSINESS about loudspeaker systems being the "weakest link" in the audio reproduction chain. A corollary to this generalization might well be that loudspeaker systems are the most poorly defined components in a high-fidelity system, in terms of their performance. It is virtually impossible to pick up two or more so-called specification sheets relating to speaker systems from as many manufacturers and make valid comparisons as to their relative quality or ability to reproduce musical programming accurately.

When you consider that the loudspeakers are, after all, the only component in the system that you *hear*, the more consistent and meaningful specifications relating to the electronic components of a system (tuners, preamplifiers, amplifiers, etc.) tend to assume less importance.

Of course, loudspeaker systems are electromechanical devices, and such devices are much more difficult to "pin down" in terms of performance. In addition, loudspeakers do not perform in a "vacuum" or even in an anechoic chamber when they are finally put to practical use. Their relationship to the room in which they are used, the amplifier which drives them and the listener who hears them form a complex physical and psychoacoustic interplay which is only now becoming the subject of much fundamental research and study.

Nevertheless, that does not justify the fact that many of the "specs" ascribed to consumer type home entertainment loudspeaker systems are totally meaningless and still others are quoted using such a great variety of references that the prospective purchaser usually ends up "trusting his ears" or relying upon specifications which have little or nothing to do with the sound he hears.

The Institute of High Fidelity (an organization composed of some fifty leading component high-fidelity manufacturers) has embarked upon a program of updating outdated measurement standards and formulating new ones for those high-fidelity components (notably speaker sys-

tems) which have never been previously standardized. Admittedly, the most difficult of these "standards" to create will be the one relating to loudspeaker measurements. Nevertheless, I'd like to offer a few thoughts on the subject which may be helpful to those engaged in this work and which may stimulate **Radio-Electronics** readers to make their opinions known to the IHF Standards Committee.

Speaker specs we don't need

In trying to come to some conclusions regarding present-day "specmanship" of speaker manufacturers, I thumbed through the brochures of at least a dozen leading loudspeaker system manufacturers. Besides the lack of uniformity used in quoting what might be considered meaningful specs, I found a few that tell absolutely *nothing* about the sonic performance of the product. These include:

Magnet structure—The weight of the permanent magnet used in a given transducer is proudly quoted by some manufacturers. In some cases it's the weight of the magnet itself—in others, it's the combined weight of the actual magnet and its retaining structure. In *both* cases I fail to see a meaningful relationship between this spec and the sound you may expect to hear from the system. Heavier magnets may or may not result in "better bass", depending upon a great variety of other factors.

Diameter Of Transducers—I have heard very accurate bass from an 8-inch woofer and some pretty "muddy", one-note boom produced by massive 15-inch drivers. One of the best selling systems currently on the market uses a multiplicity of 4-inch elements to produce astoundingly good bass. Diameters of mid-range and tweeter elements tell even less about the ultimate sound quality in this region of the audio spectrum.

Free Air Resonance—An interesting parameter of a transducer as far as the speaker system engineer is concerned (it helps him to design enclosures that *minimize* the effects of this mechanical resonance), but absolutely meaningless as far as the end-user is concerned.

Voice Coil Diameter—Again, this dimension may be helpful to the designer but does not even suggest sonic performance qualities to the purchaser. An analogous spec in an amplifier might be the diameter of the output-transistor housings—interesting, but only very marginally related to the power output capability of the product!

Crossover Frequencies—While this specification may be of interest to the user who plans to use a bi-amp or tri-amp system (separate amplifiers driving the separate transducers in the system—thought by some to be superior to passive L-C crossover systems), most speaker manufacturers who proudly proclaim their various crossover frequencies make no provision for this type of operation.

Let's do away with specs that don't tell the consumer what he's trying to find out—and thereby leave some room on the spec sheet for some meaningful, properly stated specifications!

Speaker specs we need clarified

Frequency response of a loudspeaker system is, of

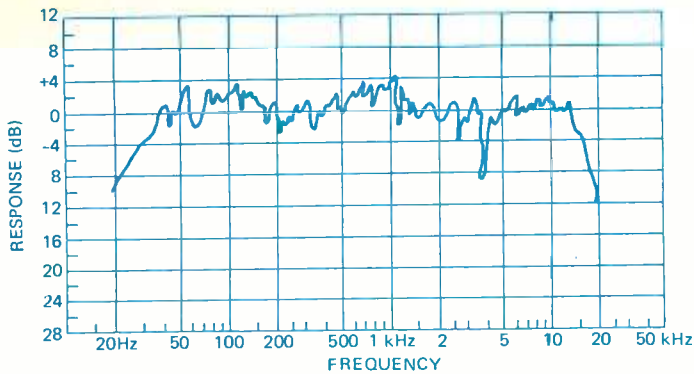


FIG. 1—FREQUENCY RESPONSE CURVE of a typical speaker system. This is a point-to-point plot.

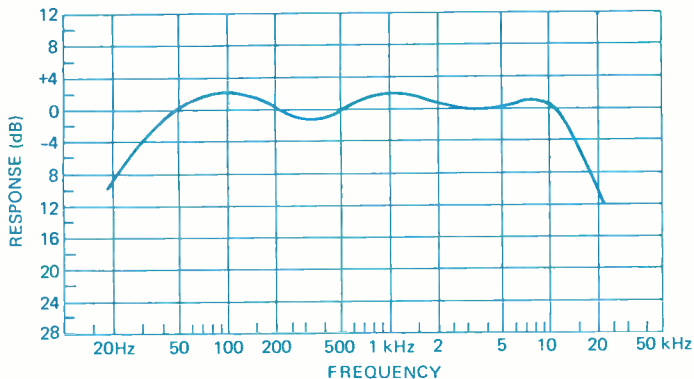


FIG. 2—IT'S THE SAME SPEAKER SYSTEM as in Fig. 1, but the curve has been "smoothed".

course, of paramount importance. The manufacturer who continues to quote frequency response without including a tolerance, or limits in decibels is, of course, guilty of gross misrepresentation. What does "Frequency Response from 30 Hz to 18,000 Hz" mean if the actual sound pressure level is down some 15 dB at 30 Hz and the output contains more harmonics than fundamental 30 Hz?

On the other hand, a statement of "30 Hz to 18,000 Hz ± 3 dB" may be misleading, as well. Consider the frequency response curves shown in Figs. 1 and 2. (Only the very bravest speaker manufacturers publish frequency response curves of any sort, these days!) Given a choice, which system would you buy? The fact is that *both* curves were taken using the *same* speaker system. That of Fig. 1 is a point-for-point plot of a given speaker system, showing all the minor peaks and valleys typical of most speaker systems. The curve in Fig. 2 has been subjected to $\frac{1}{3}$ octave "averaging"—a system whereby the output over each third of an octave has been averaged out to show a smoother response curve.

It has been suggested that human hearing cannot detect irregularities in amplitude response that are less than $\frac{1}{3}$ octave wide and that therefore this "smoother" curve corresponds more nearly to the aural sensation we will get when listening to this particular system. The reasoning may well be valid—but if it is then *all* speaker system response curves should be plotted in this fashion. We have not, of course, dwelt upon where the response curve was taken (anechoic "dead" room, free air, or "typical listening room"), a parameter which is seldom specified by even those few manufacturers who *do* present response curves.

Dispersion is another characteristic of loudspeaker systems which is often referred to by manufacturers in the most general terms. Many mid- and high-frequency transducers have a tendency to "beam" sonic energy so that if the listener is "off-axis" from the speaker system, there is an apparent diminution in high-frequency response. Much

work has gone into the design of tweeters which are capable of "wide angle dispersion," and the results are sometimes quoted in angular degrees—again, with no real reference to decibel limits. To say that a speaker system features "90° dispersion" without relating that number to *either* frequency or \pm dB limits is all but meaningless.

Polar curves such as those shown in Fig. 3 are often plotted in engineering laboratories but hardly ever included in specification sheet presentations. Note, that in this graphic presentation, not one, but several high frequencies have been plotted and as the frequency increases, the angular dispersion is generally less. There remains, of course,

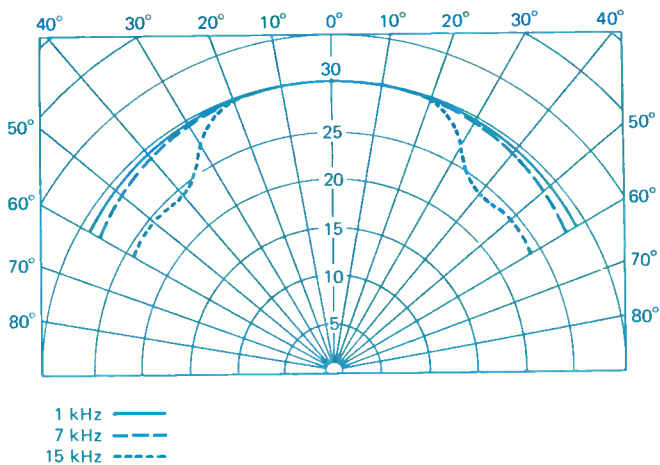


FIG. 3—POLAR CURVES, like this one, hardly ever reach the spec sheet. They show speaker dispersion. Numerals down the center are in dB.

the question of "how much dispersion *is* good", since it can be argued that an overabundance of this quality may actually tend to blur stereo (or quadraphonic) imaging, but that issue is best left to the psychoacousticians. But this quality must be stated in a consistent manner.

Efficiencies of loudspeaker systems vary over an enormous range. An electrical input of only a few watts of audio signal may produce ear-shattering loudness levels from very efficient speaker systems (large bass-reflex and folded- or corner-horn enclosures are relatively efficient systems), while the same input power fed to an inefficient system (generally, the book-shelf or "acoustic suspension" types) may produce no more than "background music" listening levels. The choice of a suitable power amplifier is, therefore, highly dependent upon this matter of efficiency. Of late, many manufacturers have begun to indicate the relative efficiency of their products in a variety of ways.

A statement as to "recommended power input" is the least definitive of these ways. The most definitive is a statement as to the sound-pressure level that will be produced at a given distance from the loudspeaker, for a given input wattage, at a given frequency. Unfortunately, those "givens" are not at all consistent from manufacturer to manufacturer. Sound intensity varies inversely with the square of the distance from the sound generating source. Thus, if 90 dB SPL (Sound Pressure Level) is measured at a distance of 1 meter from a speaker with 1 watt of electrical input, at 2 meters, the SPL will measure 84 dB (a change of 6 dB, or $\frac{1}{4}$ the *acoustic* power).

One meter seems to be the most popular reference distance, and 1 watt seems to be the most popular reference input, but since other distances are also being quoted, Table I offers a quick "translation service" from one reference to another and also quickly enables you to judge SPL's at a variety of listening positions other than the one referenced by the manufacturer.

It is important, too, that the manufacturer state the

frequency or frequencies at which the SPL measurement was made. Obviously, if he has previously offered a response curve which, of itself varies ± 3 dB or more and if he then selects the frequency at which his product is *most* efficient, there will be other frequencies at which sound output might be as much as 6 dB lower, requiring amplifier power which is *four times as great* for the same SPL.

It should be noted, too, that this inverse square-law relationship of SPL with distance is true only in "free-air". In an actual listening room (particularly one of large dimensions), the relationship holds for some distance, known as the "direct field", and falls apart in the "reverberant field" where sound intensity tends to remain constant regardless of further increase in distance from the speaker system. For most home listening situations, however, the figures in the table below will hold up pretty accurately.

Power handling capability

With such a wide range of efficiencies available in current speaker products and with today's crop of power amplifiers delivering continuous power output from a few watts to hundreds of watts, I can sympathize with the speaker manufacturer who is trying to define the power handling ability of his products. If he rates power handling in terms of "continuous power" (often erroneously termed rms power), he is, in effect, penalizing his product since he

TABLE I
RELATIONSHIP BETWEEN SPL AND
DISTANCE FROM LOUDSPEAKER

SPL AT 1 WATT AMPLIFIER INPUT	DISTANCE IN METERS FROM SPEAKER	DISTANCE IN FEET FROM SPEAKER
106.3	0.25	0.5
102.0	0.25	
100.4		1.0
96.0	0.50	
90.6		3.0
90.0	1.00	
88.2		4.0
84.6		6.0
84.0	2.00	
83.3		7.0
80.2		10.0
78.6		12.0
78.0	4.00	
76.8		15.0
75.1		18.0
74.3	6.0	

NOTE: For each doubling of power input reference, add 3 dB to SPL Figures. (E.g., if you wish to know SPL for 2 watts input at 1 meter, add 3 dB to 90 dB figure, to obtain 93 dB.

To determine SPL at various distances when a different reference is quoted, add or subtract new SPL reference from value shown at desired distance. (E.g. if speaker produces, say 80 dB for 1 watt input at 1 meter, to determine SPL at 4 meters subtract 10 dB from 4-meter value of 78 dB to obtain 68 dB).

is then specifying how much power the speaker can take when fed with a continuous sine-wave tone.

Obviously, no one listens to high-power sine-wave tones and a speaker subjected to this kind of signal for any length of time will "burn out" its voice coil with fewer watts applied than would be the case under musical programming conditions. Still, the "continuous power" concept is the most readily defined and the least arguable.

Some manufacturers use a "music power" maximum power rating, but this number is usually unrelated to the so-called "music power", dynamic power or IHF power rating used by amplifier manufacturers. The former takes into account the fact that *average* power under musical conditions will be some 10 to 15 dB lower than the peaks encountered during moments of musical crescendos, while the purely electronic "music power" term merely refers to an amplifier's ability to produce somewhat higher power output under musical input conditions than would be the case if a pure sine-wave tone were applied continuously.

Perhaps the only compromise possible would be for speaker system makers to suggest what power amplifier continuous power rating will safely operate with their product and at the same time caution the user that such safe operation is limited to *musical programming*. By so doing, he could avoid having to service products which were subjected to continuous-tone testing at this same high power level. In addition, to be perfectly safe, the manufacturer may want to specify a *time* and *continuous* power limit for his products. Thus, he might say that power capability is such that a 50-watt continuous power amplifier will safely drive his unit, but that continuous tone-testing at that power level should never exceed 10 minutes (or 2 minutes).

Speaker specs that should be added

High-fidelity power amplifiers have very linear characteristics. Feed in 0.1 V of audio signal and you get, say 1 watt of audio power output. Feed in 1.0 V and you get 100 watts out (power out varies as the *square* of the voltage out). I have heard speakers which fail to *put-out* or really "open up" until they are driven to high power levels and this effect can only be described as nonlinearity. Think of it as a form of "dynamic expansion" if you will—and one

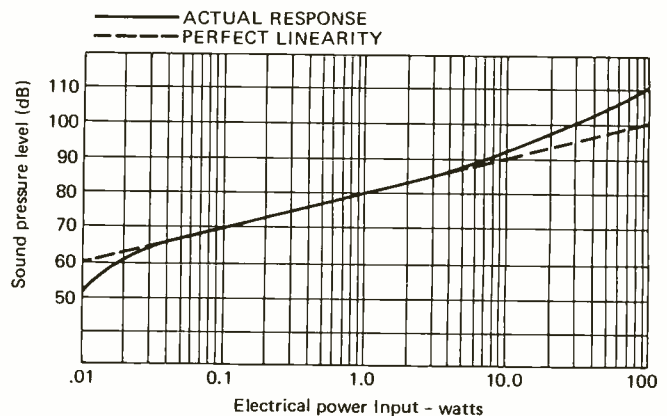


FIG. 4—PROPOSED SPEAKER-SYSTEM CURVE that would show the relationship between signal input and sound output.

which may actually be desirable, since it has the overall effect of increased dynamic range. Whatever your opinion about linearity, however, it should be specified in some meaningful way that is clear to the prospective purchaser. Perhaps a curve (Fig. 4) would provide this data.

I'd like to see a statement of *maximum* SPL attainable for a given speaker system, given in dB. Of course, such a specification would have to take into account distortion (harmonic and intermodulation) and also relate to the maximum "safe" operating level of the speaker system in

(continued on page 92)

STATE-OF-SOLID-STATE

*The latest in the semiconductor crop is a group of IC's and SCR's.
The surprise of the month is a monostable
multivibrator for use in automobile tachometers and speedometers.*

by LOU GARNER
SEMICONDUCTOR EDITOR

SEMICONDUCTOR INDUSTRY EXECUTIVES are busily wooing the automotive industry with all the ardor of the male spider courting the female black widow. The union is obviously desirable, perhaps even a necessity, but it is almost certain that the larger female will gobble up the smaller male once the marriage is consummated.

Even today, the automotive market for semiconductor devices is substantial. Solid-state ignition systems are offered either as optional or standard equipment by most auto makers. All automotive entertainment equipment . . . radios and tape systems . . . use semiconductor circuitry. Solid-state diodes are used by the tens of millions in automotive alternators. There are semiconductor voltage regulators, cruise controls, and auto burglar alarms, while at least one manufacturer offers a computer-controlled fuel injection system. But these requirements, vast as they are, represent but a drop in the proverbial bucket compared to what the automotive industry could use if it really went "all out" for solid-state circuitry.

Electronic ignition and computerized fuel-control systems could become standard for all cars to reduce emission pollutants to the levels required by Federal regulations. Seat belt electronic interlocks, anti-skid systems, "drunk driver" controls and similar safety-oriented equipment could become mandatory. Digital semiconductor clocks, tachometers and speedometers could replace conventional mechanical and dial type instruments. LEDs might replace panel lamps, while special electronic sensors and control systems could be added to warn of impending parts failures or dangerous operating conditions.

All factors considered, a typical automobile or light truck could require as many as 200 semiconductor devices, according to some experts, about half of which would be IC's, half discrete devices, such as power transistors, LED's, SCR's, photosensors, and power diodes.

Multiply this figure by an estimated annual production of 12,000,000 vehicles and we discover that the au-

tomotive industry, alone, could require some *two billion, four hundred million* devices . . . every year! The replacement market, in itself, could require hundreds of millions of devices.

While the semiconductor industry undoubtedly could meet this challenge by expanding their facilities, it might be at the expense of the smaller user—that is, those firms requiring, say, from 5,000 to 25,000 devices annually. Custom hi fi, communications receiver, and test instrument manufacturers, for example, might well find themselves up the legendary creek without an outboard motor, oar, paddle, or even a pair of waterproof gloves. At the same time, the semiconductor industry, having wooed and won its mate, and basking in the warm glow of substantial and profitable orders, would be subject to the vagaries and uncertainties of the automotive industry. A strike in Detroit, typically, could cause tens of thousands of electronics production employees to be laid off in Texas, Arizona, New Jersey, Indiana and California.

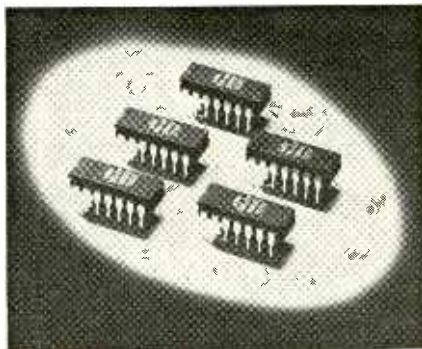


FIG. 1—STEWART-WARNER SW781 IC is a special-purpose device developed for use as an electronic tachometer and speedometer.

Despite the potential dangers, most semiconductor manufacturers feel that the prospective high profits are worth the risks. Motorola, for example, perhaps with an eye on the automotive market, recently has announced a new price schedule for its type MLED500 light emitting diode; this device can now be purchased for only *ten cents* each—in quantities of *one million*, up.

Another firm is a little more obvious in courting the automotive market . . . Stewart-Warner's Microcircuits Division (730 E. Evelyn Ave., Sunnyvale, Calif. 94086) has announced the development and production of a monolithic IC for use in automotive tachometers or speedometers.

Designated type SW781, the new device, Fig. 1, is a special-purpose monostable multivibrator with a high input threshold and extremely stable pulse output, thus permitting its use in the electrically noisy automotive environment while maintaining accuracy over wide temperature ranges and battery voltage variations. Housed in a 14-pin DIP, the SW781 comprises 11 npn transistors, 5 Zeners, 4 diodes, and 12 resistors, as shown in Fig. 2-a.

In a typical tachometer application, Fig. 2-b, trigger pulses are tapped off the distributor using two discrete resistors and a capacitor. The SW781 converts each input trigger to a pulse of closely controlled width and amplitude.

These output pulses are applied to a conventional dc meter movement through a discrete resistor. Under these conditions, the meter deflection is proportional to the dc component of the pulses received and, therefore, also proportional to the engine rpm. The constant of proportionality can be varied by varying the output pulse width, while the inertia and damping of the meter movement provides sufficient mechanical filtering, in most cases, to remove the ac component of the pulse train.

The device can be used in much the same fashion in a speedometer, except that a magnetic pick-up coupled to the wheels is used as a trigger source instead of the distributor.

If accepted and widely used, the SW781 probably will be only the first of a large family of IC's designed specifically for automotive applications.

Reader's circuit

It's truly delightful to receive letters from my readers. Unfortunately, the task of keeping up to date on the solid-state field prevents my sending a

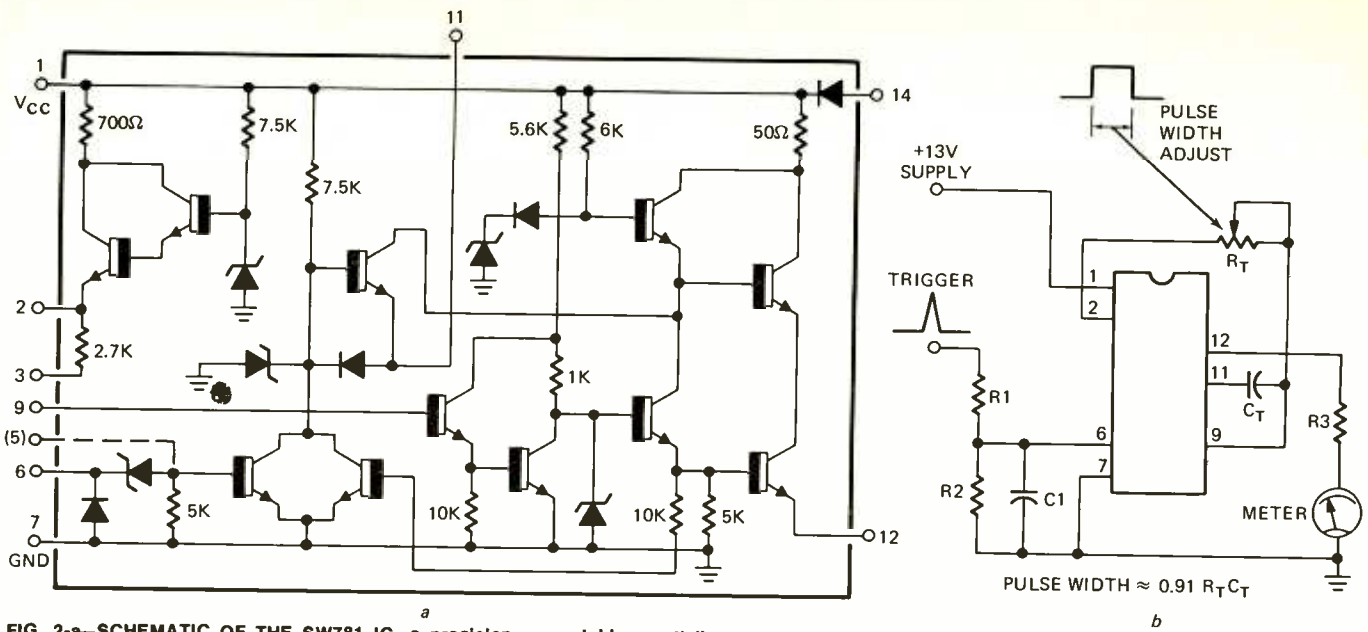


FIG. 2-a—SCHEMATIC OF THE SW781 IC—a precision monostable multivibrator featuring high noise immunity. Fig. 2-b—BASIC TACHOMETER designed around the new IC.

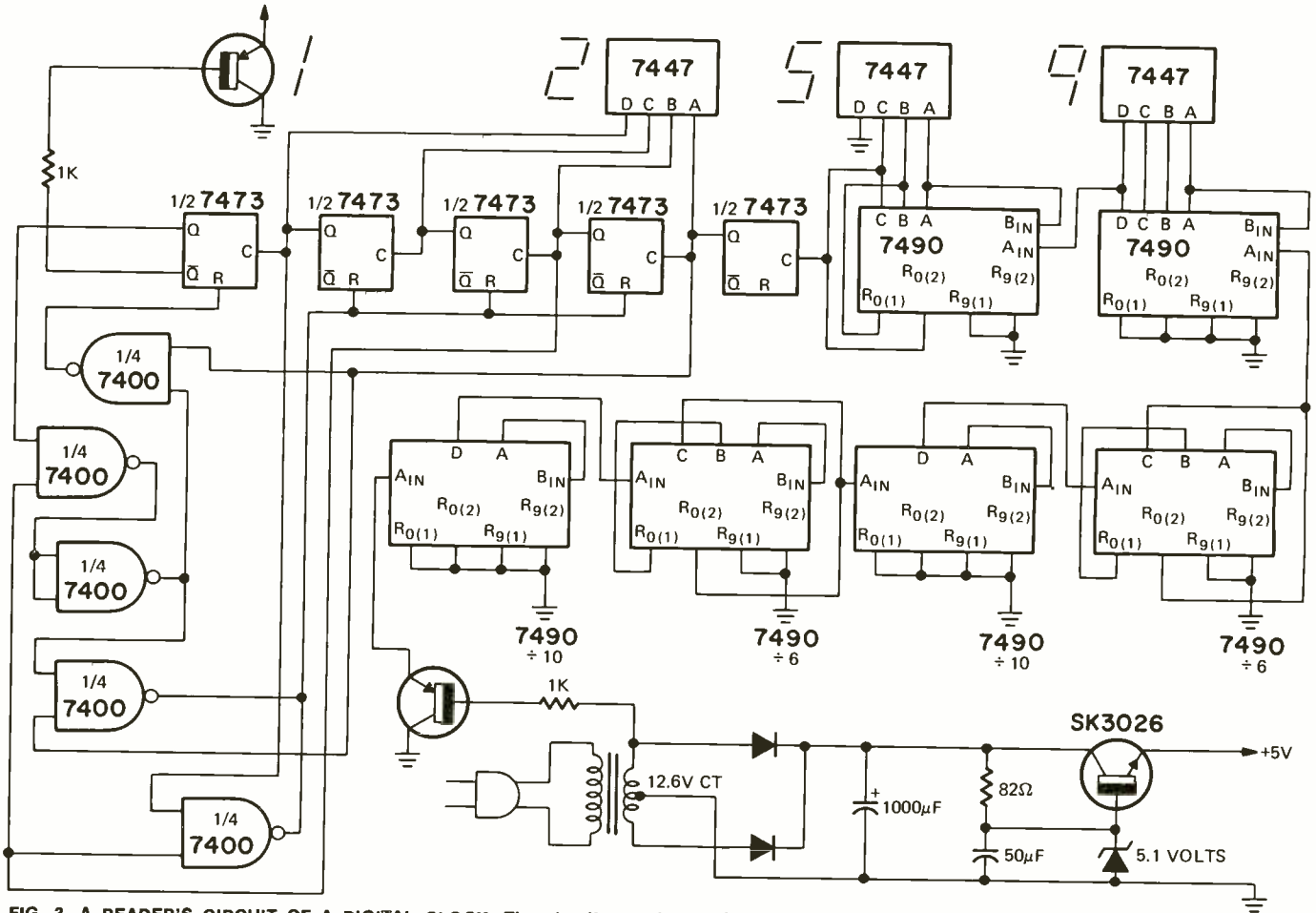


FIG. 3—A READER'S CIRCUIT OF A DIGITAL CLOCK. The circuit was designed for simplicity and low cost. You can select your favorite type of readout and adapt the circuit to fit.

personal reply to each and every letter, but *all* are read with care and your comments noted for future reference.

Where you've had complaints, I've tried to expand my coverage. Where you've had questions, I've tried to provide the answers in later columns. Often, a reader wishes to share

one of his original circuits with his fellow readers. Where appropriate, then, and space permitting, I'll be pleased to present some of these circuits from time to time.

Reader J. P. Glover (23008 - 58 - West, Mount Lake Terrace, Wash. 98043) submitted the simple digital clock circuit illustrated in Fig. 3.

Dear Lou:

I am enclosing a copy of a digital clock circuit I came up with. After looking at many schematics for clocks, I decided that they were too complicated or too fancy, so I came up with the simplest one I could. I used general-purpose transistors and low-cost IC's and readouts. The only

thing not shown is the clock setting circuit, which was just a N.C. switch at X and 2 N.O. switches, one from 60 Hz and one from 1 Hz for fast and slow set. By using JK flip-flops it was easy to get hours to count 1-12 and back to 1—you will notice the first JK flip-flop has no connection on RESET, so when 13 (RESET) comes and the clock resets, Q stays high and the rest go low. Hope you enjoy my clock circuit.

Your devoted fan,
Joseph P. Glover

Thanks, Joe, it is indeed an interesting circuit, and I'm sure many of your fellow readers will enjoy experimenting with your design. Unfortunately, you didn't indicate which readouts you used with the 7447 BCD to 7 segment decoder/drivers, but these can be used, of course, with most standard 5-volt readouts. Keep up the good work and let me know if you develop other equally interesting circuits in the future.

Product/device news

The hands at Texas Instruments' big spread (P.O. Box 5012, Dallas, Tex. 75222) have rounded up and put their TI brand on a whole corral full of new devices, including three high-power integrated transistor switches, a MOS/LSI digital storage buffer, four line drivers and receivers, two hex 32-bit MOS/LSI static shift registers, and 21 low-power Schottky TTL IC's.

Believed to be the first of their type, TI's new integrated power transistor switches are intended for high-power conversion applications which, formerly, required SCR's. They can be used in dc choppers for motor controls, in dc to ac inverters, and in ac to dc converters and power supplies. Designated types TIXH807, TIXH808, and TIXH809, each switch is housed in a conduction cooled aluminum case measuring 7 X 3.5 X 1.6 inches, as shown in Fig. 4. Typical turn-off time

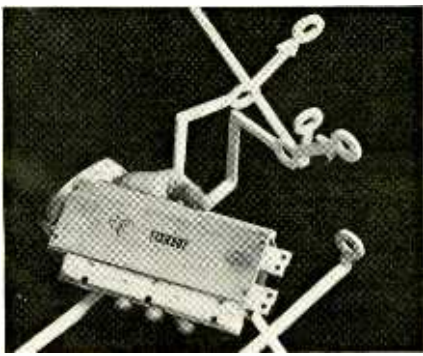


FIG. 4—HIGH-POWER INTEGRATED CIRCUIT SWITCHES, by TI, can replace SCR's.

is 0.5μsecs. Suitable turn-off time from dc to 10 kHz, the units can be driven by DTL or TTL IC's. The TIXH807 is rated at 150 A, 100 V; the

TIXH808 at 200 A, 100 V; and the TIXH809 at 60 A, 400 V. In the works is a 100 A, 500 V unit.

Identified as the TMS4024, TI's new digital storage IC is a 9-bit wide and 64-bit deep first in/first out (FIFO) storage buffer intended for use as a link between two digital systems operating at different data rates.

Data is fed into the storage buffer at a certain rate and is made available upon demand at the output, with the input and output data rates completely independent. Capable of processing data at any desired rate from dc to one-half the continuous clock frequency, the unit has a guaranteed minimum data rate of 250 kHz. The TMS4024 is offered in either a 28-pin plastic or ceramic DIP.

Two dual-line drivers, types SN75121 and SN75123, and a pair of triple-line receivers, types SN75122 and SN75124, have been added to TI's line of computer system interface circuits. The SN75121 driver and SN75122 receiver are designed for coaxial cable, strip-line or twisted-pair transmission lines with impedances of 50 to 500 ohms, while the SN-75123 and SN75124 meet the requirements of the IBM System/360 input/output interface specification.

All are TTL compatible and designed for operation from a standard 5-V dc supply. The units are offered in both 16-pin plastic and ceramic DIP's.

TI's two new hex 32-bit MOS/LSI static shift registers, designated types TMS3122 and TMS3123, are intended for applications centered around the 96-column punch card, such as keypunch, key-to-type, and key-to-disc systems. A single device can be used to store a whole tier of a 96-column card. Both devices have a single low-capacitance clock which can be driven directly by TTL IC's. Other features include recirculate logic on the chip and direct TTL interface. Maximum speed is 2 MHz. The TMS3122 is offered in either a 16-pin plastic or ceramic DIP while the TMS3123 features an output gating control and is available in an 18-pin version of the same type packages.

Supplied in both plastic and ceramic DIP's, TI's new line of 21 low-power Schottky TTL IC's includes a comprehensive variety of quad, triple and dual gates, buffers, data selector/multiplexers, and counters. Two series are available, with those carrying a SN54LS prefix intended for critical military applications while those identified with a SN74LS prefix are less expensive units suitable for commercial and industrial designs.

Meanwhile, back at the ranch in Arizona, the men of "batwing-M" (Motorola Semiconductor Products,

Inc., P.O. Box 20912, Phoenix, Ariz. 85036) are conducting their own round-up of choice devices on the hoof. Among the new units carrying the batwing-M brand are a family of Thermowatt plastic SCR's, two series of plastic sensitive gate Triacs, two new D/A converters, and a high-speed 64-bit MECL 10,000 series memory IC for buffer or cache memories.

Registered as types 2N6394 through 2N6399 and 2N6400 through 2N6405, Motorola's new plastic SCR's, Fig. 5, have peak reverse blocking voltages which range from 50 to 800 volts, depending on type. The forward



FIG. 5—MOTOROLA'S NEW PLASTIC SCR's feature V_{ROM} 's ranging from 50 to 800 volts with $I_{FM(surge)}$ ratings of 100 to 160 amps.

rms current for the 2N6394 series is 12 A and for the 2N6400 series, 16 A. Junction temperature limits are 125°C for both types. The peak forward surge current varies from 100 A for the 2N6394 series to 160 A for the 2N6400 series (1/2 cycle, sine wave, 60 Hz).

If you're using DIP IC's, you'll want to check into Vector's (Vector Electronic Co., Inc. 12460 Gladstone Ave., Sylmar, CA 91342) new line of low profile 14- and 16-pin dual-inline sockets. Illustrated in Fig. 6, the new

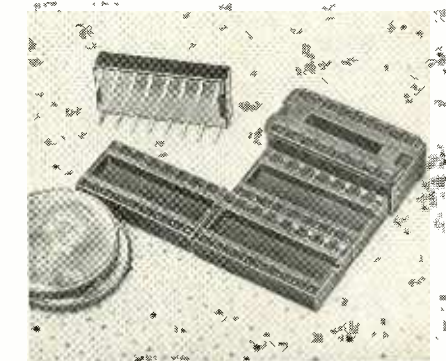


FIG. 6—NEW MOLDED SOCKETS for DIP devices are unusually shallow. They have tapered holes so the IC pins go in easily.

units feature a tapered entry way for easy automatic or manual insertion. Only 0.150 inch high, the sockets, types R714-2 and R716-2, reduce the height of installed dual in-line IC's and similarly housed devices by nearly 50 percent compared to conventional designs.

R-E

Step-By-Step TV Troubleshooter's Guide

THE MOST DIFFICULT PROBLEMS ARE NOT necessarily picked by this column deliberately, but I believe that if the tough ones are solved initially then lesser faults will soon show up. Therefore, at this point in the series, the big inductors in all television receivers—especially color—are to be dealt with in three phases: 1) those in hybrid or vacuum-tube receivers; 2) in transistor output solid-state sets; 3) and SCR deflection systems such as used by Philco and RCA.

All truths, we are told, are not always self-evident. For instance, a sawtooth voltage produces a parabola of current, a square-wave voltage induces a sawtooth of current, and a trapezoidal waveform is generated by a combination of sawtooth and rectangular pulses (Fig. 1); all to satisfy the needs

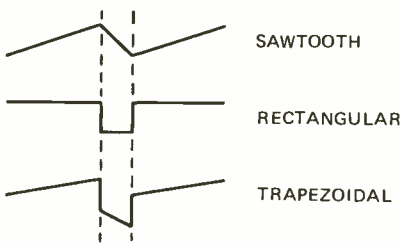


FIG. 1—TRAPEZOIDAL WAVE is a combination of sawtooth and rectangular pulses.

of practical inductors having both resistance (sawtooth) and reactance (rectangular) that, together, form a trapezoid.

A few years ago, virtually all tube-type receivers drove their horizontal and vertical outputs with trapezoidal waveforms. Today, principally because of solid-state, sawtooth vertical and rectangular horizontal driving pulses

are used. But the old trapezoid is still used—as you will shortly see—and its down (conduction) time still indicates retrace (at the horizontal output grid), and the rising portion is the forward-trace charge-time of the horizontal driver tube's waveshaping capacitors. When the grid of the output tube is cut off, magnetic flux change in the flyback produces both retrace and high-voltage pulse.

We're also entering the era of high-voltage multipliers and tuned flyback transformers. Recalling that a 52.4- μ s forward line scan amounted to a half-cycle resonance of about 20 kHz, and a 11.1- μ s retrace at 90 kHz; today's flyback systems are mostly tuned to the 3rd and 5th harmonics for maximum efficiency—usually the 5th harmonic for solid-state. The harmonic frequency is determined by multiplying the retrace fundamentals of 45 kHz by 3 or 5 for a product of about 135 or 225 kHz, respectively. This can be measured on the time base of any accurately calibrated oscilloscope. In Y1W5 in Fig. 9, for example, 2 cycles/20 $\times 10^{-6}$ = 100 kHz.

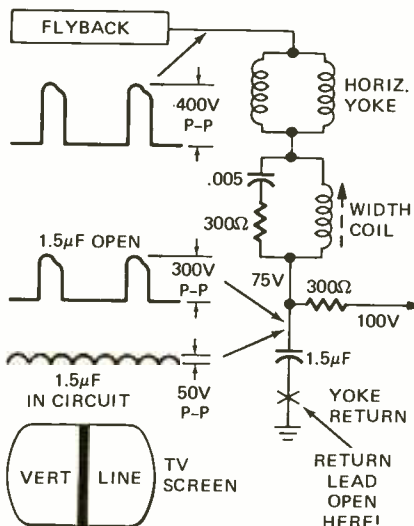


FIG. 2—OPEN YOKE was not the trouble in this circuit. See text for details.

Inductive opens

In judging the origin of flyback and yoke circuit troubles, remember

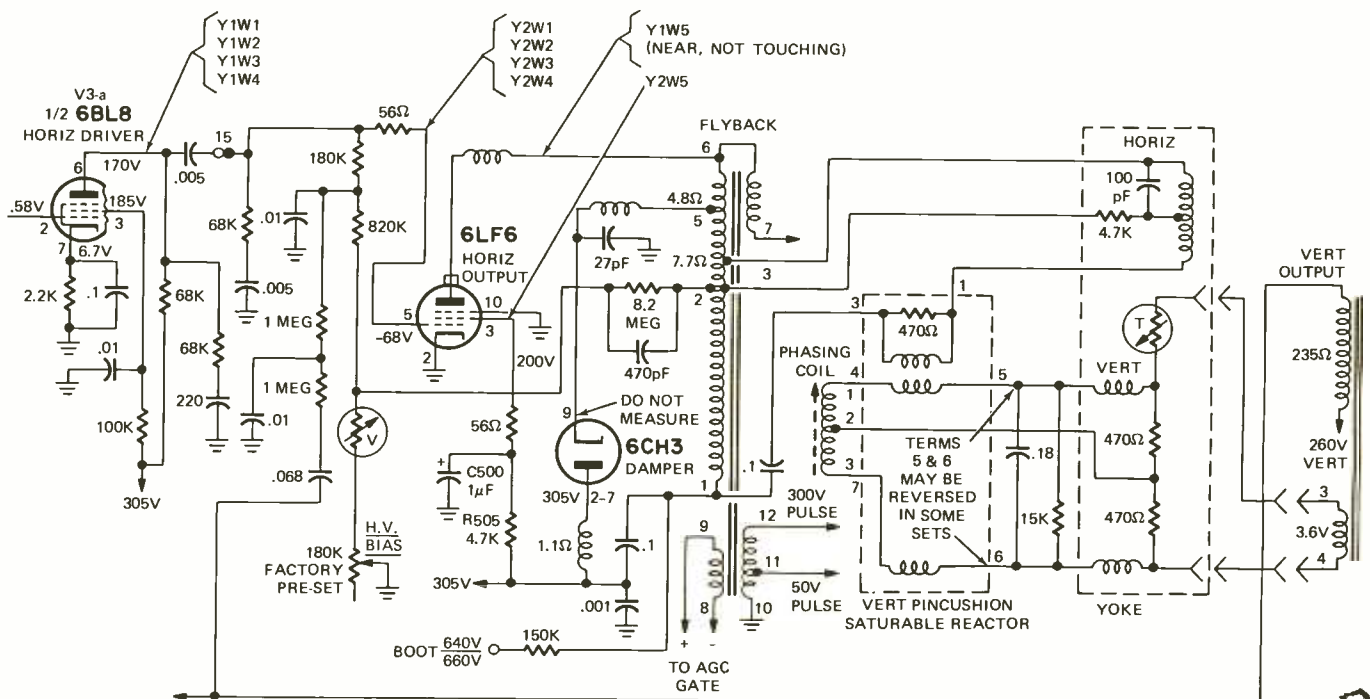


FIG. 3—HORIZONTAL DEFLECTION CIRCUIT of Motorola CATV5/6. Symptoms: no high voltage; horizontal output tube plate red.

Horizontal and vertical deflection circuits are often problems. This month we will look at typical circuits used in today's vacuum tube and hybrid receivers

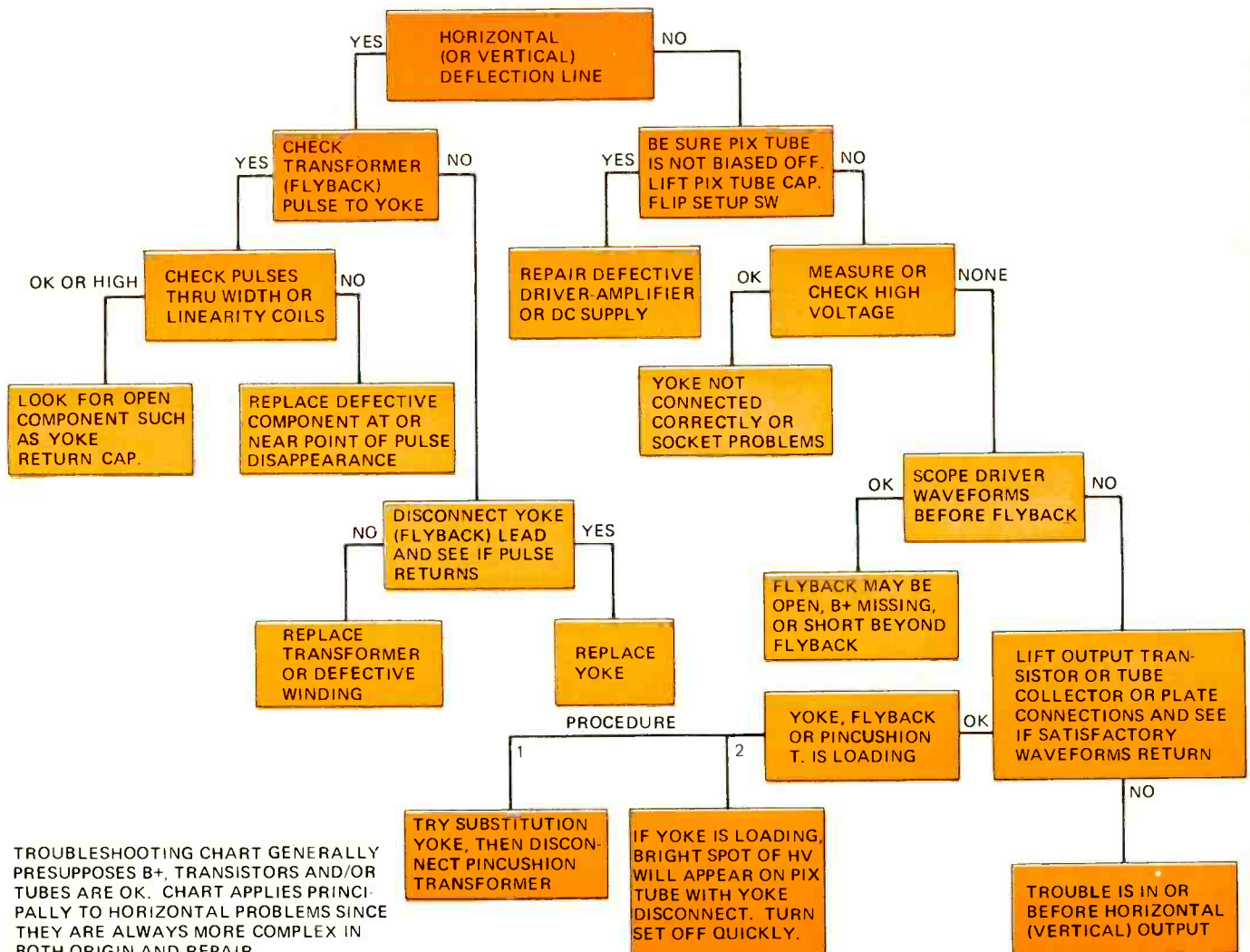
by **STAN PRENTISS**

that adequate output voltage with little or no measurable sweep produces either a thin vertical line for horizontal problems, or a horizontal line for vertical faults. This is a very important part of the initial visual procedure because you're told immediately there is either a bad connection or something has opened. Or you may have only a blank raster or a trapezoidal vertical or horizontal display that indicates (especially if wax is dripping from the flyback or there is an arcing or frying sound about either the flyback or yoke) a probable short in either inductor, but virtually never in both.

Very recently there was the case of a Motorola CTV8 (solid-state) with

a thin vertical line (Fig. 2) that had every appearance of an open deflection yoke. This receiver, of course, has plug-in boards but the field technician apparently either didn't have the magic mix or sufficient quantity. In any event, according to an oscilloscope, the flyback was putting out its good 400-volt p-p current-flux reversal pulse, and this could be measured continuously through the width coil with only about 100 volts drop. (Now some models of these receivers used to have a vertical centering circuit consisting of a pair of diodes, two resistors, and a couple of 150- μ F filter capacitors to convert pulsing dc to steady-state dc.) A CTV8 set in good operating order showed a p-p wave-

form somewhat parabolically shaped of only 50 volts p-p at the 75-volt dc end of the width coil instead of 300 V p-p. Obviously, in the defective set, there was no filtering here. The 1.5- μ F capacitor was found to have had its lower end raised above ground; actually cut with a pair of sidecutters. Therefore the width-yoke circuit had no ac ground. So with no yoke return to ground and incomplete filtering, the yoke could neither begin nor complete a sweep current, regardless of adequate drive. This 1.5- μ F capacitor is also called an S-curve compensator since it slightly bends the yoke current extremes to compensate for an almost flat (instead of a curved) faceplate picture tube.



TROUBLESHOOTING CHART GENERALLY PRESUPPOSES B+, TRANSISTORS AND/OR TUBES ARE OK. CHART APPLIES PRINCIPALLY TO HORIZONTAL PROBLEMS SINCE THEY ARE ALWAYS MORE COMPLEX IN BOTH ORIGIN AND REPAIR.

FIG. 4—STEP-BY-STEP TROUBLESHOOTING CHART for both horizontal and vertical deflection circuits using vacuum tubes.

A very live short

The preceding is a very real (not induced) instance of an open that isn't a yoke, but just looks like one. A similar model symptom is often the cause for much yoke and flyback changing that is wholly unnecessary. A second Motorola (CATV5/6) has no visible high voltage, and the horizontal output tube (Fig. 3) plate glows red before a minute's operation. (Fig. 4 details the complete troubleshooting procedure.)

Experience tells you that an ancient Wintronix 820 analyzer or a very modern B & K 1077B television analyst can drive the flyback and deflection yokes of these newer tube (in this instance) receivers and put high voltage on the picture tube, and indeed they will *if* all components along the way are all right. Such was not the case here, however, and the short indicator on the test equipment glowed fiercely when the attempt was made. Now, ordinarily, you'd stop right there and begin making disconnections—but suppose you didn't have either of these testers and also must know whether the problem is in the grid or plate circuit of the horizontal output tube. The shop technician who'd been working on this receiver said the output tube grid measured a "solid -40 volts," and this was "fine with him." The schematic calls for -68 volts, however, and a self-biased grid-leak circuit with some *average* voltage of both ac and dc can very likely be somewhat variable. Grid voltage measured with a dc scope after repairs amounted to -60 volts—a 33% difference. How this is done is illustrated in the following waveforms.

In grid-drive problems, it's necessary to know both dc levels and peak-to-peak amplitude of the tube or transistor drivers and the output grid waveforms. The top wave form in Fig.

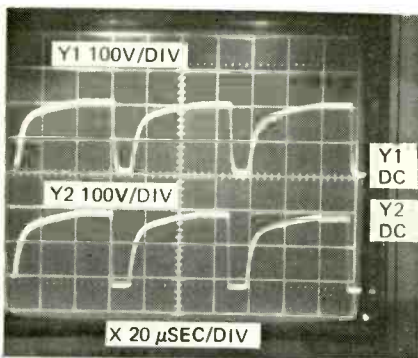


FIG. 5—TYPICAL GRID-DRIVE WAVEFORMS. Are they good or bad?

5 is the V3-a driver plate whose waveform swings from almost dc to 210 volts p-p. The Y2W1 grid drive is, of course, negatively biased voltage whose top tip hardly reaches dc. The question—is the grid waveform good

or bad? At first glance you can see grid cutoff means about 12- μ s (flyback time) and the risetime, while not a classic sawtooth, amounts to 200 volts p-p. And even though it doesn't look like the usual *uncalibrated* recurrent sweep trace, this trapezoidal waveform is probably pretty correct.

However, let's make another check. Removing the plate cap of the output tube, the Fig. 6 waveforms in-

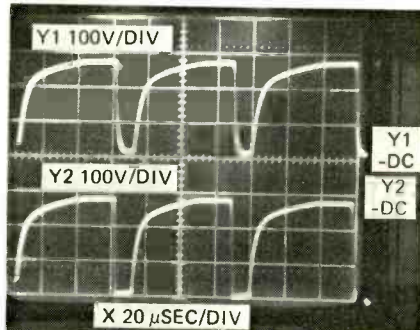


FIG. 6—GRID-DRIVE WAVEFORMS Increase in amplitude when plate cap is removed.

crease in amplitude some 80 volts. Not an unusual situation, although the dc reference at the output grid shifts somewhat because of load lift. Now let's remove the output tube entirely and see what happens. The dc level and ac amplitude of the horizontal driver is hardly affected, but the output grid voltage immediately goes quite positive (by 220 volts) and increases in amplitude to a full 300 volts. (The difference between the positions of Y2 in Fig. 6 and Fig. 7 is a relative 220 volts. In the same way,

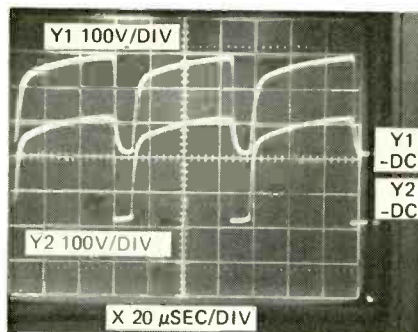


FIG. 7—REMOVE THE OUTPUT TUBE and the waveforms change drastically.

you can measure any dc level with an oscilloscope by switching from dc to ac amplifiers, add the dc blocking capacitor (ac), and simply count the number of major and minor divisions the trace rises or falls. Then multiply these by the vertical amplifier switch setting, taking into account the 10X LC probe you should always be using.

For instance, if the vertical attenuator is positioned at 10V/div and a 10X probe is connected, the graticule scale reading will be 10 X 10, or 100V/div as it is here. Now what has

this signal analysis told you? Basically that there's really nothing wrong with the grid circuit of the horizontal output, and the drive circuits are excellent. The fault, evidently, must be in the flyback or beyond.

With deflection yokes in newer (and some older) receivers connected by mating plugs and jacks, just break the connection (you may need a B+ jumper for the horizontal output screen) and see if the output tube plate still runs red. If it doesn't, plug in another yoke, watch the output tube, and listen for the ssss-tttt of high voltage. Should the tube still glow ruby, unsolder a transformer lead to the pincushion transformer (if there is one) and look and listen again. If you still have problems—and there's no trouble with the high-voltage rectifier or damper—THEN suspect the flyback.

In the CTV5/6, the difficulty happened to be the pincushion reactor which, you will notice, is in series with one side of the horizontal yoke coil. A disconnect at terminal 6, of course, removed the short, and a new pincushion transformer restored the receiver to full operation (Y1, Fig. 8). In the
(continued on page 103)

R-E's substitution guide for replacement transistors

PART VII

compiled by ROBERT & ELIZABETH SCOTT

R-E's Transistor Substitution Guide is a compilation of material abstracted from the substitution guides of eight leading semiconductor manufacturers and distributors. These are:

ARCH—Indicates the Archer brand of semiconductors sold only by Radio Shack and Allied Radio stores. Allied Radio Shack, 2725 W. 7th St., Ft. Worth, Texas 76107

G-E—General Electric Co., Tube Product Div., Owensboro, Ky. 42301

ICC—International Components, 10 Daniel Street, Farmingdale, N.Y. 11735

IR—International Rectifier, Semiconductor Div., 233 Kansas St., El Segundo, Calif. 90245

MAL—Mallory Distributor Products Co., 101 S. Parker, Indianapolis, Ind. 46201

MOT—Motorola Semiconductors, Box 2963, Phoenix, Ariz. 85036

RCA—RCA Electronic Components, Harrison, N.J. 07029

SPR—Sprague Products Co., 65 Marshall St., North Adams, Mass. 01247

SYL—Sylvania Electric Corp., 100 1st Ave., Waltham, Mass. 02154

Radio-Electronics has done its utmost to insure that the listings in this directory are as accurate and reliable as possible; however, no responsibility is assumed by Radio-Electronics for its use. We have used the latest manufacturers material available to us and have asked each manufacturer covered in the listing to check its accuracy. Where we have been supplied with corrections, we have updated the listing to include them. The first part of this Guide appeared in March 1973.

ARCH MAL MOT RCA SPR SYL

ARCH	MAL	MOT	RCA	SPR	SYL
2N1445	NA	HEP-714	NA	NA	NA
2N1446	RS276-2004	HEP-253	SK 3004	RT-120	ECG 102
2N1447	RS276-2005	HEP-254	SK 3004	RT-120	ECG 102
2N1448	RS276-2005	HEP-254	SK 3004	RT-120	ECG 102
2N1449	RS276-2005	HEP-254	SK 3004	RT-120	ECG 102
2N1450	RS276-2004	HEP-253	SK 3004	RT-120	ECG 102
2N1451	RS276-2004	HEP-254	SK 3004	RT-120	ECG 102
2N1452	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1453	RS276-2005	HEP-S5003	SK 3005	RT-118	ECG 100
2N1454	NA	HEP-254	SK 3005	RT-118	ECG 100
2N1455	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1456	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1457	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1458	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1459	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1460	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1461	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1462	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1463	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1464	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1465	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1466	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1467	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1468	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1469	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1470	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1471	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1472	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1473	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1474	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1475	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1476	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1477	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1478	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1479	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1480	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1481	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1482	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1483	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1484	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1485	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1486	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1487	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1488	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1489	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1490	RS276-2005	HEP-254	SK 3005	RT-118	ECG 100
2N1491	RS276-2009	HEP-53	SK 3048	RT-102	ECG 123A
2N1492	RS276-2009	HEP-53	SK 3048	RT-102	ECG 123A
2N1493	NA	HEP-713	NA	RT-110	ECG 154
2N1494	NA	HEP-713	NA	NA	NA
2N1495	NA	HEP-2	NA	NA	ECG 160
2N1496	RS276-2003	HEP-635	SK 3006	NA	ECG 126
2N1497	RS276-2003	HEP-2	SK 3006	NA	ECG 126
2N1500	NA	NA	SK 3012	RT-124	ECG 104
2N1501	NA	NA	SK 3012	RT-124	ECG 104
2N1502	NA	HEP-S3001	SK 3039	RT-113	ECG 108
2N1503	NA	HEP-S3001	SK 3039	RT-113	ECG 108
2N1504	NA	HEP-714	SK 3039	RT-113	ECG 108
2N1505	NA	HEP-S3020	SK 3039	RT-113	ECG 108
2N1506	NA	HEP-S3020	SK 3039	RT-113	ECG 108
2N1507	NA	HEP-S3020	SK 3039	RT-113	ECG 108
2N1508	NA	HEP-714	SK 3039	RT-113	ECG 108
2N1509	NA	HEP-S3020	SK 3039	RT-113	ECG 108
2N1510	NA	HEP-S3020	SK 3039	RT-113	ECG 108
2N1511	NA	HEP-S5001	SK 3011	RT-119	ECG 101
2N1512	NA	HEP-S5004	NA	NA	NA
2N1513	NA	HEP-S5004	NA	NA	NA
2N1514	NA	HEP-S5004	NA	NA	NA
2N1515	RS276-2003	HEP-3	SK 3006	NA	ECG 160
2N1516	RS276-2003	HEP-3	SK 3006	NA	ECG 160
2N1517	RS276-2003	HEP-3	SK 3006	NA	ECG 160
2N1518	NA	HEP-231/233	SK 3012	NA	ECG 105
2N1519	NA	HEP-233	SK 3012	NA	ECG 105
2N1520	NA	HEP-231/233	SK 3012	NA	ECG 105

NA = NOT AVAILABLE

ARCH MAL MOT RCA SPR SYL

ARCH	MAL	MOT	RCA	SPR	SYL
2N1521	NA	HEP-233	SK 3012	NA	ECG 105
2N1522	NA	HEP-233	SK 3012	NA	ECG 105
2N1523	NA	HEP-233	SK 3012	NA	ECG 105
2N1524	RS276-2003	HEP-3	SK 3008	NA	ECG 160
2N1525	RS276-2006	HEP-3	SK 3008	NA	ECG 160
2N1526	RS276-2005	HEP-638	SK 3008	NA	ECG 126
2N1527	RS276-2003	HEP-3	SK 3008	NA	ECG 160
2N1528	RS276-2009	HEP-53	SK 3124	RT-102	ECG 133A
2N1529	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1530	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1531	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1532	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1533	NA	HEP-625	SK 3009	RT-127	ECG 121
2N1534	RS276-2006	HEP-230	SK 3009	RT-127	ECG 121
2N1535	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1536	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1537	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1538	NA	HEP-625	SK 3009	RT-127	ECG 121
2N1539	RS276-2006	HEP-230	SK 3009	RT-127	ECG 121
2N1540	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1541	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1542	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1543	NA	HEP-625	SK 3009	RT-127	ECG 121
2N1544	RS276-2006	HEP-230/232	SK 3009	RT-127	ECG 121
2N1545	RS276-2006	HEP-624	SK 3009	RT-127	ECG 121
2N1546	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1547	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1548	NA	HEP-625	SK 3009	RT-127	ECG 121
2N1549	RS276-2006	HEP-230/232	SK 3009	RT-127	ECG 121
2N1550	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1551	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1552	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1553	RS276-2006	HEP-230/232	SK 3009	RT-127	ECG 121
2N1554	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1555	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1556	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1557	RS276-2006	HEP-230/232	SK 3009	RT-127	ECG 121
2N1558	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1559	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1560	RS276-2006	HEP-232	SK 3009	RT-127	ECG 121
2N1561	RS276-2003	HEP-3	NA	NA	ECG 160
2N1562	RS276-2003	HEP-3	NA	NA	ECG 160
2N1563	NA	NA	NA	NA	NA
2N1564	NA	HEP-713	NA	NA	NA
2N1565	NA	HEP-713	NA	NA	NA
2N1566	NA	HEP-713	NA	NA	NA
2N1567	NA	HEP-713	NA	NA	NA
2N1568	NA	HEP-713	NA	NA	NA
2N1569	NA	HEP-713	NA	NA	NA
2N1570	RS276-2004	HEP-253	SK 3005	RT-118	ECG 100
2N1571	NA	HEP-712	SK 3045	RT-110	ECG 154
2N1572	NA	HEP-712	SK 3045	RT-110	ECG 154
2N1573	NA	HEP-712	SK 3045	RT-110	ECG 154
2N1574	NA	HEP-712	SK 3045	RT-110	ECG 154
2N1575	RS276-2004	HEP-253	SK 3005	RT-118	ECG 100
2N1581	RS276-2004	HEP-253	SK 3005	RT-118	ECG 100
2N1583	RS276-2004	HEP-253	SK 3005	RT-118	ECG 100

NA = NOT AVAILABLE

ARCH	GE	ICC	IR	MAL	MOT	RCA	SPR	SYL	ARCH	GE	ICC	IR	MAL	MOT	RCA	SPR	SYL
2N1584	RS276-2004	GE-2	TR-05	PTC 102	HEP-253	SK 3005	RT-118	ECG 100	2N1651	RS276-2006	ICC-232	TR-01	PTC 138	HEP-232	SK 3014	RT-147	ECG 179
2N1585	RS276-2002	GE-7	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101	2N1652	RS276-2006	ICC-232	TR-01	PTC 138	HEP-232	SK 3014	RT-127	ECG 121
2N1586	RS276-2009	GE-11	TR-70	PTC 132	HEP-53	SK 3124	RT-108	ECG 107	2N1653	NA	NA	TR-01	PTC 138	HEP-236	SK 3009	RT-127	ECG 121
2N1587	RS276-2009	GE-11	TR-70	PTC 132	HEP-53	SK 3124	RT-108	ECG 107	2N1854	NA	NA	TR-01	PTC 125	NA	NA	NA	NA
2N1588	NA	GE-61	TR-21	PTC 132	HEP-S0007	SK 3122	RT-102	ECG 123A	2N1855	NA	NA	TR-01	PTC 125	NA	NA	NA	NA
2N1589	RS276-2009	GE-11	TR-70	PTC 132	HEP-53	SK 3124	RT-108	ECG 107	2N1656	NA	NA	TR-01	PTC 125	NA	NA	NA	NA
2N1590	RS276-2009	GE-11	TR-70	PTC 132	HEP-53	SK 3124	RT-108	ECG 107	2N1657	NA	NA	TR-01	PTC 136	HEP-245	NA	NA	NA
2N1591	RS276-2009	GE-61	TR-21	PTC 132	HEP-53	SK 3020	RT-102	ECG 123A	2N1663	RS276-2009	ICC-50	IRTR-51	PTC 136	HEP-50	SK 3122	RT-102	ECG 123A
2N1592	RS276-2009	GE-11	TR-95	PTC 139	HEP-53	SK 3124	RT-108	ECG 107	2N1664	NA	NA	TR-05	PTC 102	HEP-630	SK 3005	RT-118	ECG 100
2N1593	RS276-2009	GE-11	TR-95	PTC 139	HEP-53	SK 3124	RT-108	ECG 107	2N1665	NA	ICC-2	TR-17	PTC 109	HEP-2	NA	NA	ECG 160
2N1594	RS276-2009	GE-61	TR-21	PTC 133	HEP-53	SK 3124	RT-102	ECG 123A	2N1666	RS276-2006	ICC-232	TR-01	PTC 138	HEP-232	SK 3009	RT-127	ECG 121
2N1595	NA	GEMR-5	NA	NA	HEP-R1101	NA	NA	NA	2N1667	RS276-2006	ICC-230	TR-01	PTC 105	HEP-230	SK 3009	RT-127	ECG 121
2N1596	NA	GEMR-5	NA	NA	HEP-R1102	NA	NA	NA	2N1668	RS276-2006	ICC-230	TR-01	PTC 105	HEP-230	SK 3009	RT-124	ECG 104
2N1597	NA	GEMR-5	NA	NA	HEP-R1103	NA	NA	NA	2N1669	RS276-2006	ICC-230	TR-01	PTC 105	HEP-230	SK 3009	RT-124	ECG 104
2N1600	NA	NA	SCR-04	NA	HEP-R1241	NA	NA	ECG 122	2N1670	NA	ICC-2	NA	PTC 107	HEP-2	SK 3005	RT-124	ECG 104
2N1601	NA	NA	SCR-04	NA	HEP-R1243	NA	NA	ECG 122	2N1671	NA	NA	NA	PTC 103	HEP-310	NA	NA	ECG 160
2N1602	NA	NA	SCR-04	NA	HEP-R1243	NA	NA	ECG 122	2N1672	RS276-2002	ICC-641	NA	PTC 108	HEP-51	SK 3118	RT-115	ECG 159
2N1603	NA	NA	IR-1603	NA	HEP-R1244	NA	NA	ECG 122	2N1673	RS276-2005	ICC-254	IRTR-85	PTC 107	HEP-254	SK 3005	RT-122	ECG 103A
2N1604	NA	NA	IR-1604	NA	HEP-R1244	NA	NA	ECG 122	2N1674	RS276-2009	ICC-53	TR-21	PTC 133	HEP-53	SK 3122	RT-102	ECG 123A
2N1605	RS276-2001	GE-8	TR-08	PTC 108	HEP-R1245	SK 3011	RT-119	ECG 101	2N1676	RS276-2021	ICC-51	TR-73	PTC 103	HEP-51	SK 3114	RT-115	ECG 159
2N1608	RS276-2021	NA	NA	PTC 127	HEP-51	SK 3114	RT-115	ECG 159	2N1677	RS276-2021	ICC-51	TR-73	PTC 103	HEP-51	SK 3118	RT-115	ECG 159
2N1607	RS276-2021	NA	NA	PTC 127	HEP-51	SK 3114	RT-115	ECG 159	2N1678	NA	ICC-2	TR-73	PTC 107	HEP-2	SK 3008	NA	ECG 160
2N1608	RS276-2021	NA	NA	PTC 127	HEP-51	SK 3114	RT-115	ECG 159	2N1681	RS276-2005	ICC-254	IRTR-85	PTC 102	HEP-254	NA	RT-121	ECG 102A
2N1609	NA	GE-16	NA	PTC 105	NA	NA	NA	ECG 159	2N1682	RS276-2009	ICC-53	TR-86	PTC 121	HEP-53	SK 3124	RT-100	ECG 123
2N1610	NA	GE-16	NA	PTC 105	NA	NA	NA	ECG 159	2N1683	RS276-2005	ICC-254	TR-05	PTC 102	HEP-254	SK 3005	RT-118	ECG 100
2N1611	NA	GE-03	NA	NA	NA	NA	NA	ECG 159	2N1684	RS276-2004	ICC-253	TR-05	PTC 109	HEP-253	SK 3005	RT-118	ECG 100
2N1612	NA	GE-03	NA	NA	NA	NA	NA	ECG 159	2N1685	RS276-2001	ICC-641	TR-08	PTC 108	HEP-S3020	SK 3011	RT-119	ECG 101
2N1613	NA	GE-18	TR-87	PTC 144	HEP-714	SK 3024	NA	ECG 158	2N1690	NA	NA	NA	PTC 108	HEP-714	NA	NA	NA
2N1614	RS276-2004	GE-2	TR-84	PTC 125	HEP-253	NA	NA	ECG 158	2N1691	NA	NA	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N1615	NA	NA	NA	PTC 125	HEP-713	NA	NA	ECG 158	2N1694	RS276-2001	ICC-641	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N1616	NA	NA	NA	PTC 108	HEP-S5001	NA	NA	ECG 101	2N1689	NA	NA	TR-12	PTC 107	NA	NA	NA	ECG 126
2N1617	NA	NA	NA	PTC 108	HEP-S5004	NA	NA	ECG 101	2N1700	RS276-2018	ICC-243	IRTR-76	PTC 144	HEP-243	NA	RT-114	ECG 128
2N1618	NA	NA	NA	PTC 108	HEP-S5004	NA	NA	ECG 101	2N1701	NA	ICC-243	NA	PTC 144	HEP-243	NA	NA	NA
2N1620	NA	NA	NA	PTC 108	HEP-S5004	NA	NA	ECG 101	2N1702	NA	ICC-247	NA	PTC 140	HEP-247	NA	RT-131	ECG 130
2N1622	RS276-2002	GE-54	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101	2N1703	NA	NA	NA	NA	HEP-S0001	NA	RT-131	ECG 130
2N1623	RS276-2021	GE-21	RTR-88	PTC 131	HEP-51	SK 3114	RT-115	ECG 129	2N1704	RS276-2009	ICC-53	IRTR-51	PTC 121	HEP-53	SK 3122	RT-102	ECG 123A
2N1624	RS276-2001	GE-6	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101	2N1705	RS276-2005	ICC-254	TR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N1625	NA	GE-50	TR-17	PTC 107	NA	NA	NA	ECG 101	2N1706	RS276-2005	ICC-254	TR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N1631	RS276-2003	GE-9	TR-05	PTC 107	HEP-635	SK 3008	NA	ECG 126	2N1707	RS276-2005	ICC-254	TR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N1632	RS276-2003	GE-9	TR-85	PTC 107	HEP-635	SK 3008	NA	ECG 126	2N1708	RS276-2009	ICC-50	TR-21	PTC 136	HEP-50	SK 3122	RT-102	ECG 125A
2N1633	NA	GE-9	TR-17	PTC 107	HEP-2	SK 3008	NA	ECG 160	2N1709	NA	NA	NA	NA	HEP-S3010	NA	NA	NA
2N1634	NA	GE-9	TR-17	PTC 107	HEP-2	SK 3008	NA	ECG 160	2N1710	NA	NA	TR-35	PTC 110	HEP-S3010	NA	NA	NA
2N1635	RS276-2003	GE-9	TR-12	PTC 107	HEP-635	SK 3008	NA	ECG 160	2N1711	RS276-2009	ICC-736	TR-35	PTC 123	HEP-636	SK 3024	NA	NA
2N1636	RS276-2003	GE-9	TR-12	PTC 107	HEP-635	SK 3008	NA	ECG 126	2N1713	NA	NA	NA	PTC 123	HEP-638	NA	NA	NA
2N1637	RS276-2003	GE-9	IRTR-85	PTC 107	HEP-635	SK 3008	NA	ECG 126	2N1714	NA	NA	NA	PTC 144	HEP-S3020	NA	NA	NA
2N1638	RS276-2005	GE-9	TR-05	PTC 107	HEP-636	SK 3008	NA	ECG 160	2N1715	NA	NA	NA	PTC 144	HEP-714	NA	NA	NA
2N1639	RS276-2005	GE-9	TR-17	PTC 107	HEP-636	SK 3008	NA	ECG 160	2N1716	NA	NA	NA	PTC 144	HEP-S3020	NA	NA	NA
2N1640	NA	NA	TR-19	PTC 131	NA	SK 3118	RT-126	ECG 106	2N1717	NA	NA	NA	PTC 144	HEP-714	NA	NA	NA
2N1641	NA	NA	TR-19	PTC 131	NA	SK 3118	RT-126	ECG 106	2N1718	NA	NA	NA	PTC 144	HEP-714	NA	NA	NA
2N1642	NA	NA	TR-19	PTC 131	NA	SK 3118	RT-126	ECG 106	2N1719	NA	NA	NA	PTC 144	HEP-S3020	NA	NA	NA
2N1643	RS276-2021	GE-21	TR-21	PTC 153	HEP-51	SK 3114	RT-115	ECG 159	2N1720	NA	NA	NA	PTC 107	HEP-714	NA	NA	NA
2N1644	RS276-2009	GE-27	TR-21	PTC 144	HEP-53	SK 3122	RT-102	ECG 123A	2N1721	NA	NA	NA	PTC 107	HEP-714	NA	NA	NA
2N1646	RS276-2003	GE-51	TR-17	PTC 107	HEP-3	NA	NA	ECG 160	2N1722	NA	ICC-2	NA	PTC 107	HEP-2	SK 3006	NA	ECG 160
2N1647	NA	NA	NA	NA	HEP-S5000	NA	NA	ECG 160	2N1723	NA	ICC-2	NA	PTC 107	HEP-2	SK 3006	NA	ECG 160
2N1649	NA	NA	NA	NA	HEP-S5000	NA	NA	ECG 160	2N1728	NA	ICC-2	NA	PTC 107	HEP-2	SK 3006	NA	ECG 160

NA = NOT AVAILABLE

(continued, next month)

R-E's Service Clinic

Hardware Noise— A type of TVI

*How to identify
and localize it.*

JACK DARR
SERVICE EDITOR

OUTSIDE OF CERTAIN COMMERCIALS, one of the things that annoys TV viewers the most is interference or noise in the picture. It comes in all shapes and sizes; from older cars, home electrical appliances, and so on. Anything in the house can be tracked down, and identified, by simply turning it on and off. Filtering can then be used to clear it up. Some interference can come from outside sources, though. We used to call this "hash", but now I suppose we should say noise pollution. Either one is correct.

An irate reader wrote me "I've got so much interference on my TV set that I don't like to watch it. There are two wide bands of dots and streaks that roll slowly up the picture. They interfere with the sound, and even make the picture roll at times. Looks like ignition noise, but I don't think it is. What can I do about it?"

Complain loudly to the power company. I've seen this a great many times. The polite name for it is hardware noise. It's caused by old or defective equipment on the ac lines feeding your house. You'll notice that the interference shows two bands of dots, meaning that it has a characteristic 120-Hz frequency. Without going into too much detail, it's due to a corona discharge. Not on your home's service wiring, which is 230 volts maximum in most places, but on the feeders or tertiary lines which supply the pole step-down transformers. These lines run around 7,600 volts, etc.

Several things can cause it, including defective or cracked insulators, but probably the most frequent offender is the terminals on the transformers themselves. If these are old, or not correctly designed, the corona discharge takes place *inside* the transformer, above the oil, from the shank of the bolt to the metal case. I have seen some "horrible examples" of these after they'd been replaced, and the shank of the terminal bolt is actually pitted and eaten away by the

corona! There are newer types, designed to prevent this; they have plastic insulation, etc. on the shank of the bolt. Your power company, especially the REA, has a training film on this, which shows all of the effects and how to cure them.

The reason for the 120-Hz effect is simple. The corona discharge takes place twice during each cycle of the voltage; once on the positive peak and again on the negative peak. Each peak generates the corona discharge, which in turn generates a burst of high-amplitude rf "signals", which cover all frequencies. We're going to do something with this effect in a moment.

The first step should be to file a complaint, in writing, with your local power company. Tell them you have hardware noise, and they'll know what you're talking about. Most companies have noise locating equipment, and it shouldn't take them long to find the offending unit.

If you want to try finding it yourself, there are a couple of ways. Drive around the area with a radio equipped car, or even a portable radio. Set the dial off-station, somewhere near 800 kHz. For some reason, this noise peaks at that frequency. When you find a place where the noise is very loud, turn the dial of the set back and forth. It will usually be of such a high amplitude that you won't be able to use "loudness" alone to pin it down.

When you get closer to the source, the noise will start to spread; it will cover more and more of the dial. For example, if you get noise from 600 to 900 kHz, you're getting closer, but you're not there yet. Keep on looking and tuning, and when you find a place where you can get nothing but noise from one end of the dial to the other, you're getting warm—really warm.

Find the nearest pole. If it has a transformer on it, so much the better. Listen to the noise, and hit the pole a sound whack with a heavy hammer. If

(continued on page 78)

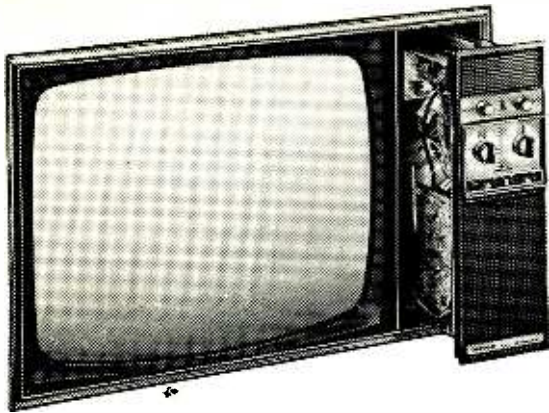
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| <input type="checkbox"/> Electrician | |

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Circle 16 on reader service card

SERVICE CLINIC

(continued from page 73)

this changes the noise, there you are.

Second method. If you have a highly directional TV antenna with a rotator, turn it all the way around, and watch the screen. Find the direction where the noise is most intense. Make a line along this bearing, on a city map. Now locate a friend with an antenna of the same type. Take a bearing on the noise with his antenna. Draw this on the map. At the point where the lines cross, there's the noise. If you can get a third bearing, preferably at a point distant from the first two, you can pin it down even more closely. We used this method on a very bad case, some time ago, and pinned it down to a very bad insulator, on a pole almost two miles away. Some nut had shot the insulator with a high-powered rifle!

Due to the fact that power lines make excellent "long-wire antennas", you may run into some ambiguity in your bearings. In fact, it's more likely that you'll see a triangle instead of a single point where they cross. At any rate, you're in the ball-park.

Go to the general area where the noise is originating and then switch to the car radio or portable. Use the frequency-spread of the noise as the in-

dicator and follow the power line until you find the pole where the noise covers the whole dial. There you are. Look for a little metal tab or label on the pole. This will give you the number, and you can report it to the power company. **R-E**

reader questions

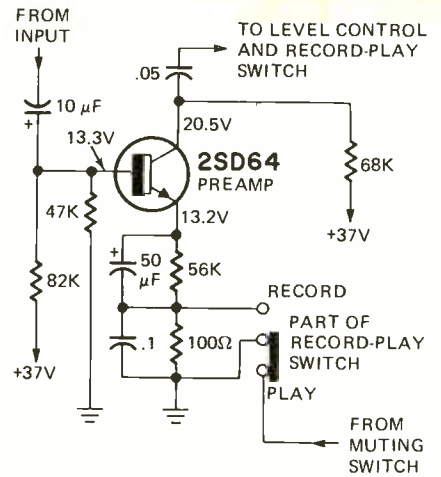
SUDDEN LOSS OF CONVERGENCE

Here's one for you. In a Sylvania D-15, I had a sudden loss of convergence. I couldn't get the center vertical line, red and green, to converge at all. The trouble turned out to be a shorted electrolytic capacitor, C-800, 6.8 μ F located on the convergence board. This might apply to other chasses, too.—Harold Jones, Harold's TV, 810 College, Bowling Green, Ky.

Thank you very much, Harold. Filed and noted for future reference.

NO SOUND

I can't get anything through the amplifier of this Sony TC-102 hybrid tape recorder. The dc voltages on the 6AU6 second af amplifier are about



+60 volts, plate and screen, but I read +8 volts on all three elements of the preamp transistor. That doesn't sound right.—H.C., Monroe, La.

It certainly doesn't. From a reading like this, you have one or two possible things; the transistor is shorted to all three elements, or there is a resistor open in the supply! Take the transistor out and check it. If it shows a normal "diode-effect" reading out of circuit, then turn the power on, and check the voltages on the transistor connections on the board.

From these readings, I'd suspect something like an open collector load resistor, R9, 68,000 ohms. If this was (continued on page 80)

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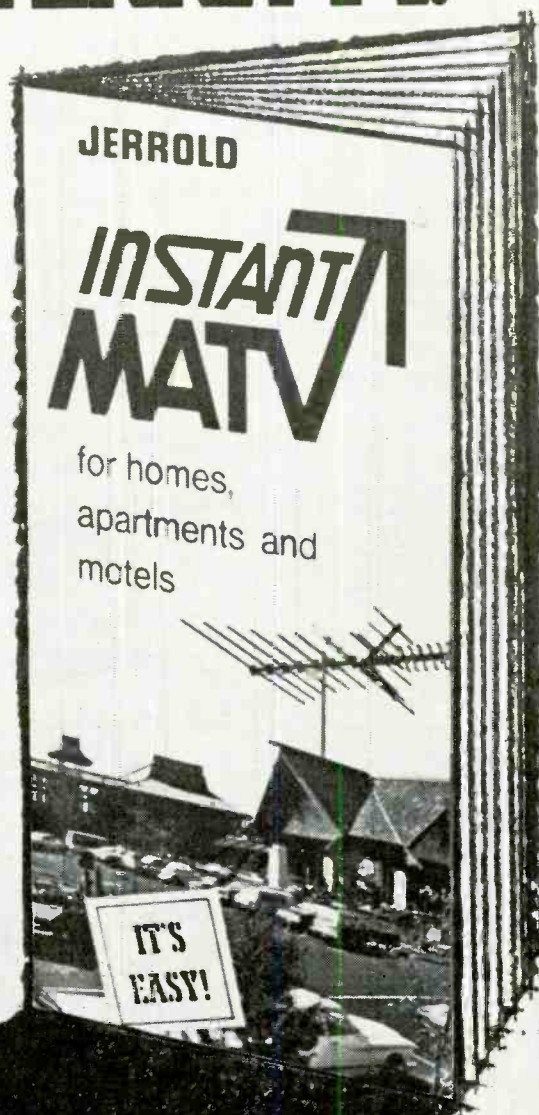
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Circle 18 on reader service card

READER QUESTIONS

(continued from page 78)

good, and the transistor shorted, you'd be reading much higher voltages.

VERTICAL SYMPTOMS, HORIZONTAL TROUBLE

The raster of this RCA CTC-55 slowly shrank, and just as it was almost gone, the circuit-breaker tripped. It does this after about 10 minutes of operation. I found nothing bad in the vertical output stage; in fact, if I feed a 30-V ac signal to the output grid, while the raster's shrinking, I can get a full raster

again. Only thing I can see is a gradual drop in the boost, while it shrinks. This is weird.—A.J., Minneapolis, Minn.

Right! Your vertical stage is OK. The raster-shrink is due to the drop in boost; this feeds the input-half plate, through the vertical size control. So you have a vertical symptom and a horizontal cause.

Find out why your boost is dropping. In quite a few of these chassis, this has been due to grid emission in the 31LZ6 horizontal output tube. It upsets the bias and makes the cathode current rise; this trips the breaker.

FOCUS PROBLEM

After I replaced the picture tube on

this Catalina 122-770B, it worked fine. I was converging it, and all of a sudden I lost focus. Smoke started coming out of the high-voltage cage. The flyback was pretty warm. I tried new tubes; same thing. 6JE6 cathode current went off-scale on 250 mA range.

Nothing helped; horizontal efficiency coil, focus adjustment, had no effect. The raster is full, but badly smeared; no focus at all. Do you think the flyback has gone?—A.S., Chicago, Ill.

Not yet, if you still have a full raster. Don't leave it on too long, or it probably will be. This sounds very much as if your focus transformer is shorted. As you can see from the diagram. It is shunted right across terminals 1 and 2 on the flyback.

CHANNELLOCK

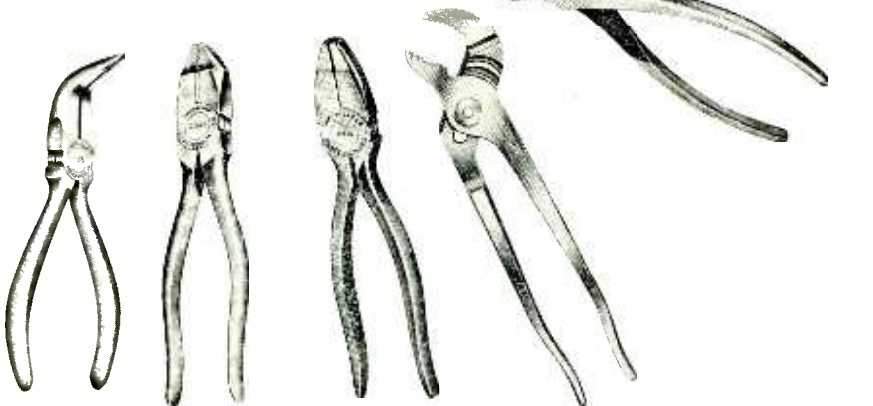
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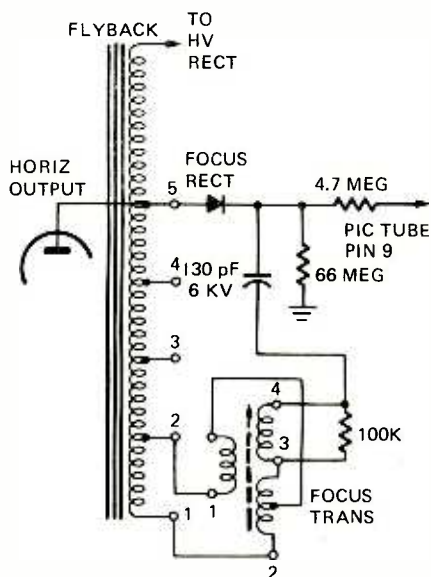
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To check, just disconnect the focus transformer from the flyback and try again. If your 6JE6 current goes back to normal, and the flyback stays fairly cool, this is it. You'll probably see much better focus, if the transformer was shorted; this is only a control on the focus voltage. Incidentally, you won't find this model listed in Sams, but the diagram of an AMC CER-75A (828-1) matches it.

COLOR SYNC LOST

This Motorola TS-918 had a bad arc-over from the ultor connection to the shield; burned up the insulating cap. After I got this fixed, I found there was very little color sync, and the color looked very odd. Should I realign the color stages?—R.G., Provo, Utah

No. The chances are that this is component damage, due to the high transients generated by the arcing. I have seen similar things happen.

In this model, check the color sync and gate stage, the 6BL8. It is quite possible that the 4700-ohm glass-film resistor has been damaged. If so,

SOUTHWEST TECHNICAL PRODUCTS CORPORATION

219 W. RHAPSODY
SAN ANTONIO, TEXAS 78216
PHONE: 512 DI 4-3140

September, 1973

Dear Radio-Electronics Readers,

I understand from my mail, phone calls and other feedback that there are still some of you out there who cannot believe our kits are any good due to the reasonable prices that we charge. It sort of makes me wonder at times if we wouldn't automatically increase our business 50% if we just doubled our prices so that they would compare with other kits that are available. At least we wouldn't have this credibility problem with our potential customers. No, don't worry, it's not about to happen, but for those doubters let me once more try to explain the deal.

This is strictly a direct mail business, for the first thing. We don't sell through dealers, and don't have any expensive, fancy company owned outlets. This type operation makes it impossible for us to demonstrate our equipment for you, but it also saves you the 30 to 40% markup that the dealer would normally get on the equipment. We are gambling that there are enough people who know a superior circuit when they see one and a good deal when one is offered them, to keep us clear of the bankruptcy courts. We are not trying to cut any corners on quality, in fact our parts are probably better than the great majority of those you see in electronic equipment. Our circuit boards are all G-10 fibreglass and all resistors are highly stable film types. How many other kit companies do you know who can honestly make a similar statement? So next time you are tempted to try a kit from the "other" kit company, but cannot believe the price, just add 1/3 to the price in our catalog. See, now don't you feel better thinking about our "Tiger .01" amplifier, for example, as a \$99.50 kit rather than a \$75.00 kit.

One thing more should be mentioned. We design our kits for people who have experience with electronics. We don't waste time and money writing "hand holding" or "overkill" instructions. We expect you to have a multimeter of some kind at the very minimum and to know how to use it. We expect you to know how to read a schematic and how to solder. In other words we expect you to be seriously involved in electronics and not just be looking for a nice hobby to pass the time. I don't consider having built 537 Heath, or EICO kits as qualifying anyone in the field of electronics anymore than I would consider having done 537 number paintings qualifying you as an artist. Please, if you are like the approximately one guy a month who returns a transformer because he tested the winding with his multimeter Ohms scale and found that it did not check out with the impedance we called for; save us both problems, and get the built-up version. Not that I have anything against beginners, or students. I am happy for them to build our kits as long as they understand the situation and are adult enough to accept the possible consequences with a minimum amount of sniveling. We have a repair department just in case you get in over your head, but service work is limited to repairs. We won't build ¾ of the kit for you.

I would like to send you a free copy of our new 30 page catalog if you are interested in our kits. Just circle our number on the "Bingo" card in the back of the magazine, or mail us a card.

Sincerely,

Dan

Daniel Meyer



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Circle 20 on reader service card

ARROW

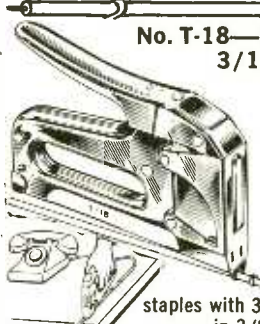
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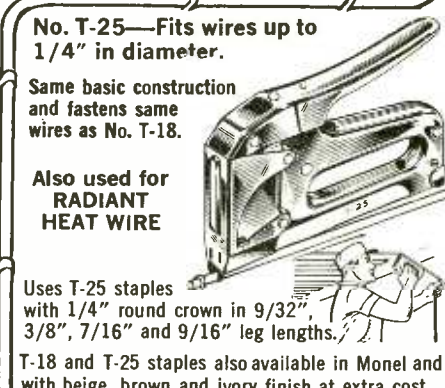
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No. T-25—Fits wires up to 1/4" in diameter.



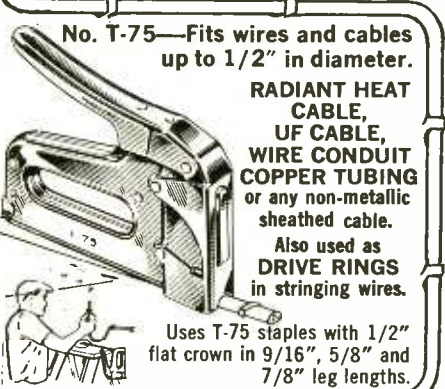
Same basic construction and fastens same wires as No. T-18.

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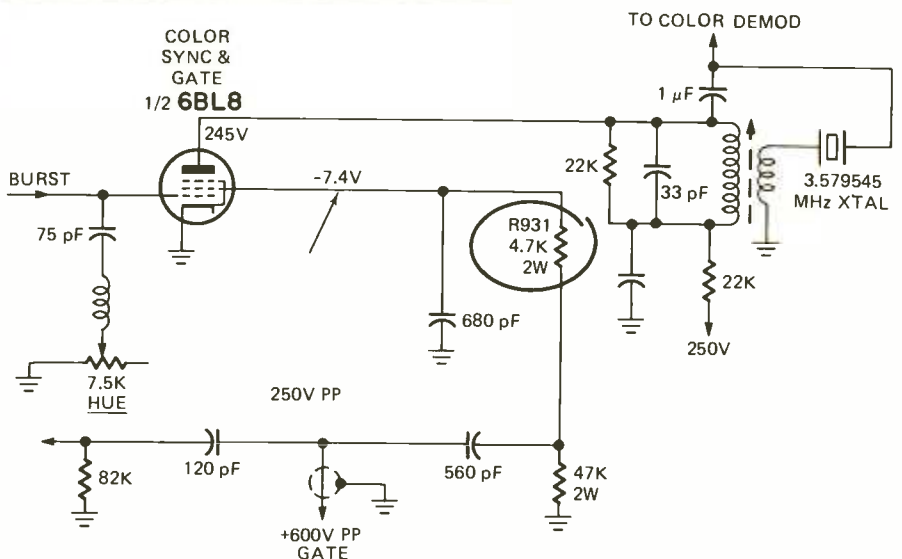
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Circle 21 on reader service card

READER QUESTIONS (continued from page 80)



you'll have no gating pulse on the 3.58-MHz signal to the crystal and no color sync at all. This is R931.

BURNT "PLATE LOAD"

The plate resistor of the pincushion-corrector tube of this Setchell-Carlson U802 burns up; so does the 15,000-ohm pot that feeds this resistor. I changed the 6GK6 pincushion-corrector tube, but that didn't help. The raster goes out of focus and pulls in.—J.A., Rome, Ga.

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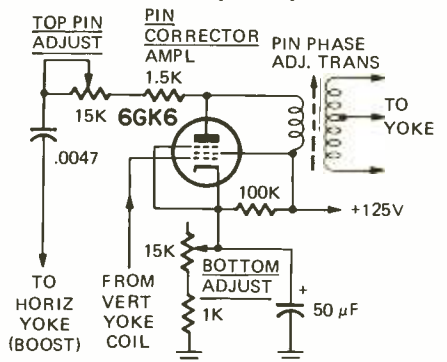
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Circle 22 on reader service card

May I make a small correction? The 15,000-ohm pot and 1500-ohm resistor do not feed dc to the pin-corrector tube. The dc plate voltage is supplied through the primary winding of

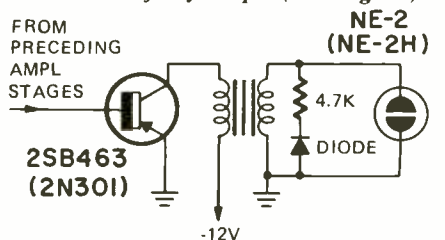


the pin-phase transformer, to the right of the tube in the diagram. If you'll notice, the dc path to the resistors is blocked by the .0047-μF capacitor. Nothing but pulses should come through here.

I believe that I'd suspect that .0047-μF capacitor of being shorted.

INDICATOR LAMP FAILURE

The neon lamp indicator in an Allied Knight KG-711 depth finder kept burning out. The original is a type NE-2. They last only a few hours. The output transistor, a 2SB463, went out on me, and I replaced it with a 2N301. The circuit looks fairly simple (see diagram).



I finally got mad and replaced the NE-2's with NE-2H's.—K.W., Sheboygan, Wis.

Right. I'll take both fixes. **R-E**

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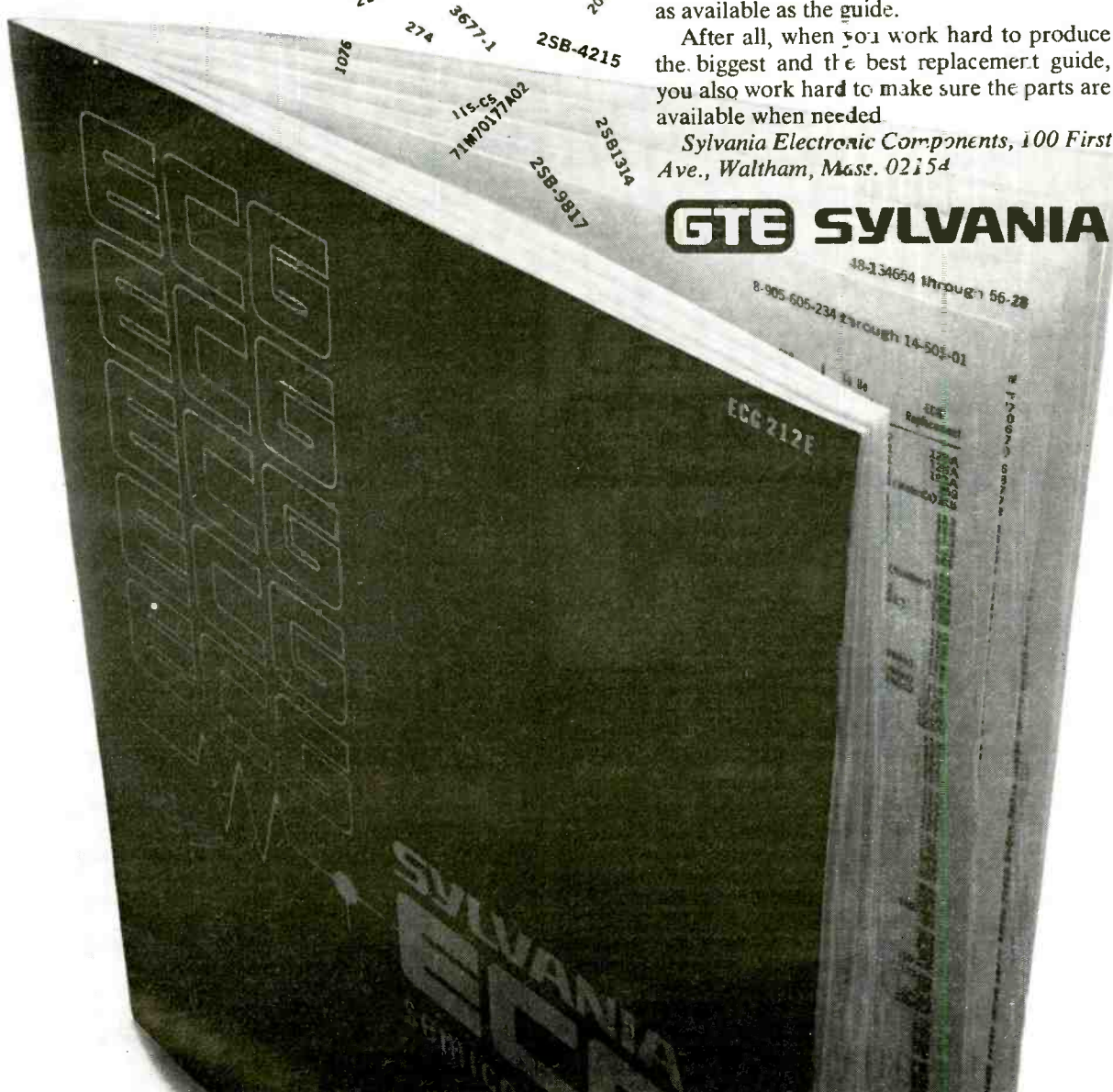
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DIGITAL MULTIMETER KIT, model 8700K is a general-purpose instrument for the hobbyist, technician or engineer. 3½ digit readout; 0.5% accuracy; all



solid-state construction. Unit measures ac volts, dc volts and ohms in four ranges for each type of measurement.—**Nobex Electronics Division, Griffith Plastics Corp.**, P.O. Box 4365, Burlingame, Calif. 94010.

Circle 31 on reader service card

AUTOMATIC ANTENNA ROTATOR, Selecta-Channel 10W 606. Decorator styled control cabinet houses a moving direction indicator light synchronized with antenna movement and shows antenna position. Weatherproof drive unit has heavy-duty precision worm-gear drive to



provide a strong turning force and lock antenna in position—preventing any chance of windmilling.

Quick connect pressure terminals speed installation and reduce chance of short circuits. Quiet operation. Comes with premounted hardware and takes four-wire rotator cables.—**RCA Parts and Accessories**, P.O. Box 100, Deptford, N.J. 08096.

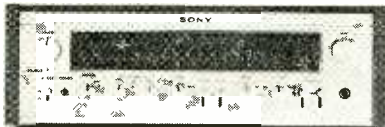
Circle 32 on reader service card

STEREO RECEIVER, model STR-7055 delivers 35 watts per channel continuous power output at all frequencies from 20

Hz to 20,000 Hz driving an 8-ohm load. Amplifier sections use differential amplifier input circuits and balanced negative and positive supplies. Resulting direct-coupled output circuit has wide-band response, minimal phase shift and a high damping factor (50 at 8-ohms). Harmonic and IM distortion is less than 0.2% at rated output.

FM tuner has new junction FET's in mixer and rf stages to provide 2.0 μV IHF sensitivity. Solid-state filters and an IC limiter produce 70 dB IHF selectivity and a capture ratio of 1 dB.

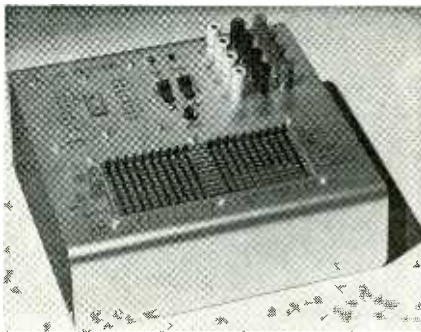
AM section has triple-tuned solid-



state filters and a new IC with agc to maintain high sensitivity, minimum distortion and optimum signal-to-noise ratios.—**Sony Corporation of America**, 47-47 Van Dam St., Long Island City, N. Y. 11101

Circle 33 on reader service card

IC TESTER, ICT-1800 is used to breadboard IC's while developing circuits. Features include internal 2-speed clock, twelve binding posts that allow



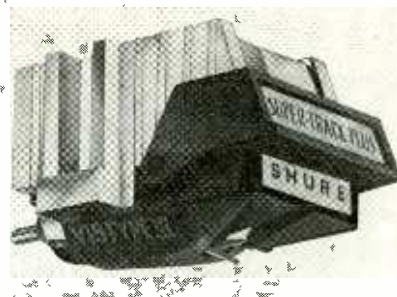
connections with external equipment such as a scope, oscillator or additional power source and 18 LED indicators which show the status of the IC under test.

Front-mounted push-button switch allows the user to advance counters, dividers and shift registers one step at a time. 10 by 20 matrix switch is used to program the functions and logic levels for the IC under test. Matrix programmer allows the patch-in of any internal or ex-

ternal function to any pin or combination of pins on the IC.—**Micro Instrumentation & Telemetry Systems, Inc.**, 2016 San Mateo N.E., Albuquerque, N.M. 87110.

Circle 34 on reader service card

STEREO CARTRIDGE, V-15 Type III has a laminated magnetic core structure and stylus assembly that results in a 25% reduction in effective stylus mass. This model has high trackability at low track-



ing force (¾ to 1¼ grams), virtually flat frequency response with no noticeable emphasis or de-emphasis at any frequency and an extended dynamic range at no loss in output level. Frequency response (using optimum load) is 10 to 25,000 Hz.

Type III should be used only in arms which are designed for low tracking forces and have low friction at all bearing surfaces. Has biradial elliptical diamond stylus; also available with spherical diamond stylus and biradial elliptical stylus with tracking force range of 1½ to 3 grams (for mono 78 rpm records). 6 grams; \$72.50.—**Shure Brothers Inc.**, 222 Hartrey Avenue, Evanston, Ill. 60204.

Circle 86 on reader service card

MOBILE MICROPHONE, model DX-116A, for use in boats, cars, trucks or at base stations. Transistor compression ampli-



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fier assures full, clear modulation and has a gain of 0-12 dB (adjustable).

Incorporates FET integrated circuits for speech clipping and compression. Frequency response is 300 to 5000 Hz; sensitivity is -42 dB and impedance is 600 ohms. Controls include volume and push-to-talk button. Wired for relay and electronic switching, comes with 5 foot coiled cord. \$23.95.—**Mura Corp.**, 50 South Service Road, Jericho, N.Y. 11753.

Circle 36 on reader service card

TWO-WAY RADIO, Messenger 210T is an AM land mobile radio. Tone-Alert selective signaling keeps the radio silent until one of your own units calls. Then the called radio emits an audible tone and a red call indicator lights. Call in-

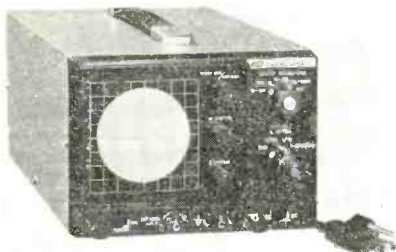


dicator remains on until operator returns the call.

System operator receives a license for operation on his own, reasonably private, channel. Five watts output. Operates from any 12-V dc negative ground system; accessories permit use in other dc or in 120-V ac systems.—**E. F. Johnson Company**, 299 Tenth Avenue S.W., Waseca, Minn. 56093.

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Circle 38 on reader service card

AC MILLIVOLT METER, LMV-89 checks audio-signal quality of 4-channel and 2-

channel (stereo) circuitry. Range is from 100 μ V to 300 V in 12 steps and full-scale accuracy is \pm 3%. Decibel scale



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Circle 39 on reader service card

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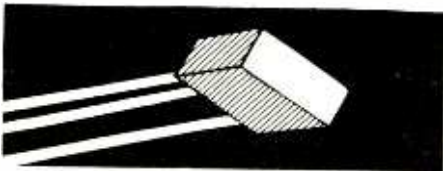
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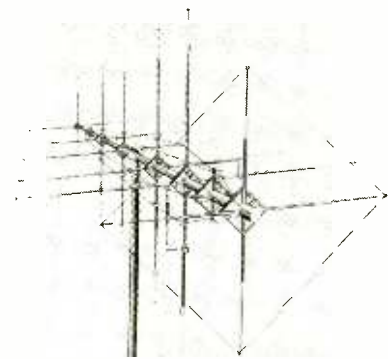
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elements plus a quad-type reflector for rejection and gain. Tunable gamma matching on both vertical and horizontal elements, gets low SWR and provides lightning protection.

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the ionosphere. When the skip changes, polarity can be changed to eliminate the unwanted interference. 31½-foot boom; 17 dB gain over isotropic, 44 dB rejection, 24 dB side rejection and 1.2:1 SWR.—**Avanti Research & Development**, 33 West Fullerton Avenue, Addison, Ill. 60101.

Circle 40 on reader service card

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dent upon receiver sensitivity and the nature of obstructions between receiver and microphone. Standard 9-volt battery is required power source.

Antenna is a short insulated wire that hangs from behind the unit. A lavalier accessory is included. Frequency range is 88 MHz to 108 MHz with drift-free stability. Tuning wand is provided to tune or change the microphone's transmitting frequency. 2½ oz.; \$29.95.—**EV Game Inc.**, 186 Buffalo Avenue, Freeport, N.Y. 11520.

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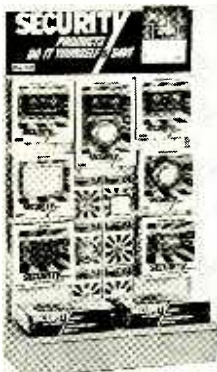


or left-hand use.

Features heavy-duty construction plus light weight with durable nylon and precision-made steel parts used in all internal construction. Can be used as a stand for the gun when not in use. 5 oz. includes solder; \$8.95.—Schurman Products, P.O. Box 13, Weymouth, Mass. 02188.

Circle 42 on reader service card

SECURITY PRODUCTS include smoke/fire alarms, car alarms, closed-circuit alarms, personal alarms and ultrasonic alarms. In addition, there are ac-



cessories that allow users to personalize their own security systems. Each bright yellow and black box includes complete installation instructions.—Mallory Distributor Products Company, 101 South Parker, Indianapolis, Ind. 46206.

Circle 43 on reader service card

LEAD BENDING BLOCK, model 710 prepares axial-leaded components for mounting on printed circuit boards or chassis. Right-angle or spring-loaded lead bends for resistors, capacitors, in-



ductors, are made for accurate alignment to mounting holes or terminals. Gives neat, rounded bends within .100" of the component body on centers up to 3". Case lengths are accommodated to 1 3/4". Adjustable gauge plate can be preset. \$14.95.—Webtek Corp., 4326 West Pico Blvd., Los Angeles, Calif. 90019. R-E

Circle 44 on reader service card

new lit

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

ELECTRONIC COMPONENTS. 8-page booklet presents perforated breadboards and terminals, breadboarding accessories, power transistor mounting kits with sockets or hardware, power transistor mounting kits diode mounting clips and battery holders & accessories.—Keystone Electronics Corp., 49 Bleecker Street, New York, N.Y. 10012.

Circle 45 on reader service card

INSTANT MATV is an 18-page catalog that contains VHF/FM system and all-channel (VHF, FM, UHF) system for: home or small motel; apartment house; motel, school or garden apartment; apartment house or hotel. Also contains instructions on connecting TV sets to tape-offs, installation tips and instant MATV products. \$1.00 at your distributor.—Jerold Electronics Corp., 200 Witmer Road, Horscham, Pa. 19044.

Circle 46 on reader service card

CREATIVE KITS brochure includes (pictures, prices and specifications) tachometer kit, crystal radio kit, Morse code kit, transmitter kit, table radio kit, one-tube radio kit, strobe lite kit, audio color organ kit, and burglar alarm kit.—Graymark Enterprises Inc., Suite 700-26, Benjamin Fox Pavilion, Jenkintown, Pa. 19046.

Circle 47 on reader service card

WIRE-WRAPPING CATALOG includes charts of bits and sleeves, sections on terminal spacing, tool specifications, various illustrations along with part numbers, descriptions and prices of every tool.—O.K. Machine & Tool Corp., 3455 Conner Street, Bronx, N.Y. 10475.

Circle 48 on reader service card

Write direct to the manufacturers for information on items listed below:

MATV PRODUCTS CATALOG, No. 109 contains 36 pages of illustrations, descriptions and specifications for over 250 products such as Ultra-Plex strip amplifiers, power panels, splitters, drop taps, line amplifiers and tilt compensators. Covered are commercial systems equipment for MATV, CCTV, ITV, ETC, CATV, NATV and sub-channel.—Winegard Company, 3000 Kirkwood Street, Burlington, Iowa 52601.

TEST EQUIPMENT 24-page catalog features field-effect multimeters, sweep-circuit analyzer, field strength meter, tube testers, picture-tube testers, transistor tester, universal power supply, oscilloscopes, color generators, sweep & marker generators, RC substitution units, time savers and AM-FM stereo analyzer. Complete specifications and photo of each model. Lists factory service centers.—Sencore, 3200 Sencore Drive, Sioux Falls, S.D. 57107. R-E

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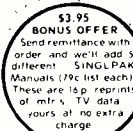
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EQUIPMENT REPORT (continued from page 30)

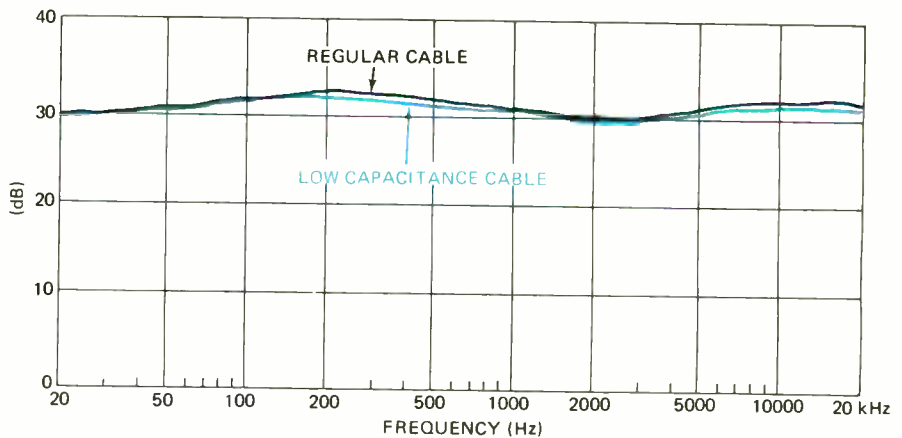
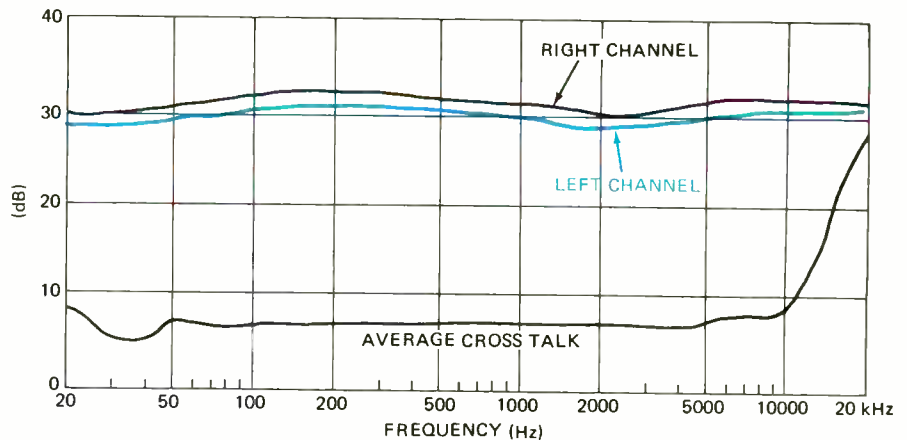


FIG. 1—(top) INCLUDING THE TOLERANCE limits of the frequency response test record and the recorder the worst-case frequency response variation of the Shure V15 Type III phono pickup was 1.5 dB, while the output level matching between the left and right channels was within 1 dB. Note the broad, notably smooth cross-talk to 10 kHz at the test record's inherent cross-talk limit of 25 dB, and this was with the recorder pen at high speed, rather than damped as is usual for cross-talk measurements. Also note the smooth reduction in separation from 10 kHz to 20 kHz. No peaks or resonances to produce noise bursts in the opposite channel. (The reduced high-frequency separation is typical of all pickups we've seen.)

FIG. 2—(above) EXCEPT FOR LESS THAN 1-DB difference at 20 kHz the frequency response from the Shure V15 type III is the same for both standard and low-capacitance connecting cables, a decided advantage if the same turntable and tone arm combination is to be used for both stereo (matrix 4-channel) and discrete (CD-4) 4-channel records. Standard cable capacitance measures between 170 pF and 200 pF for a 5-foot cable, or 34 to 40 pF per foot. Low-capacitance cables can run as low as 12 pF per foot.

nated the peak is greater; if the peak is reduced the dip is greater. Normally, pickups are designed so the overall response stays within ± 2 dB or ± 3 dB limits in production models, which meets the performance requirements of high fidelity. But any variation in frequency response is reflected as coloration in the reproduced sound. If there is little dip and a relatively large peak the sound might be de-

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scribed as *bright*, or *brilliant* (slightly accented midband and highs). If the peak is reduced by providing a broad midband dip the sound might be described as *mellow*.

In the Shure V15 Type III pickup the normal resonance has been moved above 20 kHz—above the limits of hearing—so that within the audible frequency range the pickup's output is "flat". According to Shure the V15 Type III *production* (not laboratory) models are within 2 dB in frequency response and channel output matching from 30 to almost 10 kHz with a worse-case match of about 3 dB at the extreme ends of the spectrum.

As shown in Fig. 1, the worst-case response variation from both channels 20 to 20 kHz was 1.5 dB, with an output level variation between channels no greater than 1 dB. In actual fact this performance level is within the tolerance limits of the test record and the graphic recorder, meaning, in plain terms, that the Shure V15 Type III's performance is even better. (Frequency response test records are notorious for considerable variations in response between individual records.)

Note in particular the averaged midband cross-talk (separation) of 25 dB, actually the limit of the test record. Since the record itself has a built-in 25 dB limiting factor what is important is the overall smoothness of the cross-talk curve from 20 to 10 kHz. Also note that as the separation decreases between 10 and 20 kHz (typical) there are no peaks or resonances in the curve, which would appear as noise bursts.

Of somewhat greater interest are the frequency-response variations between low and normal capacitance cables between the pickup and amplifier, an important consideration if you plan to use the same turntable and arm for both stereo and discrete (CD-4) record reproduction. While Shure specifies the typical total capacitance value of 400 to 500 pF (through the phono input), reducing the capacitance to 50% (200 pF) by using low-capacitance cables (for CD-4 pickups) produces an almost insignificant variation in frequency response, actually less than a dB at 20 kHz. (see Fig. 2).

The Shure Type III pickup is available with biradial (elliptical) or spherical styli for stereo and matrix 4-channel use, or with a biradial stylus for monaural 78's. Because of the high compliance inherent in the pickup, and because it requires minimal applied friction force from the tone arm for optimum tracking, the Shure V15 Type III is suggested for use only in tone arms of the highest quality, and the tone arms provided on the better quality "automatic" and manual turntables can be considered suitable. **R-E**

appliance clinic

BEGINNERS ONLY

by JACK DARR
SERVICE EDITOR

THIS ONE IS STRICTLY FOR BEGINNERS only—the novices and the young men who are just getting interested, in this bewildering profession of ours. So all you Double-E's and CET's go read something more difficult while I jump on the kids about some elementary but essential safety precautions about electricity.

The idea behind this is pretty simple. We want these people to *live* to become qualified technicians. If they don't observe these rules, or worse still, if they don't know about them, some of them won't make it.

Electricity is a very useful thing, but it can be lethal. (That means that this stuff can kill you, Clyde.) The standard ac line coming into your

home has two wires. There is 120 volts ac between the two. Of these two, one is always tied to a good earth ground, and the other one is "hot." The significant fact about this is that the hot side is *hot to everything that is grounded*.

What's ground? The earth itself; all water piping; all metal heating ducts; a bare cement floor. If you're standing on a cement floor in a pair of leather soled shoes, you could safely touch one side of the ac line. That is, IF you touch the grounded side. However, all you can see is two wires. How do you know which one is the hot one? The answer is you don't. Not until you make tests to find out which side is which.

For safety's sake, always wear shoes with insulating soles; rubber, plastic, etc. Leather soles, I repeat are (turn page)

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APPLIANCE CLINIC

(continued from page 89)

not insulators. If your soles are of the "spongy" type, and you've been walking in water, watch it. They can soak up enough water to become good conductors. You can be even safer if you stand on a dry rubber mat, or dry duck-boards.

There are other safety rules; the most important one probably is "Never work on anything hot:" translation, always be sure that the thing has been disconnected from the ac outlet. Pull the line plug and form a

habit of putting it on the bench where you can see it. If there's more than one thing on the bench with a line cord, be sure you can see the *right* plug.

There are several ways of testing to find the hot side of the line or to make sure that there is no power on the unit. One of the handiest of these is the little neon-lamp voltage tester sold in hardware and electrical supply stores. They have a tiny neon bulb in a plastic case, with two flexible test leads having metal tips. To find out if an outlet is hot, or if there is voltage across certain points, just touch one test-lead to each point. If there's volt-

age there, the neon lamp will glow.

Another handy tester, similar to this, is one of the oldest testers used. It's called a test-lamp, for obvious reasons. It's nothing but a weatherproof lamp socket with flexible leads. Strip the insulation off the leads for about 1/4 inch and tack the strands of wire together with solder. Then screw a small lamp into the socket and you've got a handy voltage-tester. Touch the leads to any two points in a circuit. If there's line voltage there, the lamp will light. You can make it more useful by extending the wires to about 24 inches and using standard test prods on the ends.

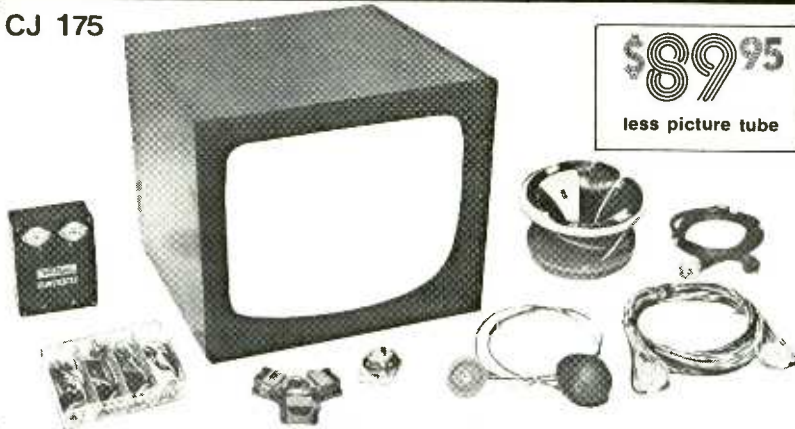
You can make it safer and handier, by attaching small alligator clips to the ends of the leads. Use the type with a rubber insulator over the jaws. You can turn the power off, and clip the leads to the points you want to test. Then, take your hands out, turn the power on and see if the lamp lights. This is handy for tests such as heating elements. Clip the test lamp across the ends of the element, and turn the switch on. If the lamp lights, this means that power is getting to the element.

The main idea behind all of this is to make *sure* that you avoid making *any body contact* with points which could be hot. You can never know that a given point isn't hot until you make some kind of test that will give you a definite answer. *Don't guess and don't take chances.* If you're wrong, you might not get another. It takes only 11-mA through the heart to cause fibrillation. This is on the arm-to-arm path, where the current passes through the chest.

So keep your cotton-pickin' fingers out of dangerous places, until you have made sure that it's safe. **R-E**

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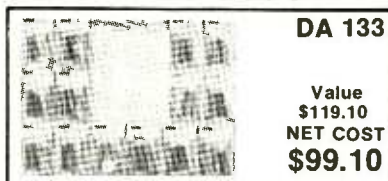
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quiz answers

(quiz on page 95)

1. npn
2. minus
3. common emitter
4. same as input
5. germanium
6. both answers correct
7. zero
8. increase

If you got all eight correct label yourself a solid-state expert. If you got six or seven correct, some study is required. If you got five or less right, we suggest you review your semiconductor basics. You've missed a few important points along the way.

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Circle 63 on reader service card

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■ 4-Channel FM Broadcasting

R-E's Contributing High-Fidelity Editor, Len Feldman explains the many different broadcast systems that have been proposed to the FCC. He shows how they work and how they differ.

■ 4-Channel Record Review

R-E's editorial staff has reviewed a mass of 4-channel matrix recordings. These reviews rate the 4-channel effect of the records. Might give you a clue as to what to use as a demonstration disc.

■ Setting Up For 4-Channel Discrete Records

We had one of our authors set up a discrete (CD-4) system. His report tells how it's done and what results to expect.

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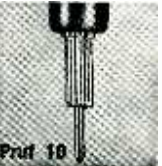
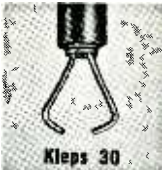
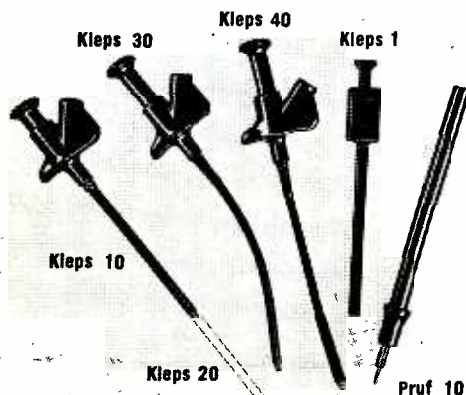
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Circle 66 on reader service card

SPEAKER SPECS

(continued from page 64)

terms of its ability to withstand the power input required to produce that maximum stated SPL.

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Efficiency: 85 dB SPL for 1 watt electrical input, at 1 kHz, measured at 1 meter from speaker system, on-axis.

Power Handling Capacity: May be used with amplifiers having up to 75 watt/channel continuous power rating for all musical programming. May be safely fed with 25 watts of continuous-tone at any frequency from 35 Hz to 10 kHz for an indefinite time period.

May be subjected to intermittent continuous power tests of up to 50 watts for periods not exceeding 5 minutes.

Maximum SPL: 104 dB at 1 meter at less than 3% THD & IM from 100 Hz to 5 kHz.

Impedance:* Nominally 8-ohms, varies from 12 ohms (at 50 Hz) to a low of 5.3 ohms at 300 Hz.

Harmonic Distortion: Less than 3% at any frequency at SPL up to 95 dB. Less than 2% at any frequency at SPL up to 90 dB. 5% at 50 Hz for SPL of 100 dB.

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Dimensions: 34" x 18" x 15" deep.

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Preferred position: On floor (shelf mounting will result in additional 3 dB of attenuation at 50 Hz.)

Weight: 35 lbs.

Finish: Walnut

Price: \$125.00

*Suitable curves may be substituted for these specifications

decimal points and zeros so commonly associated with pre-amplifier, amplifier and even tuner products, so why keep them a secret. A system that can produce, say 100 dB SPL at any audible frequency from 40 Hz to 16,000 Hz with less than 2% THD or IM will still be judged by specification sheet readers to be better than one which does the same thing at less than 4% THD or IM and the buying public is, I think, intelligent enough to compare speaker specs with speaker specs and not with amplifier specs.

To sum it all up, Shown above is my attempt to write a more meaningful "Spec Sheet" for a loudspeaker system. The actual numbers are fictitious and do not apply to any particular system. The table is presented, rather, as a format for future "specmanship" when it comes to loudspeaker system performance and measurement. **R-E**

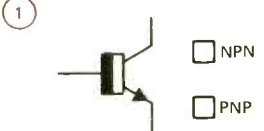
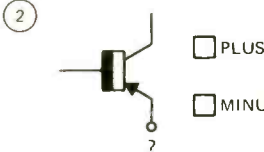
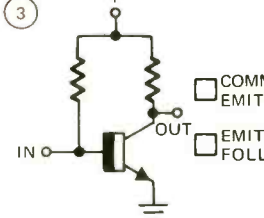
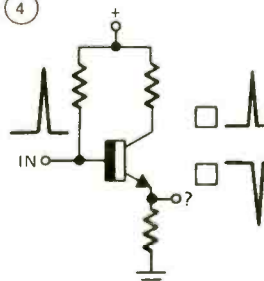
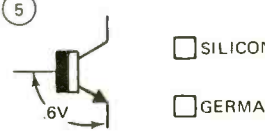
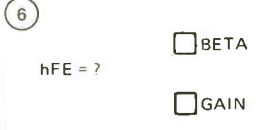
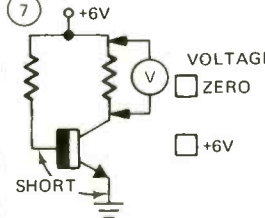
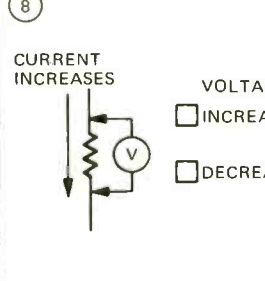
Circle 88 on reader service card

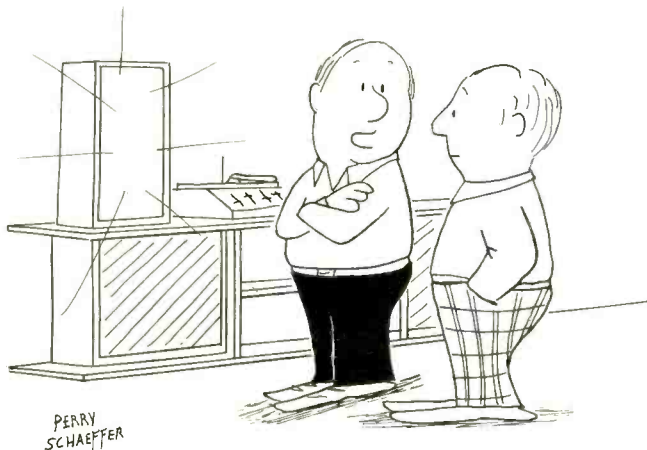
solid-state quiz

by JUD WILLIAMS

Here's a little quiz, courtesy of Jud Williams, manufacturer of the Jud Williams Model A Curve Tracer. Jud has given this quiz at several technician conferences and from the results, we can only deduce that the quiz is tougher than it looks. Why not try your hand. Answers are on page 90.

QUICK TEST

<p>① </p> <p>② </p> <p>③ </p> <p>④ </p>	<p>⑤ </p> <p>⑥ </p> <p>⑦ </p> <p>⑧ </p>
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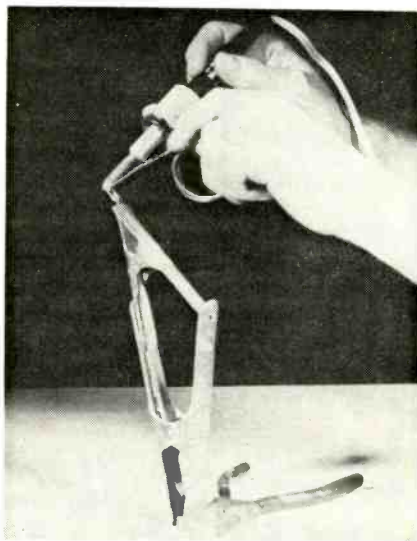
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try this

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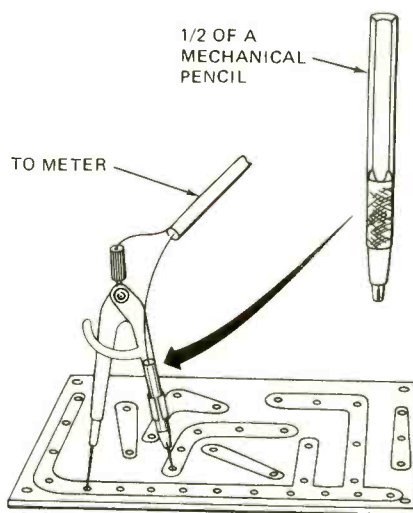
By doubling up on regular spring clamps their usefulness can be extended. One such use is shown. One handle



of the smaller clamp is slipped under the spring of the larger to clamp it securely.—R. G. Cooper

ONE-HAND TEST PROBES

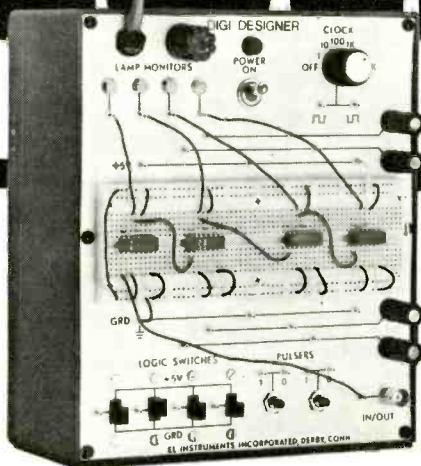
Here is how you can modify your test prods so you can handle them with one hand—particularly useful when testing small PC boards. The tool is made from an inexpensive pencil compass with the pencil replaced by half



of a mechanical pencil or ball-point pen with a metal cartridge. A needle is forced into the tip of the pencil or pen. The test lead is thin coax cable with its core soldered to the pencil tip (the *positive* prod) and the shield (the *negative* lead) is soldered to the body of the compass at the top. Connectors on the other end of the cable match your meter.—Peter Legon

R-E

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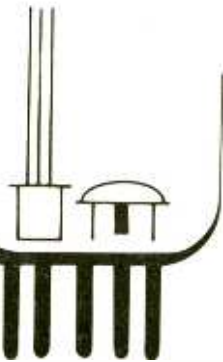
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experiments with WWVB

Concluding details on receiving methods and syncing Superclock and WWVB

by DON LANCASTER

TECHNIQUE No. 4—Add a "Flywheel." This is a sledge hammer trick and adds all sorts of parts and complexity, but it really works well and doesn't cost too much. Essentially, we build a phase-lock loop on the output whose frequency is 1 hertz and whose loop bandwidth is half a minute and is critically damped. The output of the flywheel now drives the decoder.

We can go to a 4-Hz VCO and a divide-by-four to get the one second output frequency, and gain a bunch in the "1"-"0" identification process. To do this, we decode the first three of the four states. The circuit is shown in Fig. 9.

The first state does the gated phase detection and lasts for a quarter-second time interval between 0.875 seconds on the previous second to 0.125 seconds on the next second. Normally, a sudden drop will occur precisely at 1 second. An early-late error can then be fed to the integrator which averages out a series of early-late commands to get an average error signal which the loop continuously drives to zero.

We then use a second "noise gate" to look for a low state between 0.625 and 0.875 seconds and a final noise gate to look for a low state between 0.375 and 0.625 seconds. The first noise gate tells us if a

pulse is present, while the second noise gate tells us if a "0" is *not* present. Together, we get the detected "1"s and "0"s.

Once we have a reliable signal, we have to decode it and send it to the clock. First, we have to detect 1's, 0's, and pulses. We get these ready to go from the flywheel, or we can add the 1-0 sync detectors shown in Fig. 10 instead. The "1"s and "0"s are marched through the shift register. The sync or detected P pulses detects the double pulse occurring at the beginning of each minute and sets up a two-stage shift register consisting of the third and fourth D-flops in the string. The third register goes high on second No. 2 and drops on second No. 10, with an update for the minutes and seconds being derived on the falling edge. The fourth register goes high on second No. 10 and drops on second No. 20, providing the hours update. The update process will be within a fraction of a second of true WWVB time. For more precision, the input signal can be de-

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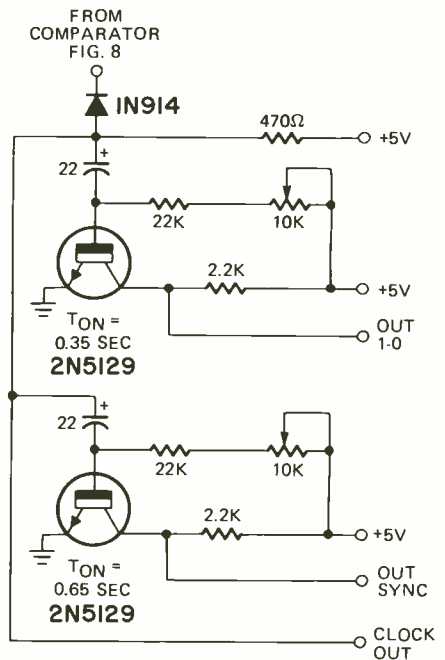


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1-0 & SYNC DETECTORS USED IN ABSENCE OF PLL FLYWHEEL

FIG. 10—SYNC DETECTOR extracts the 1's and 0's from the WWVB incoming signal.

layed slightly more and eleven seconds can be parallel loaded into the seconds counters at the precise update time. Fig. 11 is the required interface for use between the circuit in Fig. 9 and 10 and Superclock.

Local conditions

A final note on using the receivers. Some local interference can really wipe the receiver out, so be careful where you put it and how you use it. For instance, if you are within 8 feet of a television set, the horizontal oscillator can cause problems. So

(continued on page 101)

books

TRANSISTOR SPECIFICATIONS MANUAL, Fifth Edition, by Howard W. Sams Engineering Staff. Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind. 160 pp. \$4.50.

Since the first transistors were made available, the total number of types has increased tremendously. Many of these types are no longer sold, many were produced without registered type numbers and others by manufacturers no longer producing transistors. This manual contains three principal sections designed to provide a maximum of information about the transistor—a specification section, a lead identification section and an outline section. The specification section is composed of the electrical data that will be required for most applications. These are voltage, power, current and temperature limits that should not be exceeded as well as polarity, leakage and gain parameters that determine how the transistor will function in the circuit. The lead and terminal identification sections supplies the physical arrangement of the leads and identifies each as to whether it is collector, emitter or base. The outline section contains drawings of the physical shape and includes all pertinent physical dimensions. A valuable guide for anyone who may require a precise replacement transistor.

MARINE ELECTRONICS HANDBOOK by Leo G. Sands. Tab Books, Monterey & Pinola Sts., Blue Ridge Summit, Pa. 192 pp. Hardcover, \$7.95, Softcover, \$4.95.

Written for both the marine radio technician and the radio user, this handbook covers high-band FM, single sideband and low-band AM marine radio telephones and includes information about antennas, power sources, sound systems and intercoms, radio direction finders and ship-to-ship pagers. In addition, the handbook summarizes the latest FCC rules and includes comments and interpretations and suggested operating practices.

AUTOMOBILE ELECTRONICS SERVICING GUIDE by Joseph J. Carr. Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind. 128 pp. \$4.95.

Here is all the knowledge an individual needs to be proficient in automotive electronic servicing. For the purposes of this text, automotive electronics means AM car radios, FM car radios and audio tape players. Starting with a basic review of superhet theory, the reader is taken step-by-step through circuit stages and sections of common automobile electronics gear. In addition to chapters on specific equipment, there is information on noise suppression, reception problems and bench test equipment.

UNDERSTANDING RADIO ELECTRONICS, Fourth Edition, by Milton Kaufman, Herbert Welch, Herbert Watson and George Eby. McGraw-Hill Book Co., 1221 Avenue of the Americas, New York, N.Y. 10020. 709 pp. \$10.95.

Complete coverage of the communication electronics field is provided in this extensively revised edition that has been updated to include solid-state concepts. Presenting the basic electrical and electronic principles through the instruction of radio electronics, the text is designed for self-study and is specifically written for high school or college students with little or no previous training in electricity or electronics. There is a self-test at the end of each chapter to help the reader review important material and increase comprehension.

HI-FI STEREO HANDBOOK by William F. Boyce. Howard W. Sams & Co., Inc., 4300 W. 62 St., Indianapolis, Ind. 400 pp. \$5.95.

Since the first edition of this book in 1956, constant change and improvement in sound communications, storage and reproduction techniques and the development of low-cost, high-quality stereo compacts have made hi-fi stereo an economic reality for everyone. True fidelity, as you learn in the first chapter of this book, is only occasionally achieved, but modern recording techniques provide maximum control of source, location, vocal, instrumental and other elements arranged with emphasis, presence, balance and three-dimensional effect to create a final mix that can be dramatically superior to live programs. This book was prepared as a reference and guide for persons interested in high-quality sound reproduction. In addition to supplying information to help and plan in selecting and installing systems, it also describes the various system components plus what they do and how they operate. R-E

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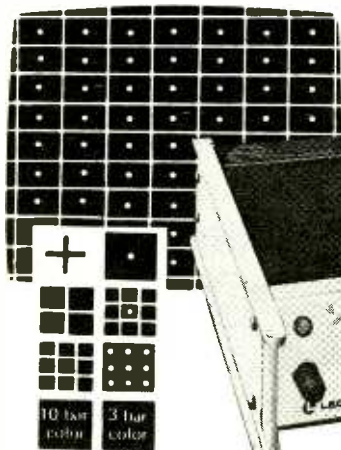
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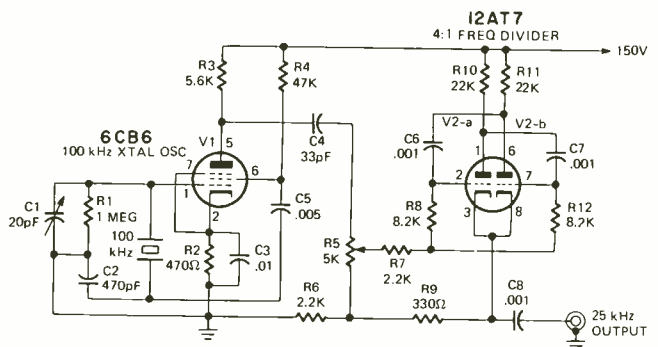
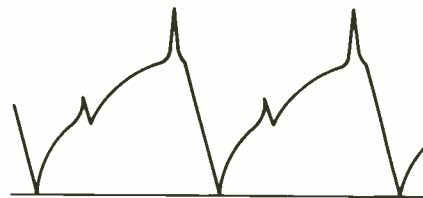


FIG. 1

followed by a 4:1 frequency divider.

After construction, it should be calibrated against WWV just like a 100-kHz calibrator. This is done with C1. Then R5 should be set so V2 divides the frequency by 4. This may be done by listening on a nearby broadcast receiver. You should hear the generator signals at 800, 825, 850, 875, 900 kHz, for example. Or you may adjust R5 while observing the output waveform on an oscilloscope. Fig. 2 shows the typical wave seen. V2-a and V2-b conduct



OUTPUT WAVEFORM OF 4:1 DIVIDER

FIG. 2

alternately, so there are four output pulses for each cycle.

The divider signals may be heard on a short-wave receiver up to at least 30 MHz. Assuming that the 100-kc oscillator has been precisely calibrated against WWV, you can determine very accurately frequencies like 14.025 MHz.

As one unusual application of this generator, you can check and adjust Citizens-Band transmitter frequencies (CB channels are on 26.965, 26.975, 26.985 MHz). Note that each frequency ends with the digit "5", so it cannot be a harmonic of 100 kHz. Certain channels, however, end with "25" or "75", so will be a harmonic of 25 kHz.

A CB transmitter may not stray more than .005% from the channel center frequency, so an error of 1,300 hertz is tolerated. If your standard generator may have 300 hertz error (see above), then the beat between your standard and the CB transmitter should not exceed 1 KHz to assure on-channel operation.

Beat signals may be measured by comparing with a calibrated audio oscillator or by feeding into a direct-reading frequency meter.—Issac Queen

R-E

can SCR light dimmers, power tool controls, and worst of all, psychedelic lighting controls. In most locations you can work inside the building or in an attic crawl space, but get away from and above any and all metal. Some rotation of the antenna might eliminate directional interference. Be sure to try several locations if you seem to have local interference or reception problems. **R-E**

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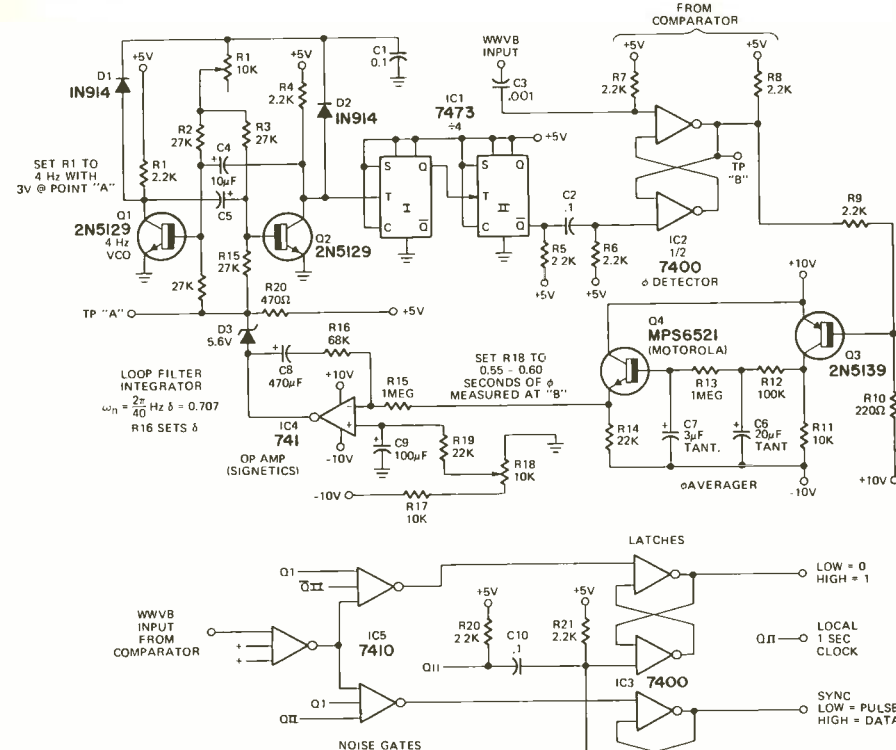


FIG. 9—OPTIONAL PHASE LOCK "FLYWHEEL" output loop to minimize noise errors. The "Q" inputs to the 7410 sections are from IC1.

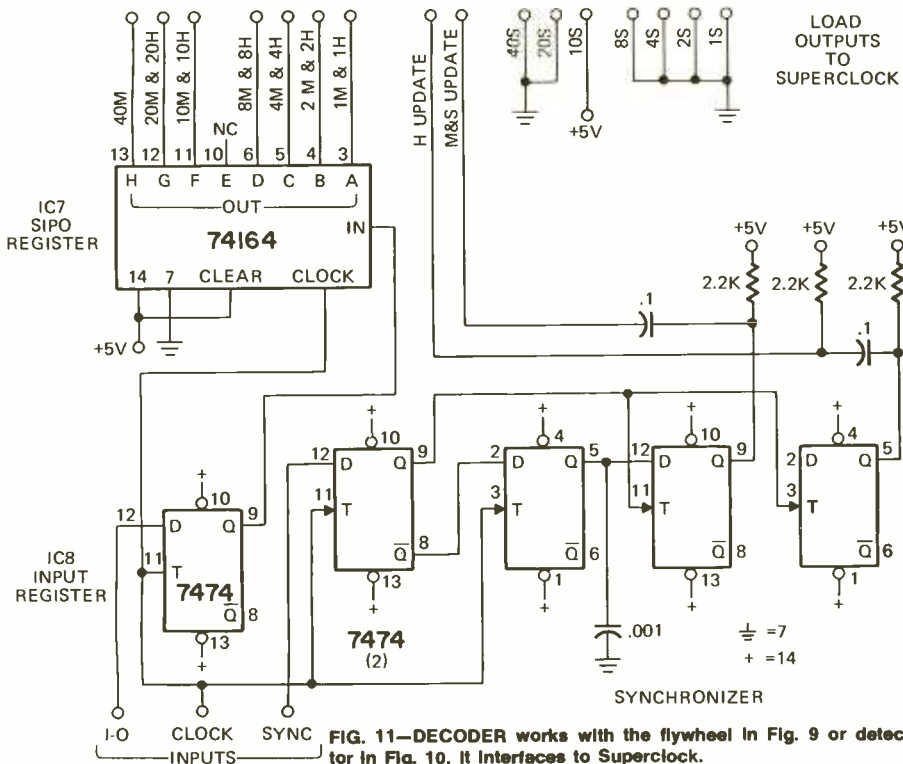


FIG. 11—DECODER works with the flywheel in Fig. 9 or detector in Fig. 10. It interfaces to Superclock.

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(continued from page 55)

charges through DECAY control R10 and diode D4.

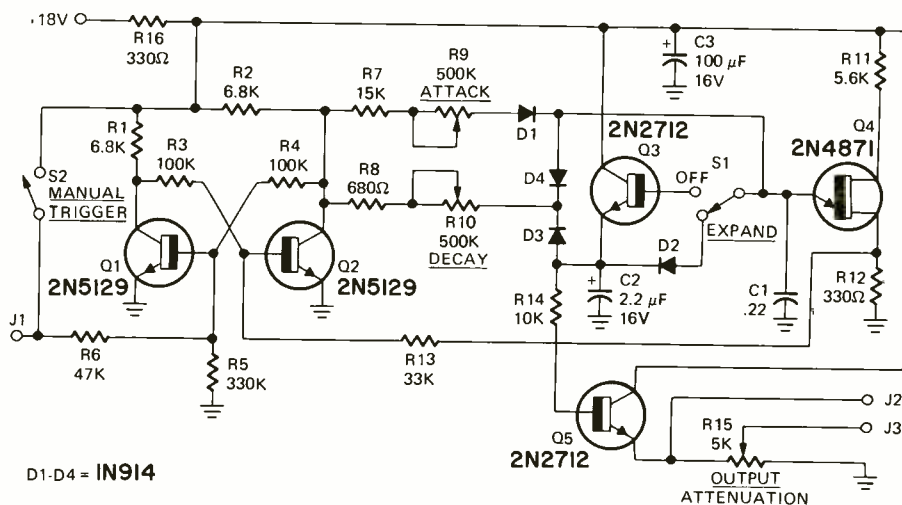
The EXPAND switch is included to provide for the wide range of attack times that are useful in electronic music production. In the off position of this switch, capacitor C2 is charged by the current supplied by emitter follower Q3 and this voltage is in turn isolated by emitter follower Q5 and appears at J2 and J3 as the control voltage output. C2 discharges through D3 and the now grounded collector of Q2 during the decay portion of the output.

When longer attack times are required, switching S1 to the EXPAND position causes C1 and C2 to be paralleled thereby expanding the attack time by a factor of approximately 20. Decay times are not affected by this switch.

If a voltage step rather than a pulse is

used to trigger the circuit the bistable is unable to reset until the input voltage is removed so the output voltage remains high until the triggering step is removed.

This module may be tested with a vom by reading the voltage between the output jacks and ground. The MANUAL trigger pushbutton can be used to trigger the generator for test purposes. With the expand switch on and both attack and decay controls rotated fully clockwise the output should take about 1 second to climb to 5V and another second to fall back to zero. As the attack and decay times are shortened the vom will be unable to follow them but an oscilloscope should show an attack time variable from 2 ms to 40 ms with the EXPAND off and 30 ms to 1 second with it on. Decay times should be variable from 5 ms to 1 second and there should be no interaction between the controls. When the MANUAL button is pressed and held the output voltage should rise to 5 volts and hold as long as the button is held down. **R-E**



D1-D4 = 1N914

BISTABLE MULTIVIBRATOR, Q1-Q2, is the heart of this function or envelope generator. Fixed and variable outputs are at J2 and J3, respectively.

All resistors 1/2W 10% unless noted

- R1, R2—6,800 ohms
- R3, R4—100,000 ohms
- R5—330,000 ohms
- R6—47,000 ohms
- R7—15,000 ohms
- R8—680 ohms
- R11—5,600 ohms
- R12, R16—330 ohms
- R13—33,000 ohms
- R14—10,000 ohms

- R9, R10—500,000 ohms, linear taper potentiometer
- R15—5,000 ohms, linear taper potentiometer
- C1—.22-μF Mylar
- C2—2.2-μF 10V electrolytic
- C3—100-μF 16V electrolytic
- D1-D4—1N914
- Q1, Q2—2N5129
- Q3, Q5—2N2712
- Q4—2N4871

The following kits containing all parts required for duplicating the modules as shown are available from PAIA Electronics, Inc., P.O. Box 14359, Okla. City, Okla. 73114

Voltage Controlled Amplifier No. 2720-1 \$12.95 postpaid

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More to come

One more module will be described next month. It is a special control oscillator used to produce such unusual effects as tremolo (a slow cyclic variation in the amplitude of a signal) and vibrato (cyclic varia-

tion in the frequency of a signal). A white-noise source is included as an integral part of this special control oscillator. White noise is indispensable for creating the sounds of wind, surf, snare drums, cymbals, and various assorted sounds of explosions.

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Circle 77 on reader service card

STEP-BY-STEP

(continued from page 70)

final Y1 waveform (Fig. 9), an LC probe (at 100V/div) is placed near the flyback transformer just to show the high voltage is operating. This is only a quick check method without actual voltage measurement, and is not quantitative in any sense, but it can save you much blind man's buff. Y2 in Fig. 9 is nothing more than the horizontal output screen voltage of this receiver showing that at 50V/div it is indeed resting at 200 volts.

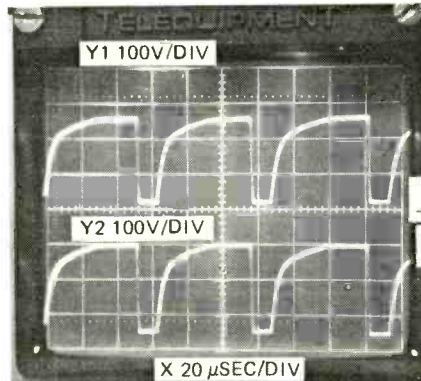


FIG. 8—NORMAL WAVEFORMS. Replacement pincushion transformer restored operation.

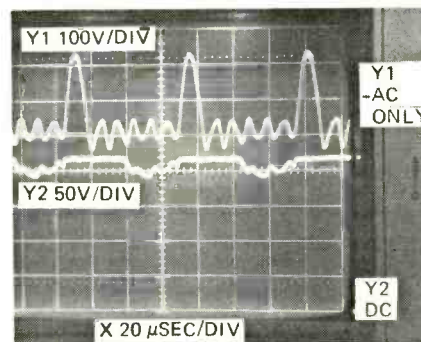


FIG. 9—PROBE HELD NEAR FLYBACK to check for HV produces this trace.

If 1- μ F C500 was open here, you'd have another 200-volt p-p waveform superimposed where the small ripple now exists. If C500 was quite leaky or shorted, R505 would either be severely singed or burned open and there would be no high voltage because the screen grid would be close to zero.

In any "no high voltage" situation, don't forget that too much or too little beam current in the picture tube can produce a blank screen. So don't neglect the luminance and pix tube cathode driver amplifiers and, by all means, at least quick check or actually measure the high voltage. With many sets, you may also flip your setup switch or remove the cap from the pix tube to see if high voltage is simply loaded down or actually doesn't exist. R-E

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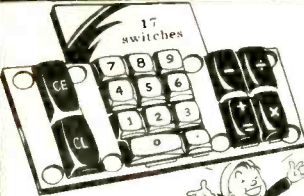
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MAN-2*	.32†	Red	Yes	2513	8.88	3 for \$24.
MAN-3*	.115	Red	Yes	SN7448	2.25	3 for \$6.
MAN-3*	.115	Red	No	SN7448	1.49	3 for \$3.
MAN-4*	.190	Red	Yes	SN7448	2.95	3 for \$8.
MAN-4*	.190	Red	No	SN7448	1.79	3 for \$5.
MAN-5*	.27	Green	Yes	SN7447	8.88	3 for \$24.
MAN-8*	.27	Yellow	Yes	SN7447	8.88	3 for \$24.
LITRONICS 707** (MAN-1)	.33	Red	Yes	SN7447	3.50	3 for \$9.
OPCOA** SLA-7 (MAN-1)	.33	Red	Yes	SN7447	3.50	3 for \$9.
OPCOA** SLA-7 (MAN-1)	.33	Red	No	SN7447	1.95	3 for \$5.

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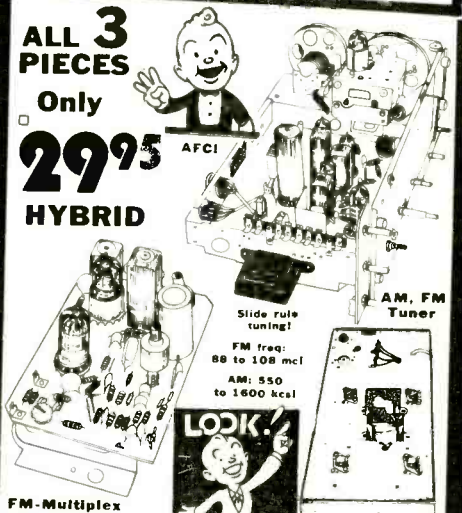
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100	20.0K
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500	50K
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750	100K
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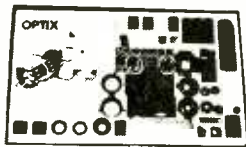
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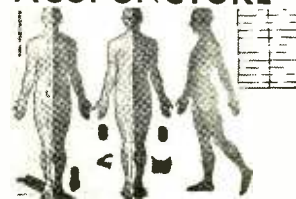
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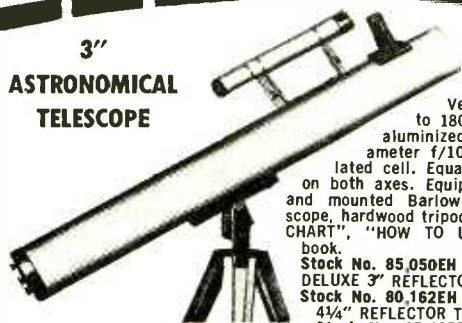
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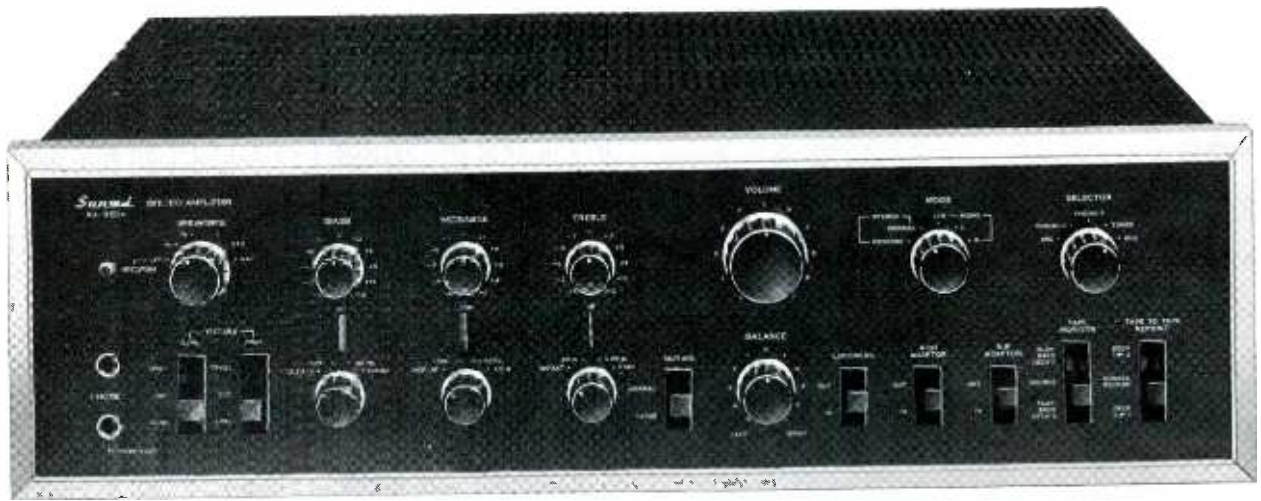
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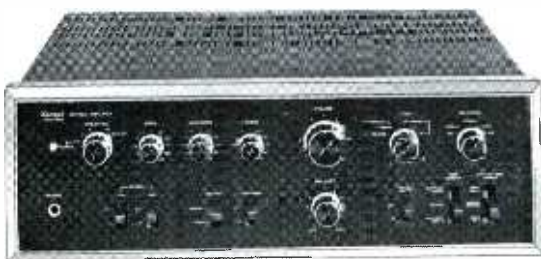
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