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Radio-Electronics

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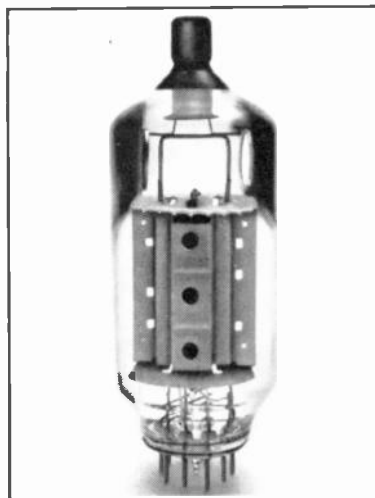
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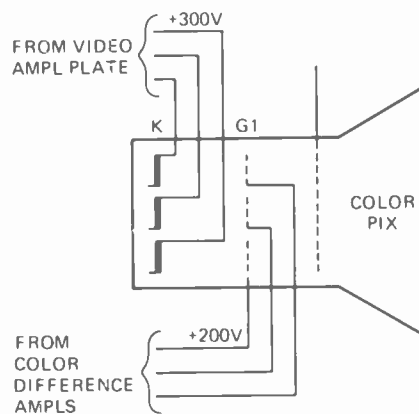
Radio-Electronics

THE MAGAZINE FOR NEW IDEAS IN ELECTRONICS

More than 65 years of electronics publishing

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TYPICAL COLOR PICTURE TUBE has voltages applied like the ones shown here. For complete data on troubleshooting this part of a color TV receiver

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looking ahead

Quadradio

Four-channel signals should be filling the air this summer in San Francisco when the EIA-sponsored National Quadriphonic Radio Committee (NQRC) begins field-testing 4-channel broadcasting systems developed by five different companies, using the facilities of FM station KIOI there. The NQRC — patterned after the NTSC which developed current standards for both monochrome and color broadcasting, and the NSRC which studied proposals leading to the FM stereo standards — is screening all proposed discrete four-channel broadcast systems and will turn the results of its studies over to the FCC.

The systems currently under study have been submitted by General Electric, Quadracast Systems Inc., Nippon Columbia, RCA and Zenith. All systems are compatible with both two-channel stereo and mono — that is, the full signal may be received as conventional stereo on a two-channel receiver or as a monophonic broadcast on a non-stereo radio. In FM stereo broadcasting, the signal is divided into left-plus-right and left-minus-right channels. Most of the systems add two additional channels of information — one for front-minus-back information and another for the left-rear-plus-left-front-minus-right-front-plus-right-rear information, defining the criss-cross relationship between diagonally opposite speakers.

Trouble is, this doesn't leave any room for an SCA channel — that extra multiplexed channel used by some FM stations for special background music systems and so forth. So one of the system proponents, RCA, is advocating two systems — one of them a complete four-channel system and the other eliminating the criss-cross separation signal. A station with an SCA channel could merely eliminate the fourth channel. This would result in somewhat less diagonal separation between speakers, but the same four-channel receivers could pick up both types of four-channel broadcasts.

Discomania

This column has been reporting a new videodisc system just about every month — so why should June be an exception? This month's videodisc comes from France, where it was invented by 28-year-old Guy Nathan, who already has many electronic inventions to his credit. Called "Optidisc," it has the distinction of

being the slowest-moving video record proposed so far, revolving — according to its inventor — at 6 rpm or even slower, as compared to 1,500 or 1,800 for other optically-scanned discs announced so far.

The other optical discs revolve at the rate of one revolution for each TV frame and have microscopically thin tracks. Nathan's disc aligns each TV scanning line perpendicular to the direction of movement, with each track about 0.6-mm wide. A light source shines through transparent turntable and transparent disc to a pickup head containing an array of photodiodes. Thus the system feeds one scanning line to the TV set at a time. Nathan claims each one-sided disc, eventually, will be able to hold one hour of color TV programming.

In the recording process, a laser beam lays down the TV signal on 35-mm film. This image is transferred photographically to a glass master disc, which serves as the negative for printing flexible video records at 50 to 100 discs per second. The promoters of the new disc system claim that the player attachment can sell for about \$200 and the discs will cost about 20 cents each for manufacture and duplication.

Instant-off

One of the casualties of the energy crisis is the "instant-on" feature, which keeps color TV cathodes cozily warm when the set is turned off, to produce an immediate picture when it's turned on. Most television manufacturers are eliminating it in their 1975 models, and it probably will be only a memory by the end of this year. Instant-on has been a target of energy-saving measures introduced into several state legislatures on the grounds it wastes electricity, and manufacturers have responded by removing the feature as quickly as possible.

It's estimated that instant-on can consume as much as 50 watts of power in a tube-type set where it keeps a number of filaments glowing at a reduced level. In solid-state sets, where it only has to warm the picture-tube, it consumes about 6 watts — less than a Christmas tree light bulb.

But impatient viewers need not despair — help is on the way. A new quick-warmup picture tube which requires no preheating has been developed by Philips of Holland, and a similar tube will be introduced here by Sylvania, and probably others. It's not quite as fast on the draw as instant-on cir-

cuits, but in solid-state sets it provides a very quick picture. And it saves those critical 6 watts!

Discrete or matrix?

Once the NQRC's material is turned over to the FCC, there's no assurance that any one of the systems will be adopted as the standard for quadriphonic broadcasting. The NQRC's principal activity is to explore discrete four-channel systems — those which would require changes in the FCC rules.

But many FM stations are already broadcasting a type of 4-channel which requires no modifications in transmitting gear and no FCC approval. This is the matrix type — the most popular of which is SQ, developed by CBS. So when the FCC finally begins to seriously consider 4-channel broadcasting, you can expect a new battle between the proponents of matrix and discrete systems, which could well be a replay of the current conflict between matrix and discrete record backers. The principal antagonists are expected to be the same — CBS vs RCA.

Vhf-uhf parity

Another longtime TV feature is vanishing with the 1975 models — the continuous uhf tuner. As mandated by the FCC, all television receivers manufactured after June 30 for use in the U.S. must be equipped with "comparable" uhf and vhf tuners. This means that if vhf channels click in with detent action, the same must be true of uhf, if vhf channels are identified by numerical readout, each individual uhf channel number must also appear. The purpose of the rule is to help uhf stations, which have suffered because they've been more difficult to tune than vhf. There's no rule against continuous uhf tuners, but the FCC says vhf and uhf tuning facility must be "comparable." Therefore, to use a continuous uhf tuner a manufacturer would also have to use a continuous vhf tuner — and they don't make them no more.

Lidar

That stands for "light detection and ranging" and is one of NASA's long-rang projects as outlined to Congress in a recent hearing. It's similar to radar, except that it uses a pulsed tunable laser beam instead of radio waves. Its function is to detect such oceanographic properties as oil pollution, plant life, depth and salinity. This highly

accurate system determines coastline depths by measuring the time difference between the return beams of a high-power laser from the surface and the bottom of bodies of water, and the composition of the water can be identified by the wavelength of the return beam. It has been under development since 1971. By mid-1975 it will be used in an attempt to measure pollution in the atmosphere. Among other NASA research projects is the development of a solid-state recorder with no moving parts to replace tape recorders.

4-channel chip

In the battle of the four-channel discs (SQ vs. CD-4), SQ proponents have had one major selling-point: SQ is inherently less expensive. This argument is being eroded by the development of an IC demodulator chip by Signetics Inc. for the CD-4, or Quadradisc, system. To be offered to manufacturers at \$1.54 each (two chips are required for each demodulator), it will bring the cost of a CD-4 demodulator to about the same as an SQ decoder. SQ still has a price advantage, however, because the cartridge, stylus and turntable for CD-4 require greater precision in manufacture.

Flat screen again

The never-ending quest for a hang-on-the-wall flat-screen TV display is still being pursued. Three systems were demonstrated at the International Electron Devices Meeting in Washington. Sony showed a 7-inch monochrome gas-discharge panel less than a half-inch thick, containing 60,000 picture elements and capable of displaying 32 grey levels, with a claimed brightness of 25 foot-lamberts and contrast ratio of 40 to 1. A Burroughs gas-discharge display is 6 by 12 inches, two inches thick, with 49,000 information cells. Hughes Aircraft demonstrated a liquid-crystal display one inch square with 10,000 picture elements.

R-E

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR

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new & timely

New superconductivity record is 23.2 degrees Kelvin

Bell Laboratories' scientists report raising the temperature of a thin film of a niobium-germanium alloy to minus 250° C (minus 418° F or 23.2° K) before it lost its superconductivity.

Superconductivity (the ability of a material to carry electric current without losses) is a phenomenon shown by some materials at temperatures near absolute zero. Scientists have continually sought new materials and new methods of raising the temperature at which superconductivity can be maintained, in the hope of developing superconductors that can be used for power generation and distribution systems and other electronic equipment. (A small increase in the temperature at which a metal will remain superconductive means a large decrease in the cost of the necessary cooling apparatus.)



PULLING A SUPERCONDUCTIVE STRIP of niobium-germanium from bath of liquid helium, where it is under test for superconductivity. Scientist is L. R. Testardi of Bell Labs.

The former record, recently set by John Gavaler of Westinghouse, was 22.3° K (minus 419.56° F). Gavaler's report led to the new work by Bell scientists L.R. Testardi, J.H. Wernick and W.A. Royer. They achieved their results by sputtering a thin film of the niobium-germanium alloy onto a heated sapphire strip, thus developing a film a thousand atoms thick, which had the desired properties.

They discovered also that the sputtered thin films showed other interesting qualities, including a remarkable resistance to corrosion and a hardness exceeding that of sapphire, one of the hardest materials known. This appears to be due to the

sputtering, which is believed to be able to "freeze" the material as it is about to change from one atomic structural arrangement to another.

"Recent work at Bell Labs," reports Mr. Testardi, "indicates that we should be able to get the desired intermediate atomic arrangements with other materials by using high-temperature sputtering techniques. However, it is not possible to predict which materials will show the conditions that favor high-temperature superconductivity." •

"Electronic Blackboard" for low-cost vision transmission

A method of transmitting visual and audio information simultaneously at much lower cost than closed-circuit television is being tested at the University of Illinois, reports Bell Laboratories, who developed the device.

The electronic blackboard is a pressure-sensitive board on which the instructor writes with ordinary chalk. The positions of the moving chalk are registered electronically, converted and transmitted over an ordinary telephone line to any desired distance. At the receiving end, the signals are reconverted into a form that can be displayed on an ordinary television set.

The audio portion of the lecture or program is carried over a second telephone line, via a portable conference telephone already in wide use by Bell System customers. It features hands-free operation, a built-in loudspeaker and two-way conversation between groups of people.

The university is using the equipment

to transmit engineering lessons from its campus in Champaign-Urbana to off-campus locations in Freeport, Rock Island, Peoria and Rockford.

Besides using the equipment for live classes, entire lectures—both audio and graphics—can be recorded on a standard tape recorder and transmitted over ordinary telephone lines to groups meeting any desired time or location. •

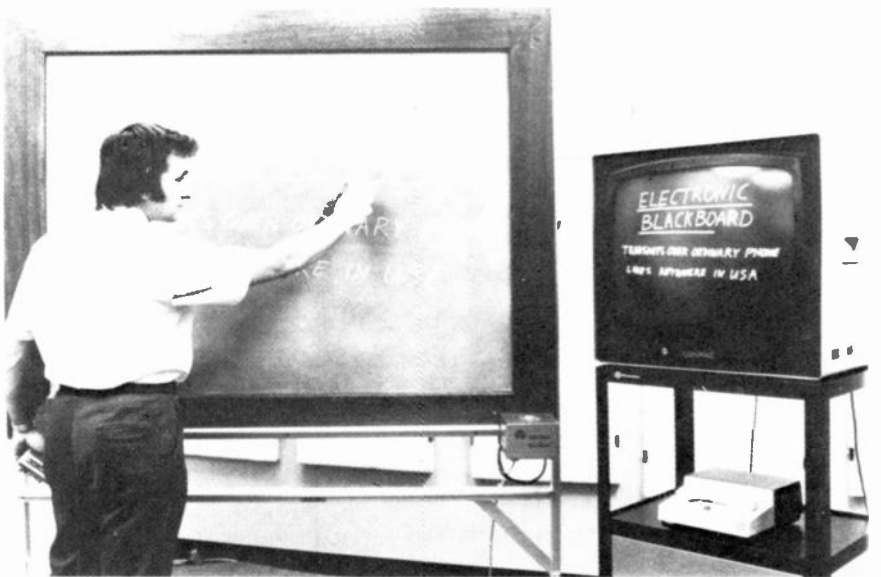
Citizens Banders aid motorists during energy crisis

Members of the Citizens Band volunteer group REACT (Radio Emergency Associated Citizens' Teams) have organized for a special effort to aid motorists equipped with Citizens Band radio during the gas scarcity period, reports *The National Reactor*, a bi-monthly publication put out by the organization's national headquarters.

Not only are the teams monitoring Channel 9 for reports of motorists stranded for lack of gas, but are advising them on distance-saving routes to their destinations. Some teams are holding drills in the art of laying out the best routes. The REACT teams are also in a position to advise motorists on the best route at a given instant, taking road conditions, construction and accidents into consideration. Some teams have compiled lists of service stations and diesel fuel outlets, as an aid to motorists running short.

Since there are nearly four million two-way Citizen Band radios in the United States, most of them installed in cars, and roughly 1000 local REACT teams monitor-

(continued on page 12)

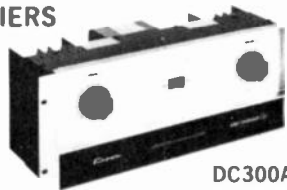


ELECTRONIC BLACKBOARD, with its TV-set monitor, demonstrated at Bell Labs, Holmdel, N.J.

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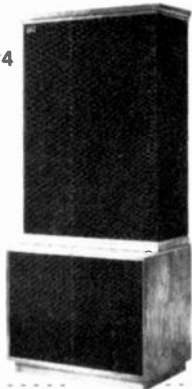
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STUDIO TRANSDUCERS

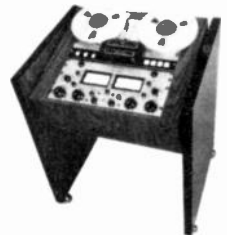
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...IN THE CONTROL ROOM

SP722 Studio Player

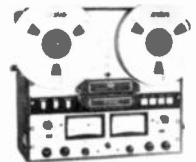
simple tape transport system has only 9 moving parts ■ remote start/stop optional, automatic stop in play mode



...ON LOCATION

SX822 Recorder/Mixer

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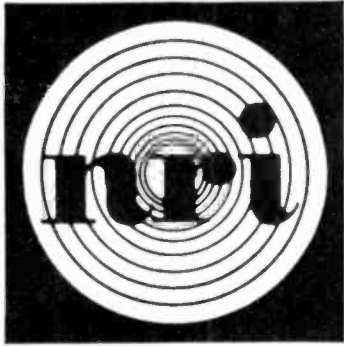
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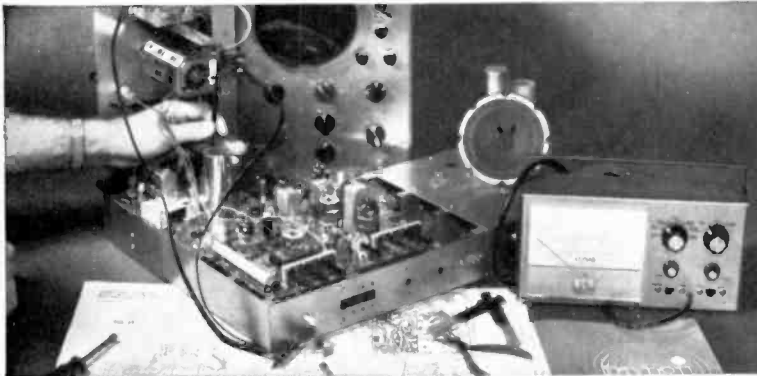
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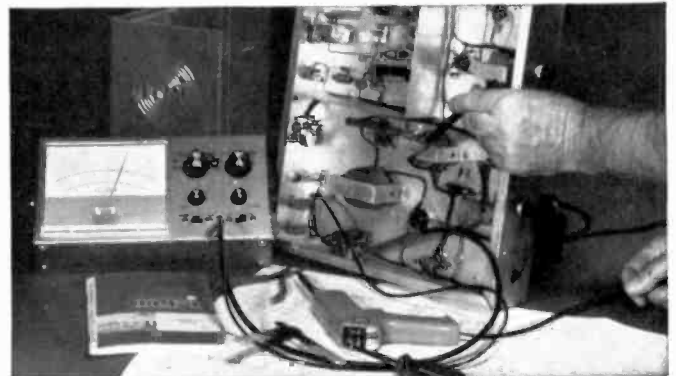


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Earn \$5 to \$7 an hour spare or full time in COLOR TV SERVICING

It's easy to learn as you build, stage-by-stage, the only custom designed Color TV receiver engineered specifically for training purposes. You grasp a professional understanding of all color circuits through logical demonstrations never before presented. The end product is a superb Color TV set that will give you and your family years of viewing pleasure. NRI gives you the option of selecting either Color or black-and-white training equipment.



There's glamour, success awaiting Technicians in COMMUNICATIONS

NRI gives you the experience you need to qualify for jobs in TV broadcasting stations, or operating and servicing mobile, marine, aviation communications equipment. You build and use a solid-state voltohmmeter; perform experiments on transmission lines and antenna systems, even build your own 25-watt, phone-cw amateur transmitter band. In all NRI Communications courses, *you must pass your FCC exams—or you get your money back.*



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Prepare quickly for a high pay career in COMPUTER ELECTRONICS

This may well be the most unique and exciting educational aid ever developed for home training—a digital computer *with memory* you build and use to learn organization, trouble shooting, operation and programming. It performs the same functions as commercial computers you encounter on the job. Lessons stress computer repair. You perform a hundred experiments, build hundreds of circuits. Your own solid-state voltohmmeter is included among the ten training kits you receive.

OVER 50 YEARS OF LEADERSHIP IN ELECTRONICS TRAINING

ing the Citizens Band 24 hours per day, their efforts should have significant results. •

Light amplifier may assist suffers from blinding disease

Persons afflicted with *retinitis pigmentosa*, a disease that gradually restricts the vision to a "beam" directly ahead while the area a little to the sides and above and below is obscured, and reduces vision in dim light nearly to zero, may be helped by

an adaption of a "snooperscope" type of light amplifier.

The device, now under development jointly by the Army's Night Vision Laboratory and the International Telephone and Telegraph Co. (ITT), is a modification of a light amplifier now in use under combat conditions in the dark. Experiments show that these devices give *retinitis pigmentosa* patients the equivalent of their best daytime vision in dim light, such as street light or moonlight.



SECRETARY OF THE FUTURE sits in her integrated office, which combines chair, desk, computer terminal—which doubles as a typewriter if it should ever become necessary to send out an ordinary letter—plus information inputs, either on-line from the computer or dictation from the main office via the microwave intercom. Accessories are a Telex machine and microfilm reading equipment.

This future office will make it possible for the secretary to do her work practically lying down, with no loss in efficiency. The way-out-in-space age piece of office equipment is the work of designer Luigi Colani, and was put into hardware by the West German firm "Comforto." This model costs about \$20,000, but the makers believe that if it ever goes into mass production, the price could be reduced considerably.

The original devices are too expensive and too high-power for sufferers from the disease, and ITT is working with the Night Vision Laboratory to produce an amplifier specially adapted to their needs. Dr. Eliot L. Berson, one of the leaders in the inves-



DR. ELIOT L. BERSON, staff member of Massachusetts Eye and Ear Infirmary, shows a patient how to use the light amplifier.

tigation of the problem and the development of the new device, points out that it will not cure the disease nor deter its progress, but will make good night-time vision possible for many patients who would otherwise be severely restricted. •

Semiconductor analog processor speeds computations by 100

"Charge sloshing" is a new technique which, say scientists of General Electric, will give a new surface charge correlator more than 100 times the computational power and speed of conventional components. It can perform 32 multiplications and additions in a microsecond.

Present charge-coupled devices contain many storage capacitors for controlling and moving ("transferring") charge packets across a silicon chip. As the charge is transferred from one capacitor to the next, a minute fraction is left behind. After a few thousand transfers, the misplaced charges build up to an appreciable fraction of the original charge, degrading the output signal.

In the new technique, the charge "sloshes" back and forth between portions of a single charge storage region. If any charge is left behind on one transfer, it is picked up on the next.

The new integrated circuit, which will be on the market in about two years, is expected to make dramatic reductions in the cost and complexity of detecting

(continued on page 14)

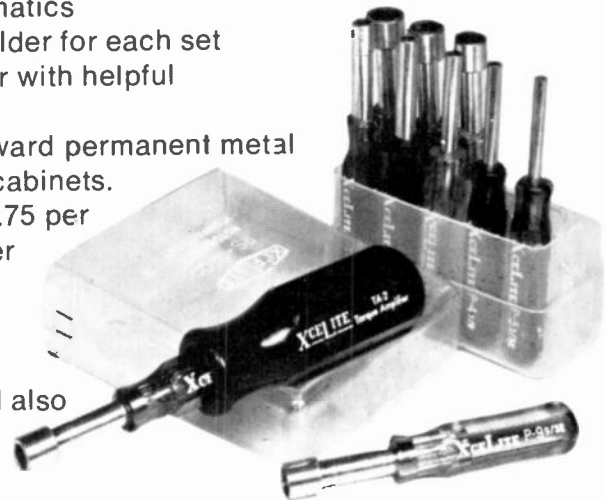
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Photofact-of-the-Month Club members receive seven new Photofact Sets every month. Those seven new sets supply detailed circuit information on over 200 of the very latest TV, radio, stereo and record player models . . . enabling club members to service the new models as efficiently as though they had worked on them for years.

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- “advance” color schematics
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All this for just \$15.75 per month—a saving of \$7.35 per month—\$88.20 per year.



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Subscribe now to P.O.M. for nine months and you will also receive, FREE, one of our New Member Bonus Offers (your choice):

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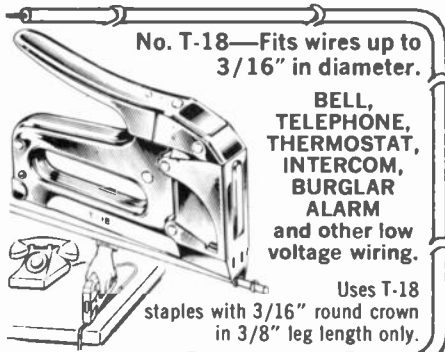
Circle 15 on reader service card

ARROW AUTOMATIC STAPLE GUNS

CUT WIRE & CABLE INSTALLATION COSTS

... without cutting into insulation!

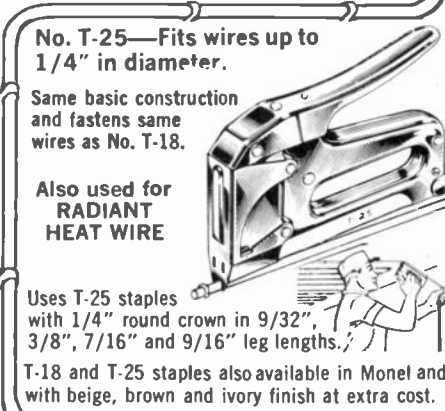
SAFE! Grooved Guide positions wire for proper staple envelopment! Grooved Driving Blade stops staple at right depth of penetration to prevent cutting into wire or cable insulation!



No. T-18—Fits wires up to 3/16" in diameter.

BELL, TELEPHONE, THERMOSTAT, INTERCOM, BURGLAR ALARM and other low voltage wiring.

Uses T-18 staples with 3/16" round crown in 3/8" leg length only.



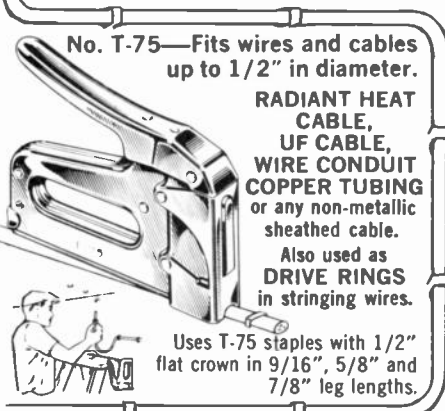
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Also used for RADIANT HEAT WIRE

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"Pioneers and Pacesetters
For Almost A Half Century"

new & timely (continued from page 12)

signals buried in noise and other interference in radar and sonar systems. •

Sarnoff urges new agency for science and technology

"During the past several years, the national commitment in science and technology has been seriously weakened, both financially and politically," stated RCA Chairman Robert W. Sarnoff, in a plea for a strong new agency, a Science and Technology Commission.

Government spending for science and technology has been cut from over 12 per cent in the Federal budget of 1965 to less than 6 per cent this year, he pointed out, also citing cuts in science education and the Administration's dismantling of the machinery that supplied top-level scientific advice to the White House.

Such a commission, said Sarnoff, would be a first step toward filling a need for "comprehensive planning and long-term commitment as basic responsibilities of government. The absence of such planning and commitment," he said, "has burdened us with failures and shortfalls: inadequate public transportation, polluted waters, blighted cities, and, at the moment, chilly homes and empty gas tanks. Our children will be assured an even more sordid legacy unless we move

now to use our resources with vision and by design." •

Acoustical holograph maker chosen "Inventor of Year"

Byron B. Brenden, researcher in acoustical holography, is the first recipient of a new award: "Inventor of the Year." It is sponsored by the Association for the Advancement of Invention and Innovation and the Robertshaw Controls Co.

Acoustical holography is a technique of making holographs with sound or ultrasonic waves instead of waves of visible or laser light, as in the better known optical holography. The technique is used for observing the interior of solids (flesh, metal or ceramics), achieving somewhat the same results as X-rays.

Mr. Brenden is vice president of Holosonics, Inc., of Richland, Wash. The company makes devices that can be used in a wide range of applications, from detecting breast tumors to finding flaws in steel castings. His latest patent is on improved fluid-filled ultrasonic lenses, in which images are created with sound waves.

The award was made in the U.S. Patent Office by the president of the Association, Edward J. Brenner, a former Commissioner of patents. •

R-E

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Circle 5 on reader service card

letters

TV TYPEWRITER NEWS

Hundreds of people must be building the TV Typewriter, judging from the parts shortages I have encountered. You may have started something — the digital equivalent of ham radio. As soon as MODEM plans are worked out, the TV Typewriter builders can send messages over the phone to each other. I hope this appears soon in Radio-Electronics.

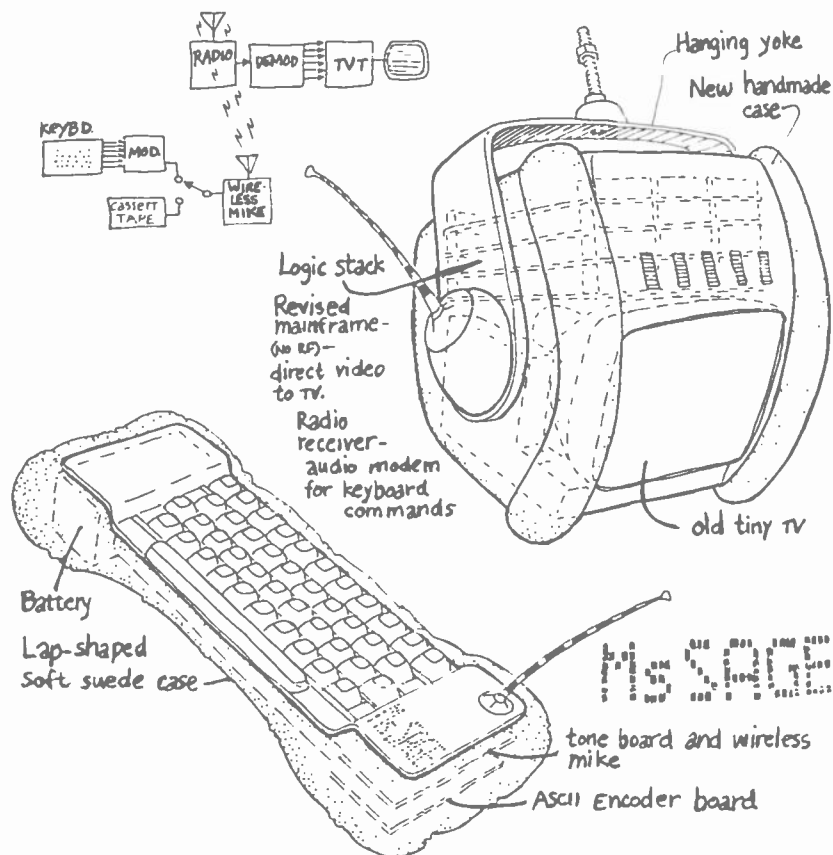
I am assuming a MODEM would handle the incoming ASCII commands, rather than than the more complex video signals. Using this concept could lead to some interesting human engineering on the final form of the project.

My version, called MS. SAGE (from MeSSAGE) will eventually broadcast from a small keyboard unit to the larger logic and TV screen unit, using a wireless-mike setup. The battery-operated keyboard will be passed around the audience at half-inch videotape showings to record anonymous comments on the material shown on tape.

I would encourage pioneers, W.G. Ob-
ringer and M. Paul Farr (*Letters*, February) to get some exchange started, at least in California.

CURTIS SCHREIER
San Francisco, Calif.

R-E

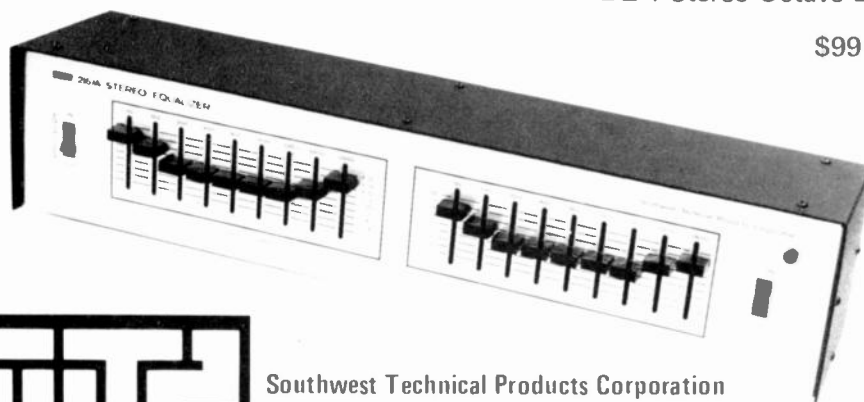


THANKS FOR WAITING—

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EQ-1 Stereo Octave Equalizer Kit

\$99.50 Postpaid



Southwest Technical Products Corporation
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Now you can get "XR" glass tubes in our economy line.

You know the EIA guidelines. Replace like with like.

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We've added 19 of the "XR" glass types to our Color Screen 85 economy line, and another 5 types to our medium price Color Bright 85® RE line. You can tell them by the

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Three lines to offer. Three prices to offer.

That should eliminate a lot of your customer's inhibitions.

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Another first from the leader

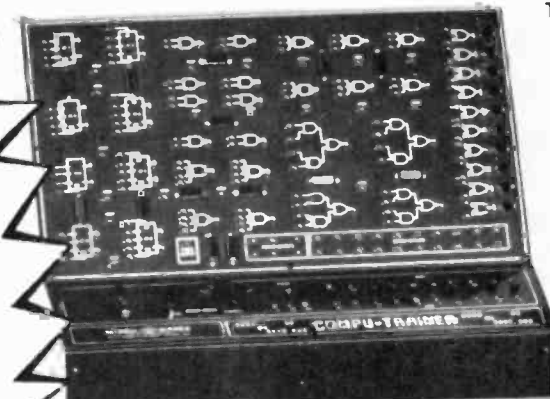
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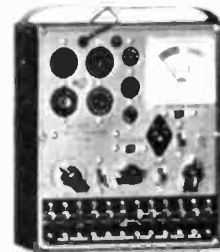
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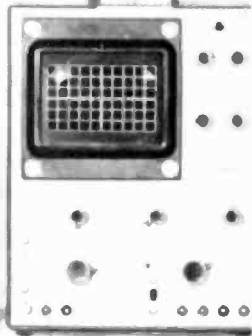
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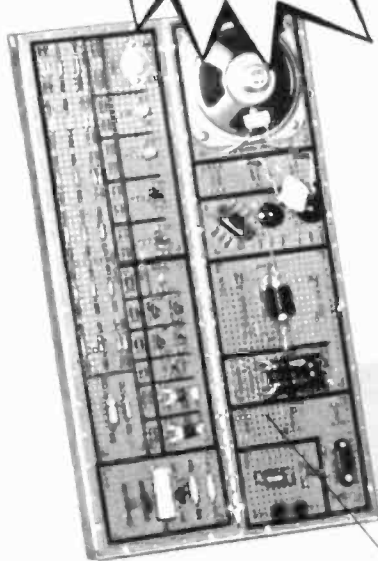
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COLOR TV WITH 315 SQ. IN. PICTURE
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Only \$10 down gets you into any NTS Home-Study Courses in Electronics.* Just \$10 that can lead to a top-dollar job, a big, bright career in electronics.

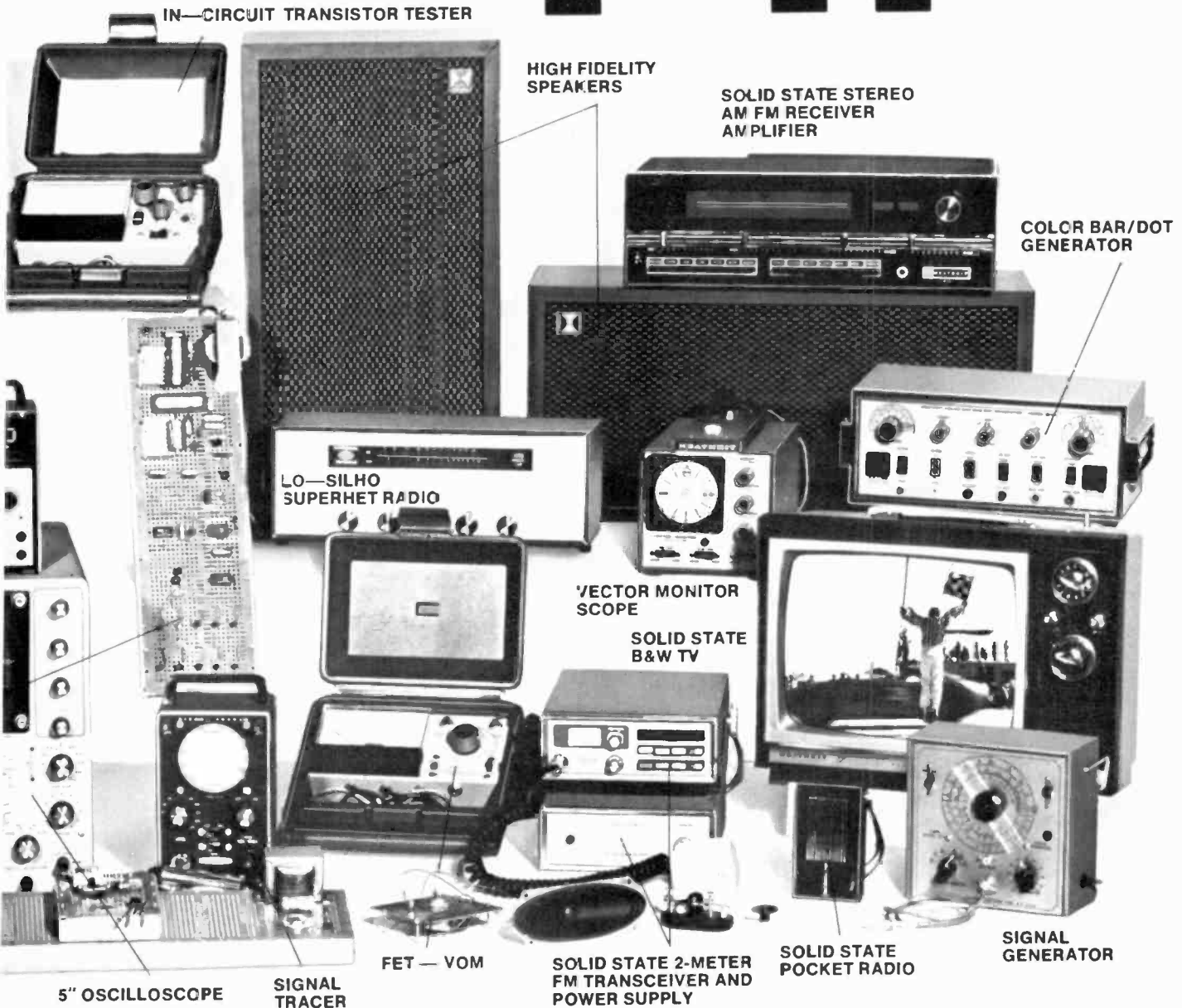
As an NTS student, you'll acquire the experience and know-how that comes with first hand training on NTS "pro" equipment. Equipment you'll build and keep. Our courses include equipment like the 5" solid-state oscilloscope, a transistor and tube-tester, a vector monitor scope, 74 sq. in. B&W TV, or a solid-state stereo AM-FM receiver. The unique

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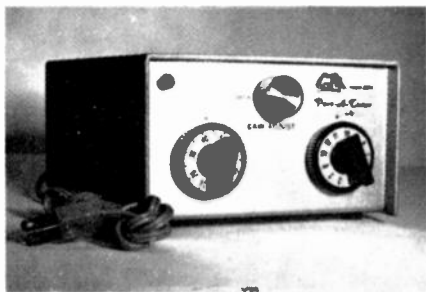
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equipment report

PTS-3001 Port-A-Tuner



Circle 90 on reader service card

PTS ELECTRONICS, INC., OF BLOOMINGTON, Ind., a nation-wide tuner repair firm, has come up with a very handy dual-purpose tuner substituter. This is their model PTS-3001 Port-A-Tuner. Housed in a neat, sturdy vinyl-clad aluminum cabinet, it has

both a vhf and a uhf tuner. The unit is ac-powered, with a power transformer.

It can be used as a regular tuner substitute, for checking both vhf and uhf tuners, as well as uhf antenna output, etc., in either the shop or the home.

The model PTS-3001 is straight ac-powered, a self-powered version, the PTS-2002, has its own battery, and a third, the PTS-3002, can be powered by either ac or a self-contained battery.

A single i.f. output cable, over 5 feet long, gives ample length to reach the i.f. input connections. It has a male RCA-type plug; a dual-female adapter is included in the accessory kit, so that this cable can be used with any plug-jack setup. A plug-in cable with alligator clips can be used, for the solder-in type of i.f. cable.

To use the Port-A-Tuner as a replacement for tuners in series-string heater sets, tube or hybrid, a small 10-watt resistor is included in the accessory kit. This can be

tack-soldered in place of the original tuner's tube heaters.

The clip-lead cable can also be used for making signal tracing tests in the i.f. stages, checking age action, and so on. Signal can be injected into the last i.f. stage, and then "walked back" to the i.f. input. An rf gain control on the front panel regulates the i.f. output signal. Separate vhf and uhf inputs are provided on the back panel. This can be handy, for making sure that the home antenna is working properly, checking CATV and MATV outlets, and so on.

The two tuners used are solid-state, high-gain low-noise types. Dc power is supplied to them from a solid-state rectifier, well-filtered. The power transformer, plus the fact that the output cable's ground is also isolated, makes this unit safe to use with any type of TV set. The power supply is protected by an internal fuse.

The case can be taken off in a very short
(continued on page 26)

INTERNATIONAL Frequency meter FM-2400CH

- Tests Predetermined Frequencies 25 to 1000 MHz
- Extended Range Covers 950 MHz Band
- Pin Diode Attenuator for Full Range Coverage as Signal Generator
- Measures FM Deviation

The FM-2400CH provides an accurate frequency standard for testing and adjustment of mobile transmitters and receivers at predetermined frequencies.

The FM-2400CH with its extended range covers 25 to 1000 MHz. The frequencies can be those of the radio frequency channels of operation and/or the intermediate frequencies of the receiver between 5 MHz and 40 MHz.

Frequency Stability: $\pm .0005\%$ from $+50^\circ$ to $+104^\circ\text{F}$.

Frequency stability with built-in thermometer and temperature corrected charts: $\pm .00025\%$ from $+25^\circ$ to $+125^\circ$ (.000125% special 450 MHz crystals available).

Self-contained in small portable case. Complete solid state circuitry. Rechargeable batteries.

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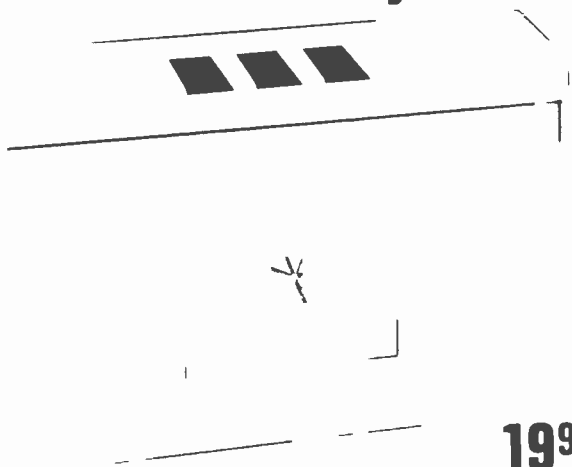
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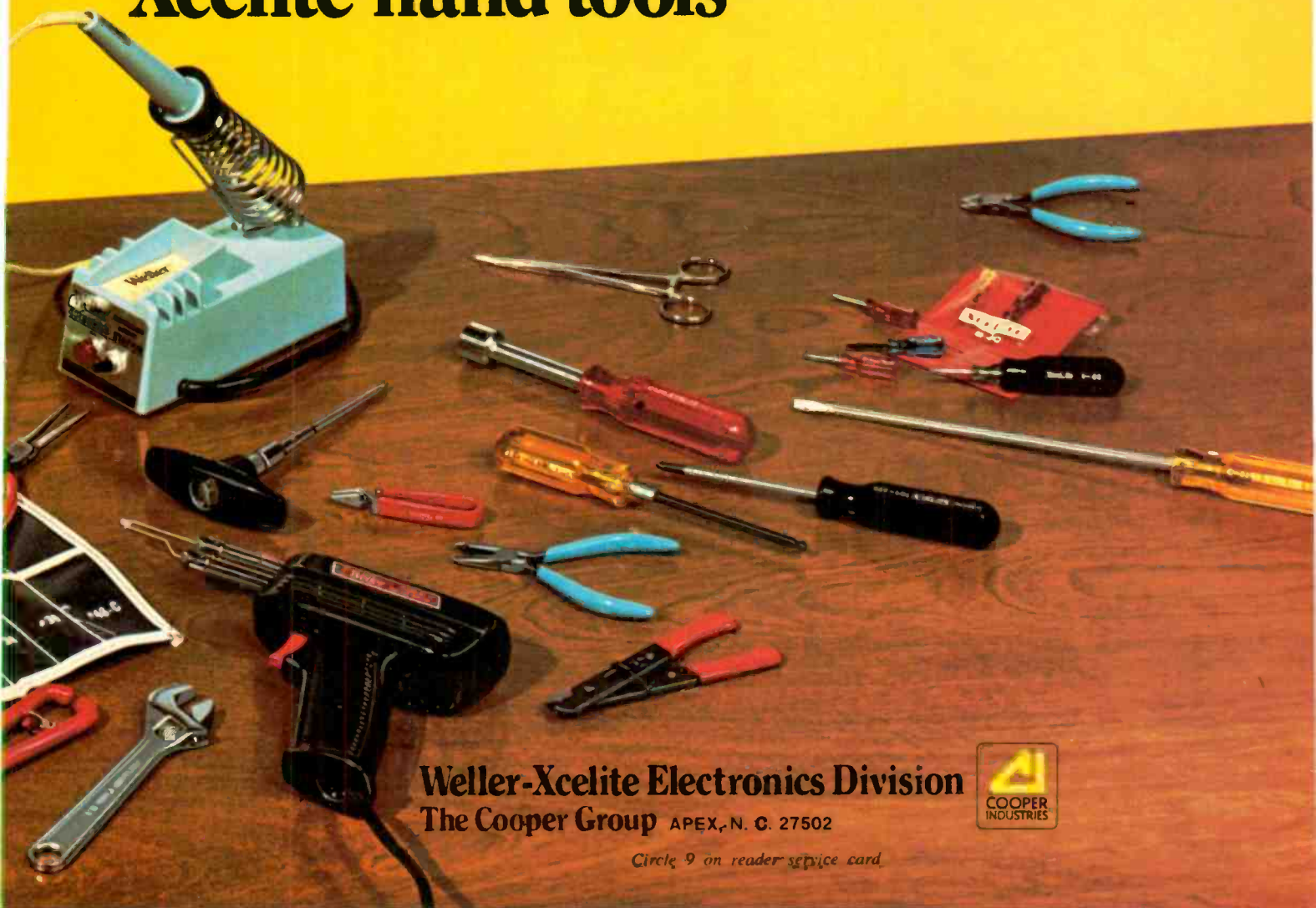
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EQUIPMENT REPORT

(continued from page 22)

time, by unscrewing the four soft rubber feet. The construction and wiring of this unit is very nice indeed. Looks very stout, and should give good service for quite a while!

We gave it the works on the bench, on several sets, and it came through very nicely. **R-E**

Sony TC-152SD
portable hi-fi cassette recorder

THE ORIGINAL CONCEPT OF THE CASSETTE recorder was a lightweight, easy to use battery powered portable suitable for, at best, voice-quality dictation. In an almost

miraculous upgrading of the cassette system to a high fidelity medium the machines got bigger and bigger, and the lifeline to the



Circle 92 on reader service card

nearest ac outlet precluded their use as portable recorders. The battery-powered

portables remained what they were — voice quality.

But there was, and remains a vast need for a truly portable *high-fidelity* cassette recorder — to record weddings, school plays and concerts, amateur and semi-pro film sound effects, etc. — which has been unmet until the recent introduction of the Sony TC-152SD cassette recorder.

The Sony TC-152SD is basically a Dolbyized stereo cassette deck of the type used in quality high fidelity installations, which in addition to the usual in-home features has a slew of conveniences specifically intended for field recording. But even more important, the TC-152SD can be powered by the ac line, four internal D-cells, a rechargeable battery pack or an auto or boat power cord (car-battery cord) available as an option.

Among the TC-152SD's features are the Dolby, tape selection for "normal" and chromium-dioxide tapes, a peak record level limiter, two calibrated VU meters, a reset counter, a 20-dB microphone input attenuator to prevent "jammed" record level control settings by high level sounds or a high level condenser microphone output level, automatic end of tape stop, and a record/play monitor speaker with its own volume and tone controls. The monitor speaker can be switched to either stereo track or combined tracks for *mono*.

Inputs are provided for microphones and line. There are outputs for line and phones. (The speaker is only a monitor device such as needed to check a tape in the field, or provide record level monitoring without tying up the main hi-fi amplifier.)

Graphic type controls are provided for the left and right record level. Standard controls are used for the speaker volume and tone (a treble cut). Switches are used for the Dolby in-out, tape type, record limiter, input selector (microphone/line/-20-dB microphone), VU meter illumination (when ac powered), battery condition test and speaker connection (L/R/Mono).

The batteries and rechargeable power pack are carried in an internal compartment. Jacks are provided for the ac line cord and remote dc power source.

The cassette mechanism is the standard hi-fi type, with control keys for eject, rewind, stop, forward, fast forward, record interlock and pause. Power to the recorder is automatically applied when the cassette operating keys are activated. When the cassette is stopped all power is removed, thereby reducing the battery drain.

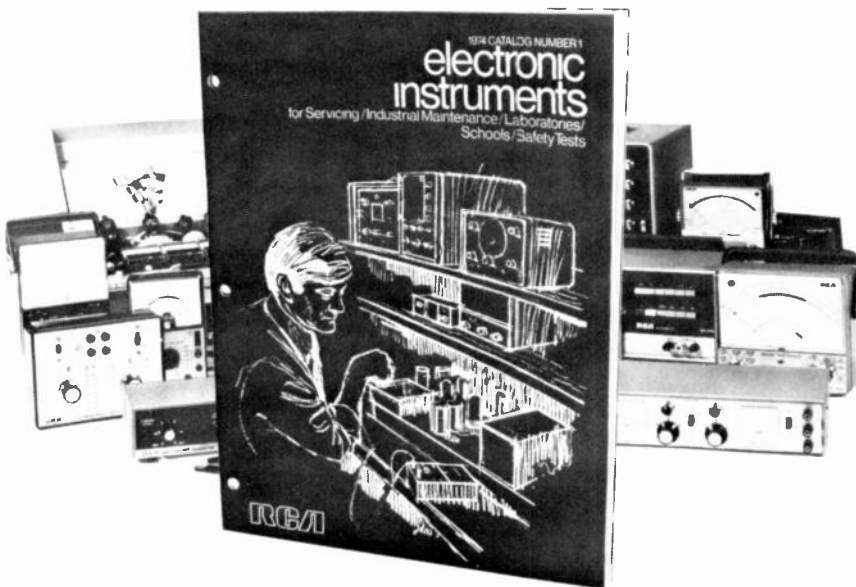
Hi-fi from 6 Vdc???

The secret behind the TC-152SD's outstanding sound performance (which we'll show later) is a dc to dc converter. In short, the recorder is *basically dc powered*. In other words, the ac that's "optional". To obtain the high operating voltage(s) needed for hi-fi amplifiers the 6 Vdc battery battery output is fed to a dc to dc converter that provides ± 24 Vdc for the record, play and Dolby amplifiers; the same voltage that would be, or is, used for ac-only powered cassette recorders. The capstan motor is a 6 Vdc servo type, immune to voltage changes within the battery pack's normal or "good" operating range. The speaker amplifier, which serves only as a monitor, is similarly powered directly from the 6 volt battery pack.

When the ac line cord is connected the batteries are automatically disconnected.

(continued on page 58)

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VIDEO TAPE RECORDERS

By Harry Kybett

This basic text on the fast-growing field of helical vtr's contains information seldom found in service manuals, which only cover specific models. It explains the fundamentals of video tape recording, describes electronic circuits and mechanical systems in currently available machines, lists basic problems encountered and their solutions; and presents recent developments in the field. 352 pages, softbound

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ELECTRONIC FLASH EQUIPMENT

By Veri Mott

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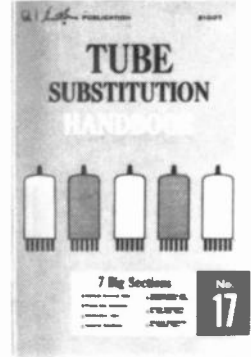


1-2-3-4 SERVICING HI-FI TURNTABLES

By Forest H. Belt

Greatly simplifies understanding of the mechanisms in terms of four divisions record changers by sections, assemblies within sections, breakdown of assemblies, and mechanical parts. The following chapters cover specifics for each type of drive system, tone arm and turntable. In addition, problem diagnosis—locating, isolating, and pinpointing faults is explained so that servicing can be accomplished quickly and easily. 192 pages, softbound

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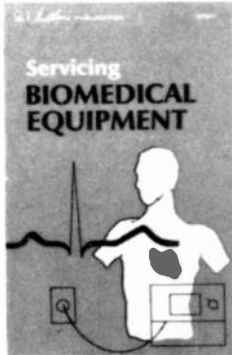


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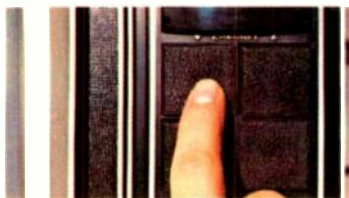
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Wait until you see channel numbers that actually flash on the screen! You can even pre-set how long you want them to stay on before fading.

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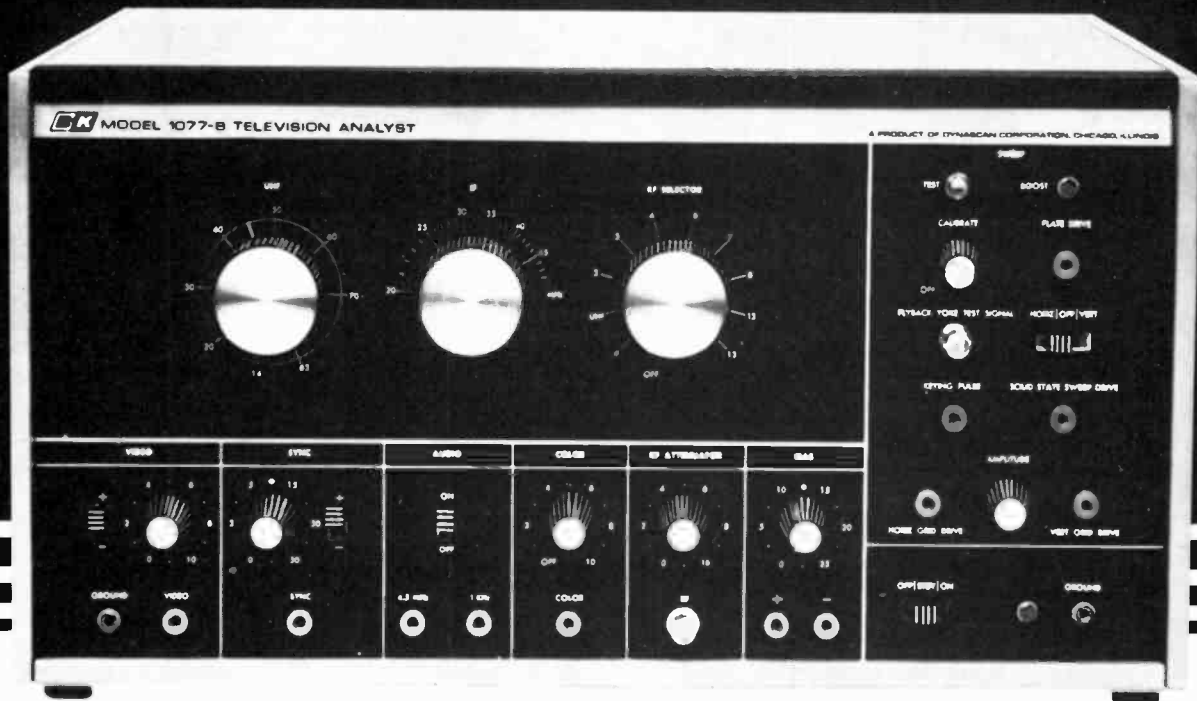
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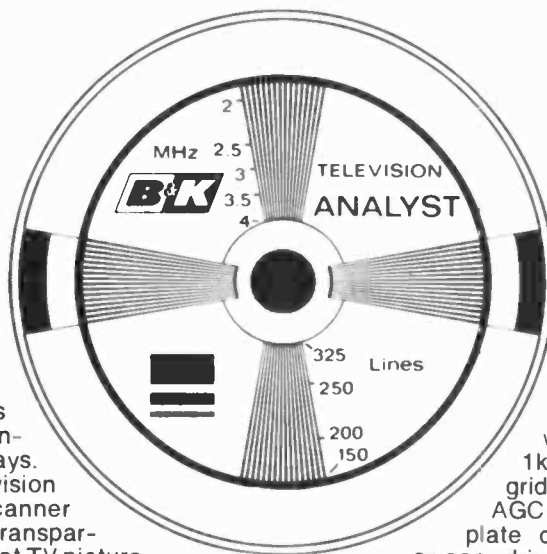
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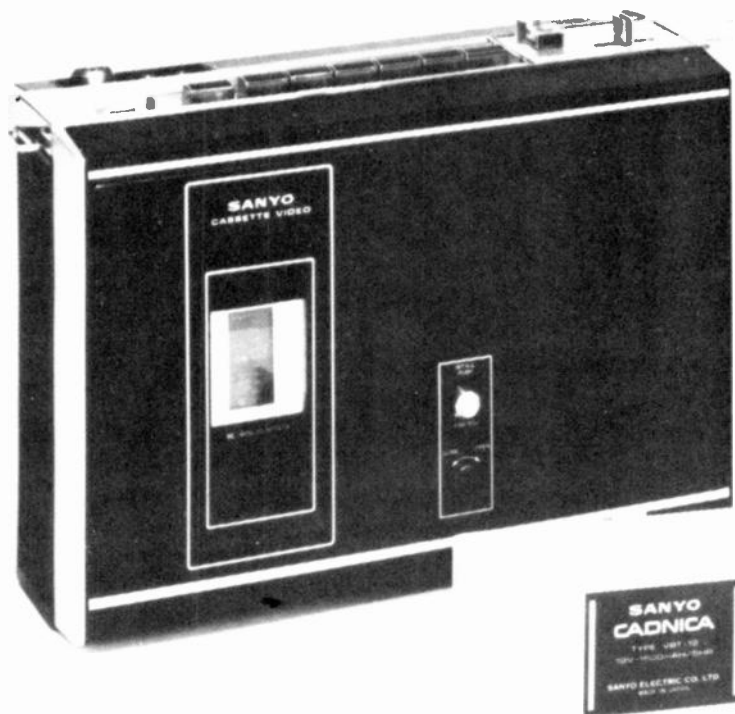
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Videotape—Videodisc today & tomorrow



by FRED PETRAS

THE NON-BROADCAST VTR FIELD TODAY is made up of several elements, to wit: A body of equipment in several formats, each in its own way a "standard;" a body of software — or software *potential* — for each of the formats; and a body of "use" technology that is expanding steadily as the equipment seeding continues.

These are the working reality of the industry. But there is more. . . . On the horizon—in laboratory breadboard form, in working prototypes, in pre-production models and at the actual test-market level—is a body of equipment representing a different but significant technology that could thoroughly disrupt the VTR (video tape recorder) industry as it exists today. That equipment technology is the video disc.

Equipment — today

The non-broadcast, private VTR industry in the U.S. is doing quite well. It is keyed to four basic formats—each one a "standard" in its own way: the three-quarter-inch "U-Matic" videocassette, the half-inch EIAJ (Electronic Industries Association of Japan) Type One/color half-inch cartridge known as "Omnivision," half-inch EIAJ Type One/color reel-to-reel, and one-inch reel-to-reel.

Each format has two or more proponents, and each may also be one of up to four formats embraced by a single company. For example, Panasonic, advocate of the Omnivision approach, also produces U-Matic,

plus half-inch and one-inch reel equipment. Concord markets machines in the two-encased formats plus half-inch reel-to-reel. JVC, committed to U-Matic, also makes several half-inch reel models. Shibaden, which markets Omnivision, also has five half-inch-reel decks. Ampex, pioneer of videotape—and still the biggest manufacturer for the broadcast professional fields—recently dropped its half-inch reel equipment in favor of expanding its one-inch line. Ampex feels one-inch tape has a greater potential for "professional" quality reproduction. Sony, developer of the U-Matic videocassette, also turns out a series of half-inch reel VTR's, including a portable system complete with camera. The U-Matic equipment line was recently broadened with the addition of a multi-broadcast-standards (NTSC, PAL, SECAM) model plus a portable recorder/player ensemble utilizing a mini-version of the U-Matic cassette; it runs for 20 minutes and is compatible with all U-Matic equipment.

The U-Matic videocassette appears under the Sony, Wollensak, Panasonic, JVC, TeleMation, and Concord brand names. The Omnivision cartridge is sold under the Panasonic, JVC Concord, Sharp, and Shibaden names.

The greatest potential as a broad standard is claimed for the EIAJ Type One/color format in "compatible" half-inch encased or open reel equipment. (This concept has the largest number of machines in use—over

100,000.) The owner of Early EIAJ-typed reel equipment can step up to the convenience of the Omnivision cartridge and still use his existing tapes; he merely threads them into a cartridge shell.

However, materials shortages and energy problems in Japan, main source for VTR equipment, is causing a shift in priorities. Whereas in the recent past the EIAJ Type One/color format had the nod as the key standard, the U-Matic concept is the one that the Japanese will promote as part of an overall effort to limit the number of types and models of VTR to be produced. This effort is based on the solid, and growing, acceptance of U-Matic in the U.S.

There is some potential for compatibility within the one-inch reel tape format also, but with equipment from only one company—International Video Corp. With over 10,000 reel machines in the marketplace, the firm is now offering one-inch cartridge gear. Owners of older IVC color or monochrome VTR's can encase their existing tapes for use in a new cartridge model. Or, tapes made on the new cartridge units can be removed from their cartridge and played as reels on IVC reel models.

But there are other VTR formats. . . . Akai America, Ltd., is marketing portable monochromatic video tape recorder outfits using quarter-inch video tape on 5-inch reels, with a running speed of 11 1/4 ips, for a total of 20 minutes playing time per reel. It also uses 1/4-inch tape in a business/

educational/home deck with 10½-inch reel capacity and 2-hour operating time. Both models use helical scanning.

Sanyo Electric Co., which had been making half-inch reel VTR's, has embraced the cassette—with a proprietary type, using half-inch tape. It runs for 20 minutes. The initial outfit is portable, with power adaptor/battery charger, plus camera.

Slowly but steadily making its presence felt in the U.S. is the Philips VCR (Video Cassette Recorder) using a proprietary cassette encasing half-inch video tape. Currently being sold via 25 outlets nationally, the system has been given a hype in the form of a \$335 price cut, bringing the cost of the basic rig down to \$1,095.

VCR is solidly entrenched in 13 European countries, where, it is reported, it is "fast becoming the standard of Europe." The format has been adopted by 15 other videocassette manufacturers. VCR users in Europe include IBM, Xerox, Chrysler, Unilever and hundreds of others in business, medicine and education.

In a special niche—here, but not quite here—is EVR, Electronic Video Recording. Combining film and magnetic sound, this concept is being marketed around the world and is gaining strong acceptance after an uncertain start. Hitachi and Mitsubishi are selling equipment, while a facility in Japan and another in England are turning out EVR software for world markets—with one exception, the U.S.

While film systems have been given a somewhat out-of-focus treatment in the overall video player picture, the concept has its merits, say open-minded industry members. The keys are the easy availability or easy creation of software—via Super-8 film, and the low cost and color-capability of the camera equipment. Commercially available software already exists in abundance and it conforms to an international standard. Anyone who can operate a movie camera can generate his own programming. And he can do it in color and also with sound. For \$800 less than the cost of the lowest priced color VTR camera in the market today—\$2,500—the consumer can own a Kodak Supermatic Film Videoplayer color-sound record/play film video system complete with color TV monitor. The player unit can function through one or more TV sets. Since the software format is international, programs can be played through NTSC, PAL and SECAM-type players. Further, the same software can be used on standard movie projectors with or without sound.

Original plans called for the Kodak Videoplayer to appear in late 1973, then early this year. The last word is that it will hit the market in July, in limited quantities, with full production to be achieved in the fall. The original projected price of the player unit is \$1,095.

Equipment — tomorrow

The following five video systems have been a coming-but-never-arriving proposition. Herewith their latest positions relative to reality.

MCA, Inc., expects to start marketing its Disco-Vision laser-beam optical-scan color video disc system the latter part of 1975, or early 1976.

Projected prices are \$400 for a player deck, and \$500 for a 10-disc changer. The firm originally did not intend to manufacture the system, but rather, have it produced by

some other firm(s). However, MCA is now weighing the feasibility of doing its own manufacturing.

The concept uses a 12-inch mylar/metal disc with up to 40 minutes of play time on its one recorded surface. MCA—which is creating the software—expects to have at least 1,000 disc albums available. Single-disc albums are expected to sell for about \$2.00.

RCA is not setting an exact date for introduction of its Selectavision MagTape three-quarter-inch tape cartridge color video recorder "pending further product development." The firm is planning "not-for-sale" market tests of MagTape, possibly this summer. While the firm is "still aiming for a \$795 target price" for a MagTape record/play deck, there is some skepticism that this will become the final price tag.

In the meantime RCA is developing a line of software, which, hopefully, will be ready for sale at the same time as the deck.

Relative to its highly secret capacitance color video disc, RCA is still working on it in two laboratories. A spokesman reported that "some impressive progress" had been made, but that the system was not yet ready for any public demonstrations. He would give few details except to say the disc looked like a conventional LP phono record, revolved at 450 rpm, and offered a half-hour of play time. Relative to a date for its introduction, the source said it would "obviously follow" MagTape. However, he cautioned, "It boils down to this: can we afford to build it?"

Initially promised for 1972, then mid-1973, then late 1973, the Teldec color video disc is expected to become a reality in the U.S. this year. Jointly developed by Telefunken and British Decca, Teldec players are already being built and stockpiled, pending marketing scheduled to begin in Germany at about the time this appears in print. The system will be sold in Germany under the "TeD" name. Production is at a factory in Berlin. Decca may begin production of its own version in the United Kingdom sometime this year.

There are also reports of a Japanese-made version by licensee Sanyo, using the NTSC color broadcast standard. The video disc is looked on favorably by Japanese manufacturers since both hardware and software could sell at lower prices than videotape products.

Software for Teldec is reportedly being developed at a fast clip, with about 150 titles from nine European record companies initially moving into stores along with the hardware. The 8-inch discs play for 10 minutes and offer stereo sound. The software includes a 3-disc Beethoven trio and a 12-disc Polish movie. A changer model of the Teldec is available for playing the multi-disc sets. Tentative prices for the U.S. are \$220 for a single-play deck and "under \$400" for a changer.

The Philips laser-beam optical color video disc—VLP (Video Long Play)—is targeted for 1975 in Europe. It will hit the U.S. at approximately the same time. The projected price of the VLP player would be "around \$500." The VLP disc plays for 30 minutes, but has a claimed potential of up to 45 minutes of play time.

Equipment — much later

The attempts to develop a video disc have resulted in some spinoffs (no pun intended)

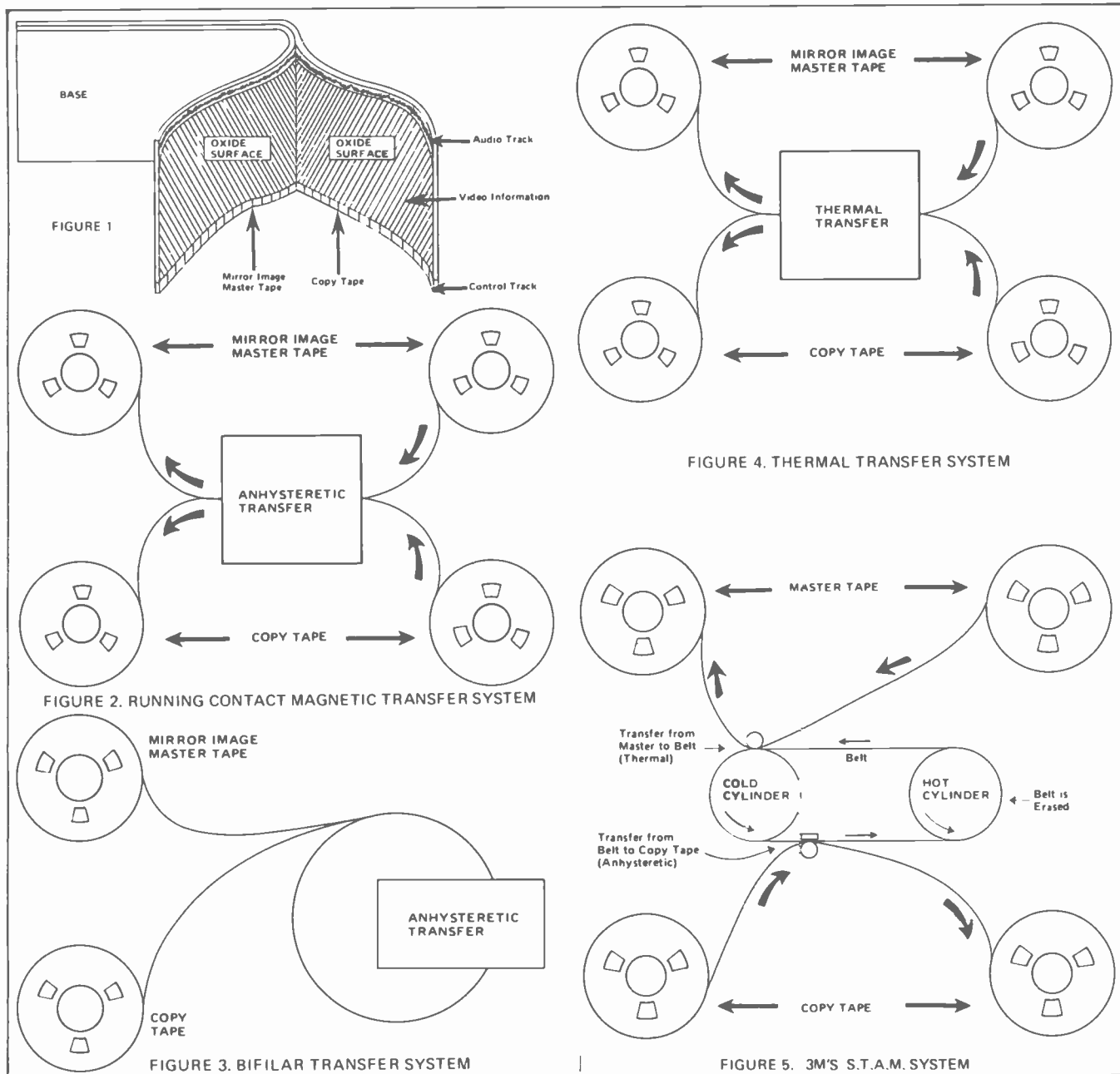
that may well bear on the distant future of the video disc. An example is a slow-speed disc technique developed in France by a young inventor Guy Nathan, head of a company named SEPO. Nathan's system operates at about 6 rpm, using a fairly wide track compared to that of the MCA and Philips disc concepts. Called "Optidisc," the system arranges scanning lines perpendicular to movement of the track, as opposed to the sequential approach requiring one-revolution-per-TV-frame at high speeds of 1800 rpm for U.S. TV, 1500 for European. Recording is via laser-beam on 35-mm film; replication is to thin transparent film discs via a high-speed photo-contact printing process. First models may reach the industrial field in France during 1975. Consumer player models, to follow, are expected to sell for about \$200. Disc prices will be "low," it was said.

Another company known to be working on a video disc is Zenith Corp. In its annual report Zenith stated, "Video recording and playback systems are among the most promising new consumer products under development at Zenith. Using the capabilities of both engineering and research, Zenith has done its own development work, and has evaluated other work done in this country and abroad. During the year, Zenith demonstrated one video disc player to distributors as a technical progress report. This and other systems are currently undergoing further development." The company is reported to have a 90-man team working on a video disc. One report indicates it is an optically-scanned transparent disc with 20 minutes of play time.

Thomson-Brandt, giant French electronics-electrical manufacturer, has been doing development work on various video concepts for several years through its Thomson-CSF division. The latest word is that Thomson-CSF has come up with a working prototype video disc outfit using laser-optical readout and a transparent disc. While a bit more development work is to be done, the company claims it has licked the major technical problems. Expected playing time of the disc is pegged at 20 to 25 minutes. Introducing and marketing plans are not finalized. Projected player price is vague—in the \$450 to \$800 range.

Another video disc idea is under development at i/o Metrics Corp., Sunnyvale, Calif. It uses a flexible, transparent 12-inch disc with an estimated (projected) playing time of one hour of color programming. The recordings are replicated from a master recording that would be made on holographic film discs, using a laser-beam recorder priced in the \$25,000 to \$30,000 range. Playback decks are expected to sell for around \$300. The discs, says the company, are likely to be priced from about \$5 to \$7.

Shown at an international consumer electronics show in Berlin the latter part of 1973 was a working model of another video disc approach. Unlike other disc formats, this one also offers recording capability. Called MDR (magnetic disc recording), it was invented by Erich Rabe, owner of a record company. It uses a special record/playback head made by Wolfgang Bogen GmbH, a tape head producer. The unit shown utilized a modified Dual phono record turntable, whose speed was upped to 156 rpm and whose pickup arm was altered to accommodate the tape head plus an extension shaft assembly with a stylus. The system uses a



12-inch magnetic-oxide-coated disc that contains an inner band of spiral grooves. The latter are used collaterally; the extension assembly with stylus rides these grooves and serves as a guide for the tape head's scanning of the outer area of the record. Also involved in the total hardware are a preamp and playback amplifier for use with any color or monochrome TV set. The developmental prototype offered five minutes of play time per side, but 12 minutes of color programming per side can be achieved by halving the speed and using a tape head with smaller gap.

MDR discs would be reusable for several hundred plays, says the inventor. The price for a player/recorder was put at "under \$400 retail."

In Japan, Matsushita Electric and subsidiary Victor Co. of Japan (JVC in the U.S.) are reported to be developing their own video disc gear, which, the reports say, will be highly sophisticated and innovative. Sanyo is also known to be working on a video disc. And Pioneer Electronics is said to be on the way to video disc system man-

ufacture, probably of equipment developed by another firm.

On a related front, video cameras, the search goes on for an inexpensive color model. The latest word is that Toshiba will be retailing a color camera at \$755 for "general household use." The timetable — this year.

Software production

In addition to a burgeoning on the creative side of VTR software, there has been an expansion on the production side.

Just as the audio industry has been working to improve its tape duplication methods, so too, has the video industry. While most of the duplication so far has been in "real time" (duplication time equal to playing time) or slower, Minnesota Mining & Manufacturing has come up with what it calls "sequential thermal anhyseretic magnetization" (STAM). This hot/cold transfer process enables duplication at 20 times real playing time for reel tapes, and 10 times playing speed for videocassettes.

Individually, major hardware suppliers

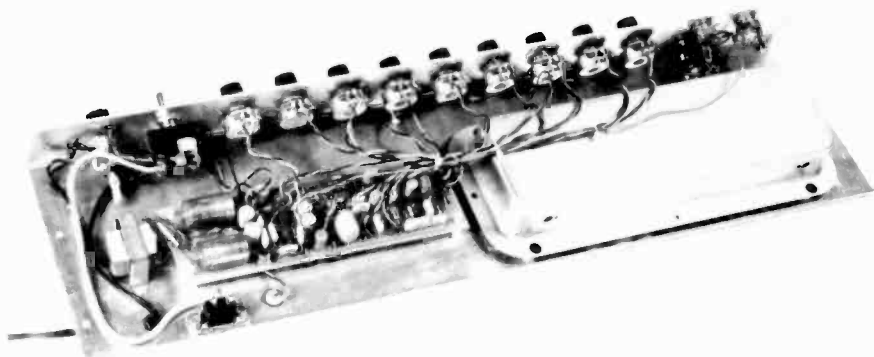
are checking into the duplication of software for their respective formats, and to some degree are getting deeper into this end of the business, to assure their "razor" purchasers that "blades" are in abundant supply. This is in line with an expressed belief that the greater the availability of software, the greater will be sales of the hardware.

Sony Corp. of America and Teletronics International have formed a duplicating company to reproduce videocassettes for the Sony U-Matic color video tape format. Known as S/T Videocassette Duplicating Corp., the firm has a 31,000 square foot plant in Leonia, N.J. It dubs from all master material in the areas of film, slides plus other video tape systems. U-Matic cassettes are also produced by 15 independent companies that own Sony D-100 series duplicators.

Philips has duplicating facilities in New York and New Jersey for its VCR format, and is in firm negotiations for similar facilities in Chicago and on the West Coast.

Panasonic by mid-year expects to have 15
(continued on page 88)

Build a Guitar Preamp



by GARY KAY

INTERESTED IN BUILDING A GUITAR PREAMP with a really unique and outstanding sound? One that has not only conventional tremolo and reverb, but also includes a full complement of five tone controls consisting of a three-octave variable basspass filter along with the conventional bass and treble controls. Note also that with the instrument preamp separate from the power amplifier, you are left with a wide choice of output power capabilities from a moderate 60 watts. (Build a 4-Channel Power Amplifier, *Radio-Electronics*, March-April 1973) to a strong 250 watts. (Tigersaurus 250-watt Hi-Fi Amplifier, *Radio-Electronics*, December 1973) to mention just two. You can also drive several power amplifiers from one preamp, starting with one power amplifier now and expanding to others as the need arises.

The outstanding feature of this preamp is the unique tone control system that provides the utmost in flexibility. Upon investigation, it became apparent that many electric guitarists try to get a sound in which the fundamental notes of the guitar are de-emphasized or toned down. The fundamental notes for most electric guitars, excluding the bass guitar, go from about 100 to a little over 1000 Hz and are generally the loudest. This leaves behind the bass notes on the low end and harmonics on the high end. For added tonal compensation, some guitar amplifiers have a single mid-range control in addition to the standard bass and treble controls, while others have a conglomeration of active filter level controls. Both operate over a fixed frequency range which cannot be varied.

With the advent of inexpensive op-amp integrated circuits and the flexibility of active filter techniques, we can now have a tone control system which can variably de-emphasize any or all of almost one full decade of the fundamental note spectrum of a guitar. The use of this particular active filter configuration also provides the introduction of what seems to be a very interesting and unique control. It has been called an EMPHASIS control, and to understand its function it is necessary to describe the active filter circuitry in detail.

SPECIFICATIONS

Sensitivity —	1.5 V rms out at -40 dB input (tone controls set for flat response — A input)
Input Impedance —	100 K — A input 40 K — B input
Output Impedance —	1 K
Maximum Input Voltage —	0.5 V rms — B input
Maximum Output Voltage —	5 V rms
Harmonic Distortion —	Less than 1% at 1 kHz
Hum and Noise —	1 mV (full volume — tone controls set for flat response)
Power Requirements —	117 Vac @ 0.25 A

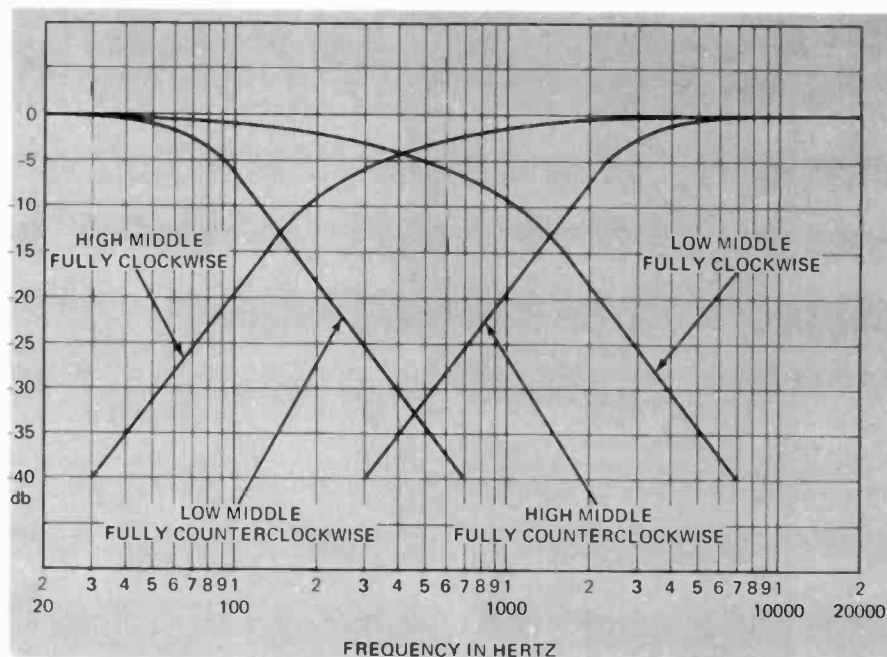
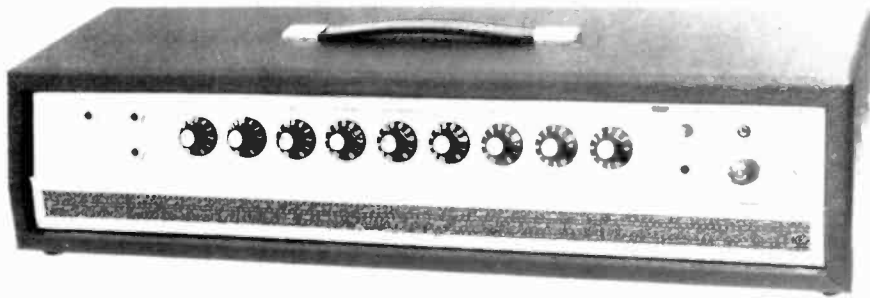


FIG. 1—FREQUENCY RESPONSE OF THE MIDDLE CONTROLS can be varied from flat at one extreme to an adjustable notch with over 30 dB attenuation at around 450 Hz.



Improve your guitar with a preamp that features high gain, tremolo, reverb and active-filter tone controls that give you the effects that you want.

Two active filters

After the input being fed into the preamp has been amplified to a reasonable level, it is simultaneously fed into two active filters: one a low-pass and the other a high-pass. Each of the two filters has a control which sets that filter's passband over almost a one decade range. The low-pass filter's corner frequency is set by the LOW MIDDLE tone control while the high-pass filter's corner frequency is set by the HIGH MIDDLE tone control. The outputs of the two filters are independent and must be mixed to recover the complete guitar output signal less the filtered portion. This is where the EMPHASIS control is used.

It is very simple to provide a control which varies the proportion of the low-pass to high-pass output being mixed while still being able to set the passbands of the individual filters with the LOW MIDDLE tone controls independently. While playing, panning the EMPHASIS control allows you to eliminate any or all of the output of either of the two filters, changing the sound of the instrument from that of a bass guitar to that of a lead guitar at the twist of a knob.

An approximate frequency response plot of the active filter tone control circuit is in Fig. 1. Note that having both MIDDLE controls fully counterclockwise creates a large notch well within the fundamental spectrum of the guitar while having both controls fully clockwise provides almost flat response. Operating the controls somewhere in between varies the degree as well as the center frequency of the notch.

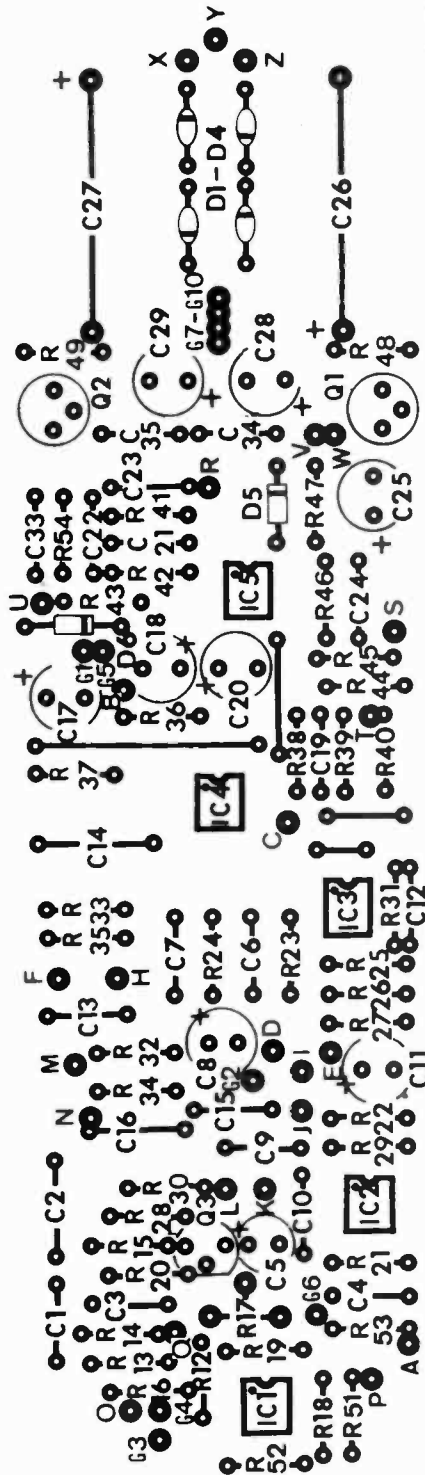
The plots were made for an EMPHASIS control setting of 4, which yields a near equal balance between low and highs. Moving the EMPHASIS control to a higher number simultaneously raises the high-frequency and lowers the low-frequency response curves while moving the controls to a lower number does just the opposite.

The tone control circuit also has conventional bass and treble controls that provide a variable 0 to 20 dB boost. Tremolo and reverb circuitry are provided as well, and both can be controlled from a remote footswitch. Two input jacks, a low level and high level, as well as two output jacks, one on the front panel and one on the bottom panel are provided for signal terminations. Ac power and power line reverse are provided by the center off toggle switch on the front panel.

Ac power for the power amplifier may be

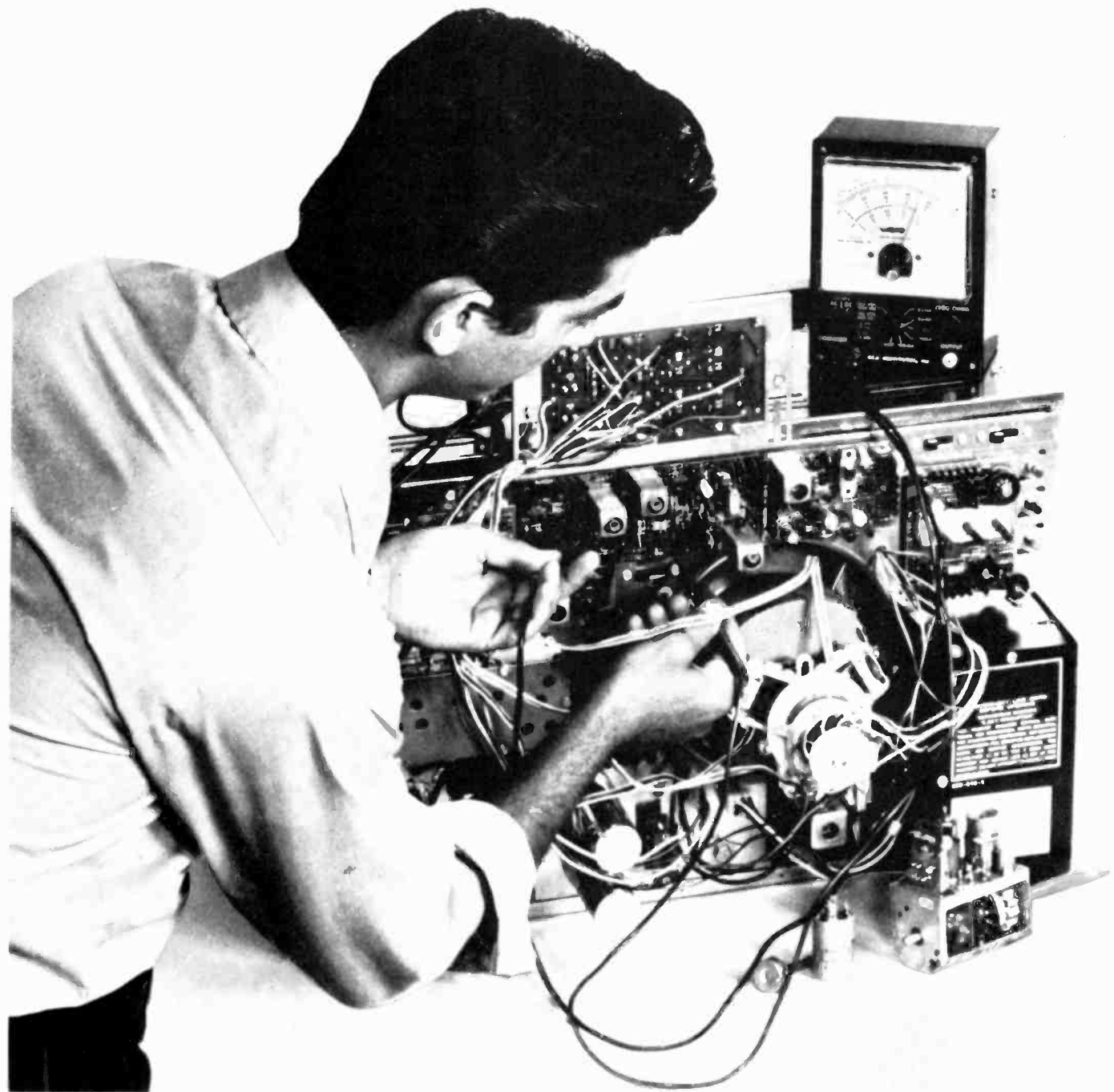
(continued on page 42)

FULL-SIZE PATTERN FOR THE CIRCUIT BOARD and parts layout diagram. You can duplicate it using your favorite process or purchase it pre-drilled or as a part of the kit.



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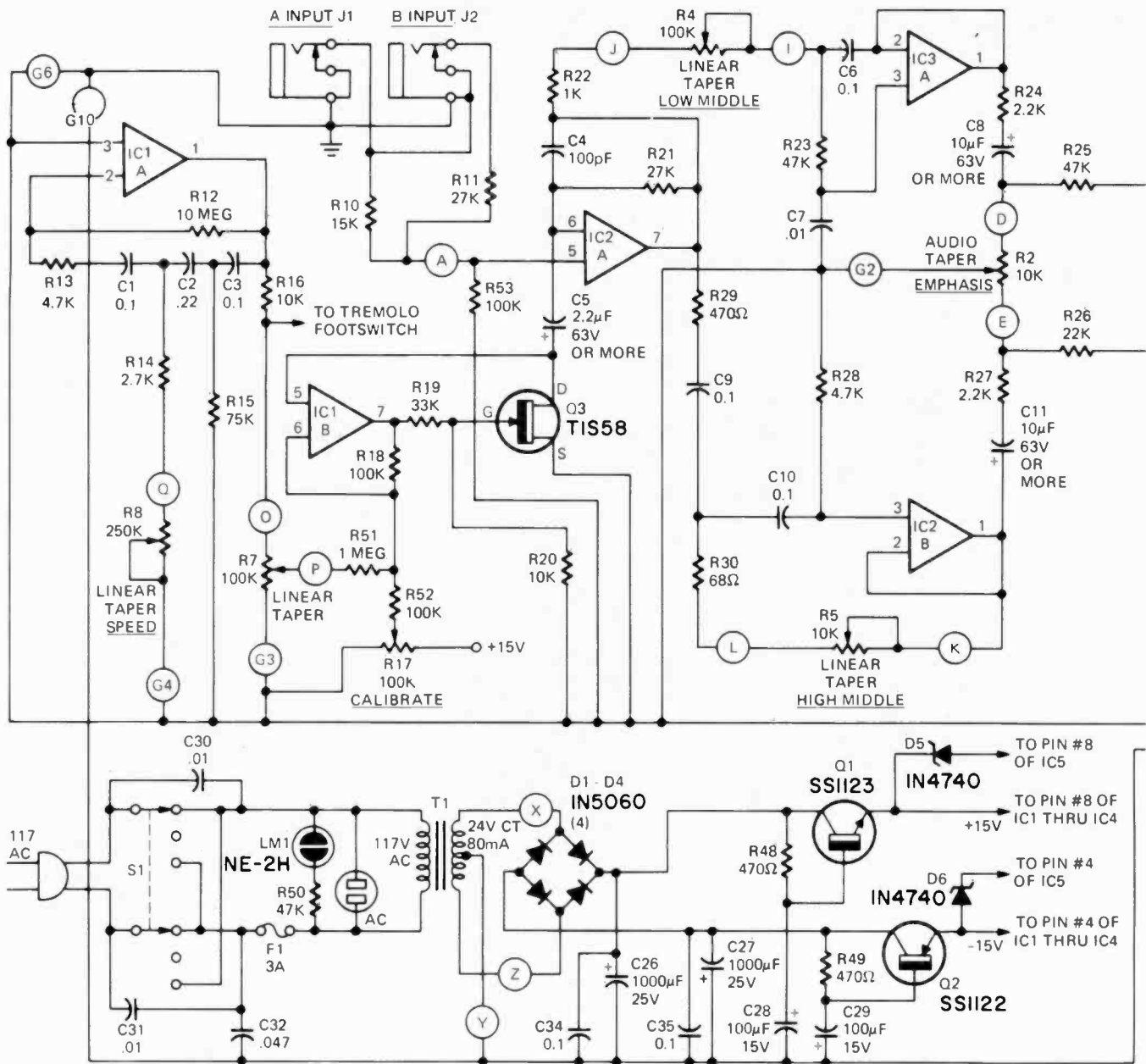
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GTE SYLVANIA



In the Master TV/Radio Servicing Program, you build and keep the all solid-state black and white TV set, the color TV set, the oscilloscope and the multimeter shown above.



All resistors 1/4 watt unless noted.

- R1—50,000 ohms, audio taper potentiometer
- R2—10,000 ohms, audio taper potentiometer
- R3, R4, R7—100,000 ohms, linear taper potentiometer
- R5, R9—10,000 ohms, linear taper potentiometer
- R6—50,000 ohms, linear taper potentiometer
- R8—250,000 ohms, linear taper potentiometer
- R10—15,000 ohms
- R11, R21—27,000 ohms
- R12—10 megohms
- R13, R28, R32—4700 ohms
- R14—2700 ohms
- R15—75,000 ohms
- R16, R20, R36, R54—10,000 ohms
- R17—10,000 ohms, trimmer resistor
- R18, R31, R35, R38, R46, R52, R53—100,000 ohms
- R19—33,000 ohms
- R22, R37, R39, R42, R43, R47—1000 ohms
- R23, R25, R41, R45, R50—47,000 ohms
- R24, R27, R34, R40—2200 ohms
- R26, R44—22,000 ohms
- R29, R33, R48, R49—470 ohms
- R30—68 ohms
- R51—1 megohm

- C1, C3, C6, C9, C10, C34, C35—0.1- μ F Mylar
- C2—0.22- μ F Mylar
- C4, C19, C21—100-pF polystyrene
- C5—2.2- μ F @ 63 Vdc or higher electrolytic
- C7, C15, C30, C31, C33—0.01- μ F Mylar
- C8, C11, C18, C25—10- μ F @ 63 Vdc or higher electrolytic

- C12, C24—60-pF polystyrene
- C13, C22, C23, C32—0.047- μ F Mylar
- C14—0.47- μ F Mylar
- C16—0.01- μ F polystyrene
- C17—30- μ F @ 15 Vdc electrolytic
- C20—4.7- μ F @ 63 Vdc or higher electrolytic
- C26, C27—1000- μ F @ 25 Vdc electrolytic
- C28, C29—100- μ F @ 15 Vdc electrolytic

- D1, D2, D3, D4—IN5060
- D5, D6—10V 400 mW or greater Zener diode IN4740 or equal
- Q1—SS1123 or 2N4238 silicon transistor
- Q2—SS1122 or 2N4235 silicon transistor
- Q3—TIS58 FET-yellow tracer
- IC1, IC2, IC3, IC4, IC5—5558 dual op-amp

- T1—Power Transformer - 117 Vac primary/24 Vac c.t. 80 mA secondary
- F1—3A standard fuse (see text)
- LM1—NE - 2H neon lamp
- S1—dpdt center-off toggle switch
- J1, J2—2-conductor shorting phone jack
- J3—3-conductor non-shorting phone jack
- J4—2-conductor non-shorting phone jack
- J5—RCA phono jack

The following parts are available from Southwest Technical Products Corp. 219 W. Rhapsody San Antonio, Texas 78216

Kit of all parts. No. 211-C \$96.50 plus postage for 7 lbs.

Circuit board only
Reverb Spring

No. 211-lb \$6.50
No. Z—1C \$11.00 pp

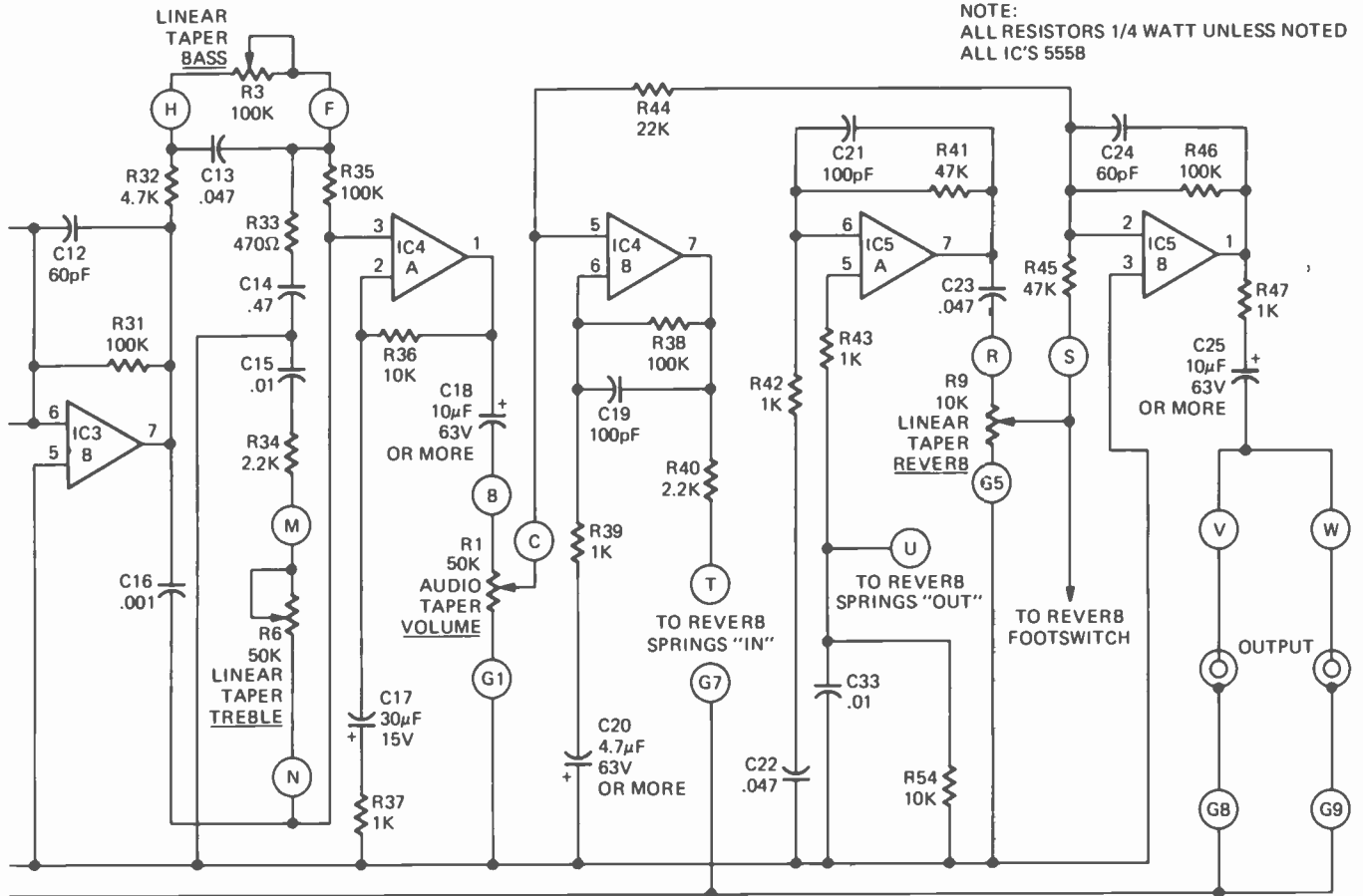
gotten from the ac receptacle on the bottom panel. Power for the preamp is provided by an internal ac supply. The reverb springs are mounted inside the chassis along with the printed circuit board and its components. The chassis is then mounted in a black-vinyl-covered wooden enclosure bringing the total dimensions to 24 1/2" long x 6 1/2" high x 7 1/2" deep.

Assembly techniques

A printed circuit board should be used for this project. Mount all of the components on the printed circuit board, making sure to orient the diodes, transistors, integrated circuits and electrolytic capacitors as indicated in the parts list and component layout figure. Bend and trim the leads on the back side of the board and solder the connections using a low-wattage iron and 60/40 alloy resin core solder. Note there are four jumpers which must be installed on the board. They can be made from some short pieces of hook-up wire and should go between the solid lines shown on the component layout figure.

Attach the plastic standoff's, terminal

NOTE:
ALL RESISTORS 1/4 WATT UNLESS NOTED
ALL IC'S 5558



THE PREAMP SCHEMATIC. The circled codes correspond to tie points on the PC board used for connections to components that are mounted on the front and bottom panels.

strip, ac outlet, RCA-type output jack, power transformer and line cord to the chassis using 6-32 hardware. Place a finished panel over the front of the chassis and secure by installing all of the potentiometers, input/output jacks, fuse holder, lamp cover and power switch.

Attach all of the wires from the component side of the printed circuit board, making twisted pairs or triples for each set of control wires. Snap the board into place and connect each wire bundle to the correct control. Position the wires as shown in the picture and use different colored wire for ease of identification. Attach and solder all of the power supply connections as well as those on the input/output connectors. Snap the reverb springs down onto the standoffs and connect the RCA plugs to the correct jack, also press all of the knobs onto the potentiometer shafts.

On the circuit board, temporarily solder a 1K 1/4-watt resistor between the Q3 end of resistor R15 and the C5 end of resistor R21 and set trimmer resistor R17 so the tab on the knurl of the control is adjacent capacitor C3. Check to make sure all connections have been soldered and insert fuse F1 into the fuse holder.

Testing and calibration

Without any input connections to the preamp, make the following settings on the controls.

Volume	- 0	Treble	- 0
Emphasis	- 4	Depth	- 0
Bass	- 0	Speed	- 0
Low Middle	-10	Reverb	- 0
High Middle	-10		

Using either one of the two output jacks, connect the preamp to a power amplifier and

speaker system. If the power amplifier has an input level control, turn it all the way down. Apply power to the preamp/power amplifier system and slowly advance the power amplifier input level control until it is at its maximum. There should be little if any noise coming from the speaker. If you have access to an audio signal generator, set it for a sine wave output of 0.1 volts rms at 1 kHz and plug it into the A input of the preamp. Slowly advance the preamp's volume control until you can hear the output through the speaker. If you never hear the output, unplug everything in the system and check the preamp, assuming you are sure your power amplifier and speaker system are working correctly. If you cannot visually locate the problem, use an oscilloscope to pinpoint the source of the trouble. If you do not have access to an audio generator, use a guitar following basically the same procedure.

Next you must calibrate the input gain for proper tremolo operation. Using either a voltmeter or oscilloscope and with the audio generator still connected, note the output level of the unit for some reference voltage input. Unsolder the 1K resistor. The output level should drop considerably. Now slowly advance trimmer resistor, R17, until the gain is the same as it was when the 1K resistor was in place. Do not advance the control any farther. The chassis may now be attached to the case.

Operation and use

Input: The unit has two input jacks with the A input being the more sensitive of the two. The B input is down about 9 dB and should be used on instruments with a very high output level.

Footswitch: The footswitch jack is provided to allow both the reverb and tremolo to be turned on and off at will. This requires an additional 3-conductor plug and pair of switches.

Volume: the volume control is a conventional level control.

Emphasis: The emphasis control determines the ratio of highs to lows and sets the overall tone of the output. An equal balance is achieved at a setting of about 4.

Bass: The bass control sets the amount of bass boost in the circuit with a setting of 0 resulting in no bass boost and 10 yielding a little under 20 dB.

Low Middle: The low-middle control determines the low-end frequency above which the mid-band notes are attenuated.

High Middle: The high-middle control determines the high-end frequency below which the mid-band notes are attenuated. The combination of low-middle and high-middle controls result in a variable mid-band notch filter providing multi-octave mid-band attenuation at one extreme (both controls at 0) or almost flat response (both controls at 10).

Treble: The treble control sets the amount of treble boost in the circuit with a setting of 10 resulting in no treble boost and 0 yielding a little under 20 dB.

Tremolo: The tremolo depth and speed controls provide a variable intensity tremolo effect varying from about 3 to 13 Hz.

Reverb: The reverb control determines the amount of reverberated sound mixed into the output of the preamplifier.

Power Switch: The center-off power switch serves the dual function of line reverse and on-off control. It also provides
(continued on page 59)

THE NEWEST CD-4 Demodulator

Discrete 4-channel phonographic reproduction has come a long way in just a few years. The latest advancement is due to a new IC that makes possible improved demodulators.

by **LEN FELDMAN**

CONTRIBUTING HIGH-FIDELITY EDITOR

MANY AUDIO ENTHUSIASTS WHO rushed right out to buy the very first "discrete" CD-4 records issued by RCA when that quadriphonic disc format was first introduced in 1972 expressed disappointment over the results when they played these more complicated discs, now popularly known as *Quadradiscs*. Invariably, the blame was placed on the discs themselves. Admittedly, the earliest releases did have poorer signal-to-noise ratios than either stereo or matrix 4-channel discs. This higher noise level stemmed from two sources. First, to accommodate the required high-frequency carrier and its front-to-back modulating difference signals, the level of the sum-signal groove modulation had to be backed off somewhat. Even if all other noise parameters were equal, this means that a higher setting of the amplifier volume control had to be used for equivalent sound levels, resulting in poorer signal-to-noise ratios. Since the system bandwidth of a *Quadradisc* is greater than that of a stereo or matrix record (from 30 Hz to 45 kHz instead of from 30 Hz to 20 kHz), the noise spectrum will be somewhat greater to start with.

The first of these problems, recording level, has been almost eliminated by improved record cutting techniques and equipment. Main, "sum" information level (left-front plus left-back, and right-front plus right-back) is now recorded at velocities approaching those used in stereo disc recording. The second factor, however, is not solely dependent upon disc cutting techniques, but is also directly related to the design approach and sophistication of the associated demodulator used to recover front-back difference information from the high-frequency carrier which is part of the complex composite signal in each groove wall of the disc. These elements are shown in Fig. 1.

FM tuner analogy

Part of the demodulator circuitry

used in decoding CD-4 records may well be thought of as an FM tuner (really two tuners, one for each groove wall signal). The carrier frequency in this case is 30 kHz (instead of the usual 88 to 108 MHz of FM broadcasting), and the modulation is a combination of FM and PM (phase modulation), with pre-emphasis and audio level compression used at the recording end and complementary FM/PM demodulation, de-emphasis and audio expansion employed at the playback end to improve overall audio performance. Since we are dealing with an FM signal, proper limiting plays a very important

role in the recovery sequence. Block diagrams of the CD-4 encoding process and decoding process are shown in Figs. 2 and 3. As might be supposed, the amount of circuitry needed to perform all of the functions shown in Fig. 3 is great and complex, if all active elements are conventional transistors and the cost of either separately available demodulators or demodulator circuits built into some of the latest quadriphonic all-in-one receivers or amplifiers is substantial.

An IC for CD-4 demodulators

Quadraeast Systems, Inc., a com-

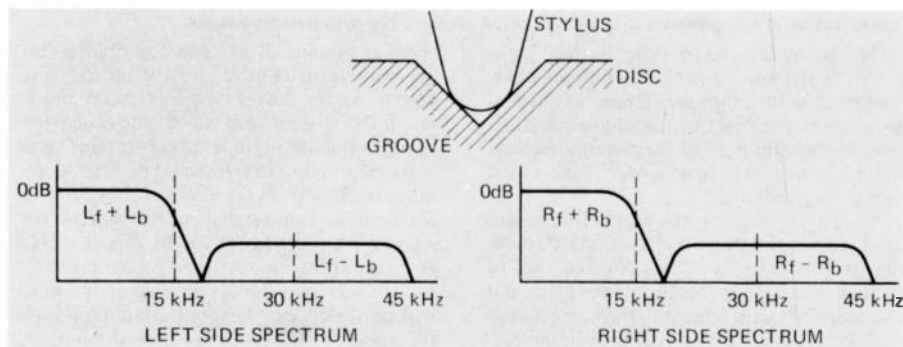


FIG. 1—FREQUENCY DISTRIBUTION AND AUDIO SIGNAL CONTENT of the groove walls of a CD-4 record.

QUADRAPHONIC IS ILLITERATE! IHF SAYS "USE QUADRIPHONIC."

Proper English usage wins. For more than a year, **Radio-Electronics** has been using the term *quadriphonic* to describe 4-channel sound systems and equipment. Now the IHF (Institute of High-Fidelity) has announced that *quadriphonic* is indeed the proper word, and the all too common *quadraphonic* is verboten.

The prefix *quadra* is not a prefix at all. It is not Latin, not Greek, not English, but garbage. **Radio-Electronics** has been using *quadriphonic* wherever possible. But this has not been easy. If a manufacturer decides to identify his product as a *quadraphonic* unit, we must use this same name in identification. However, we will continue to use *quadriphonic* except in places where we are reprinting a manufacturer's name.

pany headed by Louis Dorren (the inventor of the Dorren 4-Channel FM Broadcasting System now being considered, among others, for possible adoption by the FCC as a standard for discrete 4-channel FM broadcasting) recently announced the availability of a 28-pin IC, to be known as QS1-5022. Two of these new chips, four filter blocks and a minimum number of external parts are all that is needed to build a CD-4 demodulator that performs all the necessary functions outlined in Fig. 3. The new IC will be made available to manufacturers through Matsushita Electric Corporation of America (the company known for its Panasonic and "Technics by Panasonic" products).

In addition to the space-saving and cost considerations implicit in the use of two of these IC's, performance ad-

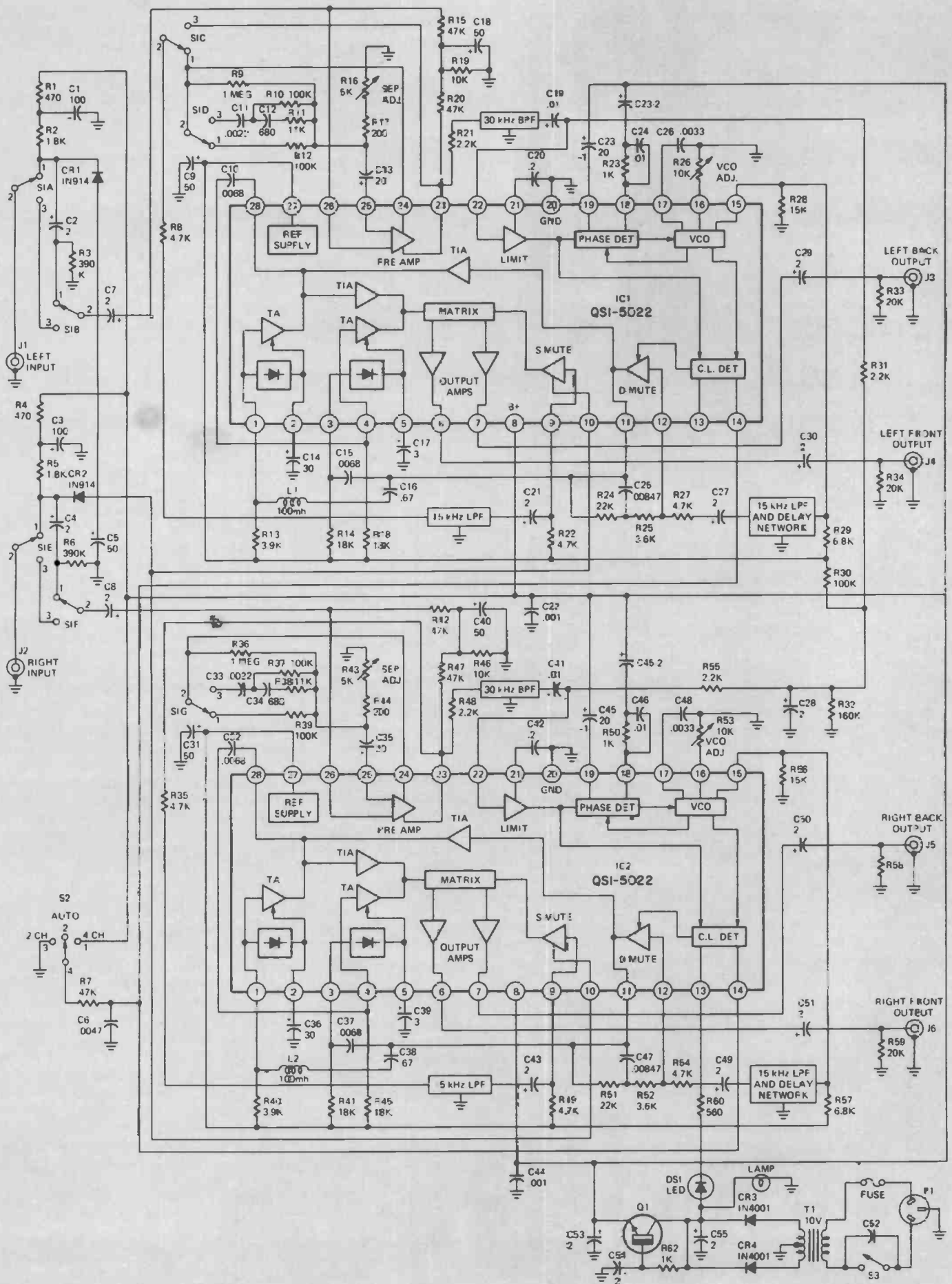


FIG. 5—COMPLETE CD-4 DEMODULATOR schematic using two QSI 5022 IC's.

vantages are ascribed to this new circuit by its designers in an informative booklet written by Gerald O'Keefe of QuadraCast Systems, Inc. A block diagram of the QSI-5022 is shown in Fig. 4.

Circuit description

Since semiconductor phonograph cartridges have been announced for use with stereo and CD-4 records, the circuit was designed to handle either magnetic cartridges or the new semiconductor types. While the latter

ways made to the 0° preamplifier output.) This is because the left channel of a semiconductor cartridge requires phase inversion to be in proper phase relationship to the right-channel output.

The signal generated in either form of cartridge is fed through S1-a and S1-b to the preamp input. The separation adjustment control is actually a gain control which adjusts preamplifier gain for an output of 150 mV rms, the proper level for application to the matrix networks. The 15-kHz low-pass fil-

plitude needed to drive a phase-lock loop circuit, which is used as the FM demodulator in the system. This type of FM demodulator has many advantages. Among them are low-distortion FM demodulation, ease of tuning (the voltage controlled oscillator is adjusted by means of a single potentiometer—there are no alignment coils, capacitors, etc.), wide-range automatic tracking once the PLL is "locked in" and a minimum of external components required.

In the QSI 5022 hard limiting is used and the ultra-linear PLL circuit has both dc and ac tracking capability. This form of limiting is said to reduce CD-4 cartridge requirements and also eliminates the need for a customer-adjustment of carrier level with changes of cartridge types. Another circuit contained in this block is a "carrier level detector" which is used to mute the Difference-Sub-System (DSS) output in the absence of a carrier signal (when playing stereo or matrix discs). When a carrier is present, the DSS is unmuted and drive is applied to the 4-channel indicator light circuit.

The attack and release time of the muting has been designed to be 600 μ s for mute-to-unmute and 20 μ s for unmute-to-mute. This slow attack and fast release timing is used as a safeguard against abnormal carrier conditions in the disc itself. In the case of high-level stereo and mono records, distortion products can sometimes occur in the passband of the PLL demodulator which might cause disturbing sounds (or flickering of the 4-channel indicator light) if not muted. Additionally, a CD-4 disc may contain high sum-signal interference or low-level, high-noise carrier signal which will cause the system to mute automatically until the carrier is once more satisfactory. Muting is designed with a slow attack time and fast decay so that its action will be inaudible to the listener. In the suggested total circuit for a complete CD-4 demodulator using this IC, a switch is included which can manually override the muting action.

The output from the PLL demodulated FM carrier is fed through a 15-kHz low-pass filter and time delay circuit to the difference sub-system muting circuit. The time delay is adjusted to match the demodulated sub-carrier audio signal with the main channel sum-signal for proper phase relationships. The feedback network around the DSS mute circuit provides proper FM/PM/FM de-emphasis. 0 dB output level of the muting circuit is 150 mV, exactly matching the level of the sum-signal which had been previously set by means of the separation adjustment control discussed earlier.

The difference signal ($L_f - L_b$ or $R_f - R_b$) is next fed to the expander cir-

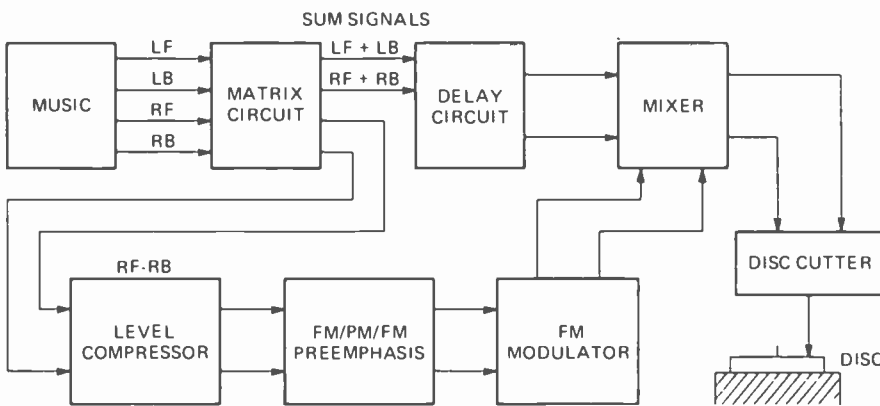


FIG. 2—SIMPLIFIED BLOCK DIAGRAM OF CD-4 disc encoding and cutting.

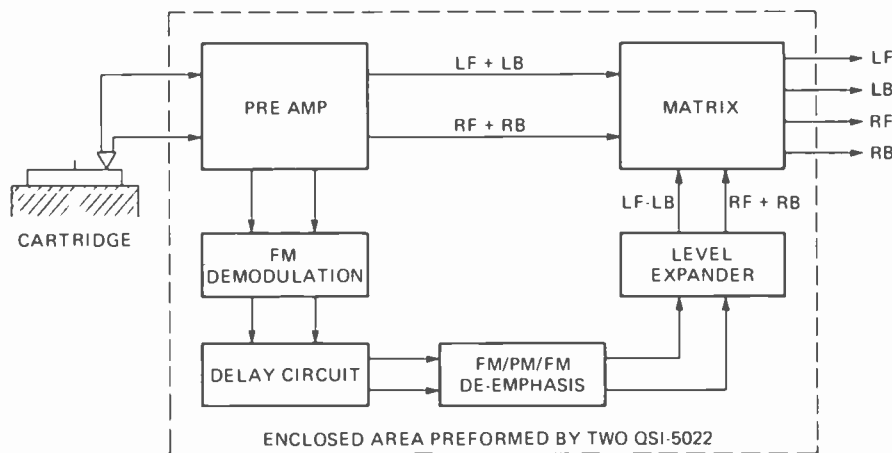


FIG. 3—DEMODULATOR BLOCK DIAGRAM shows steps needed for recovery of four independent signals.

types do not require the usual RIAA equalization, they do require a biasing current, which is supplied through a resistive voltage divider network, external to the IC itself. Switch S1, in addition to connecting this bias current to the cartridge in the SEM position, also selects a flat feedback network for semiconductor cartridges or an RIAA feedback network around the preamplifier for magnetic cartridge use. The preamplifier section has two outputs, equal in level but differing in phase by 180°. The 180° output of the preamp is used for semiconductor cartridge playback on the left side of the CD-4 decoder. (Only one side of the circuit is shown in Fig. 4—the other side is identical except that switching section S1-d is not required and connection is al-

ter (LPF) for carrier rejection between the preamplifier and the matrix network and amplifier has a typical insertion loss of approximately 6 dB, so that the actual output of the preamplifier is set to 300 mV, and since the carrier level is about 20 dB below that, a carrier level of approximately 20 mV is produced at the output of the preamplifier.

The block labelled "carrier demodulator" really consists of several circuits. After the 30-kHz carrier signal is amplified by the preamplifier (as part of the total composite signal), it is fed through a bandpass filter (BPF) having cutoff frequencies of 18 kHz and 45 kHz and then into the input of a "hard limiter" circuit. The limiter amplifies and limits the carrier to the proper am-

cuits which operate in two regions of the audio spectrum, centered at about 630 Hz and 10 kHz. The expansion that takes place is the inverse of the compression used in the encoding of the CD-4 disc. The output of the expander is, therefore, the difference between the front and back of one side of a 4-channel system.

The matrix amplifiers recombine the difference-signal and the sum-signal to produce the original front and back signals of one half of a CD-4 program. Output level at each output is approximately 300 mV rms at 0 dB recording level. A stereo signal, when played through the circuit, will produce an output of 150 mV rms. The output am-

Insertion loss no greater than 10 dB is specified. While it would appear at first glance that a less costly *high-pass* filter might be used in place of the bandpass filter, this approach is not recommended by the manufacturers of the IC because of the additional noise that would then be fed into the limiter and phase-lock-loop circuits.

The low-pass filter can also be a passive LC type or an active filter. The cutoff frequency should be set to 15 kHz and the attenuation slope should be such that at 30-kHz response from the filter is down at least 45 dB compared with output obtained within its passband. Attenuation at 30 kHz should be at least 35 dB and the rec-

the limiter and PLL circuits depends on the external components used, but is generally around 10 μ s. In the complete schematic of a typical CD-4 demodulator presented in the manual published by QSI, filter blocks manufactured by Matsushita Electric were used and these were chosen to meet the above requirements so that the use of additional external delay filters was not necessary.

In discussing this new IC with one of the engineers from QSI, we learned that samples will be available as of April, 1974 and we know from speaking to other high-fidelity component manufacturers that such samples will be eagerly gobbled up for use in the labs of many hi-fi companies as they attempt to incorporate the new device in their quadriphonic receiver and amplifier designs for 1974-5. Those of us who have heard the results obtained from CD-4 discs played through an experimental CD-4 demodulator using two of the new IC's can say, with certainty, that it consistently produces better demodulation and decoding of these discs than earlier demodulators using discrete transistors and components—not because IC's necessarily lead to better results, but because of the careful design and innovations incorporated in this particular IC chip.

A complete circuit diagram showing the hook-up of the new chips in an actual demodulator is shown in Fig. 5, in which the individual circuit blocks contained within the chip are spelled out in greater detail than in the block diagram of Fig. 4. R-E

Ohio Technicians Unite

The Certified Electronic Technicians of Newark, Ohio, was formed as a professional technicians association in January.



OFFICERS OF THE CET A OF NEWARK (not identified by our correspondent) are standing in the rear, visitors and students, sitting in front row.

The first officers of the new association, elected by ballot, are:

Chairman, Donald M. Smith, CET; assistant chairman, Roger N. Hunkins, Associate CET; secretary, Lee Van Horn, Associate CET treasurer James Feasel, CET; certification administrator, James E. Goodman, CET; public relations and code of ethics, Gary W. Coconis, CET.

The new association's purpose is to promote and upgrade the electronic industry in Newark and the surrounding county. R-E

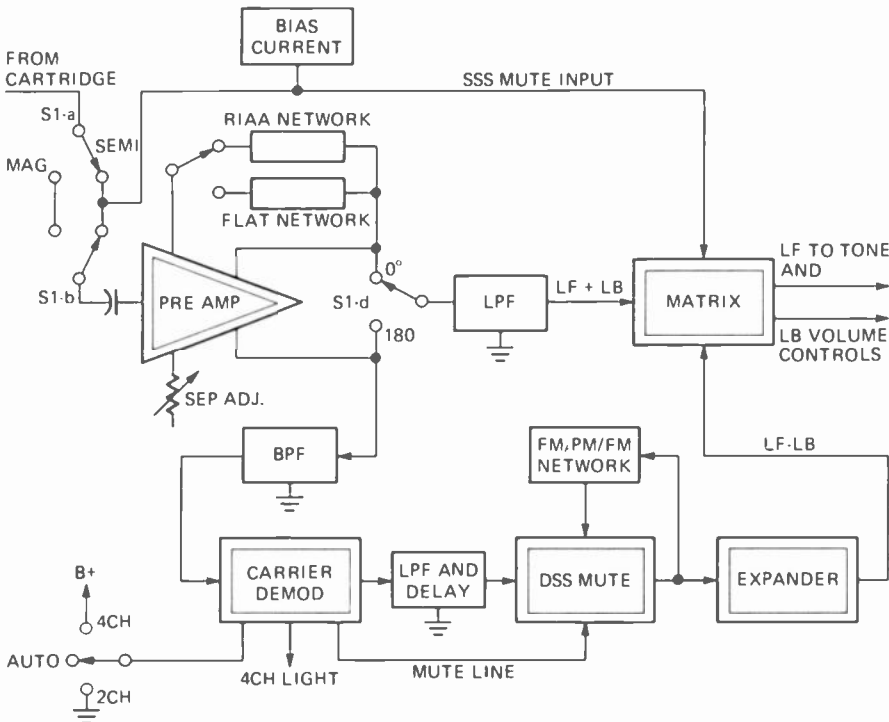


FIG. 4—QSI 5022 CD-4 DEMODULATOR BLOCK DIAGRAM for the left channels. Right side is identical, except S1-d is not used.

plifiers in the matrix block have a low impedance of less than 100 ohms. Using a 13 Vdc supply, maximum output of the IC is greater than 3 volts at each output terminal before significant amounts of distortion are introduced. This provides better than 20 dB "headroom" above 0 dB level of 300 mV nominal output.

External filter requirements

The bandpass filter used in conjunction with this new CD-4 IC can be either passive LC designed or an active filter. Because low-level signals are involved in that part of the circuit, spurious signal and noise pickup via the external filter must be avoided. Recommended cutoff frequencies for this filter are 18 kHz and 46 kHz, and the attenuation at 15 kHz should be at least 15 dB. Filters used must have good phase linearity in their passband region to avoid demodulated signal distortion.

ommended insertion loss should be less than 7 dB. It is also important that the low-pass filter used in the sub-system should be identical in phase and delay characteristics with the low-pass filter used in the difference sub-system.

Normally, the sum-signal on a CD-4 disc has a 40- μ s delay compared with the difference-signal. To make up for this delay, an equal time delay is needed in the difference sub-system of a demodulator. A delay filter can be added after the difference sub-system low-pass filter, or the group delay of the bandpass filter itself can be increased. The two low-pass filters have the same delay times. The bandpass filters have a definite delay and there is generally a delay in the carrier from the sum-signal with most CD-4 cartridges used. All these delays in the difference sub-system must equal the sub-system delay plus 40 μ s to get maximum separation. The delay of the signal through

Understanding MOS Character Generators

Many of the advances in electronic instrumentation are due to developments in read-out technology. Here's how the character generator forms those alphanumeric symbols on Strip Printers and CRT screens

by DON LANCASTER

THERE ARE LOTS OF GOOD LOW-COST ways to display numbers today, ranging from Light Emitting Diode (LED) displays, liquid-crystal readouts, printing wheels, seven-segment neon and fluorescent displays, and many more. Most of these systems can only handle ten or so numerals, plus possibly a few letters that aren't too attractive. What do you do if you want to display the entire alphabet *plus* numerals *plus* punctuation?

Some of the obvious places this need crops up is in the TV Typewriter (*Radio-Electronics*, September 1973), computer terminal displays, deaf communications aides, time and channel number TV presentations, page and strip printers, oscilloscope scale indications, and anywhere else you want to put down a message and can't afford thousands of dollars worth of mechanical or computer-backed equipment.

Your answer is to use one of a family of integrated circuit *dot matrix* character generators. They use MOS technology, ranging from older p-MOS devices through Silicon Gate and n-channel. Cost ranges from \$11 in singles on up, with questionable surplus units available as low as 50¢ each. What are they and what do they do?

Basically, these devices are really a Read Only Memory, or ROM (*Radio-Electronics*, February 1974). They accept a compact computer code called ASCII (more on this in a bit) and convert it into an open code that represents character shapes. Most often, they have to be combined with fairly elaborate system-timing arranged to get the right part of the right character put in the right place at the right time. All but the oldest devices are directly TTL compatible, while the latest n-channel versions work on the same single +5-volt supply the TTL does, and interfaces without any resistors at all. There's just enough difference between character generators that we're not going to show you specific connections—you have to get this from the individual data sheet on your own. Our interest here is the big picture—seeing what these beasts are and where they can be used, who makes them, and so on.

Why dot matrix?

Several years ago, strong arguments could be made for many different ways of generating alphanumeric, including stroke systems, special CRT symbol generators, projection displays, and the *dot matrix* technique where you put down a bunch of

dots to approximate a character shape.

Today, with few exceptions, dot matrix is the only way to go. There are many reasons. Dot-matrix systems take the least in the way of analog circuitry. They interface the simplest with conventional digital memory and logic. They take the fewest interconnections on a system basis. They use low-cost, widely available, off-the-shelf, standard IC's.

More important, they adopt themselves to the format needed by a recurrent sweep (flyback type) TV style display which is much cheaper, generally, than a true X-Y type video display. The same is true of strip printers and advertising displays where you are going to "roll down" a bunch of characters in one direction.

What's wrong with dot matrix? On the debit side, if you don't use enough dots, the characters may not be attractive enough or will cause eyestrain. And if you are into graphics (artwork, lines, schematics, etc. . . .) you're rather limited in what dot matrix can do for you. But right now, no graphics system is low cost (prices start at \$6000), so this really isn't much of a limitation for most alphanumeric applications.

How many dots?

The very first thing we have to decide is how many dots are we going to use in our matrix. Figure 1 shows the letter "R" plotted using matrices of 3x5; 5x5; 5x7; 7x9; and 16x16 dots. Obviously, the more dots we have, the better the character is going to look, and the more the thing is going to cost us in terms of system bandwidth, printhead complexity, interconnections and storage, available characters per line, character writing time, and, of course, dollars.

The 15-dot or "3x5" matrix of Fig. 1-a is normally used only for numbers and an occasional character. Some TV channel and time displays are the only use of this format, and its ugliness limits even that. While no

MOS character generator is widely available that generates a 3x5 matrix, you can easily cut your own using a programmable read-only-memory (PROM) or actually use random logic to do the job if you don't mind a bunch of low-cost IC's and diodes. Ignoring spaces, we have to do three things in the horizontal direction. Let's call them "video units", and five things in the vertical direction, which we'll call "column units".

The number of video units often sets the bandwidth we have to use and limits either the maximum print rate in a page or strip printer, or the number of characters per line for a video display of a given bandwidth. The internal ROM storage we would need for 10 numerals and 6 punctuation units (space, colon, etc. . . .) would be 16x5x3 or 240 bits. With a little bit of creative logic, you could fold this into a standard 256-bit programmable ROM, although a 512-bit one would be much simpler for system timing.

We also normally need some way to keep the numbers we are using. It's obviously easier to store a 4-bit BCD numeral than a 15-dot numeric character, since we only need 4/15 the bits using the compact code. In the case of a strip printer, the storage only has to last from the time the character is received till the time it is printed. With a video display, we have to get the characters back over and over again, once for each scan.

In fact, on a raster-scan system, you need *two* storage systems, one to keep *all* the characters from field to field, and one to keep a *line* of characters for the seven or nine passes in the fast sweep direction it takes to put down everything one dot at a time. With shift register memories, you use two separate ones, while with a random access memory, you use the same memory twice, changing the timing.

In the case of the 3x5 display, we usually need only four bits of storage per character since we are only interested in numbers and

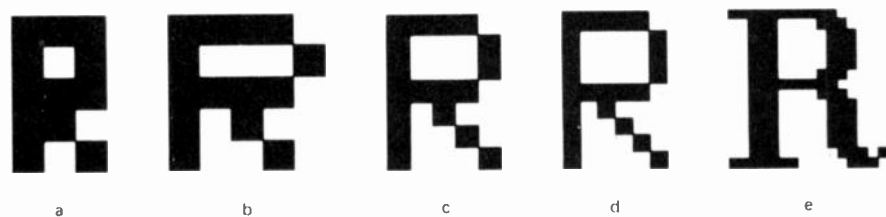
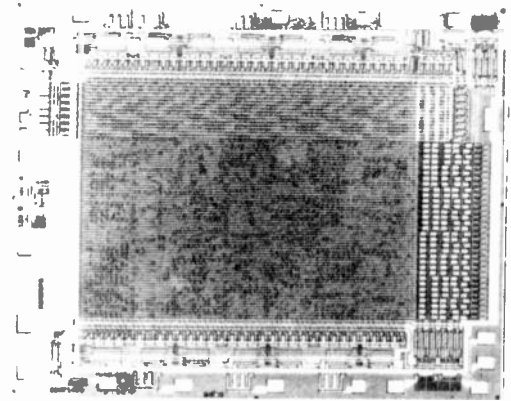
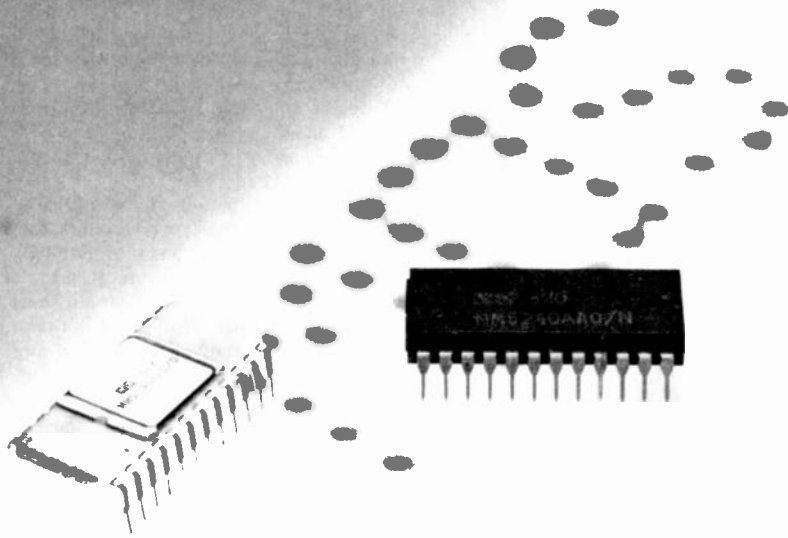


FIG. 1—READABILITY INCREASES as the number of dots or elements in the matrix is increased. Compare the 15-dot 3 x 5 format on the left with the 259-element "R" on the right.



CHARACTER GENERATORS (left) are NS MM5240's. Above is a photomicrograph of the circuit.

a very limited amount of punctuation.

The 5x5 matrix of Fig. 1-b is only slightly better, although you can display the whole upper case alphabet, as well as the numbers. This is used on thermal printers where only 25 printing dots would be needed instead of the 35 of the more standard 5x7 matrix. Five video units are needed horizontally, and five column units are needed vertically. Again, no MOS character generator is widely available for this format, but you can cheat and use a standard 5x7 and have most (but not all!) of the characters turn out OK by dropping the second and sixth horizontal rows.

The standard computer terminal matrix has been the 5x7 one of Fig. 1-c, and lots of standard IC's and interface circuits are available to handle this format. The 5x7 displays to acceptable resolution all the numbers and all the upper case letters and most punctuation. While it *can* display lower case letters and machine commands, it takes special extra IC's and more storage and is not often done. Five video units are needed in the horizontal direction and seven column units are needed vertically. With upper case letters and numbers only, six bits of storage per character are needed externally. The internal storage needed in the character generator is 5x7x64=2240 bits.

The 7x9 matrix of Fig. 1-d presents very attractive characters including lower case, provides for such things as the tail on a lower case "g" and so on. It inherently takes more speed or bandwidth, as seven video units are needed as well as needing more horizontal lines per character. Seven bits of storage per character are usually needed if lower case and machine commands are to be included, while the number of internal character generator bits needed is 7x9x128=8064. One of the penalties you have to pay for the more attractive characters is that the video bandwidth for longer lines of characters becomes far more than what a standard TV can handle. 8 to 12-MHz video is typical, and whatever is displaying the characters must, of course, be able to handle this.

The 16x16 matrix of Fig. 1-e needs incredible bandwidth and storage compared to the other methods, but it allows reasonably faithful reproduction of various printing type fonts, and is useful in larger systems where very attractive characters and long text readability are needed. Phototypesetting and composition systems are typical uses; some of these use even larger matrices

still. The needed storage of 16x16x128=32,768 bits *per font* or typeshape is well beyond what you can do with a single character generator IC at the present time, and several custom units have to be used to share the job.

For most small and simple systems, the 5x7 dot matrix is usually the best choice, with the most widely available circuitry, potential compatibility with unmodified television sets, and lowest cost combined with character shapes acceptable for everything but long text messages.

What code?

We've seen that it's best to store our input character information in the most compact

form possible, instead of the highly redundant 35 bits we'd need for actual storage of an extended 5x7 character. The storage is usually done in a code called ASCII, short for *American Standard for Computer Information Interchange* (see Fig. 2). This is the only code most character generators accept. In some isolated systems, other codes may be in use; but these are usually converted to ASCII with another ROM before character generation.

The full ASCII code consists of *eight* bits. The eighth bit is sometimes used for error indication, and is stripped and possibly used long before it gets near the character generator. This leaves us with seven bits that represent 128 possible different charac-

FIG. 2 THE ASCII OR AMERICAN STANDARD FOR COMPUTER INFORMATION INTERCHANGE.

This code is used as an input for practically all MOS character generators.

BIT NUMBERS														
		0	0	0	0	1	1	1	1					
		0	0	1	0	1	0	1	1					
		0	1	0	1	0	1	0	1					
b7	b6	b5	b4	b3	b2	b1	COLUMN	ROW						
									7					
		0	0	0	0	0	NUL	DLE	SP	0	a	P	\	p
		0	0	0	1	1	SOH	DC1	'	1	A	Q	a	q
		0	0	1	0	0	STX	DC2	"	2	B	R	b	r
		0	0	1	1	0	ETX	DC3	#	3	C	S	c	s
		0	1	0	0	0	EOT	DC4	\$	4	D	T	d	t
		0	1	0	1	1	ENQ	NAK	%	5	E	U	e	u
		0	1	1	0	0	ACK	SYN	8	6	F	V	f	v
		0	1	1	1	0	BEL	ETB	'	7	G	W	g	w
		1	0	0	0	0	BS	CAN	(	8	H	X	h	x
		1	0	0	1	0	HT	EM	)	9	I	Y	i	y
		1	0	1	0	0	LF	SUB	.	.	J	Z	j	z
		1	0	1	1	0	VT	ESC	'	.	K	|	k	{
		1	1	0	0	0	FF	FS	,	.	L	\	l	|
		1	1	0	1	0	CR	GS	-	=	M	|	m	}
		1	1	1	0	0	SO	RS	.	>	N	^	n	~
		1	1	1	1	0	SI	US	,	?	O	-	o	DEL

ASCII-4 (Numbers only) uses only column 3

ASCII-6 (Numbers & Upper Case Alphabet Only) Uses Columns 2, 3, 4 & 5.

ters. These are subdivided into four groups of 32 characters each. One group consists of upper case alphabet. A second consists of numbers and often used punctuation. The third group is made up of lower case alphabet, and the final group consists of *machine commands* that do things like line feed, carriage return, clear, start, stop, etc., but rarely appear in print except when viewing the actual machine programming instructions.

We can use as many bits as we need to provide for a given display. For instance, we could use a code we might call ASCII-4, consisting of only column 3 of the code. This gives us all the numbers with four bits and is identical to the normal BCD code. We also get a colon for the time displays free, along with a ? and some other punctuation. We *don't* get a space for blanking, so this has to worked out some other way. Usually this is easy and no problem.

ASCII-6 is used if we are only interested in the upper case alphabet and numbers and often used punctuation, and takes 6 bits and gives us columns 2, 3, 4 and 5 of the code. It is most often used in the 5 x 7 character generator systems. Finally, we need all seven bits, less the error feature for all upper and lower case alphabets. This is called ASCII-7. Both ASCII-6 and ASCII-7 provide for a blank or space command.

For more information on ASCII, see the Improved ASCII Encoder story, (Radio-Electronics, January 1974).

Some character generators

Our character generator IC has to convert a six or seven bit ASCII character command into 35 or 63 dots on a screen, group of light sources or a piece of paper. Figure 3 shows four possible character generators for the 5 x 7 format.

In Fig. 3-a, we have an IC with some power supply and ground connections, six input lines and 35 output lines. Whenever we put the ASCII command for a "R" on the input, we get a "R" in dot matrix form at the output. This is called a *read only memory* or table lookup code converter and is simply a ROM that has been factory programmed to generate characters. To change characters, change the input code. For a blank, input code 10-0000, and so on.

While this IC would be ideal for scoreboards, you can't buy it because of all the pins. Besides, do we really want all the dots at once, except possibly for scoreboard use? And can we cut down the number of output connections somehow?

For TV raster type use, we only need *one* dot at a time and should be able to get by with only *one* output lead. Now we need two types of inputs. We need six bits worth of code to select the character, and another group of inputs to tell us *which* dot of that character to output. Changing the later group of inputs, called *timing inputs*, generates a sequence of dots that let us produce the whole character one dot at a time. For instance, we could use three lines for a "what column is it?" input command, and three lines for a "what row is it?" input.

This is shown in Fig. 3-b. Now to generate a character, you input the character code and apply timing signals that get the dots out in the proper sequence. In the case of the TV type raster, it rapidly scans in the horizontal direction, and slowly goes vertically, so we put down a burst of dots correspond-

ing to the *top* line of a character, and then go on to the *next* character, and so on, changing the ASCII code as needed. On the next line, when the character we wanted came up again, we'd work on the *second* line worth of dots from our output and so on.

This is a nice IC, but once again, you can't buy it. This time you run into switching speed and settling time problems, along with an internal IC arrangement that would take far too much silicon to be practical. While this is much closer to what we want than Fig. 3-a is, some compromise is needed to make a practical low-cost IC. What can we do?

Real-world character generators appear in Figs 3-c and 3-d. One is called *COLUMNS*

output character generator. One is called a row output character generator. They are **NOT** interchangeable under any circumstances. For any system, you have to pick either a row or a *COLUMNS* device to suit your particular needs.

The row output character generator (Fig. 3-c) has five output lines corresponding to a horizontal row of dots. It has six input lines for the ASCII "What character do we want?" input, and three timing input lines for the "What vertical position of dots are we to generate?" command. Thus, at any instant, you get out *five* dots and "undots" corresponding to a *horizontal* row of a character.

Figure 4 shows how you can convert the

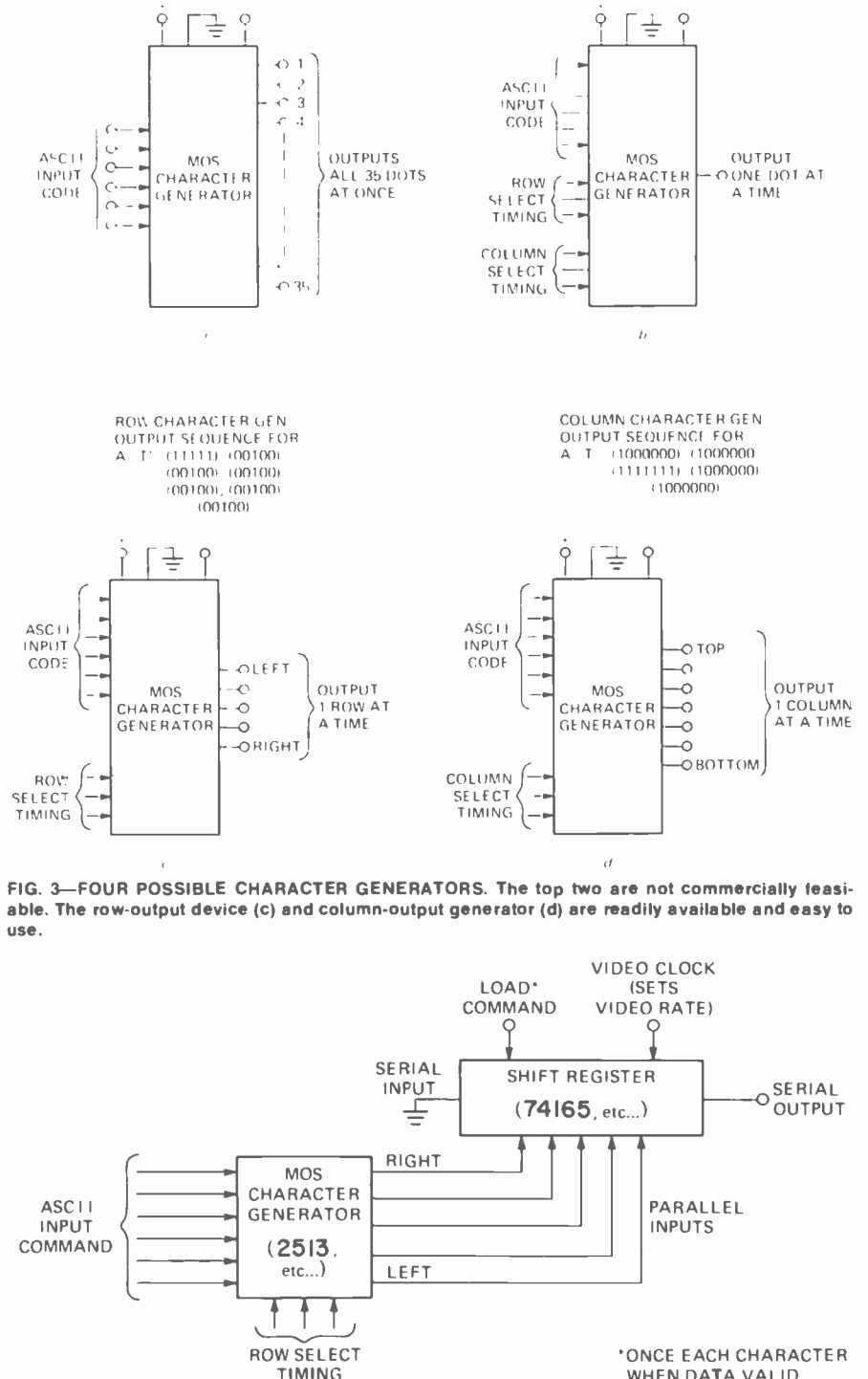


FIG. 3—FOUR POSSIBLE CHARACTER GENERATORS. The top two are not commercially feasible. The row-output device (c) and column-output generator (d) are readily available and easy to use.

FIG. 4—ADD A SHIFT REGISTER to a row-output character generator for high-speed compatible video. This type of device is used in the R-E TV Typewriter.

five outputs to serial horizontal video with an external shift register. On a *load* command, the five outputs are loaded into the shift register. The video clock then marches things out as serial video. By picking our load command timing just right, we sample the character generator after all the answers have settled. This both increases our potential video speed by a factor of five and eliminates glitches and invalid answers. Note that a data selector cannot normally be used in place of the shift register because of these settling and glitching problems.

A row output character generator is ideal for things like TV Typewriters and video terminal displays using television sets or TV like devices that sweep rapidly in the horizontal direction and slowly in the vertical direction.

On the other hand, the *COLUMN* output character generator of Fig. 3-d has seven output lines, corresponding to a vertical column of dots. This time, we have our 6-bit ASCII "What character do you want?" inputs, and three "What horizontal row position do you want?" inputs. By changing the timing signals on the column inputs, we get five sequential dot groupings of seven dots each.

The *COLUMN* output character generator is well suited to a strip printer, where the paper is moving past some sort of print head (pins, thermal, hammer and ribbon, electrostatic, etc. . . .) Seven dots or undots are put down and the paper is shifted 1/5 of a character horizontally and seven more dots or undots are put down, continuing the process five times to generate the final character. *COLUMN* output character generators are also useful for advertising sequential displays, scoreboards, and anywhere else you want the entire height of the character to appear at once, but want to or at least willing to space things out horizontally. They are also sometimes used on specialized video systems with reversed scans; they can not be used on ordinary TV systems.

Remember, for normal TV scans, use a row output character generator, for strip printers, other printing devices, film annotation, advertising displays, etc., use a *COLUMN* output character generator. Do not get the two mixed up.

What's available?

Figure 5 lists some currently popular MOS character generators, while Fig. 6 gives sources of manufacturers and data sheets. The Signetics 2513 (row output—TV) and 2516 (*COLUMN* output—strip printer) are often a good choice in simple low-cost circuits, although their availability has been rather tight recently.

What good are they?

Let's take a quick look, in block diagram form, at some popular character generator applications.

In Fig. 7, we have a single character alphanumeric display. This is handy for keyboard verification, deaf communications, teaching touch typing, remote message signalling, etc. It's intended for use where you want to transmit only a single character at a time. Input signals you need are the ASCII character on six lines, a blanking signal when you want the character to light, and power supplies. You use a 35-dot LFD matrix display such as the

FIG. 5 SOME TYPICAL MOS CHARACTER GENERATORS

Number	Mfg.*	Matrix	Type	Power	Package	Notes
S8866	AMI	5x7	Row	+5, -12	28	
S8564	AMI	5x7	Column	+5, -12	28	
EA3501	EA	5x7	Row	+10, -12	24	
EA3513	EA	5x7	Row	+10, -12	24	lower case only
EA3701	EA	5x7	Column	+10, -12	24	
3257	FAIR	5x7	Column	+5, -12	24	with counter
3258	FAIR	5x7	Row	+5, -12	16	with counter
3260	FAIR	7x9	Column	+5, -12	24	with lower case
1-2240	GI	5x7	Row	+12, -12	24	needs clocks
2561	HARS	5x7	Row	+5, -10	24	needs clocks
MF7107	MSI	7x9	Column	+5, -9	22	
MK2002	MOSK	5x7	Column	+14, -14	24	
MK2302	MOSK	5x7	Row	+5, -12	24	dual output: counter
MK2408	MOSK	5x7	Row	+5, -1w	28	dual output
MCM6571	MOT	7x9	Row	-5	24	with lower case
4240AA	NAT	5x7	Row	-12, -12	24	
2513	SIG	5x7	Row	-5, -5, -12	24	
2516	SIG	5x7	Column	+5, -5, -12	24	
2526	SIG	7x9	Row	+5, -12	24	type CM3490
2526	SIG	7x9	Column	+5, -12	24	type CM3400
TMS2400	TI	5x7	Row	-12, -12	28	
TMS4100	TI	5x7	Column	-12, -12	28	

*See Fig. 6

FIG. 6 MANUFACTURERS OF MOS CHARACTER GENERATORS

AMERICAN MICROSYSTEMS (AMI) 3800 Homestead Road Santa Clara, California, 95051	MOSTEK (MOSK) 1215 West Crosby Road Carrollton, TX, 75006
ELECTRONIC ARRAYS (EA) 501 Ellis Street Mountain View, Calif, 94040	MOTOROLA SEMICONDUCTOR (MOT) Box 20912 Phoenix, Arizona, 85036
FAIRCHILD SEMICONDUCTOR (FAIR) 313 Fairchild Drive Mountain View, Calif, 94040	NATIONAL SEMICONDUCTOR (NAT) 2900 Semiconductor Drive Santa Clara, California, 95051
GENERAL INSTRUMENTS (GI) 600 West John Street Hicksville, NY, 11802	SIGNETICS (SIG) 811 E. Arques Avenue Sunnyvale, Calif., 94086
HARRIS SEMICONDUCTOR (HARS) Box 883 Melbourne, Florida, 32901	TEXAS INSTRUMENTS (TI) Box 5012 Dallas, Texas, 75222
MICROSYSTEMS INTERNATIONAL (MSI) Box 3529 Station C Ottawa, Canada, K1Y4J1	

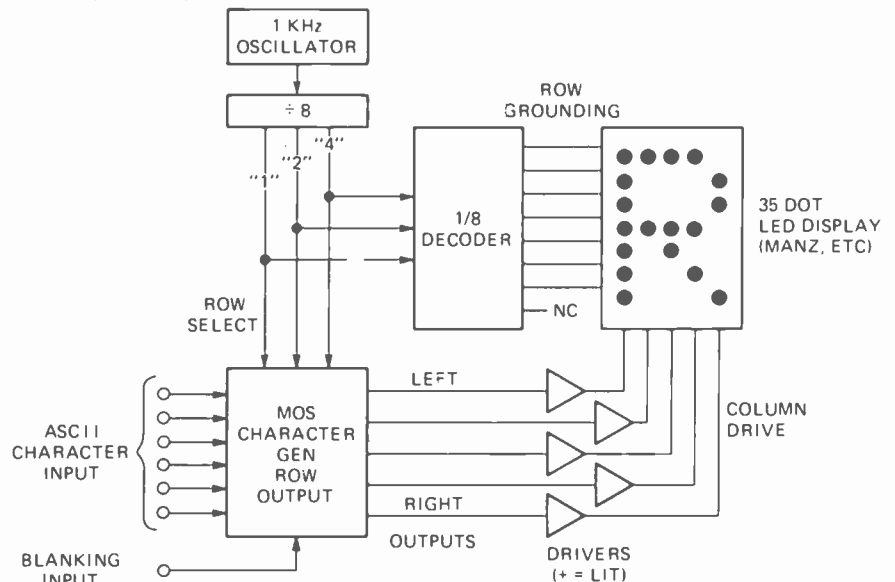


FIG. 7—SINGLE-CHARACTER ALPHANUMERIC DISPLAY. You need one for each unit in the message.

Monsanto MAN-2 as an output. An internal oscillator scans everything much faster than the eye can follow. This is followed by a divide-by-eight counter that sequentially tells the character generator which vertical row of dots to output. At the same time, the counter tells a one-of-eight decoder which bank of five LED's to ground. As the commands to the character generator advance down the character, the respective rows of LED's are also grounded so that at any instant the character generator is putting out the right code to the proper group of five LED's. If you ran things too slowly, the character would start at the top and work its way to the bottom, repeating over and over again. By speeding things up faster than the eye can follow, you see everything as normal brightness and continuously lit. Since any one dot only gets hit one eighth of the time, you run things at eight times normal brightness to make everything come out even.

Figure 8 shows a TV time display that can also be used to put the channel number or any other short (8 unit) message on a TV or an oscilloscope. Complete construction details will appear in the TV Revideo Unit (Radio-Electronics, later this year). Basically, we have the character generator of Fig. 4 (row output driving a shift register serial video converter), along with some added system timing. A four-pole (for numbers) or a six-pole (for everything) data selector of eight positions picks the character you want to display, while system timing selects the proper line number.

In operation, the vertical sync pulse of the TV starts off a delay for vertical position which in turn picks the next whole horizontal line and starts off a horizontal position delay. A video clock of 64 counts is counted out and then shut down, allowing five dots and three spaces per each of the eight character positions. The process repeats for the next seven lines and then shuts down for the rest of the active scan. Adjusting the video clock frequency handles horizontal size, while vertical size can be adjusted in increments, by using one, two or three interlaced horizontal line pairs per character generator address changes.

Figure 9 shows a video display similar to the TV Typewriter (Radio-Electronics, September 1974). Here a MOS memory (either RAM's or shift registers) stores the total number of characters to be put on the screen, often 512 or 1024. Six bits per character are needed for this buffer storage. Note that we receive each character only once, but that we have to get it back seven times on seven sequential lines of each sweep of the TV's field. System timing advances the characters and the "What line is it?" commands in the proper sequence put down one part of a row of characters one scan and then put down the part immediately below on the next scan, and so on.

Note that you can't arbitrarily increase the number of characters per line without something giving somewhere, particularly if you are using an unmodified television set. The two things that get to you are the settling and access time of the character generator and the bandwidth of the TV in use. Let's look at some numbers.

Oversee on many stock TV sets is extreme, so it's not unreasonable to allow one-half of our active scan for retrace and

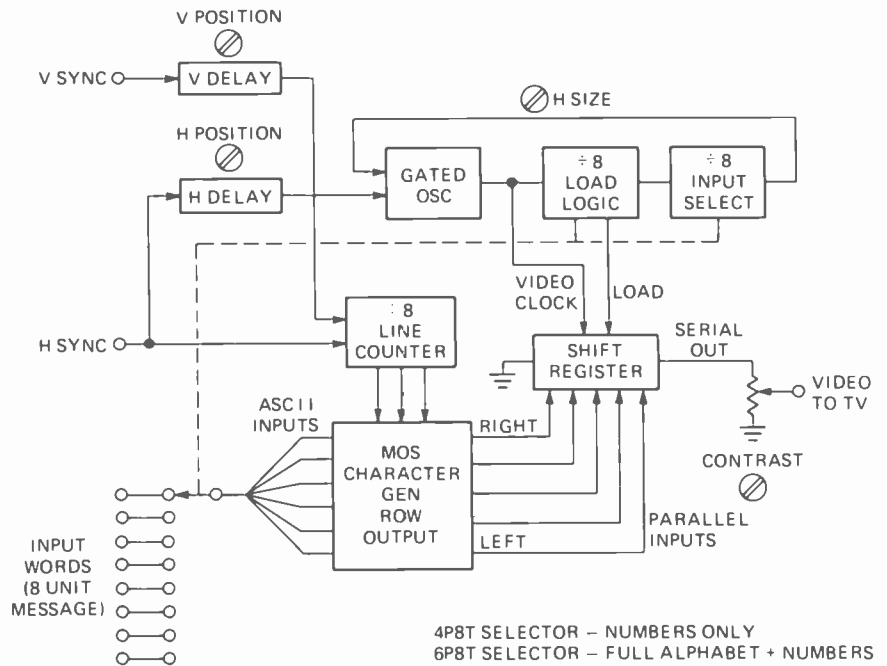


FIG. 8—TV TIME OR CHANNEL DISPLAY uses a character generator, shift register and system timing. A construction article on a device of this type will appear later this year.

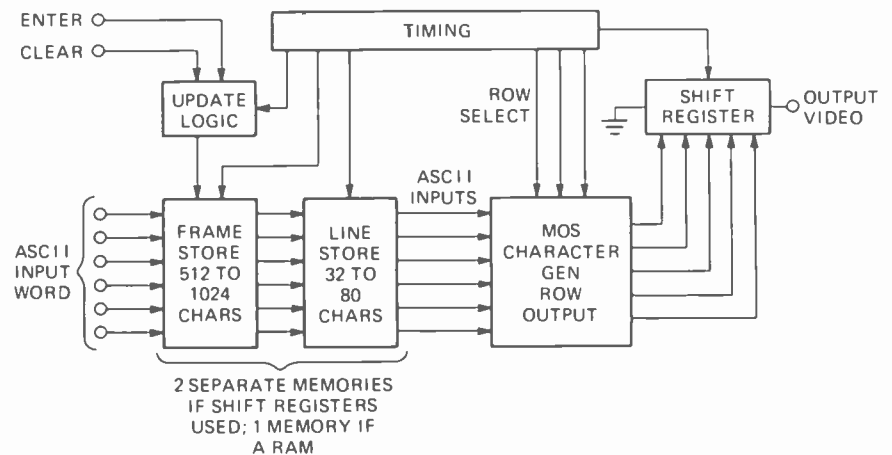


FIG. 9—VIDEO DISPLAY as used in a TV typewriter or a computer terminal. Details on a do-it-yourself video display with keyboard input appeared in September 1973.

positioning. Less than this, and you will almost certainly get into corner problems at the beginning and end of the message. Suppose we use normal TV scanning standards with an interlaced horizontal frequency of 15,750 Hz. This gives us 63.4 μ s of scan time. Cut this in half for an active scan time of 31.7 μ s. To ease the math, call this 32 μ s. Suppose we have 32 characters per line. It takes us 1 μ s per character, so the 500 μ s or so access time of the 2513 generator leaves us with lots of daylight. No problem here. Now, what about the video bandwidth?

We have five active dots, but we can't put the characters beside each other. Suppose we save two dots for spacing. This means there are seven dots in 1 μ s, or a video clocking rate of 7 MHz. With a few crude approximations, a data rate of 7 MHz equals a video rate of one half this or 3.5 MHz.

Now, the video frequency response of a television set is 4.5 MHz for black and white and 6 MHz for color, so this is no problem, right? WRONG. Those are the *i.f. bandwidths!* A black and white set must reject the 4.5-MHz sound subcarrier in its

video, so the best we can hope for is about a 3.5-MHz bandwidth. Color video bandwidth is even LESS, for it has to reject a 3.58-MHz color subcarrier, leaving us only with a 2.5 MHz or so bandwidth. Thus, at 32 characters per line, we can brightly display a black and white image but can only do a color image at somewhat reduced contrast.

But, the computer people use 72 or 80 characters per line. How do they do it? Very simply, by modifying the TV set for direct video entry and extreme bandwidth. An 80-character system takes a bandwidth of 80/32nds of 3.5 MHz or 8.75 MHz. This is why there are very few color displays of long line width. Note that at 72 or 80 characters per second, you are also at the limit of the character generator access time and have to be extremely careful with system timing.

What all these numbers are trying to say is that it's real hard to put more than 32 or 40 characters per line on an unmodified TV, particularly a color one. More than this, and you have to do some modifying. R-E

BUILD

a *NEW* music synthesizer module

You asked for it! An add-on module to provide sine-wave output and a pulse generator with a voltage-variable duty cycle.

by JOHN S. SIMONTON, JR.

WHEN WE FIRST STARTED RUNNING THE Synthesizer a few months ago (see References), we asked for reader comments and suggestions, more to see if anyone was listening than anything else. A number of people were listening and were kind enough to write with suggestions for new modules, some of which will appear in later parts of this series.

This month we'll take a look at a module that will strengthen what some people considered a weak point in the original design of the VCO—lack of a sine-wave output—and at the same time, add a useful capability that isn't even available on most of the high-priced commercial gear: a pulse output with a voltage controllable duty factor.

At the heart of the Sine Converter/Pulse Width Modulator is one of the new quad current differencing National Semiconductor amplifier IC packages. These amplifiers have been pretty thoroughly covered in the technical and hobby press over the last few months, so we won't go into the operating principle of the IC. We'll simply treat it as a little chunk of plastic that contains four relatively high-gain amplifier blocks.

When a triangular waveform is applied to the input of the module, it is buffered and amplified by the first of the gain blocks in the package before being applied to the PWM (pulse-width modulator) and sine shaping circuitry. The trimmer in the input of this first stage (R32, Fig. 1) allows the gain of the stage to be varied to compensate for level differences in the signal source.

The pulse-width modulator is essentially a summing comparator built around the second amplifier in the package. The current produced by the voltage appearing across R20—which is the triangular output of the first amplifier—is added to the sum of the currents produced by the control voltages that appear across R21, R22, and R23. The total current flow into the inverting input is compared to the reference current flowing into the non-inverting input through R25. As long as the reference current is greater than the total current flowing into the inverting input, the output of the amplifier stays high. Resistor values are selected so that the current into the inverting input exceeds the reference current for a small part of each cycle

of the triangle input. This causes the output to switch low, thereby producing a very narrow pulse for zero control voltage. As the control voltages across R21, R22, and R23 begin to rise, the total current into the inverting input of the amplifier increases, causing progressively lower points on the triangle to switch the comparator. The net result is a pulse whose width is proportional to increases in control voltage.

As the comparator switches on and off, it, in turn, switches the third amplifier in the package which inverts the pulse and squares up the rise and fall times. The diodes D6 and D7 serve the dual purpose of clamping the

outputs at about 1 volt, thereby restricting the maximum rise and consequently lessening any slew rate problems, as well as providing biasing current to the inverting inputs of the amplifiers at times that they would otherwise be reverse-biased. (One of the little goodies that the manufacturers of these IC's fail to mention in their literature is that if any of the inverting inputs are allowed to reverse-bias, it fouls up the biasing of the other amplifiers in the package and causes glitches to appear in other outputs.)

Except for biasing requirements peculiar to the Norton circuitry the sine shaper is a classic textbook non-linear feedback type

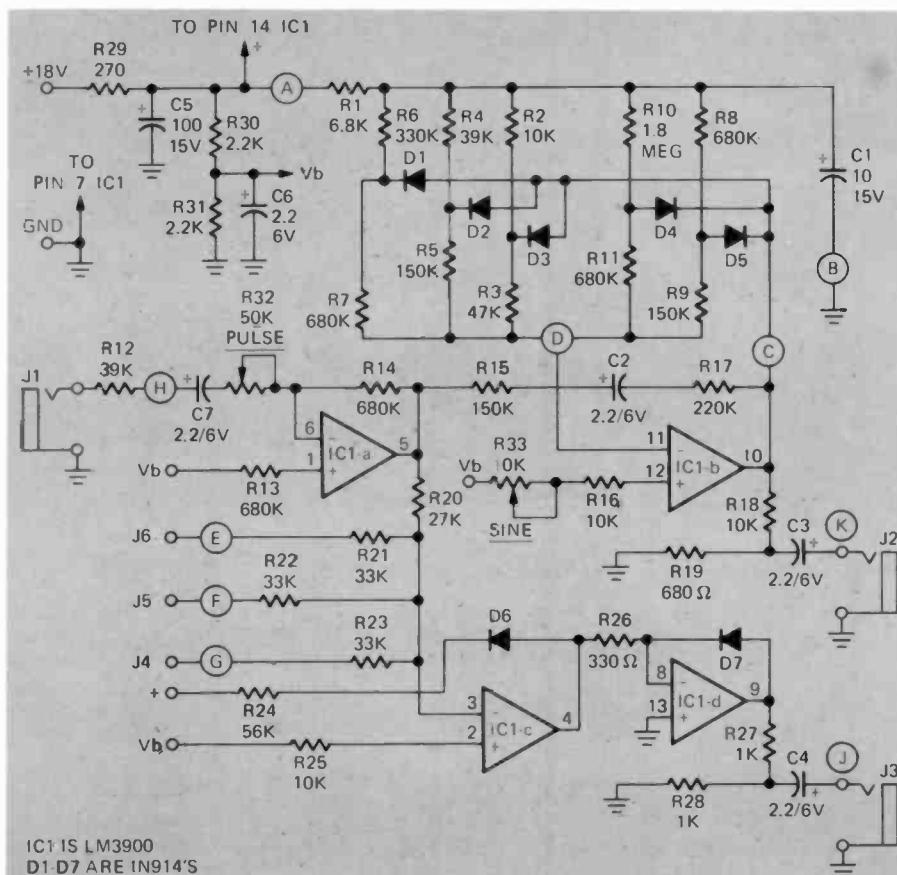


FIG. 1—SCHEMATIC OF THE SINE CONVERTER—PULSE WIDTH MODULATOR.

with diode break points in the feedback loop of the amplifier. Here we approximate a sine-wave with a series of straight line segments as shown in Fig. 2. Assume for a moment that we begin watching the sine converter at a point in time when the triangular output of the first amplifier is ramping down from the mid-point of the waveform. At the mid-point of the waveform, all the diodes in the sine converter (D1-D5) are

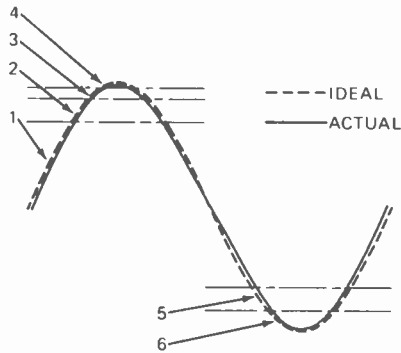


FIG. 2—SINEWAVE APPROXIMATION.

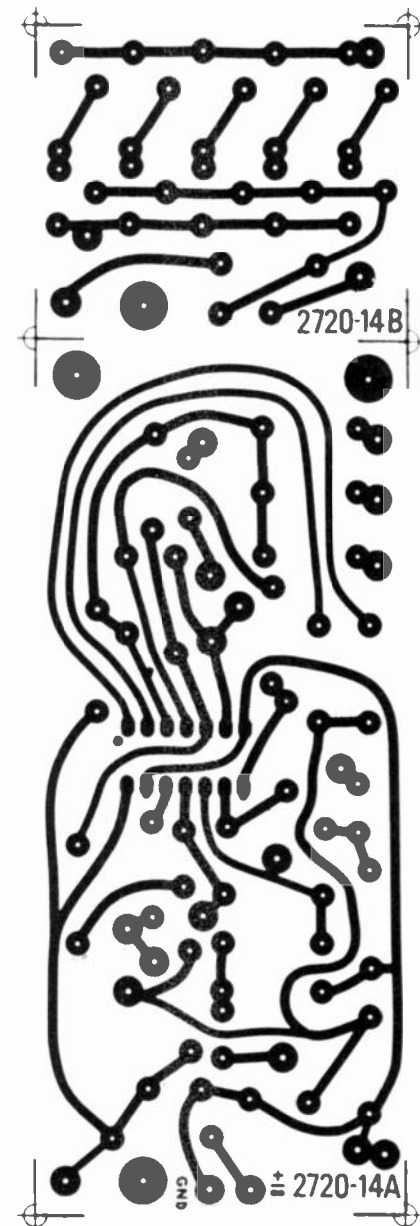
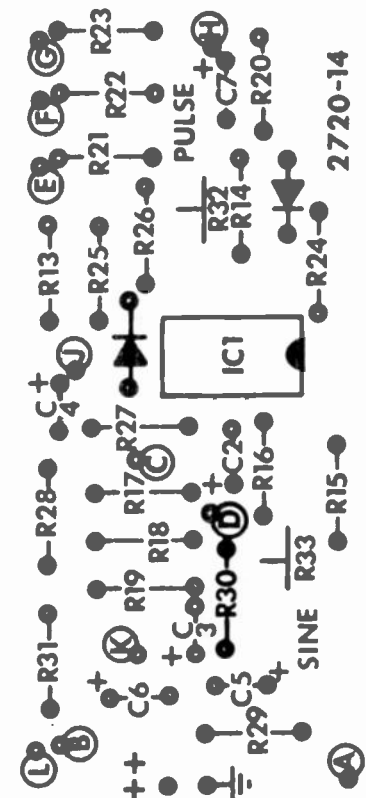
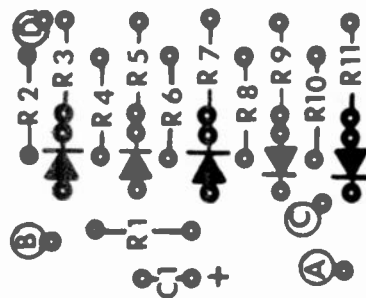


FIG. 3 (left)—FULL-SIZE PATTERNS for the triangle/sine wave converter and variable pulse-width modulator. Keep all parts on one board if you have the room behind your panel. Otherwise, cut the board as indicated. FIG. 4 (right)—HOW PARTS ARE POSITIONED on boards.

reversed-biased so that the only element in the feedback loop is R17. This resistor alone determines the gain of the stage and consequently the rate at which the output voltage of the amplifier increases. This corresponds to line segment 1 in Fig. 2.

Eventually the output voltage reaches the point at which it is greater than the voltage at the junction of the voltage divider consisting of R6 and R7. At this point, diode D1 forward-biases and parallels R7 with R17, resulting in lower gain and a new line segment (segment 2). As the output voltage increases further, it eventually reaches the point at which D2 is forward-biased, thereby paralleling R5 with R7 and R17 and resulting in line segment 3. Finally, D3 forward-biases, adding R3 to the parallel network resulting in the smallest sloped segment, 4. The end of segment 4 corresponds to the highest point on the input waveform.

On the way back down, the diodes are progressively reverse-biased, resulting in the reverse sequence of line segments. As the signal passes through the mid-point and heads lower, D4 and D5 sequentially



forward-bias, resulting in line segments 5 and 6 respectively. Ordinarily there would be a seventh breakpoint, but since the bottom corner of the triangle produced by our VCO is rounded anyway, it is unnecessary in this application.

Assembly

Even though all the active devices are contained in the single integrated circuit package, there is still a lot going on in this circuit and the external resistors and diodes required consume some space. If you're not following our modular construction technique, any method of construction may be used. In the prototype, a standard single width module (2 x 4½-inch panel) was indicated by the input and output jacks, but to fit all of the parts behind this relatively small panel, it was necessary to place the diode breakpoint components on a small auxiliary circuit board mounted above the main board.

Except for the double circuit board approach, assembly is the same as with any other project. Boards may be etched at home, using the full-size patterns shown in Fig. 3, or are available commercially. Parts placement is shown in Fig. 4. Notice in particular that input resistor R12 is not mounted on the circuit board, but rather connects between point H on the board and the hot side of the input jack (J1) on the front panel.

Watch your soldering temperatures on the IC and all the diodes; as with any semiconductor, over-tempering can knock them out. When installing the IC, also be particularly careful about the orientation of the package as it's installed. Putting this device in the circuit backwards will reverse the power

PARTS LIST

C1	—10 μF, 15 V, electrolytic
C2, C3, C4, C6, C7	—2.2 μF, 10V, electrolytic
C5	—100 μF, 15V, electrolytic
D1-D7	—1N914
IC1	—LM33900 quad current dif. amp.
R1	—6800 ohms
R2, R16, R18, R25	—10,000 ohms
R3	—47,000 ohms
R4, R12	—39,000 ohms
R5, R9, R15	—150,000 ohms
R6	—330,000 ohms
R7, R8, R11, R13, R14	—680,000 ohms
R10	—1.8 meg ohms
R17	—220,000 ohms
R19	—680 ohms
R20	—27,000 ohms
R21, R22, R23	—33,000 ohms
R24	—56,000 ohms
R26	—330 ohms
R27, R28	—1000 ohms
R29	—270 ohms
R30, R31	—2200 ohms
All above resistors	½-watt, 10%
R32	—50,000 ohms, trimmer pot
R33	—10,000 ohms, trimmer pot
Misc:	Circuit boards, front panel, wire, "L" brackets (2), 4-40 x ¼-inch screws and nuts (4), No. 4 x ¾ spacer, 4-40 x 1-inch screw, miniature phone jacks (3), etc.
The following is available from PAIA Electronics, Inc., P. O. Box 14359, Oklahoma City, OK 73114:	
Circuit Board only	
No. 2720-14pc	\$4.00 /set postpaid
Complete kit	
No. 2720	\$16.95 postpaid

References, *Electronic Music Synthesizer*
 Part I—Build a Modular Electronic Music Synthesizer, May, 1973, p. 38
 Part II—Build the Control Electronics, June, 1973, page 56
 Part III—Details of Keyboard Construction, July, 1973, p. 46
 Part IV—More Synthesizer Modules, Sept., 1973, p. 53
Using the Synthesizer, Oct., 1973, p. 60

connections to the package and will most likely result in smoke the first time the power is applied. When all the circuit board wiring is complete, solder in place wires long enough to reach from the various input and output points on the board to the front panel connections before proceeding with mechanical assembly.

The smaller board is mounted above the larger board with a 4-40 bolt and 7/8-inch spacer. When wiring these two boards together, you will be better off routing the four wires over the rear edge of the smaller board and then across the larger board to the proper connection points, as indicated in Fig. 5. With all the wiring going over one edge, servicing is simply a matter of "folding" the board off; but with wires going over

second bias source on the power supply can be used to apply a constant voltage to the VCO corresponding to about middle C (1.25v for a properly calibrated VCO).

Turn the adjusting disk of the "pulse" trimmer (R32) fully counterclockwise. There should be no sound from the module at this point. Slowly advance R32 until you first hear the familiar whine of a narrow pulse waveform, then stop.

Disconnect the amplifier from the pulse output of the module and re-connect it to the sine wave output. You should hear a tone at this output, and as the "sine" trimmer R33 is turned, the timbre of the tone should change. Some point in the rotation of this trimmer should produce a tone that is noticeably more mellow than other settings.

If an oscilloscope is available, it can be used to confirm that this setting produces the best sine wave. Figures 6, 7 and 8 show oscilloscope traces corresponding to the sine trimmer being set too far counterclockwise, too far clockwise, and correctly.

Setting the sine wave symmetry may have caused the pulse output to change slightly, so once again connect the pulse output jack to the input of the amplifier. Rotate the "pulse" trimmer R32 counterclockwise until the pulse output stops (if it hasn't already), then advance the control until the pulse can once again just be heard.

Increase the control voltage slowly to about 5, and observe that as the control voltage increases, the sound becomes progressively more "full." A scope may be used to verify that increasing control voltages increase the width of the pulse and that the duty factor of the pulse reaches 50% (square wave) when the control voltage is at $5 (\pm 10\%)$. Similarly, test the other two control voltage control inputs.

As a final test, return the control voltage to ground and listen to the pulse output as the frequency of the VCO is varied over its entire range. If at any frequency the sound of the pulse drops out, advance the "pulse" trimmer slightly until the sound returns.

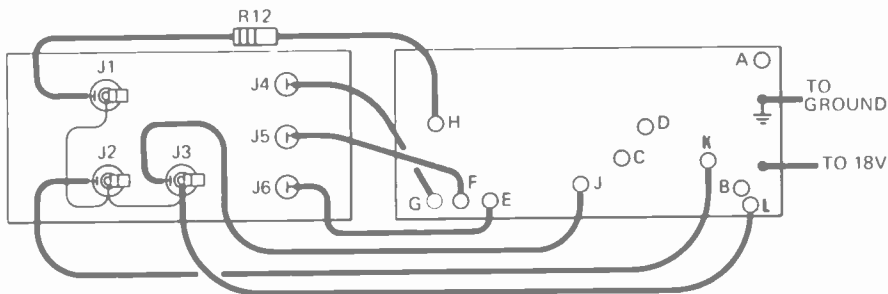
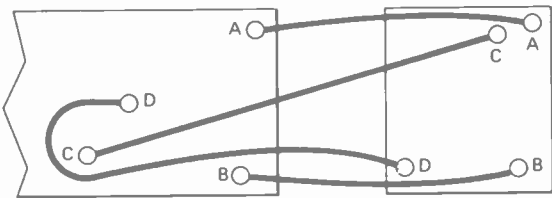


FIG. 5—THE CONNECTIONS BETWEEN main and auxiliary boards, and to front panel.

two edges, the smaller board becomes captive and can't be removed without unsoldering.

The front panel can be made from any convenient material (chrome-plated steel with screen printed designations in the prototype) and is fastened to the circuit board with small "I" brackets and 4-40 hardware.

Testing and calibration

If an oscilloscope is available, you can use it to take a look at the various waveforms as testing and calibration progresses, but it's not necessary. The only equipment you really need is a VOM, the VCO that you're going to use the module with, and an amplifier.

Connect a power source to the connections on the rear edge of the circuit board: "+" to +18V and ground to ground. The synthesizer power supply described in an earlier article is, of course, designed for this, but any power source, including a couple of 9-volt batteries, will do. Jumper the output of the triangle source to the input jack of the module and jumper the pulse output to the high (line) level input of a hi-fi or musical instrument amplifier.

Turn on the power and, this first time out, allow a couple of minutes to stabilize voltages, re-form any electrolytics that may have been stored for some time. Ground one of the Sine PWM module's control voltage inputs by connecting it to the 0 to 5-v bias supply pin jack on the synthesizer power supply and turning the bias source control knob fully counterclockwise. The

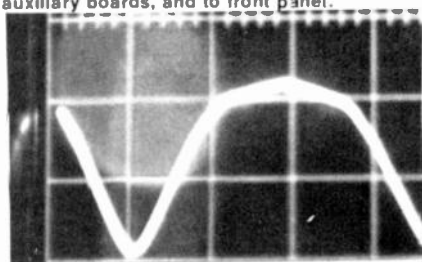


FIG. 6—TRIMMER TOO FAR CLOCKWISE.

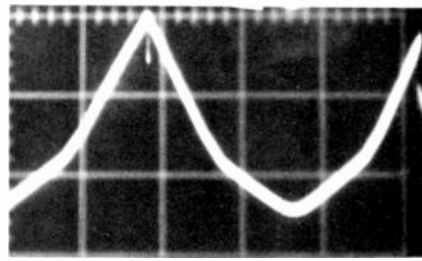


FIG. 7—NOT FAR ENOUGH CLOCKWISE.

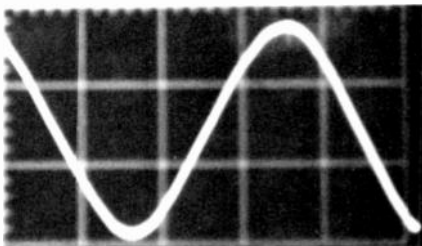


FIG. 8—CORRECT TRIMMER SETTING.

Operation

When using the Sine Converter PWM module, simply think of it as part of the VCO—expanding the versatility of an already present waveform (pulse) and adding a waveform not previously available (sine).

After playing with this module for a while, you may come to feel that a sine wave is not one of the biggie waveforms in electronic music, but it is the only pure tone (if you want to look at it that way) and the sine wave is the basic building block of all sounds. The problem, more than anything, is that it's *too* basic.

Only a couple of natural instruments come even close to producing a sinusoid. The flute is one, and Fig. 9 shows a connection using our synthesizer to produce a flute sound. Attack and decay times of the function generator should be set moderately short to properly simulate the envelope of a natural instrument. Using the controller step output to trigger the function generator provides for sustain as long as a key is held down.

Bass, conga, bongo, tom-tom; any drum that doesn't have provisions for snare produces a damped sinusoid. By using the same connection that produced the flute, we can also produce drum sounds. The difference will be in the function generator; for drum sounds, we need the shortest possible attack and a moderate decay. Whereas the step output of the controller was used for the flute, the proper trigger for drums will be the pulse.

Pulse

There's certainly nothing basic about a rectangular pulse train, and a rectangular pulse train with varying duty factor is about as far from being basic as a synthesizer is from a nose flute.

Probably the first thing you learned after you got through building one-transistor radios was that a square wave contains only odd-order harmonics. You may have even learned that the harmonic structure of a square wave is such that the relative am-

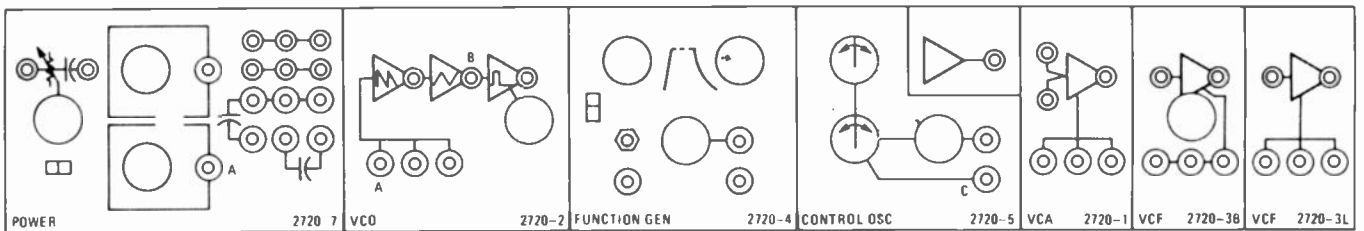
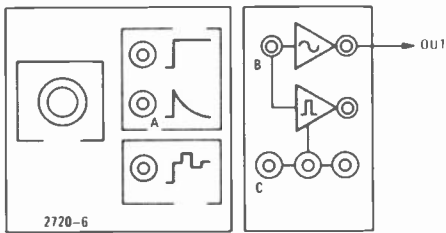


FIG. 9—CONNECTING THE SYNTHESIZER TO PRODUCE A FLUTE SOUND. By changing the attack and decay times, drum sounds can also be produced.



plitude of any given harmonic is the reciprocal of its order number—the third harmonic is 1/3 the magnitude of the fundamental, the fifth is 1/5, seventh is 1/7, and so on. Then, like the rest of us, you probably got in the sloppy habit of calling any repeating rectangular pulse train a square wave, and from there you really got fouled up by thinking that any rectangular pulse train contains only odd harmonics. Not so.

First of all, as the duty factor of a rectangular pulse train decreases below 50%, it no

d.f.	50%	33%	25%	20%	10%
fund	1	1	1	1	1
2nd	—	.5	.71	.81	.95
3rd	.33	—	.33	.54	.87
4th	—	.25	—	.25	.77
5th	.20	.20	.20	—	.65
6th	—	—	.24	.17	.51
7th	.14	.14	.14	.23	.37
8th	—	.12	—	.20	.24
9th	.11	—	.11	.11	.11
10th	—	.10	.14	—	—

Harmonic amplitude for selected duty factor pulses.

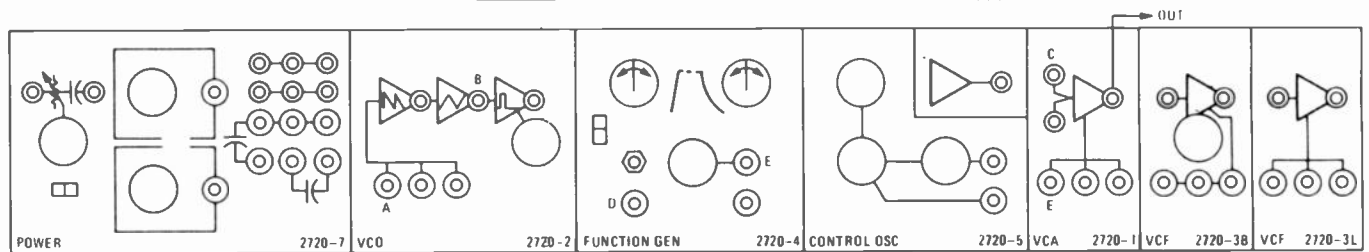
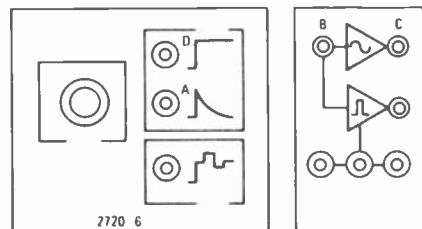


FIG. 10—CONNECTIONS FOR CHANGING PULSE DUTY FACTOR CYCLICLY.



longer contains only odd harmonics. In fact, a string of rectangular pulses with a duty factor of 25% (1/4) has a null in its spectrum at the fourth harmonic and all integral multiples of the fourth harmonic (8th, 12th, 16th, etc.). A 20% (1/5) duty factor rectangular pulse train nulls at the fifth harmonic and all integral multiples of the fifth harmonic. Similarly, a 1/10 duty factor nulls at the 10th harmonic and a 1/100 doesn't null till the 100th harmonic.

While all of these interesting things are happening to the nulled harmonics, an equally interesting thing is happening to the relative amplitudes of the harmonics that are present—they're flattening out. Whereas the first three harmonics of a 25% duty factor rectangular waveform have relative amplitudes of 1.0, 0.71, and 0.33 respectively; the first three harmonics of a 10% duty factor rectangular pulse train are 1.0, 0.95, and 0.87. For the folks that find joy in such things, the first ten harmonics of a variety of selected duty factor rectangular pulse trains

are listed in Table 1. This list doesn't prove a whole lot, but it was prepared by a computer, so it must be worth something.

What we have shown, though, is that while the square wave is generally considered to be a harmonic-rich waveform, a simple thing like reducing its duty factor makes it richer still. This is a handy thing to remember when you're working with band-pass filters, and it's naturally the reason that a filter swept over a narrow pulse produces a much more striking sound than sweeping a broad pulse.

You're probably going to get very excited the first time you use an arrangement such as that in Fig. 10 to cyclicly vary the duty factor of the pulse. This connection produces a very distinctive "phasing" type sound. The reason for this is more mathematical than would be interesting here, but qualitatively it has to do with there being two sinewaves going in and out of phase for each harmonic. If the two sines are exactly in phase, the harmonic is at maximum, and if they're out of phase, the harmonic nulls. As we said, you really have to see the math to believe it—unless, of course, you're listening to it.

One more point really needs to be mentioned before you're turned loose on your own. You will notice that in all these discussions about pulse duty factors, never once have we gone above 50%. That's because there is reciprocity of duty factors that are

equal increments above and below 50%. In other words, a 40% duty factor sounds the same as 60%; 25% the same as 75%, and so on. This is the reason that the duty factor for our maximum system standard control voltage of 5 volts is 50% rather than 100%. If for some reason you decide that you absolutely must have 100% duty factor for a 5-volt control input, you can always apply the 5 volts to two of the control voltage input jacks at the same time. Don't forget the implicit power of control voltage summation.

As a final demonstration of both reciprocity of duty factors and control voltage summation, let's suppose that you're designing a sound that requires the duty factor of the pulse to decrease as the control function to one of the other modules (VCA would be common) is increasing. Your first impulse might be to use some form of inverter to change the positive-going control voltage to a negative-going one. That's one way, but a better way would be to save the inverter for a place where you really need it and simply put a constant 5 volts into one of the PWM control voltage inputs while applying the function to one of the other control inputs. Here you're starting with a duty factor of 50% and increasing it close to 100% as the function increases. Since your ear is unable to tell whether a duty factor is increasing or decreasing from 50%, the effect is the same as starting with a broad pulse and going to a narrow one.

R-E

appliance clinic

PLUG-IN "REFRIGERATOR ANALYZER"

by JACK DARR
SERVICE EDITOR

GENERAL ELECTRIC'S MAJOR APPLIANCE Divi has come up with a real time-saver for refrigerator technicians. "Plug-in test adapters" have been used by electronics technicians for a long time. The best-known are the little socket test adapters, plugged into tube sockets, with the tube in a socket on

top. This makes all terminals easily accessible for measurement, in normal operation.

General Electric's "R-E-D" test unit (*Rapid Electrical Diagnosis*) is a very simple but very useful device. It's just a little "jack-box," with switches, a pilot light, and a pair of cables with 9-pin Molex connectors. All of the late model GE refrigerators are equipped with a plug-socket combination in the main control wiring cable. This is brought out to the front of the cabinet, at the bottom. These are separated, and the R-E-D tester plugged in. This

"fans out" the entire electrical circuitry of the refrigerator. Each lead is brought out to one of the pin jacks, numbered to correspond to the plug terminals. In this condition, all circuits are open.

A pilot light on the panel shows

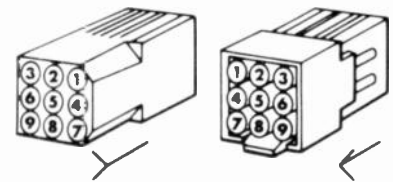
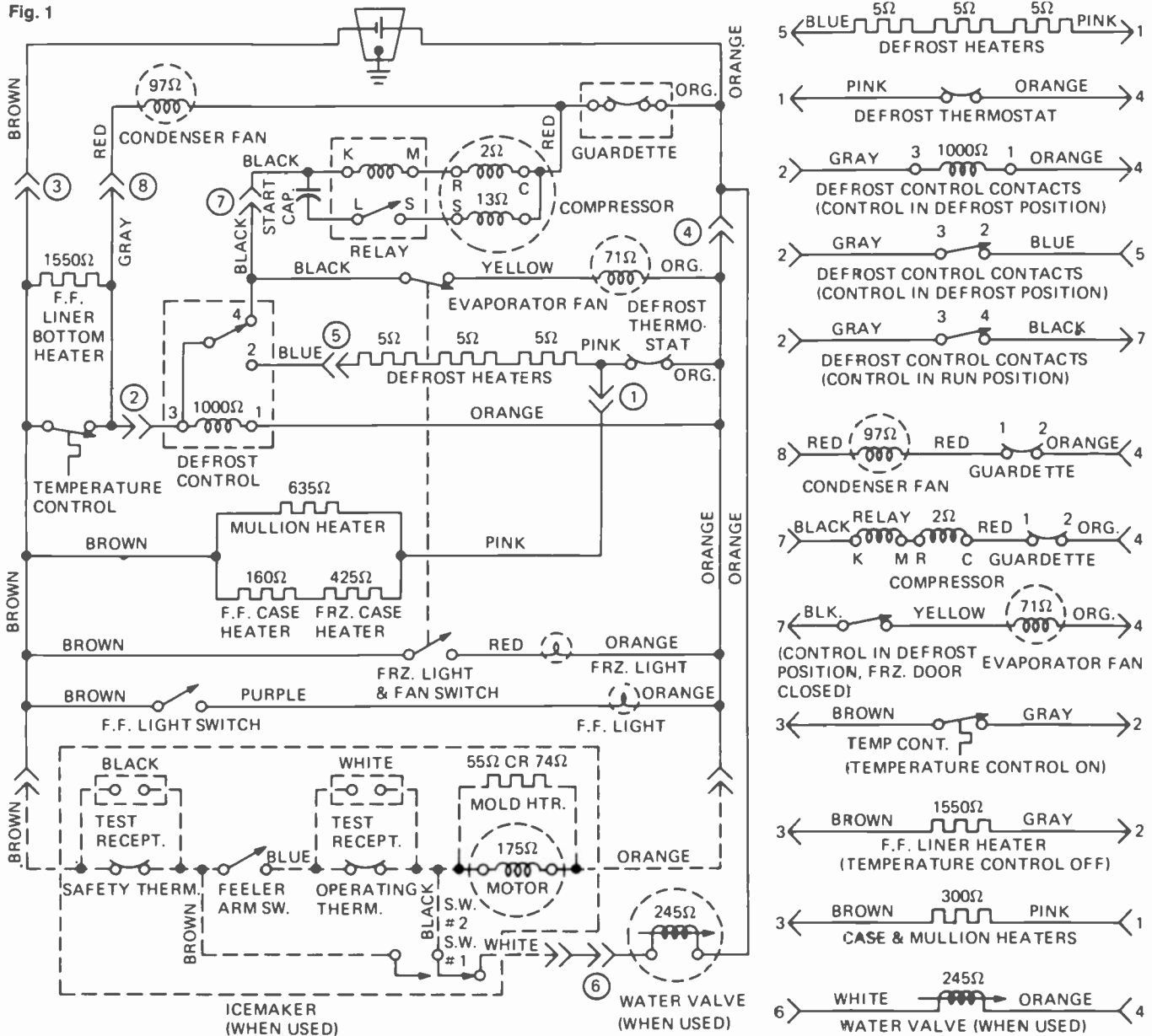


Fig. 1



whether ac power is getting to the unit or not. Power should be turned off, by turning the temperature control off, before the R-E-D unit is plugged in. If the light doesn't light, the house fuse may be open, there may be a loose lead in the cable, or the line plug may have been pulled from the outlet. The line voltage can be read at terminals 3 and 4. A schematic of the test unit is in Fig. 1.

At the bottom of the panel (see photograph), a dpst switch has its four terminals brought out to test leads with pin plugs. By plugging these into the jacks, any switch contact in the entire refrigerator can be tested. For example, if the compressor won't run, the



THE REFRIGERATOR ANALYZER checks the refrigerator's controls and components through connectors behind a bottom-front panel. Test leads are for ohmmeter resistance checks.

switch is connected to No. 3 and No. 7. Both switches are pushed; if the compressor is OK, it will run. The upper switch applies the ac power.

If the compressor does not run, the motor windings are tested by reading their resistance across the proper jacks. These can be instantly identified by checking the service manual. Figure 2 is a schematic of a typical refrigerator. Alongside it are the various parts, showing the pin numbers used in the cable. These correspond to the numbering on the R-E-D unit panel.

Ohmmeter tests can be made on switch contacts, thermostats, motor windings, heating elements, and electric valve solenoids. The normal resistance of each will be shown in the service manual. Just to make assurance doubly sure, a test resistor of 100 ohms is included in the R-E-D unit, across the two jacks seen at the bottom of the panel. These are marked **METER TEST**. This unit can save a great deal of

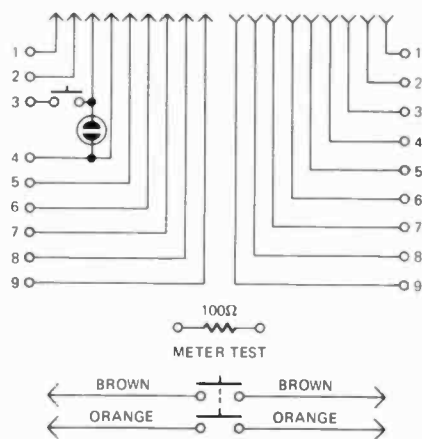


FIG. 1—SCHEMATIC of G-E refrigerator analyzer.

time, especially in making accurate tests of units that would otherwise take a lot of time and disassembly to get at. Defrost thermostats, heating elements, and many others are hard to locate. You can operate most of them by connecting the lower switch into the circuits; defrost heaters, and such things, can be turned on and off, and checked, without having to wait until the box has cooled down or warmed up enough to make them turn on normally.

This unit will check everything except the little light inside the box! However, if you have a very small helper, this is easy. Just shut him up inside the box, and he can tell. Otherwise follow standard service procedures (Take the old bulb out and put in a new one. Complicated, eh?). A real time-saver, and well worth the nominal cost.

Thanks to GE's Major Appliance Division for the data, and to Robinair Mfg. Co. for the photo. **R-E**

EQUIPMENT REPORT

(continued from page 26)

The powerline is stepped down by a transformer and is rectified and filtered to 6 volts dc, which is fed in place of the battery pack. As far as the recorder is concerned it can't distinguish between the battery and ac power source. In this manner the TC-152SD's performance remains hi-fi regardless of the power source.

Performance plus

The limiting amplifier cuts in cleanly only when record levels attempt to exceed the meter indicated +3 VU (or dB), which represents approximate tape saturation. In a typical field application where the operator is too busy to keep track of the record level, the limiter protects against excessive distortion caused by sudden high sound levels.

Two typical applications illustrate the Sony's notably good performance. In the first instance we tested the machine using ordinary "normal" tape — TDK-SD, without the Dolby for noise reduction. In the second instance we checked the machine's total hi-fi capacity by using Memorex chromdioxide tape with the Dolby active.

The overall record/play frequency response from the non-Dolby TDK-SD tape measured +1/-3 dB from 32 to 11 kHz with a 50 dB signal to noise ratio referenced to the 0-VU record level. The distortion at 0-VU record level was 1.3% THD, with about 3 dB headroom to tape saturation.

Using the chromium-dioxide tape with the Dolby active, the record/play frequency response measured ±3 dB from 32 to 15 kHz with a Dolbyized signal to noise ratio of 60 dB narrow-bandwidth. Distortion at the meter indicated 0-VU record level was 2.5% THD.

Of special note, the wow and flutter — from batteries, yet — was 0.18%.

In short, the overall performance of the TC-152SD, using either ac or battery power source, is what we expect to find the highest quality cassette recorders — those specifically touted as "high fidelity models". While the term *breakthrough* has been so misused we tend to distrust its application to electronic equipments, the battery-powered performance of the TC-152SD is a true breakthrough in every sense of its meaning, for until the TC-152SD there just wasn't any portable cassette of true high-fidelity quality or performance.

The Sony TC-152SD includes a set of batteries, ac power cord, line output connecting cords and a detachable shoulder strap. Optional equipment includes microphone, a mixer, rechargeable battery pack, car battery cord and a carrying case. **R-E**



I hope you realize because of you some poor housewife is not going to know how the world turns today!

GUITAR PREAMP

(continued from page 43)

the same function for the ac outlet located on the bottom panel of the preamp.

Fuse: The fuse holder located on the front of the preamp fuses both the preamp's power transformer as well as whatever is connected to the ac outlet located on the bottom panel of the preamp. This means that if a power amplifier is plugged into the ac outlet on the bottom panel, the fuse must be large enough to handle both the preamp's current (about 0.25 A) and the power amplifier's current which is dependent upon which power amplifier is used. A 3 A standard fuse has been specified for the preamp which is sufficient for most power amplifiers and should not be increased beyond the rating of the power switch.

Output: Two output jacks are provided on the unit. One is on the front panel while the other is on the bottom. They may be used to drive more than one power amplifier as long as the paralleled load is no less than 5K.

The guitar preamp has been designed as an independent unit and should work well with any power amplifier that does not require more than 2 volts rms for full output. Since the preamp has been packaged by itself, I recommend that you mount the power amplifier in the speaker cabinet or place it somewhere between the preamp and speaker. Do not place the preamp and power amplifier one on top of each other or side by side without first checking for increased hum pickup. The large power transformer on power amplifiers radiate 60-Hz hum that will be picked up and amplified if placed too close to the preamp.

If desired, a set of the long reverb springs can be mounted on the lower shelf of the preamp cabinet. Keep the springs as close to the left side of the cabinet as possible. There are two 1/2" holes in the bottom panel of the chassis through which the wires can pass. Use shielded cable on these wires rather

than the twisted pair used on the springs inside the chassis.

When connecting the output of the preamp to the input of the power amplifier, be sure to use high-quality shielded cable. This is especially important if the connecting cable is more than a few feet in length. Of course, shielded cable must also be used between the instrument and the input to the preamp.

To minimize hum pickup and string popping, the unit is provided with a center-off line reversing switch. Operate the unit in the position which produces the least noise. **Note also that you can receive an electrical shock by touching anything connected to the unit's chassis ground while either standing on or coming into contact with any well grounded surface if the ac reversing switch is in the high-hum/high-noise position.**

When using the preamp, try to avoid making volume corrections with the guitar's volume control. It is best to operate your guitar with its volume control wide open and to use the volume control on the preamp to set the actual output level. If your guitar has a very high output, it may be necessary to use the B input to keep from overdriving the input of the preamplifier.

How it works

The guitar output is fed into either input A or B with the B input providing about a 9-dB cut in the input signal level. The signal is amplified by IC2-a at a gain dependent upon the drain-to-source resistance of field effect transistor Q3. Trimmer resistor R17 sets Q3's dc gate bias through IC1-b for a drain-to-source resistance of about 1K. IC1-a is the phase-shift oscillator used in the tremolo circuit. Its output is summed along with part of the drain signal from transistor Q3 in IC1-b which in turn drives the gate of Q3.

The tremolo circuit varies the drain-to-source resistance of Q3 and thus causes the gain of input amplifier IC2-a to vary with the frequency of the tremolo oscillator, thus

creating the tremolo effect. The feedback connection of IC1-b to the drain of FET Q3 helps to eliminate the distortion generally encountered in FET voltage variable resistor circuits of this type. The output of IC2-a feeds the inputs of the low- and high-pass active filters composed of IC3-a and IC2-b respectively.

THE LOW MIDDLE control R4 and HIGH MIDDLE control R5 set the passbands for each of the two filter circuits while the outputs of the filters are then summed in proportions determined by EMPHASIS control R2 and amplified by IC3-b. The circuitry between the output of IC3-b and the input of IC4-a is a conventional passive bass and treble-boost circuit with BASS control R3 and TREBLE control R6 setting the boost anywhere from zero to around 20 dB. Amplifier IC4-a makes up for the signal attenuation in the tone control circuit and drives VOLUME control R1. Part of the signal from the wiper of the VOLUME control is then fed to the output of summing amplifier IC5-b, while the other part is fed to reverb driver amplifier IC4-b. Amplifier IC5-a boosts the delayed output from the reverb springs which is also fed to output summing amplifier IC5-b, after passing through the REVERB level control R9. Resistor R47 and capacitor C25 protect the output of the preamp should anything other than a power amplifier input ever be plugged into it. It will also help protect the power amplifier should the preamp fail.

The power supply for the circuit consists of a conventional full-wave rectifier that provides both a positive and negative 15 volts with respect to ground. Power line reversing switch S1 and capacitor C32 help prevent a pop when the power switch is flipped to the off position. Transistors Q1 and Q2 are used as series regulator transistors while Zener diodes D5 and D6 limit the output of IC5, as well as help reduce turn-on and turn-off transients generated in the early stages of the preamp. **R-E**

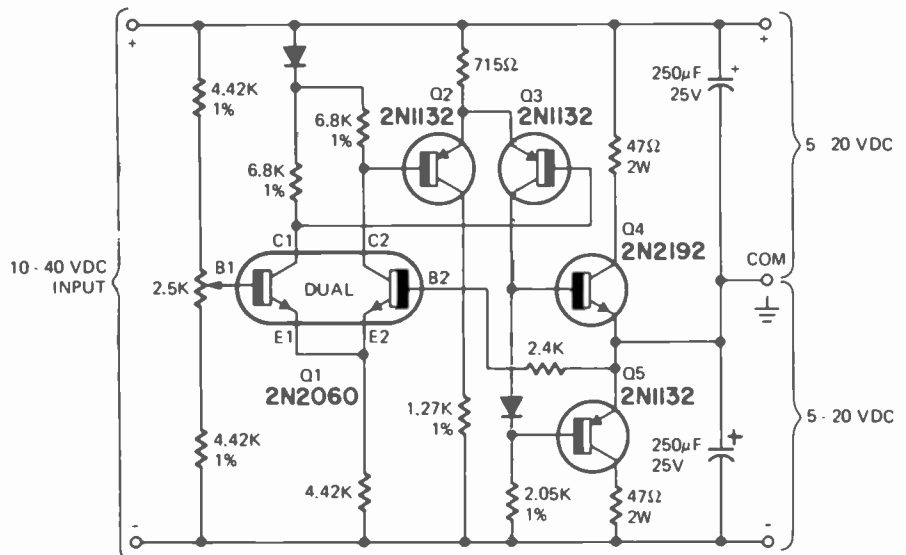
POWER SUPPLY SPLITTER FOR DUAL VOLTAGES

When working with linear IC's you usually need a power supply that delivers equal positive and negative voltages. This circuit solves the dual-supply problem. It is a splitter that operates with inputs ranging from 10 to 40 volts dc. When balanced, the output ranges from + and - 5 volts to + and - 20 volts. One-percent resistors are indicated on the diagram. You may use the nearest 5% values shown in the table.

To calibrate the output, connect two equal resistors in series across the plus and minus output and then connect a tvn or similar meter between their junction and the common terminal. This forms a bridge nulling circuit. Adjust the 2.5K pot for zero volts on the meter.

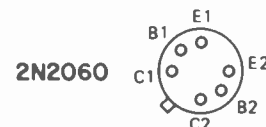
The splitter handles the difference current between the plus and minus loads so current through Q4 and Q5 is fairly low. When unbalanced operation is required, one of the output transistors carries more current than the other. Good heatsinking is required.

—Poly-Paks Engineering Department



1%	5%
4.42K	
1.27K	1.2K
2.05K	2K
715Ω	750Ω
6.8K	6.8K
2.4K	2.4K

NOTE: DIODES ARE SILICONS.
ALL RESISTORS 1/4W
UNLESS OTHERWISE NOTED.



Step-by-step TV Troubleshooters Guide

The absence of a raster on a color TV set can be caused by several circuit defects. Use this logical approach to quick and easy servicing.

by EUGENE CUNNINGHAM

IF YOU TURN A COLOR TV ON, and see no raster at all, you naturally think first of a loss of the high voltage. This is right; this is the most common cause of a loss of raster. There are others; aren't there always? Suppose you check for high voltage, and find it is normal, but there is no raster at all. Or: the high voltage comes up, and then the raster shrinks (or blooms) dims, and goes out. What do you do? Is this really a high-voltage supply problem, or something else? The right tests will show you.

How it works

The "picture" in all color TV sets, is actually *two* pictures. One is black and white, the other colors. The signal is separated, then recombined in a matrix (which just means "mixer") before it is fed to the picture tube. In the original circuit, these signals go through completely different paths. The mixing is done in the picture tube itself. Black and white (video, for short) goes to the cathodes, and colors to the grids. Even in the later "RGB" circuits, where all signals are fed to the cathodes, the two are separated first, and then matrixed in the combined color/video amplifiers.

If you have a very good black and white picture, no color at all, the trouble must lie in a circuit which handles only color signals. If the picture is pale, weak, and odd-looking, you've lost the video and are seeing only the colors. Go to the video amplifier circuits; one or the other will be open; the signal path is broken.

Both video and color amplifier circuits are directly coupled to the picture tube cathodes and grids; so, they control the dc bias on the picture tube. There are troubles which can cause a complete loss of the raster; these can lead you to a false conclusion of high-voltage trouble. If the high voltage is normal, high or quite low, this can be due to some problem in the picture tube bias circuitry! In this article, we aren't going to deal with any signal problems; this is strictly about the *dc voltages* at the picture tube base, and their effect on the high voltage.

Why is this? Simple. The high-voltage supply in the typical color TV set, has a limited output. Its maximum current capability will be only a few *milli-amperes*. Normal maximum beam current for the picture tube is about 1500 μ A for all three guns. If the picture tube is biased into excessive conduction, the high-voltage supply can be so badly overloaded that the voltage drops drastically, or even disappears completely! That's one.

You can have an exactly *opposite* bias problem, of course. In this case, the tube will be biased far beyond *cut-off*, so that no beam current can flow. This, too will black out the raster. The one thing that will help more than anything else, in such cases, is to remember that big and complex as it is, the picture tube is still just a big, fat *vacuum tube*, and so obeys all of the laws that govern every vacuum tube.

Just for a brush-up, let's see ones we need. One, grid voltage. If the grid voltage of a tube is made far more negative than it should be, with respect to the cathode, the plate current will be cut off. (Always remember that this "grid voltage" means "dc voltage with respect to the tube's own cathode". The voltage to ground is not important; it is the *difference* between grid and cathode that counts.)

Two; in this circuit, if the cathode voltage is made far too positive, this means that the grid is too far negative. Here, *both* voltages are variable. It's still only the difference between the two that counts.

Figure 1 shows a typical circuit, with dc voltages close to those you'll find in color TV sets. Cathodes around +300 volts, control grids around +200 volts. Grids are thus -100 volts to the cathodes. This sounds like a high negative voltage, but remember that 25,000 volts "plate voltage"!

These dc voltages are the ones found on the schematic. They're taken with the brightness control set for an average-brightness raster. The actual cutoff voltage of this tube depends on the setting of the three screen grid controls. The higher the screen voltage,

the more negative voltage will be needed to cut off the beam current. Average screen voltage will be around +600-700 volts.

Double variations.

This circuit is slightly unusual (compared to a stock tetrode circuit) in that *both* cathode and grid voltages are variable. The signal makes them vary, to control the tube; however, the circuitry used between the video and color amp-

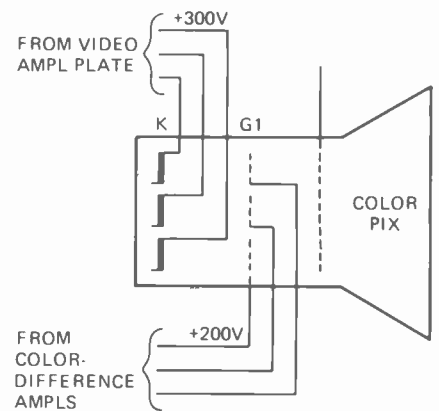


FIG. 1—TYPICAL VOLTAGES on the cathodes and control grids of a color picture tube. Grids average 100 volts lower than cathodes.

lifiers, and the picture tube itself, is *direct-coupled*. So, the dc voltages on the tube will be determined by conditions in the *amplifier stages*. Fig. 2 shows the basic circuit of this.

The plate voltage of the video output tube sets the cathode voltages of the picture tube. These are all tied together, effectively, so that the video signal controls all of them at once. The three grids are controlled by the plate voltages of the three color-difference amplifier tubes. In "action", these are driven by the color signals from the demodulators. The red and blue directly, the green being derived from the matrix action in the common cathode resistor.

So: here we have circuits which can vary both grid and cathode voltages. Once again, this does *not* have anything to do with signals; what we're interested in now is the "static" or dc

voltage conditions which could black out the raster. Defects in tubes, resistors, etc in either of them can upset the picture tube bias.

This leads us to some facts, and some "typical reactions". Remember these: they'll help you to get to the cause of the trouble a lot faster. One:

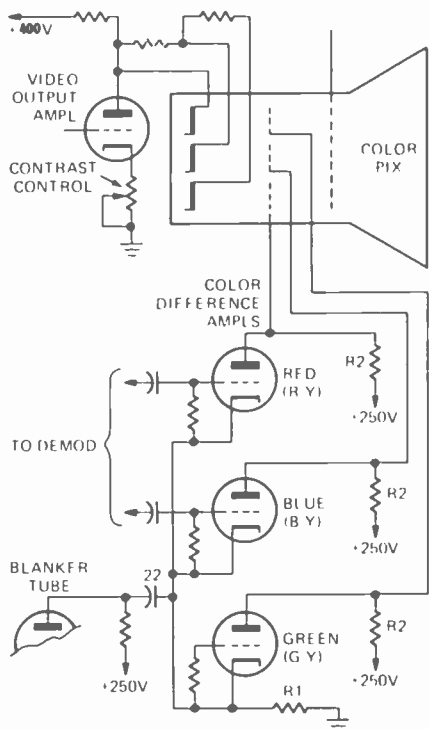


FIG. 2—BIAS ON THE CONTROL GRIDS is determined by the instantaneous plate voltages of the color-difference amplifiers.

any problems in the video circuit will affect the whole raster. This dc voltage controls all three cathodes at once, since they're effectively tied together. A shift of cathode voltage (grid remaining the same) will have an "equal but opposite" effect on the tube. Making

the grid far enough negative cuts the tube off. Making the cathode too far positive does, too.

If the video output tube goes dead, it draws no plate current. Its plate voltage rises to the supply voltage, +400 volts. So do the picture tube cathodes. Net bias on grid is now a -200 volts, (200 - 400 = -200) This is far beyond cutoff. Shorted video output tube: bias problem on its grid which makes it draw far more than its normal current — it will pull down the plate voltage, making the cathodes too far negative. Video plate drops to +200 volts. Grids stay at +200 volts. So 200 - 200 equals zero: the picture tube is at zero bias, and draws a very high current; high voltage supply drops and raster goes out.

Since each picture tube grid has its own color-difference amplifier stage, we won't have the same problems. If any one of the tubes goes out, its plate current will cease. Its plate voltage will go highly positive, taking the grid with it. This gun will conduct very heavily, and you will have an easily identified "one-color only" problem. Too much green, too much blue, etc. You can have the opposite, of course; some fault in here can bias the grid too far negative and you'll have a "one-color-missing" problem.

So, if you find all of the picture tube grids far too negative, with the raster out, there is only one basic fault that can cause this. The dc supply voltage to the 3 difference amplifiers is low or missing. This would be the -250 volt source in Fig. 2. All of the plate load resistors, marked R2, go to the same point.

Since the color-difference amplifiers have a common cathode resistor, here is another source of trouble. If this resistor should open, or have a bad solder connection, all the amplifiers would be

open-circuited at once. The plate voltages would rise to the supply value, (grids of picture tube too far positive) and the raster may go out, or "flare"; show an uncontrollably bright picture.

One more possible source of trouble in the difference amplifier circuit is seen in Fig. 2. The horizontal blanking pulse is often fed into the common cathode circuit, through the 0.22- μ F-coupling capacitor. Since the plate voltage on the blanker tube is around +250 v., any dc leakage in this capacitor will upset the bias on the difference amplifiers very badly. This will make the difference-amplifier cathodes too far positive, reducing their plate current, making picture tube grids positive, and causing a flare or blackout from overload. Oddly enough, if this coupling capacitor should open, you will get a very similar symptom; probably loss of raster: the difference-amplifier plate voltages will drop to about a -80 volts, or "negative". Reason: the high amplitude blanking pulse fed to the cathodes helps to develop the normal bias. If this pulse is missing, the difference-amplifier tubes will not have enough bias, and draw excessive plate current.

Troubleshooting techniques

The key test, which should be made first in all cases of no-raster, is reading of the high voltage. If this is close to normal, meaning a minimum 20 kV, you have probably got bias problems. Note the reaction of the high voltage at turn-on. If it comes up, makes a raster, which then pulls in or blooms then disappears, a bias problem is very likely. The test which will confirm or deny this is disconnection of the picture tube. You can pull the base, if this isn't a series-heater set, or pull the ulior lead; either one. Now, recheck the high voltage. If you now read full high vol-

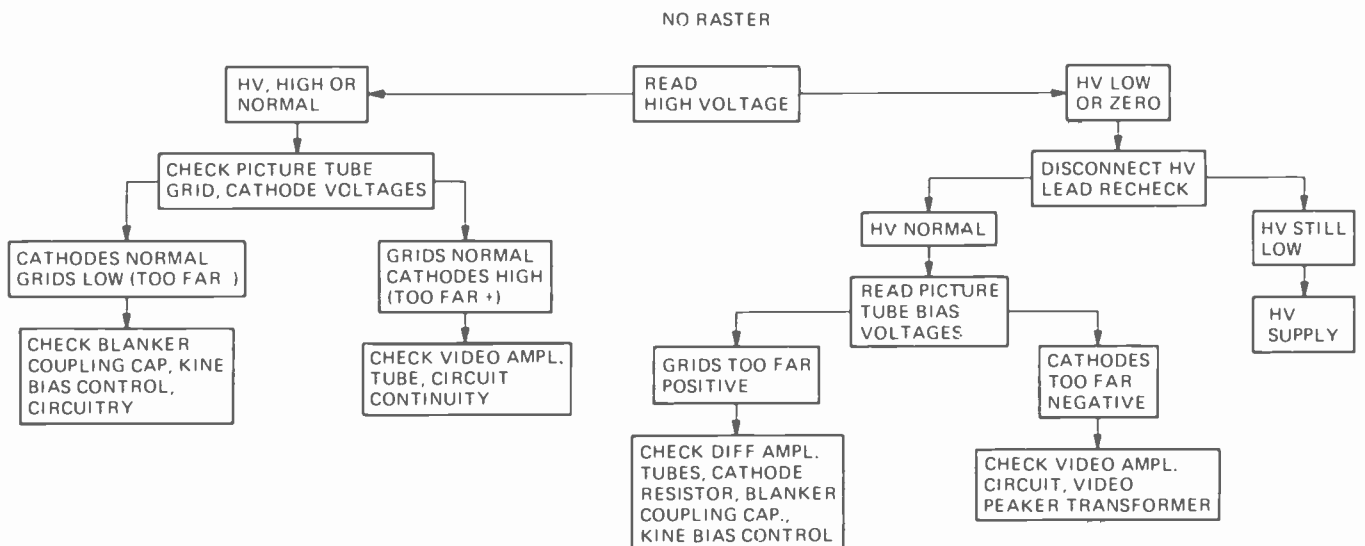


FIG. 3—TROUBLESHOOTING GUIDE for localizing circuit troubles when the symptom is "no raster". Voltage readings guide you step-by-step to the defective stage or component.

tage, or high, this would definitely point to a bias problem.

Quick-check: turn the service switch to SERVICE. If you can get the three lines by raising the screen voltage, you have high voltage, and this is a bias problem. High voltage will read slightly above normal in the SERVICE position due to reduced beam current. If the raster is out, but the high voltage is noticeably high (28 to 30 kV) this shows definitely that the picture tube is cut off.

To pin down the actual cause of the trouble, follow the steps in the chart of Fig. 3. For the first test, read the dc voltages on the picture tube grids and cathodes. In most sets, you can do this easily by following the wires from the picture tube socket to their terminals on the chassis. The standard color coding for these is solid color wires for the grids, red for red grid, etc. and yellow wires with color stripes for the cathodes. There is a small amount of tolerance; say 25 volts either way. In many sets the cathode voltages will show quite a variation as the brightness control is turned.

If the dc voltages are off at the plates, though the supply normal, suspect the tubes. Remember, if a tube is very weak, it won't be able to draw its normal plate current; plate voltage will thus be higher than it should. Substituting a new tube is quickest. If it goes back to normal, that was it. If it's still bad, check its grid bias.

CAUTION: it is NOT a good idea to pull color-difference amplifier tubes with the set on! Older sets used two twin triodes; both triodes of one, and half of the other, 6GU7, 6CG7, etc tubes. If you pull the one using both triodes (Usually the R-Y and B-Y amplifiers) you'll get a sudden surge of beam current which can actually damage the picture tube. In the later chassis using a triple-triode tube such as 6MD8's for all three, pulling this tube will make all colors flare. If you see signs of a flare, make a quick eyeball check to be sure that the heater of this tube is lit.

Oddball troubles.

All TV sets love to throw curves and this circuit is full of them. Here are a few actual cases.

1. **Raster flared up;** grids far too positive. Cause: intermittently open solder joint on common cathode resistor of difference amplifiers.

2. **Same symptom.** Observation caught the heaters of both difference-amplifier tubes going out. Cause: bad solder joint on solid wire jumper on PC board which supplied the heater of both of the tubes.

3. **Raster visible;** no video. Brightness control had no effect. Video amplifier plate voltage very high.

(Contradictory symptoms!) Contrast control, in video output tube cathode, open. Raster was visible because previous technician had turned all three screen grid controls full on!

4. **Raster came on,** flared up and went dark. High voltage dropped. Open circuit in primary of video peaking transformer, between video output tube plate and picture tube cathodes; higher positive voltage fed through this transformer to cathodes; video output tube had parallel voltage feed from lower voltage source. Picture tube cathode voltage went down, making it near zero bias, drawing very heavy beam current.

5. **After one minute,** good picture, raster pulled in from sides, dimmed, then went out. Cathode voltages normal. Grid voltages of picture tube changed, too positive. Tracing cathode circuit of difference amplifiers through picture tube bias control, found that dc circuit of picture-tube bias was completed through place-cathode of blanker tube. This tube had a thermal intermittent open in its cathode ribbon! After heating for exactly one minute, it opened!

R-E

New weather satellite works in the dark

The latest weather-watcher, Japan's Geo-stationary Meteorological Satellite, to be launched in 1976 from Cape Canaveral into an orbit that will keep it over a point 500 miles south of Tokyo, will carry equipment designed to see in the dark as well as daylight. The instrument is a Visible (and) Infrared Spin-Scan Radiometer (VISSR). It will transmit images of nearly



one-third of the earth to ground stations every 20 minutes 24 hours a day, with an infrared resolution of 5 kilometers and a

visible-light resolution of 1.2 km. It is expected to alert meteorologists to potential perilous storms, typhoons and hurricanes over an area extending from Hawaii to Pakistan.

The equipment is being planned and designed by an international contractor team consisting of Nippon Electric Co. of Tokyo and Hughes Aircraft Co. of California

300 technical seminars being given by Sencore

"Taking the company to the distributor," is the term used by Herb Bowden, president of Sencore, for the company's new Tech-a-Rama program. It uses company vans and factory trained technicians, with slide films and simplified demonstrators to put on lively and informative programs.

More than 200 of these seminars are already scheduled in Sencore News, now mailed for 125,000 readers from coast to coast. Anyone interested in electronic equipment from a service and design standpoint is welcome at any of these Tech-a-Ramas. Information on dates and locations may be obtained from the nearest Sencore distributor or from Herb Bowden, Sencore, Inc., 3200 Sencore Drive, Sioux Falls, SD 57107.

R-E's Substitution guide for replacement transistors

PART XVI

compiled by

ROBERT & ELIZABETH SCOTT

- 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
- DM—D M Semiconductor Co., P.O. Box 131, Melrose, Mass 02176
- GE—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
- WOR—Workman Electronic Products, Inc., Box 3828, Sarasota, Fla. 33578
- ZEN—Zenith Sales Co., 5600 W. Jarvis Ave., Chicago, Ill 60648

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	DM	G-E	ICC	IR	MAL	MOT	RCA	SPR	SYL	WOR	ZEN
2N3341	RS276-2009	T-50	GE-21	ICC-50	NA	PTC 103	HEP-50	SK 3114	RT-115	ECG 159	WEP-717	ZEN 100
2N3342	RS276-2021	T-51	GE-22	ICC-51	NA	PTC 103	HEP-51	NA	RT-126	ECG 106	WEP-52	ZEN 101
2N3343	RS276-2021	T-51	GE-22	ICC-51	NA	PTC 131	HEP-51	NA	RT 115	ECG 129	WEP-242	ZEN 101
2N3344	RS276-2021	T-51	GE-21	ICC-51	NA	PTC 131	HEP-51	SK 3025	RT 115	ECG 129	WEP-242	ZEN 101
2N3345	RS276-2021	T-51	GE-21	ICC-51	NA	PTC 131	HEP-51	SK 3025	RT 115	ECG 129	WEP-242	ZEN 101
2N3346	RS276-2021	T-51	GE-21	ICC-51	NA	PTC 131	HEP-51	SK 3114	RT-115	ECG 159	WEP-717	ZEN 101
2N3347	NA	T-715	NA	ICC-715	TR-20	PTC 127	HEP-715	NA	NA	NA	WEP-717	ZEN 106
2N3348	NA	T-715	NA	ICC-715	TR-20	PTC 127	HEP-715	NA	NA	NA	WEP-717	ZEN 106
2N3349	NA	T-715	NA	ICC-715	TR-20	PTC 127	HEP-715	NA	NA	NA	WEP-717	ZEN 106
2N3350	NA	T-715	NA	ICC-715	TR-30	PTC 127	HEP-715	NA	NA	NA	WEP-717	ZEN 106
2N3351	NA	T-715	NA	ICC-715	TR-30	PTC 127	HEP-715	NA	NA	NA	WEP-717	ZEN 106
2N3352	NA	T-715	NA	ICC-715	TR-30	PTC 127	HEP-715	NA	NA	NA	WEP-717	ZEN 106
2N3353	NA	NA	GE-FET-1	NA	NA	PTC 151	NA	NA	NA	NA	WEP-801	NA
2N3354	NA	NA	GE-FET-1	NA	NA	PTC 151	NA	SK 3112	NA	NA	WEP-801	NA
2N3355	NA	NA	GE-FET-1	NA	NA	PTC 151	NA	SK 3112	NA	NA	WEP-801	NA
2N3356	NA	NA	GE-FET-1	NA	NA	PTC 151	NA	SK 3112	NA	NA	WEP-801	NA
2N3357	NA	NA	GE-FET-1	NA	NA	PTC 151	NA	SK 3112	NA	NA	WEP-801	NA
2N3358	NA	NA	GE-FET-1	NA	NA	PTC 151	NA	SK 3112	NA	NA	WEP-801	NA
2N3359	NA	NA	GE-FET-1	NA	NA	PTC 151	NA	SK 3112	NA	NA	WEP-801	NA
2N3360	RS276-2003	T-3	GE-51	ICC-3	TR-17	PTC 107	HEP-3	NA	NA	ECG 160	WEP-637	ZEN 301
2N3361	NA	NA	GE-63	NA	NA	PTC 144	NA	NA	NA	NA	NA	NA
2N3362	NA	TS-3020	GE-28	ICC-S3020	IRTR-66	PTC 144	HEP-S3020	NA	NA	NA	NA	NA
2N3363	NA	T-803	NA	ICC-803	NA	NA	HEP-803	NA	NA	NA	NA	NA
2N3364	NA	NA	NA	ICC-F1035	NA	NA	HEP-F1035	NA	NA	NA	NA	NA
2N3365	NA	T-803	NA	ICC-803	NA	NA	HEP-803	NA	NA	NA	NA	NA
2N3366	NA	NA	NA	ICC-F1035	NA	NA	HEP-F1035	NA	NA	NA	NA	NA
2N3367	NA	T-803	NA	ICC-803	NA	NA	HEP-803	NA	NA	NA	NA	NA
2N3368	NA	NA	NA	ICC-F1035	NA	NA	HEP-F1035	NA	NA	NA	NA	NA
2N3369	NA	NA	NA	ICC-803	NA	NA	HEP-803	NA	NA	NA	NA	NA
2N3370	NA	NA	NA	ICC-F1035	NA	NA	HEP-F1035	NA	NA	NA	NA	NA
2N3371	NA	T-803	NA	ICC-803	NA	NA	HEP-803	NA	NA	NA	NA	NA
2N3372	NA	NA	NA	ICC-F1035	NA	NA	HEP-F1035	NA	NA	NA	NA	NA
2N3373	NA	T-803	NA	ICC-803	NA	NA	HEP-803	NA	NA	NA	NA	NA
2N3374	NA	NA	NA	ICC-F1035	NA	NA	HEP-F1035	NA	NA	NA	NA	NA
2N3375	NA	T-803	NA	ICC-803	NA	NA	HEP-803	NA	NA	NA	NA	NA
2N3376	NA	NA	NA	ICC-F1035	NA	NA	HEP-F1035	NA	NA	NA	NA	NA
2N3377	NA	NA	NA	ICC-803	NA	NA	HEP-803	NA	NA	NA	NA	NA
2N3378	NA	T-706	GE-27	NA	IRTR-87	PTC 125	NA	SK 3045	RT-110	ECG 154	WEP-712	NA
2N3379	NA	T-706	GE-27	NA	IRTR-78	PTC 117	NA	SK 3045	RT-110	ECG 154	WEP-712	NA
2N3380	RS276-2013	T-730	GE-62	ICC-730	NA	PTC 139	HEP-730	SK 3124	RT-102	ECG 123A	WEP-735	ZEN 116
2N3381	RS276-2013	T-726	GE-62	ICC-726	TR-51	PTC 139	HEP-726	SK 3124	RT-102	ECG 123A	WEP-735	ZEN 113
2N3382	RS276-2009	T-724	GE-62	ICC-724	TR-51	PTC 139	HEP-724	SK 3124	RT-102	ECG 123A	WEP-735	ZEN 112
2N3383	RS276-2009	T-723	GE-62	ICC-723	TR-51	PTC 139	HEP-723	SK 3124	RT-100	ECG 123	WEP-53	ZEN 111
2N3384	RS276-2009	T-723	GE-62	ICC-723	TR-24	PTC 139	HEP-723	SK 3124	RT-102	ECG 123A	WEP-735	ZEN 111
2N3385	RS276-2013	T-726	GE-20	ICC-726	IRTR-51	PTC 139	HEP-726	SK 3124	RT-102	ECG 123A	WEP-735	ZEN 113
2N3386	RS276-2009	T-724	GE-62	ICC-724	IRTR-51	PTC 139	HEP-723	SK 3018	RT-102	ECG 123A	WEP-735	ZEN 112
2N3387	RS276-2009	T-723	GE-62	ICC-723	IRTR-51	PTC 139	HEP-723	SK 3124	RT-102	ECG 123A	WEP-735	ZEN 111
2N3388	RS276-2013	T-726	GE-20	ICC-726	IRTR-51	PTC 139	HEP-726	SK 3124	RT-102	ECG 123A	WEP-735	ZEN 113
2N3389	RS276-2003	T-3	GE-50	ICC-3	TR-17	PTC 107	HEP-3	NA	NA	ECG 160	WEP-637	ZEN 301
2N3390	NA	T-2	GE-2	ICC-2	NA	PTC 102	HEP-2	SK 3123	NA	ECG 160	WEP-637	ZEN 300
2N3391	RS276-2021	T-51	GE-22	ICC-51	TR-28	PTC 131	HEP-51	SK 3114	RT-115	ECG 159	WEP-717	ZEN 101
2N3392	RS276-2016	T-54	GE-18	ICC-54	TR-86	PTC 123	HEP-54	SK 3124	RT-102	ECG 123A	WEP-735	NA
2N3393	RS276-2016	T-54	GE-20	ICC-54	NA	PTC 123	HEP-54	SK 3124	RT-102	ECG 123A	WEP-735	NA
2N3394	RS276-2016	T-54	GE-18	ICC-54	TR-86	PTC 123	HEP-54	SK 3124	RT-102	ECG 123A	WEP-735	NA
2N3395	RS276-2016	T-54	GE-10	ICC-54	TR-21	PTC 123	HEP-54	SK 3124	RT-102	ECG 123A	WEP-735	NA
2N3396	NA	T-55	GE-10	NA	NA	PTC 121	NA	SK 3019	RT-113	ECG 108	WEP-56	NA
2N3397	NA	TS-0004	GE-20	ICC-S0004	IRTR-64	PTC 136	HEP-S0004	NA	NA	NA	WEP-735	ZEN 127
2N3398	NA	TS-0004	GE-20	ICC-S0004	IRTR-64	PTC 136	HEP-S0004	NA	NA	NA	WEP-735	ZEN 127
2N3399	NA	TS-0004	GE-20	ICC-S0004	IRTR-64	PTC 136	HEP-S0004	NA	NA	NA	WEP-735	ZEN 127
2N3400	NA	T-2	GE-51	ICC-2	TR-17	NA	HEP-2	NA	NA	ECG 160	WEP-637	ZEN 300
2N3401	NA	TS-0002	GE-20	ICC-S0002	NA	PTC 123	HEP-S0002	SK 3124	RT-102	ECG 123A	WEP-735	ZEN 126
2N3402	RS276-2009	TS-0003	GE-10	ICC-S0003	NA	PTC 123	HEP-S0003	SK 3124	RT-102	ECG 123A	WEP-735	NA
2N3403	RS276-2009	TS-736	GE-18	ICC-736	NA	PTC 123	HEP-736	SK 3124	RT 102	ECG 123A	WEP-735	ZEN 120
2N3404	RS276-2009	TS-736	GE-17	ICC-736	NA	PTC 123	HEP-735	SK 3124	RT-102	ECG 123A	WEP-735	ZEN 119
2N3405	NA	TS-0002	GE-28	ICC-S0002	IRTR-87	PTC 110	HEP-S3002	NA	NA	NA	WEP-735	NA
2N3406	NA	TS-0002	GE-28	ICC-S0002	IRTR-87	PTC 110	HEP-S3002	NA	NA	NA	WEP-735	NA
2N3407	NA	T-720	GE-20	ICC-720	IRTR-86	PTC 115	HEP-720	NA	NA	NA	WEP-56	ZEN 109
2N3408	NA	T-720	GE-20	ICC-720	IRTR-86	PTC 115	HEP-720	NA	NA	NA	WEP-56	ZEN
2N3409	NA	TS-0004	NA	ICC-S0004	IRTR-86	PTC 136	HEP-S0004	NA	NA	NA	NA	ZEN 127
2N3410	NA	TS-0001	GE-63	ICC-S0001	IRTR-65	PTC 144	HEP-S3001	NA	NA	NA	NA	NA
2N3411	RS276-2005	T-630	GE-53	ICC-630	NA	PTC 102	HEP-630	SK 3004	RT-120	ECG 102	WEP-631	ZEN 306
2N3412	RS276-2005	T-630	GE-53	ICC-630	NA	PTC 102	HEP-630	SK 3004	RT-120	ECG 102	WEP-631	ZEN 306
2N3413	NA	NA	GE-63	NA	NA	PTC 144	NA	NA	NA	NA	NA	NA
2N3414	NA	T-801	GE-FET-1	NA	NA	PTC 152	NA	SK 3112	NA	ECG 133	WEP-801	NA
2N3415	NA	T-801	GE-FET-1	NA	NA	PTC 152	NA	SK 3112	NA	ECG 133	WEP-801	NA
2N3416	NA	NA	NA	NA	NA	NA	NA	SK 3103	NA	NA	NA	NA
2N3417	NA	TS-3021	GE-32	ICC-S3021	NA	NA	HEP-S3021	SK 3044	RT-128	ECG 124	WEP-240	ZEN 208
2N3418	NA	T-241	NA	ICC-241	NA	NA	HEP-241	NA	NA	ECG 175	WEP-241	NA

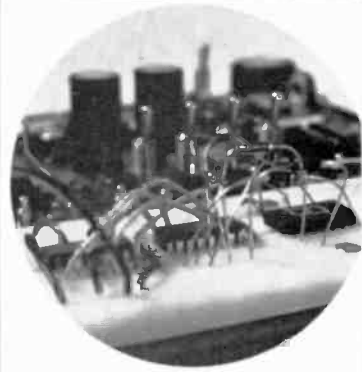
(continued on page 68)

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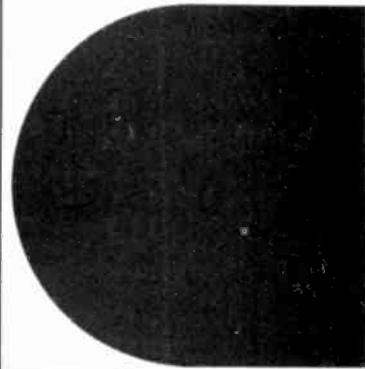
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Control
Engineering**

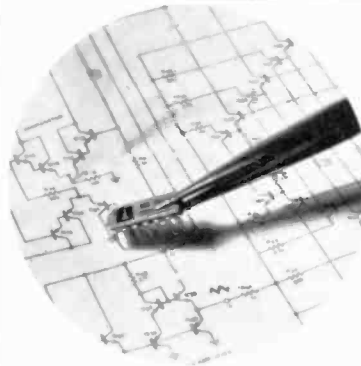


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Sonar
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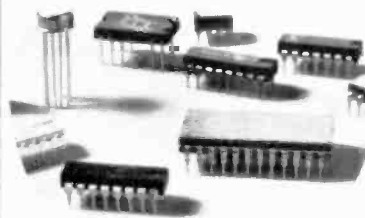
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	ARCH	DM	G-E	ICC	IR	MAL	MOT	RCA	SPR	SYL	WOR	ZEN
2N3442	NA	T-707	NA	ICC-707	NA	PTC 118	HEP-707	SK 3079	NA	NA	NA	ZEN 204
2N3443	NA	T-2	GE-2	ICC-2	NA	PTC 102	HEP-2	NA	NA	ECG-160	WEP-637	ZEN 300
2N3444	NA	TS-3002	NA	ICC-S3002	NA	PTC 144	HEP-S3002	NA	NA	NA	NA	NA
2N3445	NA	T-247	GE-14	ICC-247	NA	PTC 118	HEP-247	SK 3027	RT-131	ECG 130	WEP-247	NA
2N3446	NA	TS-5004	GE-14	ICC-S5004	NA	PTC 118	HEP-S5004	SK 3027	RT-131	ECG 130	WEP-247	NA
2N3447	NA	T-247	GE-14	ICC-247	NA	PTC 119	HEP-247	SK 3027	RT-131	ECG 130	WEP-247	NA
2N3448	NA	T-704	GE-14	ICC-704	NA	PTC 119	HEP-704	SK 3027	RT-131	ECG 130	WEP-247	NA
2N3449	RS276-2003	T-3	GE-51	ICC-3	NA	PTC 109	HEP-3	NA	NA	ECG 160	WEP-637	ZEN 301
2N3451	RS276-2003	T-52	GE-21	ICC-52	NA	PTC 103	HEP-52	SK 3114	RT-115	ECG 159	WEP-717	NA
2N34523	NA	T-801	GE-FET-1	NA	NA	PTC 151	NA	SK 3112	NA	NA	WEP-801	NA
2N3453	NA	T-801	GE-FET-1	NA	NA	PTC 151	NA	SK 3112	NA	NA	WEP-801	NA
2N3454	NA	T-801	GE-FET-1	NA	NA	PTC 152	NA	SK 3112	NA	ECG 133	WEP 801	NA
2N3455	NA	T-801	GE-FET-1	NA	NA	PTC 152	NA	SK 3112	NA	ECG 133	WEP 801	NA
2N3456	NA	T-801	GE-FET-1	NA	NA	PTC-152	NA	SK 3112	NA	ECG 133	WEP 801	NA
2N3457	NA	T-801	GE-FET-1	NA	NA	PTC 152	NA	SK 3112	NA	NA	WEP 801	NA
2N3458	NA	T-801	GE-FET-1	NA	NA	PTC 152	NA	NA	NA	NA	WEP 801	NA
2N3459	NA	T-801	GE-FET-1	NA	NA	PTC 152	NA	NA	NA	NA	WEP 801	NA
2N3460	NA	T-801	GE-FET-1	NA	NA	PTC 152	NA	SK 3112	NA	ECG 133	WEP 801	NA
2N3461	RS276-2006	T-238	NA	ICC-238	NA	NA	HEP-238	NA	NA	NA	WEP 238	ZEN 329
2N3462	RS276-2009	T-50	GE-20	ICC-50	TR-21	PTC 136	HEP-50	SK 3124	RT-102	ECG 123A	WEP 50	ZEN 100
2N3463	RS276-2009	T-50	GE-20	ICC-50	TR-21	PTC 136	HEP-50	SK 3124	RT-102	ECG 123A	WEP 50	ZEN 100
2N3464	RS276-2021	T-51	GE-20	ICC-51	NA	PTC 103	HEP-51	SK 3114	RT-115	ECG 159	WEP 51	ZEN 101
2N3465	NA	T-801	GE-FET-1	NA	NA	PTC 152	NA	SK 3112	NA	ECG 133	WEP 801	NA
2N3466	NA	T-801	GE-FET-1	NA	NA	PTC 152	NA	SK 3112	NA	ECG 133	WEP 801	NA
2N3467	NA	TS-3027	GE-67	ICC-S3027	NA	NA	HEP-S3027	NA	NA	NA	WEP S3027	NA
2N3468	NA	TS-3031	GE-67	ICC-S3021	NA	NA	HEP-S3031	NA	NA	NA	WEP S3021	NA
2N3469	RS276-2018	T-243	GE-28	ICC-243	NA	PTC 144	HEP-243	SK 3024	RT-114	ECG 128	WEP 243	NA
2N3478	RS276-2011	T-56	GE-17	ICC-56	IRTR-95	PTC 133	HEP-56	SK 3019	RT-113	ECG 161	WEP 56	ZEN 104
2N3483	NA	T-240	NA	NA	NA	NA	NA	NA	NA	ECG 175	WEP 241	NA
2N3485	RS276-2021	T-51	GE-21	ICC-51	NA	PTC 103	HEP-51	SK 3114	RT-115	ECG 159	WEP 51	ZEN 101
2N3486	RS276-2021	NA	GE-67	ICG-51	NA	PTC 103	HEP-51	SK 3114	RT-115	ECG 159	WEP 51	ZEN 101
2N3493	RS276-2011	T-56	GE-11	ICC-56	NA	PTC 132	HEP-56	SK 3039	RT-113	ECG 108	WEP 56	ZEN 104
2N3494	NA	T-710	NA	ICC-710	IRTR-88	PTC-127	HEP-710	SK-3025	RT-115	ECG 129	WEP 242	NA
2N3496	RS276-2023	T-52	GE-21	ICC-52	NA	PTC 103	HEP-52	SK 3114	RT-115	ECG 159	WEP 52	NA
2N3498	NA	T-53	GE-20	NA	NA	PTC 144	NA	NA	RT-100	ECG 123	WEP 53	NA
2N3499	NA	T-714	GE-18	NA	NA	PTC 125	NA	NA	NA	NA	WEP S3021	NA
2N3500	NA	T-713	GE-32	ICC-714	NA	PTC 144	HEP-713	SK 3104	NA	NA	WEP 53	NA
2N3501	NA	T-713	GE-18	ICC-714	NA	PTC 144	HEP-713	SK 3104	NA	NA	WEP 53	NA
2N3502	RS276-2021	T-51	GE-67	ICC-51	IRTR-88	PTC 141	HEP-51	SK 3025	RT-115	ECG 129	WEP 51	ZEN 101
2N3503	RS276-2021	T-51	GE-67	ICC-51	IRTR-88	PTC-141	HEP-51	SK 3025	RT-115	NA	WEP 51	ZEN 101
2N3504	RS276-2021	T-708	GE-67	ICC-708	TR-20	PC 127	HEP-708	SK 3114	RT-115	ECG 159	WEP 52	NA
2N3505	RS276-2021	T-51	GE-67	ICC-51	TR-20	PTC 127	HEP-51	SK 3114	RT-115	ECG 159	WEP 51	ZEN 101
2N3506	NA	TS-3002	GE-28	ICC-S3002	NA	PTC 144	HEP-S3002	SK 3024	RT-114	ECG 128	WEP S3002	NA
2N3507	NA	TS-3002	GE-28	ICC-S3002	NA	PTC 144	HEP-S3002	SK 3024	RT-114	ECG 128	WEP S3002	NA
2N3508	RS276-2011	T-56	GE-20	ICC-56	TR-25	PTC 123	HEP-56	SK 3039	RT-113	ECG 108	WEP 56	ZEN 104
2N3509	RS276-2011	T-56	GE-20	ICC-56	TR-21	PTC 123	HEP-56	SK 3124	RT-113	ECG 108	WEP 56	ZEN 104
2N3510	RS276-2009	T-50	GE-20	ICC-50	TR-25	PTC 136	HEP-50	SK 3122	RT-102	ECG 123A	WEP 50	ZEN 100
2N3511	RS276-2001	T-56	GE-20	ICC-56	TR-21	PTC 133	HEP-56	SK 3039	RT-113	ECG 108	WEP 56	ZEN 104
2N3512	NA	TS-3001	GE-18	ICC-S3001	IRTR-64	NA	HEP-S3001	NA	NA	NA	NA	NA
2N3513*	NA	TS-0001	NA	ICC-S0001	NA	PTC 144	HEP-S0001	NA	NA	NA	WEP 712	ZEN 125
2N3515*	NA	TS-0001	NA	ICC-S0001	NA	PTC 144	HEP-S0001	NA	NA	NA	WEP 712	ZEN 125
2N3516*	NA	TS-0001	NA	ICC-S0001	NA	PTC 144	HEP-S0001	NA	NA	NA	WEP 712	ZEN 125
2N3518*	NA	TS-0001	NA	ICC-S0001	NA	PTC 144	HEP-S0001	NA	NA	NA	WEP 712	ZEN 125
2N3520*	NA	T-736	NA	ICC-736	NA	PTC 123	HEP-736	NA	NA	NA	WEP 736	ZEN 120
2N3521*	NA	T-736	NA	ICC-736	NA	PTC 123	HEP-736	NA	NA	NA	WEP 736	ZEN 120
2N3522*	NA	T-736	NA	ICC-736	NA	PTC 123	HEP-736	NA	NA	NA	WEP 736	ZEN 120
2N3524*	NA	T-736	NA	ICC-736	NA	PTC 123	HEP-736	NA	NA	NA	WEP 736	ZEN 120
2N3525	NA	SR-1222	GEMR-4	ICC-R1222	IR-1778	NA	HEP-R1222	SK 3502	NA	NA	NA	NA
2N3526	NA	T-714	GE-18	ICC-714	IRTR-87	PTC 117	HEP-714	NA	NA	NA	WEP S3021	NA
2N3527	RS276-2023	T-52	GE-67	ICC-52	TR-20	PTC 127	HEP-52	SK 3019	RT-115	ECG 159	WEP 52	NA
2N3528	NA	NA	GEMR-5	ICC-621	NA	NA	HEP-621	NA	NA	NA	NA	NA
2N3529	NA	NA	NA	NA	NA	NA	NA	SK 3502	NA	NA	NA	NA
2N3542	NA	NA	GE-20	NA	NA	PTC 136	NA	NA	NA	NA	WEP 735	NA
2N3544	RS276-2011	T-56	NA	ICC-56	NA	PTC 123	HEP-56	SK 3039	RT 113	ECG 108	WEP 56	ZEN 104
2N3545	RS276-2023	T-52	GE-22	ICC-52	TR-20	PTC 123	HEP-52	SK 3114	RT-115	ECG 159	WEP 52	NA
2N3546	RS276-2024	T-57	NA	ICC-57	TR-54	PTC 127	HEP-57	SK 3114	RT-115	ECG 159	WEP 57	NA
2N3547	RS276-2023	T-52	GE-67	ICC-52	TR-20	PTC 127	HEP-52	SK 3114	RT-115	ECG 159	WEP 52	NA
2N3548	RS276-2023	T-52	GE-67	ICC-52	TR-20	PTC 127	HEP-52	SK 3114	RT-115	ECG 159	WEP 52	NA
2N3549	RS276-2023	T-52	GE-21	ICC-52	TR-20	PTC 127	HEP-52	SK 3114	RT-115	ECG 159	WEP 52	NA
2N3550	RS276-2023	T-52	GE-21	ICC-52	TR-20	PTC 127	HEP-52	SK 3114	RT-115	ECG 159	WEP 52	NA
2N3553	NA	TS-3001	GE-28	ICC-S0001	NA	PTC 144	HEP-S3001	NA	NA	NA	WEP 712	NA

*Indicates a dual transistor for high-speed switching, diff amplifier etc. Likely to be a matched pair. Use two of the type specified, matching when necessary, on a curve tracer or lab-type transistor checker.

NA=NOT AVAILABLE

(continued next month)

R-E's Service Clinic

Color oscillator— it's easy to know

*It is simple, and similar to
two circuits you know well*

THE COLOR OSCILLATOR IS A circuit that causes a good deal of confusion. It shouldn't. It's a nice friendly circuit, not at all complicated after you get acquainted. In fact, it's exactly the same as a couple of old circuits that you've been fixing for years! Learn the basic reactions, and it's easy. Not much test equipment needed, either; a color-bar generator, vtm and a diddlestick, and you're on the way.

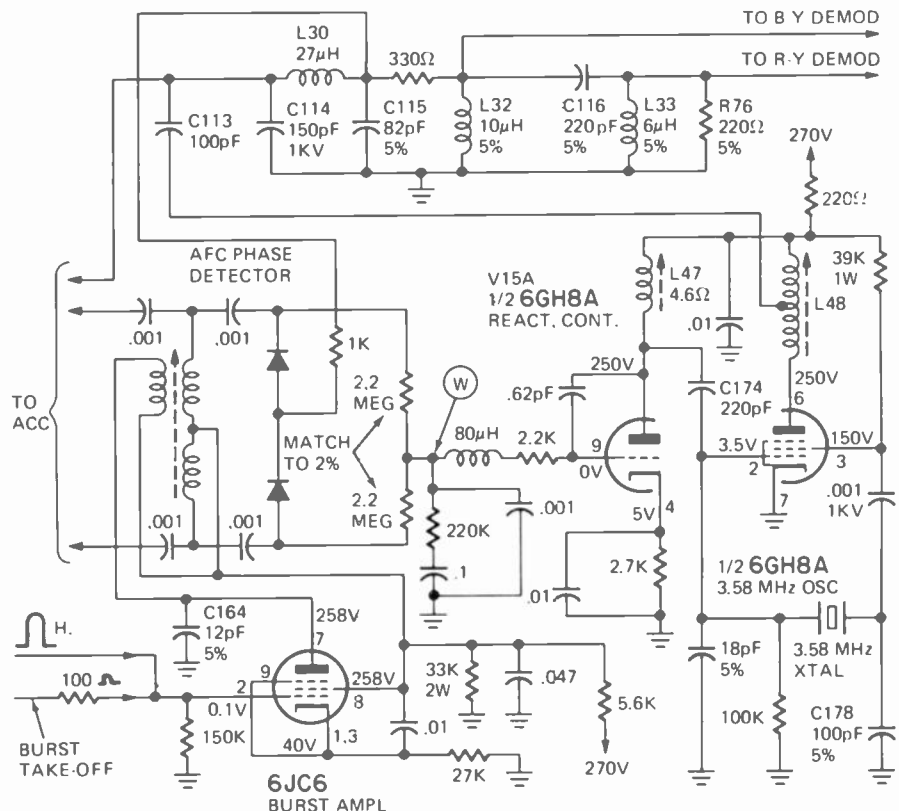
It's a crystal-controlled oscillator, running at 3.579545 MHz, which everyone calls "three-fifty-eight" for short. To reproduce colors correctly, it must be tightly locked in phase with the burst signal. This is little samples of the original 3.58-MHz signal from the transmitter, to which all of the color signals are "referred". All color signals are ac waveforms with a certain *phase* relationship to the *burst*. So, if the local color oscillator gets slightly out of phase with the burst, we still see colors, but they're not the right ones.

The local oscillator is held in phase by a circuit that works exactly like the familiar horizontal afc. It's called afpc: (Automatic Frequency and Phase Control), mostly to let

you know it isn't afc. The action is the same: the incoming burst signal is compared to the local oscillator signal. If it isn't precisely in-phase, a small dc control voltage is generated which pulls the local oscillator back in step. (Did someone say phase-locked loop? Yep. Shore is)

When we were young, we were taught that a crystal-controlled oscillator was very stable. It is. However, most of us got the idea that a crystal oscillator could not be "tuned" or its frequency varied. This isn't so. By varying either capacitance or inductance in the crystal oscillator circuit, you *can* make it change frequency. Not much, but plenty for what we need.

In practical circuits, this is done with what we call a reactance tube. This is a circuit with a tube which has its plate current out of phase with its plate voltage. So, it looks like a *reactance* to any circuit in which it's used. By varying the control-grid voltage of this tube, we can change this reactance; this in turn changes the oscillator frequency. The schematic shows a typical crystal oscillator circuit, with the reactance tube, burst amplifier, etc. Note the dual-



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

diode phase detector which varies the reactance tube grid voltage. Looks like a horizontal a/c? It is!

Like the horizontal oscillator, our crystal oscillator must be able to run, without any control at all, very close to the right frequency. (free-wheel). If it will, the frequency control can hold it with ease. So, this leads us to our first simple test. Kill the frequency control, and adjust the oscillator frequency to exactly where it must be. (A/c adjustment again!)

To do this, we need a color picture on the screen of the TV; preferably a color-bar pattern. First, we ground the input of the burst amplifier. This kills the incoming color sync. Our colors will promptly fall out of sync. If you'll notice, they will make the familiar "slanting-lines" that we see when

the horizontal oscillator isn't locked. They'll make bands of red, green and blue, or "rainbows", in slanting lines across the picture. The farther the color oscillator is off, the more rainbows we see.

By tuning the reactance coil, we can make fewer and fewer rainbows, until we eventually wind up with only three vertical color bars. A careful twiddle of the adjustment will make these lock in place on the color-bar pattern. Like horizontal bars, they'll float, since there's no sync, but the fact that we can get this momentary lock shows that the oscillator is running on-frequency.

Now, we take the ground off the burst amplifier, and check the sync. The colors should lock in and hold. Just as with a/c, if this makes the colors fall out of sync, we know where the trouble is. In the a/cpe,

NOT in the oscillator! So we check out the burst amplifier, the transformer, and the diodes.

Oscillator failure.

If we can see strong black-and-white bars on the screen, but no colors, this is usually a symptom of oscillator failure. There is one tricky reaction here that can fool you. In many sets, if the 3.58-MHz oscillator goes out, you will see a bar pattern which is lightly, but definitely blue and green! (This seems to be due to a little bit of burst getting through; the burst is in this area.) So, you may be misled into hunting for a "loss of the reds". Always check the 3.58-MHz oscillator first, just to be sure.

Another definite check is tracing the color bar waveform through the color-difference amplifiers to the picture tube grids. If you see the familiar comb pattern at these points, but it is flat-topped, your oscillator is out. The color signal is going through the bandpass amplifiers and the demodulators; without the oscillator, there is no demodulation, which would give you the normal "rocker" or lazy-S patterns on the grids.

Oscillator testing

Testing these oscillators isn't hard. Even a narrow-band scope will show you enough vertical deflection so that you can get an idea of the p-p voltage. (To find out, check an oscillator that is working; this will show you what you will see with your scope.) You do not have to see individual cycles of this waveform. This wouldn't tell you anything anyway. You check phase and frequency by simply looking at the color-bar pattern, and

(continued on page 72)

The case for more profitable service calls:

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Circle 14 on reader service card



SERVICE CLINIC

(continued from page 70)

noting whether the colors are there, and in the right place.

Control testing; reactions

You'll find quite a few sets with wrong colors, weak color sync, and so on. If you do see colors, the oscillator must be running. If they're wrong, the frequency is off. If it's off far enough, the afpc won't be able to hold it. When you change stations, the color sync will fall out. This can be due to one of two things. The oscillator circuit may be mistuned, or you may have a crystal which is slightly off frequency.

This is easy to pin down. Just run the full afpc setup adjustment. If the oscillator jumps far off-frequency when the burst is killed, it could be mistuned. (Symptom: many small rainbows on screen.) Run the tune-up procedure for the oscillator. In most sets simply adjust the reactance coil, until you see only the three color bars, and a momentary color-lock.

When the afpc is put back it should lock the colors tightly. In a lot of sets, the hold-range can be checked by reading the dc control voltage developed by the afpc, on the grid of the reactance tube. Normal voltage here, in-sync, should be zero volts. The afpc should develop equal and opposite polarity voltages, as the reactance coil is tuned through its full range. A good ball-park figure for this would be ±5 volts, zero volts with the oscillator locked.

But! What if you read about -3, or +3 volts, with the oscillator in sync? Or, if the

(continued on page 74)

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One



SG 1900—The Audio Sweep Generator provides the capabilities of both a fixed frequency (CW) and a sweep generator in a laboratory quality instrument. Modes include CW, linear sweep, and log sweep with a sweep time of 10 milliseconds to 100 seconds. Waveforms are sine, square, and triangle. The range is from 1 Hz to 100 KHz. The output has fixed attenuation levels of 0, 20, and 40 dB \pm 1 dB, as well as continuously variable attenuation. Prices: Kit \$119.95 Assembled \$149.95

Two



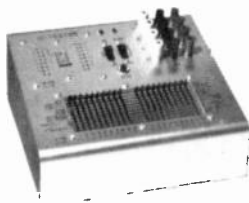
WG 1700—The Waveform Generator/Frequency Counter is well suited to a wide variety of test work. Six carrier waveforms (sine, triangle, square, ramp, sawtooth, and pulse) and three internal AM or FM modulator waveforms (sine, triangle, and square) are featured. The carrier frequency range is 1 Hz to 1.5 MHz in twelve overlapping ranges; the modulator waveform frequency range is 100 Hz to 150 KHz in six overlapping ranges. Both outputs are buffered for low output impedance. The unit also accepts external AM or FM modulating signals. The frequency counter with adjustable sensitivity measures the waveform generator output frequency and frequency of external signals from 1 Hz to over 10 MHz, with input impedance of 100K ohms. Prices: Kit \$199.95 Assembled \$249.95

Three



DV 1600—The 2-1/2 digit Digital Voltmeter is a perfect companion for MITS' other fine test equipment. Features include full scale measurement of alternating and direct current in five ranges from .1 ma to 1 amp, measurement of AC and DC voltage in four ranges to 1000 volts, and measurement of ohms in six ranges to 10 megohms. The resolution in low ranges for voltage is 10 mv; for current, 10 μ a; and for resistance, 1 ohm. The DC accuracy is \pm 5% and the AC accuracy is \pm 1%. Other features include autopolarity and 100% overrange capability on all ranges, which effectively doubles full-scale capability. Prices: Kit \$ 89.95 Assembled \$129.95

Four



ICT 1800—The Integrated Circuit Tester is ideal for testing digital integrated circuits and for breadboarding IC's while developing circuits. The eighteen LED indicators show the status of the IC under test. The internal 5 volt 1 amp power supply, which has overtemperature and overcurrent shutdown capabilities, is also available for external use. The cross bar switch allows complete programming of the IC under test. Other features include an internal two speed clock, single step capability, and four each remote outputs and inputs. Prices: Kit \$119.95 Assembled \$169.95

Plus

ICT 1810—The Operational Amplifier Tester with fast, simple GO/NO GO test capability tests operational amplifiers for gain, stability, input offset voltage, and input bias current in a dynamic operating environment. A single LED indicates IC status.

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Power Sale

PS 500—The 5 Volt Power Supply, which has overtemperature and overcurrent shutdown capability, is an ideal unit to power TTL, DTL, and other IC's. Features include load regulation at 0.6% and line regulation at 0.005%. Output voltage is 5 volts \pm .2 volt.

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SERVICE CLINIC

(continued from page 72)

control voltage will not "cross zero", but locks (with weak color sync) at something like -3 volts? This is not too common, but it can happen. It is almost always due to a crystal that is just a little bit off frequency! By carefully diddling the afpc, you can literally haul it back on-frequency, but your hold will be very bad. The oscillator is pulling against the afpc all the time, like a car with a soft front tire. For a quick check, substitute an exact-replacement crystal, and see if you can get the -5 0 +5-volt reaction, as the reactance coil is tuned. (Does this sound like tuning up an FM detector, to get an S-curve? Sure is. Same thing. That's the other familiar circuit I mentioned before.)

So there you are. Nothing mysterious about it; just a couple of old friends, used in a new way. Remember this, and you're home free.

reader questions

SLOW LOSS OF STEREO

This Motorola HS-2702 stereo tuner loses the stereo signal very gradually, after playing for about an hour. The stereo indicator light goes out, too. Turn it off, let it cool for 30 minutes, and it

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repeats the whole thing. What is this?—R.G., Ink, Ark.

This is rare but as you know, does happen. Check the little germanium diode in the base circuit of Q121, the 38-kHz doubler transistor. This diode actually serves as the frequency doubler unit. It becomes leaky, shunts the base of Q121, and kills the stereo signal and the light. Replace it with a silicon diode.

CAN'T SEE PIPS ON SCOPE

The instruction manual for my Heath-kit IG-62 color-bar generator says I should see several small pips on the
(continued on page 78)

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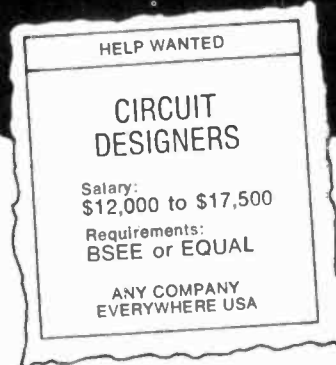
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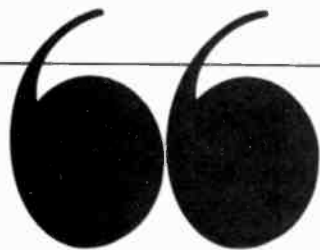
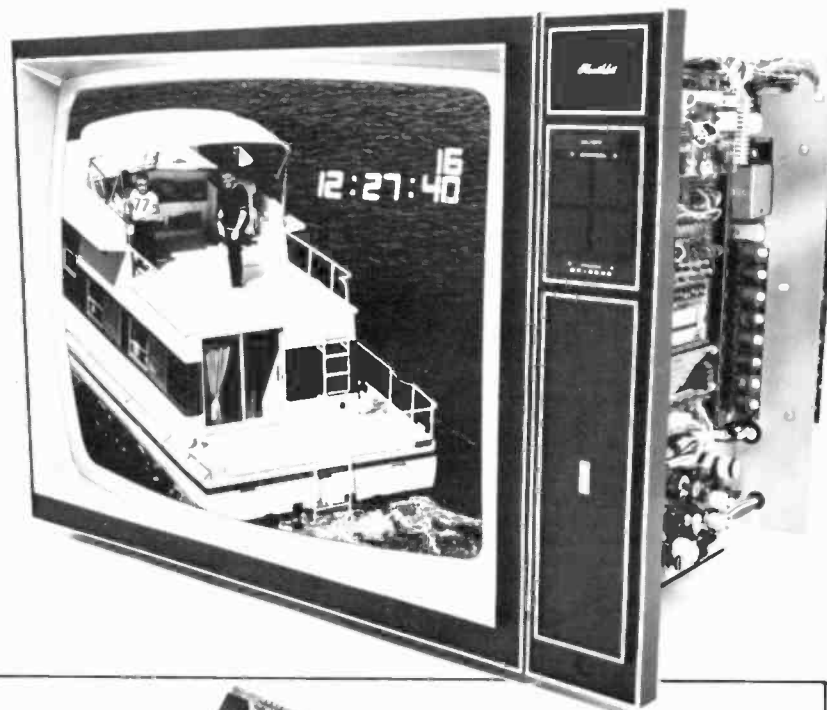
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READ WHAT THE EXPERTS SAY ABOUT THE NEW HEATHKIT DIGITAL COLOR TV



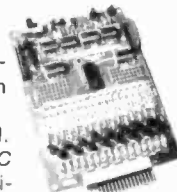
The editors of RADIO-TV REPAIR said, "With manufacturers only now beginning to get the color excellence Heath has featured for years, it was time for Heathkit to once again move ahead of the industry, and move they did..."

According to RADIO-ELECTRONICS, the Heathkit GR-2000 Digital Color TV "uses so much digital design and so many integrated circuits... it sets new standards for state-of-the-art in color TV".

The RADIO-ELECTRONICS editors said the Heathkit Digital TV has "features that are not to be found in any other production color TV being sold in the U.S.:



"On-screen electronic digital channel readout... numbers appear each time you switch channels or touch the RECALL button... On-screen electronic digital clock... an optional low cost feature... will display in 12- or 24-hour format... Silent all-electronic tuning. It's done with uhf and vhf varactor diode tuners... Touch-to-tune, reprogrammable, digital channel selection... up to 16 channels, uhf or vhf... in whatever order you wish... there's no need to ever tune to an unused channel. LC IF amplifier with fixed ten-section LC IF bandpass filter in the IF strip... eliminates the need for critically adjusted traps for eliminating adjacent-channel and in-channel carrier beats. No IF alignment is needed ever. Touch volume control... when the remote control is used... touch switches raise or lower the volume in small steps."



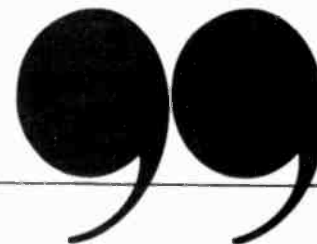
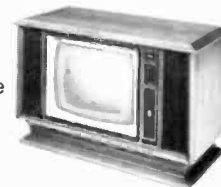
POPULAR ELECTRONICS took a look at the 25-in. (diagonal) picture and said it "can only be described as superb. The Black (Negative) Matrix CRT, the tuner and IF strip, and the video amplifier provide a picture equal to that of many studio monitors..."

Furthermore, the Heathkit GR-2000 is an easier kit-form TV to build. POPULAR ELECTRONICS pointed out that "Each semiconductor has its own socket and there are 12 factory-fabricated interconnecting cables... The complete color adjustments can be performed in less than an hour."

And here's what RADIO-TV REPAIR said about service: "...virtually every function of the TV receiver has been broken down to a miniature plug-in circuit assembly... if trouble develops you simply pop out the correct board and check it yourself... Heath provides free technical consultation, and if you do need factory service, as we said, the costs are low, well below that for (conventional color TV) insurance protection."

To sum up, POPULAR ELECTRONICS concluded its study by stating, "In our view, the color TV of the future is here — and Heath's GR-2000 is it!"

Why not see what the experts have seen? The Heathkit Digital Color TV — without question the most remarkable TV available today. Mail order price for chassis and tube, \$649.95. Remote Control, \$79.95 mail order. Clock, \$29.95 mail order. Cabinets start at \$139.95. (Retail prices slightly higher).





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A. Heathkit IB-1103 180 MHz Counter has phase-locked multiplier, extremely high resolution with $8\frac{1}{2}$ -digit readout. Pushbuttons permit multiplication by 1 (direct), 10, 100 or 1000. Also has temperature compensated crystal oscillator (TCXO) and pushbutton selection of 1 msec., 100 msec. and 1 sec. gate times. Input sensitivity is 50 mV to 120 MHz and 100 mV to 180 MHz. Has lighted indicators for MHz, kHz, Hz, Gate, Overrange and unlocked conditions. \$379.95*. Shipping weight, 12 lbs.

B. Heathkit ID-1290 Weather Station has Uni/Mag® barometer for $2\frac{1}{2}$ times greater pointer deflection; 8 wind-direction compass points that light-up in combination to give you 16-point resolution; wind speed indicator with 2 switch selectable ranges, 0-30 and 0-90 mph; dual-sensor thermometer with switch selection of indoor and outdoor temperatures. Includes weather cup and wind vane assembly, simulated walnut housing. \$89.95*. Weight, 9 lbs., 50' cable, 5.95*, 2 lbs.; 100', 9.95*, 4 lbs.; 150', 14.95*, 6 lbs.

C. Heathkit GC-1005 Electronic Alarm Clock. A six-digit timepiece that displays hours, minutes and seconds on highly visible cold-cathode readout tubes. Gentle "beeper" alarm can be set for 24-hour cycle, features snooze switch for seven more minutes of sleep. Displays time in 12-hour, or 24-hour format. \$54.95*. Mailing weight, 4 lbs.

D. Heathkit ID-1390 Digital Thermometer. A solid-state device that monitors indoor and outdoor temperatures. Switches set thermometer for alternate display of indoor/outdoor temperature at 4-second intervals, for constant display, and for readout in either degrees Fahrenheit or degrees Centigrade. Includes 85' cable and 2 sensors. \$59.95*. Mailing weight, 5 lbs.

E. Heathkit AR-2020 4-Channel Receiver offers 25 watts music power per channel, built-in decoder for

reproducing matrixed 4-channel material, and an AM/FM tuner that boasts $2\mu\text{V}$ sensitivity, 2dB capture ratio. There are individual front panel controls for all four speakers plus a "master" control, pushbuttons for all modes of operation and inputs to accommodate phono, tape and auxiliary source in stereo or 4-channel combinations. The solid-state circuitry mounts on modular plug-in boards for easy assembly and self-service. And the low kit price includes the cabinet, too! \$249.95*. Mailing weight, 31 lbs.

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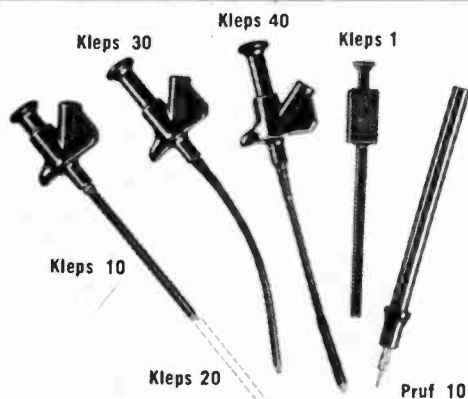
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READER QUESTIONS

(continued from page 75)

waveform, in the early stages after the 189-kHz oscillator. I can't see them. The crosshatch patterns are very stable, though, on a TV screen. What should I do?—S.G., Hayward, Calif.

If the crosshatch pattern is stable, these timers *have* to be set correctly; you don't need to see the pips. If you want to, you can usually see them by using a direct probe, with a very small capacitor, 3 to 5 pF in series. Turn vertical gain up till you can see the pips on the slanting part of the waveform.

THREE CRAWLING LINES

Every once in a while, on our local TV station, I see three very thin, equally spaced lines crawling up the screen, especially when they go to black. This doesn't happen all the time; it's intermittent. Sometimes one of the lines will be black and the other two white, or vice versa. What is this?—B.E., Ft. Smith, Ark.

Most likely cause is a three-phase glitch. This is caused by a problem in the primary power supply of the TV transmitter. Seems to happen when the mercury-vapor high-voltage rectifier tubes get just a little age on them. Due to very small bursts of rf on peaks of voltage.

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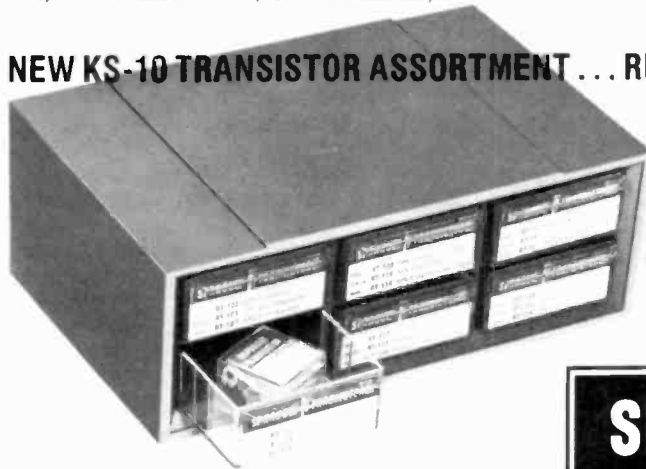
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RE6-74

Circle 28 on reader service card

new products

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

POCKET COLOR BAR GENERATOR, model 239 is hand-held, self-contained service test instrument with nine stable FCC-specification signals that include gated rainbow for testing/aligning color TV circuits. MOS LSI solid-state circuitry, instant operation, low bat-



tery drain, stability from -50° to 150° F, digital timing.

Simplified controls include two matrix slide switches for pattern selection; chroma level adjustment from 0 to 150% for bright, sharp patterns, rf adjustment for channels 2 through 4. Uses two standard 9 V batteries, 5 3/4 x 3 3/8 x 1 7/8 in.; 12 oz. — **Hickok Electrical Instrument Co.**, 10514 Dupont Avenue, Cleveland, Ohio 44108.

Circle 31 on reader service card

DIAMOND NEEDLES, Caddi-Kits. Give the servicing dealer the diamond needles he requires to service phonographs that are popular in his area. There are six Caddi-Kits: each contain an assortment of 12 diamond needles to cover the major brand names, they are designed to replace the popular diamond needles used by GE, RCA, EV, Magnavox, Zenith, BSR, Astatic, and



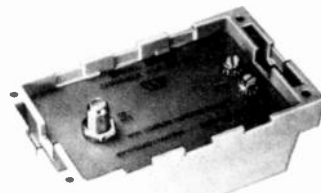
Varco. Also included is a universal kit that contains one each of the 12 fastest selling diamond needles.

Available individually or by sampler kit, SNK-6, which is one each of the six kits packaged for sales presentations. Each assortment is packed in a clear plastic box approximately 2-1/2 inches square with a self-inventory and cross reference label that is color coded.—**EV Game Inc.**, 186 Buffalo Avenue, Freeport, N.Y. 11520

Circle 32 on reader service card

VHF-FM ANTENNA PREAMPLIFIER, RD-375 features a 75-ohm output and is used in noisy signal areas or where use of 300-ohm twinlead is undesirable. High input capability (228,000

μV) eliminates strong signal overload in tough, noisy, low-signal areas where reception from a distant station is desired. High gain of +16 dB



(five times input level) cuts TV snow and interference and helps pull in hard-to-get channels. High output level (1,350,000 μV) provides enough signal to operate several TV sets in most areas. Ac powered with isolation transformer to eliminate polarity problems and shock hazard.—**Winegard Co.**, 3000 Kirkwood Street, Burlington, Iowa 52601.

Circle 33 on reader service card

PULSE GENERATOR, model 8011A has high-voltage output for testing MOS circuitry as well as linear circuits. Pulse amplitude variable from 250 mV to 16 volts. Source impedance on lower ranges is 50 ohms; in 4- to 16V range, either ohms or high impedance can be selected. Pulse polarity can be positive, negative, or symmetrical.



Repetition rate is variable from 0.1 Hz to 20 MHz. Repetition rates slower than 0.1 Hz are obtained by external triggering, or switching the instrument to square wave mode where repetition rate can be 0.05 Hz to 10 MHz. Pulse width can be varied from 25 nano-seconds to 100 milliseconds. \$435.00.—**Hewlett-Packard Co.**, 1501 Page Mill Road, Palo Alto, Calif. 94304.

Circle 34 on reader service card

DDM, model 168 automatically selects proper range and moves decimal point into correct position. Direct-reading LED display indicates all information pertinent to a reading. Two terminals for all measurements on all functions. Simple connections; no special test leads. Five functions are selected by front panel pushbuttons and cover 24 different ranges that include five ranges of ac and dc voltage, six ranges of resistance, and four ranges of ac and dc current. Basic dc accuracy is 0.1% of reading. Auto-ranging unit has two modes of resistance measurement. Operates on any voltage between 90 and 250 volts rms

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of $\pm 0.5\%$ of reading is guaranteed for frequency response down to 20 Hz Basic accuracy of $\pm 1\%$ of reading is guaranteed for all ac current ranges over 30 Hz to 5 kHz frequency response Specified reading time of 3 seconds on all ranges of all functions Automatically disconnects its input if a function button is not depressed Lockout feature prohibits selection of more than one function Single printed circuit board contains all calibration adjustments and virtually all components Almost entire digital circuitry is contained on one custom-designed IC chip that uses LSI \$299.00 — Keithley Instruments, Inc., 28775 Aurora Road, Cleveland, Ohio 44139

Circle 35 on reader service card

MODULAR AUTOMATIC TURNTABLE, model 1120 features bi-directional viscous-damped cue and pause control, adjustable anti-skate and stylus pressure control, factory-installed ceramic cartridge with diamond stylus and



fingerlift automatic pickup arm locking rest, interchangeable manual and automatic play spindles, and 11-inch turntable platter with cushioned protective mat Molded base, tinted dust cover ac and audio cords \$59.95 — Glenburn/McDonald, Inc., 787 Susquehanna Avenue, Franklin Lakes, NJ 07417

Circle 36 on reader service card

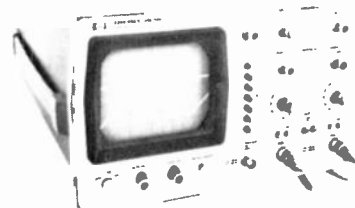
WOW AND FLUTTER METER, model M-1 uses wide-carrier-range percentage demodulator



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Continued on page 86

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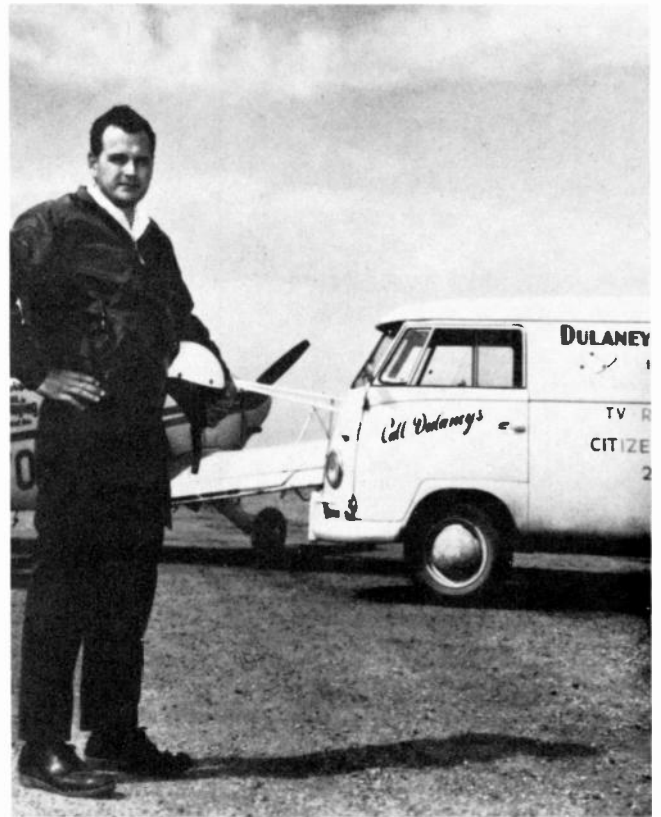
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One reason is that the United States Government doesn't permit anyone to service two-way radio systems unless he's *licensed* by the FCC (Federal Communications Commission).

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As a licensed man, working by the hour, you would usually charge at least \$5.00 per hour, \$7.50 on evenings and Sundays, plus travel expenses.

Or you could set up a regular monthly retainer fee with each customer. Your fixed charge might be \$20 a month for the base station and \$7.50 for each mobile station. Studies show that one man can easily maintain at least 135 stations—averaging 15 base stations with 120 mobiles! This would add up to at least \$12,000 a year.



Edward J. Dulaney, Scottsbluff, Nebraska, (above and at right) earned his CIE Diploma in 1961, got his FCC License and moved from TV repairman to lab technician to radio station Chief Engineer. He then founded his own two-way radio business. Now, Mr. Dulaney is also President of D & A Manufacturing, Inc., a \$1,000,000 company building and distributing two-way radio equipment of his own design. Several of his 25 employees are taking CIE courses. He says: "While studying with CIE, I learned the electronics theories that made my present business possible."

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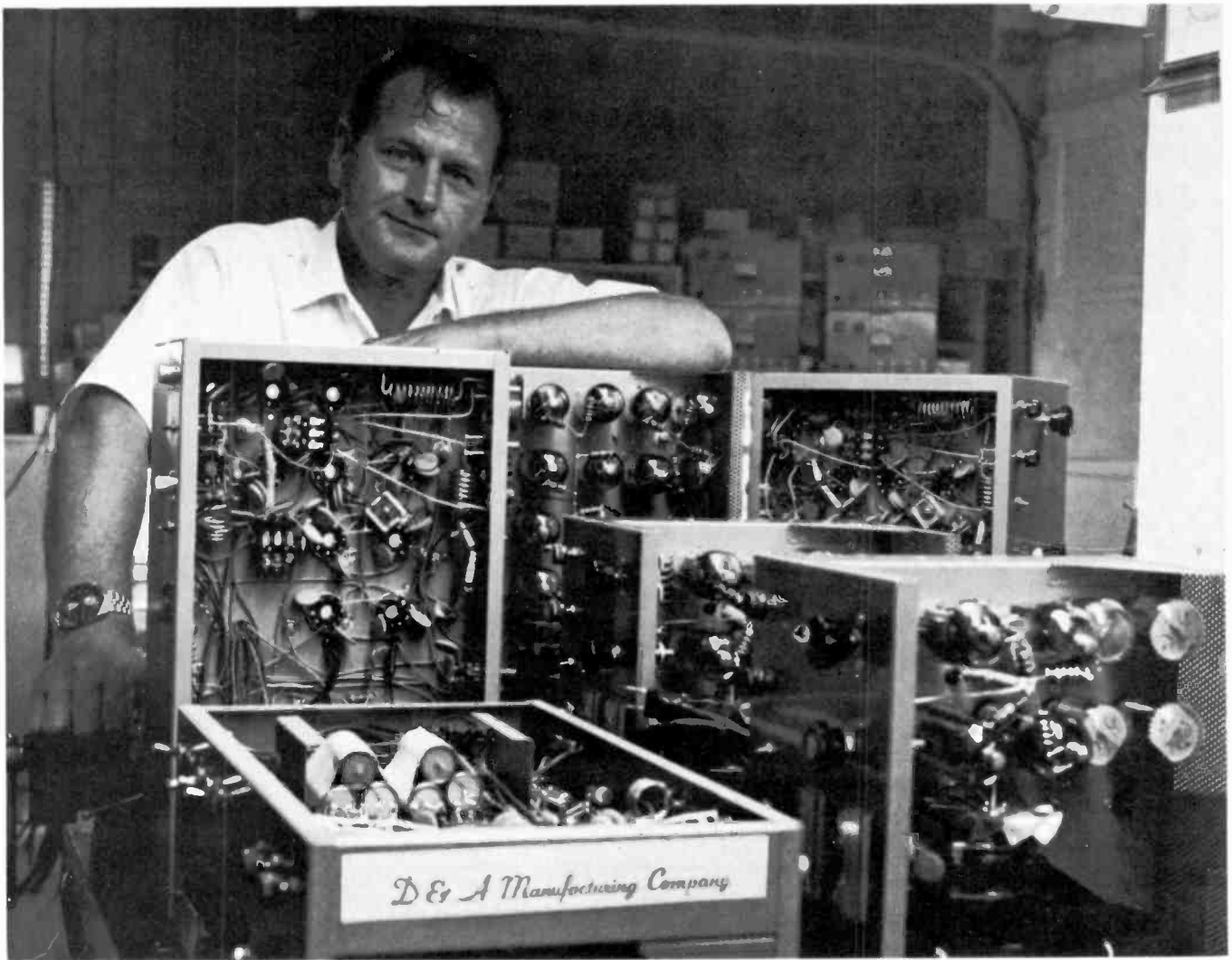
There are other advantages, too. You can become your own boss — work entirely by yourself or gradually build your own fully staffed service company. Of course, we can't promise that you will be as successful as Ed Dulaney, or guarantee that you'll establish a successful two-way radio business of your own, but the opportunities for success are available to qualified, licensed men in this expanding field.

How To Get Started

How do you break in? This is probably the best way:

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(continued from page 81)

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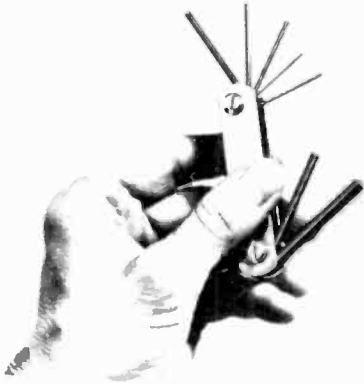
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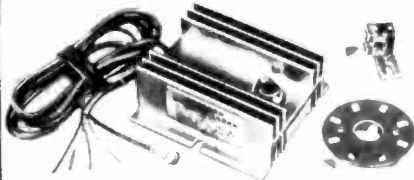
3 mm, 4 mm, and 5 mm. Blades are made of #8650 nickel-chrome-molly wrench steel and are precision drawn. Individually carded \$2.48—**Vaco Products Co.**, 510 North Dearborn Street, Chicago, Ill. 60610.

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Only **\$49⁹⁵** ● **SATISFACTION GUARANTEED!**

● Complete ● **1-YEAR FACTORY WARRANTY.**

(State Make, Year, Engine Size). (Calif. Res. add Tax).

● **CONVERT YOUR "C-D" UNIT TO BREAKERLESS!**
"TRIGGER-UNIT" ONLY \$34.95

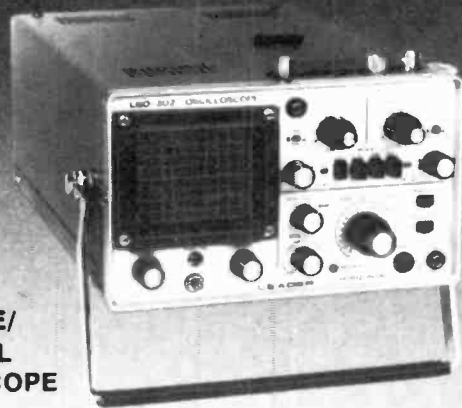
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ALLISON AUTOMOTIVE CO.

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Circle 65 on reader service card

Our little "3-incher" is bigger than anybody's!



LBO-302
**3" DUAL TRACE/
DUAL CHANNEL
TRIGGERED SCOPE**

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With accessories

Conquer the test bench squeeze! Obtain lab-grade quality! Here's solid state accuracy plus push-button convenience for trig. & auto. sweep & "free run" momentary function. ● 10MHz b'width ● 10mVp-p/div to 5Vp-p/div Vert. Sen-

sitivity, 9 steps. ● Sep. or simult. sweep display, ch 1 & 2 - alt, chopped, algebra added and X-Y vector. ● Sweep range from 1μs/div (0.2μs w/SX mag) to 0.2s/div, 17 steps. ● Polarity inversion on ch 2. ● 4 3/4"H, 10 lbs.

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INSTRUMENTS CORP.

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"Put us to the test!"

Circle 66 on reader service card

Model AT15S cartridge shown
in Model AT1009 tone arm.



THE HOT TIP IS SHIBATA ...and audio-technica!

The only phono stylus tip designed for the new discrete 4-channel records is the new Shibata multifaceted stylus.

It's the stylus we include on our AT12S, AT14S, AT15S & AT20SL Audio-Technica Dual Magnet*

cartridges. To give you correct, long-lasting performance from discrete 4-channel records. And better sound from any matrix record or present stereo disc as well.

Audio-Technica Dual Magnet cartridges are brand new and loaded with features. Like a separate, independent magnetic system for each side of the stereo groove. And smooth response to 45,000 Hz and beyond. Plus very low moving mass for superior tracking ability.

Get a tip from leading audio showrooms throughout the country who are now stocking and recommending the Audio-Technica Dual Magnet cartridges. For every modern record you own.

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*U.S. Patent No. 3,720,796; 3,761,647

AUDIO-TECHNICA U.S., INC., Dept. 64E, 1655 W. Market St., Fairlawn, Ohio 44313

Circle 67 on reader service card

VIDEOTAPE-VIDEODISC

(continued from page 35)

independent firms using its real-time duplicating equipment for dubbing of Omnivision cartridges. Later in the year the firm expects to start shipping duplicating equipment that permits 10-times-real-time duplication of the half-inch cartridge. The company also provides cartridge duplication at its own marketing/warehousing/servicing facilities in New York, Georgia, Illinois and Texas.

In addition to the above, there are scores of independent software duplicators and producers. Using pairs of recorders, they can duplicate on a one-to-one basis in any of the key formats. These companies, by providing a needed service, are helping to expand the overall VTR market. And in the process are helping themselves to expand, to become bigger, even more important in the total industry.

Will it ever be HVTR?

While VTR today is considered to be primarily an industrial/educational/medical proposition, there is a certain amount of consumer interest building up. The consumer—or "home" market for VTR is generally put at 5% of total sales.

One waggish source pointed out that a "home" market for VTR was developing at a much faster clip than most people realized. He noted that dozens of realtors had adopted VTR's as a means of selling homes, instead of transporting prospects to various home sites, the realtor merely flips a switch and the prospect can check out what's

available on a TV screen—without leaving the realtor's office. The cartridge tapes show inside and outside views of the homes up for sale, along with views of adjacent homes. The realtors are enthusiastic about the VTR approach in that it saves a lot of time and travel... and gasoline.

The bulk of today's consumer market is sales of equipment to an avant garde known as "video freaks". This group uses the equipment for its own pleasures. It is also instrumental in developing some of the software — pornographic — that is being used on a commercial level.

The latter is largely motel proprietors who operate videocassette or cartridge players through the TV sets of motel rooms, offering raunchy program fare as an inducement or "special attraction" beyond traditional services to the wayfarer. The motels are quite open about their special offerings; they run newspaper ads heralding them. A typical headline is "Adult Movies! In the privacy of your own motel room, X-Rated!"

In fact, the pornographic aspect is regarded by many observers as one of the most important "hooks" to attract "Mr. Jones" to VTR, and eventually create a consumer market of such magnitude that it will put the "home" back into the early-days phrase "Home Video Tape Recorder."

Another hook that is helping to create a home market for VTR is exposure to the concept. Scores of sales have been chalked up by video product retailers to people who have seen VTR used in schools or at their places of employment. These consumers see the value of VTR for their own use at home, as a multi-value instrument for learning, pleasure, etc.

FIVE CHEMICALS. *Blast-Off* dispenses dry air under pressure to remove dust and loose oxide deposits from delicate electronic and mechanical assemblies. *Stik-E* spray adhesive is used for permanent or temporary bond on almost any kind of material. *Corona Dope* is a high-voltage insulating spray that prevents arcing



and corona. *Slic-Spray* is a silicone spray that stops squeaks, prevents rust, and lubricates, used where sticking is a problem. *WE40*, a lubricant and moisture displacer, cleans and frees rust from tools, locks, and other metal products; corrects electrical shorts due to moisture — **Workman Electronic Products, Inc.**, Box 3828, Sarasota, Fla. 33578.

Circle 40 on reader service card

2-WAY RADIO, Messenger 130. Radiotelephone configuration features automatic control of built-in speaker function. With handset in the cradle position, the speaker is activated so incoming calls can be heard. When operator lifts the handset, the speaker is automatically silenced to permit private handset listening. Optionally, the operator can continue to have the loud-speaker active by flipping a switch to the "speaker" position.

Contains push-to-talk bar in the handle. Other controls provide full CB functions, including operation on all 23 channels plus PA

(continued on page 91)

**Accuracy like a VTVM...
Convenience like a VOM...
NEW BATTERY-OPERATED FET
SOLID-STATE VOLT-OHMMETER #116**

Easy-to-build KIT

\$32.40 = 116K

Factory-wired & Tested

\$44.90 = 116W

Now you can get all the benefits of a VTVM (laboratory accuracy, stability and wide range) but with its drawbacks gone: no plugging into an AC outlet, no waiting for warm-up, no bulkiness. New Field Effect Transistor (FET) design makes possible low loading, instant-on battery-operation and small size. Excellent for both bench and field work.

Compare these valuable features:

- High impedance low loading: 11 meg-ohms input or DC, 1 megohm on AC • 500-times more sensitive than a standard 20,000 ohms-per-volt VOM • Wide-range versatility: 4 P-P AC voltage ranges: 0-3.3, 33, 330, 1200V; 4 RMS AC voltage ranges: 0-1.2, 12, 120, 1200V; 4 DC voltage ranges: 0-1.2, 12, 120, 1200V; 4 Resistance ranges: 0-1K, 0-100K, 0-10 meg., 0-1000 meg.; 4DB ranges: -24 to +56DB.

Sensitive easy-to-read 4 1/2" 200 micro-amp meter. Zero center position available. Comprises FET transistor, 4 silicon transistors, 2 diodes. Meter and transistors protected against burnout. Etched panel for durability. High-impact bakelite case with handle useable as instrument stand. Kit has simplified step-by-step assembly instructions. Both kit and factory-wired versions shipped complete with batteries and test leads. 5 1/4" H x 6 3/4" W x 2 7/8" D. 3 lbs.



Send FREE catalog of complete EMC line and name of nearest distributor. **RE-6**

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**If you're a professional...
a \$129.00
telephone answering machine
isn't the answer.**

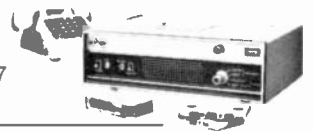
Record-O-Fone units are quality engineered with the professional in mind and offer important features not found in other makes. Say a caller wants to leave a message that's more than 10 or 20 seconds long. No problem. With Record-O-Fone he can leave as long a message as necessary... and so can you. And if something comes up, or you're delayed, Record-O-Fone lets you change the message you've left for callers without ever going back to the office! Try doing that with a \$129 unit. You don't have to wait to get back to the office to collect your messages either.

There are many more advantages to owning a Record-O-Fone for your office, such as never having to put up with annoyed or inefficient answering service operators, and the fact that Record-O-Fone is backed by the world's largest most experienced service organization. But the real question isn't whether or not you think Record-O-Fone is worth the investment... it's whether or not you think your business is.

For more information on the full line of Record-O-Fone units, fill out and return coupon. Record-O-Fone. It's the next best thing to being there.

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RCA 110° FLYBACK TRANSFORMER



We scooped the Market Latest type - standard for all 110° TV's
 RCA's design of large Coil produces 18KV - assuring adequate width Incl. Schematic Diagram application for any TV
 List price \$13.90
 Your price... **\$3.95**
 10% off in lots of 3

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Leaves messages for other for replay... Built in speaker/microphone for talk-into convenience... Records up to 3 minutes of messages... Illuminated signal shows when a message is waiting. Control adjusts playback volume without affecting recording volume... Capstan Drive;
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 Best TUNER "SARKES TARZIAN" ever made - last word for stability, definition & smoothness of operation. An opportunity - to improve and bring your TV Receiver up-to-date.
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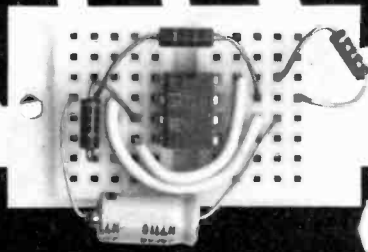
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Circle 71 on reader service card

WHILE THEY LAST!!

88.014 SECURITY 88 MHz. EQUIPMENT



SECURITY TRANSMITTER:

Crystal controlled, tone modulated, R.F. device which contains: crystal, audio+R.F. transistors, reed switch, audio+R.F. coils, etc.

\$1.25 each		10/\$8.50
2/\$2.00	8 oz. Shp. Wt.	100/\$80.00

SUPER HET. CONTROL, RECEIVER:

Crystal controlled, with re-transmitter. Contains timing circuits, electronic siren, 12 volt power supply with relay output. Operates on 110 VAC or 12 VDC.

\$5.00 each	4 lb. Ship. Wt.	100/\$300.00
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REMOTE RECEIVER:

Crystal controlled receiver includes timing circuit, power supply with relay output. Operates on 110 VAC or 12 VDC.

\$3.50 each	4 lb. Shp. Wt.	2/\$5.00
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ALL EQUIPMENT SOLD AS IS.

Include sufficient postage; excess will be refunded. NO CASH OR C.O.D., please. California residents add sales tax.

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Circle 72 on reader service card

NEW PRODUCTS

(continued from page 88)

capability. Solid-state circuitry also features automatic gain control (agc) and noise limiting (anl) on receive, plus electronic speech compression on transmit. \$199.95—complete with



mounting bracket for under-dash or transmission hump mounting—E.F. Johnson Company, Dept. 72-19, Waseca, Minn. 56093.

Circle 41 on reader service card



Everything you wanted to know about CD Ignition Systems but didn't know whom to ask.

Send for FREE Tiger booklet (20 pages) which answers all your questions.

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 Circle 73 on reader service card

Cancer's seven warning signals

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4. Thickening or lump in breast or elsewhere
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6. Obvious change in wart or mole
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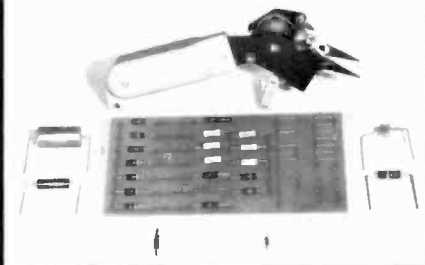
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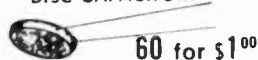


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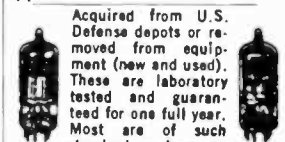
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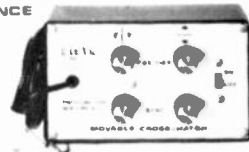
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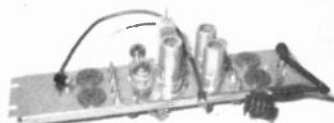
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3/16" x 5/8" x 1/4"
50, 100, 500, 2000, 5000,
10,000 and 20,000 ohms.
\$1.50 ea. 3/\$4.00

PRINTED CIRCUIT BOARD
4 1/2" x 6 1/2" single sided paper epoxy board, 1/16" thick, unetched
\$.40 ea. 5/\$1.75

NIXIE TUBES
Similar to Raytheon 8650 tubes, with socket & data sheet **\$2.25 3/\$6.00**

NSN 33 — 3 DIGIT LED ARRAY, MAN-3 SIZE (.12") INTERNALLY MULTIPLEXED AND DRIVEN BY 7448... **\$3.50 EA.**

VERIPAX PC BOARD
This board is a 1/16" single sided paper epoxy board, 4 1/2" x 6 1/2" (standard veripax). DRILLED and ETCHED which will hold up to 21 single 14 pin IC's or 8, 16 or LSI DIP IC's with buses for power supply connections. Is also etched for 22 pin connector **\$5.25**

FLV 100 VISIBLE LED **\$.50**
ME-4 IR LED **\$.50**
MCD-2 OPTO-ISOL **\$.90**
GREEN GAP OSL-16 LED **\$.90**
RED GAP OSL-3 LED **\$.60**
14 PIN DIP SOCKETS **\$.40**
10 WATT ZENERS
3.9, 4.7 OR 5.6 V **\$.75 EA**
4WATT ZENERS
3.9, 5.6, 6.8 OR 12 V **\$.30 EA**

Silicon Power Rectifiers

PRV	1A	3A	12A	50A
100	.06	.11	.30	.90
200	.07	.16	.35	1.25
400	.09	.20	.50	1.50
600	.11	.25	.70	1.80
800	.15	.35	.90	2.30
000	.20	.45	1.10	2.75

IN 4148... **14/\$1.00**
Terms: FOB Cambridge Mass. Send check or Money Order. Include Postage. Minimum Order \$3.00

TRANSISTOR SPECIALS

MPS 3391A NPN Si TO-92	5 \$1.00
2N1137B PNP GE TO-3	\$.95
2N3137 NPN Si TO-5	4/\$1.00
MPS3393 NPN Si TO-92	4 \$1.00
2N3866 NPN Si TO-5	\$.75
2N5324 PNP GE TO-3	\$.50
2N2369 NPN Si TO-18	5/\$1.00
2N3767 NPN Si TO-66	\$.70
2N2222 NPN Si TO-18	5/\$1.00
2N3055 NPN Si TO-3	\$.100
2N5296 NPN Si TO-220	\$.50
2N6109 PNP Si TO-220	\$.55
2M4898 PNP Si TO-66	\$.60
MJ2252 NPN Si TO-66	\$.90
2N3638 PNP Si TO-5	5/\$1.00
2N218A NPN Si TO-5	4/\$1.00

C/MOS (DIODE CLAMPED)

74C 02	\$.75
74C 10	\$.65
74C 157	\$2.15
74C 165	\$3.50
CD 4001	\$.65
CD 4002	\$.65
CD 4009	\$1.50
CD 4010	\$.65
CD 4011	\$.65
CD 4012	\$.65
CD 4013	\$1.60
CD 4016	\$1.25
CD 4022	\$2.25
CD 4023	\$.65
CD 4025	\$1.50
CD 4027	\$1.35
CD 4030	\$.65

CAPACITORS

6V 30 UF TANT. 5 \$1	
20V 4.7UF TANT. 5 \$1	
12V 10UF ELECT. 5 \$1	
50V 100UF ELECT. 4 \$1	
25V 30UF ELECT. 4 \$1.00	

MAN 1. RED OR YELLOW LED READOUTS \$3.25

MAN-3 LED READOUTS \$1.75

MAN-4 LED READOUTS \$2.50

Full Wave Bridges

PRV	2A	6A
200	95	1.25
400	1.15	1.50
500	1.35	1.75

1103 1024 bit RAM	\$.75
NEC 6003 2048 bit RAM	\$1.95
1101 256 bit RAM	\$.35
8225 64 bit-write RAM	\$3.50
8223 PROGRAMMABLE ROM	\$.65

5311—CLOCK CHIP 6 DIGIT BCD HOLD COUNT, OUTPUT STROBE	\$8.50
5314—CLOCK CHIP 6 DIGIT HOLD COUNT, OUTPUT STROBE	\$8.50
5316—ALARM CLOCK CHIP	\$13.95

Conductive Elastometer low profile calculator keyboard. A 2 3/4" x 3 1/4" flex key. 19SK-6 keyboard having 0-9, K + C buttons with off. on switch. **\$6.00**

Injection laser—a single diode 6W. 25A Ga As unit similar to RCA 40859 **\$10.95**

Dual tapered CDS photo cell used for optical alignment with a single plane lens. (Not included). **\$.95**

TTL IC SERIES

74100	50	7476	52
7400	24	7480	65
7401	24	7483	1.10
7402	24	7486	.48
7403	24	7489	3.00
7404	26	7490	.83
7405	26	7491	1.30
7407	50	7492	.85
7408	50	7493	.85
7410	24	7495	.99
7411	30	7496	.95
7412	45	74107	.50
7413	85	74121	.60
7416	48	74123	1.00
7417	48	74125	1.40
7420	24	74126	1.40
7422	30	74150	1.15
7426	30	74151	.95
7427	55	74154	1.65
7430	24	74157	2.05
7432	30	74164	2.25
7437	60	74165	2.05
7438	50	74173	1.80
7440	24	74176	1.80
7441	1.15	74177	1.80
7442	1.00	74192	1.50
7445	1.15	74193	1.45
7446	1.25	74195	1.00
7447	1.25	75451	1.00
7448	1.30	75452	1.00
7450	24	75491	1.10
7451	30	8210	1.50
7472	40	8211	1.50
7473	48	8220	1.50
7474	48	8520	1.75
7475	80	LM 351	1.00

Similar to 8038C IC Voltage controlled oscillator, as featured in Oct. 73 P.E. they have sine, square and triangular outputs good to 1MHz. Two of them can be used to make an FM generator... **\$5.95**

TIS 73 N FET	\$.60
2N4891 UJT	\$.50
ER900 TRIGGER DIODES 4	\$1.00

LINEAR CIRCUITS

LM 309K 5V 1A REGULATOR	\$2.25
723 -40 +40V REGULATOR	\$.75
LM 300H REGULATOR POSITIVE	\$.90
LM 320 5 or -15V REGULATOR	\$1.75
LM 376 -V to 37V POS REG.	\$1.25
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709C OPER AMP	\$.47
DUAL 709 DUAL OP AMP	\$1.25
101 OPER AMP	\$.75
LM 308 OPER AMP HI PERFORM	\$.75
LM 308 OPER AMP LOW POWER	\$1.15
747 -DUAL 741	\$1.00
536 -FET INPUT OPER AMP	\$3.25
537 -PRECISION OP AMP	\$2.50
LM 3900 -QUAD OP AMP	\$.75
LM 324 -QUAD 741	\$2.20
560 -PHASE LOCK LOOP	\$2.95
561 -PHASE LOCK LOOP	\$2.95
565 -PHASE LOCK LOOP	\$2.95
567 -TONE DECODER	\$2.95
703 -RF-IF AMP	\$.80
LM 370 -AGC SQUELCH AMP	\$1.25
555 -2 μs - 2 HR. TIMER	\$1.40
3822 -TRANSISTOR ARRAY	\$.95
LM 380 -2W AUDIO AMP	\$1.75
LM 377 -2W STEREO AUDIO AMP	\$3.25
LM 381 -STEREO PREAMP	\$1.75
LM 382 -DUAL AUDIO PREAMP	\$1.95
LM 311 -HI PER. COMPARATOR	\$1.20
LM 319 -DUAL HI SPEED COMP	\$1.50
LM 339 -QUAD COMPARATOR	\$1.95

TRIACS

PRV	1A	10A	25A	5A	6A	35A
100	.40	.70	1.30	.40	.50	1.20
200	.70	1.10	1.75	.60	.70	1.60
400	1.10	1.60	2.60	1.00	20	2.20
600	1.70	2.30	3.00			3.00

SCR'S

PRINTED circuit techniques for the hobbyist. Ferric chloride "suspension etching"; cutting epoxy glass; screen printing, etc. Booklet \$2.00. **TRUMBULL**, 833 Balra Dr., El Cerrito, Calif. 94530

DIGITAL: THEORY, DESIGN, CONSTRUCTION

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Kit Contains NORTEC calculator chip 4024, 21 driver transistors, 8 LED's, 7 segment readout by EXITON, 3 LED for overflow, low btry, over-range, a keyboard by FLEX KEY. All this \$45 value for only... \$16.50 2 for \$27

BASIC CLOCK KIT

We furnish clock chip CT 7001 and 4 first line LED readouts .3 inch hgt. You furnish the misc. minor parts. A \$35 value for... \$19.95

LIQUID CRYSTAL WATCH

Build a wrist watch or desk clock with this liquid crystal display. Recently written up in several magazines. Display with special socket reads hours and minutes... \$15 2 for \$25

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Brand new by OLIN. Use it for a swim pool monitor-alarm, use it on lake or ocean listening to underwater noises, fish, etc. Complete with hydrophone, 50 ft mike cable, speaker-amplifier console. Operates from 115 volts AC or 15 volt dry cells. 12 lbs \$25

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Circle 85 on reader service card

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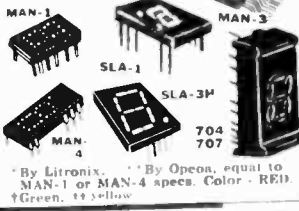
- | | |
|---|--------|
| <input type="checkbox"/> 1-MV2, TO-18, dome, green, visible | \$1.00 |
| <input type="checkbox"/> 1-MV2, green small dome, green diff. lite | 1.00 |
| <input type="checkbox"/> 2-MV2, clear small plastic dome, green diff. lite | 1.00 |
| <input type="checkbox"/> 2-MV3, micro-mini pin head dome, TO-18, green lite | 1.00 |
| <input type="checkbox"/> 2-MV3, visible, "cousin pin pak" red, mini dome lens | 1.00 |
| <input type="checkbox"/> 1-MV50, axial leads, micro-mini dome, clear, red, TO-18 | 3.95 |
| <input type="checkbox"/> 1-MV4, stud, high power, red, 2-watts | 3.95 |
| <input type="checkbox"/> 1-MV4H, stud, high power, hi-dome, red, 2-watts | 1.00 |
| <input type="checkbox"/> 5-MV10B, visible, red, clear dome lens TO-18 | 1.00 |
| <input type="checkbox"/> 5-MV10C, visible, red, diffused, dome lens, TO-18 | 1.00 |
| <input type="checkbox"/> 1-MV52, axial leads, micro-mini dome, clear, red, TO-18 | 1.00 |
| <input type="checkbox"/> 1-MV52, micro-mini, axial green lens, green lite | 1.00 |
| <input type="checkbox"/> 1-MV53, micro-mini, axial yellow lens, yellow lite | 1.00 |
| <input type="checkbox"/> 5-MV54, micro-mini, axial leads, red lens, red lite | 1.00 |
| <input type="checkbox"/> 5-MV55, micro-mini, axial leads, red lens, red lite | 1.00 |
| <input type="checkbox"/> 5-MV5012, red small dome lens, red lite, TO-18 | 1.00 |
| <input type="checkbox"/> 5-MV5013, sm. dome, 2 hi red dome, and red diff. lite, TO-18 | 1.00 |
| <input type="checkbox"/> 5-MV5020, jumbo clear dome, visible, red, TO-18 | 1.49 |
| <input type="checkbox"/> 1-MV5040, 4-LED red array, with 5-lead pak | 1.00 |
| <input type="checkbox"/> 5-MV5054, red jumbo dome lens, TO-18 red lite, upright | 1.00 |
| <input type="checkbox"/> 5-MV5080, TO-18, micro-mini dome, red lite | 1.00 |
| <input type="checkbox"/> 5-MV5080, TO-18, micro-mini flat clear lens, red lite | 1.00 |
| <input type="checkbox"/> 1-MV5094, red bi-polar, solid state lamp V to 110-115VAC-DC | 1.98 |
| <input type="checkbox"/> 2-MV5222, green jumbo dome, green lite, panel snap-in | 1.00 |
| <input type="checkbox"/> 2-MV5282, micro-mini, green lens TO-18, green lite | 1.00 |
| <input type="checkbox"/> 2-MV5322, yellow jumbo dome, yellow lite, panel snap-in | 1.49 |
| <input type="checkbox"/> 1-MV5491, jumbo, Tri-State, RED, GREEN, OFF, special | 1.49 |
| <input type="checkbox"/> 2-MT2, photo transistor, light sensor, TO-18 | 1.00 |
| <input type="checkbox"/> 2-MC22, 1500V isolation photo transistor | 1.00 |
| <input type="checkbox"/> 2-MC22, 1500V isolation photo diode | 1.00 |

7-SEGMENT LED Readouts

(All "LED" TYPES)

Type	Char.	Each	Special
MAN-1	.27	\$3.75	3 for \$9.
MAN-3	.12	1.49	3 for \$3.
MAN-4	.19	2.50	3 for \$6.

Type	Char.	Each	Special
707*	.33	2.50	3 for \$6.
704*	.33	2.50	3 for \$6.
SLA-1**	.33	2.10	3 for \$5.
SLA-3**	.70	4.95	3 for \$13.
SLA-11**	.33†	3.50	3 for \$10.
SLA-21**	.33††	3.95	3 for \$10.



*By Litronix. *By Opeco, equal to MAN-1 or MAN-4 specs. Color - RED. †Green. ††Yellow.

GIANT SALE ON 3-DIGIT READOUTS

\$2.50 9 DIGITS FOR \$6. Made by National, their Type NSN-33. With red lens filter. Properly multiplexed. Three digit size of MAN-3. Driver SN7448, 10 mils. Case only 9/16" x 3/8" x 1 1/16". 12-pins. For pc boards, or fits into standard dual in socket. For calculators, DCMs, DVM, Clocks and 1000's of indicating devices. Price is lowest we have seen! 100% perfect. Buy all good digits, not rejects as the Hewlett Packard's advertised by others.

READOUTS BY THE DIGIT!

LOWEST PRICE ANYWHERE! Per Digit **\$1.** Buy ANY 9 DIGITS FOR \$5.

Poly Paks buy complete National inventory of 1-digit missing NSN-33. Same as the \$2.50 unit except 1-digit out. Properly multiplexed, so that you may use 2 of the units. Line-up, as you wish and get the desired combination. Zero means that digit is missing. Numerical 8 meaning 100% good unit. **LOWEST PRICES ANYWHERE.** WHERE. Imagine not \$1.80 per digit, but \$1.00 per digit. **WHY PAY MORE? Order by digit and save \$555.**

LED MITY DIGIT "DCM'S"

Scientific Devices "Digital Counting Modules" outperform any other DCM on the market today. More features than ever before! Not gaseous, not incandescent, not like the modern LED. Choose from such famous manufacturers as Monsanto's MAN-1, MAN-4, Litronix 707 and 704, Opeco's SLA-1 (the last 4 having character heights of 0.33 at no extra charge). Each kit includes 3x2" pc board with fingers for a FREE edge connector, slide-mounting dip socket, LED readout of your choice, resistors, 3 IC's, and Minlex connectors (this **ELIMINATES SOLDERING YOUR IC'S**) and hooklet. **INCLUDES P.C. EDGE CONNECTOR - FREE!**

Only **\$9.99**

REASSEMBLY Char. Maker
 MAN-1 27 h. Monsanto
 MAN-4 19 h. Monsanto
 707* 33 h. Litronix
 704** 33 h. Litronix
 SLA-1* 33 h. Opeco

* Pin-for-pin MAN-1, ** Pin-for-pin MAN-4, elec. char same

IT'S NEW! THE 9 DIGIT ANTEX CALCULATOR

Only **\$9.95** 7 SEGMENT READOUT

First time advertised, the ultra-modern 9-digit LED display on a 2 1/2" x 1 1/2" ceramic substrate. 19-edge type connectors from substrate with connecting holes makes this unit the most useful array FOR EVERY KIND OF ELECTRONIC EQUIPMENT! Properly multiplexed. Individual BUBBLE LENS for enlarged viewing. Works with our \$6.95 keyboard and calculator chip. With spec sheets.

*Useful for 100's of miniature equipment!

Calculator Basics

MAKE YOUR OWN CALCULATORS WITH OUR LOW PRICED BASIC KITS

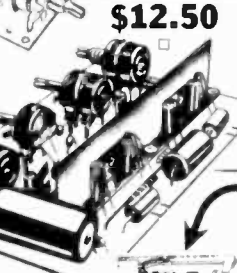
- 8-DIGIT LED Basic Kit #1 \$19.95**
Includes Case, Keyboard (by Flex-Key), CT-5002 Calculator chip for 8 digits, your choice of three 3-digit readouts, sheets.
- 6-DIGIT LED Basic Kit #2 \$19.95**
Includes Case, Keyboard (by Flex-Key), National MM5736 Calculator Chip for 6 digit indication, two 75491 segment drivers, one 75492 digit drivers, two 3-digit readouts of your choice, sheets.



4 WATT GUITAR AMP With Tremolo • SOLID STATE

Musical instrument amplifier at low, low price! Peak power output 10 watts. Two input circuits are equalized for normal or snlo guitar. The four controls are VOLUME, TONE, TREMOLO INTENSITY and TREMOLO SPEED. There are terminals on board for normally open foot switch connection. Supply voltage 18vdc. Output to 8 ohm hi-quality speaker, input impedance 33,000 ohms. Current drain 20 mls. External power supply required. Wt. 1 lb. With instructions, hookups and diagrams. Size 8 x 2 3/4 x 3.

\$9.95 AMPEREX



8 WATT STEREO AMP

Type PCA-1C-18. Provides 8 watts per channel. May be used as stereo tuner foot! Unit has 4 controls... VOLUME, BALANCE, BASS and TREBLE. Circuit has 3 stage DC coupled power amplifier with thermostat for temperature stabilization. Each channel has separate PREAMP. Input imp 1 meg. for use with ceramic crystal cartridges. Requires external power supply. Supply voltage 18VDC. Outputs to 8 ohm speakers. Freq. response 40 Hz to 30 kHz. Current per channel 180 mA. Size 7 x 3 1/2 x 3 1/2.

\$12.50 SOLID STATE

2 TRANSISTOR AM TUNER Only \$3.50

Includes carefully matched transistors. A high Q litz wire loopstick matches the autodyne converter in stage #1 followed with and IF stage with agg control. Audio output comes from transformer coupled detector thru band of filter. Matches any audio amp with 50 mv sens. With 2 gang variable capacitor. Covers 530 to 1620 KHz. Power requirements 9V @ 6 ma, 2 x 1 1/2 x 2 1/4. Use with our Sanken amplifiers. Wt. 8 oz.

KRONOS WITH "TIME BASE"*

Cabinet is 6" x 5 1/2" x 6"

CHOOSE YOUR READOUT

Type	LED	Charac.	Sale
KR-101	MAN-3	.12	\$47.
KR-103	MAN-4	.19	47.
KR-105	707†	.33	47.
KR-106	704†	.33	47.
KR-107	SLA-1†	.33	47.
KR-108	Same as SLA-1 but GREEN.		add \$12.

6-digits **\$47.** Any Type Clock less time-base **NEW FOR 1974!**

*With TIME BASE \$64.95

Scientific Devices introduces the new any LED Kronos digital clock. That's right, you can choose the "ALL-STAR" Man-1, Man-3, and Man-4, and the new reflective bar type with the larger digits, at only one price, \$47. This is a Scientific Device first! We even have the GREEN LED readouts at a slightly extra cost. We have more... for \$19.95 we have available as an extra option to Naval Observatory your clock, or making it an all-purpose, low-duty unit. For indoor and outdoor activity. This "TIME BASE" is the simplest time base manufacturers for the famous digital wrist-watches. Therefore, current drain is negligible, not like other cumbersome types. It's easy to construct, easy to construct. Its overall design is simple and connect with instructions. Its overall design is simple and connect with instructions. Its overall design is simple and connect with instructions. Its overall design is simple and connect with instructions.

CRYSTAL TIME BASE FOR ANY KRONOS* **\$19.95**
Includes precision crystal, time-base IC, pc board & accessories with info.

2 XCITON \$1 MICRO MINI YELLOW LED

XC212Y, 185 x .095 yellow diffused lens, for indicator use. 2.4V @ 10 mls viewing angle 40°. Upright.

XC209Y YELLOW MEDIUM LED
.210 x .125 yellow diffused lens, for indicator use. 2.4V @ 10 mls Upright.

MEDIUM JUMBO YELLOW LED
XC22Y, .340 x .160 yellow clear lens, point indicator use. 2.4V @ 10 mls Upright. Viewing angle 65°.

XC24Y, a XC222, illuminator use, 14° view angle.

XC26Y, a XC22Y, but diffused lens, indicator use, viewing angle 80°.

JUMBO YELLOW LED
XC22Y, wide angle illuminator. 2.4V @ 1.0 mls. 80° viewing angle. 340 H x 200 dia Yellow diffused lens.

XC-554Y-2, a XC22Y, except yellow clear lens - illuminator use. 24° angle.

XC-556Y, a XC22Y, except yellow diffused lens, indicator use. 30° view angle.

CALCULATOR CHIPS ON A "DIP"

Similar to Mostek 5001. Outperforms Texas Instruments 40-pin DIP. Adds, multiplies, subtracts, and divides. Use with 7 segment readouts, Nixies, and LEDs. DATA SHEETS

CT5001	12-digits 40-Pin	\$6.50	3 for \$18
CT5002	9 Volt version of 5001	8.50	3 for \$24
CT5003	12-digits 28-Pin	9.95	3 for \$27
MM5736	6-digits, 28-pin, 9V.	8.88	3 for \$24.

POCKET CALCULATOR KEYBOARD

For hand-held units, properly multiplexed for chip use. CT-5001, 2, 12 or Mostek 5010-12, 18 feather-touch keys, by FLEX KEY. **Only \$6.95** 3 for \$18.

OAK FEATHER-TOUCH SWITCHES

For RTTY, test data systems, printed circuits, etc. Same as used in Keyboard Calculator, SPST Normally Open, 24V 1 amp contacts. Characters and letters, easily changed. High, printed circuit. *White top, black numbers. *3 for \$1. 39¢

CALCULATOR KEYBOARD SWITCH KITS

Each switch made by Oak 2415, SPST normally open, 24V 1 amp contacts. Kit includes 0-9 (10 switches) white with black numerals, decimal, white with black dot, and CE, CL and 4 functions blue with white characters. **Kit of 17 for \$6.95** 10 pc. kit, 0 to 9 only same type as above. 2.95

4-FUNCTION MEMORY "CALCULATOR KIT"

Pocket type, the lowest price 4-function memory with all arithmetic. Complete with all parts, instruction booklet. **\$59.95**

Terms: add postage. Rated: net 10. Photo Order: Wakefield, Mass. (617) 245-3829. Retail: 16-18 Old Curline St., Wakefield, Mass. (off Water Street) C.O.D.'S MAY BE PHONED.

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7-SEGMENT READOUT
12-PIN DIP

- Three digits with right-hand decimal
- Plugs into DIP sockets
- Similar to (LITRONIX) DL337
- Magnified digit approximately .1"
- Cathode for each digit
- Segments are parallel for multiple operation

5 - 10 MA per segment
EACH \$3.95 4 (12 Digits) \$13.00

RCA 2010
Numitron Digital Display Tube, incandescent 5-volt 7-segment:
.6" High numeral visible from 30 ft
Standard 9-pin base (solderable)
Left-hand decimal point
EACH \$5.00 5 FOR \$20.00

CT5005 A single MOS chip with all the logic necessary for a 12-digit four-function calculator with an extra storage register for constant or memory applications.
.28 Lead DIL package.
Standard 9-pin base (solderable).
Left-hand decimal point.
COMPLETE W/DATA \$14.95; DATA ONLY (Refundable with purchase of chip) \$1.00

40-PIN SINGLE CHIP
Add, subtract, multiply, and divide
12-Digit display and calculate
Chain calculations
True credit balance sign output
Automatic overflow indication
Fixed decimal point at 0,2,3, or 4
Leading zero suppression
DATA ONLY (refundable with purchase of chip).....\$1.00
COMPLETE WITH DATA.....\$9.95

CD-2 COUNTER KIT
Unit includes board, 7490, 7475, quad latch, 7447 seven-segment driver, and RCA DR2010.
COMPLETE KIT only \$11.25; FULLY-ASSEMBLED \$15.00; boards can be supplied separately at \$2.00 per digit.

KEYBOARD ASSEMBLY
TRW Data Systems unit; 10 keys 0-9; 3 (or 4) 24V lamps; printed circuit board w/14 1N4001 diodes, capacitors, transistor, and resistors. All mounted in an attractive case approx. 4 1/2 x 4 1/2 x 2 1/2". These are used; no schematic is available. EACH \$6.95

LM703
RF-IF amp epoxy TO-5.
EACH \$.45 TEN FOR \$3.50

LINEARS

NE540.....	\$2.00	748.....	\$1.00
NE555.....	1.50	CA3018.....	1.00
NE560.....	3.25	CA3026.....	1.00
NE561.....	3.25	CA3045.....	1.00
NE565.....	3.25	LM100.....	1.00
NE566.....	4.00	LM105.....	1.25
NE567.....	4.00	LM302.....	1.25
NE5558.....	1.00	LM308.....	2.00
709.....	.45	LM311.....	1.75
710.....	.75	LM370.....	2.00
711.....	.40	LM703.....	.45
723.....	1.00	LM309K.....	1.00
741.....	.55	LM309K.....	2.00
747.....	1.00	LM390.....	2.00

LM1595 4-quad. mult. 2.00

Memory IC 74S206
1x256 Bipolar TTL RAM (45 ns). One bit wide by 256 deep random access memory. 3-Chip enable lines. Output is complement. Complete data supplied.
EACH \$3.95
10 FOR \$32.00

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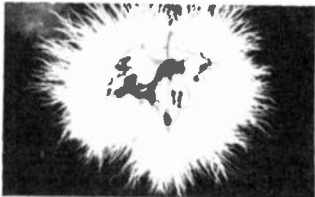
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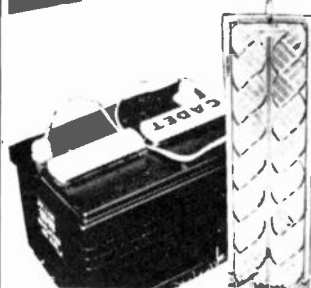
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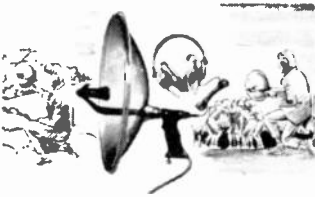


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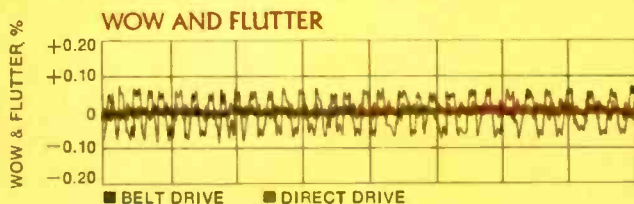
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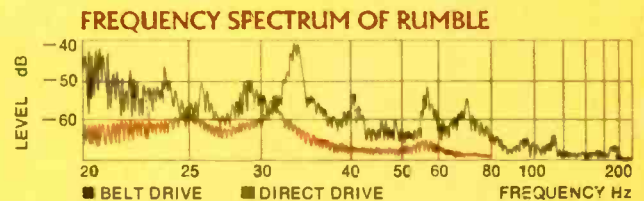
No other system measures up to direct drive. Wow and flutter are less than 0.03% WRMS. And rumble is down to -65dB (DIN A) and -70dB (DIN B).



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All Technics turntables have illuminated stroboscopes, cast aluminum platters and variable pitch controls. The SL-1200 also has a precision tone arm, viscous damped cueing and low-capacitance 4-channel phono cables.

So does the SL-1100A but with a heavier platter, bigger motor and longer tone arm.



And the SP-10 is for those who insist on choosing their own tone arm.

No matter which Technics turntable you choose, you get the finest drive system that money can buy. But don't take our word for it. Read the reviews.* And you'll agree.

The concept is simple. The execution is precise. The performance is outstanding. The name is Technics.

*SP-10: Audio, 8/71; Stereo Review, 9/71.
SL-1100A: Stereo Review, 7/73; High Fidelity, 9/73.

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