60¢ ■ MAY 1973

Radio-Electronics®

FOR MEN WITH IDEAS IN ELECTRONICS

BUILD A MODULAR ELECTRONIC MUSIC SYNTHESIZER

4-CHANNEL STEREO SQ, QS, CD4
See How Systems Compare

HEATH'S DIGITAL FM TUNER
How Its 44 Computer IC's Work

SECURITY SYSTEMS
Which One Is Best

PUBLIC ADDRESS
Setting Up A System

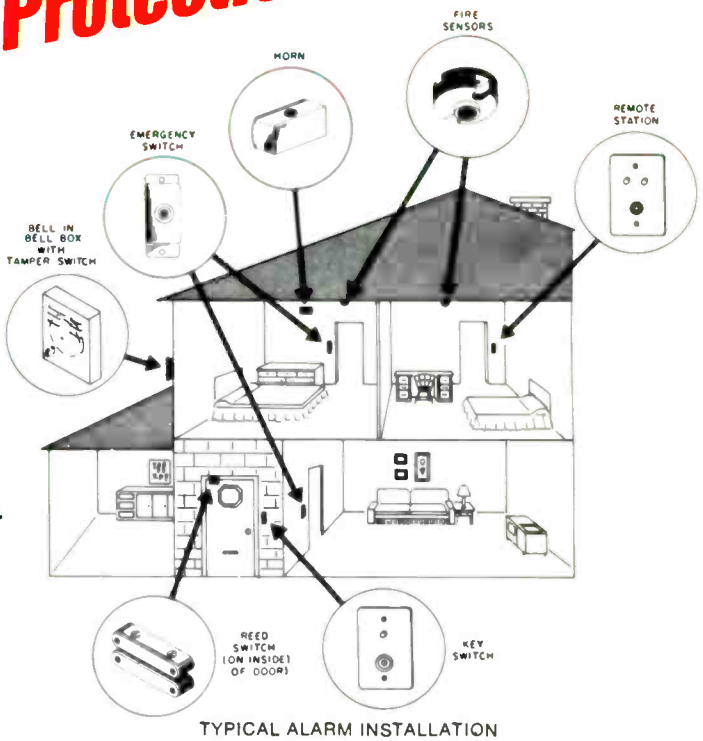
A GERNSBACK PUBLICATION

PLUS

Appliance Clinic
Speed Troubleshooting
Jack Darr's Service Clinic
Lou Garner's State-Of-Solid-State
Transistor Interchangeability Directory

NEW! EICO 'DO-IT-YOURSELF' HOME SECURITY PROTECTION SYSTEM

The Professional Home Protection everyone can Install and Afford.



TYPICAL ALARM INSTALLATION

EICO FC-100 SECURITY CONTROL CENTER

- **Start your custom Burglar/Hold-up/Fire Alarm System with the FC-100.**
- **Add on Sensors, Alarms and Accessories to suit your own needs.**
- **"Do-It-Yourself" Installers Handbook included.**
- **AC Operated-Automatic Transfer to Battery Operation in the event of Power failure**
- **No technical knowledge needed-No soldering.**
- **Ideal for Apartment, Home and certain Commercial Installations.**
- **100% Professional In Design, Reliability, Performance.**

The first professional Alarm Control Center designed for easy "Do-it-Yourself" installation. The FC-100 is the "heart" of the EICO home protection system.

It contains all circuits required for monitoring the burglar and fire detectors and sounding the alarm. It includes two indicator lights; a white "circuit test" light which automatically checks the status of the burglar alarm sensors in the system, and a red "alarm on" light, which indicates that the system has been activated. A built-in 117 VAC power supply supplies 6 volts DC for operating the system. In the event of power failure, the FC-100 automatically switches over to battery operation. The power supply also trickle charges the lantern battery when it is not in use. A meter and battery test switch allows you to check the condition of the battery. Each circuit in the FC-100 has its own set of screw terminals that allow easy installation.

Includes A-95 Security Handbook and A-105 warning decals.

Model FC-100 $69.95

EICO SS-500 BURGLAR/HOLD-UP/FIRE ALARM SYSTEM

- **Systems "HEART" is the EICO FC-100 Security Control Center.**
- **Additional Sensors, Alarms, Accessories may be added *any time* to meet future needs.**
- **"Do-it-Yourself" Installers Handbook included.**

The EICO SS-500 Security System offers you the kind of professional protection you have been looking for, at a price you can afford. The System has been designed on the EICO exclusive "Expandability Concept" that enables you to "add-on" protection to meet your own special requirements. Virtually any professional security sensing device can be easily added to the EICO SS-500.

The system is supplied with the following: FC-100 Security Control Center; SA-25 8" Alarm Bell; A-45 Entrance Key-Switch with "system-on" signal light; A-65 remote station control with signal lights; SD-20 Fire Sensors; SD-10 Door/Window Contact Switches; SD-50 Tamper Switches; SD-40 Door Cords; A-35 Emergency Buttons; A-95 Installers Handbook; A-105 6 Warning Decals; A-135 (2) Alarm Circuit Hook-Up Wire and A-137 Alarm Bell Hook-Up Wire.

Model SS-500 $129.95

"Do-it Yourself" HOME SECURITY HANDBOOK

A comprehensive 40-page Homeowners Handbook which includes a wealth of information on professional home security as well as comprehensive Installation procedures in clear non-technical language.

A-95 Handbook **$2.95**

EICO A-95 HOME SECURITY HANDBOOK

Save hundreds of dollars in alarm installation and monthly service charges. The EICO A-95 Home Security Handbook is a comprehensive 40 page booklet which can be easily understood by anyone. Written in clear non-technical language, it contains complete instructions not only on how a home protection system functions and how to install all EICO security devices, but also how to expand your EICO system. Before you purchase any security system for your home, we suggest you read the A-95 handbook and see how easy EICO makes it to "Do-it-Yourself."

Acclaimed by Editors and Consumers!

"The EICO SS-500 Home Protection system works as well as, if not better, than many so-called "professional" or industrial systems—at a lot less cost. Fact is, the system has more features than much "professional" equipment. And it certainly works a lot better than many do-it-yourself systems presently on the market that are supposedly intended for the average home owner."
(Test Report Summary E/E Magazine Aug. 1972)

"Wiring the Eico system is a breeze"
(Electronics Illustrated August 1972)

"We found that installing the security system is easy, and the only tools we needed were a screwdriver and a knife. We picked an arrangement from the manual, suitable to our needs, and went to work. In a matter of hours, the job was completed." **(Popular Electronics Sept. 1972)**

Additional security components can be added any time, at your own pace, to suit your own needs.

EICO Electronic Instrument Co., Inc., 283 Malta Street, Brooklyn, N.Y. 11207

Circle 1 on reader service card

EICO®

We taught Leonard Starr how to make money doing what he used to do for fun.

Leonard Starr's father wanted him to go to college and settle down in a *"nice clean job in a brokerage office."*

But Lennie had ideas of his own.

"I'd seen too many other guys serving time in jobs they couldn't stand — just as bored with their work as my father is with his. And getting soft.

"Not me. I knew what turned me on and it wasn't the brokerage business. I like action — hot cars, motorcycles, working with tools. Why, I started tearing down bicycles and rebuilding them when I was only a kid.

"So I asked myself — 'Why not do that for a living?' "

Well, why not? Lennie Starr got in touch with the school that really understands individuals — the school that makes a special point of helping people who have their own ideas about that one life they've got to live.

Today's ICS.

Now, Lennie Starr is doing just what he wants to do — as a Master Automotive Technician in the best dealership in town. He's pulling down a bigger dollar than any of his desk-bound friends — and he's having fun doing it. Which is more than a lot of people can say.

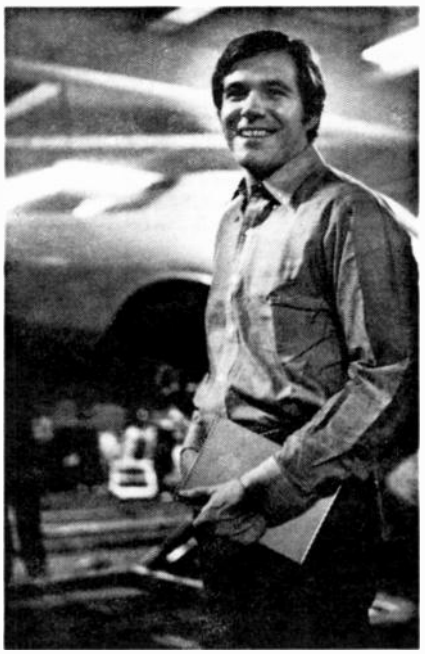
Leonard Starr is a hypothetical person — a composite of the many thousands of real individuals who are using today's ICS to change the course of their lives. But how about you?

Chances are, you're an individualist, too. Your interests are different from Lennie's, different from anybody's. And because of that, today's ICS can help you, too.

Tell us what turns you on — and we'll teach you to do it for a living!

Is electronics your bag? TV servicing? Air Conditioning? Want to earn $7-8 an hour or more as a skilled electrician? How about a first-class FCC license? Or are you shooting for a big professional career as a full-fledged civil, mechanical or electrical engineer? You name it — and today's ICS will teach it to you.

Today's ICS is for action-minded people — people who like to learn by doing. ICS technical career programs include valuable professional tools and equipment that you learn to use in practical experiments and do-it-yourself projects — then keep for your new career . . .



a 25" (diagonally measured) Motorola Quasar II® color television chassis with the ICS TV Technician program — plus an oscilloscope, VOM, and experimental lab equipment . . .

a Philco/Ford room air conditioner with the ICS Air Conditioning and Refrigeration program — plus a whole battery of professional tools, instruments and testing equipment . . .

an electronic multitester and top-quality electrician's tool kit (in leather case that attaches to your belt) with the ICS Electrician's program — plus a home laboratory for experiments . . .

a complete set of Proto hand tools (official tools of the Indy 500) and genuine Daytona test equipment with the Automotive Technician's program . . .

And so on. If you're an individual . . . if you have your own ideas about the kind of life you want to live . . . if you want to earn big money doing the things you do now just for fun . . . today's ICS can help.

School was never like this!

In fact, studying with ICS is like nothing you've ever done before. It's almost like taking up a fascinating new hobby — yet you wind up with a solid career skill you would probably never get otherwise.

Because you don't have to give up your job or take time away from home to do it.

Circle 2 on reader service card

You learn at home — in your spare time, at your own sweet pace. Yet your instruction is entirely personal. An instructor answers every question you ask. You can actually pick up the telephone and ask your questions out loud — toll free!

That's individualism for you. And speaking of individualism, it's pretty comforting to know that more than eight and a half million other individuals have enrolled in ICS before you.

Which is not bad for a school that specializes in helping individuals learn to do well the things they like to do best.

2,000 U.S. firms and government agencies —including Chrysler, Ford, U.S. Steel, Mobil, Motorola, Pan Am and Dupont—are using ICS training programs to upgrade their own employees.

ICS International Correspondence Schools
Scranton, Pennsylvania 18515

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- ☐ Communications/Broadcasting Technician
- ☐ Computer Servicing
- ☐ CATV Technician
- ☐ Diesel/Gas Mechanic
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- ☐ Drafting
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- ☐ Engineering Technician
- ☐ TV Servicing & Repair
- ☐ Surveying & Mapping
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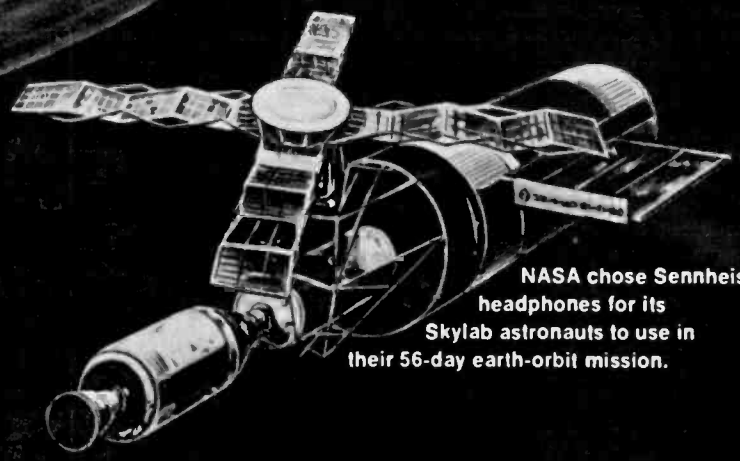
Approved for Veterans' Training and Accredited Member National Home Study Council

When we say our headphones are out of this world ...we mean it.



NASA chose Sennheiser headphones for its Skylab astronauts to use in their 56-day earth-orbit mission.

But people prefer them for down to earth reasons.

NASA selected us... but you don't have to go into orbit for comfort

Out in space or here on earth, the last thing you want is to be uncomfortable. Whether you're relaxing with your favorite music or communicating with a ground tracking station.

Which is one good reason so many people do their listening with our HD 414 "open-aire" headphones. Even if they weren't the lightest (which they *are*), they're not bulky, and don't need uncomfortable air-tight seals to get good sound.

$150.00 sound under $50.00? Ask ELECTRONICS WORLD!

According to the October, 1971 issue, our HD 414 has "the best sound of any dynamic phones" – based on factors like frequency response, transient response, sensitivity and *listening tests*. In the article's headphone comparison chart, the only really comparable headphone maker's sets were priced at $95.00 and $150.00 apiece! (As if that weren't enough, we were also rated most comfortable.)

Isolation or Communication?

The choice is yours. With "open-aire" headphones, you hear as much as you want of your surroundings. Or as little: a twist of the volume control and you're effectively alone!

A "superior...natural" headphone? Sounds like HIGH FIDELITY feels that way!

They pointed out our headphones combine "the superior close-up quality characteristic of headphone sound" with "the freedom and naturalness of loudspeaker listening." What's more, they felt that the HD 414 is cooler to use, "allowing body heat to dissipate more readily."

Hearing is believing

In this world and out, it seems more and more people rate Sennheiser "open-aire" headphones tops. But all the testimonials in the world can't tell you what your ears will. Why not visit your nearby Sennheiser dealer and put your ears in orbit. At a very down-to-earth price.

SENNHEISER ELECTRONIC CORPORATION

10 West 37th Street New York 10018 (212) 239-0190

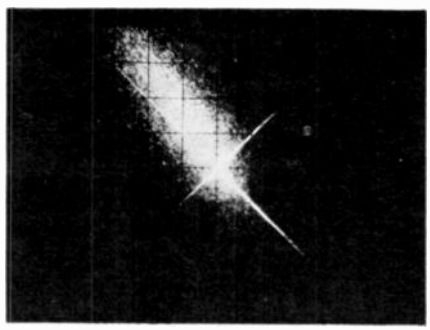
Manufacturing Plant: Bissendorf, Hannover, West Germany

Circle 3 on reader service card

Radio-Electronics

FOR MEN WITH IDEAS IN ELECTRONICS

MAY 1973



WAVEFORMS LIKE THIS ONE are the secret to unscrambling 4-channel sound. There are more than 30 different ones in this article.
. . . . see page 54

ELECTRONIC MUSIC MACHINES can be built at home. See how you can assemble your own synthesizer. . . . . see page 38

Radio-Electronics is indexed in *Applied Science & Technology Index and Readers Guide to Periodical Literature.*

Radio-Electronics, May 1973, Vol 44 No. 5. Published monthly by Gernsback Publications, Inc., 200 Park Avenue South, New York City 10003. Second-class postage paid at New York, N. Y. and additional additional mailing office. One-year subscription rate: U.S.A., U.S. possessions and Canada, $7. Pan-American countries, $8. Other countries, $8.50. Single copies 60¢

Subscription Service: Mail all subscription orders, changes, correspondence and Postmaster Notices of undelivered copies (Form 3579) to Radio-Electronics Subscription Service, Boulder, Colo. 80302.

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looking ahead

Big numbers

Americans went on an electronics buying spree last year, according to official figures released at presstime. They bought a record 17.1 million television sets—color and monochrome—equivalent to one new set for about every fourth household in the United States. Of these, slightly more than half were color sets. They also set a record in radio purchases (more than 55 million of 'em), stereo and other phonograph system (over 7.2 million) and tape recorders and/or players (a whopping 20.7 million). That's 100 million home electronic products—not counting such odds and ends as electronic guitars, organs, hearing aids, instructional kits, individual stereo components and microwave ovens.

Videodisc compatibility

A small ray of sunshine is peeking through the clouds on the stormy videodisc compatibility scene. The European electronics giant, N. V. Philips, and California-based MCA Disco-Vision—both of which have demonstrated LP videodisc systems which use a laser readout principle—have announced they've begun discussions toward achieving compatibility.

Two other videodisc systems seem to have little chance of being brought into conformity with any Philips-MCA standards, however. The German-British Teldec system (Telefunken and Decca) uses a mechanical pressure pickup and is already scheduled for production later this year. RCA's system, long under development, but never shown publicly (at least up to the deadline for this column), works on a capacitance principle: A metallized disc is coated with a thin layer of dielectric material and the metallic pickup stylus serves as the other side of the capacitor.

Bathometer

Rub-a-dub-dub, electronics in your tub. The latest gadget in Japan, where the bath is an important ritual, is a multi-purpose intercom and alarm. It sounds a warning if intruders break into the house, if a fire should start—or if the level or temperature of the bath water gets too high. At around $100, it's a good way to stay out of hot water.

Videocassette recall?

Manufacturer recalls of products are becoming increasingly prevalent, particularly in the automotive field. Now there seems to be a distinct possibility of a federally mandated recall or field modification of all videotape recorders, closed-circuit cameras and other products designed to feed into the antenna terminals of standard home television receivers.

The FCC took jurisdiction over these devices to prevent excess radiation from feeding back through antennas and interfering with reception on other TV sets. During its consideration of the new radiation rules, it permitted manufacturers to make and sell devices if they agreed to abide by certain preliminary specifications and to make modifications later, if necessary, to conform with the final rules. When the final rules were issued, they contained an unexpected provision—all devices must be equipped with antenna-disconnect switches which provide 60 dB of isolation. In other words, when the recorder, player or camera is feeding into the TV set, the antenna must be disconnected.

Manufacturers are now hurriedly developing switches designed to meet the Commission's specified 60-dB isolation for products they market in the future. They're also expected to ask to be relieved of the requirement to modify those already in use, on the ground that their signal strength is one-third of that now permitted for new devices, resulting in less interference ever if a switch with under 60-dB isolation is used. If there's a recall, it would involve perhaps 35,000 videocassette machines now in use in industry, government and education. An uncounted number of older devices sold before the FCC announced its jurisdiction probably won't be affected.

New pay-TV system

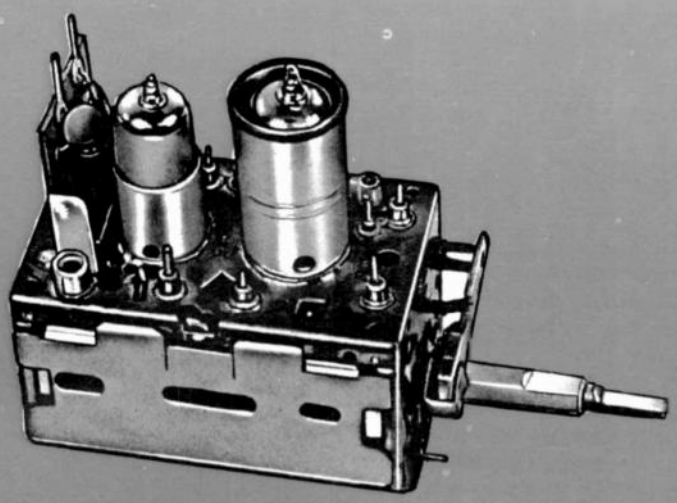
With per-program or per-channel pay-TV cable operations starting up in various parts of the country, equipment manufacturers are working overtime to develop methods for distributing programs only to those who will pay for them. The latest pay-cable system was developed by Magnavox with the backing and assistance of big CATV operator TelePrompTer Corp. Designed to operate with current CATV's, it provides a method of billing customers only for the programs they watch (special programming, such as recent movies and sports not carried on regular TV).

The "Premium TV" system involves the use of a special box in the subscriber's home, enabling him to view either of two pay-TV channels or regular TV at the touch of a button. Mounted on a telephone pole is an "interactive data exchange module" (IDEM), serving 32 subscribers in the neighborhood. When a viewer presses a pay-TV program button, the signal is unscrambled and fed into his set on a special channel. The IDEM keeps track of his viewing, and each month a CATV employe travels through town with a low-cost battery-operated audio tape recorder, which he plugs into a special terminal connected to each IDEM. The cassette is then fed into a central billing computer (either directly or by telephone). The computer prints out a monthly bill, enumerating programs watched and the cost for each individual subscriber. The system will be tested this year in an undisclosed California city. For more details see a complete description of the system on page 80.

Comsat's first decade

Communications Satellite Corp. (Comsat), the U.S. participant in the worldwide space communications consortium Intelsat, celebrated its 10th birthday recently by releasing these statistics: Some 83 Intelsat member countries now have satellite service, with 80 ground stations in 49 countries (the others receive their communications via ground lines from the nearest station). One quarter of the earth's population is now within the range of live satellite TV broadcasts. Use of satellites for telephone service has reduced the cost of a New York-to-London phone call from $12 to $5.40 for three minutes. Since the start of satellite TV, the cost of a 30-minute color transmission from New York to Paris has steadily dropped from $16,000 (for the Early Bird satellite) to $3,870 today.

by DAVID LACHENBRUCH
CONTRIBUTING EDITOR



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Universal Replacement Tuner $9.75.

This price buys you a complete new tuner built specifically by SARKES TARZIAN INC. for this purpose.

All shafts have a maximum length of 10" which can be cut to 1½".

Specify heater type parallel and series 450mA or 600mA.

CUSTOMIZE

Customized tuners are available at a cost of only $15.95. **(With trade-in $12.95)**

Send in your original tuner for comparison purposes to:

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VIRGINIA.....4538 PRINCESS ANN ROAD, Norfolk, Virginia 23502 .....TEL: 703-855-2518

Circle 4 on reader service card

new & timely

"Two-eyed" tube may improve TV color camera performance

A new two-target camera tube is expected not only to enhance the performance but to lower the cost of single-tube TV cameras. Called a BIVICON, the new 1½-inch RCA C23244 was designed originally for the RCA HoloTape system. "It is particularly well suited for generating color pictures from two-frame holographic or photographic films in which the luminance (black and white) portion of the picture is projected onto one target and the chroma (color) information, in suitable encoded form, onto the second target," according to Dr. William M. Webster, Vice President, RCA Laboratories.

The "suitable encoded form" refers to the chroma information on the HoloTape, in the color frames of which the chroma is encoded rather than appearing in actual color.

The Bivicon tube registers between the luminance and chroma information excellently without additional auxiliary coils because the beams generated by its two electron guns are controlled by a single magnetic focus and deflection system. These beams "read" out the stored picture information from the two targets and provide simultaneous output signals that can be superimposed with precision.

BIVICON CAMERA TUBE has two distinct pick-up surfaces—the dark rectangular areas.

The tube can also be used to replace single-target vidicons in one-tube color cameras that separate the luminance and chroma signals by optical filtering. It has an advantage over the vidicon in such an application because its second target can process the color signals independently. In such a camera, color filters ahead of the color target would be used to produce a point-sequential signal that could be decoded and combined with the black-and-white signal in the camera coding and control circuits, to produce an NTSC output.

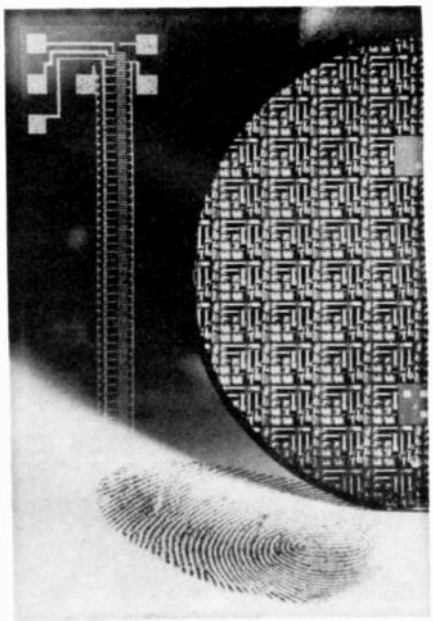
The tube can also be used in other TV applications in cameras designed to produce simultaneous optical images that can be played back on separate monitors or superimposed on a single monitor. The double-beam, double-target feature provides a desirable degree of redundancy for use in unattended cameras. A TV surveillance camera with two fixed lenses might be electronically switched from one "eye" to the other to provide close-up and wide angle shots of an area under surveillance, Dr. Webster said.

A typical raster format for the Bivicon tube is 0.50 inch by 0.38 inch with center-to-center spacing of 0.41 inch. The two rasters are scanned in parallel so that two simultaneous output signals are generated. The output signals are provided for two small metal contact buttons on the tube's faceplate while mesh contact is made through a stud in the glass bulb. All other electrical connections are brought out through the tube base.

Ion implantation improves charge-coupled devices

Charge-coupled devices consist of a series of closely spaced mos capacitors in which charges are caused to step along from capacitor to capacitor by reversing the charges along the series of plates (**Radio-Electronics**, June 1971, page 6). But part of each charge finds it difficult to pass the gap between the plates—it finds a "potential threshold" hard to step over.

Siemens has introduced an implantation step in which boron ions are implanted in the gaps between the units, thus reducing the potential threshold. In older devices, gaps had to be kept to a width of 3 microns or less. With the new technique, gaps may be as wide as 7 microns. Units with this greater gap width can be quantity-produced, thus making a wide range of applications economically possible.



CHARGE-COUPLED DEVICES are especially adapted to use in shift registers, but transfer losses can falsify data. Ion implantation has so reduced the losses in the Siemens IC shift register above that accuracy approaches 100%.

Experiments with 150-electrode devices show a transfer loss of less than 0.2%, with 7-micron gaps, whereas with older devices the losses were almost 100%.

Third Annual Hugo Gernsback Scholarship Award

M. Harvey Gernsback, publisher of **Radio-Electronics,** has announced the third annual Hugo Gernsback scholarship award for 1973. The program consists of a $125 grant to a deserving student of each of 9 technical home study schools serving in the electronics field.

The scholarships sponsored by **Radio-Electronics** were established in memory of the late Hugo Gernsback, electronic pioneer, inventor and publisher to perpetuate Mr. Gernsback's interest in developing the technological skills of young people.

(continued on page 12)

SOUTHWEST TECHNICAL PRODUCTS CORPORATION

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

April, 1973

Dear Radio-Electronics Reader,

This will be the first of a series of "random ramblings" on "things and stuff" from the "Other" kit company. I realize that all of you are not familiar with Southwest Technical Products, or the kits we make. I hope to correct that situation in the coming months.

I started this company over 10 years ago as a source for printed circuit boards used in some of my Radio-Electronics projects. At that time circuit boards were still kind of unusual and materials to make them were not widely available. Evidently you and others who build magazine projects liked the idea, because I sold a bunch of circuit boards. Many of you requested other components for the projects too, so in Jan. of 1964 I got real brave and quit my job to go into the electronic kit business full time. Fortunately none of the first kits offered were disasters (some later ones were) and my small company began a steady growth.

Our aim then, as it still is now, was to offer kits for projects that were either a bit unusual, or kits for projects that could offer you a big saving over similar products. We have always used the best quality parts possible (short of going MIL Spec) even if they cost a bit more. All of our circuit boards are fiberglass, the resistors are deposited carbon, the transistors are new and as much as possible standard types that you can buy from local sources too in case you need one in a hurry sometime. We don't try to make our kits so easy that anyone can construct one. We assume that you know how to read a schematic, solder and strip wire. If you don't, if you simply want a nice pastime that is different from number painting, go buy a kit from Heathkit, or EICO. Most of our kits have pictorials and the instructions provided are enough for anyone fairly familiar with electronic construction. By holding down the cost of instruction manuals we are able to offer those of you who are "serious" about electronics a far better deal for your money.

I, and the other engineers who work at Southwest Technical Products, enjoy electronics. Our products are generally the result of an interest that someone had in a particular circuit, or project. We have never in our existence designed something to meet a particular price, for a market that surveys indicated was out there. Maybe we would make more money if we did, but it sure would take all the fun out of it.

If you would like to see what kind of gadgets that we make, write, phone, telegraph, or circle our number on the "Bingo" card in back. I will have our catalog in the first possible return mail to you. There is no charge. We are more than happy to get one in the hands of those "serious" electronics enthusiasts among you out there. Next month I will pick one kit to talk about. I think you might be interested in some of the circuit details and neat little features that we have put into our projects. See you then. In the meantime—send for our catalog right now.

Sincerely,

Daniel Meyer

Daniel Meyer

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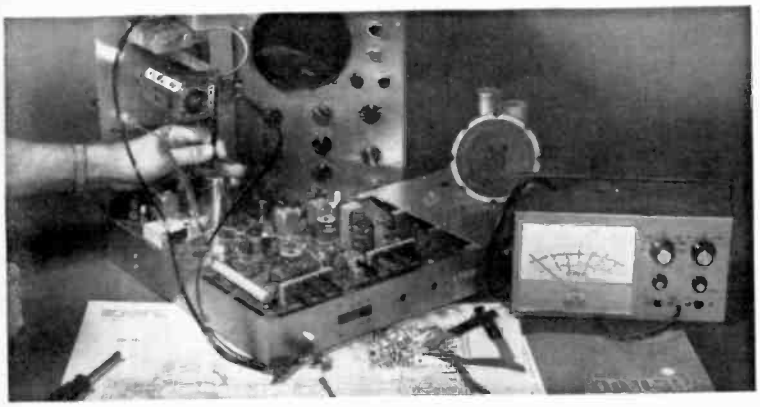
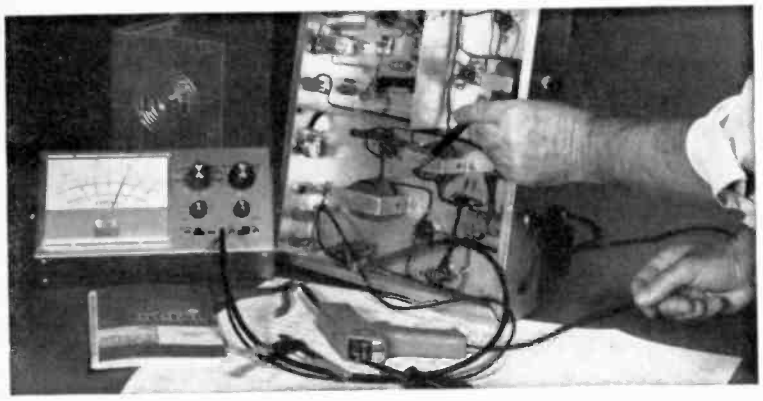


FIRST to give you Color TV training equipment engineered specifically for education—built to fit NRI instructional material, *not* a do-it-yourself hobby kit. The end product is a superb Color TV receiver that will give you and your family years of pleasure. You "open up and explore" the functions of each color circuit as you build.



FIRST to give you true-to-life experiences as a Communications Technician. Every fascinating step you take in NRI Communications training, including circuit analysis of your own 25-watt, phone/cw transmitter, is engineered to help you prove theory and later apply it on the job. Studio equipment operation and trouble shooting become a matter of easily remembered logic.

FIRST to give you completely specialized training kits engineered for business, industrial and military Electronics Technology. Shown is your own training center in solid-state motor control and analog computer servo-mechanisms. Telemetering circuits, solid-state multivibrators and the latest types of integrated circuits are included in your course.

There is so much to tell you about this latest "first" in home training from NRI, you must fill in and mail the postage-free card today to get the full story of the Complete Computer Electronics course and the amazing digital computer you build and use as you learn.

Planned from the start to include specially designed training equipment in the pioneering NRI tradition, this exceptional new course succeeds in combining kits with NRI "bite-sized" texts to give you an easy-to-understand educational package. But, unlike other home training, this is not a general electronics course. Lessons have been specifically written to stress computer repair. You perform a hundred experiments, you build hundreds of circuits. Included are over 50 modern, dual-in-line TTL integrated circuits you use in the construction of your computer. You use professional test equipment. In addition to your digital computer, you build and use your own solid-state voltohmmeter and oscilloscope. Because you work with your hands as well as your head, your training is as much *fun* as it is education.

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ACCREDITED MEMBER NATIONAL HOME STUDY COUNCIL

new & timely (continued from page 6)

Hugo Gernsback founded **Radio-Electronics** magazine in 1929 for electronics service techniclans, engineers and advanced electronics hobbyists. 1973 scholarship award winners will be announced in the magazine during the course of the year.

The 9 schools participating in the program are: Bell & Howell Schools, Career Academy, Cleveland Institute of Electronics, CREI Home Study Division of McGraw-Hill, Grantham School of Engineering, International Correspondence Schools, National Radio Institute, National Technical School and RCA Institutes.

School demonstration lasers endanger science students

Lasers "powerful enough to drill holes through diamonds" are being used in high schools and colleges without adequate safety precautions, a seven-state survey has disclosed. The survey was made by the Bureau of Radiological Health of the Food and Drug Administration, and covered the states of Florida, Illinois, Montana, Oklahoma, Pennsylvania and Washington.

"In many cases laser beams were directed at students or areas through which students might pass," the survey states. "In a few instances high school students were exposed to direct laser beams deliberately. One instructor said he wanted the students to see a beautiful effect." Lasers were also used where beams could be reflected toward students from windows or other reflective objects. Some 72% of the lasers were operated without nearby warning signs, and 52% lacked warning labels. In more than 90% of the cases studied there were factors that could pose an unsafe situation.

The Bureau recommends that direct laser viewing be avoided, that reflective objects be removed from laser beam paths and that the beam be blocked when it is not needed. It is further recommended that preparation and testing of laser classroom demonstrations be conducted when there are no students present, that key-locked switches be used to prevent the equipment from being operated by unauthorized persons, and that operable lasers never be left accessible and unattended.

HOME-SIDE "SON ET LUMIERE" light show is a hobby of Mt. Airy, Pa. science teacher and Baptist minister Hugh Cosline. He has used all surfaces of a 12 x 15 x 10-foot room, modifying a bathroom to serve as control room. The mirrored wall at rear holds some 150 light boxes, and at left is seen an ever-changing pattern of crystal slides. On the floor, Mr. Cosline, at right, discusses the production with vice president Robert Edmund of Edmund Scientific Company, from which most of the equipment was obtained.

World's slimmest calculator uses 7,000 transistors

A pocket electronic calculator only ⅜ inch thick has been placed on sale in the United States by Sinclair Radionics Ltd., England, known to many of our readers through the Sinclair pulse-width-

HAND-HELD ELECTRONIC CALCULATOR only ⅜ inch thick contains 7,000 transistors.

modulation amplifier (class D) described in **Radio-Electronics**, September 1967. Performing all the functions of a conventional desk unit, the new calculator is only 5½ inches long and 2 inches wide. It weighs 2½ ounces.

Operating on tiny hearing-aid batteries, which have a normal life of three months, the Sinclair Executive, as it is called, has a display that shows up to eight numbers, plus a fixed or floating decimal point. As the batteries age, the luminous figures become dimmer, and fade out entirely before the machine's performance is affected.

In addition to the usual addition, subtraction, multiplication and division the functions include in-calculation squaring and reciprocals, plus a "constant key" memory that permits repeated multiplication or division by a predetermined number, a useful feature in calculating interest or discounts, or in work that requires constant conversions from one unit to another.

The Sinclair Executive is priced at $195, and is marketed in the U.S. through Koret Inc., N.Y.C.

(continued on page 14)

Don't let the handy size fool you.

The Serviset E/C is a complete, self contained versatile field test instrument. A precision-built, reliable, much-used instrument to compliment your VOM, scope or other equipment, too.

The Serviset E/C is great for servicing all sorts of electronics in the field and on the bench. Whether you're a professional engineer working on communications or EDP devices. An electronics or appliance technician working in radio, television, hi-fi audio or appliance repair. Or an amateur electronics enthusiast, ham radio operator or student.

Checks you'll make with the Serviset E/C include: sync, sweep, video, audio circuits; high or low DC, RF, or pulse voltage supplies; coils, capacitors, resistors, tubes, transistors, diodes, transformers, speakers--whatever you're trouble-shooting from stage to stage, or discrete components. What's more, your Serviset E/C is safe: whatever you check, you won't blow it.

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new & timely

(continued from page 12)

First Atlantic transmission re-enacted by amateurs

To celebrate the 70th anniversary of the first transmission of a message across the Atlantic, a group of amateurs manned a special-event amateur radio station, WC1MAR, to re-enact the event, sending a duplicate of Marconi's original message. The station was set up on the original site of the Marconi station at South Wellfleet, Massachusetts, where Marconi himself tapped out the message of greeting from President (Theodore) Roosevelt to King Edward VII.

Hugo Gernsback Scholarship Winner

Cleveland Institute of Electronics has awarded its third annual Gernsback award scholarship to Peter B. Marceau of Wichita, Kansas. Peter receives $125 from **Radio-Electronics** as an outstanding student at one of 9 home study schools of electronics. Peter is a Sergeant in the U.S. Air Force. He is 22 years of age and has served 3-1/2 years with the Air Force and has recently reenlisted for another 6 years. Around the middle of February, he will be transferred to England.

A student of CIE's electronics technology with laboratory program, Sgt. Marceau and his wife, Ann, are expecting their first child in February. It is interesting to note that it was while Mrs. Marceau was hospitalized with complications associated with her pregnancy in October that Sgt. Marceau wrote his award-winning essay. He actually wrote the article one night at the hospital. **R-E**

Radio-Electronics is published by Gernsback Publications, Inc. 200 Park Ave. S. New York, N.Y. 10003 (212) 777-6400
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Measuring just 21" across and 7" high, the Mini-State is completely enclosed in an attractive sturdy plastic case that's weatherproof and resistant to dust and dirt. It weighs just 6 pounds and can be mounted almost anywhere: rooftop, chimney, window, attic and closet.

While providing excellent reception for metropolitan and suburban areas, the RCA Mini-State's compact size makes it practical for apartments and homes. Its uni-directional pattern, VHF slotted ring and multi-element UHF design, combined with its completely integrated solid state circuitry, provides excellent reception on all channels, and helps avoid interference and ghosts.

Mini-State model 5MS440, with built-in rotator, allows your customers to zero-in for best reception on any channel. Exclusive direction indicator light on the hand held control unit tells them where the antenna is aimed.

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

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

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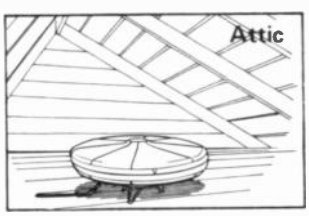

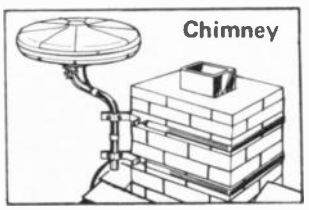

Circle 6 on reader service card

letters

RINGS THE BELL

Your editorial—"Serviceability—Something For Everyone"—rings the bell.

May I suggest that you invite technicians to send in their pet gripes.

Mine is the way backs of portable TV sets are mounted. Sometimes it takes a great deal of fiddling to get them remounted. This is an unnecessary waste of time. Therefore I say . . . no antenna inputs—no speakers—no antenna rods should be mounted on the backs. Also there should be a plastic panel in the bottom of the cabinet which can be removed to get at the bottom of the chassis.

Another sore point is the lack of standardization of the hardware—*in the same set.* Sometimes three different self-tapping screws are used on tuners.

Plastic gears on tuners are another sore point. All uhf tuners should be separately tuned—*no gearing.*

JACK LANE
Los Angeles, Calif. 90046

Jack; if you and other readers want to really help yourselves, report any serviceability problems you encounter to the National Serviceability Committee of the National Electronics Association. This trade association group is responsible for collecting comments of this sort and bringing them to the direct attention of manufacturers. In fact, in the new serviceability rating forms, back removal is a specific section of the ratings and has a definite effect on the overall serviceability rating a TV receiver can earn for itself.—Editor

TELEVISION SERVICE TOMORROW

I own and operate Bell Television, a TV service shop in Chicago. When I discuss service technicians I am talking about consumer electronic service and by consumer electronic service I mean primarily television service. I mean independent television service and I mean television service for profit.

For us to try and look into the future, it is necessary that we study the past. In 1969 and 1970, J.W. Phipps of Electronic Servicing Magazine published a wealth of statistics on TV service. Those statistics pointed out problems which were very important then, but have since become critical. Some of the conclusions reached in the study of these statistics are: there are fewer shops and these fewer shops are using more people. They are doing a larger volume of business at a smaller percentage of profit.

The reason they are making a smaller percentage of profit is that the cost of doing business has increased at a very high rate while the consumer cost of TV service has actually decreased. This decrease in profit margin makes it very hard to obtain a fair return on investments or build up a reserve for new equipment. It also makes it necessary to skimp and cut corners wherever possible.

Of course the obvious answer is to increase profits. However, I think that we will soon, if we haven't already, reach the point where the consumer may not be willing to pay what good service will cost.

To repair today's sets requires a man with a high degree of technical ability. He must be resourceful, industrious, neat and a passable amateur psychologist. The problem is that that type of man may not care to fix television sets. He can too easily find a job that is less demanding and pays more money.

With the present proliferation of basic designs, it is necessary that an effective technician be practically an engineer. We have tube chassis, plugged in and soldered in transistors in hybrid and solid state chassis. We have big boards, small boards, single-sided and double-sided boards. There are over 1200 different tube types in current use and God only knows how many different transistors.

What I am driving at is this. The public will not pay engineering prices for a service technician and we cannot sell them engineers at technician prices. This leaves open two avenues for the electronic service technician of the future. He can become a highly specialized person such as a product specialist (a man who knows very much about very little). However, to use product specialists requires a large operation and even the large operation must be specialized. A factory service operation is a perfect example. It is extremely hard for even a very large operation to effectively repair all makes and all models and make a profit doing so. The other course is for the technician to regress into a repairman. However, if this were to happen it would require that sets be easier to fix.

The present trend toward modu-

(continued on page 22)

Introducing the expensive curve tracer that doesn't cost a lot.

The B&K Model 501A.

It's a lab-quality instrument that provides fast analysis of all semiconductors including J-FET's, MOS-FET's, signal and power bipolar transistors, SCR's, UJT's and diodes.

You can test transistors in circuit for GO/NO GO condition. Badly distorted curves will indicate the stage where a defective transistor or other faulty component exists.

The 501A is complete—with scope graticule and FP-3 probe for fast, one-handed in-circuit testing. It generates true current and voltage steps, with 3% accuracy, for measuring beta at all current levels. And it has a sweep up to 100 volts and 100 milliamperes.

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With the 501A, curves are displayed on an auxiliary scope screen. And you can hook it up to any scope—old or new.

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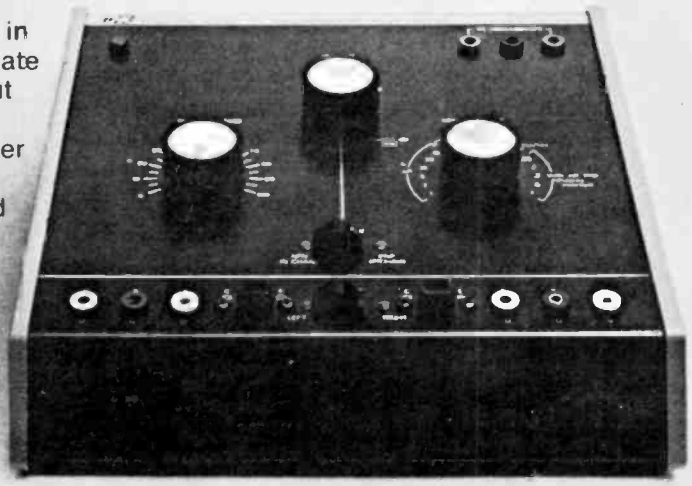
The 501A won't burn out either the semiconductors or itself.

With all these features, you'd think the 501A was an expensive curve tracer. But look at the price.

For complete technical data, call your B&K distributor. Or write Dynascan Corporation.



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

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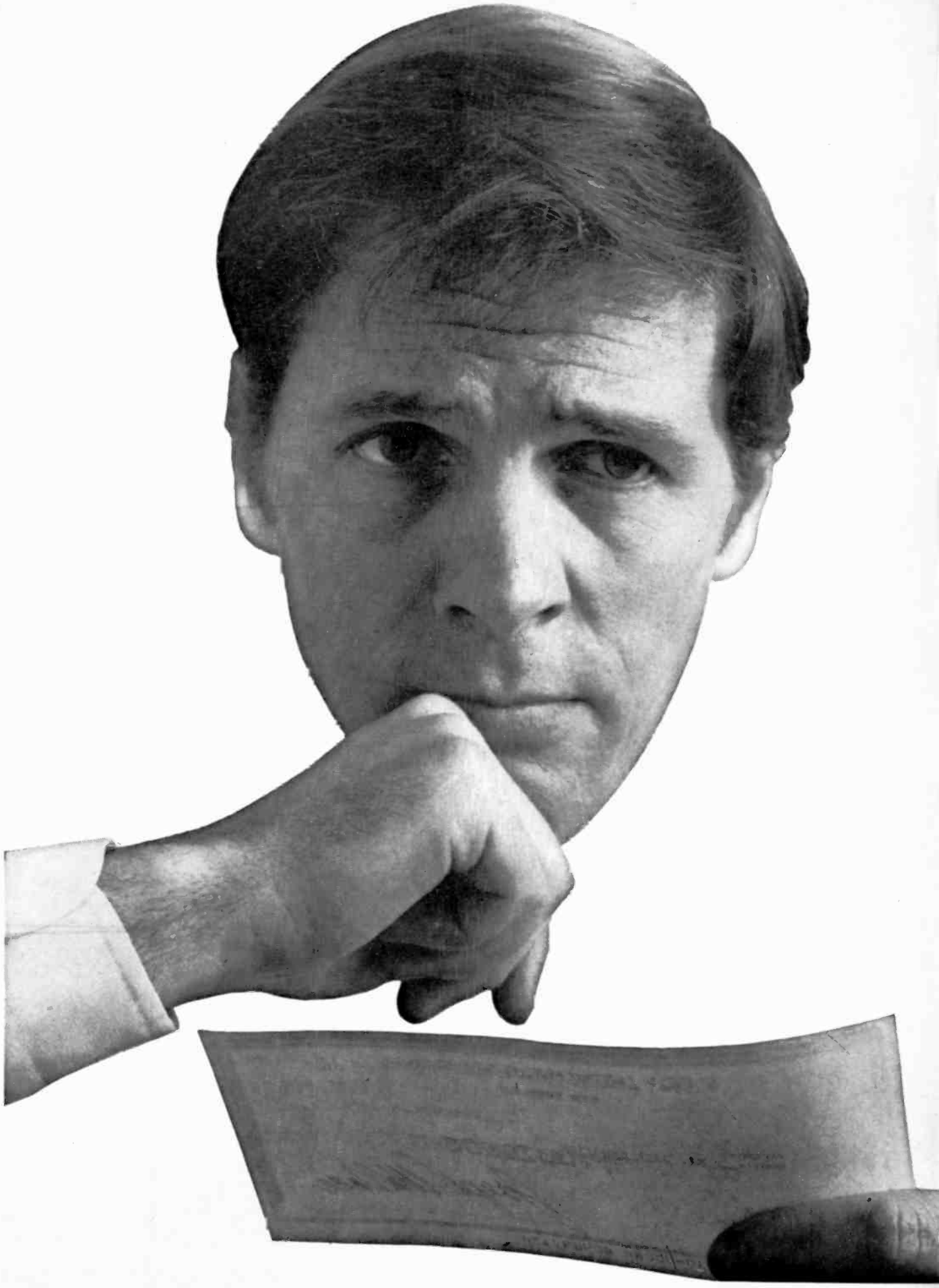

Your paycheck says a lot about you

It tells you more than how much you make. It tells you how far you've come. And if your paycheck looks very much the same as it did last year, or the year before, it simply means that you look very much the same as you did last year and the year before.

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LETTERS

(continued from page 16)

larization is a long step in that direction. Virtually all major American manufacturers are either now producing or have on the drawing boards, chassis using the modular concept. Using some of the troubleshooting guides is so simple that the less conventional electronics a man knows, the faster he will adjust to using the go—no go charts.

This does not mean that the highly skilled men now employed in our profession must take a crash course in stupidity. It simply means that they will be used in higher levels of service for we will always need someone to fix the set when the troubleshooting manual cannot.

It would be difficult to discuss the future of the TV service technician without bringing up the subject of licensing. Many, if not a majority, of service technicians have a deep fear of licensing, but most service association leaders are committed in favor of licensing. They qualify that, however, by saying that the license bill must be a "good" one. A "good" license bill provides for a license board which has as a majority of its members people who are actually "in the business". Also a good bill is one which pays for its own administration but does not provide too much surplus revenue for the State. A good bill should set minimum standards of equipment needed for shop licenses. It must provide for prompt judicial appeal of license revocations. A good license bill must not restrain new people from coming into the business but merely make sure they satisfy minimum requirements of conducting a TV repair business.

Another item for consideration is the impact of unions. The one possible good that could come from unionization is that it would standardize labor costs and thereby cut down the spread of service rates from shop to shop.

If we had licensed shops and union service technicians it is possible that we could someday earn as much as plumbers.

I think that the average shop in five years will be three to five men instead of one and will be subject to some type of government controls or registration. It will have to be much more efficient in the paperwork department. It will not serve all makes and models but will limit itself to servicing three or four major brands and three or four minor brands. These shops will be tight shops, compared to today's standards, and will enjoy a better public image and will be more rewarding in every sense of the word. **R-E**

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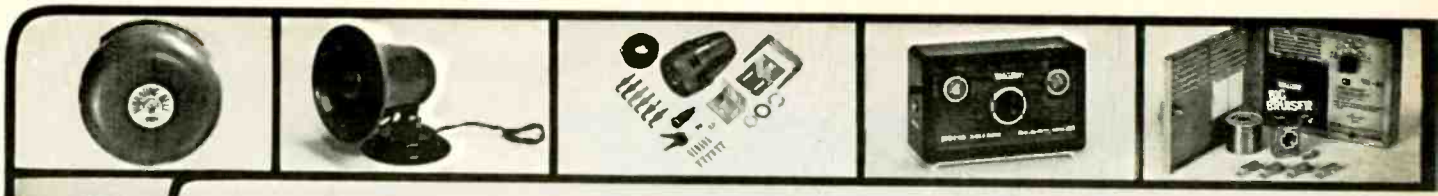

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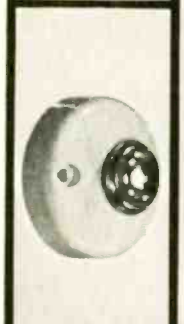

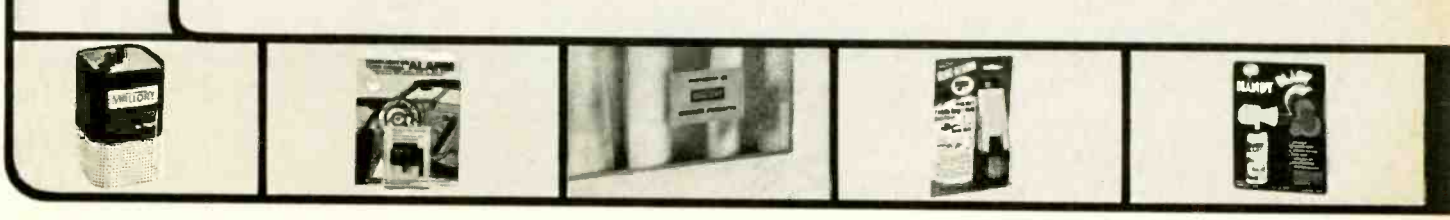

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equipment report

B&K Model 281 Digital Multimeter

Circle 27 on reader service card

EVERYTHING LATELY IS GOING "DIGITAL indicators". B & K-Precision has a new digital multimeter (DMM), the model 281. We gave one a good workout on the bench and were impressed with it. It's compact, easy to read (which is the main thing with digital instruments anyway!) and very handy.

The model 281 has 5 voltage ranges for ac and dc voltage; 0-100 mV, 0-1.0 V, 10 V, 100 V and 1,000 V. The dc voltage range has a positive and negative selector. Both dc and ac current can also be read, using the same fundamental 0-1 scale. For resistance, you can read 0-10 ohms (full-scale!) 100, 1,000, 10,000, 100,000, 1.0 megohm and 10.0 megohms. (There are two extra ohms ranges, for very low and very high resistances.)

This instrument has some cute features that make it very handy. For example, each range has a 100% "overrange" capability. This means that the 0 to 1-volt scale, for example, will read voltages up to 1.99 volts, accurately, and display the reading in that way. Even on the 0 to 1000-volt range, you can read voltages up to 1,990.

The selector switch lets you read positive or negative dc voltages. If you get the probes reversed, the 281 tells you! The "1" digit stays on, and the other two go out. This means; Reverse the probes or flip the selector switch.

If the voltage (ac or dc) goes over the 100% overrange, say above 200 volts on the 100-volt range, the '1' digit goes out, and the other two flash off and on, together.

You get the same error indication if the probes are reversed when reading dc currents. The "1" goes out and the other two blink.

The decimal point moves automatically, as the RANGE switch is turned. There's a very handy table in the instruction book, to tell you how to set each switch, and how to read the display for each range, including the maximum overrange reading. Basically, each one will come out 0 to 1.99, whether in volts or hundreds of volts.

The model 281 uses the standard IC drivers and decade counters for the digital readouts. FET's are used in several places. The dc power supplies are very closely regulated, to avoid inaccuracy caused by ac line voltage variations. Accuracy of calibration, by the way, is very good, $\pm 1\%$ of full range, or ± 1 digit.

The digital readout of the 281 uses two neon number-display tubes, similar to Nixies, and a neon lamp for the left-hand or "one" digit. This is known as a two-and-a-half digit readout.

The cabinet is compact and sturdy. It has a metal handle with detents, that can be used for carrying, or locked in place as a tilt leg to raise the front for better viewing. You can read this instrument all the way across the shop.

A handy test-probe is provided. It has a selector switch, for inserting a 100,000-ohm series isolation resistor. It reduces capacitive loading of the circuits by the probe. Because of the very high input impedance, 10 megohms on all ranges, the effect of this resistor on calibration is very small. In fact, it's only -1% of full-range reading. If you want to be nasty-nice, you can add a correction factor.

All in all, the 281 is a very handy instrument for all-around service work. We gave it a pretty good going-over on several different service jobs, and it performed very well. **R-E**

NEXT MONTH
Bob Middleton shows how you can test IC's 11 different ways, using your vtvm. Don't miss this timely article.

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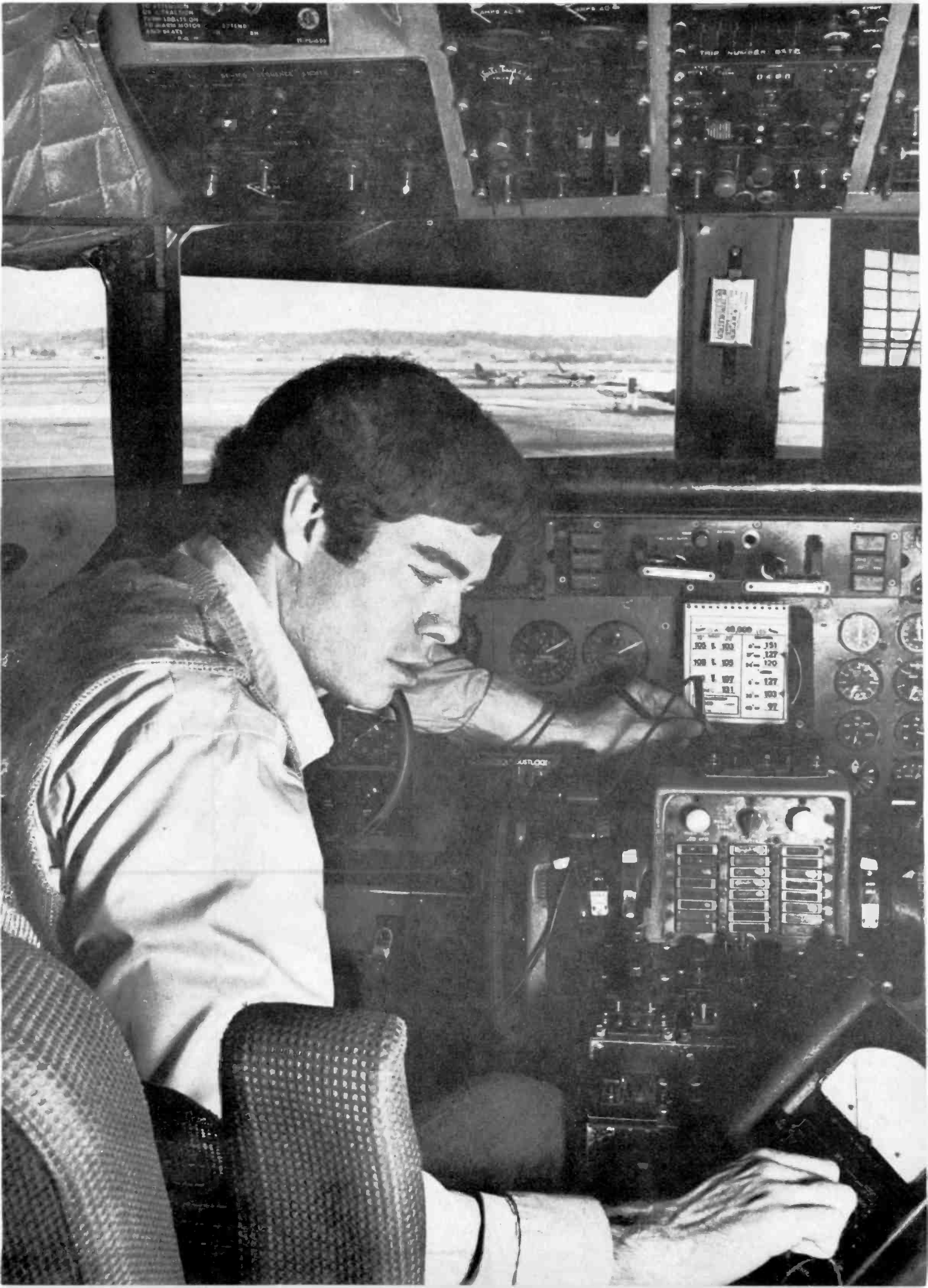
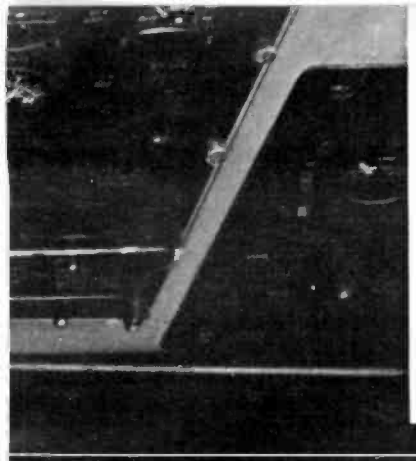
R-5-73

Circle 15 on reader service card





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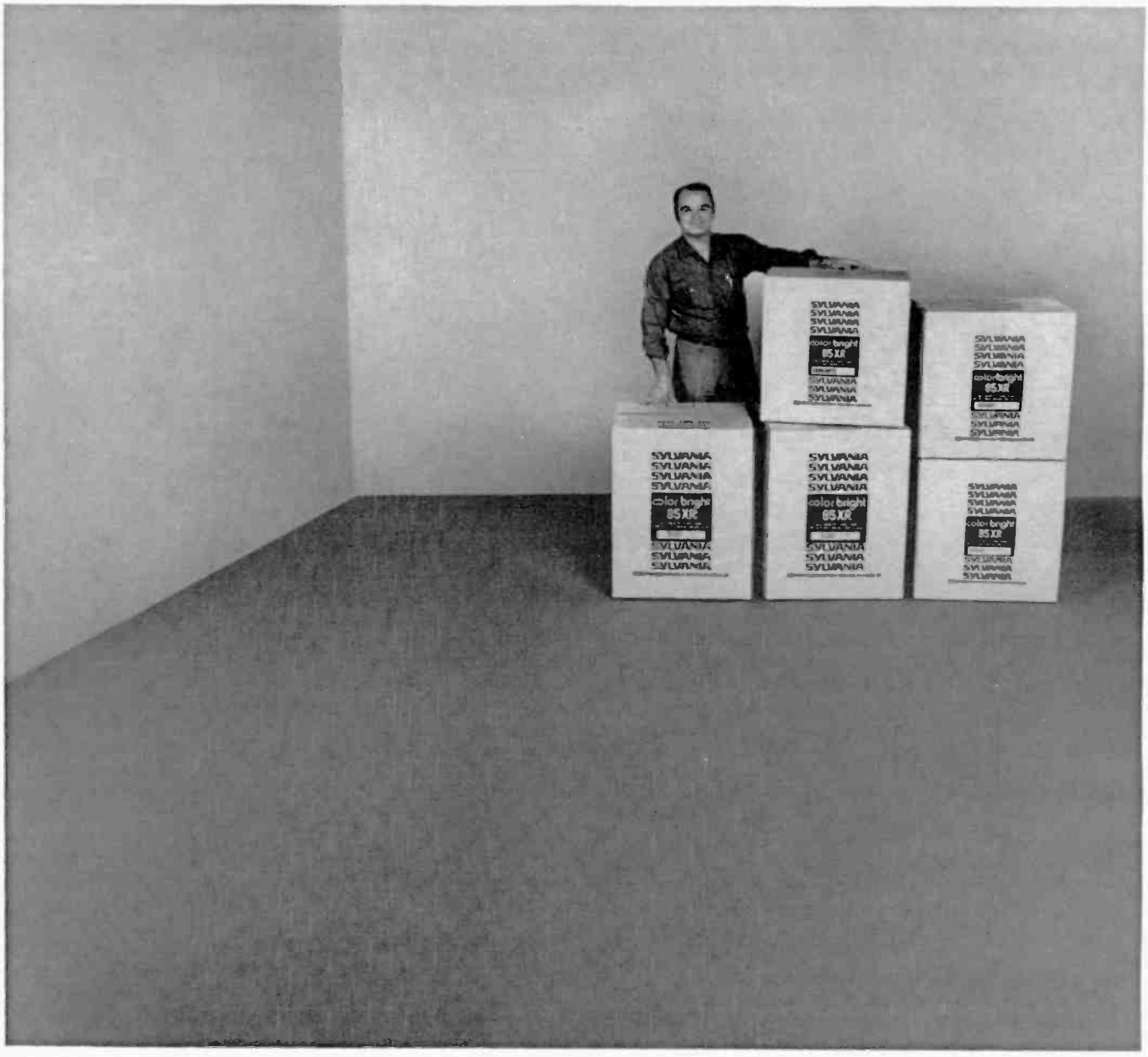
Circle 16 on reader service card



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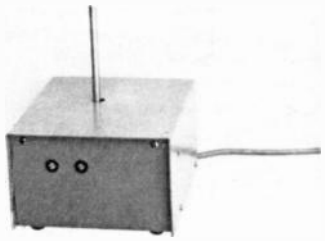
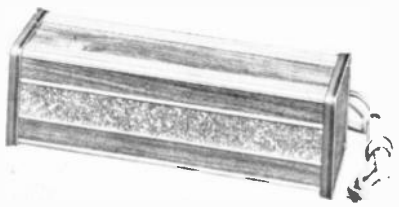


Mountain West Space Switch



Delta Products DeltAlert

how to pick the *"RIGHT"* security system

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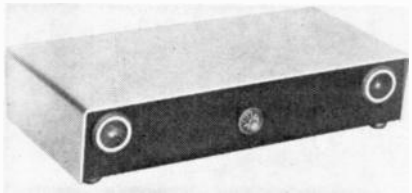

Alarm Device Motion Detector

Detectron Doppler Detectors

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There are many ways of stopping a burglar. Use the one that offers you the best protection

by GEORGE F. DURYEA*

THE BURGLAR ALARM IS, UNFORTUNATELY, rapidly becoming a necessity of modern living. But the chore of selecting a unit is staggering. There are so many different types available that it is just about impossible for anyone not knowledgeable in this field to make a sensible choice.

This article describes the many categories of alarm devices, it also explains how they work, where they work best and what their drawbacks can be.

The sooner you catch—or better, deter—a thief, the safer you are. The best way to do this is with perimeter protection—installing detectors on exterior doors, windows, gates, fences and sometimes walls and ceilings. Businesses, schools and the like which are closed at night with no watchman require this type of protection. Conversely, businesses that are open 24 hours or areas where people may wander with no intent or temptation to steal, have little use for such protection.

Perimeter protection is confined to the entry points of an area and is, therefore, ineffective against "stay-behinds," burglars who enter legitimately during business hours and hide somewhere until the place is closed. By the time they trip a perimeter alarm, they have already done their dirty work and are on their way out.

Space or specific-area protection

This is a fast-growing segment of the security field. The equipment used here detects the presence or movement of an intruder in a certain defined area. This type of protection is often used as a back-up for a perimeter system in particularly sensitive areas which need extra protection. It is an excellent defense against the "stay-behind" and is often used where perimeter protection is impractical.

Space alarms usually operate by filling a certain area with sound or radio waves. When these waves are disturbed by movement within the protected "space," the alarm is set off.

Spot or point protection

A spot protection device confines itself to one or more specific objects such as a safe, file cabinet, or jewelry case. The alarm system is set into operation whenever anyone touches—or in some cases comes close to—the protected object. This type of protection is usually used in conjunction with other types, since the object it is protecting is ordinarily very valuable. At night, the point protection backs up a perimeter system, and during the day it can still be used to warn when someone is too close to the area containing the valuables. You might consider it an "extra guard."

*Director, Security Systems Management School, 1500 Cardinal Drive, Little Falls, N.J.

Perimeter protection equipment

This section will describe in some detail those electronic security devices which are best suited for *perimeter* or *point-of-entry protection.* Perimeter protection, once again, refers to the type of protection which is intended to deter a burglar from entering the premises. By one method or another, it erects an electronic "wall" around the protected premises. Perimeter protection covers only points of entry. If and when the thief gets beyond that point, he is safe, so the equipment should be used in conjunction with other types of protection—space and/or spot—where valuable property is to be safeguarded.

The types of equipment described here are also referred to as "premise" or "intrusion" alarms.

Electro-mechanical alarms

This is probably the most common form of electronic security protection and, although its chief flaw is that it is rather easily compromised by a knowledgeable thief, its advantages should not be underestimated. The system is readily visible to a prospective burglar, and this is a double-edged sword. It warns the professional and allows him to use his skill to overcome it, but the same visibility may be just the thing to scare off amateurs and vandals.

The equipment consists of a closed electric circuit around the area to be protected. Doors, windows, transoms, skylights, etc. are wired with metallic tapes, switches, contact devices, screens and other electrical equipment which will set off an alarm when an intruder breaks the circuit.

Actually, this type of protection can be expanded to more than point-of-entry protection. Pressure-sensitive doormats, for example, can be placed in front of valuable objects such as safes or paintings. These will also break the circuit if stepped on by a thief, setting off the alarm. A burglar may have skillfully cut a window around the metallic foil tape, crossed wires to nullify the system, then step on a doormat and set off the alarm anyway.

Another variation of the electro-mechanical alarm is a simple taut wire stretched around the protected area. So small it is nearly invisible, the wire is connected to a snap-action switch which is activated whenever the tension is either too tight or too loose. Thus, the alarm is sounded whenever some intruder either brushes against it or cuts it. Since such a setup is subject to false alarms because of expansion and contraction due to weather, commercial units are available which automatically compensate for temperature changes.

Photoelectric detectors

A simple photoelectric cell, or electric eye, is a device that is ordinarily used with other forms of alarm equipment. Normally, a light beam is focused on a photocell which in turn generates a small voltage that is amplified and used to supply power to an alarm circuit. When the electric beam is shining on the light-sensitive receiver, the alarm contacts are held open. As soon as an object or intruder intercepts the light beam, the photo-cell goes dark and the output voltage drops. The drop in voltage de-energizes the circuit and the alarm contacts close.

The limitations of this simple equipment are easily recognized. If something happens to the power source—a power failure, for example—the system is dead. This can be overcome by having a separate battery for the alarm circuit, which will "fail-safe" or sound the alarm if something happens to the light.

Even more serious is the visibility of an ordinary light beam. The burglar can easily detect it and slide under it. Or he can use a flashlight beam to "fool" the photocell.

PHOTOELECTRIC ALARM system has range of up to 1000 feet. Made by Ademco.

More advanced systems use infrared or ultraviolet light, which is not visible to the naked eye. Some of these installations may still have a faint red glow which can be detected by the burglar and compromised by a flashlight beam.

The best photoelectric equipment forestalls even this possibility by introducing a pulsating beam which must correspond with the receiver. If the synchronized beam is interrupted or a different source of light introduced, the alarm will sound.

By its nature, a light beam will travel only in a straight line. This makes the equipment well suited for protecting open spaces and similar areas, while at the same time making it unsatisfactory for many-angled, winding or curved perimeters.

To more effectively use photoelectric equipment, mirrors are often used to deflect the light beam in different directions. With enough mirrors and strong enough beams, an entire area can be crisscrossed with one or more beams of light, providing space as well as perimeter protection.

One of the main advantages of this type of equipment is its capability to cover open portals, aircraft runways, driveways and other exterior applications where physical obstructions would be dangerous.

On the minus side, the light beams are narrow and can be detected and avoided by the observant intruder. When the equipment is used outdoors, it is susceptible to damage, misalignment and being compromised by dust, smoke, fog, snow or soot. Also, only straight lines (or mirrored angles) are possible. On a curved building, this equipment is usually impractical.

Space-protection gear

Perhaps the greatest advances in electronic security have taken place in the field of *space protection.* Virtually unknown a few decades ago, this type of equipment has proliferated within the past few years.

Space protection is, in fact, an excellent compromise, offsetting the disadvantages of both spot and perimeter protection. It is an even better tool used as a supplement to one or both other systems (perimeter and spot). Space protection can concentrate on an *area* which is likely to be attacked. Not only is the edge (or perimeter) of the area protected, but any movement whatever inside the specific area is detected by space protectors.

One obvious advantage of this type of equipment is its defense against "stay-behinds." As soon as the stay-behind moves out of hiding, his presence sets off an alarm. If an intruder should get beyond a perimeter alarm, he is unlikely to escape the space alarm.

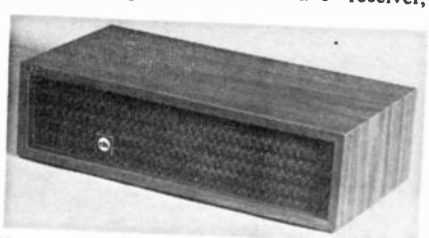
ULTRASONIC INTRUSION SENSOR by Heathkit looks just like a book.

Space alarms are easy to hide, or to disguise as some other object. They can be made to look like books, stereo speakers, etc.

Ultrasonic equipment

"Ultrasonic" is a slight misnomer, since the word means "beyond sound" and high frequency sound waves which are generated are just within the upper limits of the audible spectrum. For all practical purposes, however the sound is inaudible to the human ear, so the term is used.

Ultrasonic equipment is designed to protect an enclosed area. It operates by generating a chain of high frequency sound waves which fill the protected area with a continuous pattern. A sensitive receiver,



ULTRASONIC INTRUSION DETECTOR is a Doppler-type unit made by Detection Systems.

connected to an electronic amplifier, picks up the waves. If they are of the same frequency as the sound emitted by the transmitter, the system is neutral.

But any motion which comes from

within the protected area will send back a reflected wave of a different frequency than that generated by the transmitter. This change in frequency will be picked up and amplified in the control unit, setting off the alarm.

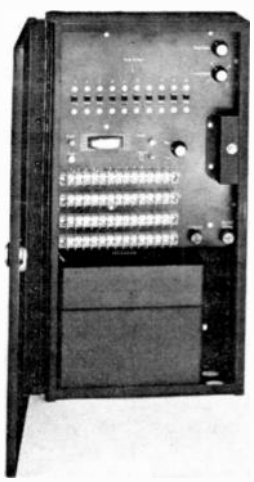
Some of the advantages of ultrasonic alarms are their comparative invisibility—devices are easy to hide or disguise as something else—and the excellent protection against all types of intruders, including the elusive "stay-behind." Ultrasonic alarms are quite flexible, and the protective pattern can be altered to suit the shape of the room. The equipment can be moved when required—in many cases it may simply be picked up and carried to another location. The devices may also be used to detect fire, which can result in large savings by eliminating the need for special additional fire-detection equipment.

Although ultrasonic equipment is generally very good for area protection, it has its drawbacks—like all other devices. For one thing, if an intruder suspects that an ultrasonic detector is present, he can take extremely slow steps—about one per second—and not be picked up by the alarm. The device is also sensitive to loud noises from outside sources or building vibrations. Either of these may trigger the alarm unnecessarily. A furrier's vault or other high sound-absorbing area cannot use this equipment because the waves are "soaked up" by the clothing. A thief who is aware of the presence of an ultrasonic detector can penetrate a wall behind a large object (which would deflect the sound waves).

Audio space equipment

A simple audio system may be thought of as just the opposite of an ultrasonic installation. Whereas the ultrasonic transmitter fills a room with sound waves, the audio space device only "listens" for sound. It reacts to *any* sound and is neutral only when the room is comparatively soundless.

An analogy can be drawn with a swimming pool full of water. In an ultrasonic system, the water would represent the ultrasonic waves. If the water were disturbed by a swimmer, an alarm would sound. A pool protected by an audio system, on the other hand, would be completely dry. The only time an alarm would sound would be when a drop of water was added to the empty pool.



SOUND DISCRIMINATOR type of intrusion detector made by Scientific Security Systems.

Unlike ultrasonic equipment, audio detectors are not disturbed by movement of air or other types of motion. What sets off an audio alarm is noise, so where loud machinery, fans or other noise-producers are a problem, audio equipment is probably not the best choice. There are, however, "cancellation" microphones available which are able to nullify specific noises.

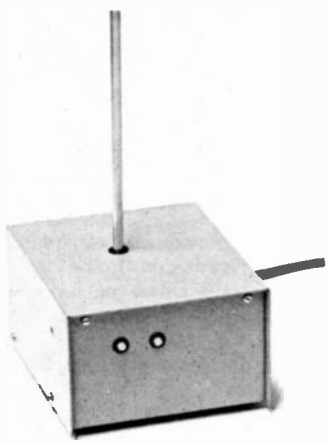
These systems are extremely sensitive and can be programmed to pick up the sound of a dropped pin. Unfortunately, such delicate sensitivity will result in many nuisance alarms with most installations.

There are several additional limitations to audio devices. They cannot, for example, be used around heavy equipment or noisy machinery. Nor should they be used in a room with heavy drapes and carpeting which will muffle sounds.

Simple audio equipment can be put to very good use in a building which has a proprietary system. A guard who is monitoring the system can turn up the receiver and listen carefully to whatever sound comes over the wires. The guard should be able to differentiate between machine noise, wind rattling a window, and other natural sounds, and the intrusive sounds of someone attempting to burglarize the building.

There are also filters which can be used to allow an alarm to discriminate between sound that is "okay" and sound which signals intrusion. Dual microphone setups can also "cancel" sound coming from an exterior source such as a passing truck. If the noise on the outside microphone is louder than the one inside, the alarm is not sounded.

Simple audio systems are best suited for large areas and can use sound equipment (such as intercoms) which has already been installed.



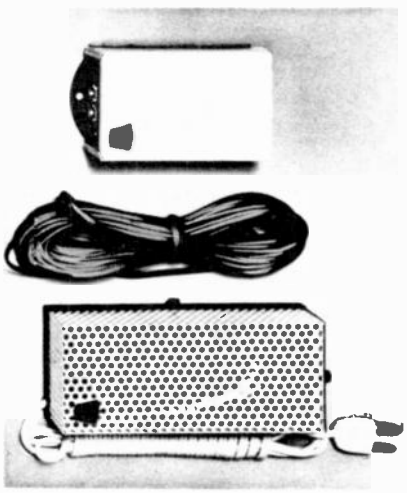
MICROWAVE RADAR detection system operates in 400-MHz range. It's made by DBX Inc.

On the minus side is the fact that no perimeter protection is provided, nor can the equipment be used where sound-absorbing materials inhibit its effectiveness. Unless expensive cancellation microphones are used to drown out noise, the equipment may be too sensitive to ordinary noises to be of much benefit.

Radar equipment

This class of equipment is very similar to the ultrasonic. Ultrasonic waves depend on movement within an area filled with high frequency *sound* waves. Radar equipment picks up movement in an area filled with high-frequency *radio* waves. In each, the movement of an object is reflected and causes a disturbance in the normal wave motion. Picture the swimming pool again—filled this time—and a swimmer diving into the water causing a series of waves.

HOME PROTECTION SYSTEM for do-it-yourselfers is made by EICO.



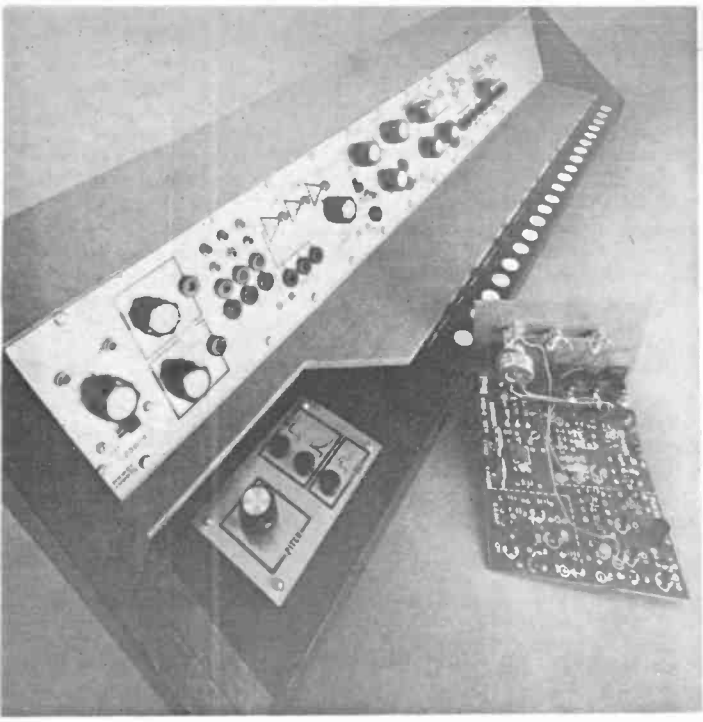
ADD A SMOKE DETECTOR like this one from Edmund Scientific for wider protection.

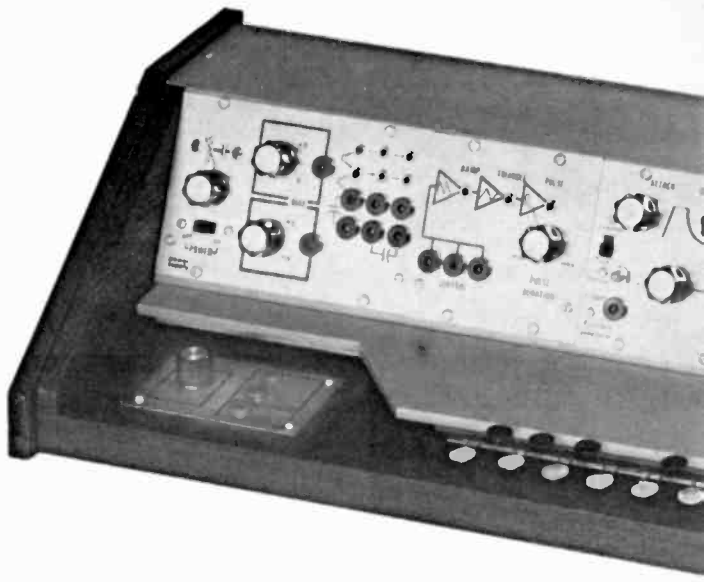
At the present time, radar-type equipment is in a state of flux. Although its potential is great, there are many problems and the solutions have not been entirely successful. The principal problem is that the radio waves cannot be contained within a specified area as well as ultrasonic waves. Radio waves travel easily through most materials, and the alarm can be tripped by a person walking by the window of a protected area.

Expert planning is vital for a successful installation. Properly engineered and maintained, this type of equipment can be top-flight. Poorly planned, it will lead to numerous false alarms and/or will be very easy to compromise.

Although these high-frequency radio waves are highly penetrating and will go through most materials, they bounce off metal objects. The location or radar antennas is of primary importance. Unless they are properly positioned, intruders could crawl behind a row of file cabinets, metal desks, etc., and their presence would not be picked up by the equipment. For the same reason, objects such as moving metal fans will set off nuisance alarms unless they are covered by metal screens. Elevators are another problem, but the equip

(continued on page 98)





BUILD A MODULAR ELECTRONIC

Developing music by synthesizing the tones electron-
Now it can be yours. This synthesizer is simple,

THERE IS NOT MUCH DOUBT THAT ELECtronic music synthesizers are the favorite toys of the music industry; hardly a record or TV commercial is produced these days without some sort of synthesizer "gimmick." Yet despite the ubiquitous nature of these devices (or perhaps because of it) there is no other collection of electronic equipment so thoroughly misunderstood not only by the layman but by a great many musicians as well.

This article will help clear the fog surrounding electronic music by going beyond the "How They Work" material that has appeared in the past. Here we will present full details of the construction of a fully compatable set of voltage-controlled synthesizer modules.

The synthesizer that is described here has been specifically designed for construction by the electronics experimenter. While some compromises have been made in the interest of improving the price/performance ratio of professionally available equipment, you will find that the equipment described is in most ways a little brother to the studio gear selling for ten times the price. There is a power supply, voltage-controlled oscillator and controller, voltage-controlled amplifier, two voltage-contolled filters, a function (envelope) generator and control oscillator/noise source. When the first three modules are completed you will have a playable, though limited, instrument.

Power supply

As you can tell from the photographs, the power supply does a little more than just act as a source of voltage for the rest of the modules. It also includes a patch panel, attenuator and two sources of bias voltage that will be used to set constant filter or amplifier parameters.

The schematic for the power supply is in Fig. 1. The actual power supply portion of the circuit consists of two separate full-wave rectifiers. One section (T1, D1–D4, C1, C2) provides the +18 and +9-volt supplies while the other (T2, D5, D6, C3) supplies the -9-volt side. Regulation is not included because the only module that requires a regulated supply (the VCO) has on-board regulation.

The series string of R2, R3 and potentiometer R5 provides a front panel voltage source that is variable from -5 to +5 volts while the combination of R1 and potentiometer R4 supplies a variable 0 to 5 volt source.

With the exception of the "conditional" jumpers between rows of jacks the patch panel is a straight-forward design. Referring to the schematic again we see that the switch contacts of the miniature phone jacks are arranged so that when a plug is inserted into J1 it isolates the top row of jacks from all jacks below it. Similarly, a plug inserted in J4 isolates the second row of jacks from the pin jacks below it (but not from the top row). Two sets of capacitor isolated jacks are provided at J11, J14 and J12, J13. The purpose of these jacks will become clear in a later article on using the synthesizer.

Potentiometer R6 provides a variable attenuator that can be used as a master volume control or in mixing applications.

Put it together

There is nothing at all critical in the power supply circuit and any construction method may be used, but an etched circuit board is desirable in the interest of ease of assembly and professional appearance. The foil pattern is in Fig. 2. Circuit boards may either be etched at home or purchased from the source mentioned in the parts list.

Assembly should begin with mounting the parts on the circuit board. Form and install the two wire jumpers, then the resistors, capacitors and diodes. Bolt the two transformers and the fuse holder to the circuit board with 4-40 hardware. When they are properly installed, the transformers will be "back to back" with the primary windings facing each other (see Fig. 3).

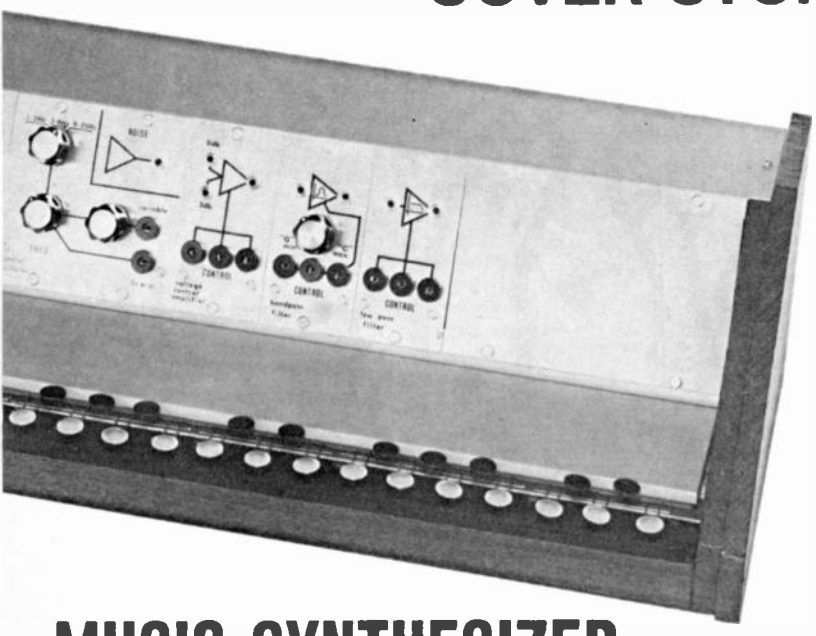
Connect the solder lugs of the fuseholder to the circuit board with short pieces of bare wire, and before putting the circuit board aside solder in place lengths of No. 22 wire to points A through F on the circuit board. Be sure to make these wires long enough to reach from the circuit board to the front panel when the two are bolted together.

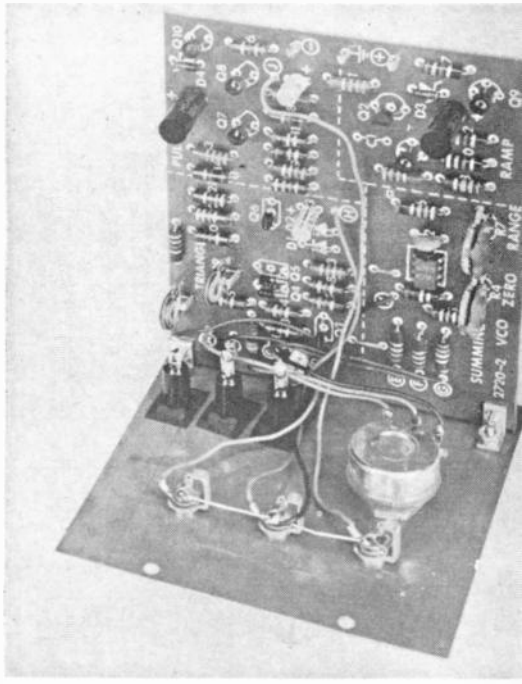
From the front panel from any flat material such as aluminum, steel or even scrap copper-clad and drill or punch the required holes before painting the panel and applying markings as desired. Install the pots, jacks and switch S1 as shown in the photos and wire the front panel before fastening the circuit board to the front panel using small "L" brackets and 4-40 hardware. Note that capacitors C4, C5 and C6 are wired in place on the front panel.

Make the final connections from the front panel controls to the circuit board and solder the line cord into the circuit board points marked ac Snap a ½-amp fuse into the fuse holder and fasten the knobs to the potentiometer shafts.

* President, PAIA Electronics

COVER STORY





MUSIC SYNTHESIZER

by JOHN S. SIMONTON, JR.*

ically is not new but has just started gaining momentum. inexpensive and designed for the experimenter.

Testing your work

There is really not much to test on the power supply, plug it in and use a vom to make sure that there is 18 volts between the ground and "++" points on the circuit board. Similarly check the "+" point for 9 volts to ground. Reverse the vom leads and check for -9 volts, between "-" and ground. Check the voltage output of the 0 to 5-volt and -5 to +5-volt bias supplies as the controls are rotated (all of these voltages are ±20%). Plug a miniature phone plug into J3 and check continuity between the hot side of this jack and all the other phone jacks in the group as well as the top row of pin jacks. Plug a phone plug into J1 and observe that it isolates the top row of phone jacks from the rest of the jacks. Test the switching on the second row of jacks to make sure that it isolated J4 through J6 from the row of pin jacks directly below it but not from J1 through J3.

Voltage-controlled oscillator

Unlike electronic organs—which for the most part generate a specific sound by adding together sine waves of the desired frequency, magnitude and phase—synthesizers employ "formant synthesis" in which a desired signal is formed by dropping out selected frequencies in a harmonic rich waveform.

Our VCO generates three waveforms that are particularly rich in harmonics; ramp, triangle and variable duration pulse. Frequency range of the oscillator is almost 6 octaves from 40 Hz to 2500 Hz, in a single voltage controllable range and the frequency of the oscillator is directly proportional to the sum of the voltages at three control voltage inputs. The implications of voltage control will be fully covered in another article, but for now it will suffice to say that without it you don't have a synthesizer, you have an organ.

How the VCO works

In a synthesizer the VCO is the one module that doesn't offer many design compromises. The human ear is more sensitive to variations in pitch than to any other musical parameter so even small amounts of drift and shift are objectionable.

As can be seen in Fig. 4, two precautions keep VCO drift to a minimum. First, power supply regulation is directly on the circuit board (Zener diodes D3 and D4 plus series-pass transistors Q9 and Q10). Second, control voltage is summed by the active network built around IC1.

The ramp portion of the VCO is a standard configuration consisting of a UJT relaxation oscillator (Q2, C1). The capacitor is charged by constant current source Q1. The output of the op-amp summing network is scaled by setting the gain (R7, RANGE) and offset (R4, ZERO) of the amplifier and is used to set the amount of current delivered by the current source.

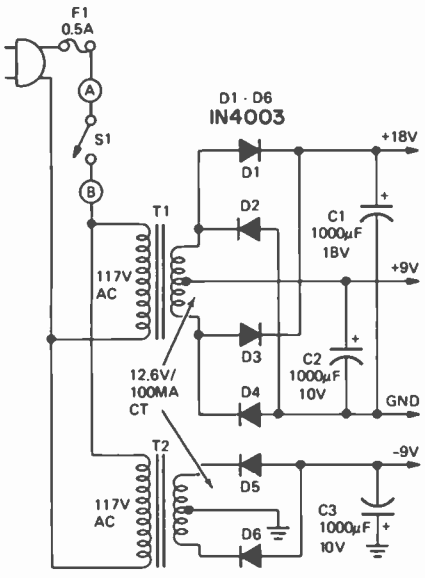
The voltage ramp that appears across capacitor C1 is isolated by emitter follower Q3 and appears at the front panel jack as the ramp output. The ramp is also used to generate the other two waveforms.

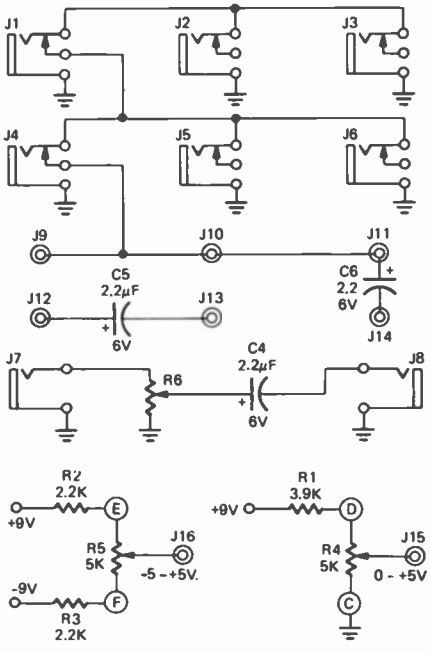
The triangle waveform is shaped by the differential pair Q4 and Q5. The voltage at the collector of Q5 is in phase with the input ramp and the voltage at the collector of Q4 is 180° out of phase (inverted from the input). Diodes D1 and D2 "select" the higher of these two collector voltages and apply it to the base of emitter follower Q6. During the lower half of the input ramp, Q4's collector voltage is higher because of the phase inversion and that section of the ramp is presented in an inverted form to the base of Q6. During the second half of the ramp the collector of Q5 is higher and this portion of the ramp is applied to the base of Q6 without an inversion. The net result is a triangular wave from the emitter of Q6. Trimmer potentiometer R19 is used to balance the gains of the transistors so that the last of the wave from Q5 and the first of the wave from Q4 occur at the same dc level.

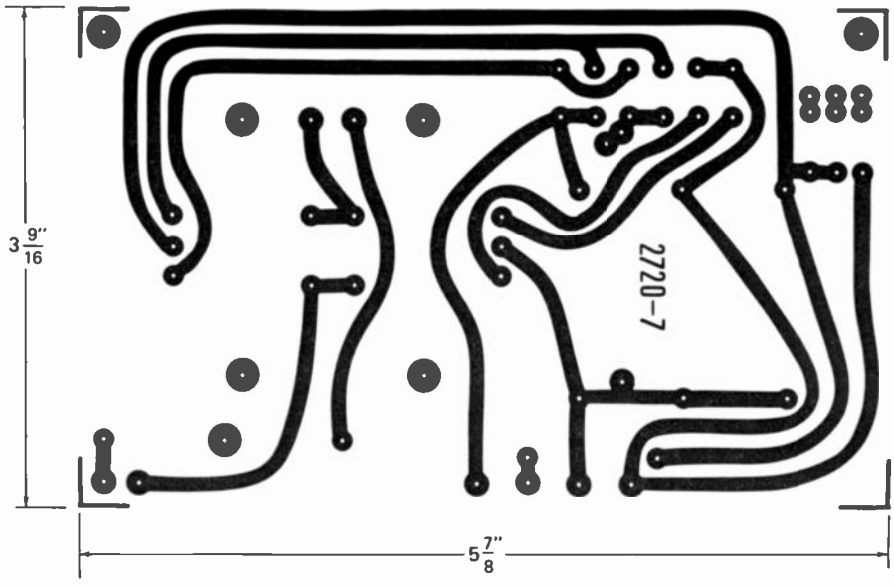
A variable-duration pulse output is derived from the ramp by applying it to the input of the Schmitt trigger (Q7 and Q8). At some point on the ramp the triggering threshold of the circuit is exceeded and the output changes from some low voltage to almost positive supply and stays in that condition until the ramp re-sets. By using R25 to vary the amplitude of the ramp, the pulse duration, as a percentage or the total period can be varied. As the amplitude is increased the duration of the pulse is also increased. Trimmer R26 provides a fine adjustment of the ramp amplitude and is set so that when the pulse duration control is fully counter-clockwise the narrowest possible pulse is produced.

Build the VCO

The VCO circuit can be assembled using any common construction technique, but an etched circuit board (Fig. 5) is recommended. Figure 6 shows parts placement on the circuit board. When all components have been mounted, solder wires to points A through K. Make sure they are long enough to reach from the board to the







PARTS LIST
(Power Supply)

C1—1000-μF 18V electrolytic
C2, C3—1000-μF 10V electrolytic
C4, C5, C6—2.2.-μF, 6V electrolytic
D1 thru D6—1N4003
F1—0.5-amp fuse
R1—3900 ohms ½W 10%
R2, R3—2200 ohms, ½W, 10%
R4, R5, R6—5000 ohms linear taper potentiometer
S1—spst slide switch
T1, T2—12.6V 100 MA C.T. transformer
MISC: Fuse holder, line cord, (8) miniature phone jacks, (8) tip jacks, (3) knobs, hardware, wire, solder, circuit board, etc.
The following items are available from, PAIA Electronics, Inc., P.O. Box 14359, Okla. City, OK 73114
No. 2720-7—Complete kit of parts for duplicating the prototype shown including circuit board and front panel. $22.00 plus postage for 2 lb. and insurance.
No. 2720-7pc—Circuit board only $4.00 postpaid.

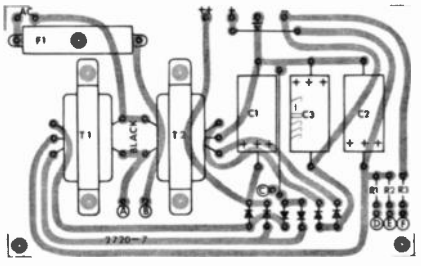


FIG. 1—(far left) COMPLETE SCHEMATIC of the power supply. FIG. 2—(top of page) FOIL PATTERN for the power supply circuit board. FIG. 3—(above) PARTS PLACEMENT on the board.

front panel controls and jacks (notice that there is no point I).

Form the front panel in the same manner as for the power supply and finish and label it before installing R25 and the input and output jacks.

Fasten the circuit board to the front panel using 4-40 screws and small "L" brackets and make the final connections between the circuit board and front panel.

Calibration and testing

Apply power to the rear connections of the circuit board; +9 volts to "+", ground to ground and -9 volts to "-". The VCO pulls a hefty 25 mA because of the regulation, so batteries are not acceptable. Give the unit about 30 minutes to stabilize before calibration.

The primary adjustment sets up the summing network so the oscillator produces a specified output frequency for a given input control voltage. This can be done using either an audio signal generator or a tuned musical instrument as the pitch reference.

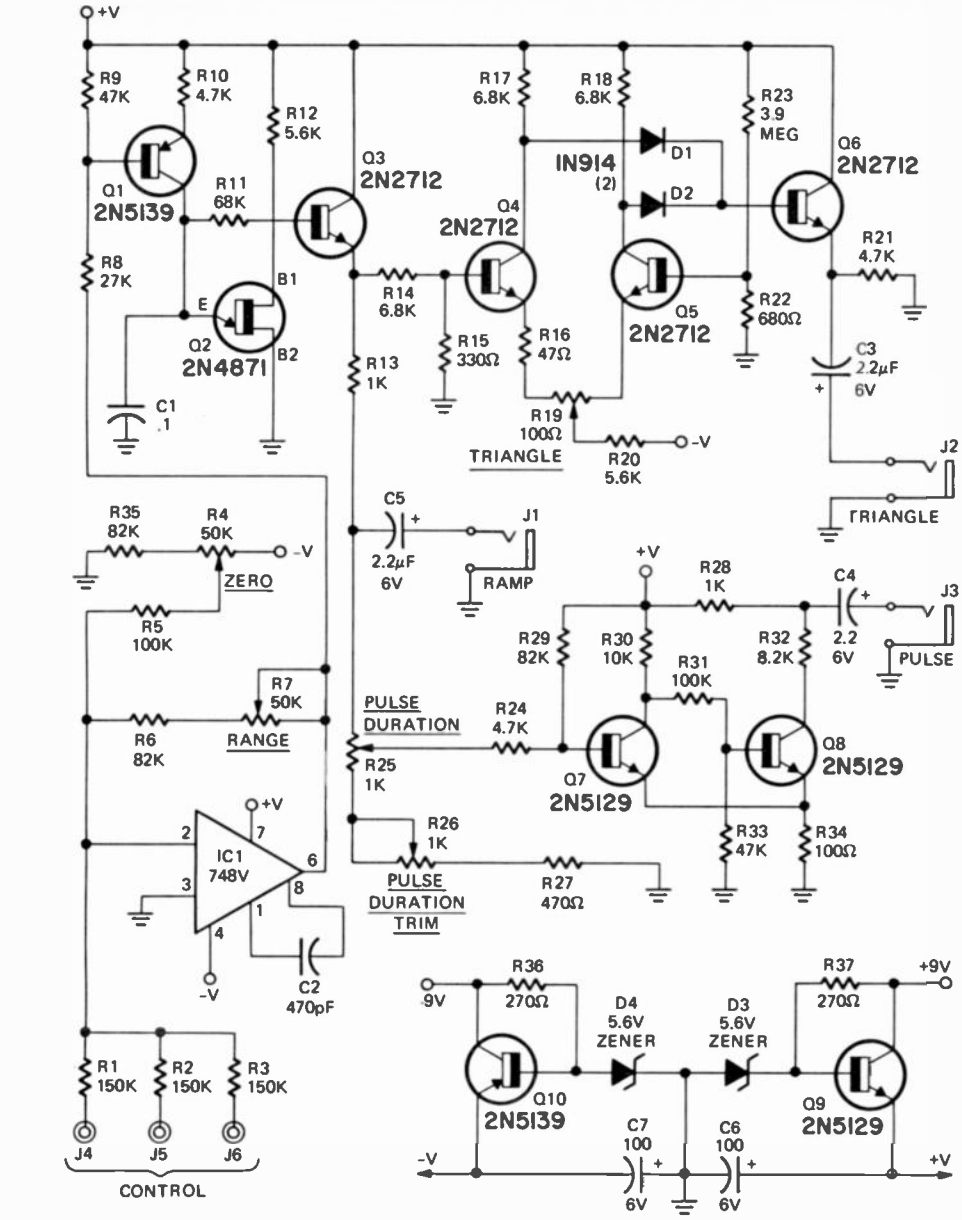
If you decide to use the signal generator method, the oscillator will be tuned using Lissajous figures. Connect the output of a test oscillator set to 260 Hz to the horizontal input of an oscilloscope and the triangle output of the VCO to the vertical input. Apply power to the VCO and jumper the 0 to 5-volt bias output of the power supply to the left hand control voltage input jack. (The input summing resistors can not be trimmed so unless matched resistors are used only one of the three inputs can be precisely calibrated.) Monitor this control voltage with a vom set to 2.5 or 5 volts dc full scale. Adjust the bias output for 0.625 volts as indicated by the vom (errors caused by inaccuracies in the vom movement will cancel when the keyboard is calibrated to the VCO.) Use VCO ZERO trimmer R4 to produce a Lissajous figure on the scope that indicates that the frequency of the signal generator is exactly twice the frequency of the VCO. Do not be overly concerned with a slow rotation of the pattern at this point.

Adjust the bias supply until the scope shows the *sideways 8* pattern that indicates that the output of the signal generator is half the frequency of the VCO. Read the vom. If the reading is *Less* than 2.5 volts, rotate RANGE trimmer R7 about 1/10 of a turn clockwise. If the reading is *greater* than 2.5 volts, rotate the trimmer about 1/10 of a turn counter-clockwise. Reset the bias output for 0.625 volts on the vom and once again adjust the "zero" trimmer to produce the Lissajous figure.

Repeat the previous adjustment for the *sideways 8* pattern and adjust the RANGE trimmer accordingly. After several passes through this procedure the vom should read exactly 2.5 volts when the Lissajous pattern indicates that the frequency of the VCO is twice that of the signal generator. At this point summing network calibration is complete.

A second method for calibrating the VCO is approximately the same as the first except that the ramp output is jumpered to the high level input of a hi-fi or musical instrument amplifier and the tone is "zero beat" against the C below middle C for an input voltage of 0.0625 volts; and C above middle C for an input of 2.5 volts. The same technique of *successive approximations* that was used with the signal generator still applies with the ZERO adjusted for zero beat with C below middle C with a control voltage of 0.625 volts. The bias supply is then adjusted so the oscillator is zero beat with C above middle C and if the vom reads more than 2.5 volts the "range" control is rotated 1/10 turn counter-clockwise. Go back and forth through these two steps until the vom reads exactly 2.5 volts when the VCO is zero beat with C above middle C.

When the linearity of the summing network has been calibrated you can set the



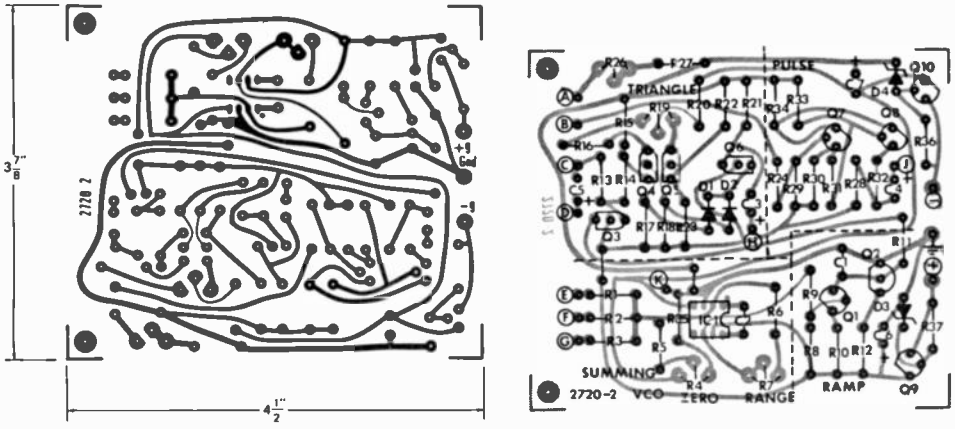


FIG. 4—(top) SCHEMATIC of the voltage-controlled oscillator. FIG. 5—(above left) FOIL PATTERN for the VCO. FIG. 6—(above right) PARTS PLACEMENT on the VCO board.

spectral purity of the triangle wave. If only an amplifier is available this adjustment can be made by jumpering the triangle output to the input of the amplifier and adjusting TRIANGLE trimmer R19 for the mellowest sound. If a scope is available you can look at the triangle output and adjust R19 so the two sides of the triangle meet at the top of the waveform.

The PULSE DURATION trimmer can also be adjusted using either an amplifier or an oscilloscope. If a scope is used rotate PULSE DURATION control R25 fully counterclockwise and adjust internal trimmer R26 so that the narrowest possible pulse appears on the screen. If an amplifier is used, adjust the trimmer so you can just barely hear the buzz of the pulse.

PARTS LIST
(Controller Electronics)

C1, C7—.01-μF disc
C2—.001-μF disc
C3, C11—2.2-μF 6V electrolytic
C4—100-pF disc
C5, C6—.1-μF mylar
C8, C9, C10—33-μF 6V electrolytic
D1 thru D5—1N914
IC1, IC2—748 op-amp
Q1, Q6—2N5139
Q2, Q5—2N5129
Q3, Q4—MPF-102
All resistors—½W 10%
R1—470 ohms
R2—10,000 ohms
R3, R17, R18, R19—680 ohms
R4—15,000 ohms
R5—100,000 ohms
R6—68,000 ohms
R7—82,000 ohms
R8—1 megohm
R9, R16, R22—3.9 megohms
R10—150,000 ohms
R11—22,000 ohms
R12—4700 ohms
R13—6800 ohms
R14, R15—33,000 ohms
R20—linear taper potentiometer, 1000 ohms
R21—1K pc mounting trimmer pot, 1000 ohms
MISC: Case, circuit board, hardware, control panel, wire, solder, etc.

The following items are available from, PAIA Electronics, Inc., P.O. Box 14359, Okla. City, OK 73114

No. 2720-6—Complete kit of all parts for duplicating the prototype shown including case, preformed springs, front panel, circuit board electronics, vinyl strip. $37.00 plus postage for 12 lbs. and insurance.

No. 2720-6pc—Circuit board only. $3.50 ppd.

No 2720-6v—Pre-cut conductive vinyl strip. $2.50 ppd.

A controller kit featuring a professional 3 octave organ keyboard is also available. Details available on request.

That's about all we have room for in this issue. Next month we will present details of the third module for the synthesizer and you can then start using your unit. We would appreciate your comments on the types of additional modules you would like to see for this instrument. We'll pass them on to the author and he may be able to provide them at a later date. See you again next month. **R-E**

KIT SUMMARY

No. 2720—Kit of all parts for duplicating the complete synthesizer. Includes all parts, panels, circuit boards and detailed instructions. $139.00 plus postage for 18 lbs and insurance

No. 2720-2—VCO kit including circuit board. $24.95 ppd.

No. 2720-2pc—VCO circuit board only. $4.00 ppd

No. 2720-6—Controller/case kit. $37.00 + 18 lbs. postage

No. 2720-6pc—Sample/Hold circuit board. $3.50 ppd.

No. 2720-7—Power Supply kit. $22.00 + 2 lbs. postage

No. 2720-7pc—Power Supply circuit board. $4.00 ppd.

A controller kit featuring a professional 3 octave organ keyboard is also available. Details available on request.

HEATH'S DIGITAL FM TUNER

The Heathkit AJ-1510 FM receiver is one of the world's most sophisticated and surely the most advanced consumer model. Take a look at how it works

by DAVID M. THOMAS*

VARIABLE-CAPACITANCE DIODES, DIGITAL tuning, programmable dividers, phase-locked loops, digital discriminator and frequency synthesizer are all terms that define established engineering techniques. New and exciting is the "Where and How" these are used. Ways of applying these techniques in commercial AM and FM receivers has long been talked about, but until recently was economically prohibitive for consumer oriented products. MSI and LSI (medium and large scale integration) technology has developed to such an extent in the last few years that these sophisticated sounding terms are now appearing in the consumer market.

The Heathkit AJ-1510 FM/FM Stereo Digital Tuner is a state-of-the-art design that uses the purest digital philosophies consistent with consumer products. Some of the tuner's special features include a sophisticated digital frequency synthesizer employing a phase-locked loop to achieve channel accuracy of better than 0.005%, an inductorless digital frequency discriminator, the very latest phase-locked multiplex demodulator, a preassembled varactor FM rf tuning unit (front end), and a four-digit, seven-segment channel-frequency readout (instead of a scale and pointer).

Also high on this list of special features are the three different modes of tuning. First, an exclusive keyboard where the user taps out the three or four-digit frequency of the FM station desired. Second, sweep/scan tuning which at the touch of a button, scans the entire FM spectrum at an adjustable rate, stopping at stereo only stations or at all stations with the quality of signal chosen by the listener through adjustable noise and agc controls. Third, preprogrammed card memory tuning.

A single front-panel meter indicates relative rf signal strength and with the flip of a switch it becomes a multipath indicator. There is no center channel "tweaking" since the frequency synthesizer sets it "right on."

Last, but by no means least, is the computer-like performance of the squelch control circuitry which eliminates any stations with noise levels above a presetable level. In addition, should a fault occur within the tuner prohibiting proper phase-locking, the squelch circuitry will lock out the audio and a fault indicator will light.

Most of the 55 integrated circuits, in addition to the more than 50 discrete transistors and 50 signal diodes, are mounted on ten computer-type printed circuit boards. Seven of these boards conveniently plug into a master board in modular form. Edgeboard connectors and cable connectors are used throughout, which means that circuit boards can be removed without having to unsolder or unwire a single connection. A system block diagram is shown in Fig. 1.

FM varicap tuner

The FM front-end is preassembled and factory aligned. Field-effect transistors (FET's) are used to get both high sensitivity and low cross-modulation with no overload on strong-signal local stations. The familiar mechanically ganged, variable capacitor has been replaced by Varicaps (voltage-variable-capacitance diodes) in each stage to provide complete electronic tuning. The dc tuning voltage is fed to the tuner from the loop filter output of the synthesizer which is discussed later.

An important note is the *extra* output from this particular tuner; the VCO (voltage-controlled oscillator) buffer output. A sample of the tuner VCO signal is extracted by an internal buffer amplifier which provides isolation and an output signal strong enough to drive the ECL gates of the VCO frequency scaler. The frequency range of this signal is 98.8 MHz (88.1 + 10.7) to 118.6 MHz (107.9 + 10.7).

I.F. and FM digital discriminator

Technological advances have finally eliminated all i.f. and discriminator adjustments while delivering near-perfect response characteristics. The 10.7 MHz i.f. circuitry consists of an input rf amplifier and two broadband amplifier-limiters. Together, these three IC's provide more than 120 dB of i.f. gain. Two fixed-tuned five-pole L-C filters separate the three amplifier stages and shape the "ideal" frequency response with true phase linearity.

The conventional L-C frequency discriminator using balanced diodes has been replaced by an inductorless and diodeless digital frequency discriminator of the pulse counting (averaging) type usually found in only the

*Senior Design Engineer, Heath Company, on the AJ-1510 project. Presently Chief Engineer, Heath Ltd., Gloucester, England.

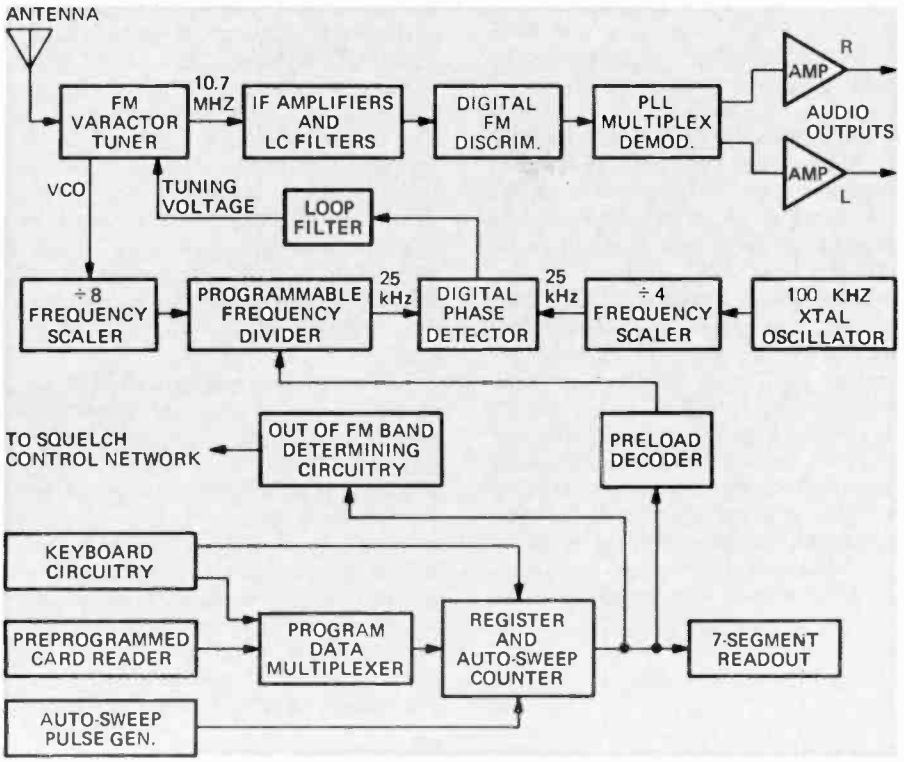


FIG. 1—A BASIC BLOCK DIAGRAM OF THE RECEIVER. Some sections will be broken down into further blocks and basic circuit diagrams as the discussion of the AJ-1510 FM receiver progresses.

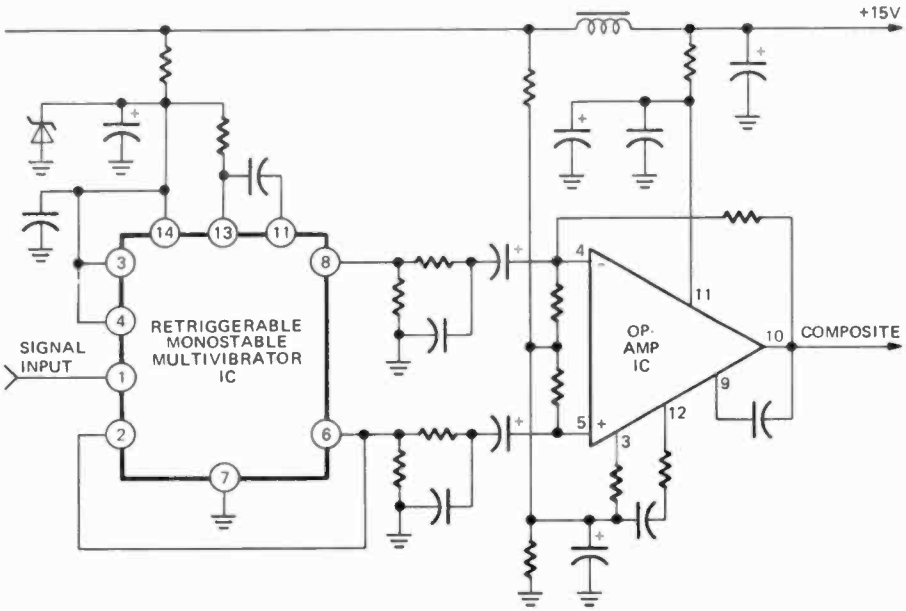


FIG. 2—BASIC CIRCUIT OF THE PULSE-COUNTING FM DETECTOR. Heretofore its use has been restricted to a few experimental receivers using very low i.f.'s.

most exotic instrumentation. This particular digital detector circuit contains two integrated circuits. One of them is a retriggerable monostable multivibrator and the other is an operational amplifier (see Fig. 2).

A signal at the input of the monostable makes it change states for a fixed period of time. The amount of time is determined by the value (time constant) of a simple RC network. However, to guarantee a high degree of pulse-width stability and thus low distortion, the monostable configuration is designed to cycle at half of the i.f.'s frequency. A digital output pulse, that has constant width and amplitude is obtained at a 5.35-MHz rate. (The FM information is contained in the slight deviations from this rate). The inverse ($\bar{Q}$) of this output waveform is also available from the monostable integrated circuit.

Both the Q and $\bar{Q}$ outputs are independently coupled to the inputs of the operational amplifier through simple RC networks. Because these signals are out of phase and applied to the amplifier (+) and (–) inputs, they are added together before they are amplified. Any in-phase noise appearing at both the (+) and (–) inputs is cancelled. This results in an improved signal-to-noise ratio of the monostable multivibrator. The operational amplifier's output is then fed to the multiplex demodulator circuit.

PLL multiplex demodulator

The very latest state-of-the-art integrated circuit phase-lock loop (PLL) multiplex demodulator is built into the tuner to deliver superior stereo performance while providing long-term circuit and alignment stability (see Fig. 3-a). This multiplex demodulator phase locks to the 19-kHz pilot of the received stereo transmission. Alignment is a simple resistance adjustment as compared to the tediously complex procedures of the past. This single adjustment "peaks" the phase-lock performance for greatest stereo separation and minimum audio distortion.

The PLL IC also has the ability to minimize the ultrasonic components (SCA) that would otherwise appear at the audio output. Previously, elaborate filters were used to do this, but there was a tendency to sacrifice high-frequency audio separation. A prealigned 19-kHz and 38-kHz L-C low-pass filter is used in both the *left* and *right* outputs to remove all unwanted signals above 15 kHz.

Frequency synthesizer

The heart of the tuner is its FREQUENCY SYNTHESIZER which includes the PROGRAMMER, the numeric readouts and an elaborate squelch control system. Each of the functional blocks in Fig. 3-b which make up this synthesizer will be discussed individually. Here we go.

Reference oscillator

Two circuits make up the reference oscillator; a 100-kHz crystal oscillator and a reference scaler (÷4). The oscillator section uses a highly accurate (±.005%) 100-kHz series fundamental crystal and the four gates of a quad 2-input NAND IC. Discrete resistors bias the gates near their switching threshold for reliable self-starting, and discrete capacitors provide proper capacitive loading of the crystal to insure good frequency stability. This circuit provides a highly accurate 100-kHz square wave, o a variable trimmer capacitor is not needed to set the frequency.

A dual JK flip-flop IC serves as the reference scaler. The two flip-flops are externally connected in series (+2+2) and divide the 100-kHz reference frequency by four. The resulting 25-kHz signal is used as the reference signal for the digital phase detector.

VCO frequency scaler (÷8)

The VCO frequency scaler divides the 98.8 to 118.6-MHz VCO frequency from the front end by eight to provide a 12.350 to 14.825-MHz square wave to the programmable divider circuit. One gate of an ECL (Emitter Coupled Logic) dual OR/NOR gate is used at the input as a buffer amplifier while the other gate is used as a driver to run a high-speed ECL type-D flip-flop, the first divide-by-two circuit. The output of the type-D then drives an ECL integrated circuit containing two J-K flip-flops externally connected in series to form a divide by four (÷2÷2). The series combination of these three flip-flops provides a scale factor of eight ($\text{VCO} \div 2 \div 2 \div 2 = \frac{\text{VCO}}{8}$). The output from the final flip-flop is coupled to two available TTL NAND gates that form an output interface to the programmable divider circuitry.

Programmable frequency divider

The programmable frequency divider divides the frequency from the VCO frequency scaler down to 25 kHz. As the front end is tuned to receive different FM channels, the frequency of its internal VCO also changes since it must remain 10.7 MHz above the received channel frequency. A different divide ratio is required for each channel to get the 25-kHz output signal. A convenient range of operation for the programmable frequency divider is one where for each adjacent channel the divide ratio is changed in steps of one. Refer to Fig. 4 for the following two examples.

Suppose we want to listen to an FM station broadcasting on 89.3 MHz. The VCO output will be 100.0 MHz (89.3 + 10.7) and the VCO scaler output will be 12.50 MHz (100.0 ÷8). The divide ratio of the programmable frequency divider will have to be 500 (12.50 MHz ÷ 500 = 25kHz). If we next wish to tune in a station two channels above at 89.7 MHz, the divide ratio of the programmable frequency divider must be changed to 502; (89.7 + 10.7) ÷8 ÷502 = 25 kHz.

The programmable frequency divider circuit consists of three programmable down counters (decade) and a recycle logic network. When several programmable divider stages are cascaded and a high toggle frequency is required, the terminal count output may be too slow, due to propagation delay, to simultaneously reload all the stages. Thus several counts may be lost. In the AJ-1510 application the terminal count is avoided and a recycle logic network is used to "anticipate" a particular count and provide a reload pulse within an acceptable gate delay time.

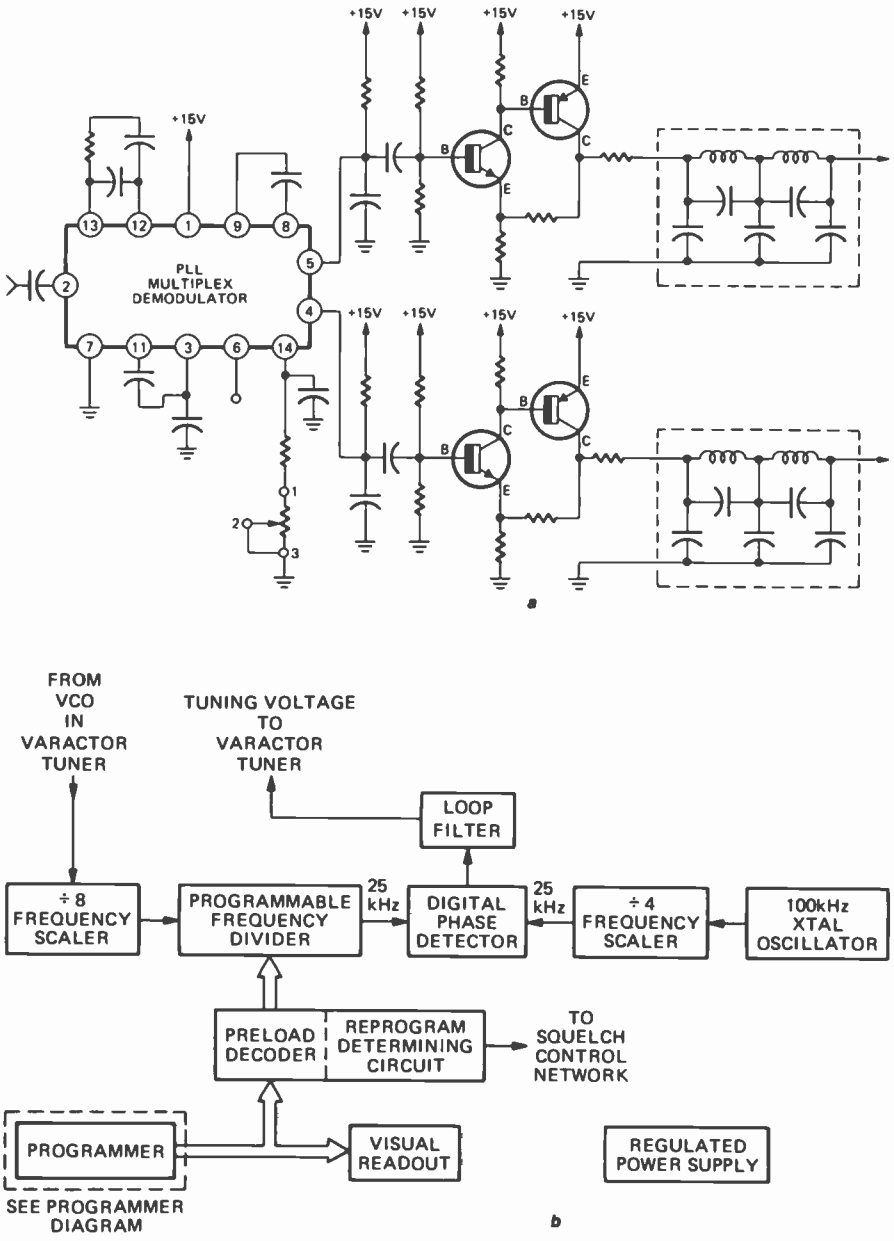


FIG. 3-a (top)—PHASE-LOCK LOOP IC is the heart of the FM multiplex system. Tuning is inductor-less. FIG. 3-b—FREQUENCY SYNTHESIZER operation is illustrated by block diagram.

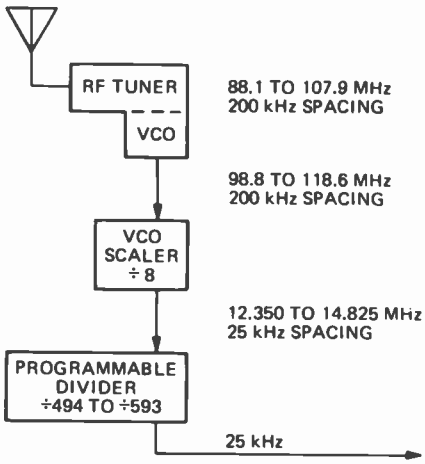


FIG. 4—FREQUENCY SCALER and programmable divider process VCO reference signal.

Digital phase detector and loop filter

The digital phase detector compares the output signal from the programmable divider (frequency scaled VCO) with the 25-kHz reference signal. When these signals differ in frequency the tuner tuning voltage is corrected, changing the rf tuning and VCO frequency so the output from the programmable divider is 25 kHz and in constant phase (but not zero) with the 25-kHz reference.

The digital phase-detector IC is commercially available and incorporates two different phase detectors with common inputs, a charge pump circuit and a high-gain amplifier. The duty cycles of the two inputs are not important since negative transitions control the operation.

The loop filter is an active integrator circuit that provides a dc tuning voltage for the tuner and establishes a control loop bandwidth. This bandwidth determines the amount of filtering on the tuner tuning voltage and also the time required to establish a stable phase-locked condition. The high-gain amplifier in the phase-detector IC along with a two-transistor dc amplifier form the active portion of this filter.

Programmer section

The programmer is the block of circuits that provides the programmable frequency divider with the required data inputs for the station frequency that has been "programmed." It provides three distinctly different modes of tuning; keyboard, preprogrammed data cards and automatic sweep/scan (Fig. 5).

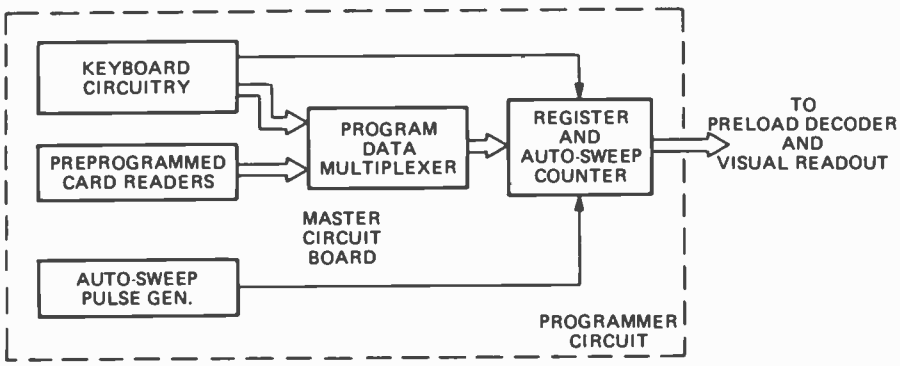


FIG. 5—PROGRAMMER SECTION handles the automatic scanning, keyboard and programmed data card inputs; processing them for the preload decoder and readouts.

Preload decoder

We need a preload decoder because the programmer is programmed with logic data that correspond to the FM channel frequencies, while the logic inputs required by the programmable divider are an entirely different set of values. Therefore, a "translator" is required. Using logic redundancies and sequential states greatly reduced this circuit complexity. Nonetheless, ten IC's were required to perform this job.

Register and auto-sweep counter

The "memory" unit of the programmer is a register consisting of four low-frequency programmable decade down-counters. The desired channel information in BCD (Binary-Coded-Decimal) form is parallel-loaded directly from the data multiplexer. During KEYBOARD programming each stage of the register is parallel-loaded individually. The completely loaded register retains this data until the RESET button is pressed to clear the register, or until a different mode of programming is selected.

Selecting AUTO-SWEEP operation changes the memory register into a serial down counter, and a reset pulse automatically loads in the highest channel frequency, 107.9 MHz. An auto-sweep count-down pulse is supplied by a pulse generator that continues the count-down sequnce until the squelch control system gives a STOP signal.

The BY-PASS key on the keyboard provides a zero voltage logic level to the "stop sweep" logic network that tells the tuner to resume or continue channel scanning. Holding this key depressed overrides any STOP signals and the tuner will continuously sweep from 107.9 to 88.1 MHz and reset to recycle until the key is released. The BY-PASS key functions only in AUTO-SWEEP.

Auto-sweep pulse generator

The auto-sweep pulse generator is an astable multivibrator that produces a 50-μs positive pulse at a rate that varies from one pulse per second to six pulses per second. These pulses are applied to the auto-sweep counter in the AUTO-SWEEP mode. The pulse rate is the channel sweep speed and is adjusted by a potentiometer located on the tuner front panel behind the hinged door. Once a good listenable station has been found, the pulse generator is automatically turned off, stopping the sweep. It is disabled in the other programming modes.

Program data multiplexer

The data multiplexer is located on the master circuit board and directs the BCD information from the three FM station selection inputs to the programmer circuit. The desired FM station selection scheme is activated when the appropriate front panel switch is depressed. Both negative and positive logic are used to minimize circuit complexity. Even so, eight IC's were required for a total of 25 logic gates.

The output of the data multiplexer is internally fixed when in AUTO-SWEEP with the BCD equivalent of 107.9 MHz. This data is the "reload" information for the auto-sweep counter circuit as it counts down to 88.1 MHz and recycles, thus providing automatic FM station scanning.

The keyboard

Keyboard tuning is the third mode. Tap out the frequency on the keys to tune in your favorite station, instantly. Touch the RESET button and you're ready to program another station.

Mounted on the keyboard circuit board are twelve spst-normally open reed keyboard switches. Ten of the keys are numbered "1" through "0" and their outputs are coupled to a simple diode matrix that provides the corresponding BCD outputs. The two remaining keys, RESET and BYPASS, provide control signals to the auto-sweep counter register. The RESET key performs a "clear" when the tuner is in the KEYBOARD mode, and the register is cleared to be programmed with another FM channel frequency.

Preprogrammed card reader

The three preprogram card readers are activated when the tuner is set to the PREPROGRAM mode. One of the three card reader switches (A, B, or C) is pressed to select the desired preprogrammed station. A simple schematic of the card reader is in Fig. 6. The corresponding outputs of the three circuits are connected to the input AND gates of the data multiplexer. The card reader hardware consists of three independent 15-line edge-board

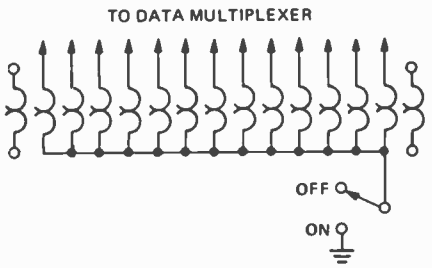


FIG. 6—CARD READER CIRCUIT. Notched card breaks unwanted circuit connections.

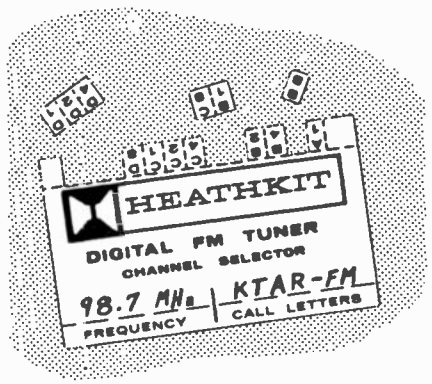


FIG. 7—CHANNEL-SELECTOR CARD. This one has been programmed for 98.7 MHz.

(continued on page 50)

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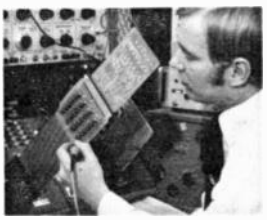

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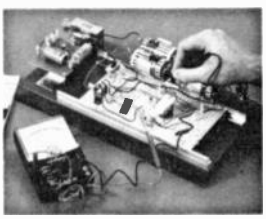

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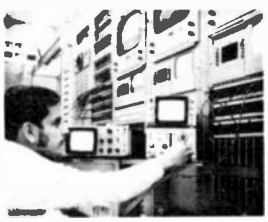

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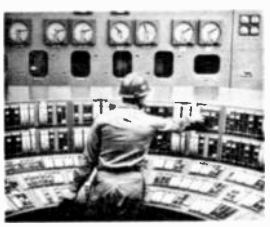

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RE-17

Circle 17 on reader service card

connectors mounted on the tuner front panel behind the lower hinged door. The contacts of these connectors have been designed to remain closed (short circuit) when in a normal state. A notched plastic channel selector card is inserted into the connector to "open" the unwanted connections. The notches (cutouts) therefore permit certain connections to remain closed which correspond to the desired channel frequency in BCD (binary coded decimal) form. A channel selector card is shown in Fig. 7 programmed for 98.7 MHz.

"Unlocked" detector

Outputs from both phase detectors of the digital phase detector IC are used as inputs to the lock detector. This detector consists of two 2-input NAND gates connected in an R-S type flip-flop configuration that is followed by an integrator and driver transistor. When the rf tuner VCO is phase-locked to the reference oscillator, the R-S flip-flop remains in a steady state which keeps the driver transistor cut off. However, if the VCO becomes unlocked from the reference oscillator, the R-S flip-flop produces a series of pulses. The first one turns on the driver transistor, and thus the "UNLOCKED" light, while at the same time supplying a signal to the squelch circuit to squelch off the audio.

"Re-program"

The United States FM broadcast band spans from 88.1 MHz to 107.9 MHz with 200-kHz channel spacing. The re-program circuitry detects when a channel frequency outside of this FM band is programmed into the Tuner (usually this occurs only in the KEYBOARD mode). Should an out-of-band frequency be entered, that frequency will appear on the front panel numerical readout, but the "RE-PROGRAM" indicator will light and the audio will remain squelched. Fig. 8 is the re-program logic diagram. Should a frequency ending in an even number, i.e. 103.4, 104.6 etc. be programmed, the tuner will automatically go to the next highest odd number, i.e. 103.5, 104.7 instead of calling for a "RE-PROGRAM".

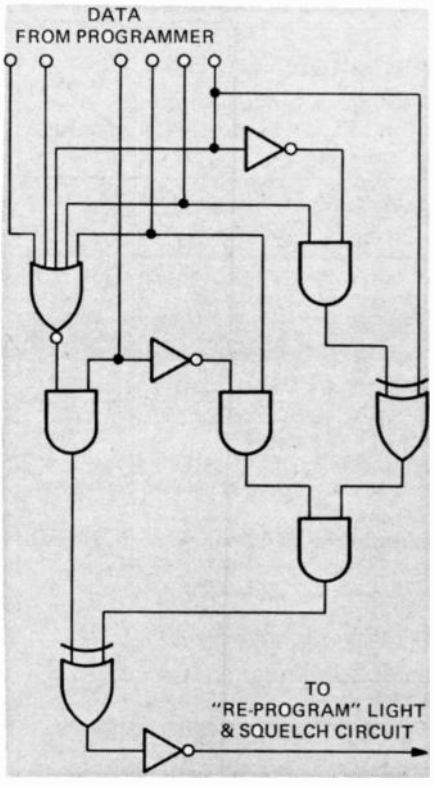


FIG. 8—RE-PROGRAM LOGIC detects when out-of-band input has been selected.

Squelch control

The AJ-1510 squelch control circuit accepts inputs from various sources within the tuner and then determine from these inputs what the state of the audio squelch control voltage should be (audio on or audio off). Here are eight conditions, all weighted equally, which contribute to the logic decision making of the squelch circuit:

1. Is the noise level from the i.f./FM discriminator above or below the acceptable limit?

2. Is the tuner rf input signal above or below the desired sensitivity setting?

3. Is the i.f. signal precisely center tuned?

4. Is the tuner receiving a stereo transmission? (This can be switched off.)

5. If the tuner is in the KEYBOARD mode, has the keyboard programming been completed?

6. Is the VOC properly phase-locked to the reference oscillator?

7. Is the SQUELCH DEFEAT switch ON?

8. Is the tuner properly programmed or is a "re-program" signal present?

(continued on page 98)

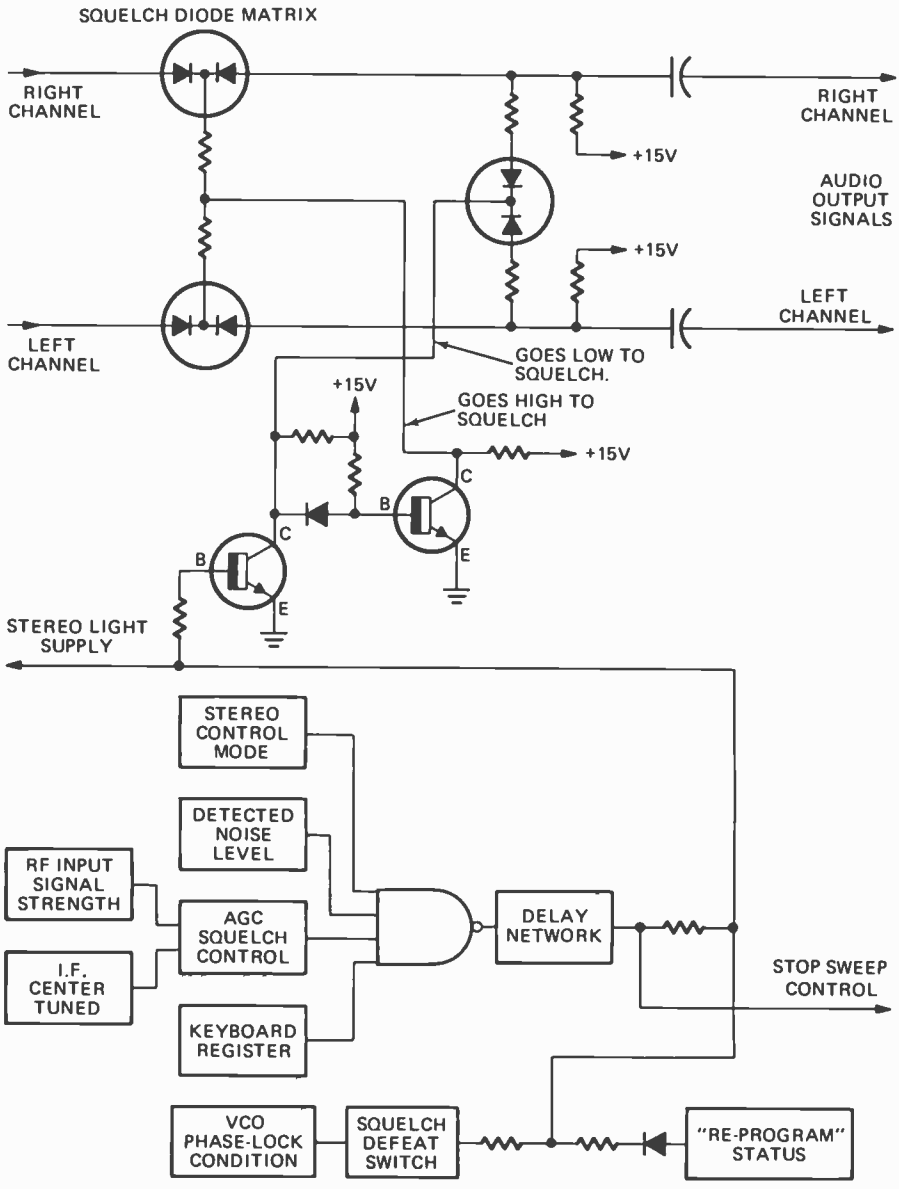


FIG. 9—SQUELCH CONTROL AND LOCK-OUT operation is illustrated by this schematic and block diagram. The logic circuits check eight important operating criteria.

How to Set Up a Public Address Speaker System

The choice, placement and layout of a speaker system can make or break a PA system. Do it this way and be sure

by BOGEN DIVISION, L.S.I.*

THERE ARE FOUR PRIMARY CONSIDERATIONS when using cone or horn speakers as a part of a PA system. These are the power available to the speakers. The number of speakers. The type of speakers. The placement and connection of speakers.

The first step is to survey the proposed installation and carefully determine how many and what type of speakers are needed. The following table may be of aid in this respect.

AMPLIFIER POWER	SPEAKERS NEEDED FOR INDOOR INSTALLATION	SPEAKERS NEEDED FOR OUTDOOR INSTALLATION
6 to 8 w	Two 8-in. speakers	One 12-in. speaker
15 to 18 w	Two 12-in. speakers	One trumpet
25 to 30 w	Four 12-in. speakers	Two trumpets
45 to 50 w	Six 12-in. speakers	Three trumpets
60 to 70 w	Eight 12-in. speakers	Four trumpets

There are several types of speakers available, and the choice of speakers depends upon five main factors:

1. **Geometry and acoustical** characteristics of the area to be covered.
2. **Ambient sound level** in which the speakers must operate.
3. **Fundamental use** of the system (i.e.—speech or music reproduction.)
4. **Fidelity and intelligibility** requirements.
5. **Economic** factors.

*A Division of Lear Siegler Inc., Paramus, N.J.

Speaker placement

The most complex step in speaker installation is their placement and hookup. Conditions under which each system must operate vary so widely with each installation that only the primary steps are given when considering speaker placement. For indoor systems, two kinds of placements can be used. The speakers may be positioned flat against the walls, and the axis of the speakers rotated so that they radiate energy at an angle from the wall. The speakers may also be positioned in the corners of a room. Variations from these two arrangements must be considered where there are alcoves, balconies, booths, dividing walls, and side rooms. In such cases, extra speakers must be set up to prevent dead spots resulting from unusual reverberations or blanking by obstacles.

For outdoor systems, the main considerations are direction of sound and the area to be covered. Here, brute-force is generally used by employing highly-directive trumpets. Bear in mind that sound pressure drops approximately 75% below the previous level each time the distance from the speaker is doubled. Also, directivity (amount of power concentrated along the speaker axis) increases with the size of the speaker horn.

Speaker connections

When connecting the speakers together, impedance matching and phase relation must be considered. Since these factors are somewhat involved, an extended discussion of impedance matching and speaker phasing follows.

Efficient transfer of power from the amplifier to the speakers is the prime consideration in a sound system. The two methods of transfer of power are connection from the amplifier directly to the speaker voice coils and connection from the amplifier to the speaker voice coils through a transformer. The first method is used when short runs of wire not over 200 feet in length and simple speaker arrangements involving low impedances are used.

The second method is used when the wire runs are over 200 feet, when

there are complex speaker arrangements, and when it is desired to have less than 15% power loss in the transmission lines. The use of transformers also simplifies impedance calculations and facilitates changes in complex speaker arrangements.

Impedance matching without transformers

For the most efficient transfer of power, it is important that the total speaker impedances match the output impedance of the amplifier. Single speakers should be matched as shown in Fig. 1.

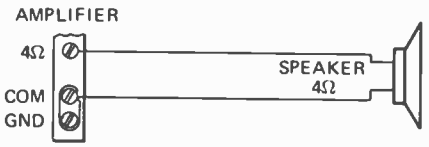


FIG. 1—SINGLE PA SPEAKER is connected like this. Just match the two impedances.

When there is more than one speaker in a sound system, calculations of total speaker impedance are based upon two formulas:

(a) For series connection of speakers, add the individual speaker impedances together to obtain the total matching impedance (see Fig. 2).

$$Z_T = Z_1 + Z_2 ..... + Z_n$$

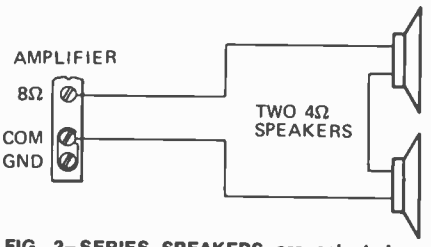


FIG. 2—SERIES SPEAKERS are selected so the sum of impedances matches amplifier.

(b) For parallel connection, add the reciprocal of the individual speaker impedances together to obtain the reciprocal of the total matching impedance (see Fig. 3).

$$\frac{1}{Z_T} = \frac{1}{Z_1} + \frac{1}{Z_2} \cdots\cdots\cdots \frac{1}{Z_n}$$

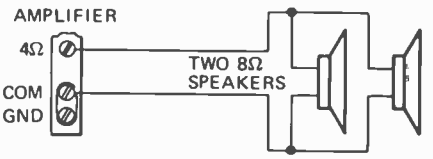


FIG. 3—PARALLEL SPEAKER connections tend to cause excessive line losses.

It is generally not advisable to use more than two speakers in parallel. Operation with less than 4 ohms impedance will result in excessive line losses.

(c) For series/parallel connections, combine the two formulas as the speaker connections indicate. For example, in Fig. 4, apply the series formula for A and B, then for C and D. Take the results of this and apply the parallel formula to obtain the final matching impedance:

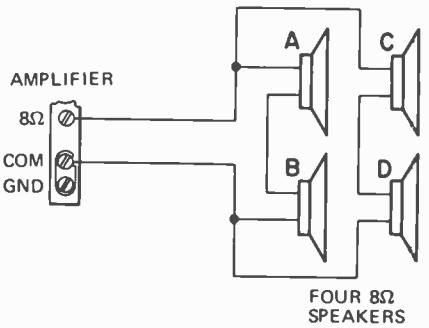


FIG. 4—SERIES-PARALLEL connections may be used to gain desired power distribution.

$$A + B = X \quad (1)$$
$$C + D = Y \quad (2)$$
$$\frac{1}{Z_T} = \frac{1}{X} + \frac{1}{Y} \quad (3)$$
$$Z_T = \frac{XY}{X+Y} \quad (4)$$

Power distribution with transformers

In a series system of speakers, all with the same voice coil impedances, equal power distribution will occur. However, if one speaker has 4 ohms impedance and another 8 ohms, the power consumed by the 8 ohm speaker will be twice that of the 4 ohm speaker.

In parallel systems of speakers, all with the same voice coil impedances, equal power consumption will result. When speakers of different impedances are connected in parallel, the smaller impedance speaker will receive the greater power. If one speaker is 8 ohms and one is 16 ohms, the 8-ohm speaker will consume twice as much power as the 16-ohm speaker.

When operating speakers on voice coil impedance (without transformer), use as heavy a wire as possible. Speaker cable runs of 100 feet or over should be at least No. 16 wire. Runs from 50-100 feet should be No. 18 wire or larger.

Impedance matching with transformers

The proper use of transformers with speakers far from the amplifier prevents comparatively large power losses in the transmission lines. In complex installations having large numbers of speakers, the use of transformers simplifies power distribution.

Constant-voltage transformers are most commonly used for this purpose, though impedance-matching transformers may be used in some sound installations. The constant-voltage transformer has its secondary tapped for different values of power (watts) for the speaker. The primary matches the constant voltage line, which is either 25 volts or 70 volts.

Constant voltage system

The constant-voltage system was developed particularly for use in large multi-speaker installations, but that does not prevent smaller installations from enjoying its advantages.

The constant-voltage method greatly reduces the amount of computation necessary to determine the proper transformer taps when varying sound levels are required. It also permits the addition to, or changing of, an existing system without recalculation of the total impedances and the power required.

A favorable load condition exists if the total power consumed by the loudspeakers is always less than or equal to the amplifier rating.

When the constant voltage transformer taps are marked in watts:

1. Choose the transformer with a matching secondary (8-ohm secondary for an 8-ohm speaker).

2. Select the power tap desired, and connect to speaker.

3. Connect the constant-voltage line to the primary.

If the transformer is marked in impedances, the required power can be determined by applying the formula:

$$Z = E^2/P$$

Where Z = Required transformer impedance in ohms E = Amplifier output voltage (25 or 70 volts) and P = Desired power at the speaker in watts

Mismatching speaker to amplifier

Mismatching upward (connecting an 8-ohm speaker to the 4-ohm output of an amplifier) will decrease the power delivered to the speaker. Power loss will be about proportional to the upward impedance mismatch (50% when connecting an 8-ohm speaker to a 4-ohm amplifier tap). Mismatching cannot ordinarily damage a well-designed amplifier.

As a general rule, no serious frequency response deficiency will be noted if upward mismatches up to about five-to-one ratio are used.

Downward mismatching (connecting a 4-ohm speaker to an 8-ohm amplifier tap) should always be avoided. It will reduce the amplifier power output and overload the output tubes or transistors, seriously affecting their life and performance.

Phasing speakers

When more than one speaker is used in a sound system installation, it is advisable to phase the speakers to reduce the cancellation effect. Speakers out of phase lose up to one-half of their normal volume and operate with degraded tone quality and increased distortion.

For speakers facing in the same general direction, the speakers are in

phase when their respective diaphragms move outward and inward at the same time. With two speakers facing each other, proper phasing is achieved when the diaphragm of one speaker moves outward as the diaphragm of the other speaker moves inward.

Phasing is done by checking the polarity of the speaker terminals with respect to the movement of the speaker diaphragm, and connecting the speakers to produce the diaphragm movement or phasing desired. With loudspeakers of the same make and model, the respective diaphragms should move in the same direction when the terminals are connected in the same manner, but it is safer to check the polarity.

Where different speakers are used, carry out the following procedure to determine the diaphragm movement with respect to the speaker terminals for speakers connected in parallel:

1. Connect one lead from a 1.5-volt dry-cell to one voice coil terminal of the speaker.

2. Momentarily touch the other lead from the dry cell to the other speaker terminal.

3. Observe direction of cone or diaphragm movement (either inward or outward) when the circuit is closed.

4. Note this direction of the movement on a slip of paper.

5. Mark the terminal connected to the positive pole of the dry cell if the movement is outward, mark the terminal connected to the negative pole if the movement is inward.

6. Repeat steps 1 through 5 for other speaker or speakers to be checked.

7. Connect the marked and unmarked terminals according to the manner of electrical arrangement shown in Fig. 5 if the speakers are facing in the same direction. If the speakers face each other, make connections as shown in Fig. 6.

In simple sound systems, it may be easier to check phasing by listening to a low audio frequency while alternating the speaker leads. The human ear can usually detect when the low frequency sound is at the higher volume, indicating that the speakers are properly phased.

Balanced line connections

In most sound installations, unbalanced speaker lines will provide satisfactory performance. A typical unbalanced line installation for a 25-volt system is shown in Fig. 7. Two-conductor unshielded cable is normally employed in such installations. One conductor is connected to the 25-volt terminal on the amplifier output strip. The other wire goes to the common

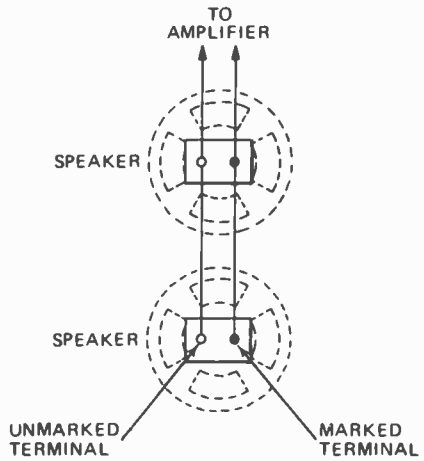


FIG. 5—PA SPEAKERS facing same way are phased with like terminals wired together.

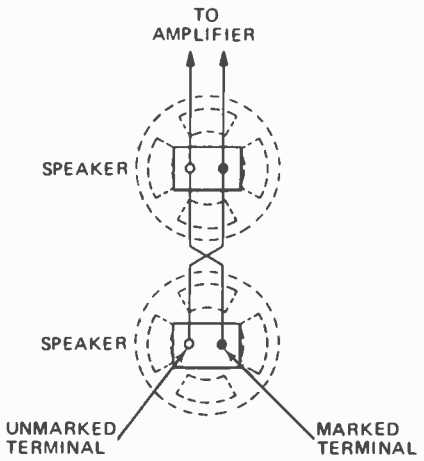


FIG. 6—SPEAKERS FACING EACH OTHER have line transposed for in-phase operation.

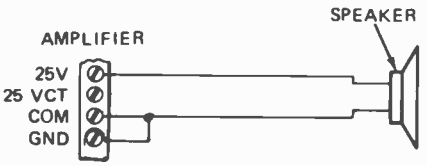


FIG. 7—A 25-VOLT UNBALANCED line is typical. Balanced lines are for special cases.

terminal, which is then connected to ground.

However, in more elaborate systems where input lines are run in close proximity to the speaker lines for extended distances, currents in the speaker lines may be picked up by the input lines. When these stray currents are fed back to the amplifier, hum and crosstalk will be introduced into the system, or the amplifier may oscillate.

For this reason, balanced line connections are recommended for installations in which long input and speaker lines are run close together. A balanced line is obtained by undergrounding the common terminal, leaving the outputs floating. In a balanced line, any current which is developed in one side of the line is offset by an equal and opposite current in the other side. This greatly reduces the possibility of inducing stray currents in nearby input lines.

In some balanced line installations, it may also be necessary to connect the appropriate center-tap terminal to ground, and to ground the amplifier chassis.

If hum or other pickup is encountered with a balanced line as described above, it may be necessary to run a shielded two-conductor cable to the speakers and to ground the shield at the amplifier end.

Sound column speakers

Sound columns are designed for sound reinforcement in theatres, auditoriums and arenas where it is necessary to cover a large area with a minimum number of speakers. A sound column consists of six or more cone loudspeakers enclosed in a rectangular cabinet lined with acoustic material. Depending on the size and type of cone speakers employed, the output rating of a sound column may range from 25 to 200 watts. The terminal strip and sometimes a plate for mounting a line-matching transformer are located on the rear panel.

The arrangement of the speakers in the column is such that their acoustic output adds up in the forward direction, so that the effective throw of the sound column far exceeds that of the individual cone speakers. The effective throw or maximum distance at which sound from the column is distinctly audible is usually between 100 and 200 feet.

Because of its configuration, the sound column produces a highly directional beam pattern, which permits the sound to be aimed over a well-defined area of the installation site. Since about 90% of the acoustic output of the column is confined to this pattern, there is virtually no random sound available to cause reverberation or reflection. Consequently, a sound column can be properly directed to cover a hall or section of a hall most effectively and to keep harmful reflections away from the floor and ceiling.

In addition, the geometrical configuration of the speakers in the column produces a sound dispersion pattern which is quite broad in the horizontal plane but much narrower in the vertical plane. In the Bogen sound columns, the horizontal dispersion pattern is 120°, which is a great deal more than that of the individual speakers. However, the cumulative effect of the in-line speakers produces a vertical dispersion pattern of approximately 25° as shown in Fig. 8.

Placing sound columns

A typical sound column installation is shown in Fig. 9. The sound

(continued on page 99)

SQ? LOGIC? QS? RM? DISCRETE? CD-4? MATRIX?

unscrambling

The pages of contemporary publications and newspaper
An expert uses the best in 4-channel equipment and a

"THE PAGES OF HISTORY ARE LITTERED with the dried bones of those who at the dawn of a new idea sat down to think it over . . . and thinking it over, died." You could not find a better description concerning the present situation in 4-channel sound.

On the one hand we have the consumer publications with their endless articles on the differences between matrix systems . . . how they aren't compatible . . . how the consumer should sit it out until the "matrix war" is resolved in favor of one system or another.

On the same side of the coin there are the originators of the various matrix systems, each of whom can conclusively prove that only their system is technically and musically viable; yet these are the same people breaking their backs to increase separation while abandoning their original designs.

Of course, we all have read—and by now accept the fact—of the many "bugs" that plague the discrete CD-4 record system, and we all *know* it will be a long time before the CD-4 system is suitable for use in this country. In fact, at the time this article is being prepared I have just read an editorial to this effect in a leading consumer magazine . . . **and all the while I'm listening to outstanding CD-4 sound from a production model JVC 4DD-5 CD-4 demodulator.** (My other equipment should be so bug-free.) The only "bug" is the sparcity of records to play through the system. And the lack of equipment to play the few available records.

On the other side of the coin we have the hi-fi retailers who actually believe the articles being written every month. They are not going out of their way to inform their customers about 4-channel "until the industry settles on one standard system."

Except for Lafayette Radio and some local firms, 4-channel sound just isn't getting the push it deserves. And while we are on the flip side of the coin let us not overlook the record producers; with very few exceptions their 4-channel attempts are at best, feeble. Even if a hi-fi salesman attempted to demonstrate 4-channel, the customer's reaction to most recordings would be: "So What! For this I should spend an extra hundred or so dollars?"

In actual fact, all existing 4-channel systems *sound good, far, far better than standard 2-channel stereo;* and do not miss the emphasis on *sound good.* Theoretically, one system might be superior to another, but in practice they are all a new and exciting experience in sound even when intermixed. For example, A QS recording played through an SQ decoder can be just as exciting as when played through its matching QS decoder, and the same goes for an SQ recording played through a QS decoder, or a "universal decoder," or even an ambient sound decoder—also known as a Dyna or synthesizer.

The real determination of whether the surround-sound effect is a new experience in listening or just another gimmick is the application of the 4-channel potential. For example, the Enoch Light Project 3 4-channel recordings are outstanding, even through basic QS and SQ decoders with their limited separation.

The performers can actually be detected in corner or center locations and the overall effect is a walk-through sound field that can be enjoyed from any location. It is not necessary to be positioned dead-center between the speakers with head locked facing the "front" speakers. By simply arranging the instrumentation specifically for the capabilities and potential of the quadrasound systems Enoch Light attains a true three-dimensional sound field regardless of the encoding or decoding equipment. This in contrast to some of the Columbia SQ library which cannot always justify the added expense of 4-channel. (Listen for yourself.)

By what is best described as an unplanned, fortunate chain of events we are now able to show you precisely what takes place with *production 4-channel equipments*—in contrast to the negative theories usually advanced. A little background so you will better understand what we shall illustrate. First, Enoch Light issued almost identical matrix recordings, the only difference being one version was recorded SQ, the other QS. Second, when **Radio-Electronics** obtained a JVC 4DD-5 CD-4 demodulator, one of the demonstration records was supplied in a plain white envelope with neither the record nor envelope carrying any identification. This turned out to be a JVC (not RCA) CD-4 mix-down from the original tapes that RCA used to make the stereo release of the show "Hair," and it was now possible to compare a CD-4 and stereo version of the same program material. Note that the sound quality of the JVC record in terms of distortion, clarity of

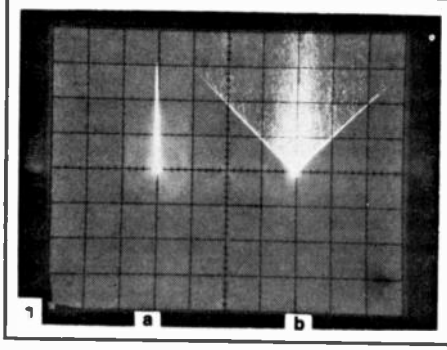
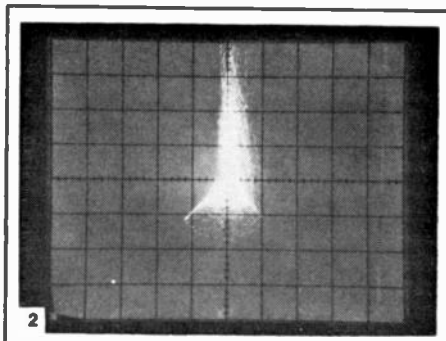


FIG. 1-a (far left)—MONO RECORD played in mono mode to produce equal-level in-phase signals at the right and left outputs of a stereo system. Vertical line indicates center-front mono image. FIG. 1-b (left)—STEREO-LIKE OUTPUT with pronounced center-front orientation is developed when mono record is played back in the stereo mode.



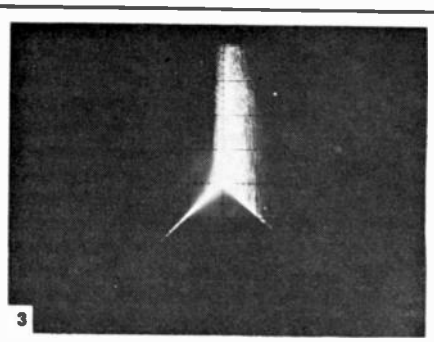


FIG. 2 (left above)—QS DECODER DERIVES A REAR SIGNAL from a mono recording. FIG. 3 (above)—SAME MONO SIGNAL through SQ decoder produces right and left rear outputs.

4-channel stereo

ads are filled with the pros and cons of 4-channel sound. vectorscope to demonstrate how the systems compare.

by HERB FRIEDMAN

sound and use of the 4-channel potential, so far outclassed the commercial releases supplied as demonstration CD-4 recordings that one could understand why CD-4 has not been as impressive as it should be—the recordings are plain rotten. (The best thing that could happen is for JVC to release their "private" recording of "Hair," destroy the presently available RCA releases and take it from there.)

Finally, JVC was willing to allow us to use their private CD-4 test records, which we added to the existing collection of 4-channel test records from CBS and United Recording Company. Between the JVC and standard Bruël & Kjaer frequency-run records we were able to check any phono pickup up to 50,000 Hz, as well as check matrix operation.

Since the important thing about any 4-channel system, or its performance, is only how it will sound in the typical home we chose as the reference equipment some of the best presently available. For SQ we used the Lafayette LR-4000 receiver which features an SQ decoder, a full logic (with wave-matching) SQ decoder and a derived ambient decoder. For both the QS and discreet 4-channel a JVC 4VN-770 amplifier was used.

For matrix tests all results are those which can be duplicated by using Shure V15 II and Empire 1000Z/E pickups. The CD-4 pickup was the JVC 4MD-20X with Shibata stylus. To avoid mistracking that could possibly mask CD-4 performance, a Garrard Zero 100 turntable was used.

Interpreting the Illustrations

Both the 2-channel and 4-channel sound fields consist of virtual and imaginary sound images. A signal fed to the left and right speakers (or left back and right back) creates a virtual sound image in the corners, for that is where the sound appears from the speaker. In the scope photographs, this virtual sound image is represented by the diagonal lines, which also indicate the relative sound power fed to the corner speakers.

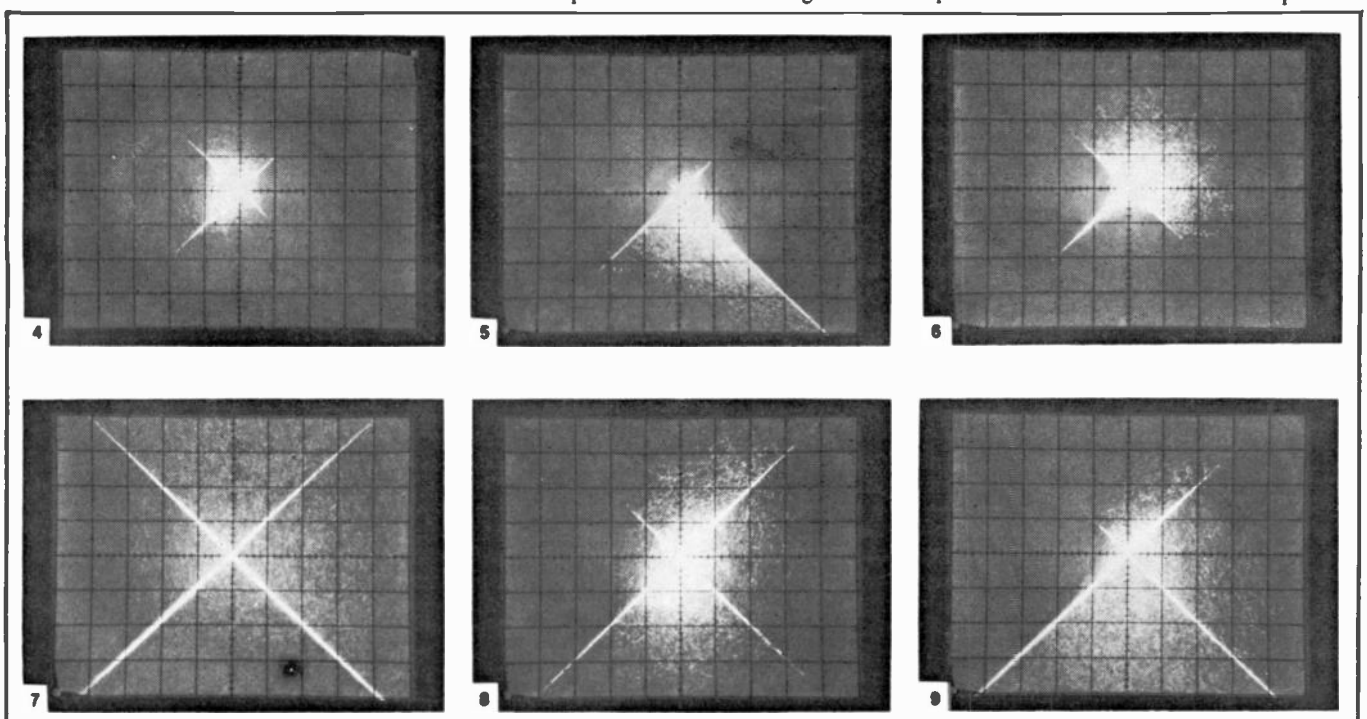
A mono sound image, however, must be created from the corner signals. If the signals to the two front speakers are identical in level and phase the sound will *appear* to the listener to be coming from a center position between the two speakers: hence, the center or derived mono signal is an imaginary sound image as it really doesn't exist—it is created by phase and balance relationships between the corner signals.

In a similar manner, if the left front and left back signals are equal and in phase the listener will perceive an imaginary mono sound image between the two speakers. In the oscilloscope illustrations the imaginary mono sound image is shown as a vertical line pointing towards the center front, center back or center sides. *In short, the scope traces indicate what the listener perceives, not the electrical power distribution.*

The scope equipment shows only the in-phase information that tends to form an imaginary image. For example, if the left and right channels are fed equal levels that are out of phase the scope indicates the power fed to the corner speakers, and the pattern will be a "V" indicating an out of phase condition: one that cannot create a mono image.

The scope illustrations represent the sound field as it would appear to someone looking into the listening room from the floor above: upper left is LF (left front), upper right is RF, lower left is LB (left back), lower right is RB. Center positions are center positions, such as CF (center front) and CB.

In each series of illustrations the amplifiers have been balanced for optimum



FIGS. 4, 5, 6, 7, 8 and 9 (top left to right and lower left to right, respectively)—SOUND FIELDS FROM SAME PASSAGE with QS and SQ encoding played through various decoders.

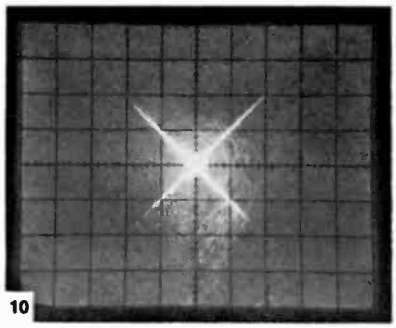


FIG. 10—STARPATTERN produced when SQ-encoded signals are applied to SQ decoder.

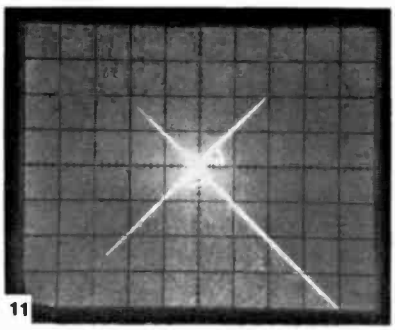


FIG. 11 (top right)—RIGHT REAR SIGNAL is pronounced when SQ-encoded signal is fed to a particular full-logic SQ decoder.

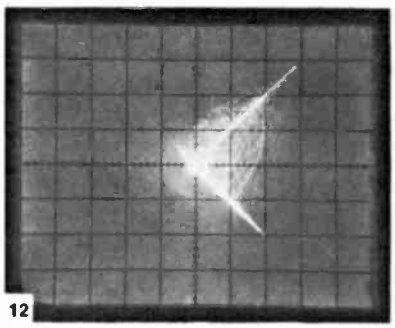


FIG. 12 (right)—QS-ENCODED signal fed through an SQ decoder produces extreme right orientation with predominant in-phase signal from right-back to center-front.

matched condition as determined by a calibration recording: the gains and/or balance was not disturbed during the series of checks and tests so that the scope illustrated what would be actually heard by the listener. If switching in a matrix decoder caused a balance shift, well that's the way it is for the listener and that's the way it's shown.

The matrix systems

All the viable matrix systems depend on a precise match of phase and amplitude relationships. During the recording process the front and rear signals are level- and phase-oriented so that inverse orientation during playback will extract the individual corner signals. Naturally, because of bandwidth limitations there is only so much—and not much to begin with—separation possible, and each individual corner signal will appear as side signals in at least two of the other corners. Depending on the particular matrix system the undesired side signals can range from -3 dB to infinite attenuation.

If the decoding equipment was precise, the playback could be an accurate reproduction of what the record's producer intended. Unfortunately, it is virtually impossible to hold phase and amplitude relationships to a precise value(s) in consumer equipment. Resistor tolerances of 10% (standard) can produce almost 20° phase variation, while an ordinary gain shift of 3 dB—unheard in stereo listening—can shift the sound orientation from a matrix playback.

To correct many deficiencies in the matrix systems CBS developed the full-logic decoder for their SQ matrix. Basically, the full-logic decoder senses whether the predominant program information is CF (center front) or CR (center rear) and varies the gain to favor the predominant information. In a similar manner the wave-matching senses the corner information and varies the gain to enhance the discrete effect. At the time this article is being prepared the full logic decoder and lesser variations of it are the only means for enhancing the matrix sound field available to the consumer. It is rumored that CBS has an even more effective system for their SQ enhancement, while Sansui claims they have also come up with an enhancement for their QS system (**Radio-Electronics**, March 1973). To keep the record straight, we have heard these rumors for almost a year, but there is still no equipment. Fact is, the full-logic SQ decoder is the fifth generation of what was supposed to be a "perfect" matrix system the first time around.

But let us get back to the heart of the problem, what the user obtains when he puts down his hard earned dollars for 4-channel sound. His problems start when he places the matrix record on the turntable, as illustrated in Fig. 1. The left illustration

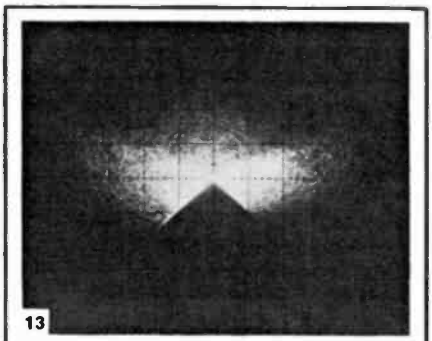


FIG. 13—SQ-ENCODED MATERIAL through an ambient-sound decoder. Program material is the same as for Figs. 4 through 9. Note similarity to QS pattern below.

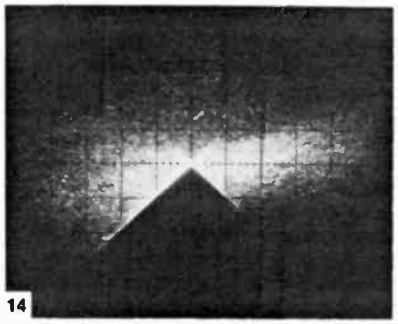
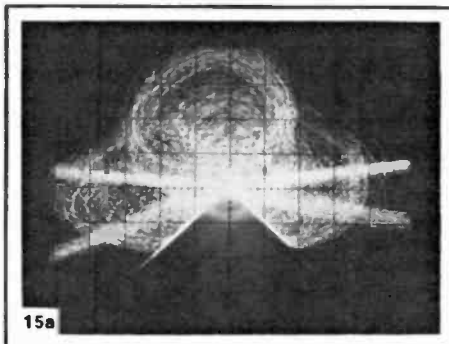
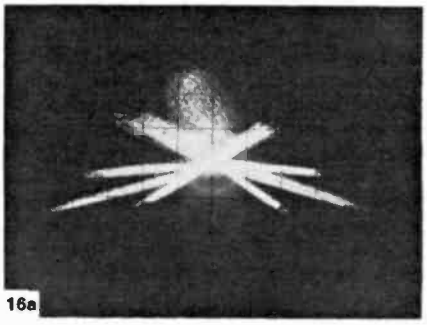
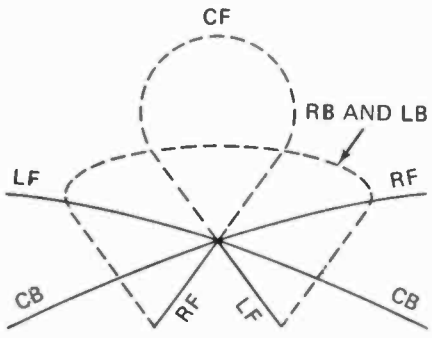


FIG. 14—QS-ENCODED single frequency through ambient (Dyna) decoder. Note the pattern is almost identical to that from SQ encoding in Fig. 13.







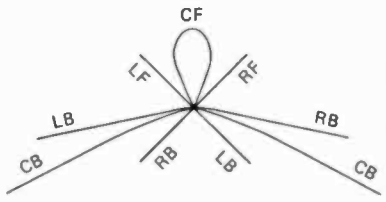


FIG. 15-a (top left)—DERIVED AMBIENT SOUND FIELD with decoder driven one channel at a time. FIG. 15-b (left above)—DIAGRAM of the derived pattern. FIGS. 16-a and -b (right top and bottom)—FIELD PATTERN AND DIAGRAM from QS encoding through ambient-sound decoder.

(Fig. 1-a) is made from a *mono* recording played with a stereo pickup with the amplifier set to *electrical mono*—both channels shorted together. The scope display is vertical, indicating *mono,* and this is what it should be even if the amplifier short was eliminated. But what really takes place is shown on the right side (Fig. 1-b with gain increased 2X for clarity). Because of phase mismatch within the pickup the one-second of mono program material is actually reproduced with a decided left-right orientation having a pronounced center or mono orientation. Now that we have a "stereo" image from a mono sound source some strange things happen. If we feed the mono-played-stereo through an QS decoder, in addition to the front output we get a predominantly in-phase rear output as shown in Fig. 2. If we play the signal through a logic SQ decoder (Fig. 3) the rear output is out of phase. Why? Who knows, it shouldn't be, *but it does still sound good.*

Now that we understand that from pickup through decoder we do not have the most precise conditions, let us look at the final results from matrix records. Each illustration represents one second of identical program information, only the decoder or matrix recording system is changed. In Figs. 4, 5 and 6 the program comes from an SQ record and is played through SQ, full-logic SQ and QS decoders. Note that the SQ decoder output is oriented predominantly LF and CL (center left), just as perceived by the listener. Through the full-logic decoder the output level is directed towards the CR and RR. Through the QS decoder the sound is predominately CF/RF/CL. Theoretically it shouldn't happen, and doesn't happen when single-frequency test tones are used; but with program material it did take place. Sound bad? No! It sounds good. After all, maybe the logic decoder output is the correct one; perhaps the straight SQ decoder output is incorrect. The listener doesn't know which is correct so both sound good. It is even possible that neither sound distribution represents what the producer had in mind, but so what, it does sound good, and it does sound three-dimensional. As another example take a look at what happens when you feed SQ through a QS decoder (Fig. 6).

Are you still fussy about the SQ sound field not being a precise representation of the producer's thoughts. Okay, look at Figs. 7, 8 and 9. The exact same program material encoded QS, and decoded by QS, SQ and logic SQ decoders. In Fig. 7 we see that QS from QS has produced what is essentially an equalized sound field from all corners. The SQ decoder in Fig. 8 has produced a minor shift in the sound field to the RB, while the logic SQ decoder in Fig. 9 has produced a decided shift RR and CR. Now we have six possible sound fields, all of which sound good to the listener.

Which one is correct? Even the mixing engineer who controlled the sound field might not have any idea. The only thing that is important is that whether the systems are matched or intermixed there is a decided enhancement of the sound field, with the full-logic SQ providing the most enhancement in front-to-rear separation. While any condition might make a shambles of a symphony recording, if the capability inherent in each system is used by the record producer for "pop" and light programs the overall sound field must come out pleasing to most listeners. This is easily checked for yourself by comparing the Enoch Light arrangements on Project 3 records with the attempts by other record companies. The finalized sound from Project 3 records might not be exactly what the producer had in mind, but it is to a major extent, spectacular.

Just for your amusement, now that you have observed the effect of different decoders on program material, observe what takes place when we used a steady-state tone. Figures 10, 11 and 12 represent the sound fields from SQ and QS encoding all channels driven, through SQ decoders. The SQ from SQ shown in Fig. 10 is what we should get. In Fig. 11 the logic has locked onto the RR signal, probably caused by the production tolerances described previously. Figure 12 is the result of QS encoding and SQ decoding. Note the RF orientation which compares with the RF program orientation in Fig. 6.

No illustrations are shown for equal level in all four channels through QS decoders because I have yet to find two QS decoders that will produce similar results, or any results that can be meaningful. Although the actual sound quality from program material is good, simultaneous four-channel test-tone drive produces a scrambled scope trace from which little reliable information can be extracted. Again, the problem might simply be one of manufacturing tolerances. I do not doubt there is a QS decoder that will illustrate four-channel drive, I just haven't run across one yet.

It has been claimed that the Dyna or derived ambient decoder closely matches QS encoding. This decoding system, which originated with David Haffler when he was head of Dyna, is based on the principle that sound reflections from the recording location get mixed into the stereo (front) signal, and these signals being out of phase with the primary direct signal can be easily extracted as a differential signal from the stereo output. Of course, at any given instant the reflections might be in phase with the program material, just as the direct stereo signal might be out of phase. In a listening test you can hear in the rear speakers what appears to be the ambient sound of the recording location as well as direct stereo information. In particular, a recording made at a live concert in Carnegie Hall does recreate in the rear speakers the noise of the audience—shouts and claps—which cannot be discerned in a straight stereo playback.

But as for "matching" the QS matrix, that is another story. Figures 13 and 14 show the 4-channel output of SQ and QS recordings. (The program material is exactly the same as in Figs. 4 through 9. Both the SQ and QS produce essentially similar 4-channel sound fields; the difference in size being the level from the disc as the amplifier and scope controls were not changed. Note that in both instances the rear channels are totally out of phase, and the sound field in no way resembles that of Figs. 4 through 9. Obviously, the differential decoder does not match either SQ or QS.

Figure 15-a shows the derived ambient (Dyna) 4-channel sound field with the decoder driven equal level all four channels, but one channel at a time to avoid obscuring the pattern with hash. The en-

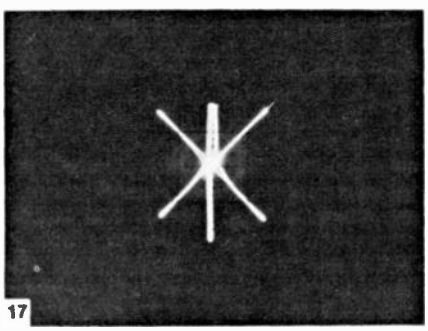


FIG. 17—FULL-LOGIC SQ DECODING is closest to full discrete. Note the "star".

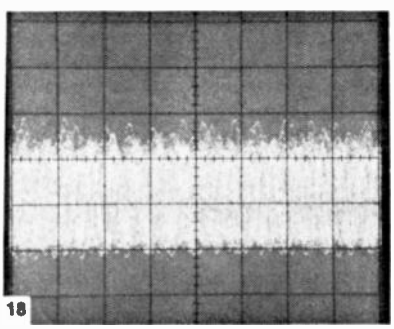


FIG. 18—LOOKS GOOD ON SCOPE but this pattern shows incorrect CD-4 channel balance.

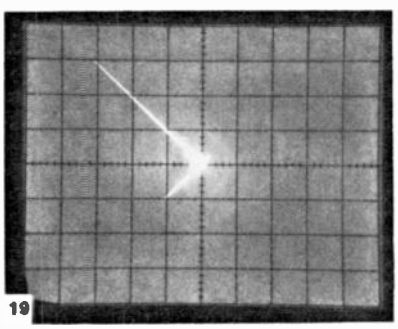


FIG. 19 (top right)—LEFT-BACK signal is result of incorrect CD-4 demodulator channel balance. With proper channel balance, only left-front pattern is seen or heard.

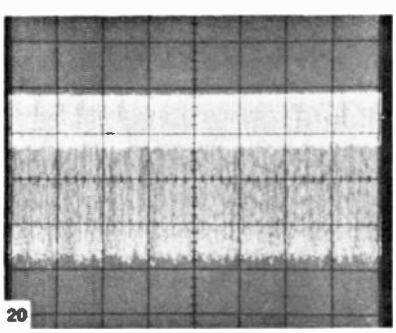


FIG. 20 (right)—SCRAMBLED SCOPE DISPLAY results when CD-4 channels are set correctly. This is the reason that CD-4 channel adjustments should be made "by ear" rather than through the use of instruments.

coding is SQ. The small diagram, Fig. 15-b, shows what each pattern represents. The same idea is shown in Fig. 16 for QS encoding: by stretching the imagination this might be interpreted as "matching" or "approaching" QS decoding, providing one ignores the interchange of RB and LB, and the appearance of these signals out at the sides.

Finally, for those who wonder what takes place when full SQ logic is applied to individual signals we present Fig. 17, the SQ "star" with corners and CF and CR single-frequency test tone. Note the almost complete absence of spill over. Presently, the full-logic SQ decoder is the matrix that comes closest to discrete 4-channel.

It should be obvious that even when matrix decoders are matched to encoders the sound field is not what is claimed by the proponents of each system, at least in production equipment. And intermixing the encoder/decoder is not the horror claimed by some. Sure the sound field and specific performer orientation is changed with matrix intermix, but it can also be changed when the matrices are matched. Is this bad? Is it important for the orientation to be correct? In most instances the answer is *no.* The listener does not know the intended sound field orientation, what the producer intended, hence, what the listener hears will be a pleasurable, dramatic effect. If the record's producer has used the full capabilities of matrix 4-channel his final product is so spectacular compared to standard stereo that variations in performer orientation can only *slightly* diminish or enhance what the producer intended, it cannot destroy the three-dimensional illusion.

In fact, modern records are the results of mix-down, where 8, 16 or more tracks are blended together for a total effect as desired by the producer; it is not natural sound to start with, so why should variations introduced by matrixing make it worse (see **Radio-Electronics**, October 1972, "How 4-Channel Records Are Made"). In short, the limitations of the matrix systems are not those of the system or systems but of the record production itself—the artistry involved in blending the multiple program tracks into a single sound source. This idea is not something to be taken at face value. Try it for yourself. Ask your hi-fi dealer to demonstrate matrix 4-channel with a Project 3 record, and with an open mind, with no preconceived ideas, simply ask yourself: "Is this good?" Most will find it is good.

Compatible, discrete—4 channel, CD-4

In the context of least side-channel signal spill and faithful reproduction of the original sound field the ideal 4-channel system for records is the discrete CD-4.

In very basic terms CD-4 works this way: The LF and LB signals are summed (added together) into a left signal which is recorded in the left groove. The RF and RB signals are similarly summed and recorded in the right groove. The result is a basic stereo recording. But along with each summed signal there is recorded a 30,000 Hz high-frequency carrier that is frequency and phase modulated with the difference frequencies, LF-LB and RF-RB. In short, each groove closely resembles a stereo FM broadcast in which the main channel carries the sum or mono program while the subcarrier carries the difference information used for converting the signal into stereo.

When a CD-4 record is played with a standard stereo pickup the output is standard stereo—at least according to its proponents. Only when the entire signal, including the high-frequency carriers, is processed through a special demodulator is the stereo signal converted to four independent signal outputs.

Since the high-frequency carriers are modulated +15/-10 kHz the total CD-4 record bandwidth is 30 Hz to 45 kHz, a formidable bandwidth for any pickup to handle. As you can imagine the foremost "bug" in the system was a pickup that could do the job. Another "bug" was record life. The minute high-frequency groove undulations are extremely sensitive to wear, and eventually required a special stylus called a Shibata stylus. This stylus, combined with high compliance, resulted in a pickup capable of tracing the undulations without causing unusually excessive wear. (As of this writing I have cycled a single inner diameter cut 57 times with no noticeable loss in signal quality.)

The CD-4 had many other bugs, most of which were in the recording process and outside the scope of this article. Suffice it to say that based on the sound quality of a CD-4 record now playing in the background these recording bugs have been overcome.

The JVC CD-4 system consists of a model 4MD-20X pickup and a model 4DD-5 demodulator. A pair of special low-capacitance pickup connecting leads are provided which must replace the existing turntable leads. Most all quality turntables—and I say *most* because there must be one somewhere that's an exception to the rule—have plug-in connecting cables. You might have to open the base to get at the plugs and sockets, but the cables do plug into phono jacks. Empire turntables have their own special plug-in cable and there is an optional adapter available from JVC. An alignment record is also provided.

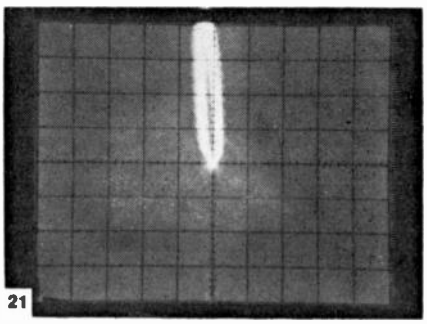
The demodulator has input jacks for the pickup and four line-level output jacks. There is also a pair of direct-output jacks which provides a direct connection from the pickup. The front panel contains the power switch, a 4-channel indicator called a RADAR and a selector knob with two positions labled 4CH AUTO and 2CH. When the selector is in the 4CH AUTO position the demodulator automatically senses the 30-kHz carrier and provides 4-channel decoding; the RADAR light is simultaneously turned on to indicate 4-channel output. When a stereo or matrix stereo record is played there is no 30-kHz carrier to turn the demodulator on and the output at the rear connections is standard stereo.

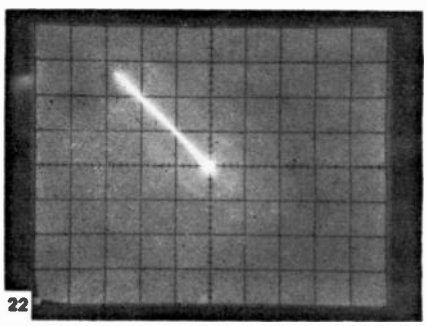
If the selector switch is set to the 2CH position the output is always stereo, even if a CD-4 record is being played. The 2CH selector position is controlled by an ON-OFF switch adjacent to the direct output jacks. When the ON-OFF switch is set to the ON position and the front panel switch is set to 2CH, the pickup's output appears only at the direct-output jacks and can be connected to an amplifier's normal magnetic phono input.

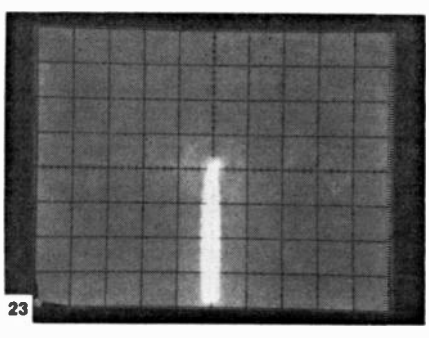
Only three user adjustments are provided: Two on the rear apron labeled L and R and one on the underside labeled 30KHZ LEVEL. The L and R controls determine the front-rear separation, the 30KHZ LEVEL control sets the carrier level into a PLL (phase-locked loop) demodulator and determines the distortion, among other characteristics.

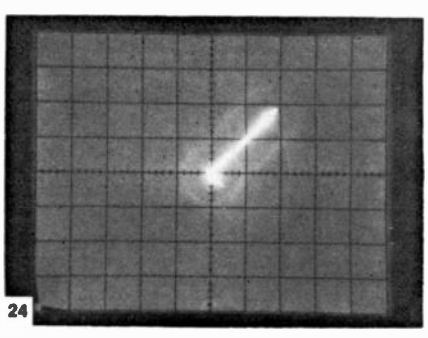
Total user alignment takes about two minutes after the unit is connected and installed, and as far as I can determine the alignment holds, without drift or need for realignment.

The alignment procedure is rather easy. The supplied alignment record has four bands: 1. A warble tone for left channels adjustment; 2. A warble tone for right channels adjustment; 3. Channel identi-









FIGS. 21, 22, 23, 24 (top left to right and bottom left to right, respectively)—INDIVIDUAL QUADRANT CD-4 INPUT SIGNALS show no side-signal spill. Even with 2X gain on center signals, the output is full discrete.

fication (voice) and balancing signal; 4. 400-Hz single tone for carrier-level adjustment. Each band feeds through to the next.

To align the demodulator the user turns down the front-channels' volume controls on the main amplifier or receiver and starts the record. When the left-channels' adjustment tone is heard he adjusts the demodulator's L control for minimum rear signal. Similarly, when the right-channels tone is heard he adjusts the R control for minimum rear signal. Turning up the amplifier's front volume control allows hearing of the channel identification and balancing signals, which seem a little too fast for me. Finally, when the 400-Hz carrier level tone is heard the detented 30KHZ LEVEL adjustment is set for minimum distortion; and there's really no problem setting for minimum distortion because it snaps rather than fades in and out. One instant there is considerable distortion, the next instant there's little distortion.

I absolutely suggest the adjustments be made "by ear" as specified by JVC, an instrument adjustment can go completely awry as scope indications for CD-4 are the reverse of what one would expect. For example, the "clean" L scope pattern shown in Fig. 18 is incorrect and produces the LB side signal output shown in Fig. 19. The "hash" scope pattern shown in Fig. 20 is the correct L adjustment. The best advice is to follow JVC's instructions as they correlate identically with the results taken from a lab-standard test record.

The test-record scope patterns are shown in Figs. 21 through 24. Even with 2X gain applied to the CF and CB test signals there is virtually no evidence of side-signal spill into adjacent channels; the system is truly discrete.

Figures 25 and 26 show program material sound distribution for proper and improper alignment. Figure 25 is proper alignment, the sound field is predominately LF/RB with considerable in phase LF-CF information. Figure 26, which looks like what many consider a "proper" matrix display (heaven forbid) indicates almost a mono front and imaged mono rear, cause by improper L and R channels adjustment.

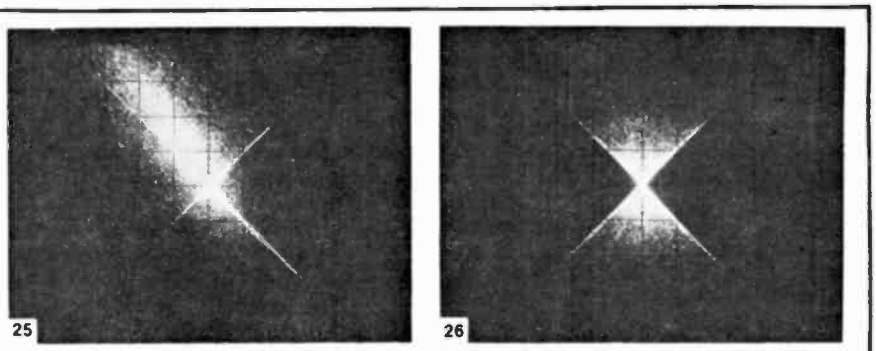


FIG. 25 (left—PREDOMINANT LF TO CF ORIENTATION shows correct CD-4 demodulator adjustment. FIG. 26 (right)—SAME PROGRAM MATERIAL through improperly adjusted demodulator.

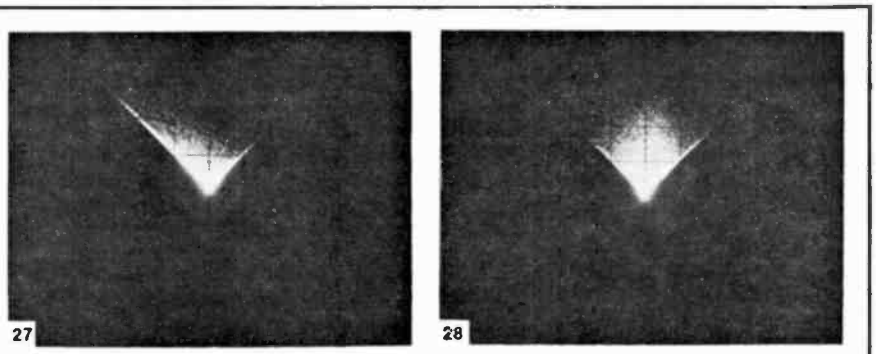


FIG. 27 (left)—PROGRAM INFORMATION from stereo version of "Hair" shows pronounced left orientation. FIG. 28 (right)—SAME PASSAGE from CD-4 encoded "Hair" is almost mono.

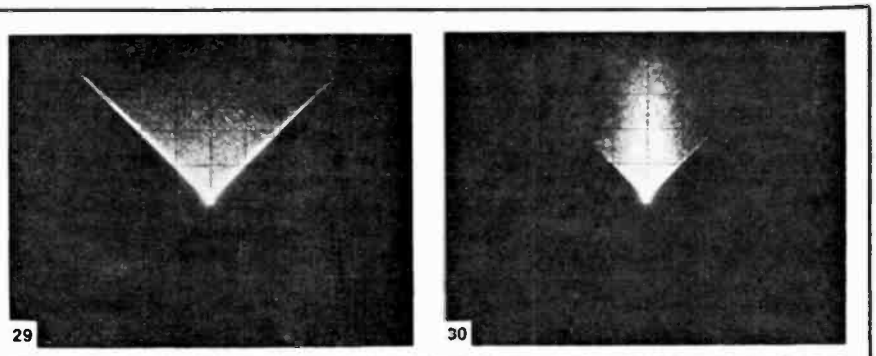


FIG. 29 (left)—PREDOMINANTLY MONO SEGMENT from stereo "Hair" comes out even more mono from CD-4 version played in stereo as shown in Fig. 30 (right above).

Overall CD-4 performance

For proper operation the JVC CD-4 system must be installed and used exactly as specified. The pickup must work into a 100,000-ohm—100-pF load for optimum high-frequency performance. You cannot use extension cables from the pickup other than those available as an option, nor can you use any run-of-the-mill booster amplifier. The pickup's frequency response when operating into its recommended load is shown in the frequency plot, an actual measurement, not figures supplied by the manufacturer. When the pickup is connected to a standard magnetic phono input the performance rolls off 2 dB at 15 kHz, as shown (again measured). As a side note, the pickup's performance on standard stereo records is excellent, comparing favorably with the finest stereo pickups, though it's necessary stylus force of 1.5 to 2 grams is somewhat higher than normally used by top-of-the-line stereo pickups. The higher tracking force is required for CD-4 records.

Had I heard this system with the commercial record releases usually supplied for demonstration I would have been somewhat impressed but not necessarily enthused; some of the classical CD-4 releases sound as if they were made 20 years ago when we argued whether we should use one mike 10 feet above the conductor's head or 20 feet above his head and 10 feet back (that sort of nonsense filled endless articles).

Fortunately, as I mentioned way back at the beginning of this discourse on 4-channel, there was this "white box" unlabeled record which turned out to be JVC's private version of the musical show "Hair." Wow, what a recording! Sound so clean it cut like a knife. Total utilization of the available surround-sound possibilities; when "Age of Aquarius" came on it was like the whole sky opened up with sound. A most spectacular and exciting musical adventure. Almost beyond description.

But as with all things, there are always clinkers. Supposedly, the CD-4 records are available with 25 minutes recording time, yet the "Hair" recording had at least two numbers missing, though it is possible they were missing because the record was made from a master supplied for Q8 4-channel cartridges; the selections might not have been on the cartridge program. No one seems to know.

The second clinker appears to be the "stereo compatibility." If you refer back to Fig. 25 you will note the decided LF sound orientation. Figure 27 is the exact same program information from the RCA stereo version of "Hair," again, note the decided LF orientation. But Fig. 28 shows the same program material from the CD-4 version played back in stereo—the sound orientation is primarily CF, it is not the equal of the stereo version.

Now it is quite possible that JVC mixed down the tracks for optimum surround-sound effects, and there is no question they succeeded in turning out a superlative recording, but does utilization of the total 4-channel capacity preclude optimum of even good stereo reproduction? Presently, there is no way to tackle this question because there is virtually nothing to work with, only in the "Hair" recordings

(continued on page 82)

SPEED TROUBLESHOOTING

Every service technician uses some that ranges from a scatter-brained system of signal tracing or inject-

by JONATHAN L. TURINO

LAST MONTH, IN THE FIRST ARTICLE of this troubleshooting series, we talked about the first steps in fixing anything. The hardware (test equipment) was discussed, the software was defined, and the admonition to "check the simple things first" was presented.

We have checked all of the usual "simple" things (including the power supply) and find that we still have a non-operating piece of equipment facing us. How do we troubleshoot it?

There are as many troubleshooting techniques as there are people who troubleshoot. The only one that should be avoided at all costs is the "shotgun" technique. It is time consuming and component consuming. and will not be discussed any further.

Of the reasonably efficient methods of troubleshooting, the one in most widespread use is probably stage-by-stage signal tracing (or signal injecting). You start at one end of the equipment and check each stage, in order, to isolate the defective "block" of the equipment. This method is logical and effective, but it can be improved upon. The improvement leads to what we described as the best troubleshooting method in existence—"cut it in half."

Look at the sample block diagram in Fig. 1. If we use the usual troubleshooting method, and our first two steps are the verification of the input and output devices, it can take a total of seven steps to isolate the nonfunctioning stage, whether we check from input to output or output to input, assuming that the last stage we check is the defective one. If, however, we apply cut-it-in-half troubleshooting, the maximum number of steps we need (including the verification of input and output) is five. Here is how the cut-it-in-half method works:

We have a known good input to Stage 1 (Fig. 1) and no output from Stage 6. The next measurement should be made *in the middle,* between stages 3 and 4. This immediately eliminates half of the stages. Suppose we find a normal signal at that point. Next, measure half way between Stage 4 and Stage 6. In this example we would measure at the input or output of Stage 5 (since the middle of three

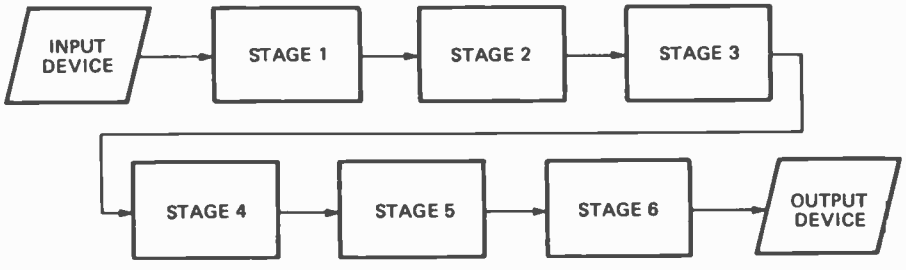


FIG. 1 (above)—SIMPLE BLOCK DIAGRAM that can be applied when servicing any type of electronic device ranging from audio, video and rf amplifiers to receivers, computers and various types of test instruments.

FIG. 2 (below)—EFFICIENCY of cut-it-in-half troubleshooting is illustrated by comparing its curve with that of step-by-step method.

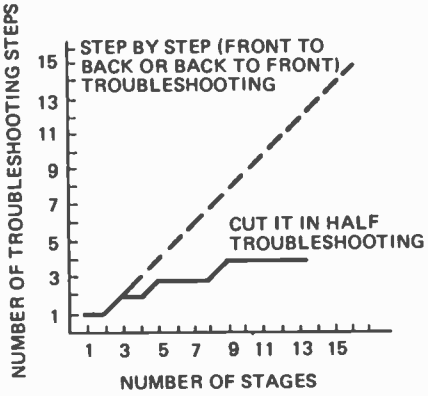
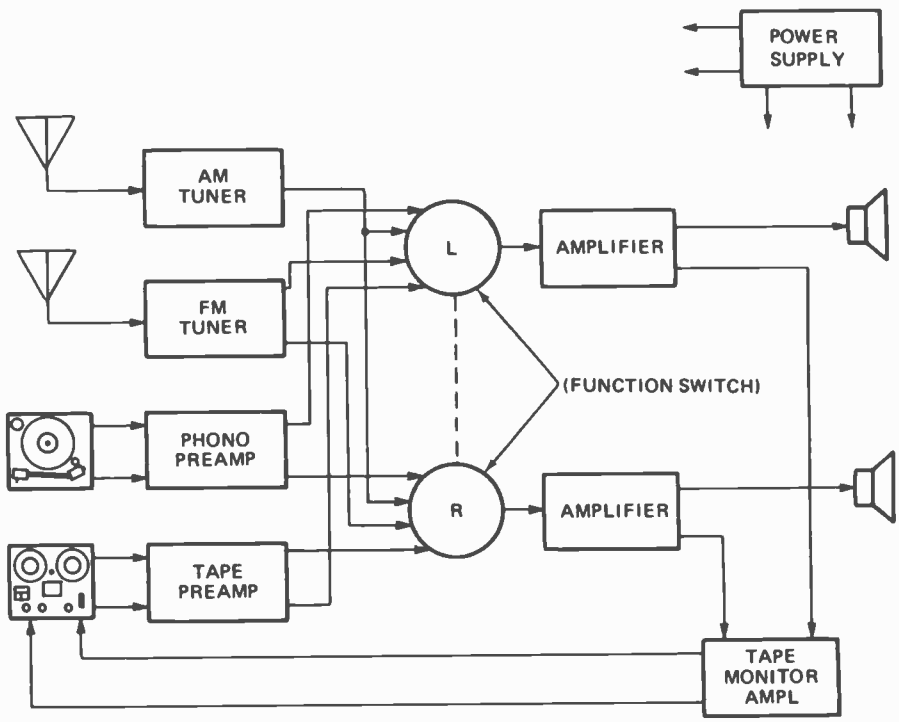


FIG. 3—(right)—TYPICAL AM-FM STEREO RECEIVER is illustrated in this block diagram. Cut-it-in-half troubleshooting leads you to the seat of the trouble in record time.



With A Logical Approach

form of troubleshooting procedure
hit-or-miss scheme to a methodical
ion. Won't you try the ultimate method?

stages is a little difficult to find). Regardless of the outcome of this measurement there remains only one measurement to completely pinpoint the defective stage. The cut-it-in-half troubleshooting method eliminated two steps in this simple example. Just to prove that is *the* most efficient way to troubleshoot, look at the graphs in Fig. 2. The number of measurements is plotted against the number of stages in a device. The outcome is obvious—the more complex the piece of equipment to be repaired, the more efficient cut-it-in-half troubleshooting is.

Now that this point has been made (and even a little belabored!) let's apply the cut-it-in-half technique to the repair of an AM-FM stereo receiver. Using just a block diagram (see Fig. 3), a set of symptoms, and the front panel indications (sound from the speakers in this case), we can do a lot of fault isolation without even removing the back of the instrument.

Let's start with the obvious one—completely dead on all functions. Where do we check first? The power supply, of course. How about no sound from the left channel on all functions? The left amplifier is the obvious answer, but before jumping to that conclusion, it would be better to see if both channels use a common power supply or whether there is a separate one for each channel (and maybe a third section for the low level stages!) There are a host of other possible symptoms and faulty sections in the receiver shown in Fig. 3, but with the block diagram, your eyes and ears, and a logical approach you can isolate down to a section without even taking an electrical measurement. The three examples that follow should serve to illustrate the kind of approach we are talking about.

Example 1—The left channel is dead on all functions. Check the speaker connections. Check the power supply (as was discussed previously). If both are all right, the problem is in the left amplifier.

Example 2—The FM tuner is dead on both channels. A little obvious, maybe, but check the antenna, the selector switch and the power supply before digging into the tuner (which is the most likely trouble.)

Example 3—Everything works except that one channel will not record on the tape recorder unless microphones are used. Check the cabling between the receiver and the tape deck. If that is all right, the problem is probably in the tape monitor amplifier. (If it was the recorder it probably would not work with the microphones.)

You can see now why a block diagram approach has been stressed as the only way to avoid being buried in complex circuitry before you isolate the defective stage in a piece of equipment. Checking the simple things first, taking everything into account, proceeding logically, and being ready to abandon a wrong guess is a surefire troubleshooting approach. When the defective section has been determined, go to cut-it-in-half troubleshooting to find the defective stage in the shortest possible time.

There are some things that make troubleshooting something like a stereo receiver a little easier. If the symptom is common to one channel, you can interchange connectors (and even components, in some cases) when you think you have found a bad one, to quickly determine what things are and are not at fault. When you get down to the circuitry part of the troubleshooting you can compare the readings in the non-operating channel with the readings in the operating channel to verify your diagnosis. (This is particularly helpful when the schematic does not give voltage readings for normal operation.)

By now you should be well on your way to being an expert logical troubleshooter (no "shotgunning"). To test your knowledge there is a quiz for the block diagram shown in Fig. 4. Just mark your answers in the blanks and mark the number that identifies the step you would perform next in the blank for "your next step."

The answers to the quiz, some troubleshooting of a digital counter and an electronic organ, and an explanation of how the logical troubleshooting method applies to circuitry (tube and transistor) will appear next month. **R-E**

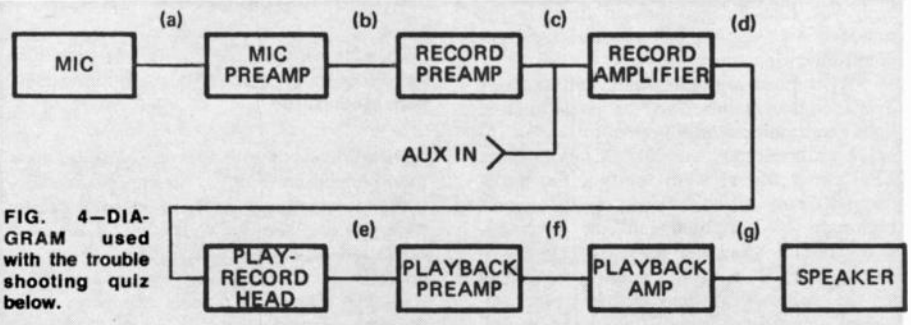


FIG. 4—DIAGRAM used with the trouble shooting quiz below.

The block diagram above shows one half of a stereo tape recorder (both channels the same). The recorder plays pre-recorded tapes properly, but one channel sounds very garbled when recording.

After switching microphones to eliminate the obvious possibility, applying cut-it-in-half troubleshooting, you would first inject a signal at point ____. The symptom with a signal injected at the above point is the same as the original symptom. Your first measurement (using a scope or signal tracer) should be at point ____.

Assume that this measurement shows a defective signal. Your next step would be to ____:

(1) Replace the tape head.
(2) Use cut-it-in-half troubleshooting in the mic preamp.
(3) Use cut-it-in-half troubleshooting in the record amp.
(4) Troubleshoot playback preamp.
(5) Check the recorder power supply fuse.

the state of SOLID STATE

Optoelectronic technology is growing and new devices are announced almost daily. Many of these spearhead this month's column

by LOU GARNER
SEMICONDUCTOR EDITOR

WILL OPTOLECTRONICS EVER BECOME a household word? Perhaps not in the near future, but solid-state optoelectronic devices are being used in ever-larger numbers in test instruments, calculators, consumer products, automotive applications, medical equipment and communications gear, as well as in computers, aircraft and military equipment. Long life, relatively low cost, low power requirements, and amazing versatility are among the many factors contributing to the increasing popularity of these interesting devices.

The solid-state optoelectronic family includes light-emitting diodes (LED's), injection-diode lasers, photosensors (such as photodiodes, phototransistors, and IC devices comprising photodetectors and integral amplifiers), numeric and alphanumeric displays, and photo-couplers.

Long life? You'd better believe it! Although not enough time has passed since these devices were first developed to accumulate factual life data, accelerated tests by major semiconductor manufacturers indicate that a LED used within its ratings should have a useful operating life of 300,000 hours, or more, to its half-brightness point. Playing it safe, some manufacturers claim a life of only 100,000 hours.

If we accept the lower figure, a LED used in a piece of equipment operated 8 hours a day, 5 days a week, 50 weeks a year, would provide *50 years* of operation before a replacement would be needed, while, with the higher figure, one would have a *150-year life* expectancy. Even if the equipment were operated 24 hours a day continuously, 365 days each year, the life expectancy would still be over 34 years!

Low cost? Cost, of course, is a relative term—what is considered expensive in one application may be dirt cheap in another. But optoelectronic device prices have dropped considerably since they were first introduced. Within the last few months, for example, Hewlett Packard (1501 Page Mill Road, Palo Alto, Calif. 94304) introduced two new LED's; types 5082-4850 and 5082-4484. They are available for only *17 cents each* in production quantities (100,000 up).

Intended for high-volume applications in appliances, automobile instrument panels and similar commercial equipment, the two new HP devices require only 20 mA at 1.6 volts for operation and furnish visible red light.

Low power? Absolutely! Actual power requirements vary with individual devices and applications, naturally, but average values may range from microwatts for photodetectors with integral IC amplifiers to the upper milliwatt levels for LED's, numeric displays, and photo-couplers. HP's 5082-7400 family of numeric indicators, typically, can provide excellent readability at power levels of only 7 mW per digit.

Versatility? Unfortunately, space limitations prohibit a detailed listing of all possible optoelectronic equipment applications, but LED's, alone, may be used as pilot lamps, polarity and logic-level indicators, on-board circuit monitors, warning signals; and, with turn-on and turn-off times in the nanosecond region, as modulated-light communication transmitters.

At a recent optoelectronic seminar, one firm's engineers described an experimental light communications system using a 5-MHz modulated carrier. Conventional LED's *(not lasers)* were used in the transmitters, and standard photodiodes and high-gain IC amplifiers in the receivers, with six-inch diameter lenses for light focusing and beam concentration. According to the report, excellent results were obtained at ranges of up to two miles in full daylight and even during rainy periods.

Several exciting new optoelectronic devices have been introduced by major semiconductor manufacturers within recent weeks, including two visible red light LED's, an unusual pnpn switch/LED, green LED's and readouts, a pair of medium voltage LED's, a family of intriguing dual LED's, and an inexpensive two-digit numeric display.

Designated types RL-4403 and RL-4440, the new full-flood red LED's, Fig. 1, are offered by Litronix, Inc. (19000 Homestead Road, Cupertino, Calif. 95014). Intended for control panel and instrument

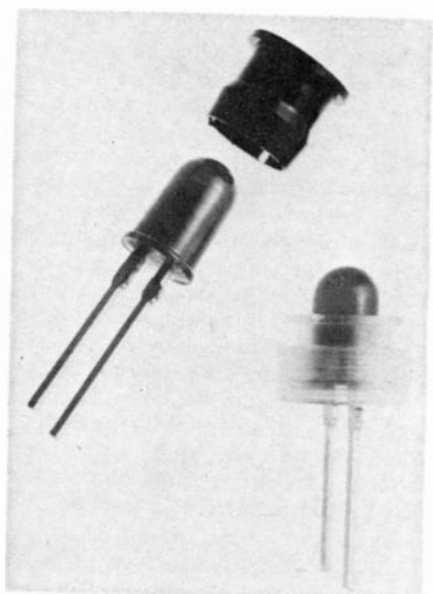


FIG. 1—FULL FLOOD LED LAMPS available from Litronix, Inc.

applications, both devices use gallium-arsenide-phosphide diodes assembled in specially designed red-diffusive molded plastic packages and require 20 mA at 1.7 volts for operation. The two units differ only in average brightness and cost, with the brighter RL-4403 somewhat more expensive than the lower rated RL-4440. Both, however, are priced at less than a dollar each in moderate production quantities. (Full-flood LED's are those in which a lens spreads the tiny spot of light from the chip over the entire viewing surface of the device.)

An interesting LED introduced by Japan's Sharp Corporation uses a four-layer pnpn structure that gives it thyristor-like fast switching properties, a comparatively high reverse breakdown voltage, and a negative resistance slope in its characteristics curve, as illustrated in Fig. 2. The new device, type GND-50G, emits infrared light that is converted into visible green light by a fluorescent phosphor coating. Sharp's

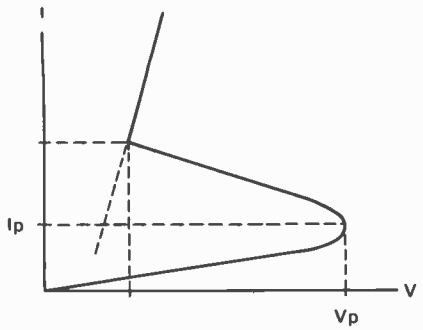


FIG. 2—NEGATIVE RESISTANCE characteristic of new Sharp GND-50G pnpn LED.

U.S. distributor is Shigoto Industries, Ltd. (Empire State Building, New York, N.Y. 10001).

Green LED's as well as numeric displays also are being offered by Opcoa (330 Talmadge Road, Edison, N.J. 08817). As predicted in our January column, prices are roughly competitive with conventional red LED's, with the green light devices priced at less than a dollar each in medium large quantities (100 up).

Designed to operate on less than 2 volts (typically, 1.5 to 1.7 volts), conventional LED's require external voltage dropping resistors when used in higher voltage applications. Recognizing this limitation, Hewlett-Packard has developed a pair of red LED's with integral IC-type resistors to permit direct operation on 5-volt dc sources, thus making the devices fully compatible with standard TTL circuitry. The new LED's, types 5082-4860 and 5082-4468, are offered in T-1¾ and T-1 size cases, respectively, and require a nominal 16 mA for operation.

Monsanto (Electronic Special Products, 10131 Bubb Road, Cupertino, Calif. 95014) has fulfilled another of our January predictions with their introduction of a device that emits red light at one voltage and green light at a higher voltage (with reversed polarity).

The new Monsanto device, type MV 5491, actually consists of two parallel anode-to-cathode LED's in a single package, one emitting red light, the other green light (see Fig. 3). The red LED is a gallium-arsenide-phosphide diode, the green LED is a gallium-phosphide unit. The MV 5491 is one of a family of dual LED devices; other types are: the MV 5094, comprising two red LED's and intended for ac or dc operation, the MV 5591, a red/yellow pair, the MV 5691, a yellow/green pair, the MV 5291, a dual green pair for ac, and the MV 5391, a dual yellow pair for ac applications. In operation, the basic red/green type, MV 5491, requires 1.65 volts at 20 mA to activate the red LED, 2.3 volts at 20 mA with reversed polarity to activate the green LED.

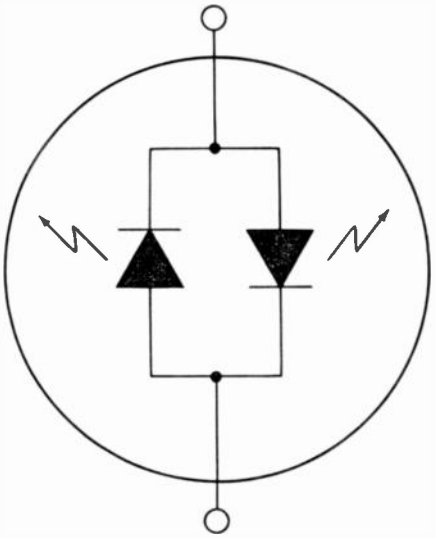


FIG. 3—SCHEMATIC OF MONSANTO'S new dual LED devices.

Illustrated in Fig. 4, is a new two-digit solid-state numeric readout announced by Litronix, Inc. Designated type DL-44, the

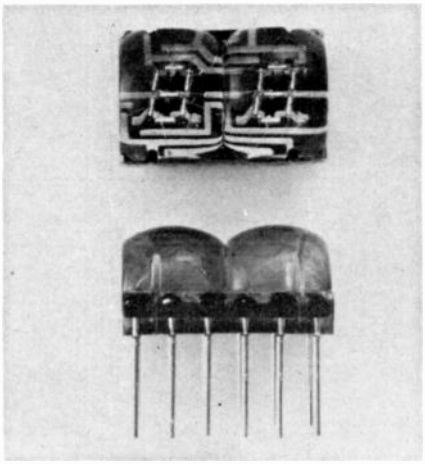


FIG. 4—LITRONIX TWO DIGIT LED module with integral magnifying lens.

new device has 0.19 inch high characters and is equipped with an integral plastic magnifying lens. Exhibiting a brightness of 250 ft-L at a current of only 5 mA per segment, the DL-44 is assembled in a standard 12-pin dual-inline package and nets for just $4.25 per digit in unit quantities. It is designed primarily for applications in low-cost equipment using multiplex drive systems.

Optical couplers

Known, variously, as opto-couplers, opto isolators, photon-couplers, light couplers, and perhaps, by a few other names, depending on each manufacturer's individual preference, optical couplers are a comparatively new class of optoelectronic devices.

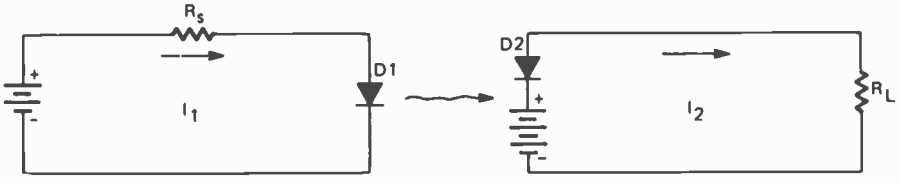


FIG. 5—BASIC ARRANGEMENT OF AN OPTICAL coupler—a LED (D1) and a photodiode (D2) coupled by a light beam.

Used primarily for interface applications between circuits, lines and sub-systems where maximum isolation is needed, they provide many times the isolation that is possible with capacitive or transformer coupling, and are used extensively in digital and analog computers, in data communications equipment, and in control systems.

As shown in Fig. 5, the basic optical coupler consists of an electrical light source, such as LED D1, and a light sensor, such as photodiode D2, arranged so that light from the source falls on the sensor and, usually, so that external light is excluded. Variations in the signal power applied to the source cause changes in its emitted light and, therefore, corresponding changes in the signal developed by the sensor. The only coupling between the source and the sensor, other than an extremely small capacitance (typically, less than 5 pF and, often, a fraction of a pF), is through the light beam or, more precisely, through the photons of energy making up the light (hence one of the names for the device).

Physically, the LED and its corresponding sensor generally are mounted in a standard TO or DIP type case with a thin film of special plastic between them, as in Fig. 6. This plastic film serves both to furnish a light path and to provide high voltage electrical insulation. A number of variations of the basic design are found in commercially available devices.

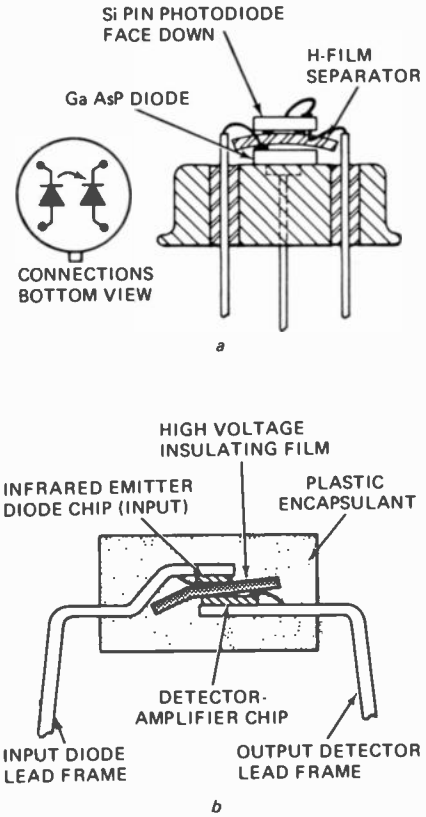
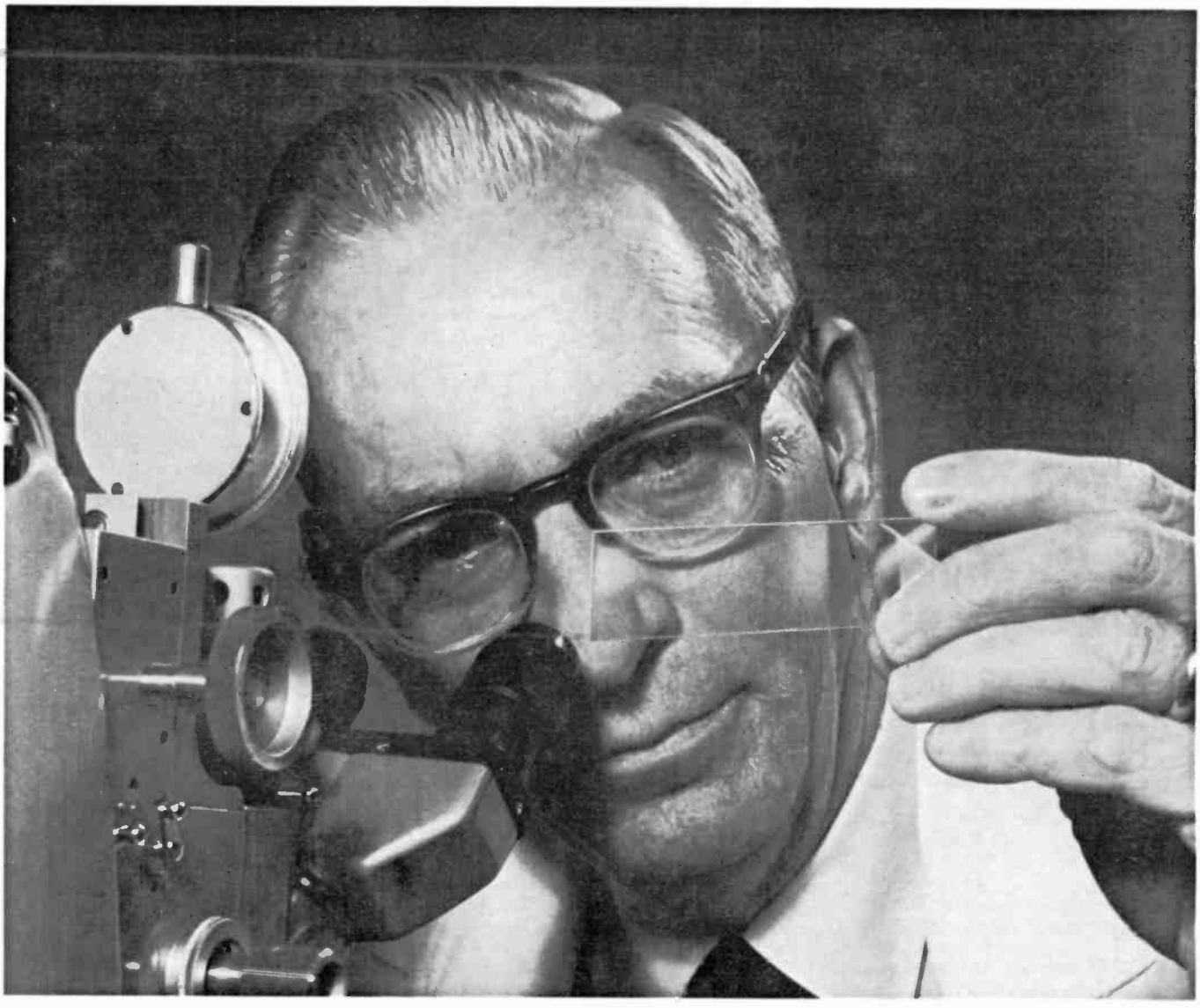


FIG. 6—CROSS-SECTION SKETCHES showing the internal construction of TO-type (a) and DIP-type (b) optical couplers.

A phototransistor or photo-Darlington may be used in place of the photodiode, for example, or, if only a simple switching action is desired, a light sensitive SCR may be used as the output device. In other commercial designs, a photodiode may be used in conjunction with an integral transistor, a Darlington pair, or even an integrated circuit amplifier chip.

(continued on page 68)



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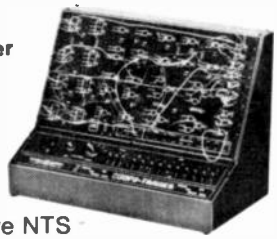

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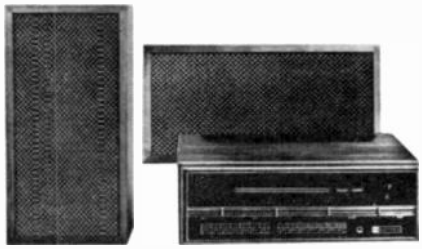

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Three 8-input digital multiplexers featuring Schottky-diode-clamped TTL structures are now available from Signetics (811 East Arques Ave., Sunnyvale, Calif. 94086). The 8-input digital multiplexer is the logical equivalent of a single-pole, 8-position switch whose position is specified by a 3-bit input address.

Type numbers for the new devices are 82S30, 82S31 and 82S32. The three devices are similar except for their exact output configuration and/or the effect of their INHIBIT inputs on output. Requiring a 5-volt dc power source, all three are furnished in plastic dual-in-line packages and all are fully compatible with standard TTL circuits, including devices in the various 54/74 series.

Texas Instruments, Inc. (P.O. Box 5012, M/S 308, Dallas, Tex. 75222) has announced a number of new devices, including three npn/pnp Darlington power transistor complementary pairs and seven npn high-voltage power transistors.

Illustrated in Fig. 7, the new power

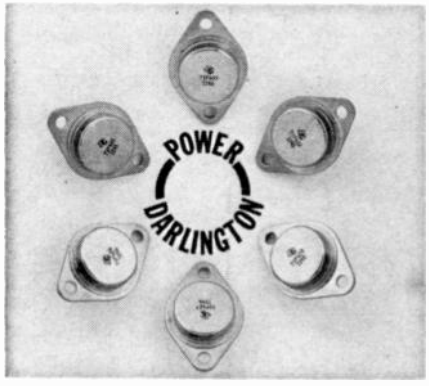

FIG. 7—NEW SERIES of complementary power Darlingtons.

Darlingtons include npn types TIP620, TIP621, and TIP622, while the complementary pnp types are designated the TIP625, TIP626, and TIP627. The collector-emitter breakdown voltages for the TIP620 and TIP625 is 60 volts, for the TIP621 and the TIP625, 80 volts, and for the TIP622 and TIP627, 100 volts. Collector current for each is 5 amperes, with a rated gain of 1000 at a V_{CE} of 3 volts and a I_C of 3 amperes. All have a specified power dissipation of 100 watts at 25°C and all are furnished in standard TO-3 metal packages.

TI's new family of npn high-voltage transistors is identified as types TIP55 through TIP58 and types TIP554 through

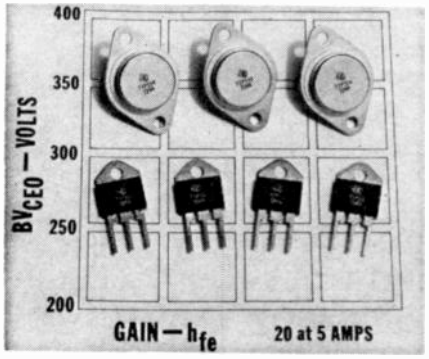

FIG. 8—HIGH-VOLTAGE power transistors now available from Texas Instruments, Inc.

TIP556. The first four are supplied in economical plastic packages, the last three in standard TO-3 metal cans, as shown in Fig. 8. Minimum collector-emitter breakdown voltages for the TIP55, 56, 57 and 58 are 250, 300, 350, and 400 volts, respectively, while for the TIP554, 555, and 556, they are 200, 300, and 400 volts. All have rated power dissipation of 125 watts at 25°C. Maximum collector currents are 7.5 amperes for types TIP55 through 58 and 5.0 amperes for types TIP554 through 556. For all, f_T is 10 MHz minimum at 10 volts and 0.2 amperes.

IC Multiplier-divider

A new self-contained IC multiplier/divider has been introduced by the Burr-Brown Research Corporation (International Airport Industrial Park, Tucson, Ariz. 85706). Hermetically sealed and internally laser trimmed in a TO-100 package, the device, type 4203K, requires *no external components* to deliver a guaranteed accuracy of 1%. In addition to division and four-quadrant multiplication, square-rooting also may be performed.

Illustrated in Fig. 9, the 4203 has a 1-

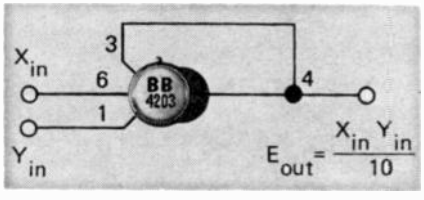

FIG. 9—BURR-BROWN'S MODEL 4203 self-contained IC multiplier/divider.

MHz bandwidth and a slew rate of 25 V/μ sec. As a companion unit, Burr-Brown also is offering the less expensive type 4201J. This model handles all the functions of the basic unit, but requires four external trimpots for adjustment of offset voltage and gain (i.e., scale factor). With external trim, the 4201J provides 2% accuracy.

Both units contain their own Zener-regulated references to reduce sensitivity to supply voltage variations, and both feature the same slew rate and bandwidth. Rated output of both is ±10V at ±5 mA. Output impedance is 1 ohm and output noise, from 10 KHz to 10 MHz, a low 3 mV, rms. A supply voltage of from ±12V dc to ±18V dc is required, with the quiescent current for the 4201J a low ±4 mA, and ±9 mA for the 4203K. The rated temperature range for the units is 0° to +70°C. Single quantity prices are $22.50 for the 4201J and $39.00 for the 4203K.

Six 10-ampere commercial npn Darlington transistors and their developmental pnp complements have been announced by RCA's Solid State Division (Route 202, Somerville, N.J. 08876). Designated types 2N6383, 2N6384, and 2N6385, and rated at 40, 60 and 80 volts V_{CBO} respectively, with 100 watts dissipation, the first device family is supplied in a JEDEC TO-3 package.

Types 2N6386, 2N6387 and 2N6388 all offer similar voltage ratings and performance, but only 40 watts dissipation and come in the RCA Versawatt package. The developmental pnp complements are designated types TA8351, TA8488, and TA8350 for the 40, 60 and 80-volt devices in the TO-3 package and types TA8204, TA-8487, and TA8203 in the Versawatt package. All devices feature a minimum gain of 1000 at 5 A, except for types 2N6386 and TA8204, which have a minimum gain of 1000 at 3 A.

Motorola has recently announced two significant advances—the introduction of economical plastic-packaged devices to their previous all ceramic-package McMOS line and the addition of nine new functional devices. The plastic-packaged devices will be priced 10% or more lower than the ceramics. The new McMOS devices are the MC14034 8-bit universal bus register, the MC14511 BCD-to-seven segment latch/decoder/driver, the MC14517 dual 64-bit static shift register, the MC14528 dual retriggerable/resettable monostable multivibrator, the MC14529 dual 4-channel analog switch or 8-channel analog data selector, the MC14530 dual 5-input majority logic gate, the MC14531 12-bit parity tree, the MC14581 4-bit arithmetic logic unit, and the MC14582 look-ahead carry block.

National Semiconductor has added five new 54C/74C devices and two new CD4000/MM4600 parts to its CMOS line, bringing to 20 the number of devices in its 54C/74C line and to 11 the items offered in its CD4000/MM4600 series. The new devices are the 74C42N BCD-to-decimal decoder, the 74C95N four-bit shift register (parallel), the 74C151N eight-bit data selector (MUX), the 74C173N quad latch with *Tri-State* outputs, the 74C900 quad bi-lateral switch, the CD4016/MM4616 quad bi-lateral switch, and the CD4035/MM4635 four-bit shift register (parallel). **R-E**

R-E's substitution guide for replacement transistors Part III

compiled by ROBERT & ELIZABETH SCOTT

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

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

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

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

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

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

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

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

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

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

	ARCH	G-E	IR	MAL	MOT	RCA	SPR	SYL
2N447	RS276-2001	GE-5	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N448	RS276-2001	GE-7	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N449	RS276-2001	GE-7	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N450	RS276-2005	GE-1	IRTR-85	PTC 109	HEP-2	SK 3006	RT-118	ECG 100
2N451	NA	NA	NA	NA	HEP-S5003	NA	NA	NA
2N452	NA	NA	NA	NA	HEP-S5003	NA	NA	NA
2N453	NA	NA	NA	NA	HEP-701	NA	NA	NA
2N454	NA	NA	NA	NA	HEP-S5003	NA	NA	NA
2N456	RS276-2006	GE-16	TR-01	PTC 122	HEP-230/232	SK 3009	RT-124	ECG 104
2N457	RS276-2006	GE-16	TR-01	PTC 122	HEP-232	SK 3009	RT-124	ECG 104
2N458	RS276-2006	GE-16	TR-01	PTC 122	HEP-232	SK 3009	RT-124	ECG 104
2N459	RS276-2006	GE-76	TR-01	PTC 105	HEP-232	SK 3012	RT-127	ECG 121
2N460	RS276-2004	GE-2	IRTR-85	PTC 135	HEP-253	SK 3004	RT-120	ECG 102
2N461	RS276-2004	GE-1	IRTR-85	PTC 135	HEP-253	SK 3004	RT-120	ECG 102
2N462	RS276-2005	GE-2	IRTR-85	PTC 109	HEP-254	SK 3004	RT-120	ECG 102
2N463	NA	NA	NA	NA	NA	SK 3012	NA	NA
2N464	RS276-2004	GE-2	IRTR-85	PTC 135	HEP-253	SK 3004	RT-120	ECG 102
2N465	RS276-2004	GE-2	IRTR-85	PTC 135	HEP-253	SK 3004	RT-120	ECG 102
2N466	RS276-2005	GE-53	IRTR-85	PTC 109	HEP-254	SK 3003	RT-120	ECG 102
2N467	RS276-2005	GE-53	IRTR-85	PTC 135	HEP-254	SK 3003	RT-120	ECG 102
2N468	RS276-2005	GE-52	IRTR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N469	NA	GE-53	NA	NA	NA	NA	NA	NA
2N470	RS276-2009	GE-60	TR-21	PTC 115	HEP-53	SK 3124	RT-100	ECG 123
2N471	RS276-2009	GE-60	TR-21	PTC 121	HEP-53	SK 3124	RT-100	ECG 123
2N472	RS276-2009	GE-60	TR-21	PTC 121	HEP-53	SK 3122	RT-102	ECG 123A
2N473	RS276-2009	GE-60	TR-21	PTC 121	HEP-53	SK 3124	RT-100	ECG 123
2N474	RS276-2009	GE-60	TR-21	PTC 121	HEP-53	SK 3122	RT-102	ECG 123A
2N475	RS276-2009	GE-61	TR-21	PTC 121	HEP-53	SK 3122	RT-102	ECG 123A
2N476	RS276-2009	GE-60	TR-21	PTC 115	HEP-53	SK 3124	RT-100	ECG 123
2N477	RS276-2009	GE-60	TR-21	PTC 121	HEP-53	SK 3124	RT-100	ECG 123
2N478	RS276-2009	GE-60	TR-21	PTC 126	HEP-53	SK 3124	RT-100	ECG 123
2N479	RS276-2009	GE-60	TR-21	PTC 121	HEP-53	SK 3124	RT-100	ECG 123
2N480	RS276-2009	GE-61	TR-21	PTC 121	HEP-53	SK 3124	RT-100	ECG 123
2N481	RS276-2004	GE-52	IRTR-85	PTC 109	HEP-253	SK 3005	RT-118	ECG 100
2N482	RS276-2004	GE-52	IRTR-85	PTC 109	HEP-250	SK 3005	RT-118	ECG 100
2N483	RS276-2004	GE-52	IRTR-85	PTC 109	HEP-250	SK 3005	RT-118	ECG 100
2N484	RS276-2005	GE-1	IRTR-85	PTC 109	HEP-2	SK 3005	RT-118	ECG 100
2N485	RS276-2004	GE-1	IRTR-85	PTC 109	HEP-250	SK 3005	RT-118	ECG 100
2N486	RS276-2003	GE-2	IRTR-85	PTC 102	HEP-635	SK 3005	RT-118	ECG 100
2N487	NA	GE-1	IRTR-85	PTC 107	HEP-635	SK 3004	RT-120	ECG 102
2N495	RS276-2023	GE-22	IRTR-88	PTC 131	HEP-52	SK 3114	RT-126	ECG 106
2N496	RS276-2023	GE-22	IRTR-88	PTC 131	HEP-52	SK 3114	RT-126	ECG 106
2N497	RS276-2018	GE-18	TR-25	PTC 143	HEP-243	SK 3024	RT-114	ECG 128
2N498	RS276-2009	GE-27	IRTR-87	NA	HEP-53	SK 3024	RT-114	ECG 128
2N499	RS276-2003	GE-9	IRTR-89	PTC 107	HEP-639	SK 3006	NA	ECG 126
2N500	RS276-2003	GE-9	IRTR-89	PTC 107	HEP-639	SK 3008	NA	ECG 126
2N501	RS276-2003	GE-9	IRTR-89	PTC 107	HEP-3	SK 3006	NA	ECG 126
2N502	RS276-2005	GE-9	IRTR-89	NA	HEP-638	SK 3006	NA	ECG 126
2N503	RS276-2003	GE-9	IRTR-85	PTC 107	HEP-2	SK 3005	RT-118	ECG 100
2N504	RS276-2003	GE-1	IRTR-89	PTC 107	HEP-3	SK 3008	NA	ECG 126
2N505	RS276-2005	GE-2	IRTR-85	PTC 102	HEP-2	SK 3005	RT-118	ECG 100
2N506	RS276-2004	GE-2	IRTR-85	PTC 109	HEP-253	SK 3004	RT-121	ECG 102A
2N507	RS276-2001	GE-8	TR-08	PTC 108	HEP-641	SK 3010	RT-122	ECG 103A
2N508	RS276-2005	GE-53	IRTR-85	PTC 135	HEP-254	SK 3003	RT-120	ECG 102
2N509	NA	GE-51	IRTR-85	PTC 107	NA	NA	NA	ECG 160

	ARCH	G-E	IR	MAL	MOT	RCA	SPR	SYL
2N511	NA	GE-3	TR-01B	PTC 105	NA	SK 3009	RT-124	ECG 104
2N512	NA	GE-3	TR-01	PTC 105	NA	SK 3009	RT-124	ECG 104
2N513	NA	GE-3	TR-01	PTC 105	NA	SK 3009	RT-124	ECG 104
2N514	NA	GE-3	TR-01	PTC 105	NA	SK 3009	RT-127	ECG 121
2N515	RS276-2002	GE-5	TR-08	PTC 108	HEP-641	SK 3011	RT-122	ECG 103A
2N516	RS276-2002	GE-5	TR-08	PTC 109	HEP-641	SK 3010	RT-122	ECG 103A
2N517	RS276-2002	GE-5	TR-08	PTC 134	HEP-641	SK 3011	RT-122	ECG 103A
2N518	RS276-2005	GE-9	IRTR-85	PTC 105	HEP-2	SK 3005	RT-118	ECG 100
2N519	RS276-2004	GE-2	IRTR-85	PTC 114	HEP-253	SK 3005	RT-118	ECG 100
2N520	RS276-2005	GE-2	IRTR-85	PTC 105	HEP-254	SK 3005	RT-118	ECG 100
2N521	RS276-2005	GE-1	IRTR-85	PTC 135	HEP-254	SK 3005	RT-118	ECG 100
2N522	RS276-2005	GE-2	IRTR-85	PTC 109	HEP-2	SK 3003	RT-118	ECG 100
2N523	RS276-2005	GE-2	IRTR-85	PTC 109	HEP-2	SK 3003	RT-118	ECG 100
2N524	RS276-2004	GE-2	IRTR-85	PTC 135	HEP-253	SK 3004	RT-120	ECG 102
2N525	RS276-2004	GE-2	IRTR-85	PTC 135	HEP-253	SK 3004	RT-120	ECG 102
2N526	RS276-2005	GE-2	IRTR-85	PTC 135	HEP-254	SK 3004	RT-120	ECG 102
2N527	RS276-2005	GE-2	IRTR-85	PTC 135	HEP-254	SK 3004	RT-120	ECG 102
2N529	RS276-2004	GE-2	IRTR-85	PTC 108	HEP-253	SK 3005	RT-118	ECG 100
2N530	RS276-2004	GE-1	IRTR-85	PTC 108	HEP-253	SK 3005	RT-118	ECG 100
2N531	RS276-2004	GE-1	IRTR-85	PTC 108	HEP-250	SK 3005	RT-118	ECG 100
2N532	RS276-2004	GE-1	IRTR-85	PTC 108	HEP-253	SK 3005	RT-118	ECG 100
2N533	RS276-2004	GE-1	IRTR-85	PTC 108	HEP-253	SK 3005	RT-118	ECG 100
2N534	RS276-2003	GE-9	IRTR-85	PTC 109	HEP-3	SK 3123	RT-121	ECG 102A
2N535	RS276-2005	GE-52	IRTR-85	PTC 107	HEP-254	SK 3003	RT-121	ECG 102A
2N536	RS276-2005	GE-52	IRTR-85	PTC 135	HEP-254	SK 3003	RT-121	ECG 102A
2N537	RS276-2003	GE-2	NA	PTC 102	HEP-3	NA	NA	ECG 160
2N538	NA	GE-3	TR-01	PTC 105	NA	SK 3009	RT-127	ECG 121
2N539	RS276-2006	GE-3	TR-01	PTC 105	HEP-233	SK 3009	RT-124	ECG 104
2N540	NA	GE-3	TR-01	PTC 105	NA	SK 3009	RT-124	ECG 104
2N541	RS276-2009	GE-60	TR-21	PTC 121	HEP-53	SK 3122	RT-102	ECG 123A
2N542	RS276-2009	GE-60	TR-21	PTC 121	HEP-53	SK 3122	RT-102	ECG 123A
2N543	RS276-2009	GE-61	TR-21	PTC 121	HEP-53	SK 3122	RT-100	ECG 123A
2N544	RS276-2003	GE-50	IRTR-89	PTC 107	HEP-3	SK 3008	NA	ECG 126
2N545	NA	NA	IRTR-87	PTC 123	NA	SK 3024	NA	NA
2N546	RS276-2009	GE-63	TR-21	PTC 123	HEP-53	SK 3124	RT-100	ECG 123
2N547	RS276-2009	GE-63	TR-21	PTC 123	HEP-53	SK 3124	RT-100	ECG 123
2N548	RS276-2009	GE-63	TR-21	PTC 123	HEP-53	SK 3124	RT-100	ECG 123
2N549	RS276-2009	GE-63	TR-21	PTC 123	HEP-53	SK 3124	RT-100	ECG 123
2N550	RS276-2009	GE-63	TR-21	PTC 123	HEP-53	SK 3124	RT-100	ECG 123
2N551	RS276-2009	GE-18	TR-21	PTC 125	HEP-53	SK 3124	RT-100	ECG 123
2N552	RS276-2009	GE-18	TR-21	PTC 125	HEP-53	SK 3124	RT-100	ECG 123
2N553	RS276-2006	GE-3	TR-01	PTC 105	HEP-232	SK 3009	RT-127	ECG 121
2N554	RS276-2006	GE-16	TR-01	PTC 105	HEP-230	SK 3009	RT-127	ECG 121
2N555	RS276-2006	GE-76	TR-01	PTC 114	HEP-230	SK 3009	RT-127	ECG 121
2N556	RS276-2001	GE-8	TR-08	PTC 108	HEP-841	SK 3011	RT-119	ECG 101
2N557	RS276-2001	GE-6	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N558	RS276-2001	GE-8	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N559	RS276-2003	GE-51	IRTR-89	PTC 107	HEP-3	NA	NA	ECG 160
2N560	RS276-2009	GE-18	TR-21	PTC 125	HEP-53	SK 3024	RT-100	ECG 123
2N561	RS276-2006	GE-16	TR-01B	PTC 122	HEP-232	SK 3009	RT-127	ECG 121
2N563	RS276-2004	GE-53	IRTR-85	PTC 102	HEP-253	SK 3004	RT-120	ECG 102
2N564	RS276-2004	GE-53	IRTR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N565	RS276-2005	GE-53	IRTR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N566	NA	GE-53	NA	PTC 102	HEP-629	SK 3004	RT-120	ECG 102
2N567	RS276-2002	GE-53	IRTR-85	PTC 102	HEP-641	SK 3004	RT-122	ECG 103A

	ARCH	G-E	IR	MAL	MOT	RCA	SPR	SYL
2N568	RS276-2005	GE-53	IRTR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N569	RS276-2005	GE-53	IRTR-85	PTC 102	HEP-254	SK 3003	RT-120	ECG 102
2N570	RS276-2005	GE-53	IRTR-85	PTC 102	HEP-254	SK 3003	RT-120	ECG 102
2N571	RS276-2005	GE-52	IRTR-85	PTC 135	HEP-254	SK 3003	RT-118	ECG 100
2N572	RS276-2005	GE-53	IRTR-85	PTC 102	HEP-254	SK 3003	RT-118	ECG 100
2N573	RS276-2003	GE-2	IRTR-85	PTC 102	HEP-633	SK 3004	RT-120	ECG 102
2N574	NA	GE-4	TR-03	PTC 106	HEP-233	SK 3004	NA	ECG 105
2N575	NA	GE-4	TR-03	PTC 106	NA	SK 3012	NA	ECG 105
2N576	RS276-2002	GE-5	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N578	RS276-2004	GE-1	IRTR-85	PTC 135	HEP-253	SK 3005	RT-118	ECG 100
2N579	RS276-2004	GE-1	IRTR-85	PTC 135	HEP-253	SK 3005	RT-118	ECG 100
2N580	RS276-2004	GE-1	IRTR-85	PTC 135	HEP-253	SK 3005	RT-118	ECG 100
2N581	RS276-2004	GE-1	IRTR-85	PTC 109	HEP-253	SK 3005	RT-118	ECG 100
2N582	RS276-2005	GE-2	IRTR-85	PTC 102	HEP-2	SK 3003	RT-118	ECG 100
2N583	RS276-2004	GE-1	IRTR-89	PTC 109	HEP-253	SK 3005	NA	ECG 126
2N584	RS276-2005	GE-2	IRTR-89	PTC 102	HEP-2	SK 3003	NA	ECG 126
2N585	RS276-2001	GE-8	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N586	RS276-2005	GE-1	IRTR-85	PTC 135	HEP-254	SK 3005	RT-118	ECG 100
2N587	RS276-2002	GE-5	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N588	RS276-2003	GE-9	IRTR-89	PTC 107	HEP-639	SK 3006	NA	ECG 126
2N589	RS276-2006	GE-3	TR-01	PTC 105	HEP-232	SK 3009	RT-127	ECG 121
2N590	NA	NA	IRTR-85	PTC 135	NA	NA	NA	ECG 102A
2N591	RS276-2005	GE-53	IRTR-85	PTC 109	HEP-638	SK 3004	RT-121	ECG 100
2N592	NA	GE-50	IRTR-85	PTC 109	NA	SK 3005	RT-118	ECG 100
2N593	NA	GE-53	IRTR-85	PTC 109	NA	SK 3005	RT-118	ECG 101
2N594	NA	GE-5	TR-08	PTC 108	NA	SK 3011	RT-119	ECG 101
2N595	NA	GE-5	TR-08	PTC 108	NA	SK 3011	RT-119	ECG 101
2N596	NA	GE-5	TR-08	PTC 108	NA	SK 3011	RT-119	ECG 101
2N597	RS276-2005	GE-1	IRTR-85	PTC 135	HEP-254	SK 3005	RT-118	ECG 100
2N598	RS276-2005	GE-1	IRTR-85	PTC 135	HEP-254	SK 3005	RT-118	ECG 100
2N599	RS276-2005	GE-1	IRTR-85	PTC 135	HEP-254	SK 3005	RT-118	ECG 100
2N600	NA	GE-51	IRTR-85	NA	NA	SK 3005	RT-118	ECG 100
2N601	NA	GE-51	NA	NA	NA	NA	NA	NA
2N602	RS276-2004	GE-50	IRTR-89	PTC 109	HEP-2	SK 3008	NA	ECG 126
2N603	RS276-2005	GE-9	IRTR-89	PTC 109	HEP-2	SK 3008	NA	ECG 126
2N604	RS276-2005	GE-5	IRTR-89	PTC 109	HEP-2	SK 3008	NA	ECG 126
2N605	RS276-2005	GE-50	IRTR-89	PTC 109	HEP-2	SK 3008	NA	ECG 126
2N606	RS276-2005	GE-50	IRTR-89	PTC 109	HEP-2	SK 3008	NA	ECG 126
2N607	RS276-2005	GE-50	IRTR-89	PTC 109	HEP-2	SK 3008	NA	ECG 126
2N608	RS276-2005	GE-50	IRTR-89	PTC 109	HEP-2	SK 3008	NA	ECG 126
2N609	RS276-2005	GE-53	IRTR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N610	RS276-2005	GE-53	IRTR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N611	RS276-2004	GE-53	IRTR-85	PTC 102	HEP-253	SK 3004	RT-120	ECG 102
2N612	RS276-2004	GE-53	IRTR-85	PTC 102	HEP-253	SK 3004	RT-120	ECG 102
2N613	RS276-2004	GE-53	IRTR-85	PTC 102	HEP-253	SK 3004	RT-120	ECG 102
2N614	RS276-2004	GE-52	IRTR-85	PTC 109	HEP-253	SK 3005	RT-118	ECG 100
2N615	RS276-2004	GE-52	IRTR-85	PTC 109	HEP-253	SK 3005	RT-118	ECG 100
2N616	RS276-2004	GE-1	IRTR-85	PTC 135	HEP-253	SK 3005	RT-118	ECG 100
2N617	RS276-2004	GE-1	IRTR-85	PTC 109	HEP-253	SK 3005	RT-118	ECG 100
2N618	RS276-2006	NA	TR-01	PTC 138	HEP-232	SK 3009	RT-127	ECG 121
2N619	NA	GE-61	IRTR-95	PTC 115	NA	SK 3039	RT-113	ECG 108
2N620	NA	GE-61	IRTR-95	PTC 115	NA	SK 3039	RT-113	ECG 108
2N621	NA	GE-61	IRTR-95	PTC 121	NA	SK 3039	RT-113	ECG 108
2N622	NA	GE-61	TR-21	PTC 132	NA	NA	RT-100	ECG 123
2N623	NA	GE-20	IRTR-89	PTC 107	NA	NA	NA	ECG 126

	ARCH	G-E	IR	MAL	MOT	RCA	SPR	SYL
2N624	NA	GE-1	IRTR-89	PTC 107	HEP-3	SK 3008	NA	ECG 126
2N625	NA	NA	TR-08	NA	NA	NA	RT-122	ECG 103
2N626	NA	GE-53	NA	NA	NA	NA	NA	NA
2N627	RS276-2006	NA	TR-01	PTC 105	HEP-628	SK 3009	RT-127	ECG 121
2N628	RS276-2006	NA	TR-01	PTC 105	HEP-628	SK 3009	RT-127	ECG 121
2N629	RS276-2006	NA	TR-01	PTC 105	HEP-628	SK 3009	RT-127	ECG 121
2N630	NA	GE-3	TR-01	PTC 138	HEP-625	SK 3009	RT-147	ECG 179
2N631	RS276-2005	GE-53	IRTR-85	PTC 135	HEP-254	SK 3003	RT-120	ECG 102
2N632	RS276-2005	GE-53	IRTR-85	PTC 109	HEP-254	SK 3004	RT-120	ECG 102
2N633	RS276-2003	GE-53	IRTR-85	PTC 109	HEP-632	SK 3004	RT-120	ECG 102
2N634	RS276-2001	GE-8	TR-10	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N635	RS276-2001	GE-8	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N636	RS276-2001	GE-5	TR-08	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N637	RS276-2006	GE-3	TR-01	PTC 105	HEP-232	SK 3009	RT-124	ECG 101
2N638	RS276-2006	GE-3	TR-01	PTC 105	HEP-232	SK 3009	RT-124	ECG 104
2N639	RS276-2006	GE-20	TR-01	PTC 122	HEP-232	SK 3009	RT-124	ECG 104
2N640	RS276-2005	GE-9	IRTR-89	PTC 107	HEP-638	SK 3008	NA	ECG 126
2N641	RS276-2005	GE-1	IRTR-89	PTC 107	HEP-638	SK 3008	NA	ECG 126
2N642	RS276-2005	GE-9	IRTR-89	PTC 107	HEP-638	SK 3007	NA	ECG 126
2N643	RS276-2004	GE-9	IRTR-89	PTC 109	HEP-2	SK 3007	NA	ECG 126
2N644	RS276-2004	GE-9	IRTR-89	PTC 109	HEP-2	SK 3007	NA	ECG 126
2N645	RS276-2004	GE-9	IRTR-89	PTC 109	HEP-2	SK 3007	NA	ECG 126
2N646	RS276-2002	GE-54	TR-08	PTC 108	HEP-641	SK 3010	RT-122	ECG 103
2N647	RS276-2002	GE-5	TR-08	PTC 108	HEP-641	SK 3010	RT-122	ECG 103A
2N648	NA	GE-8	TR-08	PTC 108	NA	SK 3010	RT-122	ECG 103
2N649	RS276-2002	GE-8	TR-08	PTC 108	HEP-641	SK 3010	RT-122	ECG 103A
2N650	RS276-2007	GE-2	IRTR-85	PTC 102	HEP-629	SK 3004	RT-120	ECG 102
2N651	RS276-2005	GE-2	IRTR-85	PTC 102	HEP-254	SK 3004	RT-120	ECG 102
2N652	RS276-2003	GE-2	IRTR-85	PTC 102	HEP-633	SK 3004	RT-120	ECG 102
2N653	RS276-2007	GE-2	IRTR-85	PTC 102	HEP-631	SK 3004	RT-120	ECG 102
2N654	RS276-2003	GE-2	IRTR-85	PTC 102	HEP-632	SK 3004	RT-120	ECG 102
2N655	RS276-2003	GE-2	IRTR-85	PTC 102	HEP-633	SK 3004	RT-120	ECG 102
2N656	RS276-2018	GE-8	TR-25	PTC 125	HEP-243	SK 3024	RT-114	ECG 128
2N657	NA	GE-27	IRTR-85	PTC 125	NA	SK 3005	RT-118	ECG 100
2N658	RS276-2004	GE-67	IRTR-82	PTC 135	HEP-253	NA	RT-127	ECG 176
2N659	RS276-2004	GE-67	IRTR-82	PTC 135	HEP-253	SK 3005	RT-127	ECG 176
2N660	RS276-2005	GE-1	IRTR-82	PTC 135	HEP-254	SK 3005	RT-127	ECG 176
2N661	RS276-2005	GE-1	IRTR-82	PTC 135	HEP-254	SK 3005	RT-127	ECG 176
2N662	RS276-2004	GE-1	IRTR-82	PTC 135	HEP-253	SK 3005	RT-127	ECG 176
2N663	RS276-2006	GE-25	TR-01	PTC 105	HEP-230	SK 3009	RT-127	ECG 121
2N665	RS276-2006	GE-25	TR-01	PTC 105	HEP-232	SK 3009	RT-127	ECG 121
2N669	RS276-2006	GE-25	TR-01	PTC 105	HEP-230	SK 3009	RT-127	ECG 121
2N670	RS276-2006	GE-53	IRTR-82	NA	HEP-238	NA	NA	NA
2N671	NA	GE-53	NA	NA	NA	NA	NA	NA
2N672	RS276-2006	GE-53	IRTR-82	NA	HEP-238	NA	RT-127	ECG 176
2N673	NA	GE-53	NA	NA	NA	NA	NA	NA
2N674	RS276-2004	GE-53	IRTR-85	NA	HEP-237	SK 3005	RT-118	ECG 100
2N675	NA	GE-53	NA	NA	NA	NA	NA	NA
2N677	RS276-2006	GE-16	TR-01	PTC 105	HEP-232	SK 3009	RT-147	ECG 179
2N678	RS276-2006	GE-16	TR-01	PTC 105	HEP-230	SK 3009	RT-147	ECG 179
2N679	RS276-2002	GE-8	NA	PTC 108	HEP-641	SK 3011	RT-119	ECG 101
2N680	RS276-2003	GE-52	IRTR-89	PTC 109	HEP-3	SK 3004	NA	ECG 126
2N681*	NA	GEMR-3	IR-682	NA	HEP-R1471	NA	NA	NA
2N682*	NA	GEMR-3	IR-682	NA	HEP-R1471	NA	NA	NA
2N683*	NA	GEMR-3	IR-683	NA	HEP-R1472	NA	NA	NA

*These devices are silicon controlled rectifiers.

(continued next month)

R-E's Service Clinic

The Trouble Tree

Causes are many, symptoms are few

by JACK DARR
SERVICE EDITOR

I'VE BEEN OVER THIS BEFORE, AND I'LL probably go back over it again—and again and again. Not only for the benefit of the new men who come into our bewildering profession each year, but for the benefit of a few forgetful old goats like myself.

It deals with the most important thing in any electronics repair job—the diagnosis. Test equipment does not make diagnoses—your brain does. All the test equipment does is give you a set of facts. *You* make the diagnosis from interpreting these.

The first thing you need to keep in mind is that in a complex device like a TV set, or even a radio, there are as many potential causes for trouble as there are parts. In multiple-function devices such as color TV, this is even more important. So when we see a given symptom, we must make up a mental Trouble Tree, like Fig. 1. At the bottom is the major symptom, and the branches are all of the things which could possibly cause it.

A single, simple symptom can have multiple causes—for example, "No High Voltage." A complaint of "No Vertical Sweep" is only a little less complex. Even "No Sound" can have quite a few possible causes.

Try growing one yourself. Sit down with a piece of paper, pick a symptom and then make up a Trouble Tree that names all of the possible causes. ALL, I said! Now, to make a useful diagnosis, start eliminating things one at a time, by testing.

To make things go faster, put the most likely or most common things first. This is easiest, and has the greatest statistical chance of success. For example, in a tube or hybrid set, experience has taught us that tubes are the most likely cause. They also plug-in. So the logical choice for the first one would be replacement of the tube.

Next would be the dc voltage supply, and so on down the line. Now; having gone this far, get out the schematic of a set, and look at it. See if you can find something you've overlooked. Remember, every part is suspect until proven innocent! (How many of you put down "crack in PC board conductor" as a possibility? See what I mean?)

With a good knowledge of how the basic circuit action works, you can take shortcuts. For example, take "Blank Screen; No Sound." Here, you have the whole signal-path of the set as a possibility. Since this is a long circuit, break it in the middle. Take a scope reading at the output of the video detector. If you see a normal video signal at this point, you've eliminated all of the stages "to the left" of this point; tuner, i.f.'s agc, etc. The trouble lies in the video amplifier, picture tube, etc.

If you find no signal at the video detector output, you know that the trouble is ahead of this point. Either the tuner, the i.f.'s, or the control circuits. For another shortcut, clamp the agc with a bias-box. It sets the control voltage at maximum gain (use the no-signal agc voltage shown on the schematic). If this produces a picture, you've cleared the signal-path stages and can proceed to the agc circuitry.

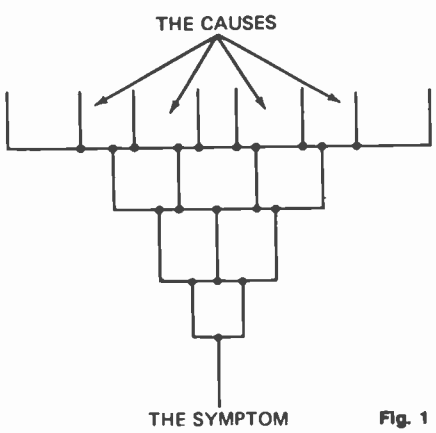

Fig. 1

If the agc clamp does not produce a picture, leave it there. Start signal tracing through the i.f.'s, to find out how far the signal goes before it stops. By feeding in a high-level, fixed pattern signal, you can read its amplitude with a crystal-detector probe on the scope. The color-bar output from a

This column is for your service problems—TV, radio, audio or general and industrial electronics. We answer all questions individually by mail, free of charge, and the more interesting ones will be printed here.

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

bar-dot generator is very good for this, in color or black and white. In most sets, you can even see the small i.f. signal output from the tuner, on the i.f. input. This clears or confirms the tuner as a suspect.

A lot of technicians place too much reliance on dc voltage readings. They're essential, of course, but *should never be used as the only diagnostic tool.* From a lot of experience and troubles, I believe that the fastest way is a combination of tests; first for the presence or absence of signals at a given point, and second for the dc voltage readings at key points in the suspected stage. In other words, if you get a signal through the first i.f. stage, you don't *have* to take dc voltage readings; they're good. Find the stage which doesn't pass the signal, and read dc voltages there.

F'rinstance No. 2: No Vertical Sweep. Touch the scope probe to the grid of the vertical output tube. If you get the normal sawtooth signal there, the oscillator is running. Now; you've established that the oscillator is working, yet there is no vertical sweep. Having eliminated the most likely suspects, go to the yoke tap of the output transformer. If you see the normal spike signal there, the output transformer is cleared.

Now you have one suspect, or do you? Open yoke, yes. Also! Broken wire in yoke cable, bad contact in yoke socket, bad contact in yoke plug! Don't overlook the little things.

The key point I hope I made in all of this is that each test must be made for a purpose. Don't just "sit there and poke at it;" a fault which we are all guilty of at times. When you pick up the probe of a test instrument, know what you want to test and go to a test-point that will tell you. **R-E**

reader questions

FINDING SHORTS IN PC SET

I've got a Magnavox 1-T-109, with PC boards; it had a short in the B+. I've changed the rectifier and filter capacitor, both shorted. Now, I read 20,000 ohms to ground on the B-plus. I think this is too low. How do I get into this type of circuitry to separate the loads?—T.P., Brooklyn, N.Y.

Actually, 20,000 ohms to ground isn't too bad on a +145 volt supply. Try reversing your ohmmeter prods and see if it isn't higher the other way. If so, OK. Try this; install the new filter capacitor and rectifier, but leave the cathode lead of the diode open. Connect an 0-500 dc milliammeter in this lead, between diode and filter.

Now, turn the set on and check for excessive current. Normal should be about 300 mA. There's a sneaky you can pull; just tack a 300-mA pilot light in series instead of the meter. If the bulb lights to full brightness, OK; if there's a short, it'll blow out.

BRIGHTNESS CONTROL WORKS BACKWARD

From a cold start, the picture on this RCA CTC-38 comes in fine. Brightness and contrast controls work normally. After about 3 minutes the picture pops out of focus, stretches vertically and pulls in on the sides; retrace lines show up.

Now, the brightness control works backward. If I turn it up, the raster goes dark. If I turn it down, I can find a place where the picture gets very bright, with good focus. However, it's much too bright, and the retrace lines are still there.

Picture tube good, high-voltage regulator tube good, yoke OK, flyback OK. Now where do I go?—A.M., Morgan Hill, Calif.

I'd say "To the video *output* stage." Monitor the plate voltage of the 12HG7 tube. See if it suddenly

drops (goes less positive) when the trouble shows up. If so, this will make the cathode voltage of the picture tube "go negative," which is the same as making the picture tube grids *more positive.* Thus, the tube tries to draw far more than its normal beam-current and the raster flares. This overloads the high-voltage supply, and the horizontal sweep is reduced; at the same time, the reduced high voltage lets the vertical sweep push the beam farther, so you get vertical stretch.

If the video output tube is OK, you can get the same effect if something happens to make the color-difference amplifier plates go more positive. This makes the picture-tube grids more positive. With the circuitry used here, one of two things could be happening. The color-difference amplifier tubes *heaters* could be going out, due to a bad solder joint, or the single cathode resistor could be opening up; same cause.

HOT CHASSIS WITH POWER TRANSFORMER

This Sylvania 580-1 color TV is definitely a "hot chassis" type now, after being hit by lightning! Works on rabbit-ears, but kicks the breaker when the external antenna is connected. The den where the set's located has a tile floor, and the customer gets free shock-treatments, which he doesn't enjoy!—C.I., Montgomery, Ala.

Most likely cause; a short to core in the primary of the power transformer. It might even be a leakage of ac from one of the secondaries, since this set uses a half-wave doubler circuit, with a big electrolytic capacitor to chassis as the lower part of the doubler circuitry.

In any case, I'd check the primary first, then disconnect and check the secondaries for leakage to the core. New power transformer will probably clear it up.

SLOW COLOR WARMUP

It takes about 20 minutes for the color to come on in this Zenith 14A9C50 chassis. I'm enclosing a list of the dc voltages around the color stages. Any ideas?—L.T., Winnipeg, Man.

One at least. You show a –0.5 volt on the color amplifier grid (pin 7, 6KT8) which is normal with no signal, or B/W signal. However, when a color signal is received, this should *change* to a +6.0 volts. It doesn't. So, your color killer circuit isn't working, or isn't starting up as it should. The color amplifier state is being cut off, at all times (or for far too long).

Check the acc/killer diodes. The dc voltages on these should be equal and *opposite,* and should change when a color signal is received. This will run about –50 volts on the anode of CR213, and +50 v. on the cathode of CR214.

Also, check for the presence of the 3.58-MHz oscillator signal. In a few sets, this oscillator is slow starting; weak tube, bad crystal, etc. This will do the same thing.

INTERMITTENT LOSS OF RED

The reader wrote: "I am getting an intermittent loss of red on a Zenith 14A9C19 chassis, with the "chip" demodulator." I replied: "Check the signal-in vs the signal-out of the demodulator chip. If it is only on the one color, and the rest work, then I'd suspect a bad chip. Be sure that external parts are definitely good."

He replied: "It *was* a defective demodulator. For your information, the Zenith distributor says that the recommended replacement for this chip is the "silver" type, Part No. 221-39, to replace the original "black" unit, Part No. 221-37."

For which many thanks to Peter Hartnett, Rahway, N.J.

AGC TOO HIGH

When I turn this Sears 9168 color set on, the picture comes on for a second, and then it whites-out. I read a

(continued on page 78)

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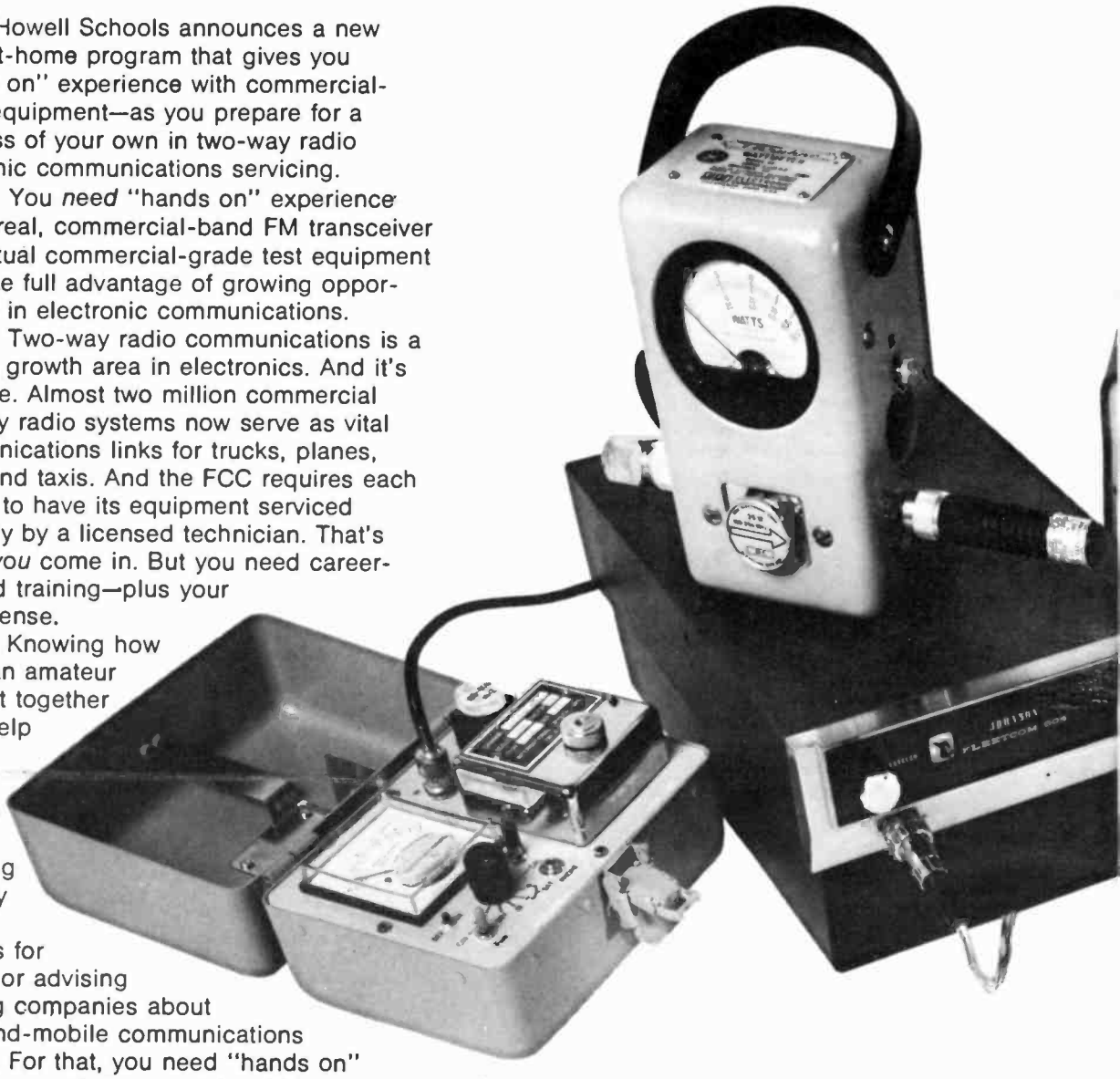

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406R3

very high negative voltage, -60 volts, on the 12AV6 agc tube plate. Where's this coming from?—G.S., Highland, Calif.

You're in the right place! This very high agc voltage is cutting off the i.f. Check to see that you do have the proper keying pulse on the plate of this tube. Should be 200 volts p-p. Also, check the 33-megohm resistor from agc to +125 volts. Could be open.

However, I believe I'd be more apt to suspect an open agc bypass capacitor somewhere in there. This would let the agc go into oscillation, and build up that excessive negative voltage on the plate. Check the cathode voltages, through that voltage-divider and the agc control. The 47,000-ohm resistor to ground may be open, or increased in value.

HIGH VOLTAGE SUPPLY

I replaced the high-voltage rectifier heater winding on this RCA CTC-25. Original was shorted. Now, I can't get the set to work properly! If I turn the brightness down to where I can barely see the picture, OK. If I try to turn it up, I get thin white streaks across the raster. I can get the same thing by turning up the pix tube screen controls. All tubes good.—G.S., Highland, Calif.

It sounds as if the heater of the 3A3 isn't getting hot enough. This would account for the big drop in the high voltage when you increase the brightness (raise the pix tube beam current.) Recheck the new heater winding; be sure that you put on exactly the same number of turns around the core that the original had! If you're one short, your heater voltage will be low, and the cathode of the tube will be too cool.

While you're in there, look for signs of arcing across the 3A3 socket. Arcs, or a bad contact, can cause the "thin white lines" symptom. Check the 3A3 plate lead for corrosion, too.

CHECKLISTS FOR DIM RASTER

The raster on this Magnavox 904 is very dim. What should I check to find out what's causing it?—W.B., Philadelphia, Pa.

OK, here's your checklist:

1. High voltage—23-25 kV minimum.
2. Focus voltage—20% of high voltage.
3. Pix tube cathode voltage.
4. Pix Tube grid(s) voltage. (The difference between these is the actual bias on the pix tube.)
5. The pix tube itself, for emission. Must have a minimum emission of 500-μA per gun for good brightness.

If the video output tube's plate voltage is low, or the color-difference amplifier tubes plate voltage is high, this will change the pix-tube bias to the point where the pic tube cannot conduct enough beam current. Faults in these little tubes can cut off the pix tube.

RASTER BREATHING

As soon as this set is turned on, the bottom of the raster moves slowly up and down for about an inch. It's a Setchell-Carlson ECL-66. I can also see thick horizontal lines about 2 inches wide moving slowly up the picture. What causes this?—G.S., Highland, Calif.

This is sometimes called "breathing." Most frequent cause is a little excess ripple on the B+ supply to the vertical output stage or oscillator. Check this line with a scope. If the ripple is higher than normal, look for a bad filter capacitor. Ripple here shouldn't be more than 0.5 volt p-p at the worst.

Don't forget to check the 6GF7 tube for heater-to-cathode leakage, too! Substitution is the quickest way.

NO VERTICAL SWEEP

This Zenith 24NC31Z came in with no raster or sound. I found a bad resistor in the B+, changed it, and it

worked. When I took it back, all I could get in the home was a horizontal bar about an inch high! Checked the service switch, tube, and so on. No help.—A.S., St. Paul, Minn.

I did the same thing not long ago! Set working perfectly on bench, on extension cables; back in cabinet, no vertical sweep. So, do what I did—check to see what isn't hooked up! There has to be something.

Crystal-ball diagnosis: check the convergence yoke, plug and socket. If this isn't plugged in, or has a bad contact on one certain pin, you'll get exactly this symptom. The vertical output tube cathode circuit returns to ground *through* the convergence circuitry. So, without this plug in properly, you have far too much resistance in this cathode, and lose practically all your height, due to excessive bias.

"SQUAWK" IN HV

Turn the brightness full up on this Motorola TS-915, and it's fine. Good pix, good focus, etc. But, if you turn the brightness down, it makes a loud squawk in the speaker, and the picture goes out. Raster has fuzzy horizontal bars, about 2-inches wide.—R.McK., De Queen, Ariz.

Turn the sound off, make it squawk, and listen around the high-voltage compartment to see if you can hear an arc. Check the high voltage. I think you'll find that it stays up, but that the focus voltage drops drastically, to 2-3 kV.

This could be in the big dropping resistor for the focus voltage, but in this chassis, it's more apt to be a breakdown in that little 2-conductor socket which carries the focus voltage to the pix-tube base. Pull this plug, and look at it. It's a light colored plastic. If you can see a tiny brown spot, replace it; the plug is breaking down and allowing the focus voltage to arc to chassis.

TOO MUCH GREEN

The screen of this RCA CTC-16 is green all the time; color and B/W. The dc voltage readings on the G-Y amplifier are OK. B-Y and R-Y plates read +80 volts. The pix tube is good. Resistors and capacitors in the color-difference amplifier circuits all check.—T.C., Cicero, Ill.

You've found the problem; that low plate voltage on the color-diff amplifiers. Since this determines the conduction of the pix-tube guns, by controlling the grid voltages, the "less-positive" voltage here shows that these two grids are almost cut off (in other words, the picture-tube grids are "too far negative," which reduces the conduction of any tube).

Most likely cause for this; a bad solder joint on the printed-circuit board, at the B+ supply point for the two 27,000-ohm plate resistors of the B-Y and R-Y amplifier stages. These are the 2-watt, light blue resistors just behind the 6GU7's. The G-Y plate resistor goes to a different connection.

LOSES COLOR PURITY

I've got an odd problem in a Motorola TS-914 chassis. It loses purity as it runs. After it's been on about 2 or 3 hours, I get blobs of color on the screen. These are hard to get out even with an external degausser. The degauss circuit seems to be OK; I read 25 ohms on the coils. Where do I go from here?—C.C. Dix Hills, N.Y.

This sounds as if it *is* a problem in the set's auto-degausser. This set has an unusual degausser circuit, operated from the focus voltage; when the DEGAUSS button is pushed, a charge is sent through the coil, from a capacitor.

If you read 25 ohms on that coil, look out. The factory schematic shows a normal resistance of only 1.1 ohms. This could indicate a bad degausser coil. Check the switch and capacitor for leakage. Incidentally, you can *not* run this set if the degausser coil isn't hooked up, it upsets the focus. Let's hear how you make out. **R-E**

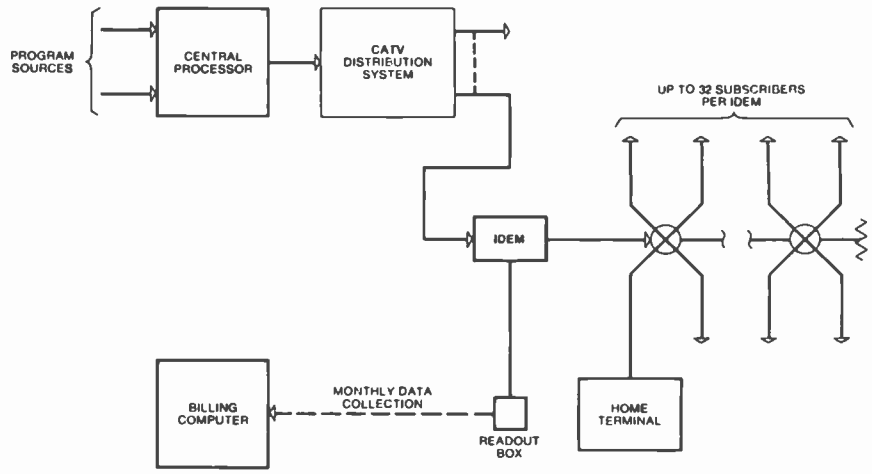
new pay tv system

Pay-for-program system provides two separate premium channels for first-run movies or special sports events

A NEW SYSTEM THAT CAN OFFER INDIvidual CATV television subscribers special cultural programs, sports events, recent movies, live plays and other special programs for a fee has been developed jointly by Magnavox and TelePrompTer. The system has been labelled *Premium Television*—the old term "Pay-TV" has been abandoned. (Pay-TV would be inappropriate in any case—the CATV subscriber pays for all his programs.) The new system will include two special or "premium" channels in addition to the regular ones of the CATV system.

The old pay-TV problems of ordering programs by phone, using special plastic cards and the like are overcome, as is that of billing for services. The subscriber has a compact Home Terminal with switches for the special channels. In most cases, he can see a short preview of the program on the premium channel he selects, after which the program becomes scrambled. If the viewer likes what has already been seen, he pushes an "accept" button and the program continues in unscrambled form.

A neighborhood unit known as an IDEM routes the programs from the CATV distribution system or "head end" to the viewer, handles the requests for previews and the "accept" orders and makes up the accounts. Each IDEM can serve up to 32 home terminals. The billing information is stored in the IDEM, and collected regularly through its read-out on an ordinary cassette tape, which is sent to the system's computer for monthly billing. In a two-way system, the accounts are transmitted direct from the IDEM to the billing computer. The same can be done with a one-way system if a return line is provided, or if telephone lines are used.



THE PREMIUM TV SYSTEM IS made up of a processor, a CATV head end, the neighborhood units called IDEM's, and numbers of home terminals, with arrangements for billing. This block diagram shows how these elements are interconnected.

HOME TERMINAL CONTAINS CHANNEL switches and an "accept" button. Pushing either premium channel switch gives a preview of its program. The third switch is for ordinary CATV.

Basically, the system (see diagram) consists of:

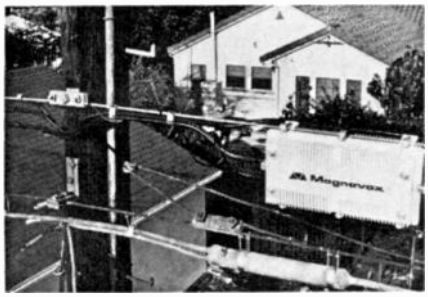
1. A Central Processor. This accepts the programs from their sources, adds the scrambling codes and controls the sequence of programs throughout the day. It can be operator-attended, or operated with a program on punched or magnetic tape that can be set up for a whole day's programming.

2. The CATV distribution system, or head end, a normal amplification

and distribution system, taking its program from the Central Processor and supplying the subscribers through the cable system.

3. The IDEM's (Interactive Data Exchange Modules). These handle the communications between the subscriber and the system, accepting orders and supplying desired programs. They also store the accounting information until it is collected via the read-out box. Since one IDEM will accomodate up to 32 subscribers, the cost of such circuitry—which in some older proposed systems was required in each subscriber's home—is much reduced.

4. The Home Terminal. It contains equipment for communicating with the IDEM, and converts the audio-video signal from it to a vhf channel on the subscriber's TV receiver. It



IDEM, NERVE CENTER OF THE SYSTEM, is the liaison between subscriber and head end.

ELECTRONIC METER READER just plugs in his cassette to record the month's bill on tape.

has pushbuttons to switch the TV to normal CATV viewing or to either of the two "premium" channels—which permit a short preview of the premium program—and an "accept" button, which gives the viewer a descrambled picture and signals the IDEM to make the appropriate charge for the service. The premium channels have key-lock switches, preventing unauthorized access to the pay channels by teen-agers or others.

Magnavox is supplying TelePrompTer with systems this spring, when a complete set of field trials will be initiated, with each subscriber initially supplied with two channels of premium programming. If tests justify it, later systems may be equipped with more than two premium channels. R-E

UNSCRAMBLE 4-CHANNEL

(continued from page 59)

do we have what appears to be an optimized CD-4 recording which can be compared with a standard stereo release. Even comparing different program segments from "Hair" tells us little, as illustrated in Figs. 29 and 30. Figure 29, program material from the stereo "Hair" with pronounced CF information is reproduced from the CD-4 version in stereo with predominant CF orientation; whether working with corner or front signals the CD-4 to stereo conversion shifts the orientation to the front.

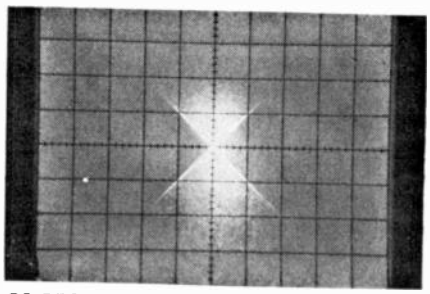
Based on my own listening experiences I feel that optimum discrete 4-channel is not coincident with optimum stereo, and somewhere along the line the powers in charge will have to make a firm decision. It will, however, be unfortunate if the capacity of CD-4 is compromised for stereo performance. My feeling, based I must admit on my experience with only the JVC "Hair" recording, is that CD-4 is to stereo as stereo is to mono.

Summing up

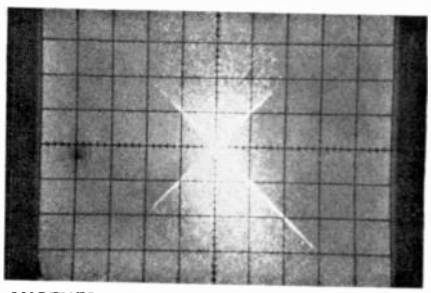
As far as creating a three-dimensional sound field is concerned, all the various matrix systems and CD-4 work; with CD-4 far and away the winner in creating vast spacial perspectives, though full-logic SQ very closely approximates the discrete system in spacial perspective.

As far as the listener is concerned there is no good reason why there cannot be two distinct incompatible systems, though it is technically feasible to combine both the matrix and CD-4 systems on a single record—and most probably, this is the wave of the future, the not-too-distant future if the various system proponents are willing to share the pie.

But while the giants of industry hassle over who will control the rights to the most popular, income-producing system, what of the consumer who is told to "sit it out," who is warned against purchasing equipment that might be obsolete if something called the "matrix war" is won by a new, yet unannounced matrix system? The truth of the matter is that the consumer is being *conned*, both by dealers who might want to unload their stock of stereo equipment, and by the system originators who see much in the way of license and royalty fees. The one who can't lose anything is the consumer, he is really sitting on top of the heap and can upgrade to 4-channel now with little possibility of obsolescence.



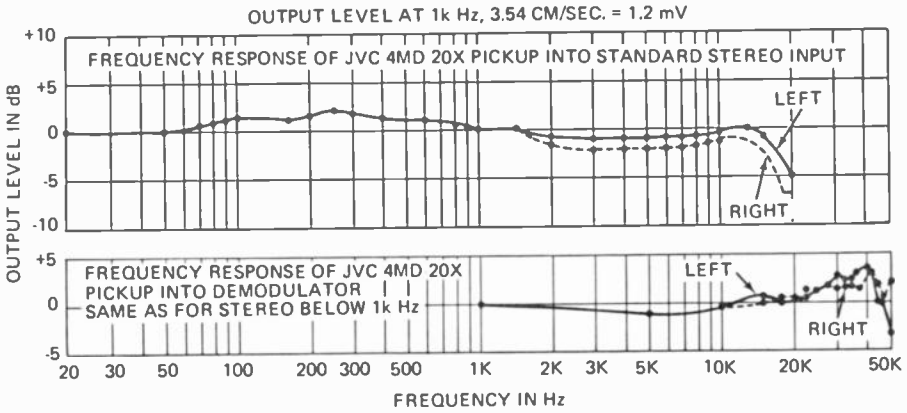
QS RECORD DECODED using Sansui QS-500 decoder/rear amplifier.



ANOTHER BAND of QS record played back through Sansui QS-500 unit.

To explain: The basic additional expense of 4-channel equipments is an extra pair of amplifiers for the rear channels, a two-speaker system and a decoder. With the full-logic SQ decoder now available on an IC chip the decoder expense is a minute part of the price of a new 4-channel amplifier or receiver. Even if a completely different matrix system is declared "the winner" of the so-called matrix war the user will still get a three-dimensional sound field from the full-logic SQ decoder, and someone, somewhere, will produce a decoder for the new matrix system that plugs into an amplifier's tape monitor or auxilary jacks. Should CD-4 eventually become the prevailing 4-channel system all the user need do is plug in a CD-4 demodulator, and get a new, wide-frequency-range cartridge.

On the other hand, suppose our audiophile favors CD-4 and purchases a 4-channel amplifier with built-in demodulator. Later, he decides there are matrix recordings he'd like to hear; again, he need only



JVC 4MD-20X PICKUP EASILY PROVIDED wide frequency response needed for optimum CD-4 performance. Note how lower load resistance and higher capacitance of standard phono input limits high-frequency response.

purchase an add-on matrix decoder.

As long as the consumer has equipment with four amplifiers for front and rear and the usual multitude of input and output "line level" connections, he can accommodate any 4-channel system at minimal extra expense. Even if he uses a stereo amplifier with one of the rock-bottom priced Dynaco-type passive ambient-sound decoders he will get a three-dimensional sound field from any stereo or matrix record.

This idea of add-on equipment is not really so far out as it might appear. Pioneer already offers 4-channel equipment with both SQ and RM decoders—RM meaning Regular Matrix, the term used in Japan for the QS system, and discrete 4-channel inputs for tape and/or demodulators. Marantz has equipment with a compartment prewired for add-on decoders; you buy the amplifier or receiver now and the decoder if and when needed. Panasonic, one of the CD-4 proponents, has equipment with three different rear-signal phase decoders as well as discrete 4-channel inputs. Most manufacturers of name-brand equipment do the same thing as Lafayette, Fisher, Harman-Kardon and Heathkit, just to name a few, who provide a jam-packed rear apron loaded from end to end with matrix and discrete 4-channel inputs.

So take your choice: any 4-channel system falls into the good-better-best category, and if you're not completely satisfied you can always upgrade to the latest technology with reasonably priced add-ons. **R-E**

new products

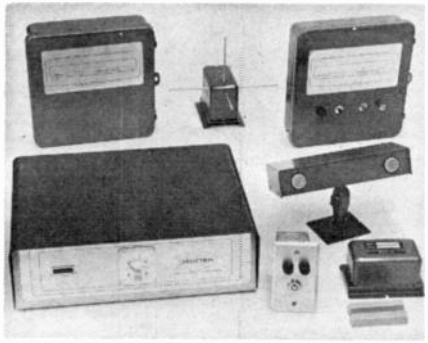
More information on new products is available from the manufacturers of items identified by a Reader Service number. Use the Reader Service Card inside the back cover.

STEREO HEADPHONES *model OA-1.* Dynamic open-air phones weigh only 10.9 oz. Impedance; 8 ohms. Maximum input power; 300 mW. Sensitivity; 100 dB at 600 Hz. Frequency response; 30 to

19,000 Hz. Distortion: less than 1%. Unit comes with a 7-foot cord and is priced at $19.95.—**Pickering & Company Inc.,** Sunnyside Blvd., Plainview, N.Y. 11803.

Circle 31 on reader service card

INTRUSION DETECTORS will detect the motion of any mass in three dimensional space using Doppler techniques and both ultrasonic and microwave frequencies. Detection range is as much as 30 feet and several detectors can be combined to cover larger areas. Also available is a stress intrusion detection

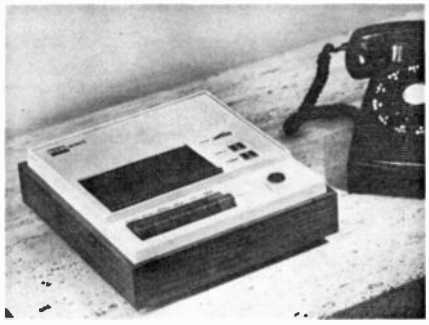


system that uses a small solid-state sensor glued to a structural member likely to flex when someone walks across it. These detectors must be used in conjunction with a security controller to process the information from the detectors.—**Detectron Security Systems Inc.,** Bay Street, Sag Harbor, N.Y. 11963.

Circle 32 on reader service card

TELEPHONE ANSWERER, designed for use in the home, answers the phone when you are not there and records up to 30 messages. All functions are push-button-activated and a message-waiting indicator light indicates when a call has been taped.

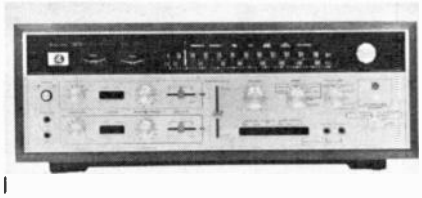
Unit is factory-set to answer after three rings, but can be adjusted to answer af-



ter as many as five rings. Unit is 9" x 10" x 2¾". $99.95.—**BSR-Metrotec,** Blauvelt, N.Y. 10913.

Circle 33 on reader service card

4-CHANNEL RECEIVER, *QEX-6500* has Variomatrix, an improved version of the Sansui QS regular matrix. Unit automatically accommodates all present 4-channel modes as well as conventional 2-channel stereo and 1-channel mono sources. The new matrix is claimed to offer drastic improvements in front-to-rear separation, greatly enhancing the 4-channel effect.



The amplifier delivers 280 watts of total IHF music power (50 watts at 4 ohms per channel). Frequency response is 20 to 30,000 Hz ±1 dB. Distortion is less than 0.5% at rated output. IHF sensitivity of the FM tuner is 1.8 mV. $699.95 complete with walnut-finished cabinet.—**Sansui Electronics Corporation,** 55-11 Queens Blvd., Woodside, N.Y. 11377.

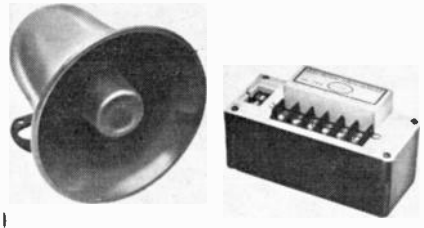
Circle 34 on reader service card

MULTITESTERS. Complete line ranging from compact 1,000 ohms-per-volt experimenters' unit to 100,000 ohms-per-volt professional unit, plus FET professional model with a 10-megohm dc input. Mini-tester *model IC-100* is $7.95. *Model IC-200*—the 20,000 ohms per volt unit—is $18.95, has 17 ranges and two color scales. *Model IC-300,* at $38.95, has 22 ranges and measures both ac and dc voltages. It is a 30,000 ohms-per-volt unit. *Model IC-400* is a 100,000

ohms-per-volt unit, priced at $49.95, and has 43 ranges. What may be the smallest FET multitester—the *IC-500*—provides 17 ranges, has a center zero feature and can measure resistance as high as 1,000 megohms. Its price is $54.95.—**International Components Corporation** 10 Daniel Street, Farmingdale, N.Y. 11735.

Circle 35 on reader service card

ELECTRONIC SIREN, *No. 700 Howler.* A solid-state sounding device that produces two distinctively different and very loud alarm signals. Unit generates a loud howling (by pulsating) sound similar to that of police and fire sirens as well as a steady-tone alarm signal. The two-channel capability enables the installer to



provide separate signals for burglary and fire.

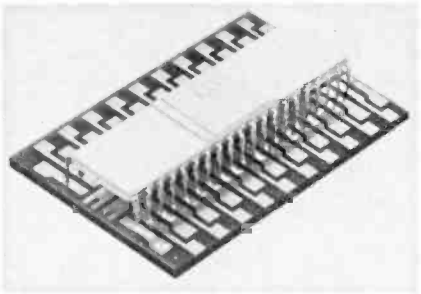
The *Howler* draws 700 mA and can be used only with a 6-volt system. It may be powered from batteries, rechargeable battery packs.—**Alarm Device Manufacturing Co.,** 165 Eileen Way, Syosset, N.Y. 11791.

Circle 36 on reader service card

MINI-MOUNTS, *LSI-42* pad provides a quick and easy way to breadboard LSI packages with up to 42 pins. Without drilling holes, you can assemble the circuit prototype on any flat surface. Pressure-sensitive adhesive on the back holds it in place while interconnecting wires are installed. Mounts can be

moved or exchanged as the circuit develops yet will remain firmly in place in the finished assembly.

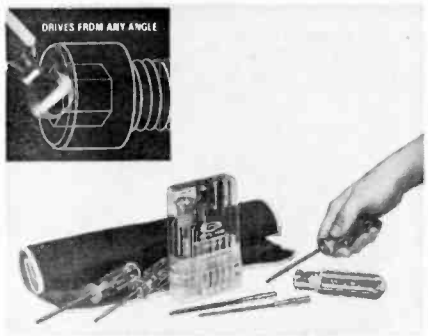
Provides a fast and flexible method of assembling high-performance electronic circuits, including analog, digital, and rf circuits from dc to the GHz re-



gion. Comes in different configurations to fit 14- and 16-pin dip's, 6-12 pin to -5 style cans, transistors, inductors, resistors and other components.—**Christiansen Radio, Inc.,** 3034 Nestall, Laguna Beach, Calif. 92651.

Circle 37 on reader service card

SCREWDRIVERS AND BLADES, *Series 99* work at any angle and handle hex socket screws which, because of obstructions, cannot be reached straight-on. Has ballpoint tip design that achieves a speed and ease in engaging and turning that is unattainable with



other drivers.

Nine sizes from .050" through 3/16", fixed handle types singly or complete kit that includes regular detachable handle, 4" extension and standup transparent plastic case.—**Xcelite Incorporated,** Orchard Park, N.Y. 14127.

Circle 38 on reader service card

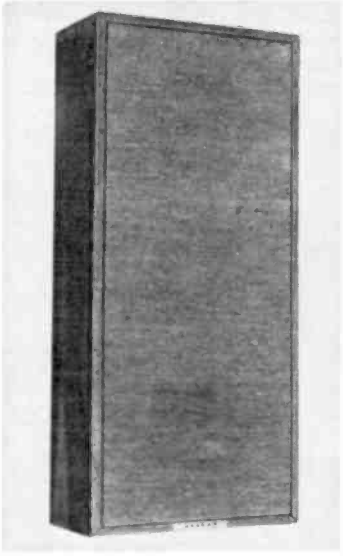
TV TUNER SUBBER, *model Mark IV.* Improved version of the original subber, this unit not only substitutes for the tuner but also substitutes the 40-MHz I.f. signal at any point in the I.f. chain up to the final i.f. stage. By substituting the signal after the agc stages, the technician can analyze the agc system without confusion. The receiver will operate normally without overriding the agc line with a fixed bias supply. Now tests can be made on the defective agc system without masking any of the defects with false biasing from the bias box.

Low-impedance output circuit matches older bandpass coupling i.f. inputs, late model link coupled inputs and

any input in the i.f. chain to the final i.f. stage. Not only is output level high, but output bandwidth is maintained so it is virtually impossible to lose the color due to mismatching. Unit is housed in a molded case and is completely self contained and battery powered, $45.95.—**Castle Television Tuner Service Inc.,** 5710 North Western Avenue, Chicago, Ill. 60645.

Circle 39 on reader service card

SOUND COLUMNS, *10/150 & No. 10/151* for sound reinforcement applications in auditoriums, churches,



schools, etc.

Directional sound dispersion pattern *model 10/150*—120° horizontal and 40° vertical, frequency response 80-15,000 Hz, program material 24 watts, peak 40

watts; *model 10/151*—120° horizontal and 30° vertical. Frequency response 60-18,000 Hz, program material 40 watts, peak 80 watts. *Model 10/150*—24"H x 10½"W x 5¼"D, 15 lbs. *Model 10/151*—47"H x 10½"W x 5¼"D, 34 lbs.

Oiled walnut veneer finish. Supplied with wall and mounting brackets. Provisions for plug-in line transformer modules.—**American Geloso Electronics Inc.,** 251 Park Avenue South, New York, N.Y. 10010.

Circle 40 on reader service card

BURGLAR ALARM SYSTEMS, *Minutemen* are a series of radio frequency, radar-type, space alarm systems which emit invisible rays that detect the slightest movement instantly.

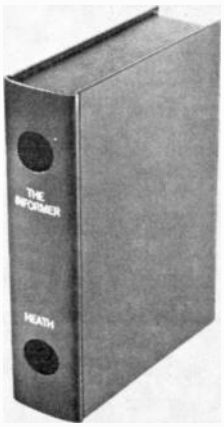
Minuteman II can cover more than one room or area with one antenna as its protective pattern can penetrate most building materials.

Space alarms protect against burglaries perpetrated by entering the premises through walls, floor or ceiling.

Contains burglar and fire alarm contacts, remote key switch, automatic resetting, central station capability and tamper-proof cables. $279.50—**GBC Closed Circuit TV Corp.,** 74 Fifth Avenue, New York, New York.

Circle 41 on reader service card

ULTRASONIC INTRUSION SENSOR, *GD-39* is valuable addition to any bookcase because this "book" keeps a vigilant watch on home and belongings.



Between the bogus covers of "The Informer" is a solid-state ultrasonic sensor that can be used to trigger an alarm, turn on a light, or both should it detect movement in the area under surveillance. To install, plug unit into an ac wall outlet, then plug the alarm and light into the receptacles provided. Unit has adjustable sensitivity, automatic and manual reset and a built-in 30-second delay circuit.

Device can be assembled in approximately two evenings and can be positioned to survey an entire room or entranceway. $49.95.—**Heath Company,** Benton Harbor, Mich. 49022.

Circle 100 on reader service card

MICROPHONE FLOOR STAND, *MS-50* is triangular-based and features wearproof grip-action clutch and scuff-resistant steel base with protective pads and anti-tip provisions for stability.

Adjustable height 35" to 63"; base size 14½"; 6½ lbs.; $8.75.—**Atlas Sound,** 10 Pomeroy Road, Parsippany, N.J. 07054.

Circle 42 on reader service card

SOLID STATE AUTOMOTIVE BURGLAR ALARMS, *MBA-335 & MBA-335R* is contained in a small plastic case with an on/off switch integral with the case and is easily concealed behind the dashboard. Senses any current change in the

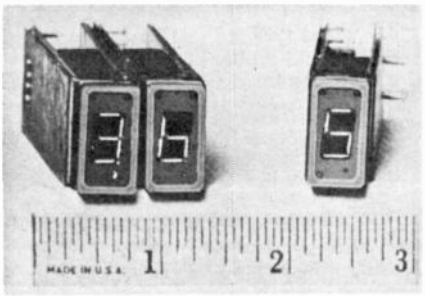
car's electrical system. After a 6 to 8-second delay, the alarm triggers, blowing the car's horn in pulsating blasts. An optional siren and parking-light flasher may be connected instead.

The sensing system eliminates the need for an external key switch and separate door trip switches. Quickly and easily connected with a single wire connection to the horn button switch wire and a wire to ground. *MBA-335*, $18.95,

for AMC, Chrysler and GM cars; *MBA-335R*, $20.95, for Ford-made cars and foreign cars that do not have a horn relay.—**Metra Electronics Corp.** 660 McDonald Ave., Brooklyn, N.Y. 11218.

Circle 43 on reader service card

MINIATURE DECADE COUNTERS, *DEC-100* offers small size (0.5 x 0.88" in viewing plane), operation from a single 5V power supply and a side-by-side plug-in feature that allows fast assembly of any number of digits with no unit-to-unit wiring for main-sequence operations. Uses 7-segment incandescent readouts. Up-down counter has preset capability, frequency response to 32



MHz, and mutual Vcc, ground, load, reset, strobe, lamp test, up-clock and down-clock signal lines. A simple plug-in adapter is available for use with systems that require a single clock line with independent up-down control logic. Single-unit price $29.50 (includes readouts).—**Compton Electronics,** P.O. Box 5326, Compton, Calif. 90224.

Circle 44 on reader service card

FIRE DETECTOR/ALARM, *Fireguard TBE800* is an all solid state, self-contained flame, smoke and heat detector and alarm. Operates on house current, automatically switches to standby batteries if line power fails.

In high sensitivity position, unit will detect the flame of a striking match up

to 10 feet distance, fire in a waste paper basket up to 30 feet distance. In low sensitivity position, a flame from a waste-paper basket 10 feet away; in total darkness, fire up to 100 feet away. Smoke detector sensitivity: average below 4%; adjustable to 1%. Heat sensitivity: fixed temperature 135°F. (200° F.).

120 Vac at 6A, delayed by about 60 seconds, is provided for turning on a sprinkler system, fire department tele-

Circle 64 on reader service card

Circle 65 on reader service card

phone dialer, police type sirens, bells or lights.—**Three • B • Electronics Inc.,** 5404 Eighth Avenue, Brooklyn, N.Y. 11220.

Circle 45 on reader service card

TAPE-RECORDER SPEED CHECKER, *LFM-30* will check tape recorder speeds using 1, 2, 3, 4, 5, 6, 7, 8 and 9 kHz test tones. Has test range of −3% to +3% with an input level of 100 mV to 10 mV rms. Input impedance is 150,000 ohms. Has an accuracy of ±5% of end scale.

Is effective for tape cassette, tape cartridge and reel-to-reel recorders. Comes with standard 4-kHz test tape and carrying case. 11"H x 3"W x 2½"D; 2 lbs., $129.95.—**Leader Instruments Corp.,** 37-27 27th Street, Long Island City, N.Y. 11101.

Circle 46 on reader service card

FIRE/INTRUDER ALARM SYSTEM, *Challenger* contains magnetic door/window guards that trigger alarm when door or window is moved. Fire sensors trigger alarm when temperature reaches 130°F.

System contains: 6 door/window guards, 4 fire sensors, alarm, electronic

control unit, master panel, 12 push-in wire connectors, 250 feet of insulated, shock-proof, ultra-fine, high-strength steel wire and illustrated step-by-step instructions. $95.00.—**Crismar Corporation,** Johnson Avenue, Plainville, Conn.

Circle 47 on reader service card

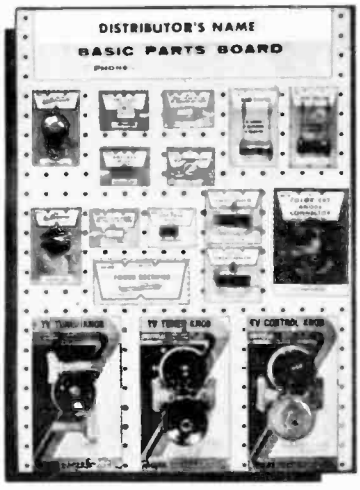
BOOKSHELF SPEAKER, *Project 100* uses an air-suspension type enclosure housing a 10-inch woofer and a 1½ inch hemispherical dome combination mid-range and tweeter. Maximum input power of 35 watts. With frequency response down to 30 Hz.

Fixed L-C network has a crossover at 1,000 Hz. Voice coil impedance is 8

ohms. 13"W x 23"H x 10½"D; 40 lbs., $99.95.—**U.S. Pioneer Electronics Corp.,** 178 Commerce Road, Carlstadt, N.J.

Circle 48 on reader service card

BASIC PARTS BOARD, *BP* contains 62 pieces of the most frequently needed replacement parts used by the TV/radio service industry. Merchandise is displayed on a 17" x 24" white pegboard consisting of fuses, fused resistors, focus rectifiers, circuit breakers, pix-tube an-



ode connectors, current limiting resistors and the completely universal TV channel selector, fine tuning and control knobs.—**Workman Electronic Products Inc.,** P.O. Box 3828, Sarasota, Fla. 33578. **R-E**

Circle 49 on reader service card

new lit

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

ALARM EQUIPMENT CATALOG, *M-73* is an 80-page catalog that describes over 400 intrusion and fire alarm products. Many are UL listed.

The alarm equipment ranges from relatively simple kits with instructions to the latest ultrasonic, radar and infrared intrusion detectors. Products are described in some detail regarding application, principle of operation and specifications.

A general alarm system discussion is followed by 8 pages of applications notes on how to use the many detector options. Some basic installation procedures are presented. For custom installations, several diagrams are presented to permit design and fabrication of basic systems.—**Mountain West Alarm Supply Co.,** 4215 North 16th Street, Phoenix, Ariz. 85016.

Circle 50 on reader service card

LOW-VOLTAGE LOW-CURRENT LAMP CATALOG includes photos, diagrams and complete specifications for such Muralites as standard lamp assemblies, Bi-Pin assemblies, lens caps, fuse type, pigtail type, neon and high brightness lamps.—**Mura Corporation,** 50 South Service Road, Jericho, N.Y. 11753.

Circle 51 on reader service card

INTEGRATED-CIRCUITS CATALOG, *WR-125F.* 36-page catalog gives salient information on the broad line of linear integrated circuits, Hall effect integrated circuits, functional electronic circuits, thin-film resistor arrays, thin-film hybrid circuits and digital integrated circuits.—**Sprague Electric Co.,** 81 Marshall Street, North Adams, Mass. 01247.

Circle 52 on reader service card

BURGLAR ALARM CATALOG. 6-page booklet contains sensors, alarms, accessories, control center/systems, automotive security, auto alarms, demonstrators and complete price list—**EICO Electronic Instrument Co. Inc.,** 283 Malta Street, Brooklyn, N.Y. 11207.

Circle 53 on reader service card

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

TUNER REPLACEMENT GUIDE & PARTS CATALOG *No. III.* 80-page book enables reader to pinpoint the tuner problem quickly and easily find the right replacement part. Includes uhf tuner parts, tuner chemicals and tools, blow-ups for vhf and uhf tuners, replacement guide for antenna coils and shafts. 2,000 available exact-replacement tuners are listed under original manufacturer number for easy exchange. **$1.00** (redeemable on first minimum parts order).—**PTS Electronics, Inc.,** P.O. Box 272, 5233 Hwy. 37 S., Bloomington, Ind. 47401. **R-E**

next month

JUNE 1973

- **Build A Phone Sentry**
  $30 gadget is used with one cassette tape player to answer your phone with a pre-recorded message. Use it with two cassette machines to take messages from callers.

- **4-Channel Matrix Logic Systems**
  Leonard Feldman, R-E's new Contributing Hi-Fi Editor reports on the latest developments in matrix logic systems that enhance front-to-rear separation. If you want to know how and what logic does for 4-channel stereo, mark this story *must reading.*

- **VTR's; Where They Stand**
  Popularity and use of video tape recorders is soaring. Here's an overview of what's happening in this exciting field and how it will affect you.

- **Test IC's With A Vtvm**
  Bob Middleton shows how you can accurately check out an IC using everyday test gear you already own.

PLUS
R-E's Guide For Replacement Transistors
Step-by-Step Troubleshooting
Jack Darr's Service Clinic
Technical Topics

Heathkit GR-900 25V Color TV with total-tuning convenience.

It's the most advanced TV circuitry you can build. Yet everything goes together with traditional Heathkit simplicity. And the built-in convergence board and test meter for at-home maintenance and self-service add further savings over the life of the set. With the GR-900 you pre-set any 12 UHF stations for positive pushbutton power tuning, and you can scan both UHF and VHF channels in either direction. An ultra-rectangular black matrix tube, voltage controlled varactor UHF tuner, MOSFET VHF tuner and an exclusive angular tint control for consistently better flesh tones combine to produce an absolutely brilliant color picture. There are four preassembled and finished cabinets to choose from, plus the Heathkit Wall Mount and wireless remote control option. Any way you look at it, the Heathkit GR-900 is one of the most rewarding kits you can build. Mailing weight, 125 lbs.

New Heathkit Solid-State B&W 19V Portable TV — a truly extraordinary set

The new Heathkit GR-1900 is like no other B&W portable! With advanced solid-state "modular" design — most circuitry mounts on just four plug-in boards. Dependable solid-state circuitry, including 23 transistors, 13 diodes, 2 ICs, and just 2 tubes; picture & high voltage. Total detent tuning on all 70 UHF channels as well as VHF. "Instant-On" for sound and pictures at a touch — plus other "big-set" front panel control features such as VHF/UHF fine tuning; brightness; contrast; master on/off; vertical hold; AGC; and height. New Ultrarectangular picture tube for a full 184 sq. in. viewing area. Automatic Vertical Linearity for rock-steady pictures — a feature usually found only on expensive color sets. Dual-Controlled AGC for improved picture/noise ratio — another "big-set" bonus feature. Extra-wide Video Bandwidth for theater-quality black-and-white pictures. Four circuits (most sets have only 3) in the grounded base VHF tuner for superior cross modulation in dense station areas. With all this, the GR-1900 is a kit even the novice can build. Both tuners come preassembled and aligned, transistors & ICs plug into sockets, and all chassis wiring is color coded. For truly extraordinary performance in B&W TV, you've got it all in the GR-1900. Mailing weight, 56 lbs.

New Heathkit Desk-top Calculator — an outstanding kit-form value.

The Heathkit IC-2108 features a sleek, low-profile case with bright ½" readout tubes in an 8-digit display — one of the largest, most legible in the industry. The color-coded keyboard is human engineered to slope down to the desk so you can rest your arm while using. And the IC-2108 is loaded with features: Four arithmetic functions. Floating and fixed decimal. Constant key. Chain calculation capability. Clear display key. Entry and result overflow indicators. Negative number indicator. 120/240 VAC operation. In addition, the IC-2108 is amazingly simple to build. Two spare evenings will do it. **Kit IC-2108,** 4 lbs.

New Heathkit "Pocketable" Calculator — you can service it yourself

The Heathkit IC-2009 is first a self-contained portable, weighing in at 11 oz. and small enough to fit in your coat pocket, but it's a desk-top calculator too. The internal Nickle-Cadmium battery gives five to eight hours use between charges. Or, the IC-2009 can be left connected to its charger for indefinite operation. And unlike other pocket calculators, the Heathkit IC-2009 is designed to be maintained by you. Plug-in keyboard and display boards, plus a complete troubleshooting section in the manual, make it easy — and economical. Add up the features for yourself: 8-digit capacity. Four arithmetic functions. Full floating decimal. Constant key. Chain calculation capability. Clear entry key. Entry and total overflow indicators. Negative answer indicator. Battery-saver circuitry. Low battery indicator. Tactile-feedback keyboard for positive entry indication. Order your IC-2009 now. You'll have it built in two or three evenings. Mailing weight, 3 lbs.

HEATH
Schlumberger

SEND FOR YOUR FREE 1973 HEATHKIT CATALOG — it describes more than 350 Heathkit projects

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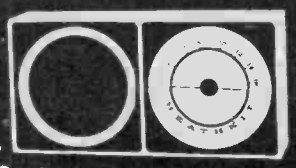


New

Heathkit GR-1008 AM Radio can be built in one evening . . . 14.95*

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

Circle 100 on reader service card

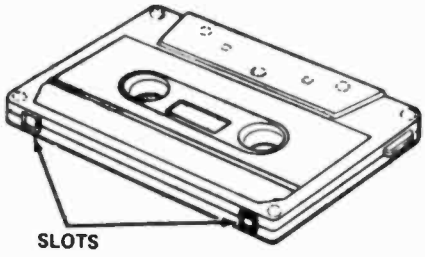
MAGNAVOX T952 CHASSIS

Elimination of 3.58-MHz beat pattern: Later versions of this chassis have a 33-pF capacitor across L19 in the delay line circuit. This capacitor identified as C75 (Part number 250508-33050) can be added to earlier versions of the chassis to reduce beat pattern.

High-voltage rectifier lead dress: In some cases of flyback transformer failure in this chassis, there were indications of improper lead dress. You should check to see that the high-voltage rectifier leads are dressed away from the flyback high-voltage (tertiary) winding. Also, the anode lead must be dressed away from the tertiary winding and the anode cap of the 3DB3 tube.—*Magnavox Service News*

TAPE CASSETTE SERVICE HINT

Tape cassettes have tabs in small slots (see drawing) that can be removed by the user to prevent accidental erasure or re-recording on the tape.



Some tape recorders are showing up in service shops with a complaint of "Will not erase or record" because the user removed the tabs and has forgotten about it.

If you get one of these complaints, look for the tabs on the user's cassettes. If none were supplied by the user, try a known good cassette before looking for fault in the set.—*Admiral Service News Letter*

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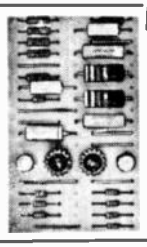
3¼" – 600' ..	.58	CASSETTE C-90	1.00
5" – 600' ..	.62	CASSETTE C-120 (TDK)	1.97
5" – 900' ..	.80	2½" TAPE REEL	.05
5" – 1200' ..	.97	3" TAPE REEL	.06
5" – 1800' ..	1.49	3¼" TAPE REEL	.07
7" – 1200' ..	.77	5" TAPE REEL	.14
7" – 1800' ..	1.12	7" TAPE REEL	.15



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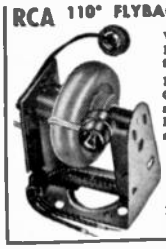
RCA 110° FLYBACK TRANSFORMER



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☐ ASTATIC PICKUP MODEL 700-89T Contains 89T ceramic cartridge LIST PRICE $17.00 ..... $2.95

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ANY 6 KITS FOR $5

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☐ 300 – ASST. ½ W RESISTORS Top Brand, Short Leads, Excellent Selection $1

☐ 100 – ASST ½ WATT RESISTORS stand, choice ohmages, some in 5% $1

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☐ MERCURY TUBE TESTER MODEL 980 Compact, latest model $39.95

☐ MIDLAND STEREO AMPLIFIER Model 26-002, 12 Watt, solid state $36.50

☐ MIDLAND STEREO AMPLIFIER Model 26-003, 25 Watt, Solid State $55.00

☐ STEREO CAR SPEAKER SET Deluxe Service Mount $6.50

☐ RCA 2 SPEAKER AM-FM CHASSIS Delure front panel, good for wall mount $20.00

Minimum Order $3.00.

IMMEDIATE DELIVERY . . . Scientific light packing for safe delivery at minimum cost.

HANDY WAY TO ORDER . . . Send check or money order, add extra for shipping. Lists of new offers will be returned in your order.

Please specify refund on shipping overpayment desired: ☐ CHECK ☐ POSTAGE STAMPS ☐ MERCHANDISE (our choice) with advantage to customer

BROOKS RADIO & TV CORP., 487 Columbus Ave., New York, N. Y. 10024 212-874 5600 TELEPHONE

Circle 78 on reader service card

SECURITY SYSTEMS

(continued from page 37)

ment can be adjusted to not "see" a moving elevator. Venetian blinds must not be allowed to wave back and forth because of breezes. These and similar problems can be avoided by expert planning.

A likely area for this type of equipment is where there is a great deal of machine or background noise. Since the radio waves are not affected by sound, this type of equipment will work when ultrasonic will not.

The radiation field is difficult to detect and an intruder may not even realize that he has tripped such an alarm. The equipment is compact and can be installed in much less time than many other types of equipment. Coverage is good when the equipment is properly installed, and it is unaffected by light or air currents. Equipment is easily moved when necessary.

The chief fault is that the waves go through walls into areas not intended for protection. People or vehicles going by outside the protected area can unknowingly cause frequent nuisance alarms.

Spot protection devices

In conjunction with perimeter protection and space protection, spot protection is important where a specific valuable object is to be safeguarded. While there is a bewildering array of electronic security devices on the market, a certain few are best suited to provide this sort of protection.

Capacitance alarms

One of the most successful applications of electronic security is typified by the class of equipment known as "proximity" or "capacitance" alarms. With this type of alarm, the protected object (safe, cabinet, etc.) acts as a unit of the tuned circuit. If an intruder wanders into the region of the protected object, the circuit will be thrown "out of kilter" and an alarm will sound.

CAPACITANCE ALARM can provide spot protection for a safe or other single item.

This type of equipment is very flexible and may be used to connect several safes or files in the same area to a single system. Unlike space alarm systems, the protective field on the object is kept down to a range of not more than a few inches from the surface of the object. Very close proximity will set off the alarm, but there is a minimum chance of accidental alarms caused by authorized persons passing within a few feet of the protected object with no intention of intrusion.

When used as intended, this type of equipment offers many advantages. It is simple to install and is extremely flexible. Almost any ungrounded metallic object can be so protected, including windows and doors. The protection so provided is invisible so that the thief never knows which object is safeguarded and which isn't. The equipment can easily be transferred from one object or location to another.

MINUTEMAN RADIO-FREQUENCY system by GBC for complete area protection.

The major problem with this equipment is sensitivity to nuisance alarms. **R-E**

NEXT MONTH IN R-E

Build the Phone Sentry

It answers your phone while you're away.

JUNE ISSUE ON SALE MAY 17

HEATH DIGITAL TUNER

(continued from page 50)

Fig. 9 shows these logic inputs and the squelch diode matrix circuit. When a squelch signal is present, the supply voltage is removed from the stereo indicator lamp to assure that it does not light. The SQUELCH DEFEAT switch prevents any of the squelch control inputs, with the exception of the re-program squelch input, from turning off the audio signals. Any time an incorrect frequency is selected, the re-program squelch input will override the squelch defeat control and cause the audio to squelch.

The readout circuit, mounted directly behind the tuner front panel window, consists of three incandescent 7-segment numerical display tubes and three BCD-to-seven-segment decoder driver IC's. A fourth display tube (the most significant figure) contains two segments that can only display the numeral 1. When frequencies below 100.1 MHz are displayed, the numerical 1 tube remains unlighted. The three integrated circuits decode the BCD information from the twelve output lines of the programmer. Pressing the L/T (light test) switch located behind the front panel hinged door lights all the display tube segments to insure that they are operative. **R-E**

(continued from page 53)

column is placed in the general vicinity of the original sound source (singer, speaker), as close as practicable to the source. Having the loudspeaker sound originate near the original source provides a more natural effect for the audience, and avoids confusion of the performer.

The column is placed so that the microphone is below and slightly behind the sound column, to minimize feedback. The sound column is oriented so that its vertical distribution will deliver nearly equal loudness to all listeners, from front to back, except have the column adjusted for maximum light reflection from the mirror.

Connecting sound columns

One or more sound columns may be connected to an amplifier in a sound system. The columns are normally connected in parallel as shown in Fig. 10.

Sound columns normally have an impedance rating of 16 ohms. If only one sound column is used, connect the amplifier leads to the 16-ohm output terminal. For two sound columns in parallel, connect the leads to the 8-ohm terminal.

There you have it, a quick guide to PA speaker installation—use it to simplify your next PA job. **R-E**

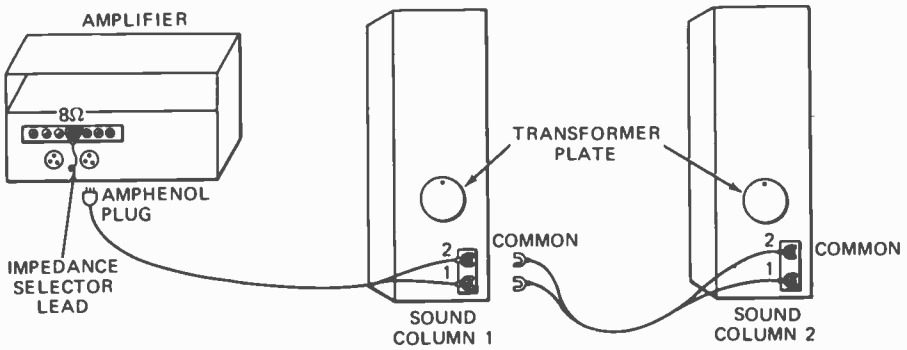


FIG. 10—ONE WAY to connect sound columns to PA amplifier system. Here two 16-ohm columns are in parallel across the amplifier output adjusted for an 8-ohm load impedance.

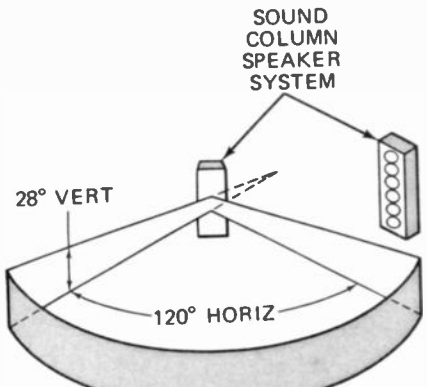


FIG. 8—RADIATION PATTERN from a vertically oriented sound column is horizontal.

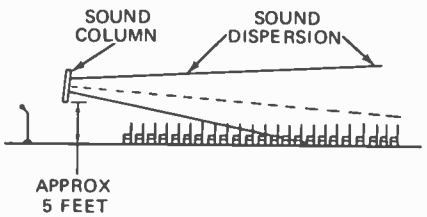


FIG. 9—HOW SOUND COLUMN IS PLACED for most effective coverage of an audience.

those who are within the effective range of the speaker's voice.

A sound column can be aimed quite accurately at this point by the light reflection method. Attach a small mirror to the face of the column center. Standing at the aiming point with a light directed at the sound column,

technotes

MAGNAVOX SPEAKER SYSTEMS

Speaker systems such as models 1S8757 through 1S8759 and 1S8762 through 1S8766 have a fusible resistor in series with the positive lead to the speakers. This resistor is rated at 0.225 ohms, 2 watts. The unusual and protective characteristics of this resistor make it necessary for you to use an exact replacement (part number 240104-3). Use the full length of resistor leads and use a heat sink while soldering them in place.—*Magnavox Service News Letter*

AUTOMATIC RADIO FNP -4052

This auto radio was dead when brought in. Its audio system was working and the trouble seemed to be in the front-end.

The trouble was traced to the second i.f. transformer. The ground lug that was soldered to the chassis had broken loose. Resoldering the lug to the chassis restored the radio to normal operation—*David Murphy*

DEGAUSSING CAUTION

Several current color TV models have a built-in 8-track tape player. When you use a degaussing coil to degauss these sets, be *very sure* that there are no recorded tapes in the player or within several feet of the set. Built-in automatic degaussing coils are adequately shielded from the built-in tape player, but an external degaussing coil can do a good job of erasing tapes!

This precaution will also apply when the customer has an accessory tape player or recorder on or near his TV set.—*Admiral Service News Letter*

CRACKED OSCILLATOR TUBE

A follow-up on reports of cracked 5JW8 horizontal oscillator tubes in the Admiral K19 chassis has traced this trouble to a small metal prong between pins 1 and 9 on the socket. This prong, by contacting the glass envelope of the tube, causes a temperature difference which results in a crack in the glass.

The prong was originally added to the socket to ground a shield but was not used for this purpose on the K19 chassis. It should be bent back so it does not contact the tube.—*Admiral Service News Letter*

MAGNAVOX T936/956/957 COLOR TV

Snivets on the left side of the screen on uhf channels may be caused by a leaky diode, D102. This diode is located in the horiztonal output section and is in series with the center arm of the high-voltage adjustment control. Replacement with Magnavox Part No. 530088-1004 diode will correct this condition.—*Magnavox Service News Letter*

MAGNAVOX UHF TUNER FAILURE

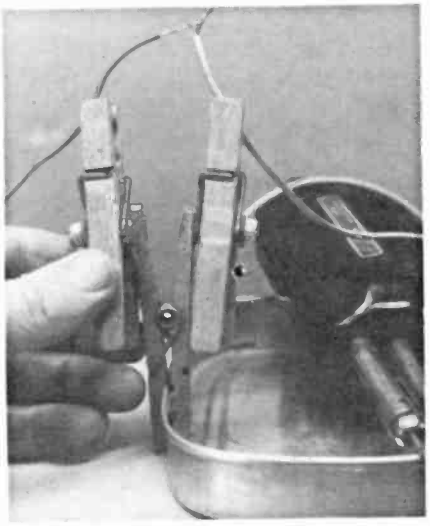
If the transistor in the uhf tuner fails in the 1T5052 and 1T5054 models, check to see if there is a ground strap from the upper right side of the tuner mounting assembly to the picture-tube shield. This strap is used in only a small number of these models and you should remove it from the models that you service.

It is suspected that a momentary arcing in the picture tube could result in sufficient conduction through this strap to damage the transistor. —*Magnavox Service News Letter* **R-E**

try this

THIRD HAND SOLDERING AID

A third or even fourth hand for delicate soldering can be quickly devised using three spring-type clothespins. To the handle of one clothespin fasten two others by small bolts through the spring "eyes" and holes drilled in the handle end of the first clothespin. The latter serves as a clamp for use on any suitable projection, rim or flange to support the other two clothespins in a flexible working position. The jaw ends will hold wire ends or solder without cooling it to make soldering easy without burning your fingers.—*Glen F. Stillwell*



THREE CLOTHESPINS form the basis for a handy soldering clamp. A coat of spray paint improves appearances.

CONTAINER SERVES DUAL PURPOSE

Many instruments and delicate parts are now shipped or packed in shaped, white plastic foam containers. Don't discard them because they make excellent holders for small parts such as screws, nuts, washers, etc. Small parts show up clearly on the white plastic and are easily located. In addition half of the container can be used as a drill-bit rack with sizes appropriately noted directly on the holder. Holes of the proper size are readily punched in this lightweight compressed plastic.—*Glen F. Stillwell* **R-E**

TWO HANDY BENCH AIDS made from foam plastic packing material used when shipping appliances and electronic devices.

INTERESTED IN OPTOELECTRONICS? Turn back to page 62, and read Lou Garner's State-of-Solid-State. It's all about optoelectronics devices.

books

MODERN RADAR: THEORY, OPERATION & MAINTENANCE, by Edward L. Stafford, Jr. TAB Books, Blue Ridge Summit, Pa. 17214. 480 pp. 5½" x 8½". Hardcover, $9.95; Softcover, $6.95.

Informative handbook covers all types of systems—land-based, aircraft, shipboard, police-car, earth to satellite, weather surveillance, etc., containing much of the information needed by technicians interested in the field of radar and radar communications. The development of radar is traced from its earliest stages, explaining the various types of systems and how each works and with schematics and photographs shows how they are put together, prescribed tests and troubleshooting procedures.

FUNDAMENTALS OF ELECTRONIC CIRCUITS by Arthur L. Pike, Prentice-Hall Inc., Englewood Cliffs, N.J. 07632. x 7 9½ In. 700 pp. Hardcover $15.50.

Those just beginning a serious study of electronics should find this a valuable text. Because electronic devices work in electric circuits, some previous knowledge of ac circuits is assumed. However, the opening chapter reviews the ac theory needed. Starting with such basic topics as Signal Flow and Efficiency for dc and ac signals the book goes on through diode devices and circuits, two-ports, triodes, basic amplifier circuits, feedback and pulse and ramp signals.

BATTERIES AND ENERGY SYSTEMS, by Charles L. Mantell. McGraw-Hill Book Co., 330 W. 42nd St., New York, NY 10036. 6⅛ x 9¼ In., 221 pp. Hardcover, $14.00.

Guide to primary and secondary batteries and energy systems, detailing military and civilian uses with special emphasis on engineering applications. Subjects include the zinc-alkali-manganese dioxide systems, silver batteries, water activated systems, nickel-cadmium system, conversion of sunlight. Detailed tables, illustrations and formulas in text, along with bibliographical references.

PRACTICAL INSTRUMENTATION TRANSDUCERS by Frank J. Oliver. Hayden Book Co. Inc., 116 W. 14 St., New York, NY 10011. 7¼ x 10 In. 340 pp. Hardcover $20.00.

A survey of physical-to-electrical transducers. Over 400 diagrams highlight the text discussion of basic operating principles and limits of accuracy of an amazing number of electrical transducers. Detailed chapters treat the specifics of selecting instruments for measuring strain, force, load, angular position, rotary speed, pressure, flow, etc.

HOME-CALL TV REPAIR GUIDE by Jay Shane. TAB Books, Blue Ridge Summit, PA 17214. 144 pp. 5¾ x 8¾ In. Hardcover, $6.95, Softcover, $2.95.

An on-the-spot repair guide with quick reference charts. Specifically designed as a troubleshooting guide for the technician working in the field. The book is arranged in logical reference sections, covering raster, video, chrominance, and other circuit troubles. By comparing the symptoms with the charts, the technician is guided through quick checks for the most logical causes of any malfunction. Separate chapters are devoted to antenna and reception troubles, portable color sets, and TV-radio combination. **R-E**

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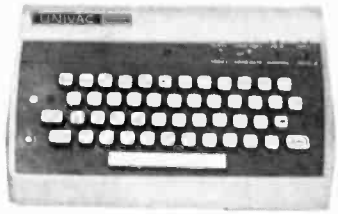

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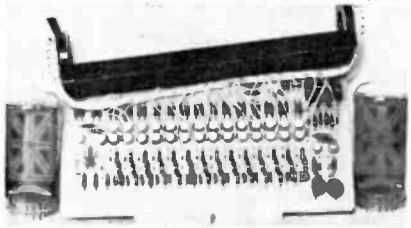

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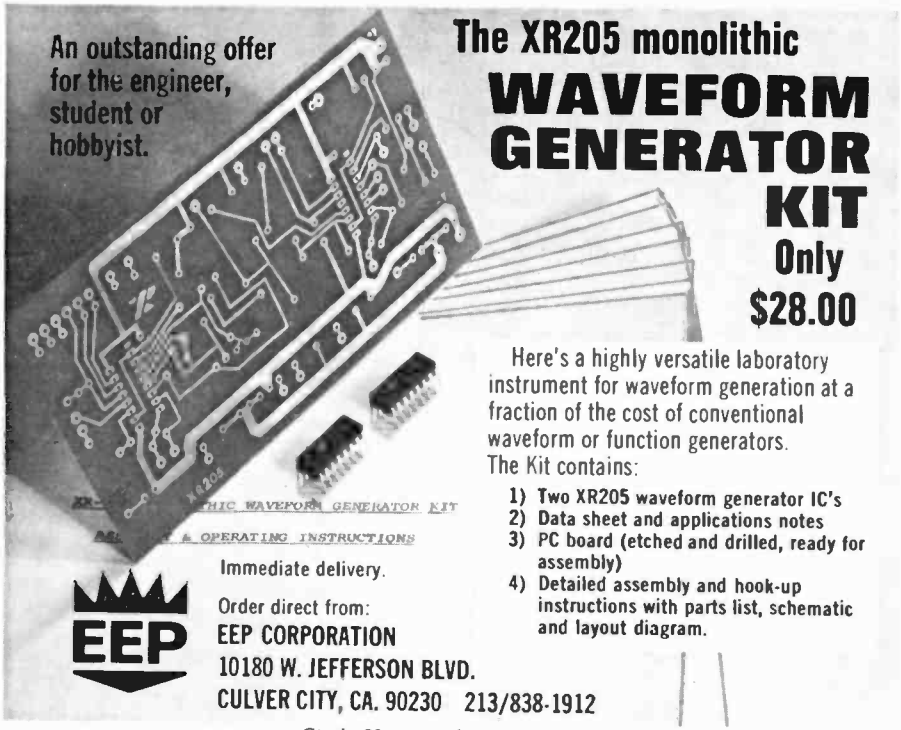

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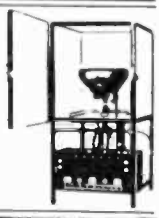

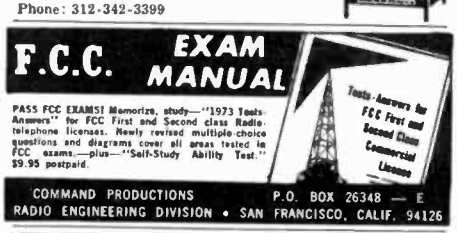

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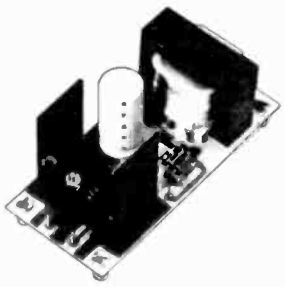

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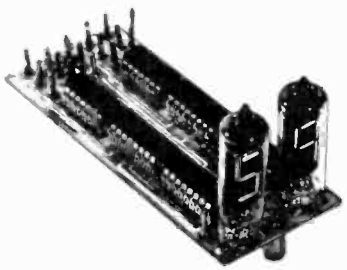

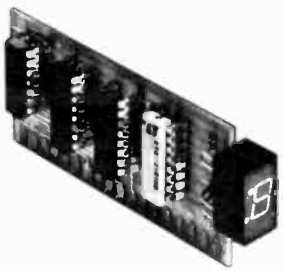

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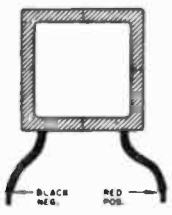

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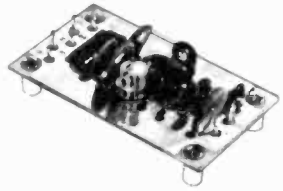

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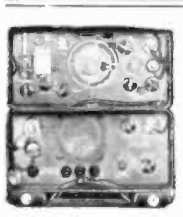

AN/GRR-5 RECEIVER

1.5 to 18 MHZ in 4 Bands. AM, CW and MCW, continuous tuning & 10 pre-set frequency, 200 KHZ crystal calibrator, 4" P.M. speaker, 12 tubes, with power supply for 115 V. 50/60 cyc., 6, 12, or 24 V. DC—Also dry cells 90 & 1.5 VDC. Size. 13½ x 8½ x 12½". Shpg. Wt., 75 lbs. USED, reparable...$49.50
CHECKED $59.50
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☐	1-LED MAN-3*, hobby special, readout, "the claw"	1.19

* Monsanto LED equivalents.

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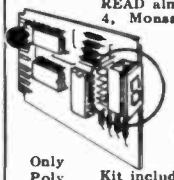
Will outperform any other DCM on the market today, not gaseous, not incandescent, but a device that will READ almost for life. MAN-4, Monsanto equal.



Digital Counting Modules by Scientific Devices

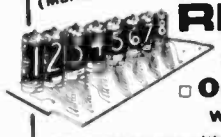
☐ **9.99**

Only Poly Paks can do it!

Kit includes: 3 x 2" printed ckt board, with fingers too! Side-mounting MAN-4 socket, resistors, 7448, 7475, 7490, booklet.

NEW! 8-Digit MUX (Multiplex)

BURROUGHS 8-DIGIT "UNIVERSAL" NEON READOUTS



PC Board Included!

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Use all 8 readouts or any number of readouts from 1 to 8 SIMPLY, EASILY. Electrical characteristics: 170 VDC. 2 decimal points, 2 anode pins. We include schematics & instructions. • **Characters 9/16" high!**

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MCA-30. 1500 volt isolation. 6-pin mini dip. Replaces all types of relays, etc. 100's of opto applications. Infra-red emitter optically coupled to photo darlington amplifier.

☐ **RCA NUMITRON 7-SEGMENT TUBES**

DR2000. Character height 0.6" x .235", 5V @ 24 mils per seg. Fit standard 9-pin tube socket. 0-to-9 numerals. **$3.99**

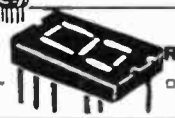
☐ **RCA DR2110 NUMITRON TUBES**

7-Segment, 10-pins, fits TO5 socket. Character size: 0.40" x .230", 5V @ 24 mils per seg. With left decimal. 0-to-9 **$3.99**

0-9 plus letters

Snaps in 14-pin DIP socket, ⅜x⅝x⅝", characters: ¼x⅜", 5V, 20-mils per seg. characters: ¼x3/16" Famous MAN-1 type.

☐ Sockets .50 ea.



LED READOUTS

☐ **4.50**

3 for $12.

LED 7-SEGMENT READOUTS

Only **$3.95** ☐ 3 for $10.

0-9 plus letters, for SN-7448. Snaps in 14-pin DIP socket. ¾" x ¼" x ⅜". 5V 10ma, with decimal point. Like MAN-1

☐ Socket for above, 50c

MAN-4 EQUAL

☐ **MAN-2* ALPHA-NUMERIC $9.99**

5x7 dot matrix (35 LEDs). 0 to 9 and A to Z. Displays 64 characters ASCII code. Requires 2513 character generator. Each diode 3V @ 20 mils. Snaps in 14-pin dip socket.

LED READOUTS ☐ $2.95

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This display is excellent for small portable electronics, such as DVM's, calculators, etc. Equivalent to Monsanto MAN 3A. Operates from 5V, 20 milliamperes, with 47 ohm dropping resistor.

☐ **MAN-5* GREEN $8.88**

0-9 Numerals, 9 letters, left decimal. Snaps in 14-pin dip socket. Size equal to MAN-1. Compatible with ICs. 3V @ 40 mils per seg., 7-segment.

☐ **MAN-8* YELLOW $12.50**

0-9 Numerals, 0 letters, left dec. pt. Snaps in 14-pin dip socket. Size equal to MAN-1. Compatible with TTL ICs. 5V @ 40 mils. 7-Seg.

☐ $5.50 3 for $15.00

COUNTING SYSTEM

Includes SN7490, decade counter, SN7475 latch, SN7441 BCD decoder driver. 0-to-9 Nixie tube, instructions.

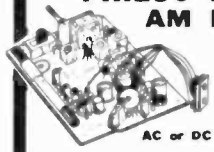
☐ **$2.95**

☐ **6-DIGIT MAN-3A MUX'D PC BOARD**

Clock DCMs, VTVM, DVM, calculators, multiplexed.

☐ **6-MAN-3A's for above board, $9.50.**

PHILCO 11 TRANSISTOR AM RADIO CHASSIS



AC or DC

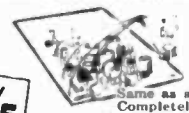
Use as:
- Mike amplifier
- Phono amplifier
- Tape amplifier
- Covers 535 Kcs to 1500 Kcs Broadcast band

☐ **Only $5.95**

One of the most versatile AM Radio and multi-purpose amplifiers we have seen at Poly Paks famous "Economy" price. Measures only 4½" x 3" x 2" high. With tuning capacitor, IF circuitry, loopstick, ant., volume control with switch, AC and phono-mike jacks. Separate switch for changing from AM radio to amplifier. Uses either 110V plug-in adapter (not with unit) and a 9-volt battery power. Exceptional sensitivity and power. Feeds into 16 ohm speaker. Complete with spec sheets, diagrams, and hookup ideas.

8 TRANSISTOR AMPLIFIER CHASSIS

Only ☐ **$3.95**



Same as above, except no AM radio section. Completely wired! With built-in preamp, mike, phono and tape inputs. Color-coded wires with diagram and hookups. Works off 9VDC transistor battery. Excellent fidelity. Shpg. wt. 1-lb.

AC-DC CHARGER-CONVERTER — Only $1.98

☐ Converts above 11-and-8-transistor chassis from 9VDC to 110VAC. Easy to hook in. Use as "NICAD" battery charger too (with instructions). Size: 2"x1¼"x1¼". 1-lb.

5-IN. "HI-FI" PM SPEAKER — Only $1.98

5-ounce ceramic, cylindrical magnet. Twin voice coil, 4 and 8 ohms. 50-16,000 cycles. Shpg. wt. 3 lbs.

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'Thar She Glows'

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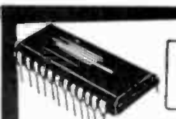

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Type G, 1/2" dia. x 1/2" high. Mounts 1/4" hole, with shaft, linear, immersion-proof legit lung.

2 for $1

Ohms		
	☐ 2.5K	
☐ 75	☐ 5.0K	☐ 25.K
☐ 100	☐ 7.K	☐ 75.K
☐ 500	☐ 10.K	☐ 100.K
☐ 2.0K	☐ 20.K	☐ 5 Meg

We stock Locknut Bushing & Screwdriver types at same low prices.

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Type F. Screwdriver adjust. **Any 4 for $1**

Ohms		
☐ 75	☐ 1.0K	☐ 25.K
☐ 100	☐ 2.5K	☐ 50.K
☐ 200	☐ 5.0K	☐ 75.K
☐ 250	☐ 7.5K	☐ 100K
☐ 500	☐ 10.0K	☐ 250K
☐ 750	☐ 20.0K	☐ 2 Meg
		☐ 5 Meg

Potter & Brumfield KAP RELAYS

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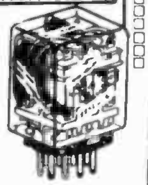

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300	☐ 1.45	☐ 1.65
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Size of cabinet: 6" x 5¼" x 6" deep

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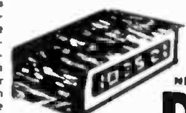

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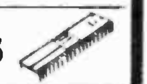

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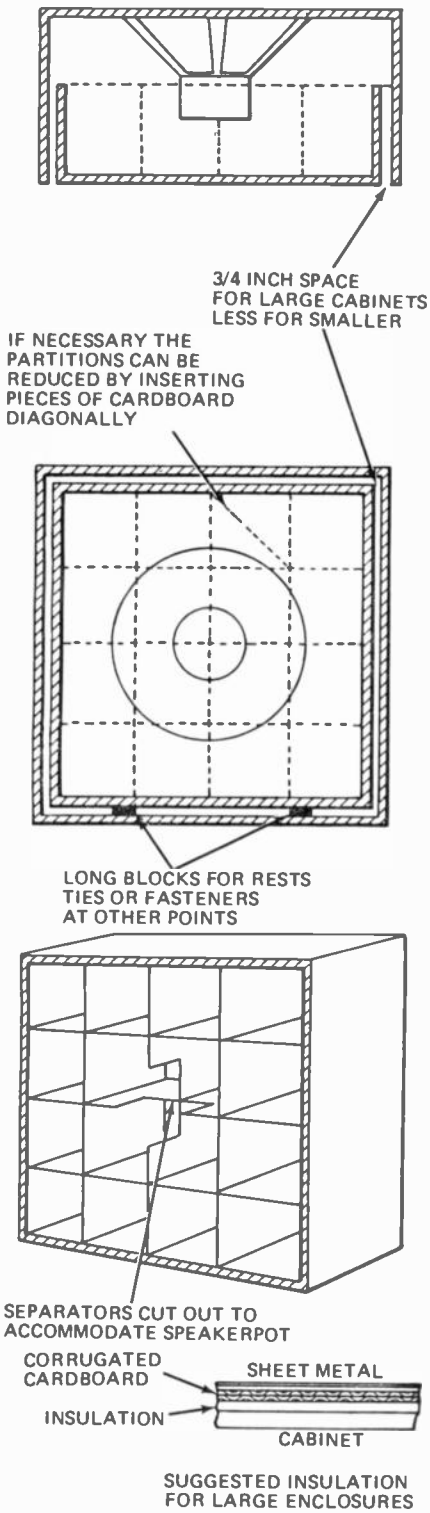
NOVEL SPEAKER ENCLOSURE

I enjoy experimenting with loudspeakers and enclosures. The drawings show the details of an enclosure that gives me very satisfactory performance. It is essentially a simple box with a smaller one inserted in it. The smaller box is divided into small compartments or pigeon-holes by corrugated cardboard separators like those used in shipping cartons for bottles and fragile glassware.

This arrangement minimizes the "boom" and reverberation within the enclosure and appears to reinforce the sound and there seems to be a better separation between all instruments.

I line large multi-speaker enclosures with one thickness of insulation—I use old carpeting—layered over with panels of thin sheet metal stapled to two thicknesses of corrugated cardboard. The hard surface and the deadness of the interior appear to contribute to the overall performance of the speaker system.

The depth that the inner unit is inserted into the outer can best be determined by experimenting. The space between the two sections is roughly equal to a ducted port in a bass reflex enclosure and can be blocked off at several points for tuning.—*Joseph Kriz* **R-E**



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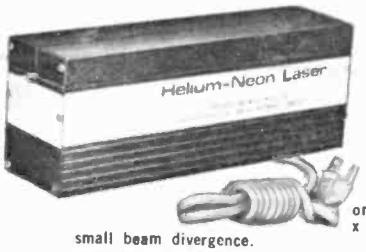

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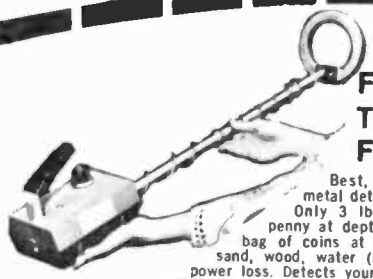

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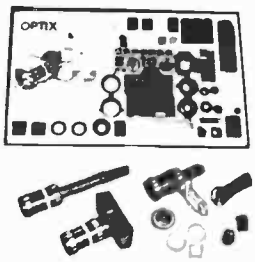

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Circle 85 on reader service card

Every time you sell an antenna for one set, you're losing money

by Bert Wolf
Manager, Jerrold DSD Division

EVERY CUSTOMER WHO BUYS AN ANTENNA FOR A NEW COLOR SET ALREADY OWNS ONE OR TWO BLACK AND WHITE TV SETS.

Chances are, he's been getting along with an indoor antenna for his old black and white set. He decided to invest in an outdoor antenna because he realized he needed more signal power and more directivity for top-notch color reception.

What your customer probably doesn't know is that he can connect two or more TV sets to a single antenna, using a 2-set antenna amplifier.

Essentially, color reception is not very different from black and white reception. Ghosts, snow and other types of interference look a lot worse in color, but they are easily discernible on a black and white set, too.

Therefore, you are doing your customer a real favor when you recommend that he hook a second set up to his new antenna. Only in this way can he get maximum value from his investment. For you, of course, the sale of a 2-set antenna amplifier represents extra profit.

COLORCASTER II IS A BREAKTHRU IN QUALITY AND PRICE

Figure 1 shows how easy it is to add a second set to an antenna system. The Jerrold Colorcaster II is an important breakthru in quality and price. Never before has it been so inexpensive to connect two or more sets to a single antenna --- even in poor signal areas --- without deterioriating picture quality.

The Colorcaster II lists for only $21.50. Yet, it amplifies all UHF and VHF TV channels, plus all FM stations. It provides more signal voltage to each TV set than the antenna would provide if connected directly to one set. Thus, it more than overcomes the splitting losses caused by ordinary passive multi-set couplers.

TWO TV SETS PLUS FM RADIO

What if the home includes not only two TV sets, but an FM stereo receiver, as well? FM stereo is a lot like color TV. FM stereo receivers require stronger signals than monophonic radios. What's more, they are subject to multi-path distortion, which is the equivalent of a "ghost" in TV reception.

Therefore, a good outdoor antenna can do wonders for FM stereo reception. However, your customer doesn't have to invest in a separate outdoor FM antenna. Many TV antennas, such as the Jerrold Super VU-Finder series, provide excellent pick-up of FM signals.

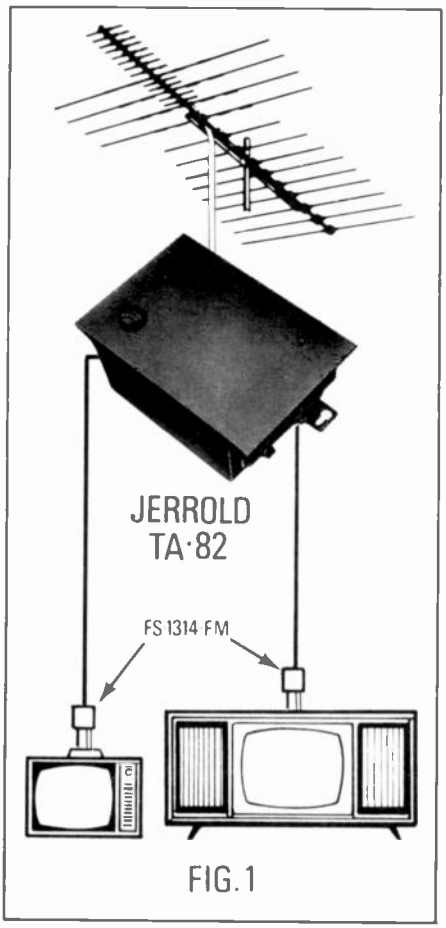

FIG. 1

The system in Figure 2 shows how easy it is to connect an FM stereo receiver to the color TV antenna. Using the Colorcaster II and a Jerrold FS-1314-FM frequency splitter as shown, you can provide superb pictures to two TV sets, plus outstanding stereo signals to the FM receiver. What's more, there is absolutely no interaction between receivers.

FOUR TV SETS PLUS FM RADIO

No, the home with three or four TV sets is no longer unusual. Black and white portables are now so inexpensive that they are frequently given to teenagers as gifts.

You can easily use a Colorcaster II to serve three or four TV sets, plus an FM stereo receiver. All you have to do is split the outputs of the Colorcaster II with Jerrold MF-82 couplers. The high gain of the Colorcaster II is sufficient to overcome the coupler.

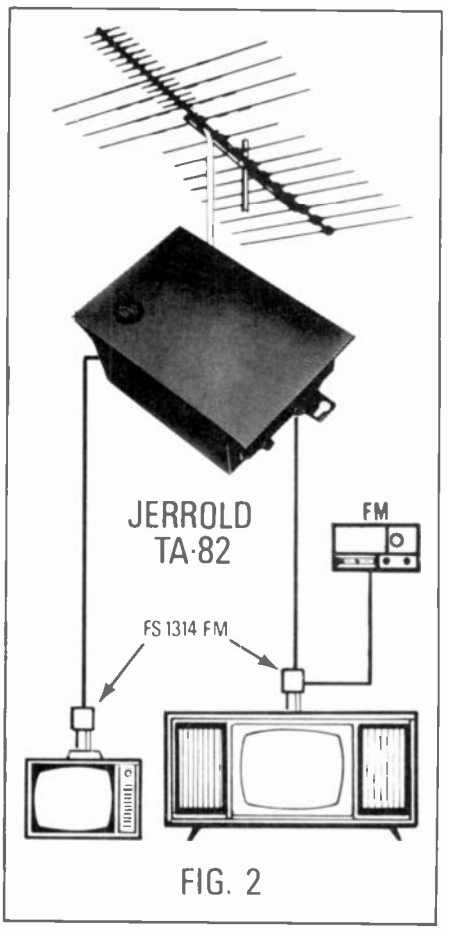

FIG. 2

An easier way of installing a 4-set home system would be to use a 4-output Colorcaster Plus, such as the Jerrold TA-84.

This brings us to another point. Jerrold has a complete line of Colorcaster Plus models, including 75 ohm models and VHF/FM only models. Thus, you can offer your customers a very wide choice for any reception area.

Jerrold also makes a full range of outdoor Powermate Plus preamplifiers for fringe and deep fringe areas. These preamps are ideal for bringing in distant channels and eliminating snow.

Finally, Jerrold offers the industry's most complete line of reception aids, including filters and traps to eliminate all kinds of interference.

When you need to improve TV or FM reception, Jerrold has the products to do it. And you should be suggesting the appropriate Jerrold reception aids with every antenna you sell. Your customers will love you for it and you'll make a lot more money.

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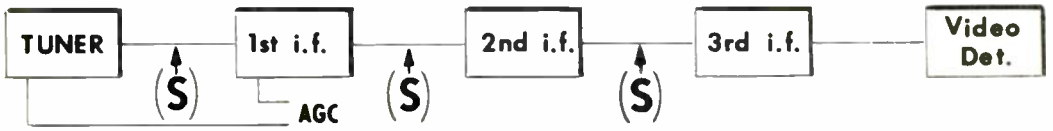

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